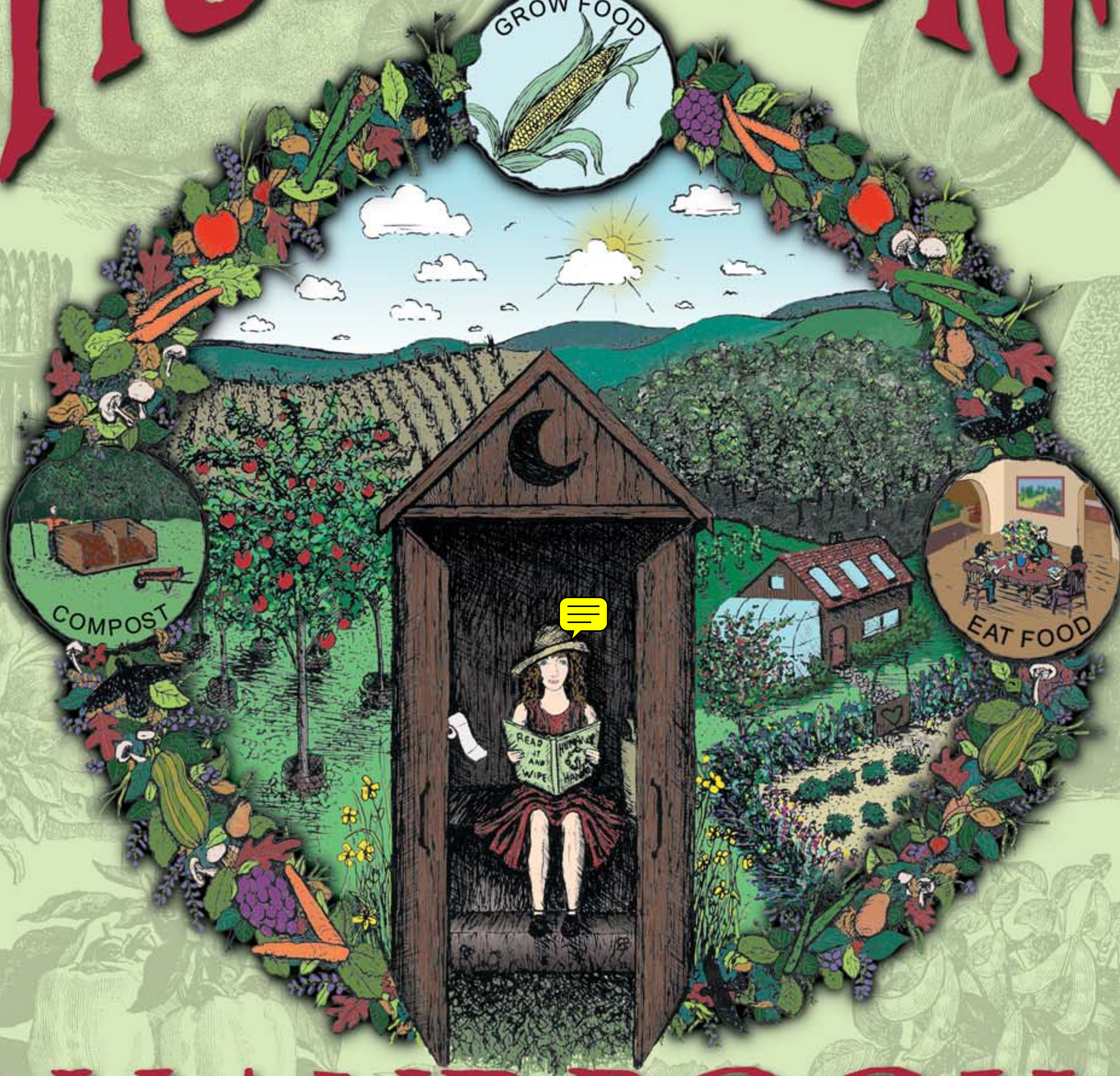
THE HUMANURE



HANDBOOK

A GUIDE TO COMPOSTING HUMAN MANURE

2nd Edition - Completely Revised, Expanded & Updated

JOSEPH JENKINS

THE HUMANURE HANDBOOK

A GUIDE TO COMPOSTING HUMAN MANURE

Second Edition - Completely Revised, Updated and Expanded

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I am grateful to the people in the composting toilet, graywater, and community composting worlds who provided me with useful information, including **John Cline** and **Jan McClain**, compost educators in Nova Scotia; **Mike Mangan** of Ecology Services in Wisconsin; **Paul Lachapelle** in Montana; **Carl Lindstrom** (www.greywater.com); and **Tad Montgomery**, Ecology, Energy and Waste Consultant in Massachusetts.

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A note of appreciation must be added for the international permaculture, organic agriculture, and sustainable gardening communities, whose existence and support has been inspirational.

Finally, a *special* note of recognition must be added on behalf of my wife, **Jeanine**, whose assistance at every stage in the creation of this work was tremendously beneficial.

The above list is by no means complete, as there were many people who provided assistance and information along the way, such as composting toilet personnel, government personnel, **readers**, and other individuals whose names are not listed here, but whose contributions were, nevertheless, greatly appreciated.

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(Back cover humanure truck by Tom Griffin.)

Photos and illustrations are by the author unless otherwise indicated. Some illustrations contain clip art, or portions of clip art. Illustrations containing old advertisements were adapted from an old magazine found in a barn.

Pot Luck Literary Appetizers

Reader Feedback from the First Edition

The first edition of this book was self-published on a meager budget and was expected, by the author, to require a total lifetime print run of about 250 copies. It was assumed that there was little, if any, interest in the topic of composting human manure, but the degree and nature of feedback that resulted from this unlikely book was surprising. The first edition of *Humanure* eventually amounted to over 10,000 copies in circulation. Excerpts from a sampling of the letters sent to the author are presented below. Some of the writers offer insight about their own composting experiences, which you, the reader, may find useful or interesting. At the very least, the following testimonials are inspiring, and they indicate that more than a few people care about our planet, and how we live on it.

"Thank you so much for your book. I believe that it is one of the most important books ever written. (I also enjoyed your web site very much.) I finished reading your book less than a month ago and have already participated in building two compost bins and am currently in the process of building the toilets to go with them." S.U. in ME

"The potential of the ideas in Humanure is so great in problems such as hollow food, landfill capacities, population densities . . . that I feel rather evangelical about the book and hope that others will also." R.S. in OH

"If this short sentence, 'We are defecating in our drinking water,' was put in front of our eyes frequently enough, more and more people would realize that this absurd behavior can't go on much longer." S.A. at BioLet International

"You have done the world a great service, and I thank you from the bottom of my f(heart)!!" B.F. in NV

"I'm so glad you wrote this book - one lady told us it should be required reading for everyone on the planet!" D.W. in PA

"My husband and I own a small sawmill with plenty of leftover sawdust needing to be put to use. Also, my 74-year old father thinks human waste should not be used in a garden, and I want to prove him wrong." A.M. in WA

"Your book is pure gold, just what I needed to give to my County Health Department head who is willing to go along with my desire for alternative systems." M.T.

"Your discovery of the proper small scale of the operation is world-shaking, together with the exemplary continuous-by-small-increments rate of production." F.A. in DE

"I enjoyed your book immensely. It clarified several technical and practical points. My mother is appalled that we would put one of 'those things' in the new house we're building, certain it can't be legal. Now that you've put the point in print we've been reduced from lawbreakers to just crazy. Pleasing me and irritating my mother, you score big in my two favorite categories." K.L.

"This wonderful book fits right into my COMPOST=REDEMPTION religious philosophy. You have answered questions I have held open since childhood." R. in MA

"May I join the chorus, too? The most exciting book I've read in a long, long time is yours. What a gem! Fun! A bumper sticker ad for the book should read, 'The Humanure Handbook Proves It: People Are Smarter than Shit!' Some people, anyway. 'Fecophobia': A new word for me and one that speaks volumes. As E.O. Wilson discovered 'biophilia,' so there is such a thing in humans as 'bio*phobia*,' and you've discovered and named very appropriately one of its roots: feco*phobia*. It's a real problem, and its solution, I think, is bio*philia,* feco*philia*. Your discovery of appropriate shit technology, including an appropriate 'throne,' makes the billions we spend so we can shit in drinking water appear finally and totally absurd." V.L. in FL

"I should have written this letter sooner. I would like to say that it is relatively rare to read a book of the calibre of the Humanure Handbook. A book that is enjoyable to read, empowering, hilarious, and has eye-candy pictures throughout. It's an unbeatable combination." J.D. in CA

"My budget is limited, so I don't buy many books. This one, however, I really had to have for my personal library. I borrowed your book via interlibrary loan and have already read it twice, but I wanted one to keep! Please send the Humanure Handbook!" L.M.

"I really celebrate your book and your willingness to step forward and break the crystallizations of fear around composting human manure. I know for a fact I would not be taking the steps toward taking responsibility for managing the feces and urine within our community without this book." L.F.

"After having finished your book, the Humanure Handbook, I'm more convinced than ever that those in charge of our society have no idea what the hell they're doing." J.R. in ME

"I knew nothing about this topic and by chance I purchased your book. Before reading I felt a little reluctance. However, once I started reading, I couldn't stop. As English is not my mother language, it took a lot of time (all the words I didn't understand I looked up in my dictionary). You are doing a great service to humanity by having the courage to publish your book. It is said that example is the best teacher." B.E. in Belgium

"Your book proved to be not only entertaining but also an invaluable source of information and reference. Thank you! At the hostel, your book has made it to the 'shelf of recommended literature.' On this shelf we display books we recommend our guests to read. Your book is placed between Thoreau's Walden and The Encyclopedia of Organic Gardening." J.N. in GA

"I just wanted to thank you for your valuable research you have done on the sawdust toilets. I enjoyed your book very much and have loaned it to many friends who seemed too embarrassed (or cheap) to buy it themselves. There must be quite a few readers of your book out there because I am seeing quite a few sawdust toilet and human manure discussions going on in the various straw bale and homesteaders news groups." D.K. in IL

"I'm just reading the Humanure Handbook and kicking myself for a fool! I've been composting for a long time. I've been buying everything I can on composting — old and new — especially on composting toilets and have been banging on about it for years, but have never managed (apart from the mouldering Clivus) to use one. Now the solution is so simple I shall simply remove our existing W.C. under the stairs and replace it with a sawdust toilet and everything else is in place! At the moment, I've been saving all my urine, which I add to the woodchip piles and that steams along merrily enough. Thanks for your book and providing the missing link! Yours steamingly," N.S. in UK

"My wife and I found a copy of your Humanure book last year, and have been living well with a sawdust toilet since then. (A blessing, after having spent gobs of time and money putting together a 150 gallon fly-breeding solar toilet — nothing like feeling little crawlies on your bum!)" P.U. in NM

"One thing you'll get a perplexing kick out of regarding Humanure and Papua New Guinea is a problem. Shit is part of you, goes local tradition. There it is, wasn't there before, dropped out of you. Therefore, it is you. Now with witchcraft being a major player here, all one has to do is pick up some of your shit and do nasty things with it (incantations or who knows what) and voila! you're done for. When I asked one very devout Seventh Day Adventist lady how her father died, she said, 'The traditional way. Someone didn't like him and made magic against him.' Joe, I don't think Humanure stands a ghost of a chance here, although I've mentioned it several times to the living. Go figure on this one." D.B. in New Guinea

"I am working as a development advisor to the Minister for Agriculture and Livestock here in Papua New Guinea, and [am] working on ways of encouraging people to shifting agriculture practices to site stable agriculture, which will require the input of more organic material as Papua New Guineans generally have insufficient finance to purchase chemical inputs. Some time ago I purchased . . . a copy of the Humanure Handbook, and I found it quite fascinating. Thanks for the information you put together in the Humanure Handbook." P.H. in Papua New Guinea

"I'm wracking my brain, trying to find a compelling way to tell you how great I think your book is. Here are some stabs: By the time I got to page 61, I had a mud bucket and a bag of sawdust set up in my bathroom." K.W. in WI

"Just finished reading your book, and I'm glad. Seeing Mr. Turdly dancing around the compost pile wasn't my ideal dream. Overall, I think your simple, low-cost and safe thermophilic system is a fantastic solution I've been looking for. I've been composting and using my own waste the past 20 years. Most of my friends think it odd. I counter that not even barbarians piss and shit in their drinking water."
E.S. in WA

"Please send me two copies of your beautiful book. I live and work at an International Youth Hostel . . . and we're using your sawdust toilets." B.S. in GA

"For 22 years, I have used scarab beetle larvae . . . they eat my shit in 5 minutes flat." C.M. in SC

"I really appreciate the fact that someone finally did their research and put it together in a pleasant, readable form. I have felt strongly about our absence in the food nutrient cycle for a long time, but lack the talent of articulation that you have shown. We have been recycling our humanure since 1979."
S.C. in WI

"Great book! Thanks so much for writing it! I had to call my dear heart long distance immediately to read her what may be the most hopeful environmental news I've heard in my 35 years, that something can transmute horrible toxins. Why aren't all the environmentalists raving about this and demanding major research on the applications?" C. in VT

"Your recently published book, the Humanure Handbook, is one of the most serious and humourous, well-researched yet humble, and motivating works I have read in a while. My personal research for some time now has focused on how to maintain soil fertility with minimal or no reliance on synthetic fertilizers. While I have focused on soil attributes that provide native fertility, I have known all along that a chunk of the cycle was absent. If you could claim credit for engineering the thermophilic decomposers, you would probably win the Nobel Peace Prize." T.C. in AZ

"From the squatting position, I request a copy of the Humanure Handbook." E.P. in RI

"I already knew that composting human waste made sense, and I had been looking for more practical information. Your book was exactly the information I was looking for, and it inspired me to put the ideas into action." B.C. in NYC, NY

"Thank you for putting the time, energy, [and] money into creating this unique, needed book. Your wit, wisdom, factual references and above all, your personal experience, make it a great and encouraging work." C.L. in NY

"Thank you for providing the information on dealing with shit in a responsible manner. As you know, the simple logic and responsible actions outlined in your book are rare in our society." J. in AK

"I recently read and thoroughly enjoyed your Humanure Handbook. I am an engineer who currently designs services, including sewers, for new developments. In recent years, however, I have become convinced that the way we deal with humanure, as you call it, is not far short of ridiculous. So, I have begun to educate myself about alternative ways of treatment and reuse." D.C. in Canada

"Thank you for your wonderful book about an environmental threat most people are unwilling to discuss, yet contribute to daily." P.K. in NH

"I have taken three dumps since finishing the Humanure Handbook, and all of them have been in plastic buckets and have been covered with sawdust." M.W. in WA

"You're right, it is the shittiest book I've ever read — but it's great! Have been a composter for a long time, but you showed me some new tricks." R.H. in WY

"I want to thank you all so much for the 'pioneering' work you have done with humanure and writing the Humanure Handbook . . . with the information you have provided I can complete the cycle." R.B. in FL

"I . . . spied an ad for your book, the Humanure Handbook . . . up until that point, it had only been a dream to somehow use my waste for fueling something that is necessary for my way of life. Now I have hope for a better future for myself, my family, and for the generations that will live on in this world after me." O.M. in CA

"A little over a year ago . . . I was in Guatemala . . . when I came upon a certain Humanure Handbook being carried around. I only had access to the book for less than one day, but . . . I devoured it, became a proselytizing devotee of the composting method and thermophilic bacteria and I am forever grateful to you for your amazingly thorough research and easily readable and digestible book." R.T. in CT

"Thank you for putting out such an important book . . . it feels good to know that there are fellow humans out there that realize that there is a way, a healthy way, to our actions that is good for all." D.D. in Canada

"Really enjoyed your book! As a public health person and 25 years as an organic gardener, the content was great." J.P.

"I am stupefied after reading your turdly book! What a masterpiece of modern literature. A real wake-up call for human types. In the future, I intend to follow all of your sensible suggestions and have a sawdust toilet." W.K. in AZ

"Your book was extremely well-written and answered all the questions I had been having for several years. I knew that somehow there was some missing info about what to do with all the 'do-do'."
R.L. in FL

"I just picked up the Humanure Handbook. It is full of humor, pluck, good advice and spirit. Someone I know locally has been championing your system for the past year. I'll have to try it myself." M.Z. in CA

"I'm almost done reading your book. Terrific. It definitely goes on a shelf next to How to Keep Your Volkswagon Alive and a few other 'anybody-can-do-this' type treasures. You've got me convinced. I'm partway through building a new house, and I've penciled in where the bucket will go." D.B. in MN

"For many years, I have wondered why we can use cow and horse and pig manure for our gardens, but not human manure. I showed this article to my father who was raised on a farm and he almost gagged. He couldn't even finish reading the article. I guess you'd call him a fecophobiac. Could you mail the handbook in a wrapper that has no mention of 'humanure'? I live with my parents." M.C. in CO (future composter)

"I recently purchased your Humanure Handbook. It is fabulous. I want to give it to EVERYONE. Please send me four more." L.F. in CA

"I have just finished your book . . . and I'm still wiping the tears off my face from laughing so hard. I never thought a book about human excretion could be so humorous, as well as very informative!" A.R. in OH

"I heard so many good things about the book while in the United States for summer holiday . . . that I combed all the bookstores for a copy of it. I am happy to report I have suffered no buyer's remorse since the purchase. The book is extremely moving, in all sorts of ways. When I leave the urban desert, I plan to practice what you preach in the book. Even more exciting is the prospect that your book has darn near sold my wife on the idea, too. When she sees the system you describe in action, I know she'll make the final step onto the bandwagon." D.G. in Abu Dhabi (United Arab Emirates)

"We had been looking for some info about safely composting our do-do for some time. Your book was a blessing and please know that it was an easy, fun read. Got the toilet installed day before yesterday and built a bin yesterday. Thank you for all of your hard work in doing the research and letting us all know that we are not alone in our way of living a more civilized way than the present barbaric generation we find ourselves among. What you have given us is the info we have been seeking, which empowers us to make an almost perfect circle with our resources." R.L. in FL

"Two things you might be interested in: a more natural way to eliminate is in the squatting position (supports the colon and all that shit). Maybe you might show (or offer the thought to future readers) of raising the knees higher — a step (simple block of wood, or big rock might be one solution). Also, more (food?) for thought. Urine is not a waste product. It is from the blood in our body. The excess nutrients and minerals that the body does not need at that moment has been filtered out (how marvelous). Taking urine internally has been going on for some time (1000s of years) and by many is considered a wonderful medicine. (Reading: 'Your Own Perfect Medicine') I take my first urine daily. Also, urine is used today in Murine's Ear Wax Removal, hand creams and other [products]. Now is that full of crap . . . or is it?" W.E. in OH

"Your book saved my butt at a town council meeting yesterday. Thank you for writing it." D.W. in CO

"With raised beds and numerous compost piles, it was only natural to be loaned a copy of the Humanure Handbook (carefully handed to me in a plain brown paper bag at church last spring). Great research, clear writing and terrific humor! I really should return that copy, so please send me one." L.U. in WV

"For over 40 years we have lived a more 'natural' way of life. Now the 'Authorities' are making it known we must conform to more (according to their beliefs) appropriate ways. He is 88 and I'm 77 — we need this help now! Please send us a copy of the Humanure Handbook." E.P. in NH

"As parasites attached to the Earth, it would seem that the only conscious thing we do that isn't killing the host, is manuring in the woods, fields or [in] a composting toilet." D.G. in MN

"In the past month I've made two humanure converts, both single women (living separately), both organic gardeners, both professional cooks. The biggest lure for them was the quality of my garden, and the opportunity to avoid purchasing fertilizer and soil amendments. Now they're hooked, preaching to their friends. Could be the start of a Big Movement." L.W. in WA

"I have just finished your book, which I found in somebody's house near Plettenberg Bay in South Africa. It took me four hours, cover to cover, and it's 3 a.m." A. M-J. in South Africa

"I just got your Humanure book and want more! We are trying to educate the Commissioners and public regarding doing the right thing and your book is timely!" T.P. in NJ

"Could you send me a copy all the way to Guatemala? Communities are ready to start a composting toilet project . . . send it as soon as you can." T.B. in Guatemala

"I liked your book. Putting back nutrients after taking them away makes sense as well as the image of dropping a turd in a five gallon toilet filled with pure drinking water seems crazy." T.O. in NH

"I work in a number of ways with state agencies that 'regulate' compost and land applications of biosolids. I will read your book with an eye toward putting copies in numerous hands — from bureaucrats to legislators to environmentalists — and more." D.R. in TX

"We are just beginning on the adventure of 'recycling' all of our human waste, including manure. And there is so little written that is available — I'm really glad that you took the time to write about your experience." D.P. in CA

"We're a couple of kids (late 60s-early 70s) pursuing composting. It's the only sensible and logical way to go." C. K-L. in OR

"I found your book entertaining, informative, and a great motivating force compelling us to start recycling our 'humanure' immediately. Having grown up with outhouses . . . I always thought there had to be a better way." B.W. in TX

"I'm the graduate student you just sent a copy of your handbook to. The book and resource list have both been just what I needed. I'm trying to get my parents thinking about composting their 'reusable' body materials (they already compost kitchen scraps, as I do). They are in the country with a very shallow well. They are already short of water and their troughs used to catch rain are dry. Dad is a Parasitologist, so you know he'll want to make sure the stuff heats up right. I would like to buy them one of your books. That'll make a good birthday present for Pops." S.M.

"We have a cabin in the mountains of North Central Washington that is off the grid, off the road and off just about everything. My wife and I spent Thanksgiving there and at this time of the year the outhouse is very uncomfortable. I believe your book will allow us to move it to more comfortable quarters."
L.V. in WA

"I've spent my whole life recycling, reducing and reusing everything but my own shit and I [am] ecstatically grateful to have your directions reach my lap." W.

"Thank you for your work in the Humanure Handbook. Your ideas have been a real encouragement to me to give composting a try in my sustainable home project. I was impressed by your research, the depth and scope of your study." J.D.

"The reason I'm writing is because I believe worm-egg phobia is overblown. I've been a pig farmer for decades, had probably literally tons of pig manure dumped on me over the years, have had pig manure get inside open bleeding wounds, have had it 'splash' into my mouth, and I can say that I've never gotten ill from it nor have I had any intestinal problems except when I got my divorce (ulcer). But I can say quite accurately that I've gotten ill a few times from eating in restaurants. I ask you, which is more dangerous, restaurant food or hog manure?" R.T. in WI

"Our son's Pa . . . was the one who tracked down your book . . . got our head librarian to order one for the Islands library and then created his own techniques. He feeds his bucket to several worm bins. They keep up with it . . . and it smells just fine. He also lines his bucket with a brown paper bag. It keeps clean-up easier — and is a great use for a bag that's had several uses but isn't fire starter yet. He found an antique porcelain receptacle with a toilet seat half buried in a vacant lot next to us and gifted me with it. A four gallon square bucket fits nicely and gives me over two weeks of use. When its full, I strap the plastic bucket onto my custom-made bike cart and off I go to our neighboring 10 acres where we are moving to this spring. I've got a bin set up using pallets on four sides — three narrow pieces of plywood overlapping on top with rubber tires to hold them down (all recycled, naturally). We've got huge piles of straw, manure, sawdust matter from the fairgrounds, bales of hay, bags of leaves and then I'll occasionally bring some kitchen scraps over. My serious winter sprouting gives me root mats after harvesting buckwheat lettuce, wheatgrass, and sunflowers. They are a great layering agent in our worm bins. I must say — this is very exciting to us — and I can't wait to dip my probe down into my pile in say, two years. I had to chuckle last week when I came around the corner on my bike with cart and bucket in tow. There was my neighbor directing this huge septic tank down into an excavated hole right next to his house. Everything about his 'new' home says toxic to me!" B.L. in WA

"Ah hah!! There is an intelligent lifeform out there. My husband and I have seen your book advertised in Countryside magazine for a good while. I finally came across it at the local library, checked it out and will eventually add it to our library. Great reading, common sense information, very well researched. We started your sawdust toilet idea at once. We are old dogs, but not too old to know a logical thing when we read it. Thanks, and bless you and yours." E. & J.C. in OH

"Thank you so much for your book, humorous and well written. We are enjoying it. We have just received it yesterday. We will be posting you the pictures of our composting toilet on the beach this week. And again many thanks." G.F. in Indonesia

"Humanure and the potential for large-scale . . . even a city size composting collection (apartment building toilets into a central collection dumpster), along with the crimes of the so-called 'septic system,' has become one of my most favored topics of conversation and promotion. Often through direct exposition at our farm. Many thanks for your noble work of art and contribution to this stinky species of ape." R.T. in CT

"I couldn't resist writing you to say how much I enjoyed your book. Normally I can't absorb the written word very easily, but I soaked yours up, which I guess is rather appropriate. I've been composting for several years now. Robotically and indifferently at first, but gradually developing to a level which I can only describe as obsessive. I bore everyone silly talking about it — except my fellow composters, that is, and there are several around here. As I got more into it, I found myself thinking about the possibility of composting bodily harvests, until it got so every time I sat on the loo and performed, I was begrudging every turd! Becoming more and more conscious of the waste and stupidity of the whole system with every plop, the idea slowly formed in my mind that perhaps I could do something about it. Reading your book clinched it. I have resolved to pull out of the mainstream sewage system, hence the ordering of the most capacious compost bin I could find. As the rest of my family find the idea abhorrent (ha, ha — in their lifetime it will most likely become law!), I'm forced to go it alone." J.M. in England

"As a small publisher and writer, I don't often take the time to write fan letters and testimonials, but this is both. We've lived on a small island in the Pacific coastal rainforest for 20 years and have been composting/mouldering our shit since we moved here. We're glad to have some new arguments to use from your book as, over the years, a few guests weren't too enthusiastic about our system." C.H. in Canada

"We've read your book from cover to cover and are planning to implement it this summer when we move to our paid-for place in the country. Thanks for the great information. I publish a Christian Homesteading magazine. We will [also] be publishing a special newsletter devoted to Y2K problems . . . deal[ing] with the nitty-gritty, how-to preparedness topics and Humanure compost toilets will fit right in." J.E.

"We live in Mexico in the high desert of San Miguel de Allende where the water is precious and the soil is lousy. You've solved two of our biggest problems . . . My husband is so FECOPHOBIC, that he swears he neither shits nor farts. Getting him sold on the idea will be a problem. Any suggestions? I, of course, will be the one to empty the bucket." L. in Mexico

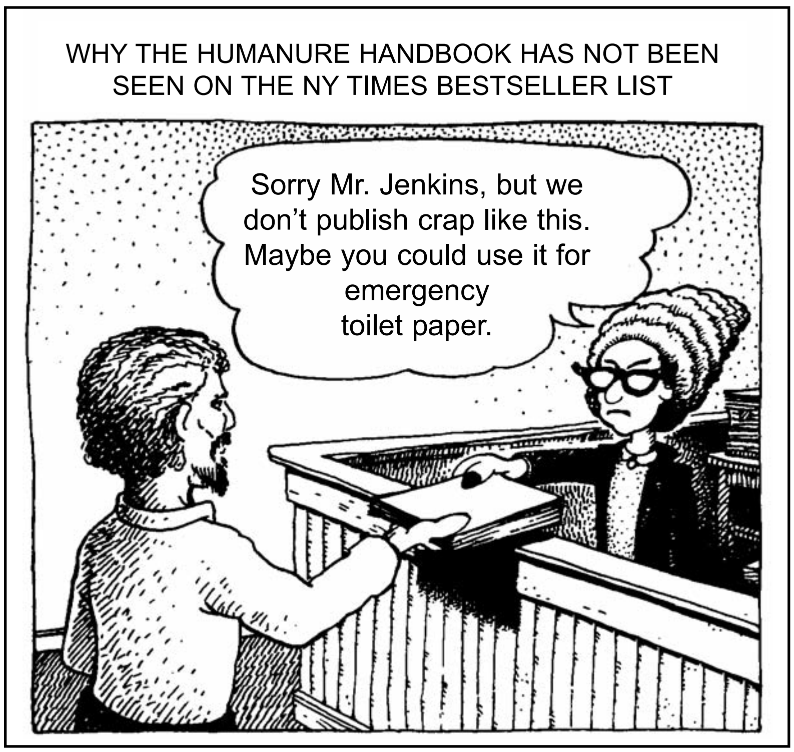
"Recently a friend of mine lent me a copy of your book The Humanure Handbook. To say that I enjoyed and found useful the contents and message of the book would be a considerable understatement. And in short i would very much like to purchase a copy of my own. Thank you for all your time and effort in making this information available." Rev. H.G. in CA

"Great book! I really loved it. We are soon to move to a new house. I can't wait to start composting humanure. Thank you for all the information in the book. It will sit on a special shelf in the bathroom — reading material for those occupied in communing with nature!" B.C.

"Twelve years ago, I designed and built a solar powered home, and have been repeatedly told (so I now believe) that I am a very creative person. So, as I was reading your incredibly inspiring, well-written, humorous, and innovative book, I kept asking myself . . . Why didn't I think of this? You are truly a gift from — and to — Mother Earth. Thank you, thank you." O.B. in ID

"I continue to be moved to hilarity by your writing, and the cartoons are pretty good too. Best of all is that your method of killing pathogens and parasite eggs and returning nutrients to the soil is virtually free. We are an environmental education center as well as a land trust community. So far we focus mainly on sustainable building, biointensive gardening, and wildlife management. I have a particular interest in a very simple lifestyle — sort of a radical eco-luddite anarchist type myself. Thanks again for the book!" M.M. in TX

"Your book came up in a search on Amazon.com and here I am, having just finished it, feeling like a man whose universe, at least one little corner of it, has condensed and collapsed, fallen into effortlessness, into rightness like a neutron star, like a compost pile. eureka! refinement! My shit makes sense! at last! Thank you." R.P. (fellow common-senser) in MA


WHY THE HUMANURE HANDBOOK HAS NOT BEEN SEEN ON THE NY TIMES BESTSELLER LIST
Sorry Mr. Jenkins, but we don't publish crap like this. Maybe you could use it for emergency toilet paper.

The Humanure Handbook - Second Edition

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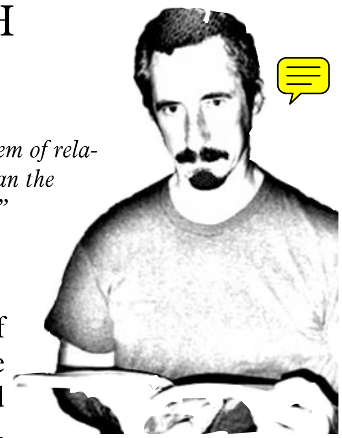
WELCOME TO PLANET EARTH

A word from the Author



"The balance of nature is . . . a complex, precise, and highly integrated system of relationships between living things which cannot be safely ignored any more than the law of gravity can be defied . . . by a man perched on the edge of a cliff."
Rachel Carson - *Silent Spring*

Who would'a thunk it? That's what a friend of mine said when he heard that the Humanure Handbook, 2nd edition, had received national book award recognition, including "Outstanding Book of the Year" and the book "Most Likely to Save the Planet." Who would'a thunk that a guy crapping in a bucket for a couple of decades could write and self-publish a book about it in 1995 that would, by 2003, be in at least 51 countries around the world? Don't people have anything better to read?

The *Humanure Handbook* has been discussed on international radio, and on U.S. television. It was covered by the Associated Press, and in various national publications — even mentioned in the Wall Street Journal and Playboy magazine. It was roundly vilified on Howard Stern's radio show where I was censored — twice! — for daring to utter words that no one must ever hear on the airwaves, including the "s" word (when I honestly asserted that one of Stern's fake call-in people was "full of shit"). More surprisingly, however, Stern censored out the following statement I made during the interview: *"I have composted all of my family's humanure in my backyard for 20 years, and have grown a food garden with it the entire time."* These words were not allowed to reach the tender ears of Howard Stern's audience. As soon as my interview was over, however, the listeners were instead titillated with playful songs about anal intercourse. Funny world, this. Funny creatures, humans.

In the United States, humans take flush toilets for granted. You take your dump into a large bowl of drinking water, then flush it. End of story. That's the civilized thing to do. But where does the flushed material go? What would happen if everyone in the world crapped in their drinking water supplies? Why doesn't any other land mammal defecate deliberately in water? Why do we? These all seem like questions any reasonably curious person would ask once in a while. What if the toilet won't flush? Then what? How long can you hold it? People actually crap in ziplock bags and put them in the trash during power outages. Really.

What if I told you that two five gallon buckets and a large bag of peat moss, sawdust, or even shredded junk mail will make an odorless, waterless, environmentally friendly emergency toilet for one person for two weeks. If a compost bin and a steady supply of sawdust, peat, leaves, etc. is available, that toilet could last indefinitely — literally for decades, even lifetimes. The system can be modified to suit a variety of environments and locales, and can be expanded, with municipal support, to conceivably deal with the odorous excretions of any number of human beings.

Nevertheless, I first published the Humanure Handbook with a great degree of trepidation. After all, recycling your own crap can be as bizarre to some people as a chicken with tits. You could suddenly beam down from the planet Uranus and raise less eyebrows than someone who refuses to flush. In fact, sometimes I feel like I *did* beam down from another planet when I see all the crazy things humans do to the Earth's environment. So I wasn't sure I even wanted anyone to *read* the book, and although I knew some people would be fascinated, I just didn't know who or where they were. I estimated there were maybe 250 people in America interested in the topic of humanure composting (roughly one in a million), so I printed a small number of books the first time around and assumed they would sit in my garage for the rest of my life until I discovered, one by one, those potential readers.

No sooner had I printed the first batch of books than a friend had to have one. Damned if he didn't show it to his girlfriend, a newspaper reporter, and she soon appeared at my door — with a camera. In a matter of days, the story of an otherwise ordinary man composting his family's you-know-what in his backyard was all over the papers, including an enormous photo of me poking around in a compost pile with a pitchfork. The TV stations thought this story was important enough to broadcast as news, and a friend called to say he saw the book mentioned on a network TV morning show. The news anchor stuttered when she tried to read the word "turd," however, much to my friend's delight. Someone should have warned her that one of the book's chapters was titled, "*A Day in the Life of a Turd.*"

Soon I got a call from a group of nuns wanting me to do a presentation about humanure at their convent. I never would have expected anything like this — I had to try to imagine nuns taking a crap, something that had never crossed my mind before. But I obliged them, and they taught me something important about spirituality and humility, which is mentioned in Chapter Four. As more time passed, I learned more and more new things from others. In fact, I suddenly became a "USM" (Universal Shit Magnet), receiving turd jokes and every conceivable shred of information about crap that can be faxed, emailed, or sent by post from everywhere in the Universe. In the meantime, I kept selling out of books and doing larger and larger reprints. More speaking engagements popped up. Then the Pennsylvania Department of Environmental Protection informed me that *Humanure* was nominated for an environmental award. Even the BBC called from London and wanted to do an interview. I seemed to be getting a lot of publicity for a guy who didn't want anyone to read his book.

Why *did* I write this book, anyway? Probably because I have personally recycled all of my family's humanure since 1979 (twenty-four continuous years at the time of this writing) using very simple, hygienic and odor-free methods. The resulting compost has always been used in our food garden. Although this may give some people the willies, we have not bought fertilizer or hauled manure for our annual gardens in decades. Instead, we produce our own fertilizer. So do you, even if you won't admit it. Yours is probably wasted, however, while ours is not.

The more research I did on this topic, the more I realized there was precious little information about safe humanure recycling available in print. It's no wonder people react with fear and loathing when confronted with the concept. Although bits and pieces of information were available, they were scattered about in hard-to-find, obscure references such as research papers or foreign publications. Where there is ignorance, there is misunderstanding, so I compiled this information and wrote this book to try to shed a small ray of light into what is otherwise a big black hole of ignorance. I do not claim, by any means, to have all the answers, nor do I consider myself an "expert." I make no pretense along those lines. But with 28 years of organic gardening and composting experience, I've learned a thing or two which may be of interest to the average reader.

This book has gone through two editions and seven printings so far. I had seriously considered letting it go out of print when the last print run started to dry up — after all, who wants to be "*the humanure guy*" all his life (or is it too late?). I have *other* books in print, too, folks, by the way (check them out at jenkinspublishing.com). Time to move on, I was telling myself. Time to write new titles, expand my horizons. I was thinking along the lines of "A Pictorial Guide to the World's Nude Beaches." But something made me change my mind — perhaps the feedback I receive on a regular basis from all sorts of people who somehow have managed to derive a tiny benefit from this book (other than using it for toilet paper, I mean). So here it is again, like a turd that won't flush, back at ya, the Humanure Handbook. Ta Da!

What sort of feedback could possibly have deterred me from a nude beach research project? Here's a very small sampling of recent letters:

⋆⋆⋆

"I just wanted to let you know that I have just finished setting up a composting toilet system, according to your design. Well, to my surprise...the outhouse has no odor whatsoever and you would think you were using a "modern flush toilet," it smells so clean. I have a physical disability that causes me the need to use a wheelchair and this system is wonderful. I can move the sawdust toilet into the bedroom and there are no odors as with a regular bedside commode."

⋆⋆⋆

"Let me thank you for such a wonderful book. I wish I had found it several years ago. However, it has caused marital problems. My wife thinks I get more excited about your book than her."

⋆⋆⋆

"When I first heard about this system I was cynical, 'it must be smelly, it must have lots of flies all over it.' It isn't, it doesn't. It, for me, is the Rolls Royce of toilets. It is simple, it is humble, it is effective."

"I showed the book to friends, some of whom thought it was great, but most of whom thought I was a few sandwiches short of a picnic. Now, here it is about five years later, and I know a bunch of other folks who use the system outlined in the book full time, all of whom have had great results."

⋆⋆⋆

"We took our old outhouse, made a few alterations, and now we are the proud owners of a smart, clean, odour free, Humanure Hut!"

⋆⋆⋆

"The book was the magic key to saving water and not producing sewage plus there is a bonus... free fertilizer! This is a win win win situation. We have a small eco-education camp in Mexico for kids and we use four sawdust toilettes that have been working like Swiss clocks for years!"

⋆⋆⋆

"I'm now in Ghana, Africa. I've had your book for over a year now and it is groundbreaking indeed. Since I'll probably be in Africa for the next 2 years, I want to start a project on water treatment and waste management."

⋆⋆⋆

"I set up a 'sawdust' toilet in our house. I've been using junk mail and cereal boxes. I run the papers through a confetti-type paper shredder. This material has worked well for cover, and the compost bin seems to like it, too. So now thanks to your guidance, a number of materials that were being treated as waste are now being used as true resources."

⋆⋆⋆

"I wanted to thank you for bringing me and my obsession over composting out of the closet. I now feel very confident in telling everyone I know that they can take their fecophobia and flush it."

⋆⋆⋆

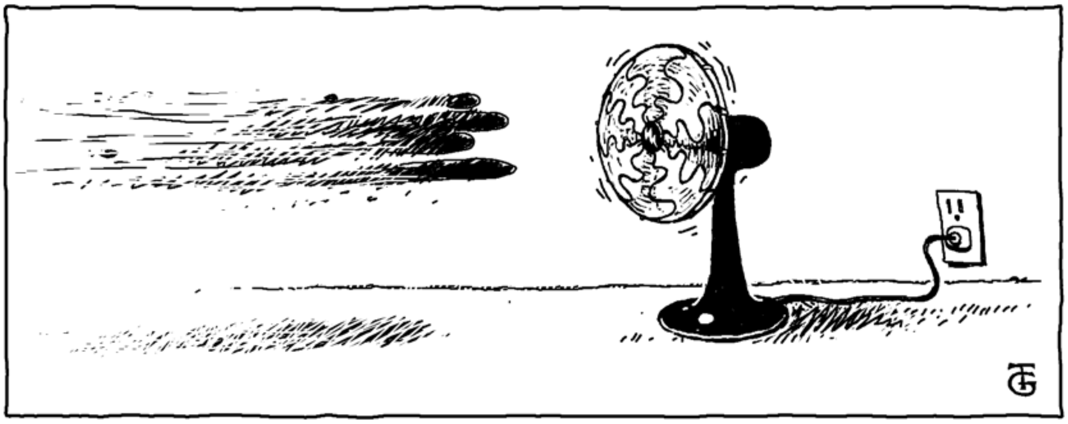
"I was in Kenya supervising the construction of our Street Children Home. Of course, one of the features in the home will be a Humanure system. Our visit to the sanitation department sparked a great deal of interest in Humanure as an option for the public toilet system in Kenya."

That sort of sums it up, folks. Check out my web site at **humanurehandbook.com**. I have humanure videos available there (by popular demand!). Post a message on the public message board there. Send in a photo of your own personal alternative toilet! Drop us a line at **mail@josephjenkins.com**, but don't be disappointed if I don't personally reply to your email. If I'm lucky, I'll be on a nude beach somewhere — if I'm not called back to Uranus first.

JCJ, Spring 2003

CRAP HAPPENS

Something's About to Hit the Fan



"Human beings and the natural world are on a collision course . . . No more than one or a few decades remain before the chance to avert the threats we now confront will be lost and the prospects for humanity immeasurably diminished."
1600 Senior Scientists from 71 countries, including half of all Nobel Prize winners, November 18, 1992
World Scientists Warning to Humanity

There is a disturbing theory about the human species that has begun to take on an alarming level of reality. It seems that the behavior of the human race is displaying uncanny parallels to the behavior of pathogenic, or disease-causing, organisms.

When viewed at the next quantum level of perspective, from which the Earth is seen as an organism and humans are seen as microorganisms, the human species looks like a menace to the planet. In fact, the human race is looking a lot like a disease-causing pathogen, which is an organism excessively multiplying, consuming, and producing harmful waste, with no regard for the health and well-being of its host — in this case, planet Earth.

Pathogenic organisms are a nasty quirk of nature, it seems, although they do have their constructive purposes, namely killing off the weak and infirm and ensuring the survival of only the fittest. They do this by overwhelming their hosts, by essentially sucking the vitality out of them and leaving poisonous wastes in their wake. Pathogens do not give a damn about their host organisms, and they often kill them outright.

This may seem a silly way for a species to maintain its own existence — afterall, if you kill the host upon which you feed and upon which your life depends, then you must also die. But pathogens have evolved a special survival tactic that allows them to carry on the existence of their own species even after their host has died. They simply travel to another host, sending out envoys to seek out and infect other organisms even as their main pathogenic population succumbs along with their original host. A man dying of tuberculosis coughs on his deathbed, an act instigated by the infecting pathogen, ensuring that the disease has a chance to spread to others. A child defecates on the dirt outside her home, unwittingly satisfying the needs of the parasites inhabiting her intestines, which require time in the soil as part of their life cycle. A person stricken with cholera defecates in an outhouse which leaches tainted water into the ground, contaminating the village well-water and allowing the disease to spread to other unsuspecting villagers.

In the case of pathogenic organisms that kill their host, the behavior is predictable: multiply without regard for any limits to growth, consume as if there were no tomorrow, and excrete waste products that grievously harm the host. When this is translated into human terms, it rings with a disquieting familiarity, especially as we relentlessly equate human success with growth, consumption, material wealth, and profit.

Suppose we humans are, in fact, exhibiting disease behavior: we're multiplying without regard for limits, consuming natural resources as if there were no tomorrow, and producing waste products that are distressing the planet upon which our very existence depends. Well, there are two factors which we, as a species, are not taking into consideration. First is the survival tactic of pathogens, which requires additional hosts to infect. We do not have the luxury of that option, at least not yet. If we succeed at continuing our dangerous behavior, we also succeed in marching straight toward our own demise. In the process, we can also drag many other species down with us, a dreadful syndrome that is already underway. This is evident by the threat of extinction that hangs, like the sword of Damocles, over an alarming number of the Earth's species.

Second, however, there is one remaining consideration: infected host organisms fight back. As humans become an increasing menace, can the Earth try to defend itself? Absolutely, and in several ways. Number one is climate change, also known as global warming. When a disease organism infects a human being, for example, one of the defense mechanisms our body deploys is the elevation of its own temperature. This rise in temperature not only inhibits the growth of the infecting pathogen, but also greatly enhances the disease fighting capability within the body. Global warming may be the Earth's way of inducing a fever — as a reaction to human pollution of the atmosphere and human over-consumption of fossil fuels. Sound ludicrous? Don't laugh — read on.

When the internal human body tempera-

PATHOGEN ALERT!

Earth's atmospheric concentrations of CO_2 have climbed to the highest level in 150,000 years.

ture rises, the micro-climate of the body changes, allowing for the sudden and rapid proliferation of antibodies, T-cells, white blood cells, and other defenders against disease. As the *global* climate changes, and as the natural environment chokes with pollution, we humans do have an idea of what sort of organisms nature can and will suddenly unleash to confront us. They're already beginning to show themselves as insect pest population booms, as well as new strains of deadly bacteria, viruses, and algae particularly toxic to humans.

So Earth's temperature slowly and inexorably rises, and, despite the potentially perilous consequences, humans try to ignore it. Global carbon emissions from fossil fuels are expected to reach nine billion tons per year by 2010,[1] and are expected to raise the Earth's temperature by two to six degrees Fahrenheit in the next century.[2] The Earth's temperature in 1998 was the highest ever recorded and exhibited the largest annual increase, setting *"a new record by a wide margin,"* according to NASA scientists.[3] The 15 warmest years on record have occurred since 1980.[4] The highest ever sea temperature in the North Atlantic was recorded in 1995, the same year that twice the normal number of tropical storms occurred. Today, ecologists are shocked to see large portions of Antarctica melting, breaking off, and falling into the Southern Sea.[5] All the while, spokespersons for the fossil fuels industry, the largest economic enterprise in human history, dismiss the frightening evidence as merely environmentalist scare tactics, unsubstantiated by valid scientific proof.

As the planet's temperature rises, it gains a momentum that cannot be stopped, no matter how desperate or repentant we humans may eventually become. The Earth's "fever," like a spinning flywheel, will only subside in *its* own time. With global warming and climate change, we may have created a Frankenstein's monster of astronomical proportions. Unless, of course, we are pathogenic organisms. If so, then we really don't care, do we?

"A great change in our stewardship of the Earth and life on it is required, if vast human misery is to be avoided and our global home on this planet is not to be irretrievably mutilated."
World Scientists Warning to Humanity

Pathogens can often dwell for quite some time within the host organism without causing disease symptoms. Then something happens to spark their growth — they gain a sudden foothold and begin proliferating rapidly. It is at this point that disease effects begin to undeniably show themselves.

Humans began to *strongly* show their pathogenic potential toward the planet during the 1950s, ravenously devouring natural resources and discarding waste into the environment with utter carelessness. Since then, for example, our fish catch has increased by a factor of five, paper consumption by a factor of six, grain consumption tripled, fossil fuel burning quadrupled and atmospheric concentrations of CO_2 have reached the highest level in 150,000 years.[6]

Human consumption can be roughly measured by our output of material goods. Since 1950, the global output of human goods and services grew sixfold. Between 1990 to 1997, human global output grew as much as it did from the beginning of civilization until 1950. In fact, the global economy grew more in 1997 alone than during the entire 17th century.[7]

Now, at the end of the 20th century, our consumptive and wasteful lifestyles have painted a critical global picture. Almost half of the world's forests are gone. Between 1980 and 1995, we lost areas of forestland larger than the area of Mexico, and we are still losing forests at a rate of 16 million hectares a year.[8] Water tables are falling on every continent from one to three meters per year. Fisheries are collapsing, farmland is eroding, rivers are drying, wetlands are disappearing, and species are becoming extinct.[9] Furthermore, the human population is now increasing by 80 million people each year (roughly the population of ten Swedens). Such population growth virtually guarantees increased consumption as well as increased waste with each passing year.[10]

The damage of human over-consumption shows itself in other ways. Today, half of the coastlines and nearly 60% of the coral reefs on the planet are threatened with overdevelopment, pollution, and overfishing. Although almost no species of ocean fish was overexploited in 1950, now nearly 70% of fish species are either fully exploited or overexploited by humans.[11] Oceans and other bodies of water have long been used as dumps by the human species. For example, since 1950, mercury contamination has increased by a factor of five in the Baltic Sea. In the Black Sea, 85% of the marine species have disappeared.[12]

What about extinctions? The natural background rate of extinctions is estimated to be about one to ten species per year. Currently, it's estimated that we're instead losing *1,000 species per year*. More than 10% of all bird species, 25% of all mammals, and 50% of all primates are threatened with extinction. Freshwater fish now face a 37% extinction rate in America, 42% in Europe, and 67% in South Africa.[13]

Plant life is not immune to the forces of destruction that are threatening so many species either. Of 242,000 plant species surveyed by the World Conservation Union in 1997, one out of every eight (33,000 species) was threatened with extinction.[14]

PATHOGEN ALERT!
Although the natural background rate of extinctions is estimated to be about one to ten species per year, we are currently losing 1,000 species per year.

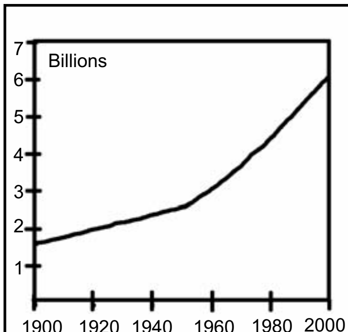
What would drive a species to damage its life support system in this way? Why would we humans disregard our host organism, the Earth, as if we were nothing more than pathogens intent upon its destruction? One answer, as we have seen, is consumption. Somewhere along the line we learned to embrace the idea that more is better, measuring success with the yardstick of material wealth. Some startling statistics bear this out: the

225 richest people in the world (0.000003% of the world's population) have as much acquired wealth as the poorest *half* of the entire human race, while the wealth of the world's three richest people is equivalent to the total output of the poorest 48 countries. We in the United States certainly can raise our hands and be counted when it comes to consumption — our intake of energy, grain, and materials is the highest on the planet. We Americans can admit to using three tons of materials per month, each of us, and that's not counting food and fuel. Despite the fact that we are only 1/20 of the globe's population, we use 1/3 of the globe's resources. To sustain the entire world at this level of consumption would require no less than three planet Earths.[15]

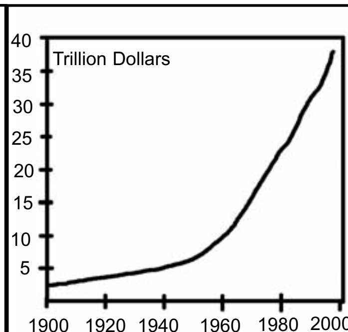
"There is an exceptional degree of agreement within the scientific community that natural systems can no longer absorb the burden of current human practices."
World Scientists Warning to Humanity

Wanton consumption breeds wanton wastefulness. Since the 1950s, more than 750 million tons of toxic chemical wastes have been dumped into the environment.[16] By the end of the 1980s, production of human-made synthetic organic chemicals linked to cancer had exceeded 200 billion pounds per year, *a hundred-fold increase in only two generations.*[17] By 1992, in the US alone, over 435 billion pounds of carbon-based synthetic chemicals were being produced.[18] In 1994, well over a million tons of toxic chemicals were released into the environment. Of these, 177 million pounds were known or suspected carcinogens.[19]

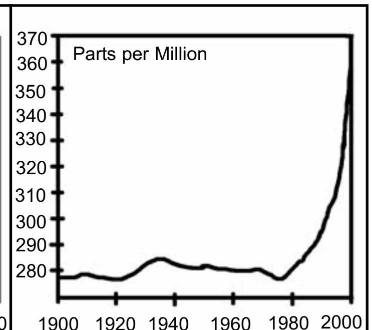
There are now about 75,000 chemicals in commercial use, and 3,750 to 7,500 are estimated to be carcinogenic (cancer-causing) to humans. That means that one out of every ten commercial chemicals may be cancer-causing — chemicals dispensed into your home via such common household items as aerosols, air fresheners, deodorizers, furniture polish, or the lumber used in the construction of your picnic table.



World Population 1900-1998
Source: State of the World 1999, p. 8



Gross World Product 1900-1997
Source: State of the World 1999, p. 10



Atmospheric Carbon Dioxide, 1900-1997
Source: State of the World 1999, p. 26

Toxic chemicals have been carelessly dumped into the environment since their creation. Forty thousand of the most notorious dump sites and hazardous waste landfills have been termed Superfund sites. Of these, there are 1,231 "priority" sites, with 40 million people (one in every six Americans) living within four miles of one.[20]

Today, as a result, 40% of Americans can expect to contract cancer in their lifetimes. I can think of quite a few people, personal friends, who have contracted cancer in the past few years. Marcia, an artist in her mid-forties, got breast cancer a couple years ago and had to have part of one breast removed. Kristin, a school teacher in her mid-forties, and a lifetime organic gardener, also contracted breast cancer last year. Nina (mid-forties) got breast cancer a few years ago and now she has no breasts at all. Kaye (mid-forties), a healthy, Bach Flower Remedy practitioner and natural food advocate, suddenly came down with breast cancer and died. She left several beautiful daughters behind. Sandy, another apparently healthy, slender school teacher in her forties, got cancer of the uterus and had it removed. She never had any children. My mother had lung cancer. Two of my aunts died of cancer. Several of my friend's fathers have died of cancer, as well as several of my father's friends. Other friends or their parents have had bouts with cancer, but survived. Some of these were people who lived healthy lifestyles, ate nutritious food, and were active. They still developed cancer. But then, so do animals in the wild, so do fish and sea mammals. Lifestyle seems to have little effect on whether one comes down with the disease. Why? Because there is no escape from the cancer-causing chemicals that now pervade our environment and enter our bodies through the food we eat, the air we breathe, and the water we drink. Even household pets are not immune.

The World Health Organization has concluded that at least 80% of all cancer is attributed to environmental influences. One glaring example of this lies in the fact that industrialized countries have a lot more cancers than countries with little or no industry. Breast cancer rates are thirty times higher in the United States than in parts of Africa, for example. Childhood cancers have risen by one third since 1950, and now one in every four hundred Americans can expect to develop cancer before the age of *fifteen*. Between 1950 and 1991, incidences of all types of cancer combined have risen 49.3% in the United States. Cancer is now the second leading cause of death overall, and the leading cause of death among Americans between the ages of 35 to 64. Furthermore, the US EPA projects that tens of thousands of additional fatal skin cancers will result from the ozone depletion that has already occurred over North America.[21]

Cancer is not the only issue associated with the synthetic organic chemicals that we humans have created and have carelessly allowed to pollute the environment. Disturbing new evidence indicates that some of these pollutants mimic natural hormones and can wreak havoc with the endocrine (hormone) systems of many animals, including humans. Male fish are being found with female egg sacs, male alligators with shriveled penises, and *human* male sperm counts are plummeting. Some of these common organic chemical pollutants mimic estrogen, a powerful natural hormone governing the female reproductive system, an excess of which has been linked to cancer. Other chemical pollutants interfere with testosterone, the male sex hormone, or with thyroid metabolism. These chemical pollutants lodge in animal fat cells, traveling up the food chain to concentrate in higher animals — like us. They are becoming increasingly concentrated in human mother's milk, and they cross the placental barrier to enter developing fetuses. It's a well-documented fact that synthetic organic chemical pollutants have traveled far enough to pervade every corner of the world — you may have heard some of their names: dioxin, PCBs, DDT, 2,4-D. *The average person can now expect to find at least 250 of these chemical contaminants in his or her body fat*.[22]

Are cancer and endocrine disruption two of Mother Nature's defense mechanisms against organisms that have rudely gone awry? Are they not-so-subtle ways nature tells us that we're doing something wrong? Perhaps, and unfortunately the victims are often the innocent ones who bear no responsibility for the diseased state of the environment.

Our environmental misdeeds may be sowing the seeds of our own destruction in other ways as well. Damaging environmental changes seem to be contributing to the emergence of new toxic organisms, as well as the proliferation of old menaces such as malaria. Fifty new diseases have emerged since 1950, including Ebola, Lyme's Disease, Hantavirus, and HIV.[23] The World Health Organization reports that AIDS (HIV virus) is approaching epidemic proportions in several countries in Africa, and is spreading to India and China.[24] Researchers warn of the epidemic potential of the malarial mosquito population should global warming continue.[25] Others report epidemic levels of coastal algal blooms, some of which are highly toxic to humans as well as fish, and are directly linked to excessive human pollution.[26] Are these disease organisms some of nature's defense mechanisms, emerging in order to attack the human race? Although this is a chilling thought, it's not so chilling as the theory that this is just the beginning of the appearance of new diseases targeting the human race, and that future viruses may be as deadly as the plague and transmitted as easily as is the common cold.

"In effect, we are behaving as if we have no children, as though there will not be a next generation."
Lester R. Brown

Some would say that it looks like our environment is going to hell in a handbasket. Others would postulate that the human race is going along with it. Yet there are still those who would scoff at the idea that a tiny organism such as humanity could affect such an ancient and immense being as Mother Earth. This is a ludicrous concept, they argue; the very idea that the human species can be powerful enough to inflict illness on a planetary being is nothing more than egotism. Perhaps. Afterall, where is there any evidence that a planet can get sick and die? Where could we ever witness a planet that had once possibly teemed with life, where rivers flowed on its surface but long since dried up? Well, how about Mars?

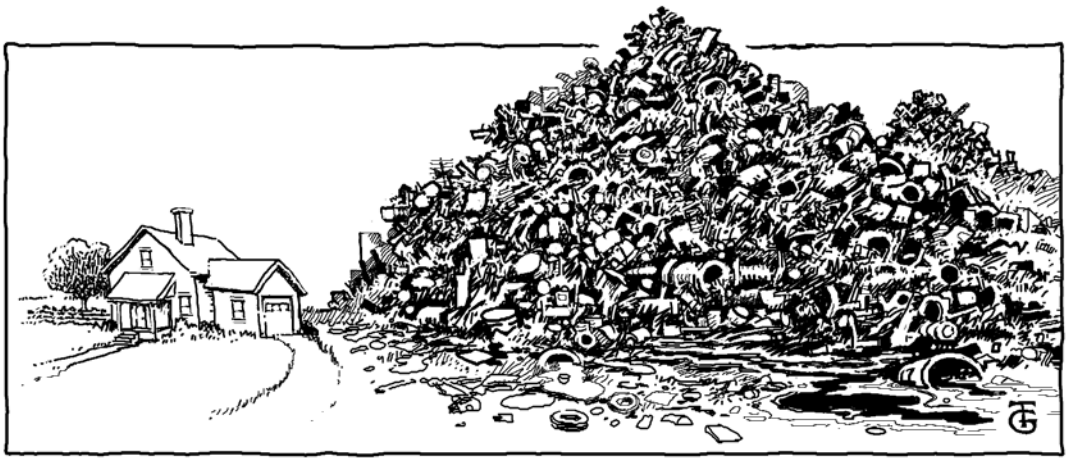
What *did* happen to Mars, anyway? Our next door neighbor, the Red Planet, apparently was once covered with flowing rivers. What happened to them? Rivers suggest an atmosphere. Where is it? Was Mars once a vital, thriving planet? If so, why does it now appear dead? Could a lifeform on its surface have proliferated so abundantly, so profligately, and so recklessly that it deleteriously altered the planet's atmosphere, thereby knocking it off-kilter, and, in time, killing it? Is that what's happening to our own planet? Is it our legacy in this solar system to leave behind another dead rock to revolve around the sun? Or will we simply destroy ourselves while the Earth, stronger than her Martian brother, overcomes our infection and survives to flourish another billion years?

The answer, if I may wildly speculate, is neither — we will destroy neither the Earth nor ourselves. Instead, we will learn to live in a symbiotic relationship with our planet. To put it simply, the human species has reached a fork in the road of its evolution. We can continue to follow the way of disease-causing pathogens, or we can chart a new course as dependent and respectful inhabitants. The former requires only an egocentric lack of concern for anything but ourselves, living as if there were no tomorrow, as if there will be no future human generations. The latter, on the other hand, requires an awareness of ourselves as a *dependent* part of a Greater Being. This may require a hefty dose of humility, which we can either muster up ourselves, or wait until it's meted out to us, however tragically, by the greater world around us. Either way, we have to collectively make a decision, and the time is running out.

Fortunately, many competent people are already aware of and working on the problems touched upon in this chapter. Each of these problems is a piece to a puzzle, and each of them, when addressed individually, adds up to an overall solution. Like ants, we each work away at our particular areas of concern, doing our tiny bit to be a part of the solution to these problems, whether they be toxic waste, water pollution, global warming, cancer, or species extinctions.

It is ironic, however, that we humans have consistently ignored one problem that is very near to each of us — one waste issue that all of us contribute to each and every day — an environmental problem that has stalked our species from our genesis, and which will accompany us to our extinction. Perhaps one reason we have taken such a head-in-the-sand approach to the recycling of human *excrement* is because we can't even talk about it. If there is one thing that the human consumer culture refuses to deal with constructively, it's body excretions. This is the taboo topic, the unthinkable issue. It's also the one we are about to dive headlong into. For *waste* is not found in nature — it's strictly a human concept, a result of our own ignorance. It's up to us humans to unlock the secret to its elimination. Nature herself provides us with the key, and she has held it out to us for many thousands of years.

WASTE NOT WANT NOT



"WASTE: . . . Spoil or destruction, done or permitted, to lands, houses, gardens, trees, or other corporeal hereditaments, by the tenant thereof, to the prejudice of the heir, or of him in reversion or remainder . . . Any unlawful act or omission of duty on the part of the tenant which results in permanent injury to the inheritance . . ."
Black's Law Dictionary

America is not only a land of industry and commerce, it's also a land of consumption and waste, producing between 12 and 14 *billion* tons of waste annually. Approximately 210 million tons of that total constitutes our annual production of Municipal Solid Waste (MSW), which is the trash each of us personally throws "out" every day.[1] Much of our waste consists of *organic* material including food residues, municipal leaves, yard materials, agricultural residues, and human and livestock manures, all of which should be returned to the soil from which they originated. These organic materials are very valuable agriculturally, a fact well known among organic gardeners and farmers.

What does "organic" mean? The answer is interesting, as there are two opposing sides to this issue. Organic farmers and gardeners contend the word "organic" means that synthetic chemicals are not used in farming or gardening processes. Chemists chuckle at this interpretation of the word, because in chemistry, "organic" is defined simply as any molecule containing carbon atoms. Many synthetic chemicals are therefore considered "organic" by the chemists of the world, simply because they contain carbon. When a chemist really wants to irk an organic gardener, he simply argues that his synthetic organic compounds (pesticides, for example) are "organic" by definition, and that his chemical garden therefore qualifies as "organic" as well. Technically, both sides are correct, although there is a huge distinction that must be taken into consideration.

Carbon is the basic building block of life. When the plant life of millions of years ago became extinct and settled into the earth, it was transformed into "fossil fuels" such as coal, oil, and gas, leaving plenty of carbon embedded in these fuels. These ancient resources have become the basic stock for the petro-chemical industry, which manufactures many synthetic "organic" (i.e., carbon-bearing) chemicals, including the 2.23 *billion* pounds of synthetic organic pesticides Americans use each year.[2] Technically, these chemicals *are* "organic" because they're derived from what was once plant life.

The ancient chemical stocks are altered and synthesized in laboratories to be *similar* to the physiological chemicals of today, which is why they work so well at killing insects and plants — they can enter their living systems and wreak havoc. Many synthetic organic chemicals make their way into human bodies as well, accumulating in the fat cells and fooling the body into thinking they belong there. They don't.

Unfortunately, synthetic organic chemicals can mimic natural human hormones, thereby dangerously interfering with the body's normal functioning. They can also damage human chromosomes, and cause cancer and numerous other diseases. Although technically "organic" because they contain carbon and are derived from ancient life, synthetic organic chemicals have become an environmental disaster due to their persistence (they hang around a long time in the environment), their pervasiveness (they have spread all over the world), and their ability to interfere with the normal functioning of the bodies of many animals (not just humans). For example, human mother's milk has consistently shown contamination from synthetic organic chemicals since 1951,[3] and the incidence of human breast cancer has risen dramatically since then.

In a nutshell, that is why organic gardeners and farmers won't touch synthetic organic chemicals with a ten foot tomato stake. Instead, they use only organic materials agriculturally that are from the *current* era (i.e., from things that were recently alive, such as trees, lawns, and animals, although peat may be an exception). Therein lies the difference in definitions of the word "organic." To a chemist, any molecule that contains carbon is organic, no matter how altered it is from its natural state, but to an organic agriculturist, organic material must be benign and beneficial, not toxic and cancer-causing.

WASTE desperdicios مهملات ゴミ袋 垃圾袋 कूड़ा - करकट

ELIMINATING WASTE

"It is difficult to overstate the urgency of reversing the trends of environmental deterioration."

Lester Brown and Christopher Flavin, State of the World 1999

Feces and urine are examples of natural, beneficial, organic materials excreted by the bodies of animals after completing their digestive processes. They are only "waste" when we discard them. When recycled they are resources, and are often referred to as manures, but never as waste, by the people who do the recycling.

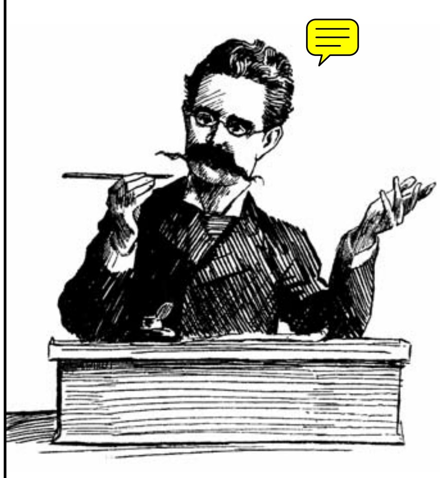
We do not recycle waste. It's a common misuse of semantics to say that waste is, can be, or should be recycled. Resource materials are recycled, but waste is never recycled. That's why it's called "waste." Waste is any material with no inherent value that is discarded and has no further use. We humans have been so wasteful for so long that the concept of waste *elimination* is new to us. Yet, it is an important concept that must become imbued into human consciousness.

When a potato is peeled, the peels aren't kitchen waste — they're still potato peels. When they're collected for recycling as a resource, no waste is produced. Those of you who separate your organic material for recycling are creating no organic waste — a small but highly satisfying achievement.

Many people, especially compost, municipal, and academic professionals, nevertheless adamantly insist upon referring to these recycled materials as "waste." This is called the "waste mentality." Many of the people who are developing municipal composting programs came from the waste management field, a field in which refuse has always been waste. Today, however, refuse is increasingly becoming recognized as the resource it always was. Those of us who recycle are eliminating waste, and the term "waste" should not be associated with us. The use of the term "waste" to describe recycled materials is an unpleasant semantic habit that must be abandoned. If we're eliminating waste, we should talk like it, and be proud of it.

Following the semantics of the waste mentality, one would refer to leaves in the autumn as "tree waste," because they are no longer needed by the tree and are discarded. Yet, when one walks into the forest, where does one see waste? The answer

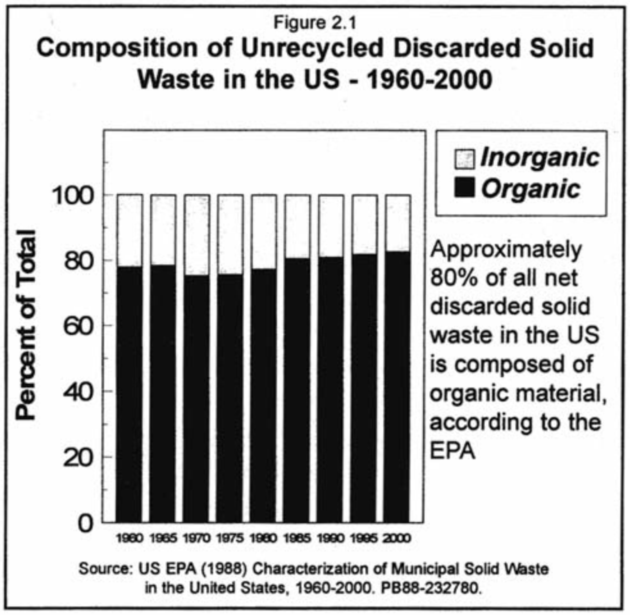
FUN FACTS



Waste Not — Want Not

America is a land of waste. Of the top fifty municipal solid waste producers in the world, America is fifth in line, being outranked only by Australia, New Zealand, France, and Canada. Although the US population increased by 18% between 1970 and 1986, its trash output increased by 25% during that time period, indicating that as time passes, we become more wasteful as a nation. Today, every individual in America produces about four pounds of trash daily, which will add up to 216 million tons per year by the year 2000, almost ten percent more than in 1988. If this sounds like a lot, sit down for a minute: municipal solid waste (the 210 million tons per year just mentioned) makes up only *one* percent of the *total* solid waste created annually in the US. The rest comes from industry, mining, utilities, and other sources.

Source: Hammond, A., et al. (Eds.) (1993). 1993 Information Please Environmental Almanac. Compiled by World Resources Institute. Houghton Mifflin Co. New York. (pp.50-51 and 339).



is "nowhere," because the organic material is recycled naturally, and no waste is created. Ironically, leaves and grass clippings are referred to as "yard waste" by some compost professionals, another example of the persistent waste mentality plaguing our culture. Many of us humans are trying to mimic nature by eliminating waste *as well as* the mentality that accompanies it, and many of us are succeeding. Hopefully the composting professionals who are stuck in the waste mindset will eventually jump on the "resource recycling" bandwagon. They should, afterall, because compost professionals are the front line of an emerging army of people intent upon eliminating waste. Our species has created the concept of waste. It is up to us to avoid it altogether.

For many years in the United States, when people mowed their lawns, they raked the cut grass, stuffed it into large plastic garbage bags, and set it out on the curbside to be picked up by a garbage truck. The grass was then hauled away and buried in landfills along with the deodorant cans, disposable diapers, magazines, and the host of other objects of America's throw-away obsession. Having lived in the country for many years and having had a compost pile since I was first able to dig the earth, I was not aware of this cult-like fanaticism among American suburbanites.

Then one day I visited some friends in the small town near where I live. They were a young couple; he had a Ph.D. and was a professor at the local university and his wife was just finishing her Ph.D. dissertation. They had just mowed their lawn and had the green bags of grass clippings sitting out along the curb, open, with the contents plainly visible. I looked at the bags, but the sight of *grass clippings* being thrown out as if they were trash was so incongruous to me that, at first, it didn't register, until I did a double-take. "Why are you throwing out these grass clippings?" I asked incredulously.

"We've always done that."

"Why would you do that?"

"That's what you're supposed to do."

"Don't you have a compost pile, for heaven's sake?"

"What's a compost pile? Oh, you mean those big smelly heaps that rats get into? We don't have room for that."

"You can use the grass clippings for mulch," I suggested, as I glanced around their roomy garden, seeing lots of places for compost bins. "Look, see those roses over there? They would love these grass clippings spread around them."

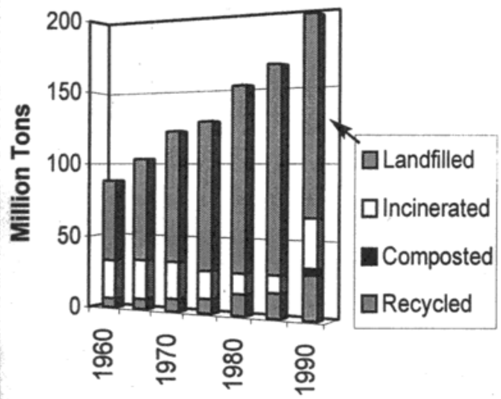
"Nah, we'll just let the municipality take care of our *yard waste* (emphasis mine)."

At that moment, I realized my poor friends had been working so hard at becoming experts, that they didn't have time to learn about the value of grass clippings. I also suspected that our educational system has been rather remiss in its responsibilities by ignoring fundamental basics of life, such as the need for organic material recycling. After some gentle persuasion, I took the bags and spread the grass around the roses, creating a lovely green carpet, while explaining the benefits of mulch and the powerful soil nutrients resident in grass clippings. My friends watched nervously, but soon relaxed after they realized no one was going to get hurt and no rats were going to jump out at them. I think maybe they learned something valuable that day, but would certainly get no credit for it at their university.

I must give credit where credit is due, however. Many people have realized that the disposal of organic yard and garden material in landfills is unwise, and now, in the US, many states have completely banned the dumping of these materials into landfills. Some of the people who've been responsible for these policies were highly educated, yet they *still* managed to figure it out.

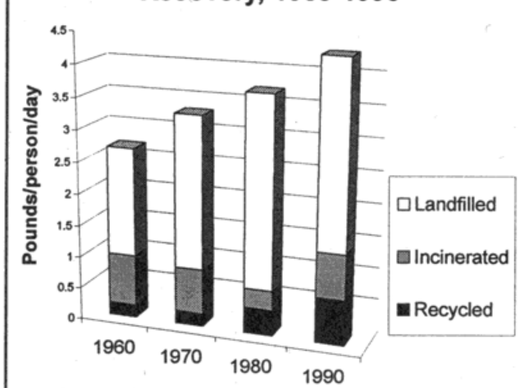
Regardless of the benefits or the hindrances of one's education, we still find no waste in nature. One organism's excrement is another's food — it's that simple. Everything is recycled through natural systems so waste doesn't exist. Humans create waste because we insist on ignoring the natural systems that we are dependent upon. We are so adept at doing so that we take waste for granted and have given the word a prominent place in our vocabulary. We have kitchen "waste," garden "waste,"

Figure 2.2
US Municipal Solid Waste, 1960-1990



Source: US EPA, Office of Solid Waste and Emergency Response. Characterization of Municipal Solid Waste in the United States: 1992 Update, Table 24, p. 3-2 (Washington DC: EPA/OSWER, 1992).

Figure 2.3
US Per Capita Waste Generation and Recovery, 1960-1990



Source: US EPA, Characterization of Municipal Solid Waste in the United States: 1992 Update, Table 35, p. 5-2 (Washington DC: EPA, 1992).

agricultural "waste," human "waste," municipal "waste," "biowaste," and on and on. Yet, our long-term survival as a species requires us to learn to live in harmony with our host planet. This also requires that we understand natural cycles and incorporate them into our day to day lives. In essence, this means that we humans must eliminate waste altogether. As we progressively eliminate waste from our living habits, we can also progressively eliminate the word "waste" from our vocabulary. We can start with the term "human waste."

"Human waste" is a term that has traditionally been used to refer only to human excrements, namely fecal material and urine, which are by-products of the human digestive system. When *discarded*, these materials are colloquially known as human *waste*. When *recycled* for agricultural purposes, however, they're known by various names, including night soil (when applied raw to fields in Asia) and human manure or *humanure*. Humanure is not waste — it is a valuable organic resource material rich in soil nutrients, in contrast to human *waste*, which is a dangerous discarded pollutant. Humanure originated from the soil and can be quite readily returned to the soil, especially if converted to humus through the composting process. Admittedly, humanure is not as benign and easy to work with as grass clippings, but when properly recycled, it makes a wonderful soil additive.

Human *waste* (*discarded* feces and urine), on the other hand, creates significant environmental problems, provides a route of transmission for disease, and deprives humanity of valuable soil fertility. It's also one of the primary ingredients in sewage, and is largely responsible for much of the world's water pollution.

A clear distinction must be drawn between humanure and sewage. Sewage can include waste from many sources (industries, hospitals, and garages, for example) as well as the host of contaminants that seep from these sources (industrial chemicals, heavy metals, oil, and grease, for example). Humanure is strictly human fecal material and urine.

What, in truth, *is* human waste? Human waste is cigarette butts, plastic six-pack rings, styrofoam clamshell burger boxes, deodorant cans, disposable diapers, worn out appliances, unrecycled pop bottles, wasted newspapers, junk car tires, spent batteries, most junk mail, nuclear contamination, food packaging, shrink wrap, toxic chemical dumps, exhaust emissions, the five billion gallons of drinking water we flush down our toilets every day, and the millions of tons of organic material discarded into the environment year after year after year.

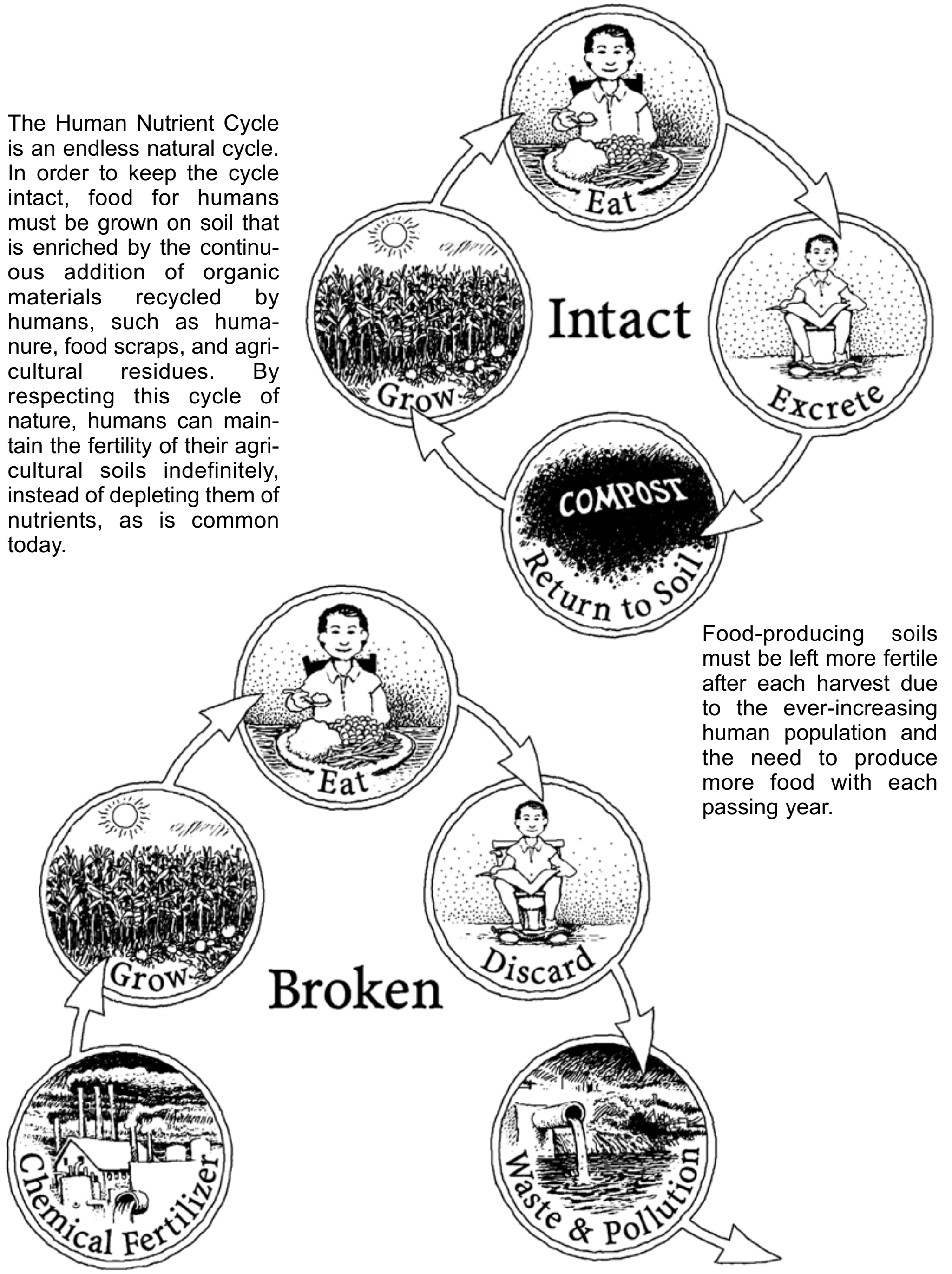
THE HUMAN NUTRIENT CYCLE

"For the living, three things are inevitable: death, taxes, and shit."
Dan Sabbath and Mandel Hall in *End Product*

When crops are produced from soil, it is imperative that the organic residues resulting from those crops, including animal excrements, are returned to the soil from which the crops originated. This recycling of all organic residues for agricul-

Figure 2.4

THE HUMAN NUTRIENT CYCLE *INTACT* and *BROKEN*

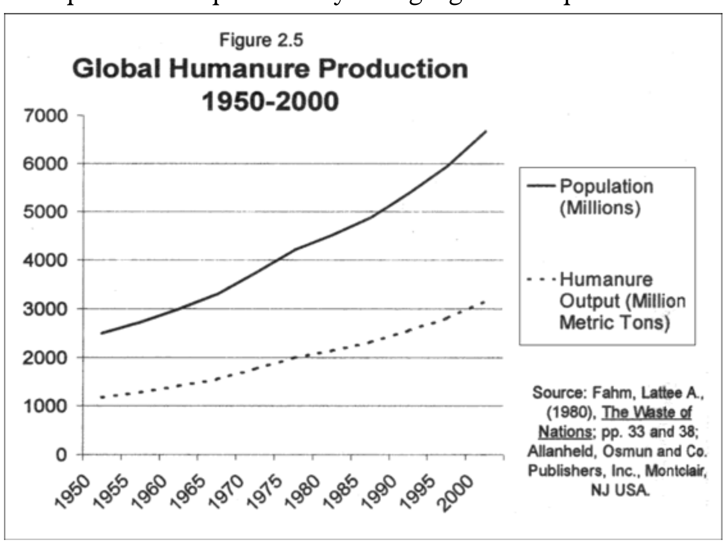


tural purposes should be axiomatic to sustainable agriculture. Yet, spokespersons for sustainable agriculture movements remain silent about using humanure for agricultural purposes. Why?

Perhaps because there is currently a profound lack of knowledge and understanding about what is referred to as the "human nutrient cycle" and the need to keep the cycle intact. The human nutrient cycle goes like this: a) grow food, b) eat it, c) collect and process the organic residues (feces, urine, food scraps, and agricultural materials), and d) return the processed organic material back to the soil, thereby enriching the soil and enabling more food to be grown. The cycle is repeated, endlessly. This is a sustainable process that mimics the natural cycles of nature and enhances our ability to survive on this planet. When our food refuse is instead discarded as waste, the natural human nutrient cycle is broken, creating problems such as *pollution, loss of soil fertility, and abuse of our water resources*.

We in the United States each waste about a thousand pounds of humanure every year, which is discarded into sewers and septic systems throughout the land. Much of the discarded humanure finds its final resting place in a landfill, along with the other solid waste we Americans discard, which, coincidentally, also amounts to about a thousand pounds per person per year. For a population of 250 million people, that adds up to nearly *250 million tons of solid waste personally discarded by us every year, at least half of which is valuable as an agricultural resource.*

The practice we humans have frequently employed for waste disposal has been quite primitive — we dump our garbage into holes in the ground, then bury it. That's called a landfill, and for many years they were that simple. Today's new "sanitary" landfills are lined with waterproof synthetic materials to prevent the leaching of garbage juice into groundwater supplies. Yet, only about one third of the active dumps in the US have these liners.[4] Interestingly, the lined landfills bear an uncanny resemblance to gigantic disposable diapers. They are gargantuan plastic lined receptacles where we lay our crap to rest, the layers being carefully folded over and the end products of our wasteful lifestyles buried as if they were in garbage mausoleums intended to preserve our sludge and kitchen trash for posterity. We conveniently flush our toilets and the resultant sewage sludge is transported to these landfills, tucked into



these huge disposable diapers, and buried.

This is not to suggest that sewage should instead be used to produce food crops. In my opinion, it should not. Sewage consists of humanure collected with hazardous materials such as industrial, medical, and chemical wastes, all carried in a common waterborne waste stream. Or in the words of Gary Gardner (State of the World 1998), *"Tens of thousands of toxic substances and chemical compounds used in industrial economies, including PCBs, pesticides, dioxins, heavy metals, asbestos, petroleum products, and industrial solvents, are potentially part of sewage flows."* Not to mention pathogenic organisms. When raw sewage was used in Berlin in 1949, for example, it was blamed for the spread of worm-related diseases. In the 1980s, it was said to be the cause of typhoid fever in Santiago, and in 1970 and 1991, it was blamed for cholera outbreaks in Jerusalem and South America, respectively.[5]

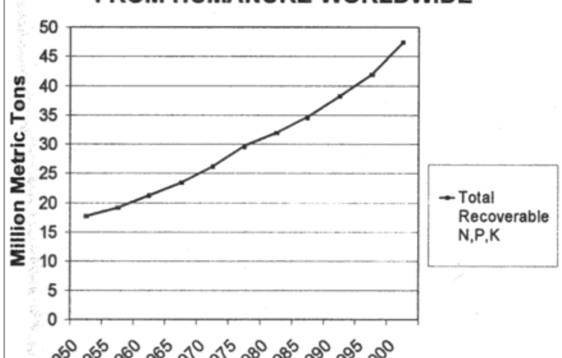
Humanure, on the other hand, when kept out of the sewers, collected as a resource material, and properly processed (composted), makes a fine agricultural resource suitable for food crops. When we combine our manure with other organic materials such as our food discards, we can achieve a blend that is irresistible to certain very beneficial microorganisms.

The US EPA estimates that nearly 22 million tons of food waste are produced in American cities every year. Throughout the United States, food losses at the retail, consumer, and food services levels are estimated to have been 48 million tons in 1995.[6] That would make great organic material for composting with humanure. Instead, only 2.4% of our discarded food was being composted in the US in 1994; the remaining 97.6% was apparently incinerated or buried in landfills.[7]

In 1998, industrial countries were only reusing 11% of their organic garbage.[8] The Organization for Economic Cooperation and Development, a group made up primarily of western industrial countries, estimates that 36% of the waste in their member states is organic food and garden materials. If paper is also considered, the organic share of the waste stream is boosted to nearly an incredible two thirds! In developing countries, organic material typically makes up one-half to two-thirds of the waste stream.[9] According to the EPA, almost 80% of the net discarded solid waste in the US is composed of organic material (see Figure 2.1).

Figure 2.6

AGRONUTRIENTS RECOVERABLE FROM HUMANURE WORLDWIDE



ɔurce: Fahm, Lattee A., (1980), The Waste of Nations; pp. 33 and 38; Allanheld, Osmun and Co. Publishers, Inc., Montclair, NJ USA.

It is becoming more and more obvious that it is unwise to rely on landfills to dispose of recyclable materials. Landfills fill up, and new ones need to be built to replace them. The estimated cost of building and maintaining an EPA approved landfill is now nearly $125 million and rising. The 8,000 operating landfills we had in the United States in 1988 had dwindled to 5,812 by the end of 1991. By 1996, only 3,091 remained.[10]

In fact, we may be lucky that landfills are closing so rapidly. They are notorious polluters of water, soil, and air. Of the ten thousand landfills that have closed since 1982, 20% are now listed as hazardously contaminated Superfund sites. A 1996 report from the state of Florida revealed that groundwater contamination plumes from older, unlined landfills can be longer than 3.4 miles, and that 523 public water supplies in Florida are located within one mile of these closed landfills, while 2,700 lie within three miles of one.[11] No doubt similar situations exist throughout the United States.

Organic material disposed of in landfills also creates large quantities of methane, a major global-warming gas. US landfills are *"among the single greatest contributors of global methane emissions,"* according to the Natural Resources Defense Council. According to the EPA, methane is 20 to 30 times more potent than CO2 as a greenhouse (global warming) gas on a molecule to molecule basis.[12]

Tipping fees (the fee one pays to dump waste) at landfills in every region of the US have been increasing at more than twice the rate of inflation since 1986. In fact, since then, they have increased 300% and are expected to continue rising at this rate.[13]

In developing countries, the landfill picture is also bleak. In Brazil, for example, virtually all (99%) of the solid waste is dumped into landfills, and three-fourths of the 90,000 tons per day ends up in open dumps.[14] Slowly we're catching

Figure 2.7

US Organic Yard Material Discards and Recovery, 1960-1990

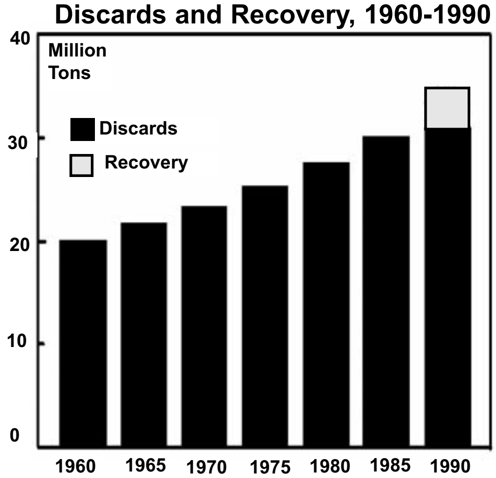
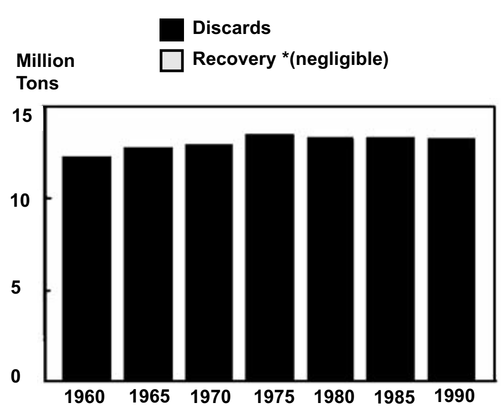


Figure 2.8

US Food Discards and Recovery*, 1960-1990



Source: EPA Characterization of Municipal Solid Waste in the United States: 1992 Update (1992).

on to the fact that this throw-away trend has to be turned around. We can't continue to throw "away" usable resources in a wasteful fashion by burying them in disappearing, polluting, increasingly expensive, landfills.

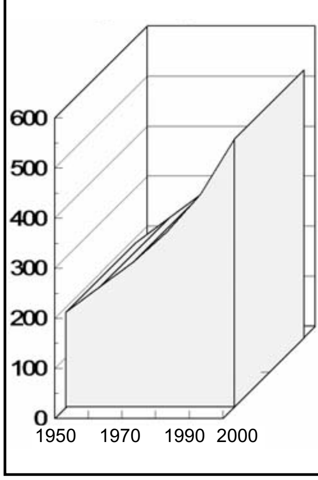
As a result, recycling is now becoming more widespread in the US. Between 1989 and 1992, recycling increased from 9 to 14%, and the amount of US municipal solid waste sent to landfills decreased by 8%.[15] The national average for the recycling of all materials in US cities had jumped to 27% by 1998.[16] Composting is also beginning to catch on in a big way in some areas of the world. In the United States, the 700 composting facilities in 1989 grew to more than 3,200 by 1996. Although this is a welcomed trend, it doesn't adequately address a subject still sorely in need of attention: what to do with humanure, which is rarely being recycled anywhere in the western world.

If we had scraped up all the human excrement in the world and piled it on the world's tillable land in 1950, we'd have applied nearly 200 metric tons per square mile at that time (roughly 690 pounds per acre). In the year 2000, we'll be collecting significantly more than *double* that amount because the global population is increasing, but the global land mass isn't. In fact, the global area of agricultural land is steadily *decreasing* as the world loses, for farming and grazing, an area the size of Kansas each year.[17] The world's burgeoning human population is producing a ballooning amount of organic refuse which will eventually have to be dealt with responsibly and constructively. It's not too soon to begin to understand human organic refuse materials as valuable resource materials begging to be recycled.

In 1950, the dollar value of the agricultural nutrients in the world's gargantuan pile of humanure was 6.93 billion dollars. In 2000, it will be worth 18.67 billion

Figure 2.9

Amount of Humanure Available Worldwide per Square Mile of Tillable Land



If the world's output of human excrement were collected and applied only to arable land, we would have applied nearly 200 metric tons per square mile in 1950. By the year 2000, we will have over double that amount. This does not take into account the loss of farmland due to desertification.

Source: Fahm, L., The Waste of Nations, 1980, Osmund and Co.,New Jersey, pp. 37-38.

Population outgrowing farmland

World population is growing eight times faster than cultivated land area, says Population Action International, according to USA Today, April, 1995. PAI urges governments to take action to stabilize populations, improve agricultural yields, and preserve resources.

dollars (calculated in *1975* prices).[18] This is money currently being flushed out somewhere into the environment where it shows up as pollution and landfill material. Every pipeline has an outlet somewhere; everything thrown "away" just moves from one place to another. Humanure and other organic refuse materials are no exception. Not only are we flushing "money" away, we're paying through the nose to do so. The cost is not only economic, it's environmental.

SOILED WATER

"The practice of injecting 'waste' products and toxic materials into the arterial waterways of Earth is comparable to the idea of using our own bloodstream as a disposal site for hazardous compounds."
Keith Helmuth

The world is divided into two categories of people: those who shit in drinking water and those who don't. We in the western world are in the former class. We defecate in water, usually purified drinking water. After polluting the water with our body's excrements, we flush the once pure but now polluted water "away," meaning we probably don't know where it goes, nor do we care.

This ritual of defecating in water may be useful for maintaining a good standing within western culture. If you don't deposit your feces into a bowl of drinking water on a regular basis, you may be considered a miscreant of sorts, perhaps uncivilized or dirty or poverty stricken. You may be seen as a non-conformist or a radical.

Yet, the discarding of human organic waste into water supplies obviously affects water quality. By defecating directly into water, we pollute it. Every time we flush a toilet, we launch five or six gallons of polluted water out into the world.[19] That would be like defecating into a five gallon office water jug and then dumping it out before anyone could drink any of it. Then doing the same thing when urinating. Then doing it every day, numerous times. Then multiplying that by about 250 million people in the United States alone.

Even after the contaminated water is treated in wastewater treatment plants, it may still be polluted with excessive levels of nitrates, chlorine, pharmaceutical drugs, industrial chemicals, detergents, and other pollutants. This "treated" water is discharged directly into the environment.

A visit to the local library for a cursory review of sewage pollution incidents in the United States

Water may cause wars as growth hits cities

The United Nations warned that water shortages created by the world's skyrocketing population and extravagant use could spark wars in the 21st century, according to Reuters News Service in 1996.

yielded the following:

•In the mid 1980s, the 2,207 publicly owned coastal sewage treatment works were discharging 3.619 *trillion* gallons per year of treated wastewater into the coastal environment.[20]

•More than 2,000 beaches and bays in twelve states were closed in 1991 because of bacterial levels deemed excessive by health authorities.

•In 1991, the city of Honolulu faced penalties of about $150 million for some 9,000 alleged sewage discharge violations that were recorded since 1985.[21]

•In 1991, Ohio Environmental Protection Agency fined Cincinnati's Metropolitan Sewer District $170,000, the largest fine ever levied against an Ohio municipality, for failure to enforce its wastewater treatment program.[22]

•In 1991, California was required to spend $10 million to repair a leaking sewer pipeline that had forced the closure of twenty miles of southern California beaches. The broken pipeline was spilling up to 180 million gallons of sewage per day into the Pacific Ocean less than one mile offshore, resulting in a state of emergency in San Diego County. This situation was compounded by the fact that a recent heavy storm had caused millions of gallons of raw sewage from Mexico to enter the ocean from the Tijuana River.[23]

•Environmental advocates sued the city of Portland, Oregon in 1991 for allegedly discharging untreated sewage as often as 3,800 times per year into the Willamette River and the Colombia Slough.[24]

•In 1992, the US EPA sued the Los Angeles County Sanitation Districts for failing to install secondary sewage treatment at a plant which discharges wastewater into the Pacific Ocean, and for fourteen years of raw sewage spills and other discharges.[25]

•In April of 1992, national environmental groups announced that billions of gallons of raw waste pour into lakes, rivers, and coastal areas each year from combined sewers. Such sewers carry storm water *and* sewage in the same pipe and tend to overflow during heavy rains, causing many cities to suffer from discharges of completely untreated sewage.[26] Combined sewers are found in about 900 US cities.[27]

•In 1997, pollution caused at least 4,153 beach closings and advisories, 69% of which were caused by elevated bacterial pollution in the water. The elevated bacteria levels were primarily caused by storm-water runoff, raw sewage, and animal wastes entering the oceans. The sources of the pollution included inadequate and overloaded sewage treatment plants, sewage overflows from sanitary sewers and combined sewers, faulty septic systems, boating wastes, and polluted storm water from city streets and agricultural areas.[28]

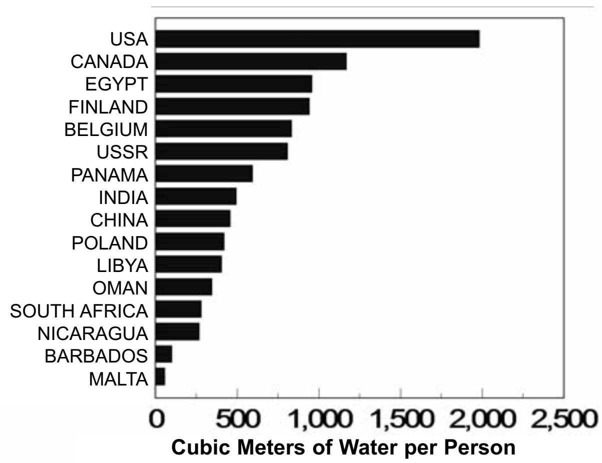
It is estimated that by 2010, at least half of the people in the US will live in coastal cities and towns, further exacerbating water pollution problems caused by sewage. The degree of beach pollution becomes a bit more personal when one realizes that current EPA recreational water cleanliness standards still allow 19 illnesses per 1,000 saltwater swimmers, and 8 per 1,000 freshwater swimmers.[29] Some of the diseases associated with swimming in wastewater-contaminated recreational waters include typhoid fever, salmonellosis, shigellosis, hepatitis, gastroenteritis, pneumonia, and skin infections.[30]

If you don't want to get sick from the water you swim in, you can always follow another standard recommendation: don't submerge your head. Otherwise, you may end up like the swimmers in Santa Monica Bay. People who swam in the ocean there within 400 yards (four football fields) of a storm sewer drain had a 66% greater chance of developing a "significant respiratory disease" within the following 9 to 14 days after swimming.[31] This should come as no surprise when one takes into consideration the emergence of antibiotic-resistant bacteria. The use of antibiotics is so widespread that many people are now breeding antibiotic resistant bacteria in their intestinal systems. These bacteria are excreted into toilets and make their way to wastewater treatment plants where *the antibiotic resistance can be transferred to other bacteria*. Wastewater plants can then become breeding grounds for resistant bacteria, which are discharged into the environment through effluent drains. Why not just chlorinate the water before discharging it? It usually *is* chlorinated beforehand, but research has shown that chlorine seems to *increase* bacterial resistance to some antibiotics.[32]

Not worried about antibiotic resistant bacteria in your swimming area?

Figure 2.10

Average Annual Per Capita Water Use in Selected Countries



Cubic Meters of Water per Person

Source: World Resources Institute, 1986; World Resources 1986. As seen in The Water Encyclopedia, Van der Leeden, et al.

Report: Water bodies remain too polluted

Nearly four out of every ten lakes, rivers, and estuaries remain too polluted to allow fishing, swimming or other aquatic uses at any time of the year, the United States Environmental Protection Agency reported in December of 1995. Sewage, disease-causing bacteria, fertilizer, toxic metals, oil, and grease are among the most frequent pollutants. (Associated Press, 12/15/95)

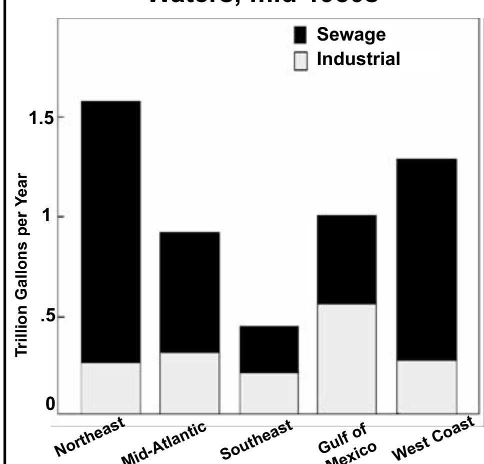
Here's something else to chew on: 50 to 90% of the pharmaceutical drugs people take can be excreted down the toilet and out into the waterways *in their original or biologically active forms*. Furthermore, drugs that have been partially degraded before excretion can be converted to their original active form by environmental chemical reactions. Pharmaceutical drugs such as chemotherapy drugs, antibiotics, antiseptics, beta-blocker heart drugs, hormones, analgesics, cholesterol-lowering drugs, and drugs for regulating blood lipids have turned up in such places as tap water, groundwater beneath sewage treatment plants, lake water, rivers, and in drinking water aquifers. Think about *that* the next time you fill your glass with water.[33]

Long Island Sound receives over a billion gallons of treated sewage every day, the waste of eight million people. So much nitrogen was being discharged into the Sound from the *treated* wastewater that it caused the aquatic oxygen to disappear, rendering the marine environment unsuitable for the fish that normally live there. The twelve treatment plants that were to be completed along the Sound by 1996 were expected to remove 5,000 pounds of nitrogen daily. Nitrogen is normally a soil nutrient and agricultural resource, but instead, when flushed, it becomes a dangerous pollutant.[34]

Previous to December 31, 1991, when disposing of US sewage sludge into the ocean was banned, much of the sewage sludge along coastal cities in the United States was simply dumped out at sea. Nevertheless, the city of New York was unable to meet that deadline and was forced to pay $600 per dry ton to dump its sludge at the Deepwater Municipal Sludge Dump Site, 106 miles off the coast of New Jersey. Illegal dumping of sewage into the sea also continues to be a problem.[35] A bigger problem is what to do with sewage sludge now that landfill space is diminishing and

Figure 2.11

Discards to US Coastal Waters, mid 1980s



Source: DOC/NOAA/ORCA. The National Coastal Pollutant Discharge Inventory Database (1987).

Table 2.1

COMPARING THE NUTRIENT VALUE OF HUMANURE TO COMMERCIAL FERTILIZER IN SELECTED COUNTRIES

Country	Available Humanure compared to Commercial Fertilizer Applied (%)
Kenya	136
Tunisia	52
Indonesia	49
Zimbabwe	38
Colombia	31
Mexico	31
South Africa	29
Egypt	28
India	26

Source: Brown, Lester R., et al.; State of the World 1998, p. 105.

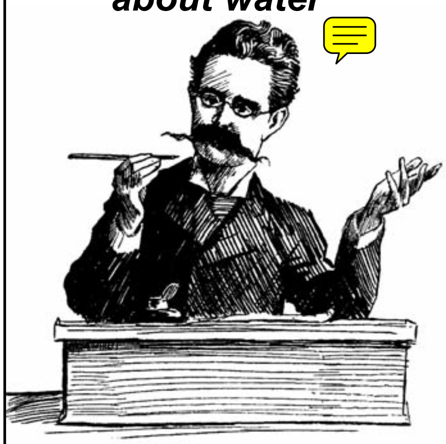
sludge can no longer be dumped into the ocean.

The dumping of sludge, sewage, or wastewater into nature's waterways invariably creates pollution. The impacts of polluted water are far-ranging, causing the deaths of 25 million people each year, three-fifths of them children.[36] Half of all people in developing countries suffer from diseases associated with poor water supply and sanitation.[37] Diarrhea, a disease associated with polluted water, kills six million children each year in developing countries, and it contributes to the death of up to 18 million people.[38] At the beginning of the 21st century, one out of four people in developing countries still lacked clean water, and two out of three lacked adequate sanitation.[39]

Proper sanitation is defined by the World Health Organization as any excreta disposal facility that interrupts the transmission of fecal contaminants to humans.[40] This definition should be refined to include excreta *recycling* facilities, as excreta are valuable organic resources which should not be discarded. Compost toilet systems are now becoming internationally recognized as constituting "proper sanitation," and are becoming more and more attractive throughout the world due to their relatively low cost when compared to waterborne waste systems and centralized sewers. In fact, compost toilet systems yield a dividend — *humus*, which allows such a sanitation system to yield a net profit, rather than being a constant financial drain (no pun intended).

The almost obsessive focus on flush toilets throughout the world is causing the problems of international sanitation to remain unresolved. Many parts of the world cannot afford expensive and water consumptive waste disposal systems. Or, in the words of Gary Gardner (Vital Signs 1998), *"The high costs leave developing countries spending less than a third of what they should in order to provide adequate sanitation,*

FUN FACTS
about water



- **If all the world's drinking water were put in one cubical tank, the tank would measure only 95 miles on each side.**
- **Number of people currently lacking access to clean drinking water: 1.2 billion.**
- **Percent of the world's households that must fetch water from outside their homes: 67**
- **Percent increase in the world's population by the middle of the 21st century: 100**
- **Percent increase in the world's drinking water supplies by the middle of the 21st century: 0**
- **Amount of water Americans use every day: 340 billion gallons.**
- **Number of gallons of water needed to produce a car: 100,000**
- **Number of cars produced every year: 50 million.**
- **Amount of water required by a nuclear reactor every year: 1.9 cubic miles.**
- **Amount of water used by nuclear reactors every year: the equivalent of one and a third Lake Eries.**

Sources: Der Spiegel, May 25, 1992; and Annals of Earth, Vol. 8, Number 2, 1990; Ocean Arks International, One Locust Street, Falmouth, MA 02540.

according to WHO. . . Prospects for providing universal access to sanitation are dismal in the near to medium term. . . Despite the attention focused on sanitation, governments have not demonstrated the will to meet this growing challenge." [41]

Modern toilets tax water

291 cities and towns in Japan face water shortages due to the spread of flush toilets, reported the Construction Ministry in April of 1998. Some cities have had to build dams to provide enough water to flush the increasingly popular toilets.

Illness related to polluted water afflicted 111,228 Americans from 1971-85. Forty-nine percent of these were caused by untreated or inadequately disinfected groundwater.[42] Approximately 155 million people in the US obtain their drinking water from surface water sources.[43] Several American cities have suffered from outbreaks of cryptosporidia (protozoa which cause severe diarrhea) since 1984. These protozoa are transmitted when people drink water contaminated by infected human and other animal feces. Outbreaks occurred in Braun Station, Texas, in 1984; in Carrollton, Georgia, in 1987; in Medford and Talent, Oregon, in 1992; and in Milwaukee, Wisconsin, in 1993. The outbreak in Carrollton, Georgia, afflicted 13,000 people, and was caused by contaminated water from a water treatment plant. Hundreds of thousands of people have been afflicted by this bug, for which there is no treatment. The illness runs its course in about fourteen days in healthy people, but can be deadly to people who have weak immune systems.[44]

In 1995, there were still nearly 10 million people in the US connected to public drinking water supplies from surface sources that were not in compliance with federal standards for the removal of microorganisms. Furthermore, scientists esti-

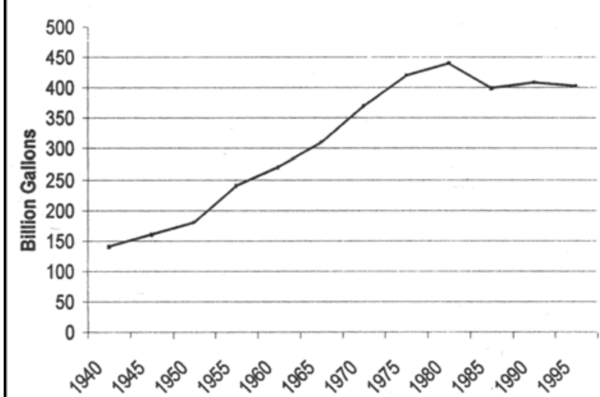
Paris

More than 1 billion people lack access to clean water

The U.N. International Conference on Water and Sustainable Development in 1998 reported that five to ten million people die each year as a result of drinking polluted water, while about 1.2 billion people lack access to clean water. *"Fresh water needed for human needs is rapidly getting scarce . . . ,"* they reported.

Figure 2.12

US Water Withdrawals 1940-1995



Source:Statistical Abstracts of the United States 1998, p. 240.

PATHOGEN ALERT!

Humans discharge 3.619 trillion gallons of polluted sewage water into US coastal waterways each year.

mate that up to seven million Americans still get sick annually from contaminated drinking water.[45]

Sanitation problems could be avoided by composting, instead of discarding, humanure. Keeping fecal material out of the environment and out of streams, rivers, wells, and underground water sources eliminates the transmission of various diseases. Composting effectively converts fecal material into a hygienically safe humus, yet composting the humanure of municipal populations is not even being considered as an option in most of the western world.

Not only are we polluting our water, we're using it up, and flushing toilets is one way it's being wasted. Of 143 countries ranked for per capita water usage by the World Resources Institute, America came in at #2 using *188 gallons per person per day* (Bahrain was #1).[46] Water use in the US increased by a factor of 10 between 1900 and 1990, increasing from 40 billion gallons per day to 409 billion gallons per day.[47] The amount of water we Americans require overall (used in the finished products each of us consumes, plus washing and drinking water) amounts to a staggering 1,565 gallons per person per day, which is three times the rate in Germany or France.[48] This amount of water is equivalent to flushing our toilets 313 times every day, about once every minute and a half for eight hours straight. By some estimates, it takes one to two thousand tons of water to flush one ton of human waste.[49] Or, in the words of Carol Stoner, *"For one person, the typical five gallon flush contaminates each year about 13,000 gallons of fresh water to move a mere 165 gallons of body waste."* [50] Not surprisingly, the use of groundwater in the United States exceeds replacement rates by 21 billion gallons a day.[51]

WASTE VS. MANURE

"Science now knows that the most fertilizing and effective manure is the human manure . . . Do you know what these piles of ordure are . . . All this is a flowering field, it is green grass, it is the mint and thyme and sage . . . it is the guilded wheat, it is the bread on your table, it is the warm blood in your veins."

Victor Hugo

By dumping soil nutrients down the toilet, we increase our need for synthetic chemical fertilizers. Today, pollution from agriculture, caused from siltation (erosion) and nutrient runoff due to excessive or incorrect use of fertilizers,[52] is now the *"largest diffuse source of water pollution"* in our rivers, lakes, and streams.[53] Chemical fertilizers provide a quick fix of nitrogen, phosphorous, and potassium for impoverished soils. However, it's estimated that 25-85% of chemical nitrogen applied to soil and 15-20% of the phosphorous and potassium are lost to leaching, much of which can pollute groundwater.[54] This pollution shows up in small ponds which become choked with algae as a result of the unnatural influx of nutrients. In 1992, for example, the state of Florida was required to build some 35,000 acres of marshlands to filter farm-related runoff that was polluting the Everglades.[55]

From 1950 to 1990, the global consumption of artificial fertilizers rose by 1000%, from 14 million tons to 140 million tons.[56] In 1997, US farmers used 20 million tons of synthetic fertilizers,[57] and half of all manufactured fertilizer ever made has been used just since 1982.[58] All the while, hundreds of millions of tons of compostable organic materials are generated in the US each year, and either buried in landfills, incinerated, or discharged into the environment as waste.

Nitrate pollution from excessive artificial fertilizer use is now one of the most serious water pollution problems in Europe and North America. Such pollution can cause cancer, and even brain damage or death in infants.[59] Most cases of infant poisoning occur when infant *formula* is made with nitrate polluted water.[60] A 1984 US EPA survey indicated that out of 124,000 water wells sampled, 24,000 had elevated levels of nitrates and 8,000 were polluted above health limits (10 mg/liter).[61] In fact, a 1990 EPA survey indicated that 4.5 million Americans were potentially exposed to elevated levels of nitrates from drinking water wells alone.[62]

The squandering of our water resources, and pollution from sewage and synthetic fertilizers results in part from the belief that humanure and food scraps are waste materials rather than recyclable natural resources. There is, however, an alternative. Humanure and food refuse can be composted and thereby rendered hygienically safe for agricultural or garden use. Much of the eastern world recycles humanure. Those parts of the world have known for millennia that humanure is a valuable resource which should be returned to the land, as any animal manure should.

Farmers know that animal manure is valuable. They know that animal manures are digested crops, and that crops are soil, water, air, and sunshine converted into food, and the best way to use that manure is to put it back into the fields

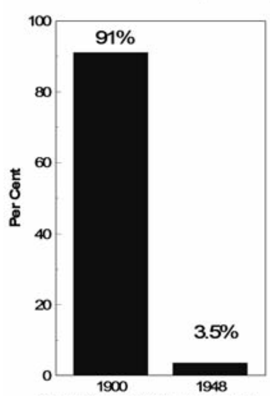


Figure 2.13

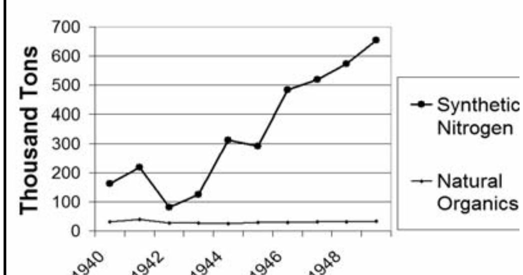
Amount of Nitrogen Used in Fertilizers in the USA Derived From Organic Sources, 1900 and 1948

In 1900 in the USA, natural organics supplied 91% of all the nitrogen used in commercial fertilizers. In 1948, the same sources supplied only 3.5%, the remainder coming primarily from chemical ammonia compounds.

Source: Markham, Jessee W., (1958), The Fertilizer Industry; Greenwood Press; p. 96.

Figure 2.14

US Consumption of Fertilizer Nitrogen 1940-1949



Source: Collings, Gilbeart H., Ph.D. (1955); Commercial Fertilizers - Their Sources and Use; McGraw-Hill Book Company, p. 144.

from where it originated. So the farmer loads up the manure spreader and flings the manure back onto the fields, thereby cleaning up his barn, saving himself lots of money on fertilizers, and keeping his soil healthy. Sounds reasonable enough. But what about *human* manure?

Humanure is a little bit different. It shouldn't simply be flung around in a fresh and repulsive state. It should undergo a process of bacterial digestion first, usually known as composting, in order to destroy possible pathogens. This is the missing link in the human nutrient recycling process. The process is similar to any animal's: a human grows food for herself on a field, or in a garden. The food is consumed and passes into the digestive system where the body extracts what it needs, rejects what it doesn't need at the time, or what it can't use, then excretes the rejected material.

At that moment, the digestive system is no longer responsible for the excretion. It's now time for the brain to go to work. The human mind has basically two choices — consider the excretion to be waste and try to get rid of it, or consider the excretion to be a resource which must be recycled. Either way, the body's excretion must be collected. As waste, the material must be dispensed with in a manner that is safe to human health and to the environment; as a resource, the humanure should be naturally recycled.

In some areas of the world, such as Asia, humanure may be applied raw to fields without being composted beforehand. Containers of human excrement are set outside residences in Asia to be picked up during the night and taken to the fields. The content of these containers is called, appropriately enough, "night soil." *That is NOT what this book is about.*

Properly composted humanure yields a rich, loamy, pleasant-smelling, hygienically safe soil-building material, here being applied to spring garden beds.

Raw humanure carries with it a significant potential for danger in the form of disease pathogens. These diseases, such as intestinal parasites, hepatitis, cholera, and typhoid are destroyed

In some areas of the world, such as Asia, humanure may be applied raw to fields without being composted beforehand. Containers of human excrement are set outside residences in Asia to be picked up during the night and taken to the fields. The content of these containers is called, appropriately enough, "night soil." *That is NOT what this book is about.*

by composting, either when the retention time is adequate in a low temperature compost pile (usually considered to be two years) or when the composting process generates internal, biological heat (which can kill pathogens in a matter of minutes). Raw applications of humanure to fields, on the other hand, are not hygienically safe and can assist in the spread of various diseases which may be endemic to areas of Asia. Americans who have traveled to Asia tell of the "horrible stench" of night soil that wafts through the air when it is applied to fields. For these reasons, it is imperative that humanure always be composted before agricultural applications. Proper thermophilic (heat-producing) composting destroys possible pathogens and results in a pleasant-smelling material. Low temperature composting, given adequate time, will yield a compost also suitable for agricultural purposes.

At the very least, raw night soil applications to fields in Asia do return humanure to the land, thereby recovering a valuable resource which is then used to produce food for humans. *Composted* humanure is used in Asia as well. Cities in China, South Korea, and Japan recycle night soil around their perimeters in greenbelts where vegetables are grown. Shanghai, China, a city with an expected population of 14.2 million people in 2000,[63] produces an exportable surplus of vegetables in this manner.

Humanure can also be used to feed algae which can, in turn, feed fish for aquacultural enterprises. In Calcutta, such an aquaculture system produces 20,000 kilograms of fresh fish daily.[64] The city of Tainan, Taiwan, is well known for its fish, which are farmed in over 6,000 hectares of fish farms fertilized by humanure. Here, humanure is so valuable that it's sold on the black market.[65]

RECYCLING HUMANURE

"We stand now where two roads diverge . . .the one 'less traveled by' offers our last, our only chance to reach a destination that assures the preservation of our Earth."

Rachael Carson - *Silent Spring*

Humanure can be naturally recycled by feeding it to the organisms that crave it as food. These voracious creatures have been around for millions, and theoretically *billions* of years, and they've patiently waited for us humans to discover them. Mother Nature has seeded our excrements, as well as our garbage, with these "friends in small places," who will convert our organic discards into a soil-building material right before our eyes. Invisible helpers, these creatures are too small to be seen by the human eye and are therefore called *micro*organisms. The process of feeding organic material to these microorganisms is called *composting*, and proper composting ensures the destruction of potential human pathogens (disease-causing microorganisms) in humanure. Composting also completely converts the humanure into a new, benign, pleasant-smelling, and beneficial substance called *humus*, which is then returned to the soil to enrich it and enhance plant growth.

Incidentally, *all* animal manures benefit from composting, as today's farmers are now discovering. Compost doesn't leach like raw manures do. Instead, it helps hold nutrients in soil systems. Composted manures also reduce plant disease and insect damage and allow for better nutrient management on farms. In fact, two tons of compost will yield far more benefits than five tons of manure.[66]

Human manure can be mixed with other organic materials from human activity such as kitchen and food scraps, grass clippings, leaves, garden refuse, paper products, and sawdust. This mix of materials is necessary for proper composting to take place, and it will yield a soil additive suitable for food gardens as well as for agriculture.

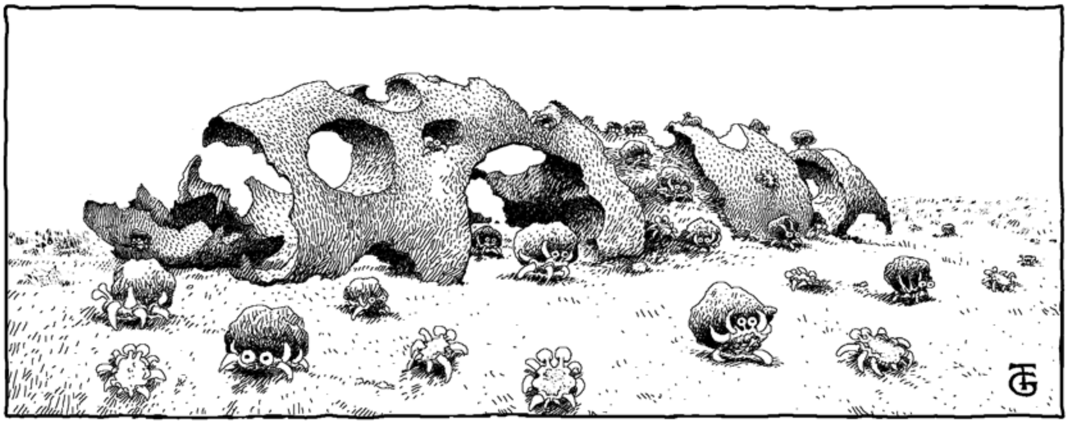
One reason we humans have not "fed" our excrement to the appropriate organisms is because we didn't know they existed. We've only learned to see and understand microscopic creatures in our recent past. We also haven't had such a rapidly growing human population in the past, nor have we been faced with the dire environmental problems that threaten our species today, like buzzards circling an endangered animal.

It all adds up to the fact that the human species must inevitably evolve. Evolution means change, or as Rachel Carson stated almost four decades ago, we must realize that we are now standing at a fork in the road. Change is often resisted, as old habits die hard, and flush toilets and bulging garbage cans represent well entrenched but non-sustainable habits that must be rethought and reinvented. You will not find profligate, wasteful, and polluting behavior taken for granted on "the road less traveled."

Consumer cultures of today must evolve toward sustainability. This is a shift that will likely be fought tooth and nail by those powerful, non-sustainable industries that stand to lose profits, and by their paid spokespersons in the newspapers, radio, television, congresses, and senates of the world. Nevertheless, if we humans are half as intelligent as we think we are, we'll join together cooperatively and eventually get our act together. In the meantime, there are those of you who are doing your share, shifting as you can, incrementally, but surely toward sustainable lifestyle choices. You are also further educating yourselves, as the reading of this book indicates, and perhaps realizing that nature holds many of the keys we need to unlock the door to a sustainable, harmonious existence on this planet. Composting is one of the keys that has been relatively recently discovered by the human race. Its utilization is now beginning to mushroom worldwide.

MICROHUSBANDRY

Harnessing the Power of Microscopic Organisms



"Anyone starting out from scratch to plan a civilization would hardly have designed such a monster as our collective sewage system. Its existence gives additional point to the sometimes asked question, Is there any evidence of intelligent life on the planet Earth?"
G. R. Stewart

There are four general ways to deal with human excrement. The first is to *dispose of it* as a waste material. People do this by defecating in drinking water supplies, or in outhouses or latrines. Most of this waste ends up dumped, incinerated, buried in the ground, or discharged into waterways.

The second way to deal with human excrement is to *apply it raw to agricultural land.* This is popular in Asia where "night soil," or raw human excrement, is spread on fields. Although this keeps the soil enriched, it also acts as a vector, or route of transmission, for disease organisms. In the words of Dr. J. W. Scharff, former chief health officer in Singapore, *"Though the vegetables thrive, the practice of putting human [manure] directly on the soil is dangerous to health. The heavy toll of sickness and death from various enteric diseases in China is well-known."* The World Health Organization adds, *"Night soil is sometimes used as a fertilizer, in which case it presents great hazards by promoting the transmission of food-borne enteric [intestinal] disease, and hookworm."* [1] (It is interesting, incidentally, to note Dr. Scharff's only alternative to the use of raw night soil: *"We have been inclined to regard the installation of a water-carried system as one of the final aims of civilization."*)[2] This book, therefore, is *not* about recycling night soil by raw applications to land, which is a practice that should be discouraged when sanitary alternatives, such as composting, are available.

The third way to deal with human excrement is to *slowly compost it over an* *extended period of time*. This is the way of most commercial composting toilets. Slow composting generally takes place at temperatures below that of the human body, which is 37^{0}C or 98.6^{0}F. This type of composting eliminates most disease organisms in a matter of months, and should eliminate all human pathogens eventually. Low temperature composting creates a useful soil additive that is at least safe for ornamental gardens, horticultural, or orchard use.

Thermophilic composting is the fourth way to deal with human excrement. This type of composting involves the cultivation of heat-loving (thermophilic) microorganisms in the composting process. Thermophilic microorganisms, such as bacteria and fungi, can create an environment in the compost which destroys disease organisms that can exist in humanure, converting humanure into a friendly, pleasant-smelling, humus safe for food gardens. Thermophilically composted humanure is *entirely different* from night soil. Perhaps it is better stated by the experts in the field: *"From a survey of the literature of night soil treatment, it can be clearly concluded that the only fail-safe night soil method which will assure effective and essentially total pathogen inactivation, including the most resistant helminths [intestinal worms] such as Ascaris [roundworm] eggs and all other bacterial and viral pathogens, is heat treatment to a temperature of 55^0 to 60^{0}C for several hours."* [3] The experts are specifically referring to the heat of the *compost pile*.

VINTAGE COMPOST

"One of the most fascinating aspects of composting is that it still retains elements of art . . . Producing good compost requires the same level of knowledge, engineering, skill, and art required for producing good wine."
Roger Haug - The Practical Handbook of Compost Engineering

I first moved out to the country and started living off the land at the age of 22. Being fresh out of college, I knew little of practical value. One word that was a mystery to me was "compost"; another was "mulch." Although I didn't know what either of these were, I knew they had something to do with organic gardening, and that's what I wanted to learn about. Of course, it didn't take me long to understand mulch. Anyone who can throw a layer of straw on the ground can mulch. But compost took a bit longer.

My compost-learning experiences paralleled my winemaking experiences. Back then, having just graduated from the university, I had been conditioned to believe that the best way to learn was by using books. I had little awareness that instinct or intuition were powerful teachers. Furthermore, simple, natural processes had to be complicated with charts, graphs, measurements, devices, and all the wonderful tools of science, otherwise the processes had no validity. It was with this attitude that I set out to learn how to make wine.

The first thing I did was obtain a scientific book replete with charts, graphs, tables, and detailed step-by-step procedures. The book was titled something like "Foolproof Winemaking," and the trick, or so the author said, was simply to follow his procedures *to the letter.* This was no simple feat. The most difficult part of the process was acquiring the list of chemicals which the author insisted must be used in the winemaking process. After much searching and travel, I managed to get the required materials. Then I followed his instructions *to the letter.* This lengthy process involved boiling sugar, mixing chemicals, and following laborious procedures. To make a long story short, I succeeded in making two kinds of wine. Both tasted like crap; one was bad and the other worse, and both had to be thrown out. I was very discouraged.

Soon thereafter, a friend of mine, Bob, decided he would try *his* hand at winemaking. Bob asked a vineyard worker to bring him five gallons of grape juice in a five gallon glass winemaking carboy. When the grape juice arrived, Bob took one look at the heavy carboy of juice and said, *"Buddy, would you mind carrying that into the basement for me?"* Which the worker obligingly did.

That was it. That utterance of eleven words constituted Bob's entire effort at winemaking. Two seconds of flapping jaws was the only work he did toward making that wine. He added no sugar, no yeast, did no racking, and certainly used no chemicals. He didn't do a damn thing to that five gallons of grape juice except abandon it in his basement with an airlock on top of it. Yet, a year later that carboy yielded the best homemade wine I had ever drank. It tasted good and had a heck of a kick to it.

I admit, there was an element of luck there, but I learned an important lesson about winemaking: the basic process is very simple — start with good quality juice and keep the air out of it. That simple, natural process can be easily ruined by too many complicated procedures, and heck, all those charts and graphs took the *fun* out of it. Making compost, I soon learned, was the same sort of phenomenon.

COMPOST DEFINED

According to the dictionary, compost is *"a mixture of decomposing vegetable refuse, manure, etc. for fertilizing and conditioning the soil."* The Practical Handbook of Compost Engineering defines composting with a mouthful: *"The biological decomposition and stabilization of organic substrates, under conditions that allow development of thermophilic temperatures as a result of biologically produced heat, to produce a final product that is stable, free of pathogens and plant seeds, and can be beneficially applied to land."*

The On-Farm Composting Handbook says that compost is *"a group of organic residues or a mixture of organic residues and soil that have been piled, moistened, and allowed to undergo aerobic biological decomposition."* The Compost Council adds their two cents worth in defining compost: *"Compost is the stabilized and sanitized product of composting; compost is largely decomposed material and is in the process of humification (curing). Compost has little resemblance in physical form to the original material from which it is made."* That last sentence should be particularly reassuring to the humanure

BENEFITS OF COMPOST

ENRICHES SOIL
- Adds organic material
- Improves fertility and productivity
- Suppresses plant diseases
- Discourages insects
- Increases water retention
- Inoculates soil with beneficial microorganisms
- Reduces or eliminates fertilizer needs
- Moderates soil temperature

PREVENTS POLLUTION
- Reduces methane production in landfills
- Reduces or eliminates organic garbage
- Reduces or eliminates sewage

FIGHTS EXISTING POLLUTION
- Degrades toxic chemicals
- Binds heavy metals
- Cleans contaminated air
- Cleans stormwater runoff

RESTORES LAND
- Aids in reforestation
- Helps restore wildlife habitats
- Helps reclaim mined lands
- Helps restore damaged wetlands
- Helps prevent erosion on flood plains

DESTROYS PATHOGENS
- Can destroy human disease organisms
- Can destroy plant pathogens
- Can destroy livestock pathogens

SAVES MONEY
- Can be used to produce food
- Can eliminate waste disposal costs
- Reduces the need for water, fertilizers, and pesticides
- Can be sold at a profit
- Extends landfill life by diverting materials
- Is a less costly bioremediation technique

Source: US EPA (October 1997). *Compost-New Applications for an Age-Old Technology.* EPA530-F-97-047. And author's experience.

composter.

J. I. Rodale states it a bit more eloquently: *"Compost is more than a fertilizer or a healing agent for the soil's wounds. It is a symbol of continuing life . . . The compost heap is to the organic gardener what the typewriter is to the writer, what the shovel is to the laborer, and what the truck is to the truckdriver."* [4]

In general, composting is a process managed by humans involving the cultivation of microorganisms that degrade organic matter in the presence of oxygen. When properly managed, the compost becomes so heavily populated with thermophilic microorganisms that it generates quite a bit of heat. Compost microorganisms can be so efficient at converting organic material into humus that the phenomenon is nothing short of miraculous.

NATURALCHEMY

In the Middle Ages, alchemists sought to change base metals, such as lead, into gold. Old German folklore tells of a tale in which a dwarf named Rumpelstiltskin had the power to spin flax straw into precious metal. Somewhere in the psyche of the western mind was a belief that a substance of little or no worth could be transmuted by a miraculous process into something of priceless value. Our ancestors were right, but they were barking up the wrong tree. The miraculous process of *composting* will transmute humanure into humus. In this way, potentially dangerous waste materials become soil additives vital for human life.

Our ancestors didn't understand that the key to this alchemy was right at their fingertips. Had they better known and understood natural processes they could have provided themselves with a wealth of soil fertility and saved themselves the tremendous suffering caused by diseases originating from fecal contamination of the environment. For some reason, they believed that gold embodied value, and in pursuit of glittering riches they neglected the things of real value: health, vitality, self-sufficiency, and sustainability.

Our ancestors had little understanding of a vast, invisible world which surrounded them, a world of countless creatures so small as to be quite beyond the range of human sight. And yet, some of those microscopic creatures were already doing work for humanity in the production of foods such as beer, wine, cheese, or bread. Although *yeasts* have been used by people for centuries, *bacteria* have only become harnessed by western humanity in recent times. Composting is one means by which the power of microorganisms can be utilized in a big way for the betterment of humankind. Unfortunately, our ancestors didn't understand the role of microorganisms in the decomposition of organic matter, nor the efficacy of microscopic life in converting humanure, food scraps, and plant residues into soil. They didn't understand compost.

The composting of organic materials requires armies of bacteria. This microscopic force works so vigorously that it heats the material to temperatures hotter than are normally found in nature. Other micro and macro organisms such as fungi and insects help in the composting process, too. When the compost cools down, earthworms often move in and eat their fill of delicacies, their excreta becoming a further refinement of the compost.

Successful composting requires the maintenance of an environment in which bacteria and fungi can thrive. This is also true for wine, except the microorganisms

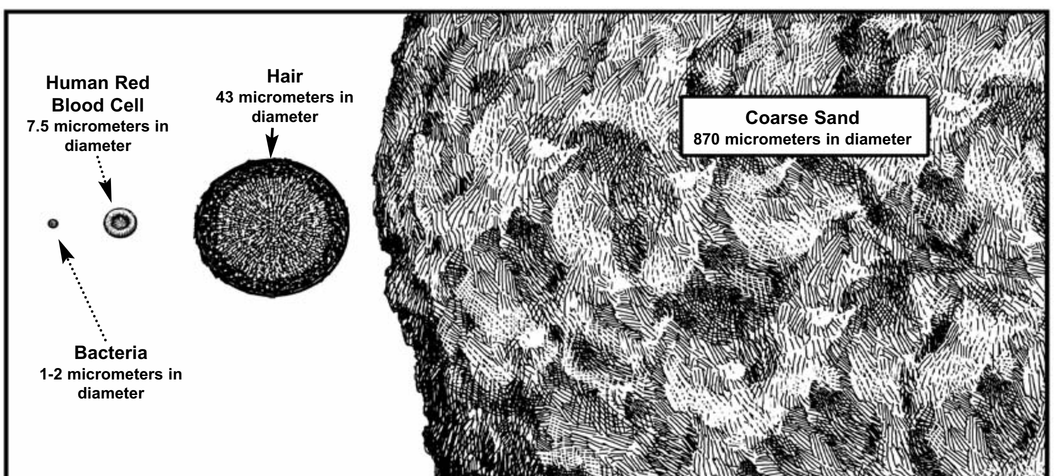


Figure 3.1
Size of Bacteria Relative to a Red Blood Cell, a Hair, and a Grain of Coarse Sand
Source: Gest, Howard (1993). Vast Chain of Being. Perspectives in Biology and Medicine. Volume 36, No. 22, Winter 1993. University of Chicago, Division of Biological Sciences. p. 186.

are yeast, not bacteria. Same for bread (yeast), beer (yeast), yogurt (bacteria), sauerkraut (bacteria), and cheese (bacteria); all of these things require the cultivation of microorganisms which will do the desired work. All of these things involve simple processes which, once you know the basic principles, are easy to carry out successfully. Sometimes bread doesn't rise, sometimes yogurt turns out watery, sometimes compost doesn't seem to turn out right. When this happens, a simple change of procedure will rectify the matter. Once you get the hang of it, you'd think even a chimpanzee could be trained to make compost.

Often, in our household, we have yogurt being made by billions of hard-working bacteria in a few quart mason jars beside the cookstove. At the same time, millions of yeast cells are cheerfully brewing beer in carboys in the back pantry, while millions more yeasts are happily brewing wine beside the beer. Sauerkraut is blithely fermenting in a crock behind the stove; bread is rising on the kitchen counter; and fungi are tirelessly forcing their fruits from oak logs on the sunporch. And then there's the compost pile. At times like these, I feel like a slave driver. But the workers never complain. Those little fellas work day and night, and they do a real nice job.

SOLAR POWER IN A BANANA PEEL

Organic refuse is stored solar energy. Every apple core or potato peel holds a tiny amount of stored energy, just like a piece of firewood, which is converted into useable plant food by the compost pile. Perhaps S. Sides of the *Mother Earth News* states it more succinctly: *"Plants convert solar energy into food for animals (ourselves included). Then the [refuse] from these animals along with dead plant and animal bodies, 'lie down in the dung heap,' are composted, and 'rise again in the corn.' This cycle of light is the central reason why composting is such an important link in organic food production. It returns solar energy to the soil. In this context such common compost ingredients as onion skins, hair trimmings, eggshells, vegetable parings, and even burnt toast are no longer seen as garbage, but as sunlight on the move from one form to another."* [5]

The organic material used to make compost could be considered anything on the Earth's surface that had been alive, or from a living thing, such as manure, plants, leaves, sawdust, peat, straw, grass clippings, food scraps, and urine. A rule of thumb is that anything that will rot will compost, including such things as cotton clothing, wool rugs, rags, paper, animal carcasses, junk mail, and cardboard.

To compost means to convert organic material ultimately into soil or, more accurately, *humus*. Humus is a brown or black substance resulting from the decay of organic animal or vegetable refuse. It is a stable material that does not attract insects or nuisance animals. It can be handled and stored if necessary with no problem, and it is beneficial to the growth of plants. Humus holds moisture, and therefore increases the soil's capacity to absorb and hold water. Compost is said to hold nine times its weight in water (900%), as compared to sand which only holds 2%, and clay 20%.[6]

Compost also adds slow-release nutrients essential for plant growth, creates air spaces in soil, helps balance the soil pH, darkens the soil (thereby helping it absorb heat), and supports microbial populations that add life to the soil. Nutrients such as nitrogen in compost are slowly released throughout the growing season, making them less susceptible to loss by leaching than the more soluble chemical fertilizers.[7] Organic matter from compost enables the soil to immobilize and degrade pesticides, nitrates, phosphorous, and other things that can become pollutants. Compost binds pollutants in soil systems, reducing their leachability and absorption by plants.[8]

The building of topsoil by Mother Nature is a centuries long process. Adding compost to soil will help to quickly restore fertility that might otherwise take nature hundreds of years to replace. We humans deplete our soils in relatively short periods of time. By composting our organic refuse and returning it to the land, we can restore that fertility also in relatively short periods of time.

Fertile soil yields food that promotes good health. One group of people, the Hunzas of northern India, has been studied to a great extent. One man who studied them extensively, Sir Albert Howard, stated, *"When the health and physique of the various northern Indian races were studied in detail the best were those of the Hunzas, a hardy, agile, and vigorous people, living in one of the high mountain valleys of the Gilgit Agency . . . There is little or no difference between the kinds of food eaten by these hillmen and by the rest of northern India. There is, however, a great difference in the way these foods are grown . . . [T]he very greatest care is taken to return to the soil all human, animal and vegetable [refuse] after being first composted together. Land is limited: upon the way it is looked after, life depends."* [9]

GOMER THE PILE

There are several reasons for piling the composting material. A pile keeps the material from drying out or cooling down prematurely. A level of moisture (50-60%) is necessary for the microorganisms to work happily.[10] A vertical stack prevents leaching and waterlogging, and holds heat in the pile. Vertical walls around a pile, especially if they're made of wood, or bales of straw, keep the wind off and will prevent one side of the pile (the windward side) from cooling down prematurely.

A neat, contained pile looks better. It looks like you know what you're doing, instead of looking like a garbage dump. A constructed compost bin also helps to keep out nuisance animals such as dogs.

A pile makes it easier to layer or cover the compost. When a smelly deposit is added to the top, it's a good idea to cover the raw refuse with clean organic material in order to eliminate unpleasant odors and to trap necessary oxygen in the pile. Therefore, if you're going to make compost, don't just fling it out in your yard in a heap. Construct a nice bin and do it right. That bin doesn't have to cost money; it can be made from recycled wood or cement blocks. Wood (not pressure-treated) may be preferable as it will insulate the pile and prevent heat loss and frost penetration. A compost bin doesn't have to be complicated in any way. It doesn't require electricity, technology, gimmicks, or doodads. You don't need shredders, choppers, grinders, or any machines whatsoever.

Compost *pits* are more likely to be used in dry, arid, or cool climates where conservation of moisture and temperature is imperative. The main disadvantage of pits is that they can become waterlogged in the event of an unexpected cloudburst, and excessive water will rob the pile of oxygen, a critical element in the process of decomposition by aerobic microorganisms. Therefore, when pits are used, a roof over them may be an advantage, and air channels may be necessary to allow oxygen to enter the compost.

FOUR NECESSITIES FOR GOOD COMPOST

Moisture

Compost must be kept moist. A dry pile will not work. When people who don't understand compost try to picture a humanure compost pile in someone's backyard, they imagine a giant heap of crap, draining all manner of noxious, smelly liquids out the bottom of the compost bin, and leaching into the groundwater. However, a compost pile is not a pile of garbage or waste. It's a living, breathing mass, a biological sponge which requires quite a bit of moisture. It's not likely to create a leaching problem unless subjected to very heavy rains while uncovered.

Why does compost require moisture? For one thing, composted materials shrink incredibly (40-80%),[11] mostly because of water loss. Compost can undergo considerable drying when wet materials are composted.[12] An initial moisture content of 65% can dwindle down to 20 to 30% in only a week, according to some researchers.[13] It is more likely that one will have to *add* moisture to their compost than have to deal with excess moisture leaching from it.

The amount of moisture a compost pile receives or needs depends on the materials put into the pile and on the location of the pile. In Pennsylvania, there are about 36 inches (about one meter) of rainfall per year, and compost only needs watering during an unusual drought. According to Sir Albert Howard, watering a compost pile in England (where the annual rainfall is 24 inches) is also unnecessary. Nevertheless, the water required for compost-making may be around 200 to 300 gallons for each cubic yard of finished compost.[14] This moisture requirement will be met when human urine is used in humanure compost and the top of the pile is open and receiving adequate rainfall. Additional water comes from moist organic materials such as food scraps. If adequate rainfall is not available and the contents of the pile are not moist, watering will be necessary to produce a moisture content equivalent to a squeezed-out sponge. Graywater from household drains or collected rainwater would suffice for this purpose.

Oxygen

We want to cultivate *aerobic* bacteria in the compost pile to ensure thermophilic decomposition. This is done by adding bulky materials to the compost pile in order to trap interstitial air spaces. Aerobic bacteria will suffer from a lack of oxygen if drowned in liquid, which is a common problem with commercial and home made composting toilets when improperly managed.

Bacterial decomposition can also take place anaerobically, but this is a slower, cooler process, which can, quite frankly, stink. Anaerobic odors can smell like rotten eggs (caused by hydrogen sulfide), sour milk (caused by butyric acids), vinegar (acetic acids), vomit (valeic acids), and putrification (alcohols and phenolic compounds).[15] Obviously, we want to avoid such odors by maintaining an aerobic compost pile.

Good, healthy, aerobic compost need not offend one's sense of smell. However, in order for this to be true, a simple rule must be followed: *anything added to the compost that smells bad must be covered with a clean, organic material*. This means you must cover the deposits in your compost toilet *and* on your compost pile. When you defecate or urinate in your toilet, cover it. Use sawdust, use peat, use clean soil,

Figure 3.2: The author probing a humanure compost pile in late winter.
This compost had not yet become thermophilically active.
Of the two thermometers, one has a long probe and the other a short one.
PHOTO BY JEANINE JENKINS.

use leaves, but keep it covered. Then there will be no odor. When you deposit smelly manure on your compost pile, cover it. Use weeds, use straw, use hay, whatever you can get your hands on (especially bulky material which will trap oxygen in the compost), but keep it covered. That's the simple secret to the odor issue.

Temperature

Dehydration will cause the compost microorganisms to stop working. So will freezing. Compost piles will not work if frozen, which often occurs during the cold winters of the north. However, don't despair, the microorganisms will wait until the temperature rises and then they'll thaw out and, once again, work feverishly. You can continue to add to an outdoor compost pile all winter, even when the pile is frozen solid as a rock. The freezing stage helps to destroy some potential pathogens and, after the thaw, the pile works up a steam as if nothing happened.

Balanced Diet

A good carbon-nitrogen balance (a good blend of materials) is required for a nice, hot compost pile. Since most of the materials commonly added to a compost pile are very high in carbon, this means that a source of nitrogen must be incorporated into the blend of composting ingredients. This isn't as difficult as it may seem. You can carry bundles of weeds to your compost pile, add hay, straw, leaves, and garbage, but you'll still need one thing: nitrogen. Of course the solution is simple — add manure. Where can you get manure? From an animal. Where can you find an animal? *Look in a mirror.*

Rodale states in *The Complete Book of Composting* that the average gardener may have difficulty in obtaining manure for the compost heap, but with *"a little ingenuity and a thorough search,"* it can be found. A gardener in the book testifies that when he gets *"all steamed up to build myself a good compost pile, there has always been one big question that sits and thumbs its nose at me: Where am I going to find the manure? I am willing to bet, too, that the lack of manure is one of the reasons why your compost pile is not the thriving humus factory that it might be."*

Hmmm. WHERE can a large animal like a human being find manure? Gee, that's a tough one. Let's think real hard about that one. Perhaps with a little "ingenuity and a thorough search" we can come up with a source. Where IS that mirror, anyway? Might be a clue there.

Table 3.1
NITROGEN LOSS AND CARBON/NITROGEN RATIO

Initial C/N Ratio	Nitrogen Loss (%)
20.0	38.8
20.5	48.1
22.0	14.8
30.0	0.5
35.0	0.5
76.0	-8.0

Source: Gotaas, Composting, 1956, p. 92

THE CARBON/NITROGEN RATIO

One way to understand the blend of ingredients in your compost pile is by using the C/N ratio (carbon/nitrogen ratio). Quite frankly, the chance of the average person measuring and monitoring the carbon and nitrogen quantities of their organic material is almost nil. This is like making wine the "foolproof" way. If composting requires this sort of drudgery, no one would do it.

However, I've found that by using all of the organic refuse my family produces, including humanure, urine, food refuse, weeds from our garden, rotting sawdust (which is hauled in), grass clippings, and maybe a little straw or hay now and then, we get the right mix of carbon and nitrogen for successful thermophilic composting. We do not compost newspapers or other burnable materials, we recycle them or burn them in our woodstove.

Nevertheless, no discussion of composting is complete without a review of the subject of the carbon/nitrogen ratio. A good C/N ratio for a compost pile is between 20/1 and 35/1.[16] That's 20 parts of carbon to one part of nitrogen, up to 35 parts of carbon to one part of nitrogen. Or, for simplicity, you can figure on shooting for an optimum 30/1 ratio.

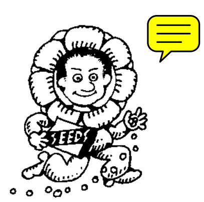
For microorganisms, carbon is the basic building block of life and is a source of energy, but nitrogen is also necessary for such things as proteins, genetic material, and cell structure. Microorganisms that digest compost need about 30 parts of carbon for every part of nitrogen they consume. That's a balanced diet for them. If there's too much nitrogen, the microorganisms can't use it all and the excess is lost in the form of smelly ammonia gas. Nitrogen loss due to excess nitrogen in the pile (a low C/N ratio) can be over 60%. At a C/N ratio of 30 or 35 to 1, only one half of one percent of the nitrogen will be lost (see Table 3.1). That's why you don't want too much nitrogen (manure, for example) in your compost: the nitrogen will be lost in the air in the form of ammonia gas, and nitrogen is too valuable for plants to allow it to escape into the atmosphere.[17]

That's also why humanure and urine alone *will not* compost. They contain too much nitrogen and not enough carbon, and microorganisms, like humans, gag at the thought of eating it. Since there's nothing worse than several billion gagging microorganisms, a carbon-based material must be added to the humanure in order to make it appealing. Plant cellulose is a carbon-based material, and therefore plant by-products such as hay, straw, weeds, or even paper products if ground to the proper consistency, will provide the needed carbon. Kitchen food scraps are generally C/N balanced, and they can readily be added to humanure compost. Sawdust (preferably *not* kiln-dried) is a good carbon material for balancing the nitrogen of humanure. Sawmill sawdust has a moisture content of 40-65%, which is good for compost.[18] Lumber yard sawdust, on the other hand, is kiln-dried and is biologically inert due to the dehydration. Therefore, it is not as desirable in compost unless rehydrated with water (or urine) before being added to the compost pile. Also, lum-

Table 3.2

CARBON/NITROGEN RATIOS

Material	%N	C/N Ratio
Activated Sludge	5-6	6
Amaranth	3.6	11
Apple Pomace	1.1	13
Blood	10-14	3
Bread	2.10	---
Cabbage	3.6	12
Cardboard	0.10	400-563
Coffee Grounds	---	20
Cow Manure	2.4	19
Corn Cobs	0.6	56-123
Corn Stalks	0.6-0.8	60-73
Cottonseed Meal	7.7	7
Cranberry Plant	0.9	61
Farmyard Manure	2.25	14
Fern	1.15	43
Fish Scrap	10.6	3.6
Fruit	1.4	40
Garbage (Raw)	2.15	15-25
Grass Clippings	2.4	12-19
Hardwood Bark	0.241	223
Hardwoods (Avg.)	0.09	560
Hay (General)	2.10	---
Hay (legume)	2.5	16
Hen Manure	8	6-15
Horse Manure	1.6	25-30
Humanure	5-7	5-10
Leaves	0.9	54
Lettuce	3.7	---
Meat Scraps	5.1	---
Mussel Residues	3.6	2.2
Mustard	1.5	26
Newsprint	0.06-0.14	398-852
Oat Straw	1.05	48
Olive Husks	1.2-1.5	30-35
Onion	2.65	15
Paper	---	100-800
Pepper	2.6	15
Pig Manure	3.1	14
Potato Tops	1.5	25
Poultry Carcasses	2.4	5
Purslane	4.5	8
Raw Sawdust	0.11	511
Red Clover	1.8	27
Rice Hulls	0.3	121
Rotted Sawdust	0.25	200-500
Seaweed	1.9	19
Sewage Sludge	2-6.9	5-16
Sheep Manure	2.7	16
Shrimp Residues	9.5	3.4
Slaughter Waste	7-10	2-4
Softwood Bark	0.14	496
Softwoods (Average)	0.09	641
Soybean Meal	7.2-7.6	4-6
Straw (General)	0.7	80
Straw (Oat)	0.9	60
Straw (Wheat)	0.4	80-127
Telephone Books	0.7	772
Timothy Hay	0.85	58
Tomato	3.3	12
Turkey Litter	2.6	16
Turnip Tops	2.3	19
Urine	15-18	0.8
Vegetable Produce	2.7	19
Water Hyacinth	---	20-30
Wheat Straw	0.3	128-150
Whole Carrot	1.6	27
Whole Turnip	1.0	44



Sources: Gotaas, Harold B. (1956). Composting - Sanitary Disposal and Reclamation of Organic Wastes (p.44). World Health Organization, Monograph Series Number 31. Geneva. *and* Rynk, Robert, ed. (1992). On-Farm Composting Handbook. Northeast Regional Agricultural Engineering Service. Ph: (607) 255-7654. pp. 106-113. Some data from Biocycle, Journal of Composting and Recycling, July 1998, p.18, 61, 62; and January 1998, p.20.

ber yard sawdust nowadays can often be contaminated with wood preservatives such as chromated copper arsenate (from "pressure treated lumber"). Both chromium and arsenic are human carcinogens, so it would be wise to avoid such materials.

The C/N ratio of humanure is between five and ten, averaging eight parts of carbon to one part of nitrogen. Therefore, you need to add a fair amount of carbon to humanure to get a 30/1 ratio (see Tables 3.2 and 3.3). I've found that the proper balance is obtained by putting all the organic refuse of my household (excluding printed material and burnable paper packaging) in the same compost pile, layered with weeds, straw, hay, leaves, or whatever organic material happens to be within reach. The humanure, when collected in the toilet, is covered with clean, partially rotted, hardwood or softwood sawdust, or another carbon-based material such as peat moss or rice hulls. This carbonaceous "cover material" not only balances the nitrogen, but also prevents odors remarkably well.

It has recently become popular for backyard composters to refer to organic materials as "browns" and "greens." The browns (such as dried leaves) supply carbon, and the greens (such as fresh grass clippings) supply nitrogen. It's recommended that two to three volumes of browns be mixed with one volume of greens in order to produce a mix with the correct C/N ratio for composting.[19] However, since

Table 3.3

COMPOSITION OF HUMANURE

Fecal Material:
0.3-0.6 pounds per person per day (135-270 grams), wet weight.

Organic Matter (dry weight)	88-97%
Moisture Content	66-80%
Nitrogen	5-7%
Phosphorous	3-5.4%
Potassium	1-2.5%
Carbon	40-55%
Calcium.	4-5%
C/N Ratio	5-10

Urine:
1.75-2.25 pints per person per day (1.0-1.3 liters)

Moisture	93-96%
Nitrogen	15-19%
Phosphorous	2.5-5%
Potassium	3 -4.5%
Carbon	11-17%
Calcium	4.5-6%

Source: Gotaas, Composting, (1956), p. 35

Table 3.4

DECOMPOSITION RATES OF SELECTED SAWDUSTS

SAWDUST	RELATIVE DECOMPOSITION RATE
Red Cedar	3.9
Douglas Fir	8.4
White Pine	9.5
Western White Pine	22.2
Average of all softwoods	12.0
Chestnut	33.5
Yellow Poplar	44.3
Black Walnut	44.7
White Oak	49.1
Average of all hardwoods	45.1
Wheat straw	54.6

The lower the number, the slower the decomposition rate. According to this data, hardwood sawdust decomposes faster than softwood sawdust.

Source: Haug, Roger T. (1993). The Practical Handbook of Compost Engineering. CRC Press, Inc., 2000 Corporate Blvd. N.W., Boca Raton, FL 33431 USA. as reported in Biocycle - Journal of Composting and Recycling. December, 1998. p. 19.

most backyard composters are not humanure composters, many backyard composters have a pile of material sitting in their compost bin showing very little activity. What is usually missing is nitrogen as well as moisture, two critical ingredients to any compost pile. Both of these are provided by humanure when collected with urine and a carbon cover material. The humanure mix can be quite brown, but is also quite high in nitrogen. So the "brown/green" approach doesn't really work, nor is it necessary, when composting humanure along with other household organic material. Let's face it, humanure composters are in a class by themselves.

THERMOPHILIC MICROORGANISMS

A wide array of microorganisms live in a compost pile. Bacteria are especially abundant and are usually divided into several classes based upon the temperatures at which they grow best. The low temperature bacteria are the *psychrophiles*, which can grow at temperatures down to -10°C, but whose optimum temperature is 15°C (59°F) or lower. The *mesophiles* live at medium temperatures, 20-45°C (68-113°F), and include human pathogens. *Thermophiles* thrive above 45°C (113°F), and some live at or even above the boiling point of water.

Strains of thermophilic bacteria have been identified with optimum temperatures ranging from 55°C to an incredible 105°C (above the boiling point of water), and many temperatures in between.[20] The strains that survive at extremely high temperatures are called, appropriately enough, extreme thermophiles, or hyperthermophiles, and have a temperature optimum of 80°C (176°F) or higher. Thermophilic bacteria occur naturally in hot springs, tropical soils, compost heaps, in your excrement, in hot water heaters (both domestic and industrial), and in your garbage, to name a few places.[21]

Thermophilic bacteria were first isolated in 1879 by Miquel, who found bacteria capable of developing at 72°C (162°F). He found these bacteria in soil, dust, *excrement,* sewage, and river mud. It wasn't long afterward that a variety of thermophilic bacteria were discovered in soil — bacteria that readily thrived at high

Table 3.5

COMPARISONS OF DIFFERENT TYPES OF MANURES

Manure	% Moisture	% Nitrogen	% Phosphorous	% Potassium
Human	66-80	.5-7	.3-5.4	1.0-2.5
Cattle	80	1.67	1.11	0.56
Horse	75	2.29	1.25	1.38
Sheep	68	3.75	1.87	1.25
Pig	82	3.75	1.87	1.25
Hen	56	6.27	5.92	3.27
Pigeon	52	5.68	5.74	3.23
Sewage	---	.5-10	2.5-4.5	3.0-4.5

Source: Gotaas, Harold B. (1956). Composting - Sanitary Disposal and Reclamation of Organic Wastes . pp. 35, 37, 40. World Health Organization, Monograph Series Number 31. Geneva.

temperatures, but not at room temperature. These bacteria are said to be found in the sands of the Sahara Desert, but not in the soil of cool forests. Composted or manured garden soils may contain 1-10 percent thermophilic types of bacteria, while field soils may have only 0.25% or less. Uncultivated soils may be entirely free of thermophilic bacteria.[22]

Thermophiles are responsible for the spontaneous heating of hay stacks which can cause them to burst into flame. Compost itself can sometimes spontaneously combust. This occurs in larger piles (usually over 12 feet high) that become too dry (between 25% and 45% moisture) and overheat.[23] Spontaneous fires have started at two American composting plants (Schenectady and Cape May) due to excessively dry compost. According to the EPA, fires can start at surprisingly low temperatures (194^{0}F) in too-dry compost, although this is not a problem for the back yard composter. When growing on bread, thermophiles can raise the temperature of the bread to 74^{0}C (165^{0}F). Heat from bacteria also warms germinating seeds, as seeds in a sterile environment are found to remain cool while germinating.[24]

Both mesophilic and thermophilic microorganisms are found widely distributed in nature, and are commonly resident on food material, garbage, and manures. This is not so surprising when considering mesophiles, because the temperatures they find to be optimum for their reproduction are commonly found in nature. These temperatures include those of warm-blooded animals, which excrete mesophiles in their stools in huge numbers.

A mystery presents itself, on the other hand, when we consider *thermophilic* microorganisms, since they prefer living at temperatures not commonly found in nature, but in hot springs, water heaters, and compost piles. Their preferences for hot temperatures has given rise to some speculation about their evolution. One theory suggests that the thermophiles were among the first living things on this planet, developing and evolving during the primordial birthing days of Earth, when surface temperatures were quite hot. They have thus been called the "Universal Ancestor." Estimated at 3.6 billion years old, they are said to be so abundant as to *"comprise as much as half of all living things on the planet."* [25] This is a rather startling concept, as it would mean that thermophilic organisms are perhaps more ancient than anything else alive. Their age would make dinosaurs look like new born babes, still wet behind the ears (however extinct). Of course, we humans, in comparison, have just shown up on the Earth. Thermophiles could, therefore, be the common ancestral organism of all life forms on our planet.

Just as startling is the concept that thermophiles, despite their need for a hot environment, are found everywhere. They're lingering in your garbage, and in your stool, and have been since we humans first began to crawl on this planet. They have quietly waited since the beginning of time, and we haven't been aware of them until recently. Researchers insist that thermophiles do not grow at ambient or room temperatures.[26] Yet, like a miracle, when we collect our organic refuse in a tidy pile, the thermophiles seem to be sparked out of their dormant slumber to work furiously toward creating the primordial heat they so long for. And they succeed — if we help them by creating compost piles. They reward us for our help by converting our garbage and other organic discards into life-sustaining earth.

The knowledge of living creatures incomprehensibly ancient, so small as to be entirely invisible, thriving at temperatures hotter than those normally found in nature, and yet found alive everywhere, is remarkable enough. The fact that they are so willing to work for our benefit, however, is rather humbling.

By some estimates, humanure contains up to 1,000,000,000,000 (a trillion) bacteria per gram.[27] These are, of course, mixed species, and not by any means all thermophiles. A trillion bacteria is equivalent to the entire human population of the Earth multiplied by 166, and all squeezed into a gram of organic material. These microbiological concepts of size and number are difficult for us humans to grasp. Ten people crammed into an elevator we can understand. A trillion living organisms in a teaspoonful of crap is a bit mind-boggling.

Has anyone identified the species of microorganism that heats up compost? Actually, a large variety of species, a *biodiversity*, is critical to the success of compost. However, the thermophilic stage of the process is dominated by thermophilic bacteria. One examination of compost microorganisms at two compost plants showed that most of the bacteria (87%) were of the genus *Bacillus,* which are bacteria that form spores,[28] while another researcher found that above 65°C, the organisms in the compost were almost purely *Bacillus stearothermophilus.*[29]

FOUR STAGES OF COMPOST

There is a huge difference between a backyard humanure composter and a municipal composter. Municipal composters handle large batches of organic materials all at once, while backyard composters continuously produce a small amount of organic material every day. Municipal composters, therefore, are "batch" composters, while backyard composters tend to be "continuous" composters. When organic material is composted in a batch, four stages of the composting process are apparent. Although the same phases occur during continuous composting, they are not as apparent as they are in a batch, and, in fact, they may be occurring concurrently rather than sequentially.

The four phases include: 1) the mesophilic phase; 2) the thermophilic phase; 3) the cooling phase; and 4) the curing phase.

Compost bacteria combine carbon with oxygen to produce carbon dioxide and energy. Some of the energy is used by the microorganisms for reproduction and growth, the rest is given off as heat. When a pile of organic refuse begins to undergo the composting process, mesophilic bacteria proliferate, raising the temperature of the composting mass up to 44°C (111°F). This is the first stage of the composting process. These mesophilic bacteria can include *E. coli* and other bacteria from the human intestinal tract, but these soon become increasingly inhibited by the temperature, as the thermophilic bacteria take over in the transition range of 44°C-52°C (111°F-125.6°F).

This begins the second stage of the process, when thermophilic microorganisms are very active and produce a lot of heat. This stage can then continue up to about 70°C (158°F),[30] although such high temperatures are neither common nor desirable in backyard compost. This heating stage takes place rather quickly and may last only a few days, weeks, or months. It tends to remain localized in the upper portion of a backyard compost bin where the fresh material is being added, whereas in batch compost, the entire composting mass may be thermophilic all at once.

After the thermophilic heating period, the humanure will appear to have been digested, but the coarser organic material will not. This is when the third stage of composting, the cooling phase, takes place. During this phase, the microorganisms that were chased away by the thermophiles migrate back into the compost and get back to work digesting the more resistant organic materials. Fungi and macroorganisms such as earthworms and sowbugs that break the coarser elements down into humus also move back in.

After the thermophilic stage has been completed, only the readily available nutrients in the organic material have been digested. There's still a lot of food in the pile, and a lot of work to be done by the creatures in the compost. It takes many months to break down some of the more resistant organic material in compost such as "lignin" which comes from wood materials. Like humans, trees have evolved with a skin that is resistant to bacterial attack, and in a compost pile those lignins resist breakdown by thermophiles. However, other organisms, such as fungi, can break down lignin, given enough time; since they don't like the heat of thermophilic compost, they simply wait for things to cool down before beginning their job.

The final stage of the composting process is called the curing, aging, or maturing stage, and it is a long and important one. Commercial composting professionals often want to make their compost as quickly as possible, usually sacrificing the compost's curing time. One municipal compost operator remarked that if he could shorten his compost time to four months, he could make three batches of compost a year instead of only the two he was then making, thereby increasing his output by 50%. Municipal composters see truckloads of compost coming in to their facilities daily, and they want to make sure they don't get inundated with organic material waiting to be composted. Therefore, they feel a need to move their material through the composting process as quickly as possible to make room for the new stuff coming in. Household composters don't have that problem, although there seem to be plenty of backyard composters who are obsessed with making compost as quickly as possible. However, the curing, aging, or maturing of the compost is a critically important stage of the compost-making process. And, as in wine-making, an important element to figure into the equation is *patience*.

A long curing period (e.g., a year after the thermophilic stage) adds a safety net for pathogen destruction. Many human pathogens only have a limited period of viability in the soil, and the longer they are subjected to the microbiological competition of the compost pile, the more likely they will die a swift death.

Immature compost can be harmful to plants. Uncured compost can produce phytotoxins (substances toxic to plants), can rob the soil of oxygen and nitrogen, and can contain high levels of organic acids. So relax, sit back, put your feet up, and let your compost reach full maturity *before* you even think about using it.

COMPOST BIODIVERSITY

Compost is normally populated by three general categories of microorganisms: bacteria, actinomycetes, and fungi (see Figure 3.3 and Table 3.6). It is the bacteria, and specifically the thermophilic bacteria, that create the heat of the compost pile.

Although considered bacteria, actinomycetes are effectively intermediate between bacteria and fungi because they look similar to fungi and have similar nutritional preferences and growth habits. They tend to be more commonly found in the later stages of the compost, and are generally thought to follow the thermophilic bacteria in succession. They, in turn, are followed predominantly by fungi during the last stages of the composting process.

There are at least 100,000 species of fungi known, the overwhelming majority of them being microscopic.[31] Most fungi cannot grow at 50°C (it's too hot) although some are heat tolerant (thermophilic fungi). Fungi tend to be absent in compost above 60°C, and actinomycetes tend to be absent above 70°C. Above 82°C biological activity effectively stops (extreme thermophiles are not found in compost).[32]

To get an idea of the microbial diversity normally found in nature, consider this: a teaspoon of native grassland soil contains 600-800 million bacteria comprising 10,000 species, plus perhaps 5,000 species of fungi, the mycelia of which could be stretched out for several miles. In the same teaspoon, there may be 10,000 individual protozoa of perhaps 1,000 species, plus 20-30 different nematodes from as many as 100 species. Sounds crowded to me. Obviously, good compost will reinoculate depleted, sanitized, chemicalized soils with a wide variety of beneficial microorganisms (see Figures 3.4 and 3.5).[33]

COMPOST MICROORGANISMS "SANITIZE" COMPOST

One of the most frequent questions asked of me is, "How do you know that ALL parts of your compost have been subjected to high enough temperatures to kill ALL potential pathogens?" The answer should be obvious: you don't. You never will. Unless, of course, you examine every cubic centimeter of your compost for pathogens in a laboratory. This would probably cost many thousands of dollars, which would make your compost the most expensive in history.

It's not *only* the heat of the compost that causes the destruction of human, animal, and plant pathogens, it's a combination of factors including:

- competition for food from compost microorganisms;
- inhibition and antagonism by compost microorganisms;
- consumption by compost organisms;
- biological heat generated by compost microorganisms; and
- antibiotics produced by compost microorganisms.

For example, when bacteria were grown both in an incubator and separately in compost at 50°C, they died in the compost after only seven days, but lived in the incubator for seventeen days. This indicated that it is more than just temperature that determines the fate of pathogenic bacteria. The other factors listed above undoubtedly affect the viability of non-indigenous microorganisms (such as human pathogens) in a compost pile. Those factors require as large and diverse a microbial population as possible, which is best achieved by temperatures below 60°C (140°F). One researcher states that, *"Significant reductions in pathogen numbers have been observed in compost piles which have not exceeded 40°C [104°F]."* [34]

There is no doubt that the heat produced by thermophilic bacteria kills pathogenic microorganisms, viruses, bacteria, protozoa, worms and eggs that may inhabit humanure. A temperature of 50°C (122° F), if maintained for twenty-four hours, is sufficient to kill all of the pathogens, according to some sources (see Chapter Seven). A lower temperature will take longer to kill pathogens. A temperature of 46°C (115°F) may take nearly a week to kill pathogens completely, a higher temperature may only take minutes. What we have yet to determine is how low those temperatures can be and still achieve satisfactory pathogen elimination. Some researchers insist that all pathogens will die at ambient temperatures (normal air temperature) given enough time.

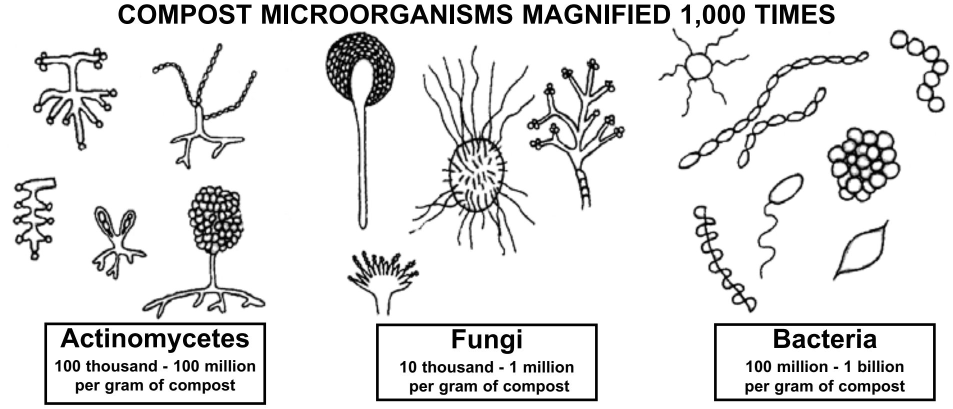
When Westerberg and Wiley composted sewage sludge which had been inoculated with polio virus, *Salmonella*, roundworm eggs, and *Candida albicans*, they found that a compost temperature of 47-55°C (116-130°F) maintained for three days killed all of these pathogens.[35] This phenomenon has been confirmed by many other researchers, including Gotaas, who indicates that pathogenic organisms are unable to survive compost temperatures of 55-60°C (131-140°F) for more than thirty minutes to one hour.[36] The first goal in composting humanure, therefore, should be to create a compost pile that will heat sufficiently to kill all potential human pathogens that may be found in the manure.

Nevertheless, the heat of the compost pile is a highly lauded characteristic of compost that is a bit overblown at times. People think that it's only the heat of the compost that destroys pathogens, so they want their compost to become as hot as possible. This is a mistake. In fact, compost can become too hot, and when it does, it destroys the biodiversity of the microbial community. As one scientist states, *"Research has indicated that temperature is not the only mechanism involved in pathogen suppression, and that the employment of higher than necessary temperatures may actually constitute a barrier to effective sanitization under certain circumstances."* [37] Perhaps only one species (e.g., *Bacillus stearothermophilus*) may dominate the compost pile during periods of excessive heat, thereby driving out or just outright killing the other inhabitants of the compost, which include fungi and actinomycetes, as well as the bigger organisms that you can actually see.

A compost pile that is too hot can destroy its own biological community and

Figure 3.3

COMPOST MICROORGANISMS MAGNIFIED 1,000 TIMES



Reproduced with permission from On-Farm Composting Handbook. NRAES-54, published by NRAES, Cooperative Extension, 152 Riley-Robb Hall, Ithaca, New York 14853-5701. (607) 255-7654. Quantities of microorganisms from: Sterritt, Robert M. (1988). Microbiology for Environmental and Public Health Engineers. p. 200. E. & F. N. Spon Ltd.,, New York, NY 10001 USA.

Table 3.6

MICROORGANISMS IN COMPOST

Actinomycetes	Fungi	Bacteria
Actinobifida chromogena	*Aspergillus fumigatus*	*Alcaligenes faecalis*
Microbispora bispora	*Humicola grisea*	*Bacillus brevis*
Micropolyspora faeni	*H. insolens*	*B. circulans* complex
Nocardia sp.	*H. lanuginosa*	*B. coagulans* type A
Pseudocardia thermophilia	*Malbranchea pulchella*	*B. coagulans* type B
Streptomyces rectus	*Myriococcum themophilum*	*B. licheniformis*
S. thermofuscus	*Paecilomyces variotti*	*B. megaterium*
S. thermoviolaceus	*Papulaspora thermophila*	*B. pumilus*
S. thermovulgaris	*Scytalidium thermophilim*	*B. sphaericus*
S. violaceus-ruber	*Sporotrichum thermophile*	*B. stearothermophilus*
Thermoactinomyces sacchari		*B. subtilis*
T. vulgaris		*Clostridium thermocellum*
Thermomonospora curvata		*Escherichia coli*
T. viridis		*Flavobacterium* sp.
		Pseudomonas sp.
		Serratia sp.
		Thermus sp.

Source: Palmisano, Anna C. and Barlaz, Morton A. (Eds.) (1996). Microbiology of Solid Waste. Pp. 125-127. CRC Press, Inc., 2000 Corporate Blvd., N.W., Boca Raton, FL 33431 USA.

leave a mass of organic material that must be re-populated in order to continue the necessary conversion of organic matter to humus. Such sterilized compost is more likely to be colonized by unwanted microorganisms, such as *Salmonella*. Researchers have shown that the biodiversity of compost acts as a barrier to colonization by such unwanted microorganisms as *Salmonella*. In the absence of a biodiverse "indigenous flora," such as happens through sterilization, *Salmonella* were able to regrow.[38]

The microbial biodiversity of compost is also important because it aids in the breakdown of the organic material. For example, in high-temperature compost (80°C), only about 10% of sewage sludge solids could be decomposed in three weeks, whereas at 50-60°C, 40% of the sludge solids were decomposed in only seven days. The lower temperatures apparently allowed for a richer diversity of living things which in turn had a greater effect on the degradation of the organic matter. One researcher indicates that optimal decomposition rates occur in the 55-59°C (131-139°F) temperature range, and optimal thermophilic activity occurs at 55°C (131°F), which are both adequate temperatures for pathogen destruction.[39] A study conducted in 1955 at Michigan State University, however, indicated that optimal decomposition occurs at an even lower temperature of 45°C (113°F).[40] Another researcher asserts that maximum biodegradation occurs at 45-55°C (113-131°F), while maximum microbial diversity requires a temperature range of 35-45°C (95-113°F).[41] Apparently, there is still some degree of flexibility in these estimates, as the science of "compost microhusbandry" is not an utterly precise one at this time. Control of excessive heat is rarely a concern for the backyard composter.

Some thermophilic actinomycetes, as well as mesophilic bacteria, produce antibiotics that display considerable potency toward other bacteria, and yet exhibit low toxicity when tested on mice. Up to one half of thermophilic strains can produce antimicrobial compounds, some of which have been shown to be effective against *E. coli* and *Salmonella.* One thermophilic strain with an optimum growth temperature of 50°C produces a substance that *"significantly aided the healing of infected surface wounds in clinical tests on human subjects. The product(s) also stimulated growth of a variety of cell types, including various animal and plant tissue cultures and unicellular algae."* [42]

Figure 3.4

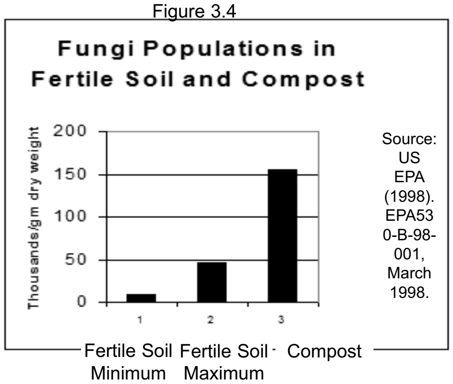
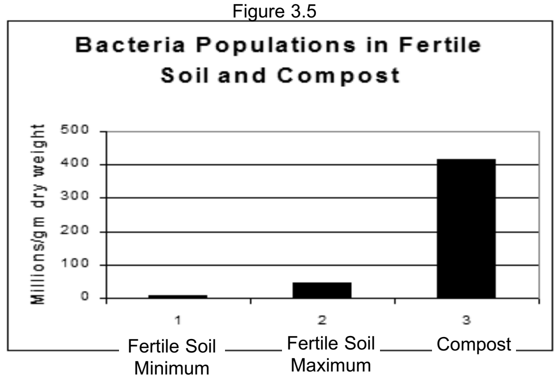


Figure 3.5



The production of antibiotics by compost microorganisms theoretically assists in the destruction of human pathogens that may have existed in the organic material before composting.

Even if every speck of the composting material is not subjected to the high internal temperatures of the compost pile, the process of thermophilic composting nevertheless contributes immensely toward the creation of a sanitary organic material. Or, in the words of one group of composting professionals, *"The high temperatures achieved during composting, assisted by the competition and antagonism among the microorganisms [i.e., biodiversity], considerably reduce the number of plant and animal pathogens. While some resistant pathogenic organisms may survive and others may persist in cooler sections of the pile, the disease risk is, nevertheless, greatly reduced."* [43]

If a backyard composter has any doubt or concern about the existence of pathogenic organisms in his or her humanure compost, s/he can use the compost for horticultural purposes rather than for food purposes. Humanure compost can grow an amazing batch of berries, flowers, bushes, or trees. Furthermore, lingering pathogens continue to die after the compost has been applied to the soil, which is not surprising as human pathogens prefer the warm and moist environment of the human body. As the World Bank researchers put it, *"even pathogens remaining in compost seem to disappear rapidly in the soil."* [*Night Soil Composting*, 1981] Finally, compost can be tested for pathogens by compost testing labs.

Some say that a few pathogens in soil or compost are ok. *"Another point most folks don't realize is that no compost and no soil are completely pathogen free. You really don't want it to be completely pathogen free, because you always want the defense mechanism to have something to practice on. So a small number of disease-causing organisms is desirable. But that's it."* [44] Pathogens are said to have "minimum infective doses," which vary widely from one type of pathogen to another, meaning that a number of pathogens are necessary in order to initiate an infection. The idea, therefore, that compost must be sterile is incorrect. It must be *sanitary*, which means it must have a greatly weakened, reduced, or destroyed pathogen population.

In reality, the average backyard composter knows whether his or her family is healthy or not. Healthy families have little to be concerned about, and can feel pretty confident that their thermophilic compost will be safe for their garden, provided the simple instructions in this book are followed regarding compost temperatures and retention times, as discussed in Chapter Seven. On the other hand, there will always be those people who are fecophobic, and who will never be convinced that humanure compost is safe. These people are not likely to compost their humanure anyway, so who cares?

COMPOST MYTHS

TO TURN OR NOT TO TURN: THAT IS THE QUESTION

What is one of the first things to come to mind when one thinks of compost? Turning the pile. *Turn, turn, turn*, has become the mantra of composters worldwide. Early researchers who wrote seminal works in the composting field, such as Gotaas, Rodale, and many others, emphasize turning compost piles, almost obsessively so.

Much of compost's current popularity in the West can be attributed to the work of Sir Albert Howard, who wrote *An Agricultural Testament* (1943) and several other works on aspects of what has now become known as *organic* agriculture. Sir Howard's discussions of composting techniques focus on the Indore process of composting, a process developed in Indore, India, between the years of 1924 and 1931. The Indore process was first described in detail in Sir Howard's work (co-authored with Y. D. Wad), *The Waste Products of Agriculture,* in 1931. The two main principles underlying the Indore composting process include: 1) mixing animal and vegetable refuse with a neutralizing base, such as agricultural lime; and 2) managing the compost pile by physically turning it. The Indore process subsequently became adopted and espoused by composting enthusiasts in the West, and today one still commonly sees people turning and liming compost piles. For example, Robert Rodale wrote in the February, 1972 issue of *Organic Gardening* concerning composting humanure, "*We recommend turning the pile at least three times in the first few months, and then once every three months thereafter for a year.*"

A large industry has emerged from this philosophy, one which manufactures expensive compost turning equipment, and a lot of money, energy, and expense goes into making sure compost is turned regularly. To some compost professionals, the suggestion that compost doesn't need to be turned at all is utter blasphemy. Of course you have to turn it — it's a compost pile, for heaven's sake.

Or do you? Well, in fact, NO, you don't, especially if you're a backyard composter, and not even if you're a large scale composter. The perceived need to turn compost is one of the myths of composting.

Turning compost potentially serves four basic purposes. First, turning is supposed to add oxygen to the compost pile, which is supposed to be good for the aerobic microorganisms. We are warned that if we do not turn our compost, it will become anaerobic and smell bad, attract rats and flies, and make us into social pariahs in our neighborhoods. Second, turning the compost ensures that all parts of the pile are subjected to the high internal heat, thereby ensuring total pathogen death, and yielding a hygienically safe, finished compost. Third, the more we turn the compost, the more it becomes chopped and mixed, and the better it looks when finished, rendering it more marketable. Fourth, frequent turning can speed up the composting process. Since backyard composters don't actually market their compost, usually don't care if it's finely granulated or somewhat coarse, and usually have no good reason to be in a hurry, we can eliminate the last two reasons for turning compost right off the bat. Let's look at the first two.

Aeration is necessary for aerobic compost, which is what we want. There are numerous ways to aerate a compost pile. One is to force air into or through the pile using fans, which is common at large-scale composting operations, where air is sucked from under the compost piles and out through a biofilter. The suction causes air to seep into the organic mass through the top, thereby keeping it aerated. However, this air flow is more often than not a method for trying to reduce the temperature of the compost, because the exhaust air draws quite a bit of heat away from the compost pile. Mechanical aeration is never a need of the backyard composter, and is limited to large scale composting operations where the piles are so big they can smother themselves if not subjected to forced aeration.

Aeration can also be achieved by poking holes in the compost, driving pipes into it, and generally impaling it. This seems to be popular among some backyard composters. A third way is to physically turn the pile. A fourth, largely ignored way, however, is to build the pile so that tiny interstitial air spaces are trapped in the compost. This is done by using coarse materials in the compost, such as hay, straw, weeds, and the like. When a compost pile is properly constructed, no additional aeration will be needed. Even the organic gardening pros admit that, *"good compost can be made without turning by hand if the materials are carefully layered in the heap which is well-ventilated and has the right moisture content."* [45]

This is especially true for "continuous compost," which is different from "batch compost." Batch compost is made from a batch of material that is composted all at once. This is what commercial composters do — they get a dumptruck load of garbage or sewage sludge from the municipality and compost it in one big pile. Backyard composters, especially humanure composters, produce organic residues daily, a little at a time, and rarely, if ever, in big batches. Therefore, continuous composters add material continuously to a compost pile, usually by putting the fresh material on the top. This causes the thermophilic activity to be in the upper part of the pile, while the thermophilically "spent" part of the compost sinks lower and lower to be worked on by fungi, actinomycetes, earthworms, and lots of other things. Turning continuous compost dilutes the thermophilic layer with the spent layers and can quite abruptly stop all thermophilic activity.

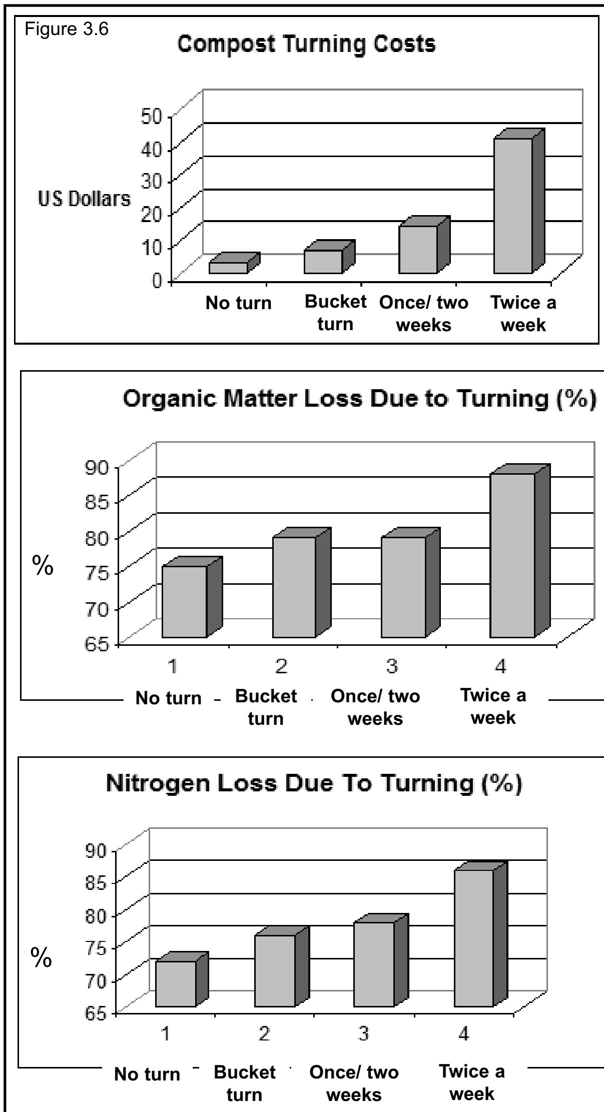
Researchers have measured oxygen levels in large-scale windrow composting operations (a windrow is a long, narrow pile of compost). One reported, *"Oxygen concentration measurements taken within the windrows during the most active stage of the composting process, showed that within fifteen minutes after turning the windrow — supposedly aerating it — the oxygen content was already depleted."* [46] Other researchers compared the oxygen levels of large, turned and unturned batch compost piles, and have come to the conclusion that compost piles are largely self-aerated. *"The effect of pile turning was to refresh oxygen content, on average for [only] 1.5 hours (above the 10% level), afterwhich it dropped to less than 5% and in most cases to 2% during the active phase of com-*

posting . . . Even with no turning, all piles eventually resolve their oxygen tension as maturity approaches, indicating that self-aeration alone can adequately furnish the composting process . . . In other words, turning the piles has a temporal but little sustained influence on oxygen levels." These trials compared compost that was not turned, bucket turned, turned once every two weeks, and turned twice a week.[47]

Interestingly enough, the same trials indicated that bacterial pathogens were destroyed whether the piles were turned or unturned, stating that there was no evidence that bacterial populations were influenced by turning schemes. There were no surviving *E. coli* or *Salmonella* strains, indicating that there were *"no statistically significant effects attributable to turning."* Unturned piles can benefit by the addition of extra coarse materials such as hay or straw, which trap extra air in the organic material and make additional aeration unnecessary. Furthermore, unturned compost piles can be covered with a thick insulating layer of organic material, such as hay, straw, or even finished compost, which will allow the temperatures on the outer edges of the pile to warm enough for pathogen destruction.

Not only can turning compost piles be an unnecessary expenditure of energy, but the above trials also showed that when batch compost piles are turned frequently, some other disadvantageous effects can result (see Figure 3.6). The more frequently compost piles are turned, the more they lose agricultural nutrients. When the finished compost was analyzed for organic matter and nitrogen loss, the unturned compost showed the least loss. The more frequent-

Figure 3.6



Source: Brinton, William F. Jr. (date unknown). *Sustainability of Modern Composting - Intensification Versus Cost and Quality*. Woods End Institute, PO Box 297, Mt. Vernon, Maine 04352 USA.

ly the compost was turned, the greater was the loss of both nitrogen *and* organic matter. Also, the more the compost was turned, the more it cost. The unturned compost cost $3.05 per wet ton, while the compost turned twice a week cost $41.23 per wet ton, a 1,351% increase. The researchers concluded that *"Composting methods that require intensification [frequent turning] are a curious result of modern popularity and technological development of composting as particularly evidenced in popular trade journals. They do not appear to be scientifically supportable based on these studies . . . By carefully managing composting to achieve proper mixes and limited turning, the ideal of a quality product at low economic burden can be achieved."* [48] Backyard composters like the "low economic burden" part of that statement.

When large piles of compost are turned, they give off emissions of such things as *Aspergillus fumigatus* fungi, which can cause health problems in people. Aerosol concentrations from static (unturned) piles are relatively small when compared to mechanically turned compost. Measurements thirty meters downwind from static piles showed that aerosol concentrations of *A. fumigatus* were not significantly above background levels, and were "33 to 1800 times less" than those from piles that were being moved.[49]

Finally, turning compost piles in cold climates can cause them to lose too much heat. It is recommended that cold climate composters turn less frequently, if at all.[50]

Do you need to inoculate your compost pile?

No. This is perhaps one of the most astonishing aspects of composting. In October of 1998, I took a trip to Nova Scotia, Canada, to observe the municipal composting operations there. The Province had legislated that as of November 30, 1998, no organic materials could be disposed of in landfills. By the end of October, with the "ban date" approaching, virtually all municipal organic garbage was being collected and transported instead to composting facilities, where it was effectively being recycled and converted into humus. The municipal garbage trucks would simply back into the compost facility building (the composting was done indoors), and then dump the garbage on the floor. The material consisted of the normal household and restaurant food materials such as banana peels, coffee grounds, bones, meat, spoiled milk, and paper products such as cereal boxes. The occasional clueless person would contribute a toaster oven, but these were sorted out. The organic material was then checked for other contaminants such as bottles and cans, run through a grinder, and finally shoved into a concrete compost bin. Within 24-48 hours, the temperature of the material would climb to 70°C (158°F). No inoculants were required. Incredibly, the thermophilic bacteria were already there, waiting in the garbage for this moment to arrive.

Researchers have composted materials with and without inocula and found that, *"although rich in bacteria, none of the inocula accelerated the composting process or* *improved the final product . . . The failure of the inocula to alter the composting cycle is due to the adequacy of the indigenous microbial population already present and to the nature of the process itself . . . The success of composting operations without the use of special inocula in the Netherlands, New Zealand, South Africa, India, China, the USA, and a great many other places, is convincing evidence that inocula and other additives are not essential in the composting of [organic] materials."* [51] Others state, *"No data in the literature indicate that the addition of inoculants, microbes, or enzymes accelerate the compost process."* [52]

Lime

It is not necessary to put lime (ground agricultural limestone) on your compost pile. The belief that compost piles should be limed is a common misconception. Nor are other mineral additives needed on your compost. If your soil needs lime, put the lime on your soil, not your compost. Bacteria don't digest limestone; in fact lime is used to *kill* microorganisms in sewage sludge (lime-stabilized sludge).

Aged compost is not acidic, even with the use of sawdust. The pH of finished compost should slightly exceed 7 (neutral). What is pH? It's a measure of acidity and alkalinity which ranges from 1-14. Neutral is 7. Below seven is acidic, above seven is basic or alkaline (see Figure 3.7). If the pH is too acidic or too alkaline, bacterial activity will be hindered or stopped completely. Lime and wood ashes raise the pH, but wood ashes should also go straight on the soil. The compost pile doesn't need them. It may seem logical that one should put into one's compost pile whatever one also wants to put into one's garden soil, as the compost will end up in the garden eventually, but that's not the reality of the situation. *What one should put into one's compost is what the microorganisms in the compost want or need, not what the garden soil wants or needs.*

Sir Albert Howard, one of the most well-known proponents of composting, as well as J. I. Rodale, another prominent organic agriculturist, have recommended adding lime to compost piles.[53] They seemed to base their reasoning on the belief that the compost will become acidic during the composting process, and therefore

ESSENTIAL READING FOR INSOMNIACS

Figure 3.7

pH MEANS HYDROGEN POWER

It is a measure of the degree of alkalinity or acidity of a solution, and is often expressed as the logarithm of the reciprocal of the hydrogen ion concentration in gram equivalents per liter of solution. pH7=.0000001 gram atom of hydrogen per liter. Pure distilled water is regarded as neutral with a pH of 7. pH values range from 0 to 14. From 0 to 7 indicate acidity, and from 7 to 14 indicate alkalinity.

0	7	14
ACIDIC ◄·········►	NEUTRAL ◄·········►	ALKALINE

the acidity must be neutralized by adding lime to the pile while it's composting. It may well be the case that some compost becomes acidic during the process of decomposition, however, it seems to neutralize itself if left alone, yielding a neutral, or slightly alkaline end product. Therefore, it is recommended that you test your *finished* compost for pH before deciding that you need to neutralize any acids.

I find it perplexing that the author who recommended liming compost piles in one book, states in another, *"The control of pH in composting is seldom a problem requiring attention if the material is kept aerobic. . . the addition of alkaline material is rarely necessary in aerobic decomposition and, in fact, may do more harm than good because the loss of nitrogen by the evolution of ammonia as a gas will be greater at the higher pH."*[54] In other words, don't assume that you should lime your compost. Only do so if your finished compost is consistently acidic, which would be highly unlikely. Get a soil pH test kit and check it out. Researchers have indicated that maximum thermophilic composting occurs at a pH range between 7.5 to 8.5, which is slightly alkaline.[55] But don't be surprised if your compost is slightly acidic at the start of the process. It should turn neutral of slightly alkaline and remain so when completely cured.

According to a 1991 report, scientists who were studying various commercial fertilizers found that agricultural plots to which composted sewage sludge had been added made better use of lime than plots without composted sludge. The lime in the composted plots changed the pH deeper in the soil, indicating that organic matter assists calcium movement through the soil *"better than anything else,"* according to Cecil Tester, Ph.D., research chemist at USDA's Microbial Systems Lab in Beltsville, MD.[56] The implications are that compost should be added to the soil when lime is added *to the soil.*

Perhaps Gotaas sums it up best, *"Some compost operators have suggested the addition of lime to improve composting. This should be done only under rare circumstances such as when the raw material to be composted has a high acidity due to acid industrial wastes or contains materials that give rise to highly acid conditions during composting."* [57]

WHAT NOT TO COMPOST? YOU CAN COMPOST ALMOST ANYTHING

I get a bit perturbed when I see compost educators telling their students that there is a long list of things "NOT to be composted!" This prohibition is always presented in such an authoritative and serious manner that novice composters begin trembling in their boots at the thought of composting any of the banned materials. I can imagine naive composters armed with this misinformation carefully segregating their food scraps so that, god forbid, the wrong materials don't end up in the compost pile. Those banned materials include meat, fish, dairy products, butter, bones, cheese, lard, mayonnaise, milk, oils, peanut butter, salad dressing, sour cream, weeds with seeds, diseased plants, citrus peels, rhubarb leaves, crab grass, pet manures, and, perhaps worst of all: human manure. Presumably, one must segregate half-eaten peanut butter sandwiches from the compost bucket, or any sandwich with mayonaisse or cheese, or any left-over salad with salad dressing, or spoiled milk, or orange peels, all of which must go to a landfill and be buried under tons of dirt instead of being composted. Luckily, I was never exposed to such instructions, and my family has composted EVERY BIT of food scrap it has produced, including meat, bones, butter, oils, fat, lard, citrus peels, mayonnaise, and everything else on the list; we've done this in our backyard for almost 25 years with NEVER a problem. Why would it work for me and not for anyone else? The answer, in a word, if I may hazard a guess, is *humanure*, another forbidden compost material.

When compost heats up, much of the organic material is quickly degraded. This holds true for oils and fats, or in the words of scientists, *"Based on evidence on the composting of grease trap wastes, lipids [fats] can be utilized rapidly by bacteria, including actinomycetes, under thermophilic conditions."* [58] The problem with the materials on the "banned" list, is that they do require thermophilic composting conditions for best results. Otherwise, they can just sit in the compost pile and only very slowly decompose. In the meantime, they can look very attractive to the wandering dog, cat, raccoon, or rat. Ironically, when the forbidden materials, including humanure, are combined with other compost ingredients, thermophilic conditions will prevail. When humanure and the other controversial organic materials are segregated from compost, thermophilic conditions may not occur at all. This is a situation that is probably quite common in most backyard compost piles. The solution is not to segregate materials from the pile, but to add nitrogen and moisture, as is commonly found in manure.

As such, compost educators would provide a better service to their students if they told them the truth: almost any organic material will compost, rather than give them the false impression that some common food materials will not. Granted, some things do not compost very well. Bones are one of them, but they do no harm in a compost pile.

Nevertheless, toxic chemicals *should* be kept out of the backyard compost pile. Such chemicals are found, for example, in "pressure treated" (i.e. poison-soaked) lumber, which is saturated with cancer-causing chemicals (chromated copper arsenate). What not to compost: sawdust from pressure treated lumber, which is, unfortunately, a toxic material that is more and more available to the average gardener.

COMPOST MIRACLES

COMPOST CAN DEGRADE TOXIC CHEMICALS

Compost microorganisms not only convert organic material into humus, but they also degrade toxic chemicals into simpler, benign, organic molecules. These chemicals include gasoline, diesel fuel, jet fuel, oil, grease, wood preservatives, PCBs, coal gasification wastes, refinery wastes, insecticides, herbicides, TNT, and other explosives.[59]

In one experiment in which compost piles were laced with insecticides and herbicides, the insecticide (carbofuran) was completely degraded, and the herbicide (triazine) was 98.6% degraded after 50 days of composting. Soil contaminated with diesel fuel and gasoline was composted, and after 70 days in the compost pile, the total petroleum hydrocarbons were reduced approximately 93%.[60] Soil contaminated with Dicamba herbicide at a level of 3,000 parts per million showed no detectable levels of the toxic contaminant after only 50 days of composting. In the absence of composting, this biodegradation process normally takes years.

Compost also seems to bind lead in soils, making it less likely to be absorbed by living things. One researcher fed lead-contaminated soil to rats, either with compost added, or without. The soil to which compost had been added showed no toxic effects, whereas the soil without compost did exhibit some toxic effects.[61] Compost seems to strongly bind metals and prevent their uptake by both plants and animals, thereby preventing transfer of metals from contaminated soil into the food chain.[62] Plants grown in lead contaminated soil with ten percent compost showed a reduction in lead uptake of 82.6%, compared to plants grown in soil with no compost.[63]

Fungi in compost produce a substance that breaks down petroleum, thereby making it available as food for bacteria.[64] One man who composted a batch of sawdust contaminated with diesel oil said, *"We did tests on the compost, and we couldn't even find the oil!"* The compost had apparently "eaten" it all.[65] Fungi also produce enzymes that can be used to replace chlorine in the paper-making process. Researchers in Ireland have discovered that fungi gathered from compost heaps can provide a cheap and organic alternative to toxic chemicals.[66]

Compost has been used in recent years to degrade other toxic chemicals as well. For example, chlorophenol contaminated soil was composted with peat, sawdust, and other organic matter, and after 25 months, the chlorophenol was reduced in concentration by 98.73%. Freon contamination was reduced by 94%, PCPs by up to 98%, and TCE by 89-99% in other compost trials.[67] Some of this degradation is due to the efforts of fungi at lower (mesophilic) temperatures.[68]

Table 3.7
MICROORGANISMS THAT HELP REMOVE METALS FROM WASTEWATER

MICROORGANISM	METAL
Zooglea ramigera	Copper
Saccharomyces cerevisieae	Uranium
Trichoderma viride	Copper
Penicillium spinulosum	Copper, Cadmium, Zinc
Aspergillus niger	Copper, Cadmium, Zinc
Chlorella vulgaris	Gold, Zn, Cu, Mercury
Rhizopus arrhizus	Uranium

Source: Bitton, Gabriel (1994). Wastewater Microbiology. p. 302. Wiley-Liss, Inc. 605 Third Avenue, New York, NY 10518-0012.

Some bacteria even have an appetite for uranium. Derek Lovley, a microbiologist, has been working with a strain of bacteria that normally lives 650 feet under the Earth's surface. These microorganisms will eat, then excrete, uranium. The chemically altered uranium excreta becomes water insoluble as a result of the microbial digestion process, and can consequently be removed from the water it was contaminating (see Table 3.7).[69]

An Austrian farmer claims that the microorganisms he introduces into his fields have prevented his crops from being contaminated by the radiation from Chernobyl, the ill-fated Russian nuclear power plant, which contaminated his neighbor's fields. Sigfried Lubke sprays his green manure crops with compost-type microorganisms just before plowing them under. This practice has produced a soil rich in humus and teeming with microscopic life. After the Chernobyl disaster, crops from fields in Lubke's farming area were banned from sale due to high amounts of radioactive cesium contamination. However, when officials tested Lubke's crops, no trace of cesium could be found. The officials made repeated tests because they couldn't believe that one farm showed no radioactive contamination while the surrounding farms did. Lubke surmises that the humus just "ate up" the cesium.[70]

Compost is also able to decontaminate soil polluted with TNT from munitions plants. The microorganisms in the compost digest the hydrocarbons in TNT and convert them into carbon dioxide, water, and simple organic molecules. The method of choice for eliminating contaminated soil has thus far been incineration. However, composting costs far less, and yields a material that is valuable (compost), as opposed to incineration, which yields an ash that must itself be disposed of as toxic waste. When the Umatilla Army Depot in Hermiston, Oregon, a Superfund site, composted 15,000 tons of contaminated soil instead of incinerating it, it saved approximately $2.6 million. Although the Umatilla soil was heavily contaminated with TNT and RDX (Royal Demolition Explosives), no explosives could be detected after composting, and the soil was restored to *"a better condition than before it was contaminated."* [71] Similar results have been obtained at Seymour Johnson Air Force Base in North Carolina, the Louisiana Army Ammunition Plant, the US Naval Submarine Base in Bangor, Washington, Fort Riley in Kansas, and the Hawthorne Army Depot in Nevada.[72]

The US Army Corps of Engineers estimates that we would save $200 million if composting, instead of incineration, were used to clean up the remaining US munitions sites. The ability of compost to bioremediate toxic chemicals is particularly meaningful when one considers that in the US there are currently 1.5 million underground storage tanks leaking a wide variety of materials into soil, as well as 25,000 Department of Defense sites in need of remediation. In fact, it is estimated that the remediation costs for America's most polluted sites using standard technology may reach $750 billion, while in Europe the costs could reach $300 to $400 billion.

As promising as compost bioremediation appears, however, it cannot heal all wounds. Heavily chlorinated chemicals show considerable resistance to microbiological biodegradability. Apparently, there are even some things a fungus will spit

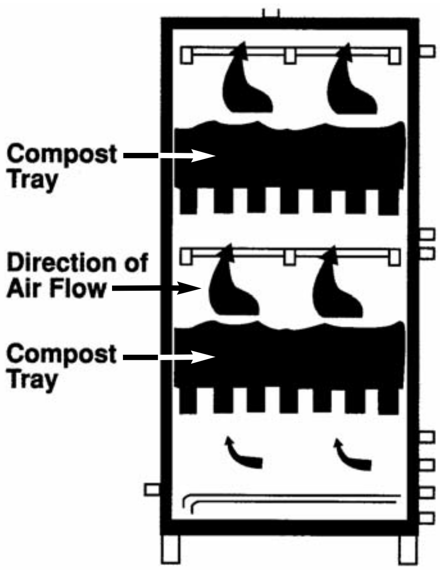


Figure 3.8

VAPOR PHASE COMPOST BIOFILTER

Air is purified by drawing it through layers of compost, where microorganisms convert the contaminants into carbon dioxide and water.

Source: US EPA (October 1997). *Innovative Uses of Compost - Bioremediation and Pollution Prevention.* EPA530-F-97-042.

out.[73] On the other hand, some success has been shown in the bioremediation of PCBs (polychlorinated biphenyls) in composting trials conducted by Michigan State University researchers in 1996. In the best case, PCB loss was in the 40% range. Despite the chlorinated nature of the PCBs, researchers still managed to get quite a few microorganisms to choke the stuff down.[74]

Compost can filter polluted air and water

Compost can control odors. Biological filtration systems, called "biofilters," are used at large-scale composting facilities where exhaust gases are filtered for odor control. The biofilters are composed of layers of organic material such as wood chips, peat, soil, and compost through which the air is drawn in order to remove any contaminants. The microorganisms in the organic material eat the contaminants and convert them into carbon dioxide and water (see Figures 3.8 and 3.9).

In Rockland County, New York, one such biofiltration system can process 82,000 cubic feet of air a minute, and guarantee no

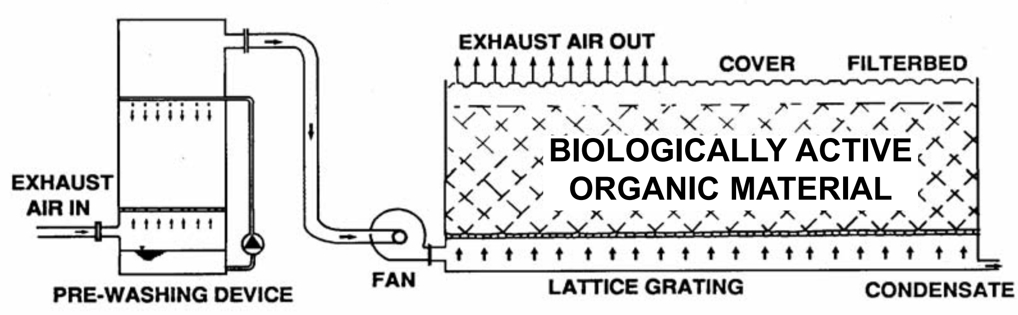


Figure 3.9 **BIOFILTER -** Used to clean contaminated air

Adapted from: EPA (1990). Autothermal Thermophilic Aerobic Digestion of Municipal Wastewater Sludge. EPA/625/10-90/007, September 1990.

detectable odor at or beyond the site property line. Another facility in Portland, Oregon, uses biofilters to remediate aerosol cans prior to disposal. After such remediation, the cans are no longer considered hazardous, and can be disposed of more readily. In this case, a $47,000 savings in hazardous waste disposal costs was realized over a period of 18 months. Vapor Phase Biofilters can maintain a consistent Volatile Organic Compound removal efficiency of 99.6%, which isn't bad for a bunch of microorganisms.[75] After a year or two, the biofilter is recharged with new organic material, and the old stuff is simply composted or applied to the land.

Compost is also now used to filter stormwater runoff (see Figure 3.10). Compost Stormwater Filters use compost to filter out heavy metals, oil, grease, pesticides, sediment, and fertilizers from stormwater runoff. Such filters can remove over 90% of all solids, 82% to 98% of heavy metals, and 85% of oil and grease, while filtering up to eight cubic feet per second. These Compost Stormwater Filters prevent stormwater contamination from polluting our natural waterways.[76]

COMPOST DEFENDS PLANTS FROM DISEASES

The composting process can destroy many plant pathogens. Because of this, diseased plant material should be thermophilically composted rather than returned to the land where reinoculation of the disease could occur. The beneficial microorganisms in thermophilic compost directly compete with, inhibit, or kill organisms that cause diseases in plants. Plant pathogens are also eaten by micro-arthropods, such as mites and springtails, which are found in compost.[77]

Compost microorganisms can produce antibiotics which suppress plant diseases. Compost added to soil can also activate disease resistance genes in plants, preparing them for a better defense against plant pathogens. Systemic Acquired Resistance caused by compost in soils allows plants to resist the effects of diseases such as *Anthracnose* and *Pythium* root rot in cucumbers. Experiments have shown

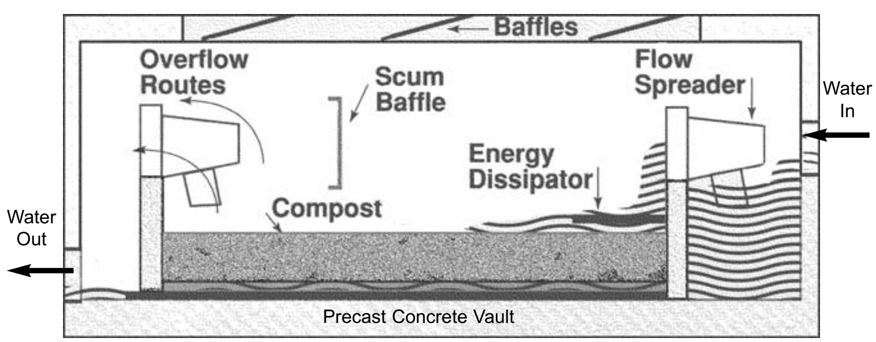


Figure 3.10
COMPOST STORMWATER FILTER
Contaminants are removed from stormwater when filtered through layers of compost.
Source: US EPA (October 1997). *Innovative Uses of Compost - Bioremediation and Pollution Prevention.* EPA530-F-97-042.

that when only some of the roots of a plant are in compost amended soil, while the other roots are in diseased soil, the entire plant can still acquire resistance to the disease.[78] Researchers have shown that compost combats chili wilt (*Phytophthora*) in test plots of chili peppers, and suppresses ashy stem blight in beans, *Rhizoctonia* root rot in black-eyed peas,[79] *Fusarium oxysporum* in potted plants, and gummy stem blight and damping off diseases in squash.[80] It is now recognized that the control of root rots with composts can be as effective as synthetic fungicides such as methyl bromide. Only a small percentage of compost microorganisms can, however, induce disease resistance in plants, which again emphasizes the importance of biodiversity in compost.

Studies in 1968 by researcher Harry Hoitink indicated that compost inhibited the growth of disease-causing microorganisms in greenhouses by adding beneficial microorganisms to the soil. In 1987, he and a team of scientists took out a patent for compost that could reduce or suppress plant diseases caused by three deadly microorganisms: *Phytophtora*, *Pythium*, and *Fusarium*. Growers who used this compost in their planting soil reduced their crop losses from 25-75% to 1% without applying fungicides. The studies suggested that sterile soils could provide optimum breeding conditions for plant disease microorganisms, while a rich diversity of microorganisms in soil, such as that found in compost, would render the soil unfit for the proliferation of disease organisms.[81]

In fact, compost *tea* has also been demonstrated to have disease-reducing properties in plants. Compost tea is made by soaking mature (but not overly-mature) compost in water for three to twelve days. The tea is then filtered and sprayed on plants undiluted, thereby coating the leaves with live bacteria colonies. When sprayed on red pine seedlings, for example, blight was significantly reduced in severity.[82] Powdery mildew (*Uncinula necator*) on grapes was very successfully suppressed by compost tea made from cattle manure compost.[83] *"Compost teas can be sprayed on crops to coat leaf surfaces and actually occupy the infection sites that could be colonized by disease pathogens,"* states one researcher, who adds, *"There are a limited number of places on a plant that a disease pathogen can infect, and if those spaces are occupied by beneficial bacteria and fungi, the crop will be resistant to infection."* [84]

Besides helping to control soil diseases, compost attracts earthworms, aids plants in producing growth stimulators, and helps control parasitic nematodes.[85] Compost "biopesticides" are now becoming increasingly effective alternatives to chemical bug killers. These "designer composts" are made by adding certain pest-fighting microorganisms to compost, yielding a compost with a specific pest-killing capacity. Biopesticides must be registered with the US EPA and undergo the same testing as chemical pesticides to determine their effectiveness and degree of public safety.[86]

Finally, composting destroys weed seeds. Researchers observed that after three days in compost at 55^{0}C (131^{0}F), all of the seeds of the eight weed species studied were dead.[87]

Compost can recycle the dead

Dead animals of all species and sizes can be recycled by composting. Of the 7.3 billion chickens, ducks, and turkeys raised in the US each year, about 37 million die from disease and other natural causes before they're marketed.[88] The dead birds can simply be composted. The composting process not only converts the carcasses to humus which can be returned directly to the farmer's fields, but it also destroys the pathogens and parasites that may have killed the birds in the first place. It is preferable to compost diseased animals on the farm where they originated rather than transport them elsewhere and risk spreading the disease. A temperature of 55^{0}C maintained for at least three consecutive days maximizes pathogen control.

Composting is considered a simple, economic, environmentally sound, and effective method of managing animal mortalities. Carcasses are buried in, well, a compost pile. The composting process ranges from several days for small birds to six or more months for mature cattle. Generally, the total time required ranges from two to twelve months depending on the size of the animal and other factors such as ambient air temperature (time of year). The rotting carcasses are never buried in the ground where they may pollute groundwater, as is typical when composting is not used. Animal mortality recycling can be accomplished without odors, flies, or scavenging birds or animals.

Originally developed to recycle dead chickens, the animal carcasses that are now composted include full-grown pigs, cattle, and horses, as well as fish, sheep, calves, and other animals. The biological process of composting dead animals is identical to the process of composting any organic material. The carcasses provide nitrogen and moisture, while materials such as sawdust, straw, corn stalks, and paper provide carbon and bulk for air impregnation. The composting can be done in temporary three-sided bins made of straw or hay bales. A layer of absorbent organic material is used to cover the bottom of the bin, acting as a sponge for excess liquids. Large animals are placed back down in the compost, with their abdominal and thoracic cavities opened, and covered with organic material (sawmill sawdust has been shown to be one of the most effective organic materials with which to compost dead animals). After filling the bin with properly prepared animal mortalities, the top is covered with clean organic material that acts as a biofilter for odor control. Although large bones may remain after the composting process, they are easily broken when applied to the soil.[89]

Backyard composters can also make use of this technique. When a small animal has died and the carcass needs to be recycled, simply dig a hole in the top center of the compost pile, deposit the carcass, bury it over with the compost, and cover it all with a clean layer of organic material such as straw, weeds, or hay. You will never see the carcass again. This is also a good way to deal with fish, meat scraps, milk products, and other organic materials that may otherwise be attractive to nuisance animals. However, one should have thermophilic compost in order to do this, and one can greatly increase the likelihood of his or her backyard compost being thermophilic by adding the nitrogen and moisture that humanure provides.

I keep some ducks and chickens on my homestead, and occasionally one of them dies. A little poking around in the compost pile to create a depression in the top, and a plop of the carcass into the hole, and another creature is on the road to reincarnation. We've also used this technique regularly for recycling other smaller animal carcasses such as mice, baby chicks, and baby rabbits. After I collect earthworms from my compost pile to go fishing at the local pond, I filet the catch and put it in the freezer for winter consumption. The fish remains go straight into the compost, buried in the same manner as any other animal mortality. We have five outdoor cats, and they wouldn't be caught dead digging around in thermophilic humanure compost looking for a bite to eat. Nor would our dog — and dogs will eat anything, but not when buried in thermophilic compost.

Compost recycles pet manures

Can you use dog manure in your compost? I can honestly say that I've never tried it, as I do not have a source of dog manure for experimentation (my dog is a free-roaming outdoor dog, and he leaves his scat somewhere out of sight). Numerous people have written to ask me whether pet manures can go into their household compost pile, and I have responded that I don't know from experience. So I've recommended that pet manures be collected in their own separate little compost bins with cover materials such as hay, grass clippings, leaves, weeds, or straw, and perhaps occasionally watered a bit to provide moisture. A double bin system will allow the manures to be collected for quite some time in one bin, then aged for quite some time while the second bin is being filled. What size bin? About the size of a large garbage can, although a larger mass may be necessary in order to spark a thermophilic reaction.

On the other hand, this may be entirely too much bother for most pet owners who are also composters, and you may just want to put pet and human manures into one compost bin. This would certainly be the simpler method. The idea of composting dog manure has been endorsed by J. I. Rodale in the Encyclopedia of Organic Gardening. He states, *"Dog manure can be used in the compost heap; in fact it is the richest in phosphorous if the dogs are fed with proper care and given their share of bones."* He advises the use of cover materials similar to the ones I mentioned above, and recommends that the compost bin be made dog-proof, which can be done with straw bales, chicken wire, boards, or fencing.

One way to recycle junk mail

Composting is a solution for junk mail, too. A pilot composting project was started in 1997 in Dallas-Ft. Worth, Texas, where 800 tons of undeliverable bulk mail are generated annually. The mail was ground in a tub grinder, covered with wood chips so it wouldn't blow away, then mixed with zoo manure, sheep entrails, and discarded fruits and vegetables. The entire works was kept moist and thoroughly mixed. The result — a finished compost *"as good as any other compost commercially available."* It grew a nice bunch of tomatoes, too.[92]

What about newspapers in backyard compost? Yes, newspaper will compost, but there are some concerns about newsprint. For one, the glossy pages are covered with a clay that retards composting. For another, the inks can be petroleum-based solvents or oils with pigments containing toxic substances such as chromium, lead and cadmium in both black and colored inks. Pigment for newspaper ink still comes from benzene, toluene, naphthalene, and other benzene ring hydrocarbons which may be quite harmful to human health if accumulated in the food chain. Fortunately, quite a few newspapers today are using soy-based inks instead of petroleum-based inks. If you really want to know about the type of ink in your newspaper, call your newspaper office and ask them. Otherwise, keep the glossy paper or colored pages in your compost to a minimum. Remember, ideally, compost is being made to use for producing human food. One should try to keep the contaminants out of it, if possible.[93]

Wood's End Laboratory in Maine did some research on composting ground up telephone books and newsprint, which had been used as bedding for dairy cattle. The ink in the paper contained common cancer-causing chemicals, but after composting it with dairy cow manure, the dangerous chemicals were reduced by 98%.[94] So it appears that if you're using shredded newspaper for bedding under livestock, you *should* compost it, if for no other reason than to eliminate some of the toxic elements from the newsprint. It'll probably make acceptable compost too, especially if layered with garbage, manure, and other organic materials.

What about things like sanitary napkins and disposable diapers? Sure, they'll compost, but they'll leave strips of plastic throughout your finished compost which are quite unsightly. Of course, that's OK if you don't mind picking the strips of plastic out of your compost. Otherwise, use cloth diapers and washable cloth menstrual pads instead.

Toilet paper composts, too. So do the cardboard tubes in the center of the rolls. Unbleached, recycled toilet paper is ideal. Or you can use the old fashioned toilet paper, otherwise known as corncobs. Popcorn cobs work best, they're softer. Corncobs don't compost very readily though, so you have a good excuse not to use them. There are other things that don't compost well: eggshells, bones, hair, and woody stems, to name a few. We throw our eggshells back to our chickens, or into the woodstove. Bones go into the woodstove, or to the cats or dog. Hair goes out to the birds for nests, if not into the compost pile.

Compost professionals have almost fanatically seized upon the idea that wood chips are good for making compost. Nowadays, when novice composters want to begin making compost, the first thing they want to know is where they can get wood chips. In fact, wood chips do NOT compost very well at all, unless ground into fine particles, as in sawdust. Even compost professionals admit that they have to screen out their wood chips *after* the compost is finished because they didn't decompose. They insist on using them anyway, because they break up the compost consistency and maintain air spaces in their large masses of organic material. However, a home composter should avoid wood chips and use other bulking materials that degrade more quickly, such as hay, straw, sawdust, and weeds.

Finally, never put woody stemmed plants, such as tree saplings, on your compost pile. I hired a young lad to clear some brush for me one summer and he innocently put the small saplings on my compost pile without me knowing it. Later, I found them networked through the pile like iron reinforcing rods. I'll bet the lad's ears were itching that day — I sure had some nasty things to say about him. Fortunately, only Gomer, the compost pile, heard me.

VERMICOMPOSTING

Vermicomposting, or worm composting, involves the use of redworms (*Eisenis fetida* or *Lumbricus rubellus*) to consume organic material either in specially designed worm boxes, or in large-scale, outdoor compost piles. Redworms prefer a dark, cool, well-aerated space, and thrive on moist bedding such as shredded newspaper. Kitchen food scraps are placed in worm boxes and are consumed by the worms. Worm castings are left in their place, which can be used like finished compost to grow plants. Vermicomposting is popular among children who like to watch the worms, and among adults who prefer the convenience of being able to make compost under their kitchen counter or in a household closet.

Although vermicomposting involves microorganisms as well as earthworms, it is not the same as thermophilic composting. The hot stage of thermophilic composting will drive away all earthworms from the hot area of the compost pile. However, they will migrate back in after the compost cools down. Earthworms are reported to actually eat root-feeding nematodes, pathogenic bacteria, and fungi, as well as small weed seeds.[91]

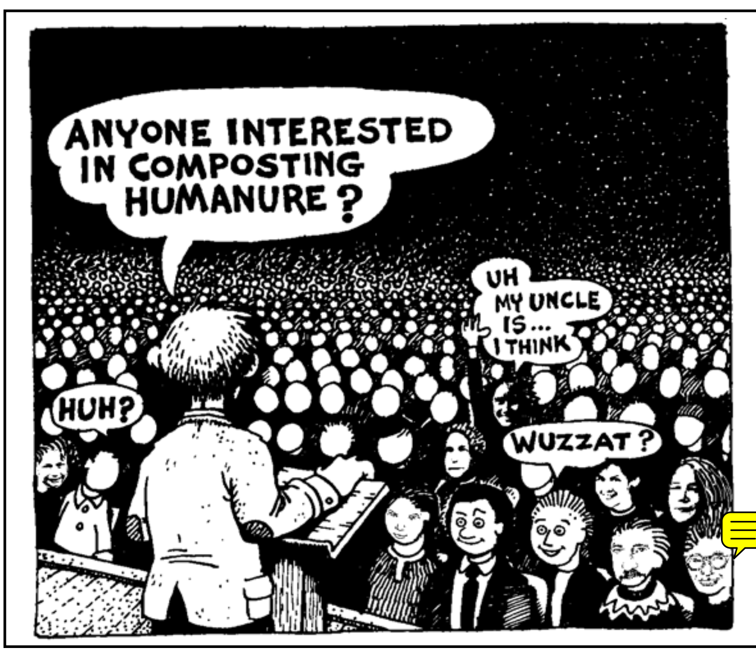
When thermophilic compost is piled on the bare earth, a large surface area is available for natural earthworms to migrate in and out of the compost pile. Properly prepared thermophilic compost situated on bare earth should require no addition of earthworms, as they will naturally migrate into the compost when it best suits them. My compost is so full of natural earthworms at certain stages in its development that, when dug into, it looks like spaghetti. These worms are occasionally harvested and transformed into fish. This is a process which converts compost directly into protein, but which requires a fishing rod, a hook, and lots of patience.

PRACTICE MAKES COMPOST

"Composting is easier to do than to describe, and, like lovemaking, magic when you do it well."
Sim Van der Ryn

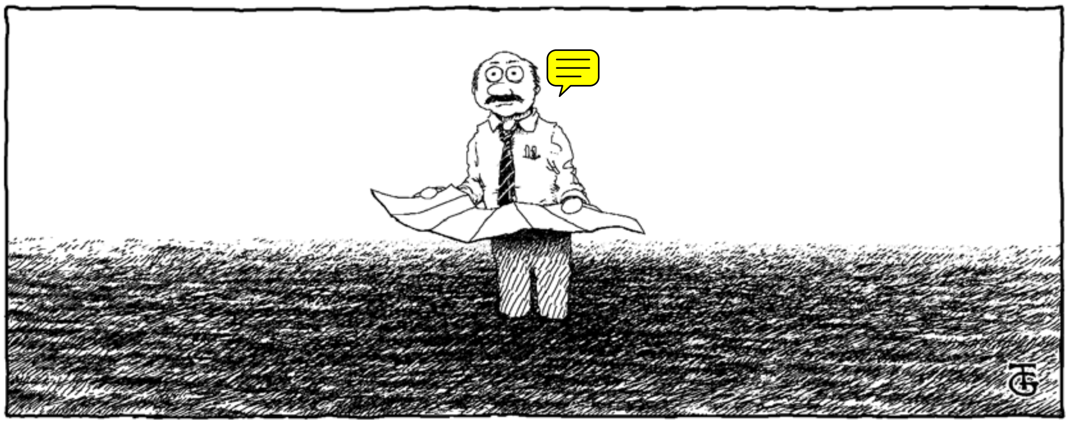
After reading this chapter one may become overwhelmed with all that is involved in composting: bacteria, actinomycetes, fungi, thermophiles, mesophiles, C/N ratios, oxygen, moisture, temperatures, bins, pathogens, curing, and biodiversity. How do you translate this into your own personal situation and locate it all in your own backyard? How does one become an accomplished composter, a master composter? That's easy — just do it. Then keep doing it. Throw the books away (not this one, of course) and get some good, old-fashioned experience. There's no better way to learn. Book learning will only get you so far, but not far enough. A book such as this one is for inspiring you, for sparking your interest, and for reference. But you have to get out there and *do it* if you really want to learn.

Work with the compost, get the feel of the process, look at your compost, smell the finished product, buy or borrow a compost thermometer and get an idea of how well your compost is heating up, then use your compost for food production. Rely on your compost. Make it a part of your life. Need it and value it. In no time, without the need for charts or graphs, Ph.D.s, or worry, your compost will be as good as the best of them. Perhaps someday we'll be like the Chinese who give prizes for the best compost in a county, then have intercounty competitions. Now *that's* getting your shit together.



DEEP SH*T

(*Philosophy and Speculation)



"From the Latin word humus for earth, true humility grounds the seeker in truth."
Edward Hayes - Prayers for a Planetary Pilgrim
(Special thanks to Sister Barbara of Villa Maria, PA)

Composting humanure is an act of humility, and the practice of humility is an exercise that strengthens one's spirit. The Earth provides us with life; it gives us our children, allows us to pursue our dreams. All of the beauty and joy that makes up our lives ultimately springs from her breasts to nurture and strengthen us. We suckle from her — and then we give back feces and urine — usually in the form of surface and water pollutants.

Shortly after the first edition of this book was published, I was invited to speak to a group of nuns at a convent. It was my first speaking invitation, and I still remember the phone call:

"Mr. Jenkins, we recently bought a copy of your book, *Humanure*, and we would like to have you speak at our convent."

At this time, I was still doubtful that anyone was even interested in the topic of humanure composting, so I responded, "What about?"

"About the topic of your book."

"Composting?"

"Yes, but specifically, *humanure* composting." At this point I was somewhat speechless. I couldn't understand exactly why a group of nuns would be interested in composting their own shit. Somehow I couldn't imagine standing in front of a room full of nuns in habits, speaking about turds. But I kept the stammering to a minimum and accepted the invitation.

It was Earth Day, 1995. The presentation went well. After I spoke, the group showed slides of their gardens and compost piles, and then we toured the compost area and poked around in the worm compost boxes. A delightful lunch followed, during which time I asked them why they were interested in *humanure*, of all things.

"We are the Sisters of Humility," they responded. *"The words 'humble' and 'humus' come from the same semantic root, which means 'earth.' We also think these words are related to the word 'human.' Therefore, as part of our vow of humility, we work with the earth. We make compost, as you've seen. And now we want to learn how to make compost from our toilet material. We're thinking about buying a commercial composting toilet, but we want to learn more about the overall concepts first. That's why we asked you to come here."*

A light bulb went off in my head. Of course, composting *is* an act of humility. The people who care enough about the earth to recycle their personal by-products do so as an exercise in humility, and not because they're going to get rich and famous for it. That makes them better people. Some people go to church on Sunday, others make compost. Still others do both. Others go to church on Sunday, then throw all their garbage out into the environment. The exercising of the human spirit can take many forms, and the simple act of cleaning up after oneself is one of them. Carelessly dumping waste out into the world is a self-centered act of arrogance.

Humanure composters can stand under the stars at night gazing at the heavens, and know that, when nature calls, their excretions will not foul the planet. Instead, those excretions are humbly collected, fed to microorganisms, and returned to the Earth as healing medicine for the soil. Although today's religious leaders may scoff at anyone who does not kowtow to the men at the top of their hierarchy, humble composters can ignore the pressures of religious conformity, and instead hold a grain of pure spiritual truth in the palm of their hand.

THE EGO VS. THE ECO

There are numerous theoretical reasons why we humans have strayed so far from a benign symbiotic relationship with the planet, and have instead taken on the visage, if not the behavior, of planetary pathogens. One of my favorites is "The Ego vs. The Eco" theory, also sometimes called the "Microcosm vs. the Macrocosm," or, more simply, "Humans vs. Nature," which I will attempt to explain in brief.

Human beings, like all living things on this planet, are inextricably intertwined with all of the elements of nature. We are threads in the tapestry of life. We constantly breathe the atmosphere that envelopes the planet; we drink the fluids that flow over the planet's surface; we eat the organisms that grow from the planet's skin. From the moment an egg and a sperm unite to spark our existence, each of us grows and develops from the elements provided by the Earth and sun. In essence, the soil, air, sun, and water combine within our mother's womb to mold another living creature. Nine months later, another human being is born. That person is a separate entity, with an awareness of an individual self, an Ego. That person is also totally a part of, and completely dependent upon, the surrounding natural world, the Eco.

When the ego and the eco are balanced, the creature lives in harmony with the planet. In this theory, such a balance is considered to be the true meaning of *spirituality*, because the individual is a conscious part of, attuned to, and in harmony with a greater level of actual Being. When too much emphasis is placed on the self, the ego, an imbalance occurs and problems result, especially when that imbalance is collectively demonstrated by entire cultures. To suggest that these problems are only environmental, and therefore not of great concern, is incorrect. Environmental problems (damage to the eco) ultimately affect all living things, as all living things derive their existence, livelihood, and well-being from the planet. We cannot damage a thread in the web of life without the risk of fraying the entire tapestry.

When the ego gets blown out of proportion, we get thrown off balance in a variety of ways. Our educational institutions teach us to idolize the intellect, often at the expense of our moral, ethical, and spiritual development. Our economic institutions urge us to be consumers, and those who have gained the most material wealth are glorified. Our religious institutions often amount to little more than systems of human-worship, where divinity is only personified in human form, and only human creations (e.g., books and buildings) are considered sacred.

By emphasizing the intellect at the expense of intuition, creativity, and conscience, our educational systems yield spiritually imbalanced individuals. No discussion of a subject should be considered complete without an examination of its moral, philosophical, and ethical considerations, *as well as* a review of the intellectual and scientific data. When we ignore the ethics behind a particular issue, and instead focus on intellectual achievements, it's great for our egos. We can pat ourselves on the back and tell ourselves how smart we are. It deflates our egos, on the other hand, to realize that we are actually insignificant creatures on a speck of dust in a corner of the universe, and that we are only one of the millions of life forms on this speck, all of whom must live together.

In recent decades, an entire generation of western scientists, a formidable force of intelligence, focused all its efforts on developing new ways to kill huge numbers of human beings all at once. This was the nuclear arms race of the 1950s through the present — a race that left us with environmental disasters yet to be cleaned up, a huge amount of natural materials gone to total waste (5.5 *trillion* dollars worth),[1] a military death toll consisting of hundreds of thousands of innocent non-combatants, and the threat of nuclear annihilation hanging over all of the peace-loving peoples of the world, even today. Surely this is an example of the collective ego being out of balance with the eco.

Religious movements that worship humans are ego-centered. It is ironic that a tiny, insignificant lifeform on a speck of dust at the edge of a galaxy lost somewhere in a corner of the universe would declare that the universe was created by one of their own kind. This would be a laughing matter if it were not taken so seriously by so many members of the human species, who insist on believing that the source of all life is another human, colloquially referred to as "God."

We humans have evolved enough to know that the idea of a human-like creator-deity is simply myth. We can't begin to comprehend the full nature of our existence, so we *make up* a story that works until we figure out something better. Unfortunately, human-worship breeds an imbalanced collective ego. When we actually *believe* the myth, that humans are the pinnacle of life and the entire universe was created by one of our own kind, we go off the deep end. We stray too far from truth and wander, lost, with no point of reference to take us back to a balanced spiritual perspective we need for our own long-term survival on this planet. We become like a person knee deep in his own excrement, not knowing how to free himself from his unfortunate position, staring blankly at a road map with a look of utter incomprehension.

Today, new perspectives are emerging regarding the nature of human existence. The Earth itself is becoming recognized as a living entity, a level of Being immensely greater than the human level. The galaxy and universe are seen as even higher levels of Being, with multiverses (multiple universes) theorized as existing at a higher level yet. All of these levels of Being are thought to be imbued with the energy of life, as well as with a form of consciousness which we cannot even begin to comprehend. As we humans expand our knowledge of ourselves and recognize our true place in the vast scheme of things, our egos must defer to reality. We must admit our absolute dependence upon the ecosystem we call Earth, and try to balance our egotistical feelings of self-importance with our need to live in harmony with the greater world around us.

Getting back to compost, organic material, and soil nutrients, I must propose some additional philosophical speculation. Theoretically, the Asians evolved over the millennia with spiritual perspectives that maintained, to some extent, a view of the Earth, and of nature, as sacred. These perspectives did not single out the human race as the pinnacle of creation, but instead recognized the totality of interconnected existence as divine, and advocated human harmony with that totality.

Contrast this to our western religious heritage which taught us that divinity lies only in human form, and that peoples who revere nature are "pagans," "heathens," "witches," and worse. Admittedly, this is a broad and contentious topic, too broad for the scope of this book. Perhaps a few quotes here, however, will help to illustrate the point.

Hinduism, more common to India, but reaching into the Far East, seems to be sensitive to the sanctity of the natural world:

> *"When Svetaketu, at his father's bidding, had brought a ripe fruit from the banyan tree, his father said to him, Split the fruit in two, dear son.*
> *Here you are. I have split it in two.*
> *What do you find there?*
> *Innumerable tiny seeds.*
> *Then take one of the seeds and split it.*

I have split the seed.

And what do you find there?

Why, nothing, nothing at all.

Ah, dear son, but this great tree cannot possibly come from nothing. Even if you cannot see with your eyes that subtle something in the seed which produces this mighty form, it is present nonetheless. That is the power, that is the spirit unseen, which pervades everywhere and is all things. Have faith! That is the spirit which lies at the root of all existence, and that also art thou, O Svetaketu."

(Chandogya Upanishad)[2]

Buddhism is a dominant influence in vast sections of Asia:

"May all living things be happy and at their ease! May they be joyous and live in safety! All beings, whether weak or strong — omitting none — in high, middle, or low realms of existence, small or great, visible or invisible, near or far away, born or to be born — may all beings be happy and at their ease! Let none deceive another, or despise any being in any state; let none by anger or ill will wish harm to another! Even as a mother watches over and protects her only child, so with a boundless mind should one cherish all living beings, radiating friendliness over the entire world, above, below and all around without limit; so let him cultivate a boundless good will toward the entire world, uncramped, free from ill will or enmity."

The Metta Sutra[3]

Zen is a transliteration of the Sanskrit word "dyhana" meaning meditation, or more fully, "contemplation leading to a higher state of consciousness," or "union with Reality." It can be described as a blend of Indian mysticism and Chinese naturalism with a Japanese influence:

"When the mind rests serene in the oneness of things . . . dualism vanishes by itself."

From the Hsis-hsis-ming by Seng-ts'an[4]

"Zen does not go along with the Judaic-Christian belief in a personal savior or a God — outside the Universe — who has created the cosmos and the human race. To the Zen view, the Universe is one indissoluble substance, one total whole, of which humanity is a part."

Nancy Wilson Ross[5]

Confucius, like Buddha, was born in the sixth century B.C. and preached a philosophy of common Chinese virtue:

"The path of duty lies in what is near and people seek for it in what is remote. The work of duty lies in what is easy and people seek for it in what is difficult."

Confucius[6]

The Tao (the way), written by Lao Tsu, a contemporary of Confucius, has provided one of the major underlying influences in Chinese thought and culture for 2,500 years:

"Those who know do not talk. Those who talk do not know. Keep your mouth closed. Guard your senses. Temper your sharpness. Simplify your problems. Mask your brightness. Be at one with the dust of the earth. This is primal union. He who has achieved this state is unconcerned with friends and enemies, with good and harm, with honor and disgrace. This therefore is the highest state of humanity."

Lao Tsu[7]

Christianity, the primary religious influence of the western world, strongly supports the idea that humans are separate from and dominant over the natural world:

"And God said, Let us make man in our image, after our likeness, and let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and over every creeping thing that creepeth on the earth. And God blessed them, and God said unto them, Be fruitful and multiply, and replenish the earth, and subdue it: and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth."

The Bible[8]

Far Eastern religion has traditionally been imbued with the concepts of oneness, with the belief that the highest state of human evolution is one of harmony and peace with one's inner self and with the natural world. This would certainly seem to contribute to the development of sustainable agricultural methods. When one accepts the sacredness of life, one can easily understand why one should create compost and soil rather than waste and pollution.

For those of you readers who are devout Christians, this analysis of religious history is not intended to be "Christian-bashing," nor is it intended to offend anyone. Christianity must be singled out to some extent because the writer is writing from, and for, a culture that developed from an overwhelmingly Christian heritage. It is interesting to note that direct translations of Christian teachings from the Aramaic language (which Jesus spoke) as preserved in the Dead Sea Scrolls, indicate that Nature was, at that time, considered sacred by practicing Christians (refer to the translations of Edmund Bordeaux Szekeley). Those early teachings became buried under Biblical translations tailored to suit the European cultures of the late Middle Ages, which were hierarchic and male-dominated. Today, Christians can be among the most vocal defenders of the environment.

Historically, Christianity had periods that modern Christians would like to forget about, periods when the human egos involved grew to outrageous and terribly threatening proportions. During these times, male religious leaders claimed divinity and disbelievers were simply terrorized or destroyed. Those dark ages of Christianity adversely affected our understanding of the origins and nature of disease.

Unfortunately, *most* major religions today have drawn their focus toward human-worship, whether it be the Hindu worship of Krishna, the Buddhist worship of Buddha, the Islamic worship of Mohammed, the Christian worship of Jesus, or the bowing to the various human gurus and religious leaders which takes place all over the world. Patriarchal, hierarchic religious institutions still foster bloated egos the farther up the hierarchy one looks. Eventually, the human race will cast aside limiting, static, religious perspectives like a butterfly casts aside a cocoon. In the meantime, a metamorphosis must, and will, take place. That is what we should be focusing on, regardless of the religious institution to which we may currently belong.

ASIAN RECYCLING

The Asian people have recycled humanure for thousands of years. The Chinese have used humanure agriculturally since the Shang Dynasty 3-4000 years ago. Why haven't we westerners? The Asian cultures, namely Chinese, Korean, Japanese and others, evolved to understand human excrement to be a natural resource rather than a waste material. Where we have human waste, they have night soil. We produce waste and pollution; they historically have produced soil nutrients and food. It's clear to me that Asians have been more advanced than the western world in this regard. And they should be, since they've been working on developing sustainable agriculture for four thousand years on the same land. For *four thousand years* those people have worked the same land with little or no chemical fertilizers and, in many cases, have produced greater crop yields than western farmers, who are quickly destroying the soils of their own countries through depletion and erosion.

A fact largely ignored by people in western agriculture is that *agricultural land must produce a greater output over time. The human population is constantly increasing; available agricultural land is not. Therefore, our farming practices should leave us with land <u>more</u> fertile with each passing year.* However, we are doing just the opposite.

Back in 1938, the US Department of Agriculture came to the alarming conclusion that *a full 61% of the total area under crops in the US at that time had <u>already</u> been completely or partly destroyed, or had lost most of its fertility.*[9] Nothing to worry about? We have artificial fertilizers, tractors, and oil to keep it all going. True, US agriculture is now heavily dependent upon fossil fuel resources. However, in 1993, we were importing about half our oil from foreign sources, and it's estimated that the US will be out of domestic oil reserves by 2020.[10] A heavy dependence on foreign oil for our food production seems unwise *at best*, and probably just plain foolish, especially when we're producing soil nutrients every day in the form of organic refuse and throwing those nutrients "away" by burying them in landfills or incinerating them.

Why aren't we following the Asian example of agronutrient recycling? It's certainly not for a lack of information. Dr. F. H. King wrote an interesting book, published in 1910 titled Farmers of Forty Centuries.[11] Dr. King (D.Sc.) was a former chief of the Division of Soil Management of the US Department of Agriculture who traveled through Japan, Korea, and China in the early 1900s as an agricultural visitor. He was interested in finding out how people could farm the same fields for millennia without destroying their fertility. He states:

"One of the most remarkable agricultural practices adopted by any civilized people is the centuries long and well nigh universal conservation and utilization of all human waste [sic] in China, Korea and Japan, turning it to marvelous account in the maintenance of soil fertility and in the production of food. To understand this evolution it must be recognized that mineral fertilizers so extensively employed in modern Western agriculture have been a physical impossibility to all people alike until within very recent years. With this fact must be associated the very long unbroken life of these nations and the vast numbers their farmers have been compelled to feed.

When we reflect upon the depleted fertility of our own older farm lands, comparatively few of which have seen a century's service, and upon the enormous quantity of mineral fertilizers which are being applied annually to them in order to secure paying yields, it becomes evident that the time is here when profound consideration should be given to the practices the Mongolian race has maintained through many centuries, which permit it to be said of China that one-sixth of an acre of good land is ample for the maintenance of one person, and which are feeding an average of three people per acre of farm land in the three southernmost islands of Japan.

[Western humanity] is the most extravagant accelerator of waste the world has ever endured. His withering blight has fallen upon every living thing within his reach, himself not excepted; and his besom of destruction in the uncontrolled hands of a generation has swept into the sea soil fertility which only centuries of life could accumulate, and yet this fertility is the substratum of all that is living." [12]

According to King's research, the average daily excreta of the adult human weighs in at 40 ounces. Multiplied by 250 million, a rough estimate of the current US population, Americans each year produce 1,448,575,000 pounds of nitrogen, 456,250,000 pounds of potassium, and 193,900,000 pounds of phosphorous. Almost all is discarded into the environment as a waste material or a pollutant, or as Dr. King puts it, *"poured into the seas, lakes or rivers and into the underground waters."*

According to King, *"The International Concession of the city of Shanghai, in 1908, sold to a Chinese contractor the privilege of entering residences and public places early in the morning of each day and removing the night soil, receiving therefor more than $31,000 gold, for 78,000 tons of waste [sic]. All of this we not only throw away but expend much larger sums in doing so."*

In case you didn't catch that, the contractor *paid* $31,000 gold *for* the humanure, referred to as "night soil" and incorrectly as "waste" by Dr. King. People don't pay to buy waste, they pay money for things of value.

Furthermore, using Dr. King's figures, the US population today produces approximately 228,125,000,000 pounds of fecal material annually. That's 228 billion pounds. You could call that the *really Gross* National Product.

Admittedly, the spreading of raw human excrement on fields, as is done in Asia, will never become culturally acceptable in the United States, and rightly so. The agricultural use of raw night soil produces an assault to the sense of smell, and provides a route of transmission for various human disease organisms. Americans who have traveled abroad and witnessed the use of raw human excrement in agricultural applications have largely been repulsed by the experience. That repulsion has instilled in many Americans an intransigent bias against, and even a fear of the use of humanure for soil enrichment. However, few Americans have witnessed the *composting* of humanure as a preliminary step in its recycling. Proper thermophilic composting converts humanure into a pleasant smelling material devoid of human pathogens.

Although the agricultural use of raw human excrement will never become a common practice in the US, the use of composted human refuse, including humanure, food refuse, and other organic municipal refuse such as leaves, can and should become a widespread and culturally encouraged practice in the United States. The act of composting humanure instead of using it raw will set Americans apart from Asians in regard to the recycling of human excrements, *for we too will have to constructively deal with all of our organic by-products eventually.* We can put it off, but not forever. As it stands now, at least many of the Asians are recycling much of their organic discards. We're not.

THE ADVANCES OF SCIENCE

How is it that Asian peoples developed an understanding of human nutrient recycling and we didn't? After all, we're the advanced, developed, scientific nation, aren't we? Dr. King makes an interesting observation concerning western scientists. He states: *"It was not until 1888, and then after a prolonged war of more than thirty years, generated by the best scientists of all Europe, that it was finally conceded as demonstrated that leguminous plants acting as hosts for lower organisms living on their roots are largely responsible for the maintenance of soil nitrogen, drawing it directly from the air to which it is returned through the processes of decay. But centuries of practice had taught the Far East farmers that the culture and use of these crops are essential to enduring fertility, and so in each of the three countries the growing of legumes in rotation with other crops very extensively, for the express purpose of fertilizing the soil, is one of their old fixed practices."* [13]

In western culture, we wait for the experts to figure things out before we claim any real knowledge. This appears to have put us several centuries behind the Asians. It certainly seems odd that people who gain their knowledge in real life through practice and experience are largely ignored or trivialized by the academic world and associated government agencies. Such agencies only credit learning that has taken place within an institutional framework. As such, it's no wonder that Western humanity's crawl toward a sustainable existence on the planet Earth is so pitifully slow.

"Strange as it may seem," says King, *"there are not today and apparently never have been, even in the largest and oldest cities of Japan, China or Korea, anything corresponding to the hydraulic systems of sewage disposal used now by Western nations. When I asked my interpreter if it was not the custom of the city during the winter months to discharge its night soil into the sea, as a quicker and cheaper mode of disposal [than recycling], his reply came quick and sharp, 'No, that would be waste. We throw nothing away. It is worth too much money.' "* [14] *"The Chinaman,"* says King, *"wastes nothing while the sacred duty of agriculture is uppermost in his mind."* [15]

Perhaps, a few centuries from now, we also will understand.

WHEN THE CRAP HIT THE FAN

While the Asians were practicing sustainable agriculture and recycling their organic resources and doing so over millennia, what were the people of the west doing? What were the Europeans and those of European descent doing? Why weren't our ancestors returning their manures to the soil, too? After all, it does make sense. The Asians who recycled their manures not only recovered a resource and reduced pollution, but by returning their excrement to the soil, they succeeded in reducing threats to their health. There was no putrid sewage collecting and breeding disease germs. Instead, the humanure was, for the most part, undergoing a natural, non-chemical purification process in the soil which required no technology.

Granted, a lot of "night soil" in the Far East today is not composted and is the source of health problems. However, even the returning of humanure raw to the land succeeds in destroying many human pathogens in the manure, and it also returns nutrients to the soil.

Let's take a look at what was happening in Europe regarding public hygiene from the 1300s on. Great pestilences swept Europe throughout recorded history. The Black Death killed more than half the population of England in the fourteenth century. In 1552, 67,000 patients died of the Plague in Paris alone. Fleas from infected rats were the carriers of this disease. Did the rats dine on human waste? Other pestilences included the sweating sickness (attributed to uncleanliness), cholera (spread by food and water contaminated by the excrement of infected persons), "jail fever" (caused by a lack of sanitation in prisons), typhoid fever (spread by water contaminated with infected feces), and numerous others.

Andrew D. White, cofounder of Cornell University, writes, *"Nearly twenty centuries since the rise of Christianity, and down to a period within living memory, at the appearance of any pestilence the Church authorities, instead of devising sanitary measures,* *have very generally preached the necessity of immediate atonement for offenses against the Almighty. In the principal towns of Europe, as well as in the country at large, down to a recent period, the most ordinary sanitary precautions were neglected, and pestilences continued to be attributed to the wrath of God or the malice of Satan."* [16]

It's now known that the main cause of such immense sacrifice of life was a lack of proper hygienic practices. It's argued that certain theological reasoning at that time resisted the evolution of proper hygiene. According to White, *"For century after century the idea prevailed that filthiness was akin to holiness."* Living in filth was regarded by holy men as evidence of sanctity, according to White, who lists numerous saints who never bathed parts or all of their bodies, such as St. Abraham, who washed neither his hands nor his feet for fifty years, or St. Sylvia, who never washed any part of her body except her fingers.[17]

Interestingly, after the Black Death left its grim wake across Europe, *"an immensely increased proportion of the landed and personal property of every European country was in the hands of the church."* [18] Apparently, the church was reaping some benefit from the deaths of huge numbers of people. Perhaps the church had a vested interest in maintaining public ignorance about the sources of disease. This insinuation is almost too diabolical for serious consideration. Or is it?

Somehow, the idea developed around the 1400s that Jews and witches were causing the pestilences. Jews were suspected because they didn't succumb to the pestilences as readily as the Christian population did, presumably because they employed a unique sanitation system more conducive to cleanliness, including the eating of kosher foods. Not understanding this, the Christian population arrived at the conclusion that the Jews' immunity resulted from protection by Satan. As a result, attempts were made in all parts of Europe to stop the plagues by torturing and murdering the Jews. Twelve thousand Jews were reportedly burned to death in Bavaria alone during the time of the plague, and additionally thousands more were likewise killed throughout Europe.[19]

In 1484, the "infallible" Pope Innocent VIII issued a proclamation supporting the church's opinion that witches were causes of disease, storms, and a variety of ills affecting humanity. The feeling of the church was summed up in one sentence: *"Thou shalt not suffer a witch to live."* From the middle of the sixteenth to the middle of the seventeenth centuries, women *and* men were sent to torture and death by the thousands, by both Protestant and Catholic authorities. It's estimated that the number of victims sacrificed during that century in Germany alone was over a hundred thousand.

The following case in Milan, Italy, summarizes the ideas of sanitation in Europe during the seventeenth century:

The city was under the control of Spain, and it had received notice from the Spanish government that witches were suspected to be en route to Milan to "anoint the walls" (smear the walls with disease-causing ointments). The church rang the alarm from the pulpit, putting the population on the alert. One morning, in 1630, an old woman looking out of her window saw a man who was walking along the street wipe his fingers on a wall. He was promptly reported to the authorities. He claimed he was simply wiping ink from his fingers which had rubbed off the ink-horn he carried with him. Not satisfied with this explanation, the authorities threw the man into prison and tortured him until he "confessed." The torture continued until the man gave the names of his "accomplices," who were subsequently rounded up and tortured. They in turn named *their* "accomplices" and the process continued until members of the foremost families were included in the charges. Finally, a large number of innocent people were sentenced to their deaths, all reportedly a matter of record.[20]

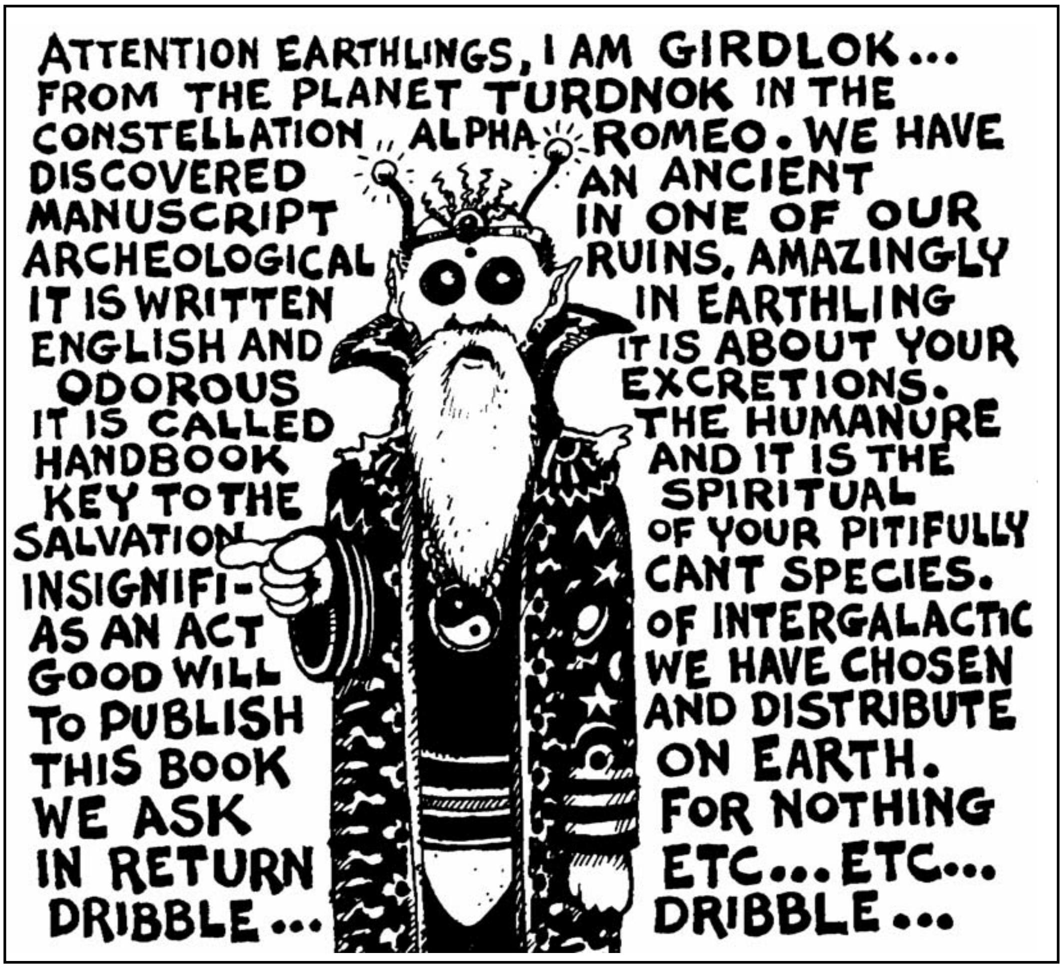
One loathsome disease of the 1500s through the 1700s was the "jail fever." The prisons of that period were filthy. People were confined in dungeons connected to sewers with little ventilation or drainage. Prisoners incubated the disease and spread it to the public, especially to the police, lawyers and judges. In 1750, for example, the disease killed two judges, the lord mayor, various aldermen, and many others in London, not to mention prisoners.[21]

The pestilences at that time in the Protestant colonies in America were also attributed to divine wrath or satanic malice, but when the pestilences afflicted the Native Americans, they were considered acts of divine mercy. *"The pestilence among the Indians, before the arrival of the Plymouth Colony, was attributed in a notable work of that period to the Divine purpose of clearing New England for the heralds of the gospel."* [22]

Perhaps the reason the Asian countries have such large populations in comparison to Western countries is because they escaped some of the pestilences common to Europe, especially pestilences spread by the failure to responsibly recycle human excrement. They presumably plowed their manure back into the land because their spiritual perspectives supported such behavior. Westerners were too busy burning witches and Jews with the church's wholehearted assistance to bother thinking about recycling humanure.

Our ancestors did, eventually, come to understand that poor hygiene was a causal factor in epidemic diseases. Nevertheless, it was not until the late 1800s in England that improper sanitation and sewage were suspected as causes of epidemics. At that time, large numbers of people were still dying from pestilences, especially cholera, which killed at least 130,000 people in England in 1848-9 alone. In 1849, an English medical practitioner published the theory that cholera was spread by water contaminated with sewage. Ironically, even where sewage was being piped away from the population, the sewers were still leaking into drinking water supplies.

The English government couldn't be bothered with the fact that hundreds of thousands of mostly poor citizens were perishing like flies year after year. So it rejected a Public Health Bill in 1847. A Public Health Bill finally became an Act in 1848 in the face of the latest outbreak, but wasn't terribly effective. However, it did bring poor sanitation to the attention of the public, as the following statement from the General Board of Health (1849) implies: *"Householders of all classes should be*


ATTENTION EARTHLINGS, I AM GIRDLOK...
FROM THE PLANET TURDNOK IN THE
CONSTELLATION ALPHA ROMEO. WE HAVE
DISCOVERED AN ANCIENT
MANUSCRIPT IN ONE OF OUR
ARCHEOLOGICAL RUINS, AMAZINGLY
IT IS WRITTEN IN EARTHLING
ENGLISH AND IT IS ABOUT YOUR
ODOROUS EXCRETIONS.
IT IS CALLED THE HUMANURE
HANDBOOK AND IT IS THE
KEY TO THE SPIRITUAL
SALVATION OF YOUR PITIFULLY
INSIGNIFI- CANT SPECIES.
AS AN ACT OF INTERGALACTIC
GOOD WILL WE HAVE CHOSEN
TO PUBLISH AND DISTRIBUTE
THIS BOOK ON EARTH.
WE ASK FOR NOTHING
IN RETURN ETC... ETC...
DRIBBLE... DRIBBLE...

warned that their first means of safety lies in the removal of dung heaps and solid and liquid filth of every description from beneath or about their houses and premises." This may make one wonder if a compost pile would have been considered a "dung heap" in those days, and therefore banned.

Sanitation in England was so bad in the mid to late eighteen hundreds that, *"In 1858, when the Queen and Prince Albert had attempted a short pleasure cruise on the Thames, its malodorous waters drove them back to land within a few minutes. That summer a prolonged wave of heat and drought exposed its banks, rotten with the sewage of an overgrown, undrained city. Because of the stench, Parliament had to rise early."* Another story describes Queen Victoria gazing out over the river and asking aloud what the pieces of paper were that so abundantly floated by. Her companion, not wanting to admit that the Queen was looking at pieces of used toilet paper, replied, *"Those, Ma'am, are notices that bathing is forbidden."* [23]

The wealthy folks, including the Tories or "conservatives" of the English government still thought that spending on social services was a waste of money and an unacceptable infringement by the government on the private sector (sound familiar?). A leading newspaper, "The Times," maintained that the risk of cholera was preferable to being bullied by the government into providing sewage services. However, a major Act was finally passed in 1866, the Public Health Act, with only grudging support from the Tories. Once again, cholera was raging through the population, and it's probably for that reason that any act was passed at all. Finally, by the end of the 1860s, a framework of public health policy was established in England. Thankfully, the cholera epidemic of 1866 was the last and the least disastrous.[24]

The powers of the church eventually diminished enough for physicians to have their much delayed say about the origins of disease. Today, the church is no longer an obstacle to the progress of society, and in many cases acts as a force for peace, justice, and environmental awareness in the western world.

Our modern sanitation systems have finally yielded a life safe for most of us, although not without shortcomings. The eventual solution developed by the west was to collect humanure in water and discard it, perhaps chemically treated, incinerated, or dehydrated — into the seas, into the atmosphere, onto the surface of the land, and into landfills.

ASIAN UPDATE

It would be naive to suggest that the Asian societies are perfect by any stretch of the imagination. Asian history is rife with the problems that have plagued humanity since the first person crawled on this planet. Those problems include such things as oppressive rule by the rich, war, famine, natural catastrophes, oppressive rule by heathens, more war, and now overpopulation.

Today, Asians are abandoning the harmonious agricultural techniques that

Dr. King observed nearly a century ago. In Kyoto, Japan, for example, *"night soil is collected hygienically to the satisfaction of users of the system, only to be diluted at a central collection point for discharge to the sewer system and treatment at a conventional sewage treatment plant."* [25]

A Humanure Handbook reader wrote an interesting account of Japanese toilets in a letter to the author, which is paraphrased here:

> *"I just got through reading your Humanure Handbook. This is the book of the year! Your book really opened my eyes about humanure. I never even thought about using sawdust/leaves/hay as a solution to odors and about thermophilic composting. How brilliant! My only real experience, outside of continuously composting yard refuse/kitchen scraps either in an open pile or directly burying them and then using them on my vegetable garden for over twenty years, comes from living in Japan from 1973-1983. I'll take this opportunity to tell you all I directly experienced about their humanure recycling. As my experience is dated, things may have changed (probably for the worse as toilets and life were becoming 'westernized' even toward the end of my stay in Japan).*
>
> *My experience comes from living in small, rural towns as well as in metropolitan areas (provincial capitals) from 1973-1983. Homes/businesses had an 'indoor outhouse.' The Vault: Nothing but urine/feces were deposited into the large metal vault under the toilet (squat style, slightly recessed in the floor and made of porcelain). No cover material or carbonaceous stuff was used. It stunk !! Not just the bathroom, but the whole house! There were many flies, even though the windows were screened. Maggots were the main problem. They crawled up the sides of the vault onto the toilet and floor and sometimes even made it outside the bathroom into the hall. People constantly poured some kind of toxic chemical into the vaults to control the smell and maggots. (It didn't help — in fact, the maggots really poured out of the vault to escape the chemicals.) Occasionally a slipper (one put on special 'bathroom slippers' as opposed to 'house slippers' when entering the bathroom) fell into the disgusting liquid/maggot filled vault. You couldn't even begin to think about getting it out! You couldn't let little children use the toilet without an adult suspending them over it. They might fall in! Disposal: When the vault was full (about every three months), you called a private vacuum truck which used a large hose placed in an outside opening to suck out the liquid mass. You paid them for their services. I'm not sure exactly what happened to the humanure next but, in the agricultural areas near the fields were large (10 feet in diameter) round, concrete, raised containers, similar in looks to an above ground swimming pool. In the containers, I was told, was the humanure from the 'vacuum trucks.' It was a greenish-brown liquid with algae growing on the surface. I was told this was spread onto agricultural fields." E.A. in IL*

In 1952, about 70% of Chinese humanure was recycled. This had increased to 90% by 1956, and constituted a third of all fertilizer used in the country.[26] Lately, however, humanure recycling in China seems to be going downhill. The use of synthetic fertilizers has risen over 600% between the mid 1960s to the mid 1980s, and now China's average annual fertilizer usage per hectare is estimated to be double that of the world's average. Between 1949 and 1983, agricultural nitrogen and phosphorous inputs increased by a factor of ten, while agricultural yields only tripled.[27]

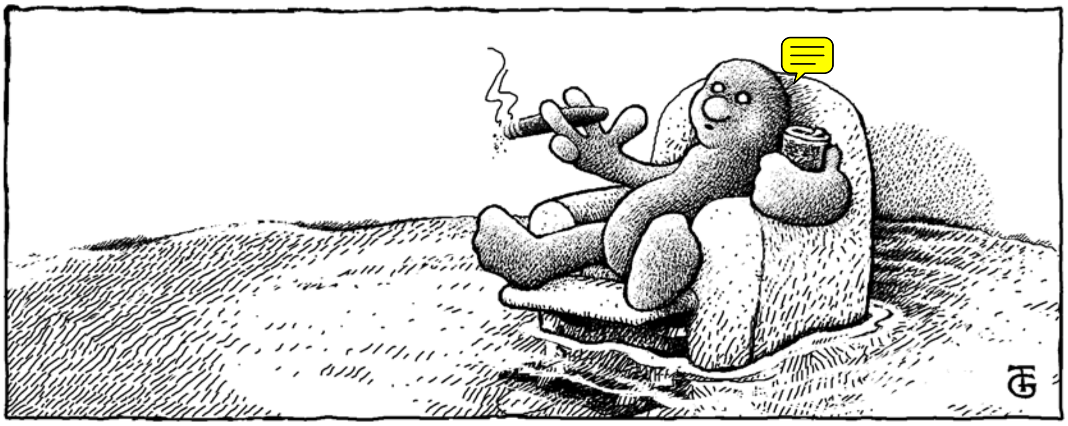
Water pollution in China began to increase in the 1950s due to the discarding of sewage into water. Now, about 70% of China's wastewater is said to be dumped into China's main rivers. By 1992, 45 billion tonnes of wastewater were flowing into China's rivers and lakes annually, 70% untreated. In urban areas, 80% of the surface water is polluted with nitrogen and ammonia, and most lakes around cities have become dumping grounds for large quantities of sewage. It is estimated that 450,000 tonnes of humanure are dumped into the Huangpu River alone in a year. Half a million cases of hepatitis A, spread by polluted water, occurred in Shanghai in 1988. Soilborne diseases, practically non-existent in China twenty years ago, are now also causing problems. *"Increasingly, Chinese urban authorities are turning to incineration or landfill as the ways of disposing of their solid wastes rather than recycling and composting, which means that China, like the west, is putting the problem onto the shoulders of future generations."* [28]

For a sense of historical perspective, I'll leave you with a quote from Dr. Arthur Stanley, health officer of the city of Shanghai, China, in his annual report for 1899, when the population of China amounted to about 500 million people, roughly double that of the US today. At that time, no artificial fertilizers were employed for agricultural purposes — only organic, natural materials such as agricultural residues and humanure were being used:

"Regarding the bearing on the sanitation of Shanghai of the relationship between Eastern and Western hygiene, it may be said, that if prolonged national life is indicative of sound sanitation, the Chinese are a race worthy of study by all who concern themselves with public health. It is evident that in China the birth rate must very considerably exceed the death rate, and have done so in an average way during the three or four thousand years that the Chinese nation has existed. Chinese hygiene, when compared to medieval English, appears to advantage." [29]

Sounds like an understatement to me.

A DAY IN THE LIFE OF A TURD



"If I urinated into a pitcher of drinking water and then proceeded to quench my thirst from the pitcher, I would undoubtedly be considered crazy. If I invented an expensive technology to put my urine and feces into my drinking water, and then invented another expensive (and undependable) technology to make the same water fit to drink, I might be thought even crazier. It is not inconceivable that some psychiatrist would ask me knowingly why I wanted to mess up my drinking water in the first place."
Wendell Berry

When I was a kid, I listened to veterans talking about their stints in the Korean War. Usually after a beer or two, they'd turn their conversation to the "outhouses" used by the Koreans. They were amazed, even mystified about the fact that the Koreans tried to lure passersby to use their outhouses by making the toilets especially attractive. The idea of someone wanting someone else's crap always brought out a loud guffaw from the vets. Only a groveling, impoverished, backward gink would stoop so low as to beg for a turd. Haw, Haw.

Perhaps this attitude sums up the attitudes of Americans. Humanure is a waste product, plain and simple. We have to get rid of it and that's all there is to it. Only fools would think otherwise. One of the effects of this sort of attitude is that Americans don't know and probably don't care where their humanure goes after it emerges from their backsides, as long as they don't have to deal with it.

MEXICAN BIOLOGICAL DIGESTER

Well, where it goes depends on the type of "waste disposal system" used. Let's start with the simplest: the Mexican biological digester, also known as the stray

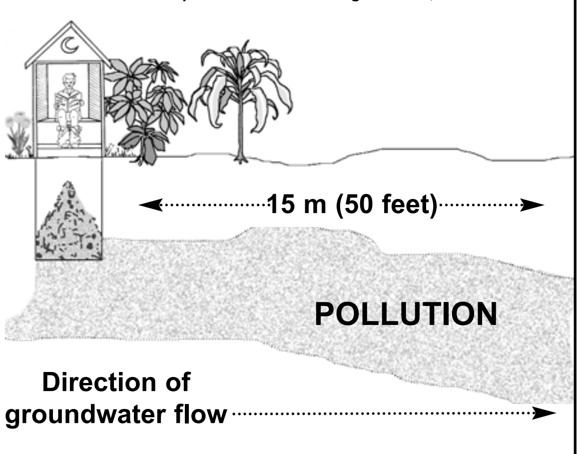
Figure 5.1
BIOLOGICAL DIGESTER
South India

dog. In India, this may be known as the stray pig (see Figure 5.1). I spent a few months in southern Mexico in the late 1970s in Quintana Roo on the Yucatan peninsula. There, toilets were not available; people simply used the sand dunes along the coast. No problem, though. One of the small, unkempt, and ubiquitous Mexican dogs would wait nearby with watering mouth until you've done your thing. Burying your excrement in that situation would have been an act of disrespect to the dog. No one wants sand in their food. A good, healthy, steaming turd at the crack of dawn on the Caribbean coast never lasted more than 60 seconds before it became a hot meal for a human's best friend. Yum.

THE OLD-FASHIONED OUTHOUSE

Next up the ladder of sophistication is the old-fashioned outhouse, also known as the pit latrine (see Figures 5.2-5.5). Simply stated, one digs a hole and defecates in it, and then does so again and again until the hole fills up, after which it's covered with dirt. It's nice to have a small building (privy) over the hole to provide some privacy and to keep off the elements. However, the concept is simple: dig a hole and bury your excrement. Interestingly, this level of sophistication has not yet been surpassed in America. We still bury our excrement, in the form of sewage sludge, in landfill holes.

Figure 5.2
SPREAD OF POLLUTION THROUGH WET SOIL BY OUTHOUSES (PIT LATRINES)
Source: Franceys, R. et al. (1992). A Guide to the Development of On-Site Sanitation. p. 40. World Health Organization, Geneva.



The first farmhouse I lived in during the mid-seventies had an outhouse behind it and no plumbing whatsoever. What I remember most about the outhouse is the smell, which could be described as quite undesirable, to say the least.

The flies and wasps weren't very inviting either, and of course the cold weather made the process of "going to the bathroom" uncomfortable. When the hole filled up, I simply dug another hole twenty feet away from the first and dragged the outhouse from one hole to the other. The dirt from the second hole was used to cover the first. The excrement was left in the ground, probably to contaminate groundwater. Of course, I didn't know I might be contaminating anything because I had just graduated from college and was quite ignorant about practical matters. Therefore, I plead not guilty to environmental pollution on the grounds of a college education.

Outhouses create very real health, environmental, and aesthetic problems. The hole in the ground is accessible to flies and mosquitoes which can transmit disease over a wide area. The pits leak pollutants into the ground even in dry soil. And the smell — *hold your nose.*

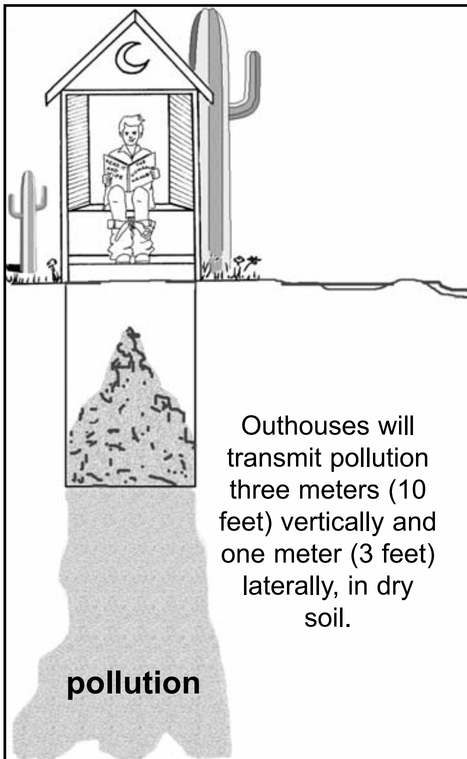


Figure 5.3

SPREAD OF POLLUTION THROUGH DRY SOIL BY OUTHOUSES (PIT LATRINES)

Source: Rybczynski, et al. (1982). Appropriate Technology for Water Supply and Sanitation - Low-Cost Technology Options for Sanitation, A State of the Art Review and Annotated Bibliography. World Bank. p. 52.

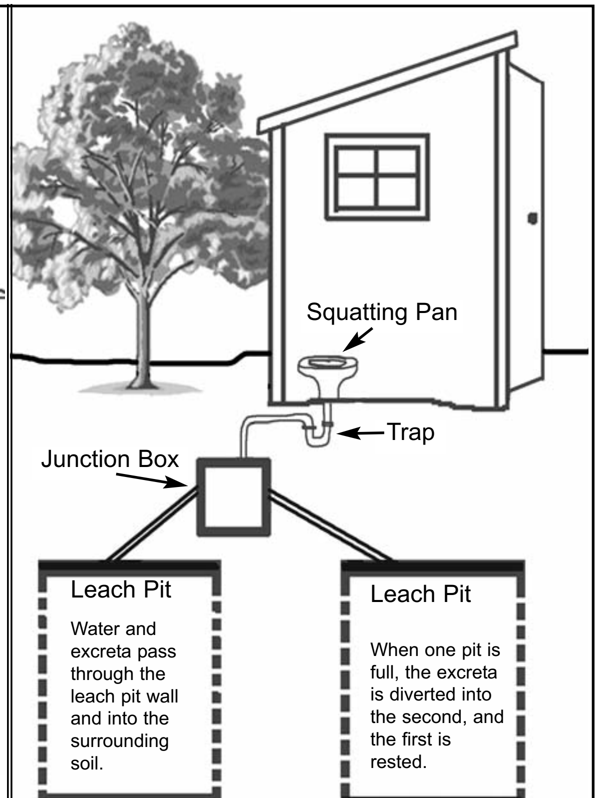


Figure 5.4

POUR FLUSH LATRINES

Excreta deposited into the pan are flushed by about 2-3 liters of water per flush. After 1-2 years of retention time, the pathogens will be rendered harmless.

Source: Mara, D. Duncan (1985). The Design of Pour Flush Latrines. TAG Technical Note #15. Technological Advisory Group of the United Nations.

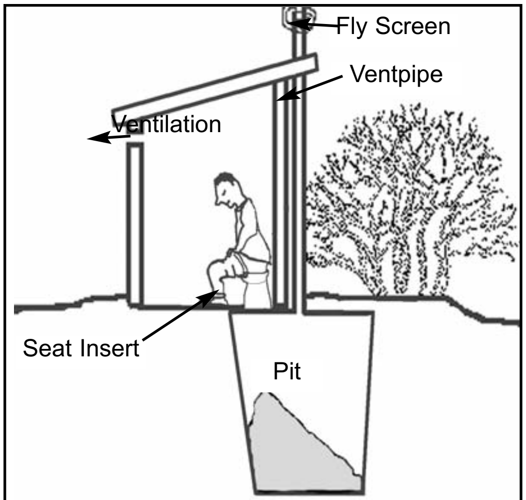


Figure 5.5

THE BOTVIP LATRINE: BOTSWANA'S RURAL VENTILATED IMPROVED PIT LATRINE

Source: van Nostrabd, John, and Wilson, James G. (1983). United Nations TAG Technical Note #8. Rural Ventilated Improved Pit Latrines: A Field Manual for Botswana. November 1983.

SEPTIC SYSTEMS

Another step up the ladder one finds the septic tank, a common method of human waste disposal in rural and suburban areas of the United States. In this system the turd is deposited into a container of water, usually pure drinking water, and the whole works are flushed away (see Figures 5.6 and 5.7).

After the floating turd travels from the house inside a sewage pipe, it plops into a fairly large underground storage tank, or septic tank, usually made of concrete and sometimes of fiberglass. In Pennsylvania (US), a 900 gallon tank is the minimum size allowed for a home with three or fewer bedrooms.[1] The heavier solids settle to the bottom of the tank and the liquids drain off into a leach field, which consists of an array of drain pipes situated below the ground surface allowing the liquid to seep out into the soil. The wastewater should be undergoing anaerobic decomposition while in the tank. When septic tanks fill up, they are pumped out and the waste material is supposed to be trucked to a sewage treatment plant (sometimes they're illegally dumped).

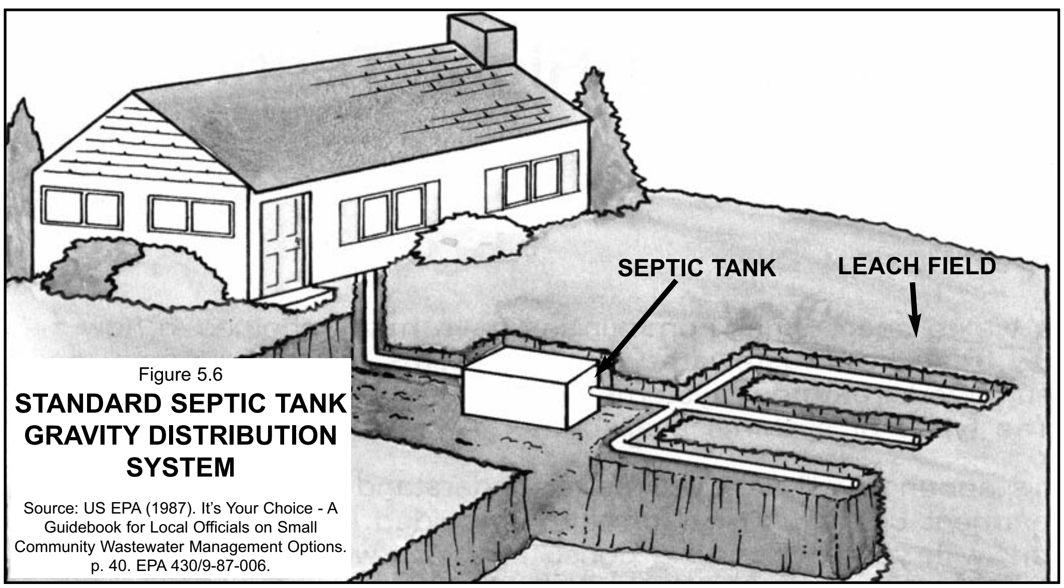


Figure 5.6

STANDARD SEPTIC TANK GRAVITY DISTRIBUTION SYSTEM

Source: US EPA (1987). It's Your Choice - A Guidebook for Local Officials on Small Community Wastewater Management Options. p. 40. EPA 430/9-87-006.

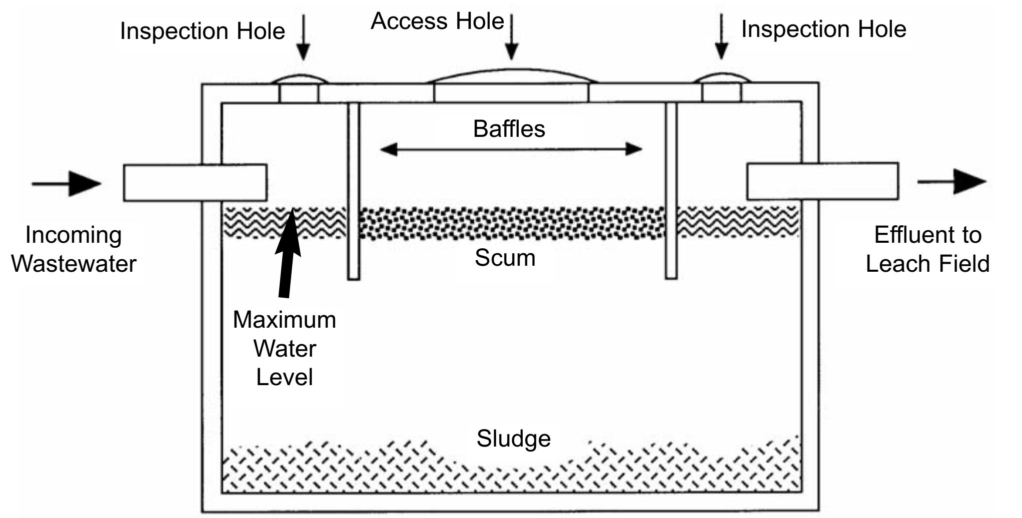


Figure 5.7

CROSS SECTION OF A SEPTIC TANK

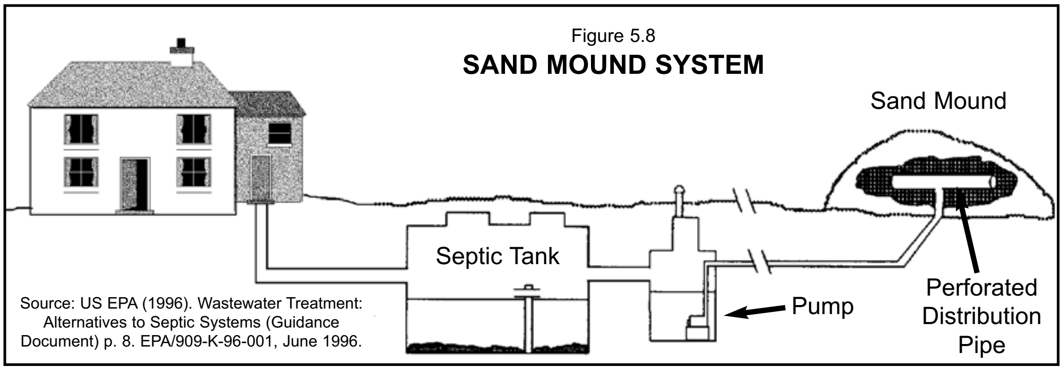
Source: Penn State College of Agriculture, Cooperative Extension, Agricultural Engineering Fact Sheet SW-165.

SAND MOUNDS

In the event of poorly drained soil, one with a high clay content or else low-lying, a standard leach field will not work very well, especially when the ground is already saturated with rain water or snow melt. One can't drain wastewater into soil that is saturated with water. That's when the *sand mound* sewage disposal system is employed. When the septic tank isn't draining properly, a pump will kick in and pump the effluent into a pile of sand and gravel above ground (although sometimes a pump isn't necessary and gravity does the job). A perforated pipeline in the pile of sand allows the effluent to drain down through the mound. Sand mounds are usually covered with soil and grass. In Pennsylvania, sand mounds must be at least one hundred feet downslope from a well or spring, fifty feet from a stream, and five feet

Figure 5.8

SAND MOUND SYSTEM



Source: US EPA (1996). Wastewater Treatment: Alternatives to Septic Systems (Guidance Document) p. 8. EPA/909-K-96-001, June 1996.

from a property line.[2] According to local excavating contractors, sand mounds cost $5,000 to $12,000 to construct. They must be built to exact government specifications, and aren't usable until they pass an official inspection (see Figure 5.8).

GROUND WATER POLLUTION FROM SEPTIC SYSTEMS

We civilized humans started out by defecating into a hole in the ground (outhouse), then discovered we could float our turds out to the hole using water and never have to leave the house. However, one of the unfortunate problems with septic systems is, like outhouses, they pollute our groundwater.

There are currently 22 million septic system sites in the United States, serving one fourth to one third of the US population. They are leaching contaminants such as bacteria, viruses, nitrates, phosphates, chlorides, and organic compounds such as trichloroethylene into the environment. An EPA study of chemicals in septic tanks found toluene, methylene chloride, benzene, chloroform, and other volatile synthetic organic compounds related to home chemical use, many of them cancer-causing.[3] Between 820 and 1,460 *billion* gallons of this contaminated water are discharged per year to our shallowest aquifers.[4] In the US, septic tanks are reported as a source of ground water contamination more than any other source. Forty-six states cite septic systems as sources of groundwater pollution; nine of these reported them to be the primary source of groundwater contamination in their state (see Figures 5.9 and 5.10).[5]

The word "septic" comes from the Greek "septikos" which means "to make putrid." Today it still means "causing putrefaction," putrefaction being "the decomposition of organic matter resulting in the formation of foul-smelling products" (see Webster). Septic systems are not designed to destroy human pathogens that may be in the human waste that enters the septic tank. Instead, septic systems are designed to collect human wastewater, settle out the solids, and anaerobically digest them to some extent, leaching the effluent into the ground. Therefore, septic systems can be highly pathogenic, allowing the transmission of disease-causing bacteria, viruses, protozoa, and intestinal parasites through the system.

One of the main concerns associated with septic systems is the problem of human population density. Too many septic systems in any given area will overload the soil's natural purification systems and allow large amounts of wastewater to contaminate the underlying watertable. A density of more than forty household septic systems per square mile will cause an area to become a likely target for subsurface

Figure 5.9

GROUNDWATER CONTAMINANTS IN THE UNITED STATES

Number of States Reporting as Major Contaminants

Source: US EPA National Water Quality Inventory, 1986 Report to Congress. EPA-440/4-87-008.

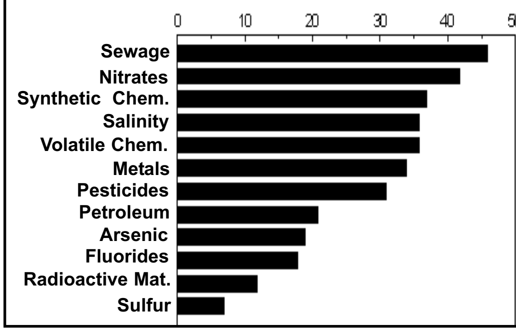
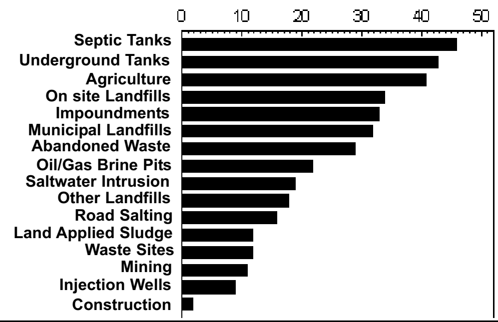


Figure 5.10

SOURCES OF GROUNDWATER CONTAMINATION IN THE US

Number of States Reporting Source

Source: US EPA National Water Quality Inventory, 1986 Report to Congress. EPA-440/4-87-008.



contamination, according to the EPA.[6]

Toxic synthetic organic chemicals are commonly released into the environment from septic systems because people dump toxic chemicals down their drains. The chemicals are found in pesticides, paint and coating products, toilet cleaners, drain cleaners, disinfectants, laundry solvents, antifreeze, rust proofers, septic tank and cesspool cleaners, and many other cleaning solutions. In fact, over 400,000 gallons of septic tank cleaner liquids containing synthetic organic chemicals were used in one year by the residents of Long Island alone. Furthermore, some synthetic organic chemicals can corrode pipes, thereby causing heavy metals to enter septic systems.[7]

In many cases, people who have septic tanks are forced to connect to sewage lines when the lines are made available to them. A US Supreme Court case in 1992 reviewed a situation whereby town members in New Hampshire had been forced to connect to a sewage line that simply discharged untreated, raw sewage into the Connecticut River, and had done so for 57 years. Despite the crude method of sewage disposal, state law required properties within 100 feet of the town sewer system to connect to it from the time it was built in 1932. This barbaric sewage disposal system apparently continued to operate until 1989, when state and federal sewage treatment laws forced a stop to the dumping of raw sewage into the river.[8]

WASTEWATER TREATMENT PLANTS

"Over 90% of all sewage in third world countries is discharged completely untreated; in Latin America the figure is 98%."

Ecological Sanitation, p.2

There's still another step up the ladder of wastewater treatment sophistication: the wastewater treatment plant, or sewage plant. The wastewater treatment plant is like a huge, very sophisticated septic tank because it collects the waterborne excrement of large numbers of humans. Inevitably, when one defecates or urinates into water, one pollutes the water. In order to avoid environmental pollution, that "wastewater" must somehow be rendered fit to return to the environment. The wastewater entering the treatment plant is 99% liquid because all sink water, bath water and everything else that goes down one's drain ends up at the plant too, which is why it's called a *water* treatment plant. In some cases, storm water runoff also enters wastewater treatment plants via *combined sewers*. Industries, hospitals, gas stations, and any place with a drain add to the contaminant blend in the wastewater stream.

Many modern wastewater plants use a process of activated sludge treatment whereby oxygen is vigorously bubbled through the wastewater in order to activate microbial digestion of the solids. This aeration stage is combined with a settling stage that allows the solids to be removed (see Figures 5.11 and 5.12). The removed solids (sludge) are either used to reinoculate the incoming wastewater, or they're dewatered to the consistency of a dry mud and buried in landfills. Sometimes the sludge is applied to agricultural land, and now, sometimes, it's composted. The microbes that digest the sludge consist of bacteria, fungi, protozoa, rotifers, and nematodes.[9] US sewage treatment plants generated about 7.6 million dry tons of sludge in 1989.[10] New York City alone produces 143,810 dry tons of sludge every year.[11] In 1993, the amount of sewage sludge produced annually in the US was 110-150 million wet metric tons. The water left behind is treated (usually with chlorine) and discharged into a stream, river, or other body of water. Sewage treatment water releases to surface water in the United States in 1985 amounted to nearly *31 billion gallons per day*.[12] Incidentally, the amount of toilet paper used (1991) to send all this waste to the sewers was 2.3 million tons.[13]

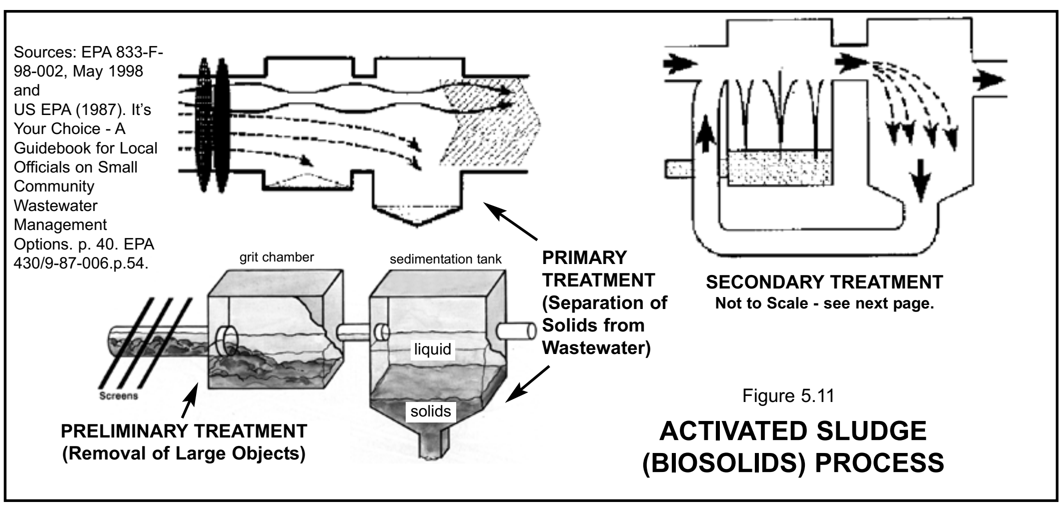
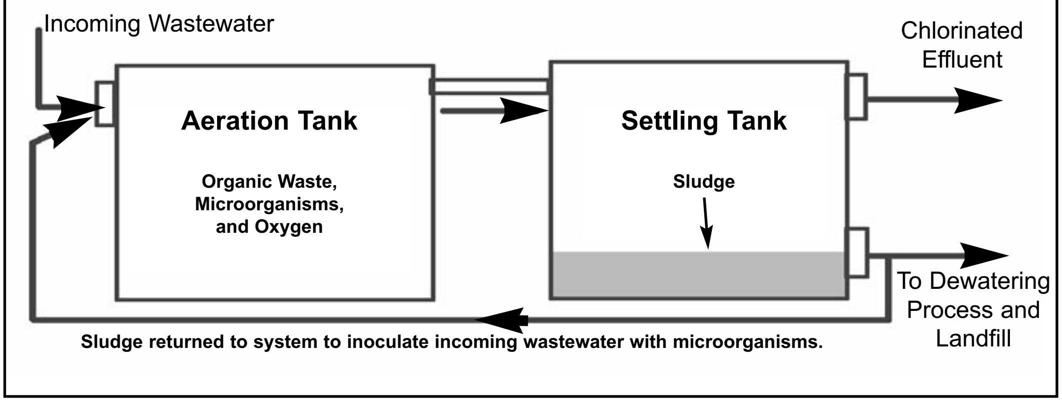


Figure 5.11

ACTIVATED SLUDGE (BIOSOLIDS) PROCESS

Figure 5.12

ACTIVATED SLUDGE WASTEWATER TREATMENT PROCESS



WASTE STABILIZATION PONDS

Perhaps one of the most ancient wastewater treatment methods known to humans are waste stabilization ponds, also known as oxidation ponds or lagoons (see Figure 5.13). They're often found in small rural areas where land is available and cheap. Such ponds tend to be only a meter to a meter and a half deep, but vary in size and depth, and may be three or more meters deep.[14] They utilize natural processes to "treat" waste materials, relying on algae, bacteria, and zooplankton to

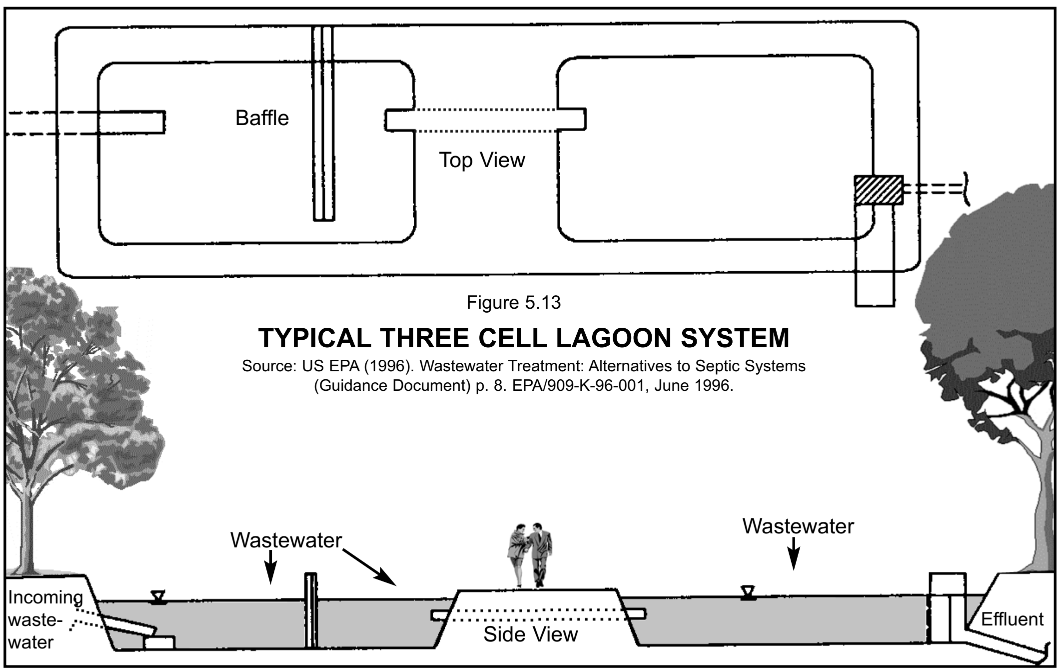


Figure 5.13

TYPICAL THREE CELL LAGOON SYSTEM

Source: US EPA (1996). Wastewater Treatment: Alternatives to Septic Systems (Guidance Document) p. 8. EPA/909-K-96-001, June 1996.

reduce the organic content of the wastewater. A "healthy" lagoon will appear green in color because of the dense algae population. These lagoons require about one acre for every 200 people served. Mechanically aerated lagoons only need 1/3 to 1/10 the land that unaerated stabilization ponds require. It's a good idea to have several smaller lagoons in series rather than one big one; normally, a minimum of three "cells" are used. Sludge collects in the bottom of the lagoons, and may have to be removed every five or ten years and disposed of in an approved manner.[15]

CHLORINE

Wastewater leaving wastewater treatment plants is often treated with chlorine before being released into the environment. Therefore, besides contaminating water resources with feces, the act of defecating into water often ultimately contributes to the contamination of water resources with *chlorine*.

Used since the early 1900s, chlorine is one of the most widely produced industrial chemicals. About 10 million metric tons are manufactured in the US each year — $72 billion worth.[16] Annually, approximately 5%, or 1.2 billion pounds of the chlorine manufactured is used for wastewater treatment and drinking water "purification." The lethal liquid or green gas is mixed with the wastewater from sewage treatment plants in order to kill disease-causing microorganisms before the water is discharged into streams, lakes, rivers, and seas. It is also added to household drinking water via household and municipal water treatment systems. Chlorine kills microorganisms by damaging their cell membranes, which leads to a leakage of their proteins, RNA, and DNA.[17]

Chlorine (Cl_2) doesn't exist in nature. It's a potent poison which reacts with water to produce a strongly oxidizing solution that can damage the moist tissue lining of the human respiratory tract. Ten to twenty parts per million (ppm) of chlorine gas in air rapidly irritates the respiratory tract; even brief exposure at levels of 1,000 ppm (one part in a thousand) can be fatal.[18] Chlorine also kills fish, and reports of fish kills caused chlorine to come under the scrutiny of scientists in the 1970s.

The fact that harmful compounds are formed as *by-products* of chlorine use also raises concern. In 1976, the US Environmental Protection Agency (EPA) reported that chlorine use not only poisoned fish, but could also cause the formation of cancer-causing compounds such as chloroform. Some known effects of chlorine-based pollutants on animal life include memory problems, stunted growth and cancer in humans; reproductive problems in minks and otters; reproductive problems, hatching problems, and death in lake trout; and embryo abnormalities and death in snapping turtles.[19]

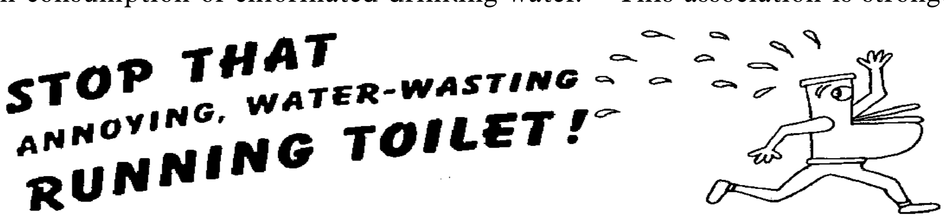
In a national study of 6,400 municipal wastewater treatment plants, the EPA estimated that two thirds of them used too much chlorine, exerting lethal effects at all levels of the aquatic food chain. Chlorine damages the gills of fish, inhibiting their ability to absorb oxygen. It also can cause behavioral changes in fish, thereby affecting migration and reproduction. Chlorine in streams can create chemical "dams" which prevent the free movement of some migratory fish. Fortunately, since 1984, there has been a 98% reduction in the use of chlorine by sewage treatment plants, although chlorine use continues to be a widespread problem because a lot of wastewater plants are still discharging it into small receiving waters.[20]

Another controversy associated with chlorine use involves "dioxin," which is a common term for a large number of chlorinated chemicals that are classified as possible human carcinogens by the EPA. It's known that dioxins cause cancer in laboratory animals, but their effects on humans are still being debated. Dioxins, by-products of the chemical manufacturing industry, are concentrated up through the food chain where they're deposited in human fat tissues. A key ingredient in the formation of dioxin is chlorine, and indications are that an increase in the use of chlorine results in a corresponding increase in the dioxin content of the environment, even in areas where the only dioxin source is the atmosphere.[21]

In the upper atmosphere, chlorine molecules from air pollution gobble up ozone; in the lower atmosphere, they bond with carbon to form organochlorines. Some of the 11,000 commercially used organochlorines include hazardous compounds such as DDT, PCBs, chloroform, and carbon tetrachloride. Organochlorines rarely occur in nature, and living things have little defense against them. They've been linked not only to cancer, but also to neurological damage, immune suppression, and reproductive and developmental effects. When chlorine products are washed down the drain to a septic tank, they're producing organochlorines. Although compost microorganisms can degrade and make harmless many toxic chemicals, highly chlorinated compounds are disturbingly resistant to such biodegradation.[22]

"Any use of chlorine results in compounds that cause a wide range of ailments," says Joe Thorton, a Greenpeace researcher, who adds, *"Chlorine is simply not compatible with life. Once you create it, you can't control it."* [23]

There's no doubt that our nation's sewage treatment systems are polluting our drinking water sources with pathogens. As a result, chlorine is also being used to disinfect *the water we drink* as well as to disinfect discharges from wastewater treatment facilities. It is estimated that 79% of the US population is exposed to chlorine.[24] According to a 1992 study, *chlorine is added to 75% of the nation's drinking water* and is linked to cancer. The results of the study suggested that at least 4,200 cases of bladder cancer and 6,500 cases of rectal cancer each year in the US are associated with consumption of chlorinated drinking water.[25] This association is strongest in



people who have been drinking chlorinated water for more than fifteen years.[26]

In December, 1992, the US Public Health Service reported that pregnant women who routinely drink or bathe in chlorinated tap water are at a greater risk of bearing premature or small babies, or babies with congenital defects.[27]

According to a spokesperson for the chlorine industry, 87% of water systems in the US use free chlorines; 11% use chloramines. Chloramines are a combination of chlorine and ammonia. The chloramine treatment is becoming more widespread due to the health concerns over chlorine.[28] However, EPA scientists admit that we're pretty ignorant about the potential by-products of the chloramine process, which involves ozonation of the water prior to the addition of chloramine.[29]

Of course, we don't have to worry. The government will take care of us, and if the government doesn't, then industry will. Won't they? Well, not exactly. According to a US General Accounting Office report in 1992, consumers are poorly informed about potentially serious violations of drinking water standards. In a review of twenty water systems in six states, out of 157 drinking water quality violations, the public received a timely notice in only 17 of the cases.[30]

ALTERNATIVE WASTEWATER TREATMENT SYSTEMS

New systems are being developed to purify wastewater. One popular experimental system today is the *constructed,* or *artificial wetlands system*, which runs wastewater through an aquatic environment consisting of aquatic plants such as water hyacinths, bullrushes, duckweed, lilies, and cattails (see Figure 5.14). The plants act as marsh filters, and the microbes which thrive on their roots do most of the work, breaking down nitrogen and phosphorous compounds, as well as toxic chemicals. Although they don't break down heavy metals, the plants absorb them; they can then be harvested and incinerated or landfilled.[31]

According to EPA officials, the emergence of constructed wetlands technology shows great potential as a cost effective alternative to wastewater treatment. The wetlands method is said to be relatively affordable, energy efficient, practical, and effective. Scientists don't yet have the data to determine with assurance the performance expectations of wetlands systems, or contaminant concentrations released by these systems into the environment. However, the treatment efficiency of properly constructed wetlands is said to compare well with conventional treatment systems.[32] Unfortunately, wetlands systems don't recover the agricultural resources available in humanure.

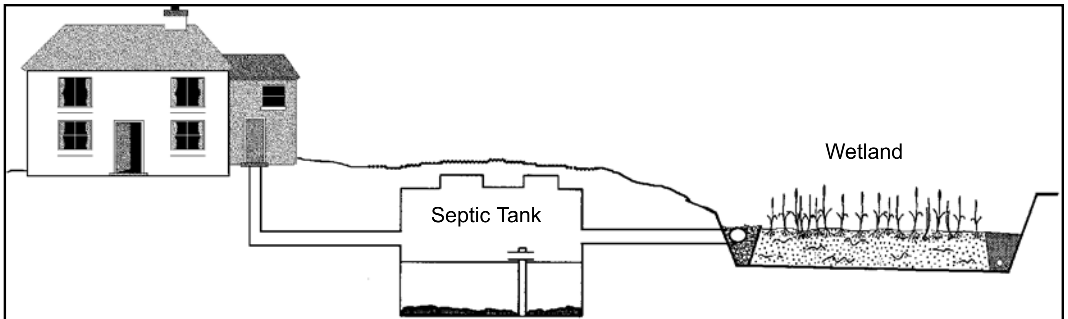


Figure 5.14

CONSTRUCTED WETLAND WASTEWATER TREATMENT SYSTEM
for Septic Tank Facilities

Another system uses solar powered greenhouse-like technology to treat wastewater. This system uses hundreds of species of bacteria, fungi, protozoa, snails, plants and fish, among other things, to produce advanced levels of wastewater treatment. These Solar Aquatics systems are also experimental, but appear hopeful.[33] Again, the agricultural resources of humanure are lost when using any disposal method or wastewater treatment technique instead of a humanure recycling method.

When a household humanure recycling method *is* used, however, and sewage is *not* being produced, most households will still be producing graywater. Graywater is the water that is used for washing, bathing, and laundry, and it must be dealt with in a responsible manner before draining into the environment. Most households produce sewage (blackwater). Households that produce *only* graywater are rare, and may even be beyond the comprehension of many government authorities who may insist that every household have a sewage system (e.g., septic system) whether they produce sewage or not. Yet, households which compost their humanure may produce no sewage at all; these households are prime candidates for *alternative* graywater systems. Such alternative systems are discussed in Chapter 9.

AGRICULTURAL USE OF SEWAGE SLUDGE

Now here's where a thoughtful person may ask, "Why not put *sewage sludge* back into the soil for agricultural purposes?"

One reason: government regulation. When I asked the supervisor of my local wastewater treatment plant if the one million gallons of sludge the plant produces each year (for a population of 8,000) was being applied to agricultural land, he said, *"It takes six months and five thousand dollars to get a permit for a land application. Another problem is that due to regulations, the sludge can't lie on the surface after it's applied, so it has to be plowed under shortly after application. When farmers get the right conditions to plow their fields, they plow them. They can't wait around for us, and we can't have sludge ready to go at plowing time."* It may be just as well.

Problems associated with the agricultural use of sewage sludge include groundwater, soil, and crop contamination with pathogens, heavy metals, nitrate, and toxic and carcinogenic organic compounds.[34] Sewage sludge is a lot more than organic human refuse. It can contain DDT, PCBs, mercury, and other heavy metals.[35] One scientist alleges that more than 20 million gallons of used motor oil are dumped into sewers every year in the United States.[36]

America's largest industrial facilities released over 550 million pounds of toxic pollutants into US sewers in 1989 alone, according to the US Public Interest Research Group. Between 1990 and 1994, an additional 450 million pounds of toxic chemicals were dumped into sewage treatment systems, although the actual levels of toxic discharges are said to be much higher than these.[37]

Of the top ten states responsible for toxic discharges to public sewers in 1991, Michigan took first prize with nearly 80 million pounds, followed in order by New Jersey, Illinois, California, Texas, Virginia, Ohio, Tennessee, Wisconsin and Pennsylvania (around 20 million pounds from PA).[38]

An interesting study on the agricultural use of sludge was done by a Mr. Purves in Scotland. He began applying sewage sludge at the rate of 60 tons per acre to a plot of land in 1971. After fifteen years of treating the soil with the sludge, he tested the vegetation grown on the plot for heavy metals. On finding that the heavy metals (lead, copper, nickel, zinc and cadmium) had been taken up by the plants, he concluded, *"Contamination of soils with a wide range of potentially toxic metals following application of sewage sludge is therefore virtually irreversible."* [39] In other words, the heavy metals don't wash out of the soil, they enter the food chain, and may contaminate not only crops, but also grazing animals.[40]

Other studies have shown that heavy metals accumulate in the vegetable tissue of the plant to a much greater extent than in the fruits, roots, or tubers. Therefore, if one must grow food crops on soil fertilized with sewage sludge contaminated with heavy metals, one might be wise to produce carrots or potatoes instead of lettuce.[41] Guinea pigs experimentally fed with swiss chard grown on soil fertilized with sewage sludge showed no observable toxicological effects. However, their adrenals showed elevated levels of antimony, their kidneys had elevated levels of cadmium, there was elevated manganese in the liver and elevated tin in several other tissues.[42]

Estimated to contain 10 billion microorganisms per gram, sludge may contain many human pathogens.[43] "*The fact that sewage sludge contains a large population of fecal coliforms renders it suspect as a potential vector of bacterial pathogens and a possible contaminant of soil, water and air, not to mention* *crops. Numerous investigations in different parts of the world have confirmed the presence of intestinal pathogenic bacteria and animal parasites in sewage, sludge, and fecal materials."* [44]

Because of their size and density, parasitic worm eggs settle into and concentrate in sewage sludge at wastewater treatment facilities. One study indicated that roundworm eggs could be recovered from sludge at all stages of the wastewater treatment process, and that two-thirds of the samples examined had viable eggs.[45] Agricultural use of the sludge can therefore infect soil with 6,000-12,000 viable parasitic worm eggs, per square meter, per year. These eggs can persist in some soils for five years or more.[46] Furthermore, *Salmonellae* bacteria in sewage sludge can remain viable on grassland for several weeks, thereby making it necessary to restrict grazing on pastureland for several weeks after a sludge application. Beef tapeworm (*Taenia saginata*), which uses cattle as its intermediate host and humans as its final host, can also infect cattle that graze on pastureland fertilized with sludge. The tapeworm eggs can survive on sludged pasture for a full year.[47]

Table 5.1

BRAND NAMES OF SEWAGE SLUDGE FERTILIZERS ONCE MARKETED

SOURCE CITY	NAME*
Akron, OH	Akra-Soilite
Battle Creek, MI	Battle Creek Plant Food
Boise, ID	B.I. Organic
Charlotte, NC	Humite & Turfood
Chicago, IL	Chicagro & Nitroganic
Clearwater, FL	Clear-O-Sludge
Fond du Lac, WI	Fond du Green
Grand Rapids, MI	Rapidgro
Houston, TX	Hu-Actinite
Indianapolis, IN	Indas
Madison, WI	Nitrohumus
Massillon, OH	Greengro
Milwaukee, WI	Milorganite
Oshkosh, WI	Oshkonite
Pasadena, CA	Nitroganic
Racine, WI	Ramos
Rockford, IL	Nu-Vim
San Diego, CA	Nitro Gano
San Diego, CA	San-Diegonite
S. California	Sludgeon
Schenectady, NY	Orgro & Gro-hume
Toledo, OH	Tol-e-gro

*Names are registered brand names.

Sources: Rodale, J. I. et al. (Eds.). (1960). The Complete Book of Composting. Rodale Books Inc.: Emmaus, PA. pp. 789, 790. and Collins, Gilbeart H., (1955). Commercial Fertilizers - Their Sources and Use, Fifth Edition. McGraw-Hill Book Co., New York

Another interesting study published in 1989 indicated that bacteria surviving in sewage sludge show a high level of resistance to antibiotics, especially penicillin. Because heavy metals are concentrated in sludge during the treatment process, the bacteria that survive in the sludge can obviously resist heavy metal poisoning. These same bacteria also show an inexplicable resistance to antibiotics, suggesting that somehow the resistance of the two environmental factors are related in the bacterial strains that survive. The implication is that sewage sludge selectively breeds antibiotic-resistant bacteria, which may enter the food chain if the agricultural use of the sludge becomes widespread. The results of the study indicated that more knowledge of antibiotic-resistant bacteria in sewage sludge should be acquired before sludge is disposed of on land.[48]

This poses somewhat of a problem. Collecting human excrement with wastewater and industrial pollutants seems to render the organic refuse incapable of being adequately sanitized. It becomes contaminated enough to be unfit for agricultural purposes. As a consequence, sewage sludge is not highly sought after as a soil additive. For example, the state of Texas sued the US EPA in July of 1992 for failing to study environmental risks before approving the spreading of sewage sludge in west Texas. Sludge was being spread on 128,000 acres there by an Oklahoma firm, but the judge nevertheless refused to issue an injunction to stop the spreading.[49] Considering that the sludge was from New York City, who can blame the Texans?

Now that ocean dumping of sludge has been stopped, where's it going to go? Researchers at Cornell University have suggested that sewage sludge can be disposed of by surface applications in forests. Their studies suggest that brief and intermittent applications of sludge to forestlands won't adversely affect wildlife, despite the nitrates and heavy metals that are present in the sludge. They point out that the need to find ways to get rid of sludge is compounded by the fact that many landfills are expected to close over the next several years and ocean dumping is now banned.

Under the Cornell model, one dry ton of sludge could be applied to an acre of forest each year.[50] New York state alone produces 370,000 tons of dry sludge per year, which would require 370,000 acres of forest each year for their sludge disposal. Consider the fact that forty-nine other states produce 7.6 million dry tons of sludge. Then there's figuring out how to get the sludge into the forests and how to spread it around. With all this in mind, a guy has to stop and wonder — the woods used to be the only place left to get away from it all.

The problem of treating and dumping sludge isn't the only one. The costs of maintenance and upkeep of wastewater treatment plants is another. According to a report issued by the EPA in 1992, US cities and towns need as much as $110.6 billion over the next twenty years for enlarging, upgrading, and constructing wastewater treatment facilities.[51]

Ironically, when sludge is *composted*, it may help to keep heavy metals *out* of the food chain. According to a 1992 report, composted sludge lowered the uptake of lead in lettuce that had been deliberately planted in lead-contaminated soil. The lettuce grown in the contaminated soil which was amended with composted sludge had a 64% lower uptake of lead than lettuce planted in the same soil but without the compost. The

Dripless toilets China's top priority

BEIJING, June 7 —— With oceans of scarce water literally going down China's drains, Communist Party chief Jiang Zemin has made the dripless toilet a national priority. "If the country can send satellites and missiles into space, it should be able to dry up its latrines," today's China Daily quoted Jiang as saying. The Construction Ministry estimates leaky toilets sold by negligent manufacturers waste 200 million cubic meters of water a year. Vice Minister of Construction Ye Rutang launched a purge of leaky and substandard toilet hardware. Three hundred of China's 570 cities, including the capital, Beijing, face serious water shortages, China Daily said.

From a Saudi Arabian Newspaper, 1994

composted soil also lowered lead uptake in spinach, beets, and carrots by more than 50%.[52]

Some scientists claim that the composting process transforms heavy metals into benign materials. One such scientist who designs facilities that compost sewage sludge states, *"At the final product stage, these [heavy] metals actually become beneficial micro-nutrients and trace minerals that add to the productivity of soil. This principle is now finding acceptance in the scientific community of the USA and is known as biological transmutation, or also known as the Kervran-Effect."* Composted sewage sludge that is microbiologically active can also be used to detoxify areas contaminated with nuclear radiation or oil spills, according to the same researcher. Clearly, the composting of sewage sludge is a grossly underutilized alternative to landfill application, and it should be strongly promoted.[53]

Other scientists have shown that heavy metals in contaminated compost (such as sludge compost) are *not* biologically transmuted, but are actually *concentrated* in the finished compost. This is most likely due to the fact that the compost mass shrinks considerably during the composting process showing reductions of 70%, while the amount of metals remains the same. Some researchers have shown a decrease in the concentrations of *some* heavy metals and an increase in the concentrations of others, for reasons that are unclear. Others show a considerable decrease in the concentrations of heavy metals between the sludge and the finished compost. Results from various researchers *"are giving a confusing idea about the behavior of heavy metals during composting. No common pattern of behavior can be drawn between similar materials and the same metals . . ."* [54] However, metals concentrations in finished compost seem to be low enough that they are not considered to be a problem, perhaps largely because metal-contaminated sludge is greatly diluted by other clean organic materials when composted.[55]

GLOBAL SEWERS AND PET TURDS

Let's assume that the whole world adopted the sewage philosophy we have in the United States: defecate into water and then treat the polluted water. What would that scenario be like? Well, for one thing it wouldn't work. It takes between 1,000 and 2,000 tons of water at various stages in the process to flush one ton of humanure. In a world of just five billion people producing a conservative estimate of one million metric tons of human excrement daily, the amount of water required to flush it all would not be obtainable.[56] Considering the increasing landfill space that would be needed to dispose of the increasing amounts of sewage sludge, and the tons of toxic chemicals required to "sterilize" the wastewater, one can realize that this system of human waste disposal is far from sustainable and cannot serve the needs of humanity in the long term.

According to Barbara Ward, President of the International Institute for Environment and Development, *"Conventional 'Western' methods of waterborne sewer-*

age are simply beyond the reach of most [of the world's] communities.They are far too expensive. And they often demand a level of water use that local water resources cannot supply. If Western standards were made the norm, some $200 billion alone [early 1980s] would have to be invested in sewerage to achieve the target of basic sanitation for all. Resources on this scale are simply not in sight."

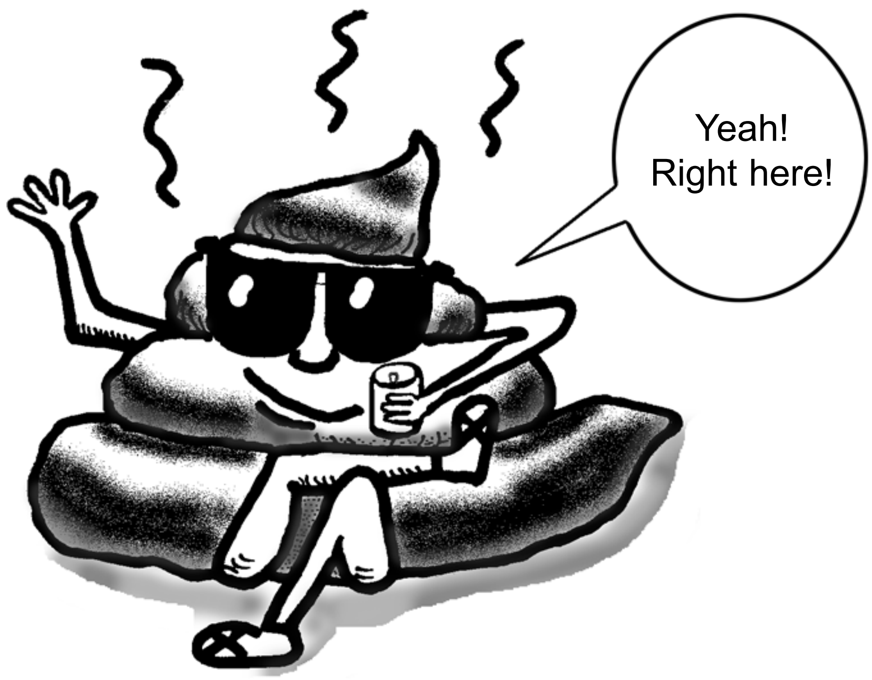
To quote Lattee Fahm, *"In today's world [1980], some 4.5 billion people produce excretal matters at about 5.5 million metric tons every twenty-four hours, close to two billion metric tons per year. [Humanity] now occupies a time/growth dimension in which the world population doubles in thirty five years or less. In this new universe, there is only one viable and ecologically consistent solution to the body waste problems — the processing and application of [humanure] for its agronutrient content."* [57] This sentiment is echoed by World Bank researchers, who state, *"[I]t can be estimated that the backlog of over one billion people not now provided with water or sanitation service will grow, not decrease. It has also been estimated that most developing economies will be unable to finance water carriage waste disposal systems even if loan funds were available."* [58]

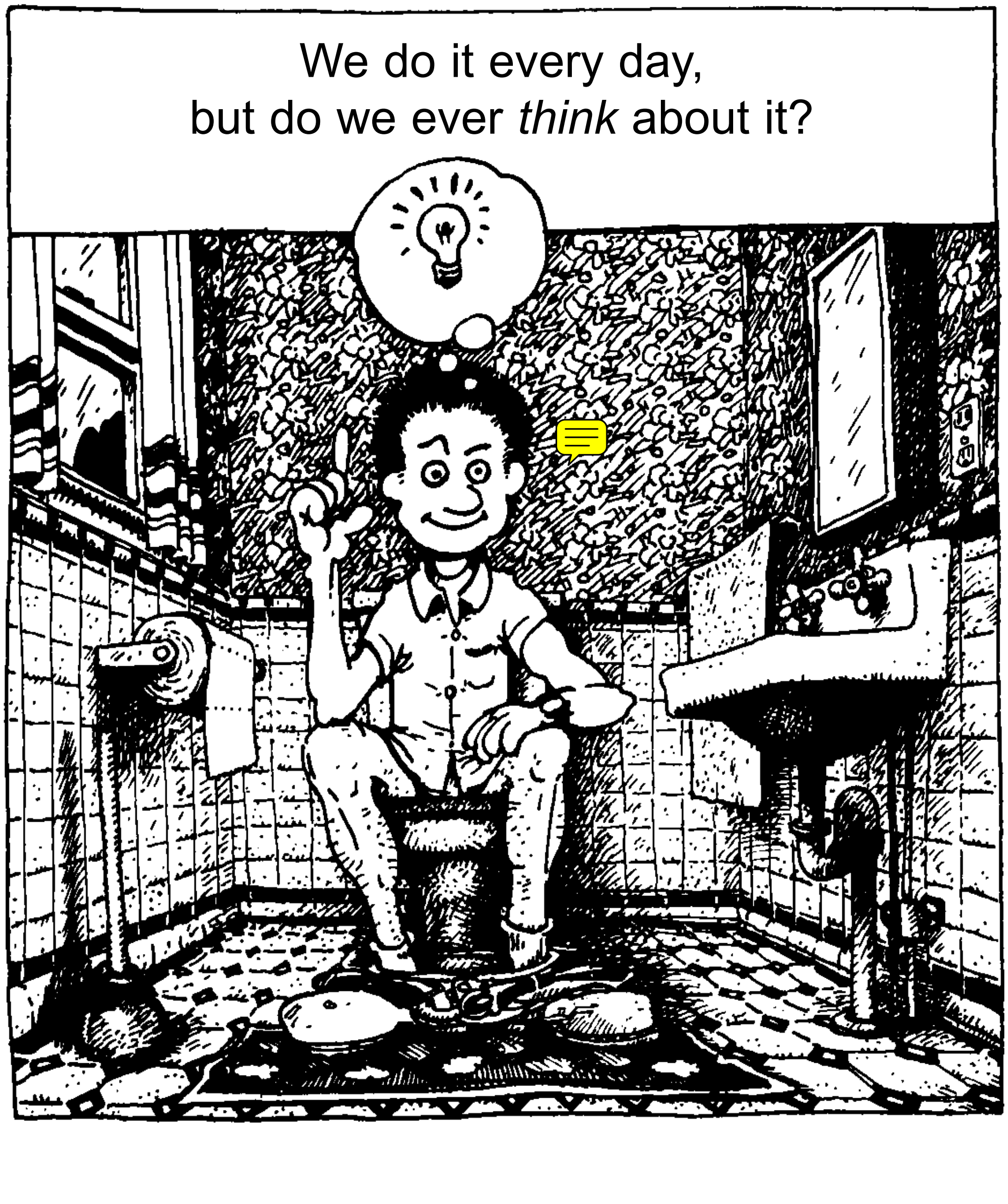
In other words, we have to understand that humanure is a natural substance, produced by a process vital to life (human digestion), originating from the earth in the form of food, and valuable as an organic refuse material that can be returned to the earth in order to produce more food for humans. That's where composting comes in.

But hey, wait, let's not be rash. We forgot about incinerating our excrements. We can dry our turds out, then truck them to big incinerators and burn the hell out of them. That way, instead of having fecal pollution in our drinking water or forests, we can breathe it in our air. Unfortunately, burning sludge with other municipal waste produces emissions of particulate matter, sulfur dioxide, nitrogen oxides, carbon monoxide, lead, volatile hydrocarbons, acid gases, trace organic compounds, and trace metals. The leftover *ash* has a high concentration of heavy metals, such as cadmium and lead.[59] Doesn't sound so good if you live downwind, does it?

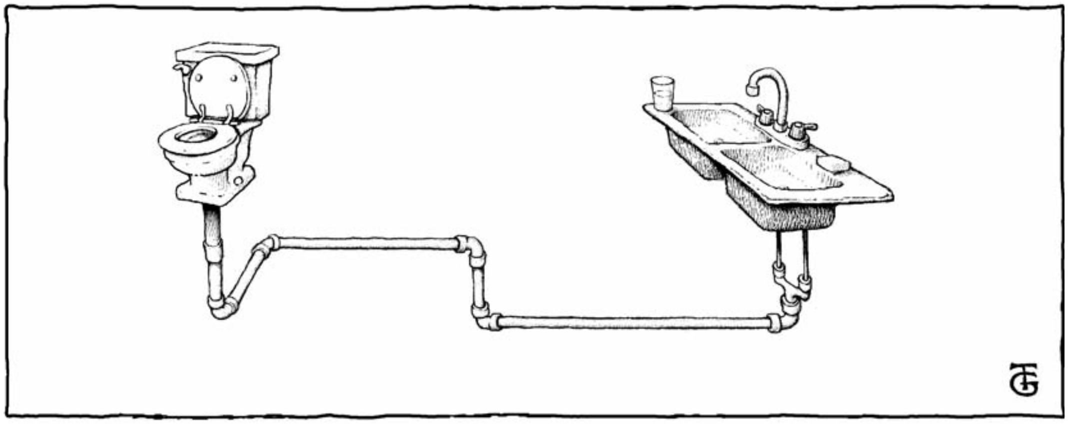
How about microwaving it? Don't laugh, someone's already invented the microwave toilet.[60] This just might be a good cure for hemorrhoids, too. But heck, let's get serious and shoot it into outer space. Why not? It probably wouldn't cost too much per fecal log after we've dried the stuff out. This could add a new meaning to the phrase "the Captain's log." Beam up another one, Scotty!

Better yet, we can dry our turds out, chlorinate them, get someone in Taiwan to make little plastic sunglasses for them, and we'll sell them as pet turds! Now that's an entrepreneurial solution, isn't it? Any volunteer investors out there?


Yeah!
Right here!


We do it every day,
but do we ever *think* about it?

COMPOSTING TOILETS AND SYSTEMS



"Simplicity of life, even the barest, is not misery but the very foundation of refinement."
William Morris

Technically, a "composting toilet" is a toilet in which composting takes place. Usually, the composting chamber is located under the toilet. Other toilets are simply collection devices in which humanure is deposited, then removed to a separate composting location away from the toilet area. These toilets are components of "composting toilet systems," rather than composting toilets, *per se*.

Humanure composting toilets and systems can generally be divided into two categories based on the composting temperatures they generate. Some toilet systems produce thermophilic (hot) compost; others produce low-temperature compost. Most commercial and homemade composting toilets are low-temperature composting toilets, sometimes called "mouldering toilets."

The most basic way to compost humanure is simply to collect it in a toilet receptacle and add it to a compost pile. The toilet acts only as a collection device, while the composting takes place at a separate location. Such a toilet requires little, if any, expense, and can be constructed and operated by people of simple means in a wide range of cultures around the world. It is easy to create thermophilic (hot) compost with such a collection toilet. This type of toilet is discussed in detail in Chapter 8, "The Tao of Compost."

The toilets of the future will also be collection devices rather than waste disposal devices. The collected organic material will be hauled away from homes and composted under the responsibility of municipal authorities, perhaps under contract with a private sector composting facility. Currently, other recyclable materials such as bottles and cans are collected from homes by municipalities; in some areas organic food materials are also collected and composted at centralized composting facilities. The day will come when those collected organic materials will include toilet materials.

In the meantime, homeowners who want to make compost rather than sewage must do so independently by either constructing a composting toilet of their own, buying a commercial composting toilet, or using a simple collection toilet with a separate composting bin. The option one chooses depends upon how much money one wants to spend, where one lives, and how much involvement one wants in the compost-making process.

A simple sawdust toilet (a collection toilet) with a separate compost bin is the least expensive, but tends to be limited to homes where an outdoor compost bin can be utilized. Such a toilet is only attractive to people who don't mind the regular job of emptying containers of compost onto a compost pile, and who are willing to responsibly manage the compost to prevent odor and to ensure thermophilic conditions.

Homemade composting toilets, on the other hand, generally include a compost bin underneath the toilet and do not involve carting humanure to a separate compost pile. They tend to be less expensive than commercial composting toilets, and they can be built to whatever size and capacity the household requires, allowing for some creativity in their design. They are usually permanent structures located under the dwelling in a crawl space or basement, but they can also be free-standing outdoor structures. The walls are typically made of a concrete material, and the toilets are most successful when properly managed. Such management includes the regular addition to the toilet contents of sufficient carbon-based bulking material, such as sawdust, peat moss, straw, hay, or weeds. Homemade composting toilets generally do not require water or electricity.

Commercial composting toilets come in all shapes, types, sizes, and price ranges. They are usually made of fiberglass or plastic, and consist of a composting chamber underneath the toilet seat. Some of them use water and some of them require electricity. Some require neither. A list of commercial compost toilet manufacturers follows this chapter.

COMPOSTING TOILETS MUST BE MANAGED

We have used flush toilets for so long that after we defecate we expect to simply pull a handle and walk away. Some think that composting toilets should behave in the same manner. However, flush toilets are *disposal* devices that create pollution and waste soil nutrients. Composting toilets are recycling devices that should create no pollution and should recover the soil nutrients in human manure and urine. When you push a handle on a flush toilet, you're paying someone to dispose of your waste for you. Not only are you paying for the water, for the electricity, and for the wastewater treatment costs, but you are also contributing to the environmental problems inherent in waste disposal. When you use a composting toilet, you are *getting* paid for the small amount of effort you expend in recycling your organic material. Your payment is in the form of compost. Composting toilets, therefore, require some management. You have to *do* something besides just pushing a handle and walking away.

The degree of your involvement will depend on the type of toilet you are using. In most cases, this involves simply adding some clean organic cover material such as peat moss, sawdust, rice hulls, or leaf mould to the toilet after each use. Instead of flushing, you cover. Nevertheless, someone must take responsibility for the overall management of the toilet. This is usually the homeowner, or someone else who has volunteered for the task. Their job is simply to make sure sufficient cover materials are available and being used in the toilet. They must also add bulking materials to the toilet contents when needed, and make sure the toilet is not being used beyond its capacity, not becoming waterlogged, and not breeding flies. Remember that a composting toilet houses an organic mass with a high level of microscopic biodiversity. The contents are alive, and must be watched over and managed to ensure greatest success.

FECOPHOBIA AND THE PATHOGEN ISSUE

The belief that humanure is unsafe for agricultural use is called *fecophobia,* a term, I admit, I made up. People who are fecophobic can suffer from severe fecophobia or a relatively mild fecophobia, the mildest form being little more than a healthy concern about personal hygiene. Severe fecophobics do not want to use humanure for food growing, composted or not. They believe that it's dangerous and unwise to use such a material in their garden. Milder fecophobics may, however, compost humanure and use the finished compost in horticultural applications. People who are not fecophobic may compost humanure and utilize it in their food garden. Some may even use it raw, a practice *not* recommended by the author.

It is well known that humanure contains the *potential* to harbor disease-causing microorganisms (pathogens). This potential is directly related to the state of health in the population which is producing the excrement. If a family is composting its own humanure, for example, and it is a healthy family, the danger in the production and use of the compost will be very low. If one is composting the humanure from orphanages in Haiti where intestinal parasites are endemic, then extra precautions must be taken to ensure maximum pathogen death. Compost temperatures must rise significantly above the temperature of the human body (37°C or 98.6°F) in order to begin eliminating disease-causing organisms, as human pathogens thrive at temperatures similar to that of their hosts. On the other hand, most pathogens only have a limited viability outside the human body, and given enough time, will die even in low-temperature compost.

Humanure is best rendered hygienically safe by thermophilic composting.

To achieve this, humanure can simply be collected and deposited on an outdoor compost pile like any other compost material. Open-air, outdoor compost piles with good access are easily managed and offer a no-cost, odorless method to achieve the thermophilic composting of humanure. However, such a system does require the regular collection and cartage of the organic material to the compost pile, making it relatively labor intensive when compared to low-temperature, stationary, homemade and commercial composting toilets.

Many people will use a composting toilet only if they do not have to do anything in any way related to the toilet contents. Therefore, most homemade and commercial composting toilets are comprised of large composting chambers under the toilet seat. The organic material is deposited directly into a composting chamber, and the contents are emptied only very occasionally.

Thermophilic conditions do not seem to be common in these toilets, for several reasons. For one, many commercial composting toilets are designed to *dehydrate* the organic material deposited in them. This dehydration is achieved by electrical fans, which rob the organic mass of moisture *and* heat. Commercial toilets also often strive to reduce the *quantity* of material collecting in the composting chamber (mostly by dehydration), in order to limit the frequency of emptying for the sake of the convenience of the user. Bulky air-entrapping additions to the compost are not encouraged, although these additions will encourage thermophilic composting. Yet, even passive, low-temperature composting will eventually yield a relatively pathogen-free compost after a period of time.

Low-temperature composting toilets include most commercial and many homemade units. According to current scientific evidence, a few months retention time in just about any composting toilet will result in the deaths of nearly all human pathogens (see Chapter 7). The most persistent pathogen seems to be the roundworm (*Ascaris lumbricoides*) and particularly the egg of the roundworm, which is protected by an outer covering which resists chemicals and adverse environmental conditions. Estimates of the survival time of *Ascaris* eggs in certain soil types under certain conditions are as high as ten years. Although the *Ascaris* eggs are readily destroyed by thermophilic composting, they may survive in conditions generated by a low-temperature toilet. This is why the compost resulting from such toilets is generally not recommended for garden use if it comes in contact with food crops.

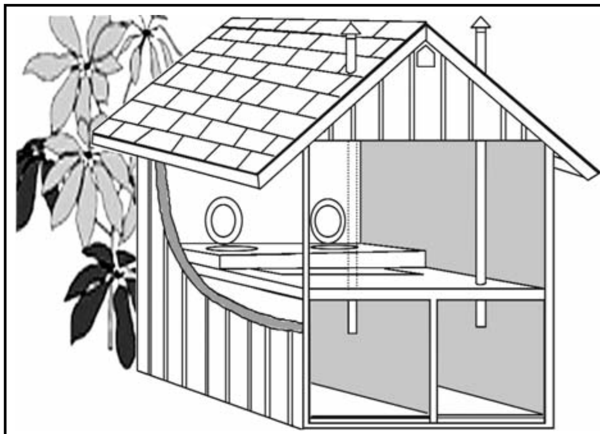
People can become rather obsessive about this issue. One man who published a book on this topic wrote to me to say that a two year retention time in a low-temperature composting toilet is generally considered adequate for the destruction of *Ascaris* ova (eggs). He indicated that he would never consider using his own low-temperature compost until it had aged at least two years. I asked him if he was infected with roundworms. He said no. I asked him if anyone else was using his toilet. No. I asked him what he was worried about then. Why would he think there could be roundworm eggs in his compost when he knew he didn't have roundworms in the first place? Sometimes common sense is not so common. The *potential* dangers of humanure can be blown way out of proportion. This is similar to the phobic person who would never go to a movie theater because there may be someone in the theater who has tuberculosis and who may sneeze. Although this is a risk we all take, it's not likely to be a problem.

OWNER-BUILT COMPOSTING TOILETS

Owner-built composting toilets are in widespread use throughout the world since many people do not have the financial resources required to purchase commercially produced toilets. They tend to be low-temperature composting toilets, although they can conceivably be thermophilic toilet systems if properly managed.

The objectives of any composting toilet should be to achieve safe and sanitary treatment of fecal material, to conserve water, to function with a minimum of maintenance and energy consumption, to operate without unpleasant odors, and to recycle humanure for agricultural use.

The primary advantage of low-temperature toilets is the passive involvement of the user. The toilet collection area need not be entered into very often unless, perhaps, to rake the pile flat. The pile that collects in the chamber must be raked somewhat every few months (which can be done through a floor access door), and the chamber is emptied only after nothing has been deposited in it for at least a year or two, although this time period may vary depending on the individual system used.



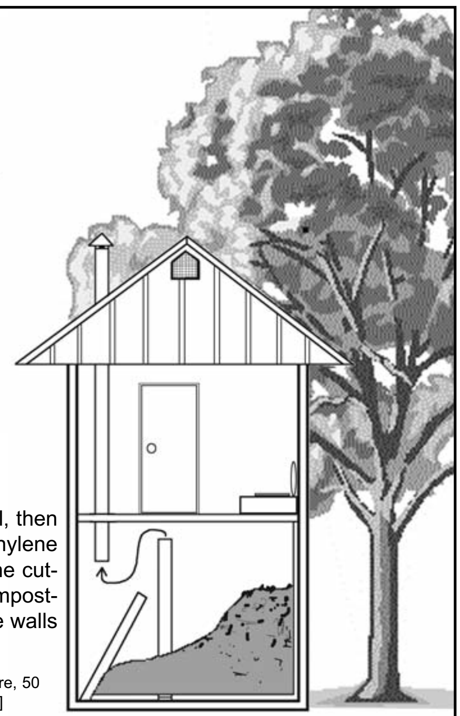


Figure 6.1

Owner-Built Mouldering Toilet

This toilet has two composting chambers, one is used until full, then the other is used. This design uses a false bottom of polyethylene mesh to allow air to circulate under the composting matter. The cutaway view above does not show the insulated doors to the composting chambers. The floors are made of poured concrete and the walls are made of concrete block.

For additional information contact Douglas Clayton at Gap Mountain Permaculture, 50 Bullard Rd., Jaffrey, NH 03452 USA. 603-532-7321 [dnclayton@monad.net]

In order for this system to work well, each toilet must have two chambers. Fecal material and urine are deposited into the first chamber until it's full, then the second chamber is used while the first ages. By the time the second side is full, the first should be ready to empty. It may take several years to fill a side, depending on its capacity and the number of users. In addition to feces, carbonaceous organic matter such as sawdust, as well as bulky vegetable matter such as straw and weeds, are regularly added to the chamber in use. A clean cover of such material is maintained over the compost at all times for odor prevention (see Figure 6.1).

Some of these composting toilets involve the separation of urine from feces. This is done by urinating into a separate container or into a diversion device which causes the urine to collect separately from the feces. The reason for separating urine from feces is that the urine/feces blend contains too much nitrogen to allow for effective composting and the collected material can get too wet and odorous. Therefore, the urine is collected separately, reducing the nitrogen, the liquid content, and the odor of the collected material (see Figure 6.2).

An alternative method of achieving the same result which does not require the separation of urine from feces does exist. Organic material with too much nitrogen for effective composting (such as a urine/feces mixture) can be balanced by adding more carbon material such as sawdust, rather than by removing the urine. The added carbon material absorbs the excess liquid and will cover the refuse sufficiently to eliminate odor completely. This also sets the stage for thermophilic composting because of the carbon/nitrogen balancing.

One may also "precharge" the toilet with a "biological sponge," a thick layer of absorbent cellulose material filling the bottom of the compost chamber to a depth of up to 50% of its capacity. Some suggest that the toilet can be filled to 100% of its

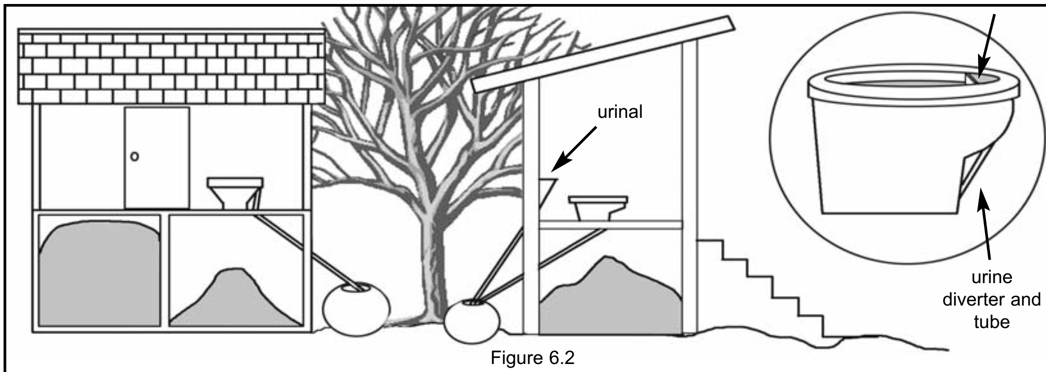


Figure 6.2

GUATEMALAN COMPOSTING TOILET

A variation of the Vietnamese Double Vault, this two chambered composting toilet requires the segregation of urine from feces. The enlarged diagram of the toilet seat at right shows the urine diversion tube, which allows the urine to be diverted to an outside receptacle. The center diagram shows a wall-mounted urinal. The diagram on the left shows one compost chamber full, and the other being filled. The seat is moveable.

Source: Schiere, Jacobo (1989). LASF Una Letrina Para la Familia. Cornite Central Menonita, Technologia Apropriada, Santa Maria Cauque, Sacatepequez, Apartado Postal 1779, Guatemala Cuidad, Guatemala.

capacity before beginning to be used, because if the material is loose (such as loose hay), it will compress under the weight of the added humanure. A bottom sponge may consist of bales of hay or straw buried in sawdust. These materials absorb the excess urine as it is added to the toilet. Fecal material is covered after each use with materials such as sawdust, peat, leaf mould, or rice hulls. A drain into a five gallon bucket (perhaps pre-filled with sawdust) will collect any leachate, which can simply be deposited back on the compost pile. Extra bulking materials such as straw, weeds, hay, and food scraps are regularly added to the compost chamber to help oxygenate and feed the growing organic mass in order to promote thermophilic decomposition. Ventilation can be enhanced by utilizing a vertical pipe installed like a chimney, which will allow air to passively circulate into and out of the compost chamber.

NEW, OWNER-BUILT COMPOSTING TOILET CONCRETE FLOOR with engraved instructions for use

Such systems will need to be custom-managed according to the circumstances of the individuals using them. Someone needs to keep an eye on the toilet chambers to make sure they're receiving enough bulking material. The deposits need to be flattened regularly so that they remain covered and odorless. Chutes that channel humanure from the toilet seat to the compost chamber must be cleaned regularly in order to prevent odors. When one compost chamber is filled, it must be rested while the other is filled. A close eye on the toilet contents will prevent waterlogging. Any leachate system must be monitored. In short, *any* composting toilet will require some management. Remember that you are actively recycling organic material, and that means you are *doing* something constructive. When you consider the value of the finished compost, you can also consider this: every time you deposit into a composting toilet, it's as if you're putting money in the bank.

Homemade low temperature composting toilets offer a method of composting humanure that is attractive to persons wanting a low-maintenance, low-cost, fairly passive approach to excrement recycling. Any effort which constructively returns organic refuse to the soil without polluting water or the environment certainly demands a high level of commendation.

ASIAN COMPOSTING

It is well known that Asians have recycled humanure for centuries, possibly millennia. How did *they* do it? Historical information concerning the *composting* of humanure in Asia seems difficult to find. Rybczynski et al. state that composting was only introduced to China in a systematic way in the 1930s and that it wasn't until 1956 that composting toilets were used on a wide scale in Vietnam.[1] On the other hand, Franceys et al. tell us that composting *"has been practiced by farmers and gardeners throughout the world for many centuries."* They add that, *"In China, the practice of composting [humanure] with crop residues has enabled the soil to support high population densities without loss of fertility for more than 4000 years."* [2]

However, a book published in 1978 and translated directly from the original Chinese indicates that composting has *not* been a cultural practice in China until only recently. An agricultural report from the Province of Hopei, for example, states that the standardized management and hygienic disposal (i.e., composting) of excreta and urine was only initiated there in 1964. The composting techniques being developed at that time included the segregation of feces and urine, which were later "*poured into a mixing tank and mixed well to form a dense fecal liquid*" before piling on a compost heap. The compost was made of 25% human feces and urine, 25% livestock manure, 25% miscellaneous organic refuse, and 25% soil.[3]

Two *aerobic* methods of composting were reported to be in widespread use in China, according to the 1978 report. The two methods are described as: 1) surface aerobic continuous composting; and 2) pit aerobic continuous composting. The surface method involves constructing a compost pile around an internal framework of bamboo, approximately nine feet by nine feet by three feet high (3m x 3m x 1m). Compost ingredients include fecal material (both human and non-human), organic refuse, and soil. The bamboo is removed from the constructed pile and the resultant holes allow for the penetration of air into this rather large pile of refuse. The pile is then covered with earth or an earth/horse manure mix, and left to decompose for 20 to 30 days, after which the composted material is used in agriculture.

The pit method involves constructing compost pits five feet wide and four feet deep by various lengths, and digging channels in the floor of the pits. The channels (one lengthwise and two widthwise) are covered with coarse organic material such as millet stalks, and a bamboo pole is placed vertically along the walls of the pit at the end of each channel. The pit is then filled with organic refuse and covered with earth,

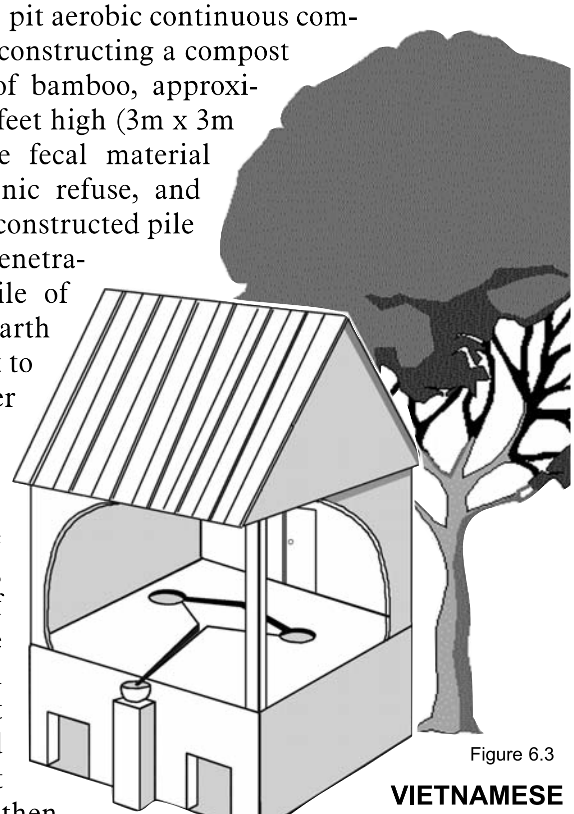


Figure 6.3

VIETNAMESE DOUBLE VAULT

(CUTAWAY VIEW)

and the bamboo poles are removed to allow for air circulation.[4]

A report from a hygienic committee of the Province of Shantung provides us with additional information on Chinese composting.[5] The report lists three traditional methods used in that province for the recycling of humanure:

1) Drying it — "*Drying has been the most common method of treating human excrement and urine for years.*" It is a method that causes a significant loss of nitrogen;

2) Using it raw, a method that is well known for pathogen transmission; and

3) "*Connecting the household pit privy to the pigpen . . . a method that has been used for centuries.*" An unsanitary method in which the excrement was simply eaten by a pig.

No mention is made whatsoever of *composting* being a traditional method used by the Chinese for recycling humanure. On the contrary, all indications were that the Chinese government in the 1960s was, *at that time,* attempting to establish composting as preferable to the three traditional recycling methods listed above, mainly because the three methods were hygienically unsafe, while composting, when properly managed, would destroy pathogens in humanure while preserving agriculturally valuable nutrients. This report also indicated that soil was being used as an ingredient in the compost, or, to quote directly, "*Generally, it is adequate to combine 40-50% of excreta and urine with 50-60% of polluted soil and weeds.*"

For further information on Asian composting, I must defer to Rybczynski et al., whose World Bank research on low-cost options for sanitation considered over 20,000 references and reviewed approximately 1200 documents. Their review of Asian composting is brief, but includes the following information, which I have condensed:

There are no reports of composting privys (toilets) being used on a wide scale until the 1950s, when the Democratic Republic of Vietnam initiated a five-year plan of rural hygiene and a large number of *anaerobic* composting toilets were built. These toilets, known as the Vietnamese Double Vault, consisted of two above ground watertight tanks, or *vaults*, for the collection of humanure (see Figure 6.3). For a family of five to ten people, each vault was required to be 1.2 m wide, 0.7 m high, and 1.7 m long (approximately 4 feet wide by 28 inches high and 5 feet 7 inches long). One tank is used until full and left to decompose while the other tank is used. The use of this sort of composting toilet requires the segregation of urine, which is diverted to a separate receptacle through a groove on the floor of the toilet. Fecal material is collected in the tank and covered with soil, where it anaerobically decomposes. Kitchen ashes are added to the fecal material for the purpose of reducing odor.

Eighty-five percent of intestinal worm eggs, one of the most persistently viable forms of human pathogens, were found to be destroyed after a two month composting period in this system. However, according to Vietnamese health authorities, forty-five days in a sealed vault is adequate for the complete destruction of all bacteria and intestinal parasites (presumably they mean pathogenic bacteria). Compost from such latrines is reported to increase crop yields by 10-25% in comparison to the use of raw humanure. The success of the Vietnamese Double Vault required *"long and persistent health education programs."* [6]

When the Vietnamese Double Vault composting toilet system was exported to Mexico and Central America, the result was *"overwhelming positive,"* according to one source, who adds, *"Properly managed there is no smell and no fly breeding in these toilets. They seem to work particularly well in the dry climate of the Mexican highlands. Where the system has failed (wetness in the processing chamber, odours, fly breeding) it was usually due to non-existent, weak, or bungled information, training and follow-up."* [7] A lack of training and a poor understanding of the composting processes can cause any humanure composting system to become problematic. Conversely, complete information and an educated interest will ensure the success of humanure composting systems.

Another anaerobic double-vault composting toilet used in Vietnam includes using both fecal material *and* urine. In this system, the bottom of the vaults are perforated to allow drainage, and urine is filtered through limestone to neutralize acidity. Other organic refuse is also added to the vaults, and ventilation is provided via a pipe.

In India, the *composting* of organic refuse and humanure is advocated by the government. A study of such compost prepared in pits in the 1950s showed that intestinal worm parasites and pathogenic bacteria were completely eliminated in three months. The destruction of pathogens in the compost was attributed to the maintenance of a temperature of about 40°C (104°F) for a period of 10-15 days. However, it was also concluded that the compost pits had to be properly constructed and managed, and the compost not removed until fully "ripe," in order to achieve the total destruction of human pathogens. If done properly, it is reported that *"there is very little hygienic risk involved in the use and handling of [humanure] compost for agricultural purposes."* [8]

In short, it doesn't look like the Asians have a lot to offer us with regard to composting toilet designs. Perhaps we should instead look to the Scandinavians, who have developed many commercial composting toilets.

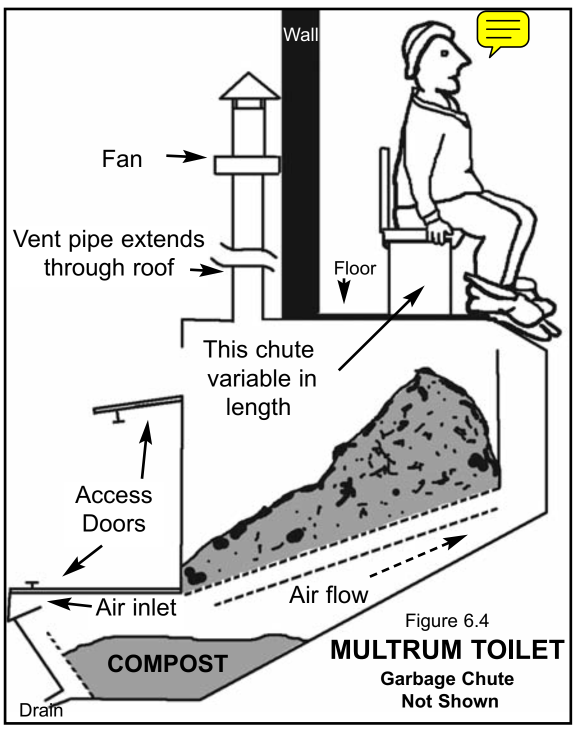


Figure 6.4
MULTRUM TOILET
Garbage Chute Not Shown

COMMERCIAL COMPOSTING TOILETS

Commercial composting toilets have been popular in Scandinavia for some time; at least twenty-one different composting toilets were on the market in Norway alone in 1975.[9] One of the most popular types of commercially available composting toilets in the United States today is the multrum toilet, invented by a Swedish engineer and first put into production in 1964 (see Figure 6.4). Fecal material and urine are deposited together into a single chamber with a double bottom. The decomposition takes place over a period of years, and the finished compost gradually falls down to the very bottom of the toilet chamber where it can be removed. Again, the decomposition temperatures remain cool, not usually climbing above 32^{0}C (90^{0}F). Therefore, it is recommended that the finished compost be buried under one foot of soil or used in an ornamental garden.[10]

Because no water is used or required during the operation of this toilet, human excrement is kept out of water supplies, conserving water. According to one report, a single person using a Clivus (pronounced Clee-vus) Multrum (see Figure 6.5) will produce 40 kg (88 lbs) of compost per year while refraining from polluting 25,000 liters (6,604 gallons) of water annually.[11] The finished compost can be used as a soil additive where the compost will not come in contact with food crops.

A 1977 report issued by Clivus Multrum USA analyzed the nutrient content in finished compost from seven Clivus Multrum toilets which had been in use for 4 to 14 years. The compost averaged 58% organic matter, with 2.4% nitrogen, 3.6%

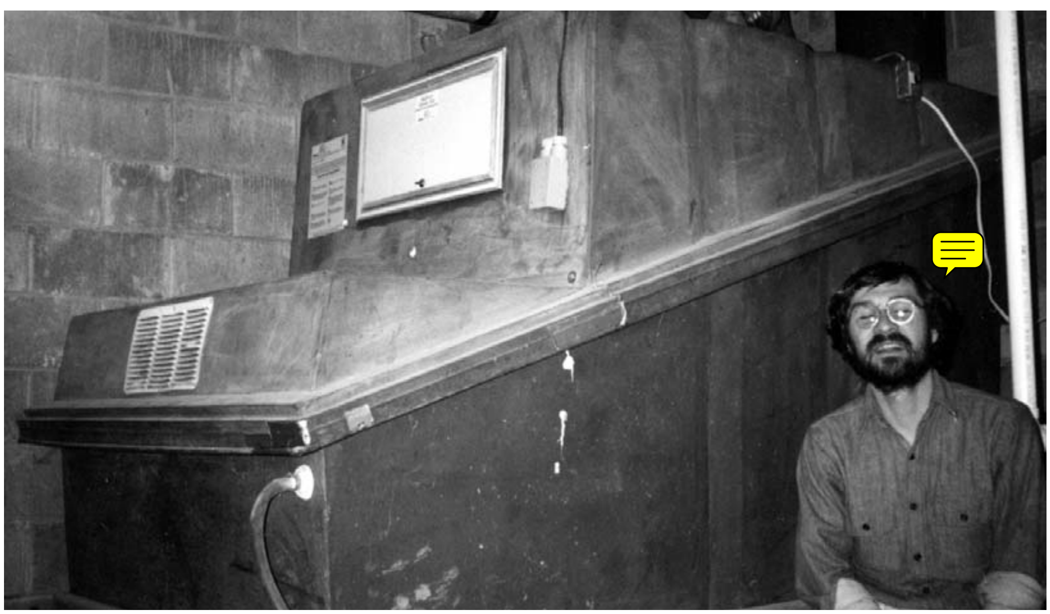


Figure 6.5
CLIVUS MULTRUM
In a Slippery Rock University Building

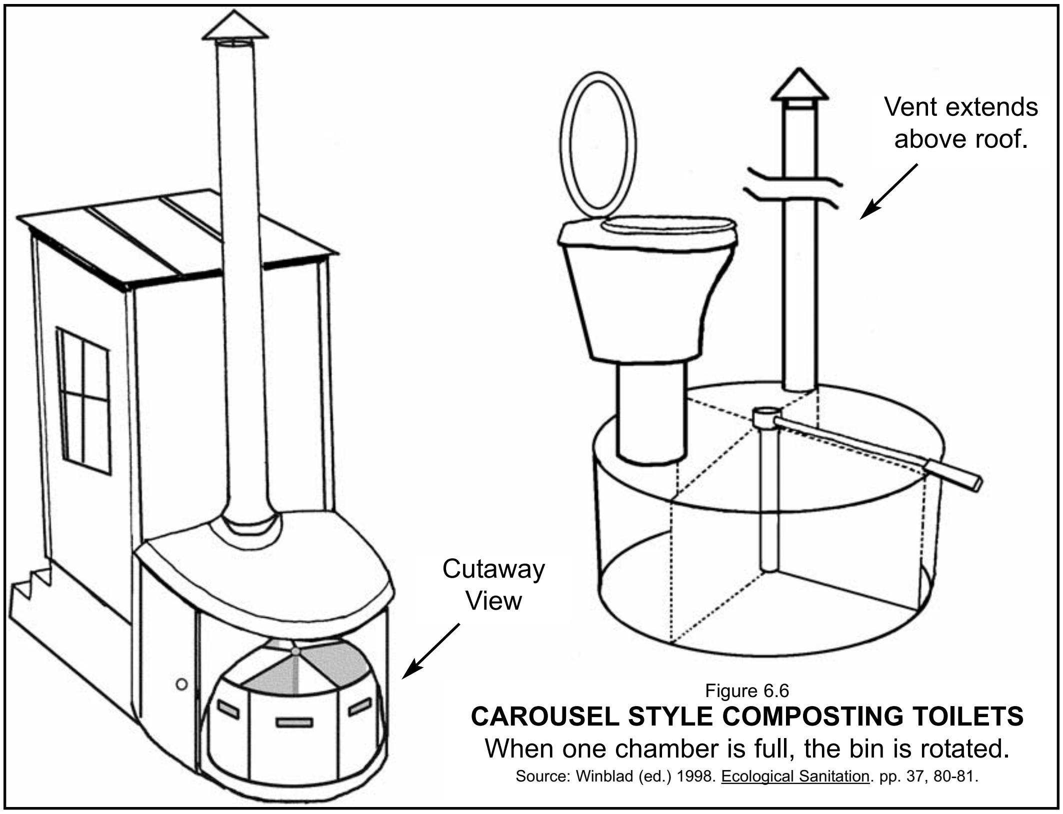


Figure 6.6
CAROUSEL STYLE COMPOSTING TOILETS
When one chamber is full, the bin is rotated.
Source: Winblad (ed.) 1998. Ecological Sanitation. pp. 37, 80-81.

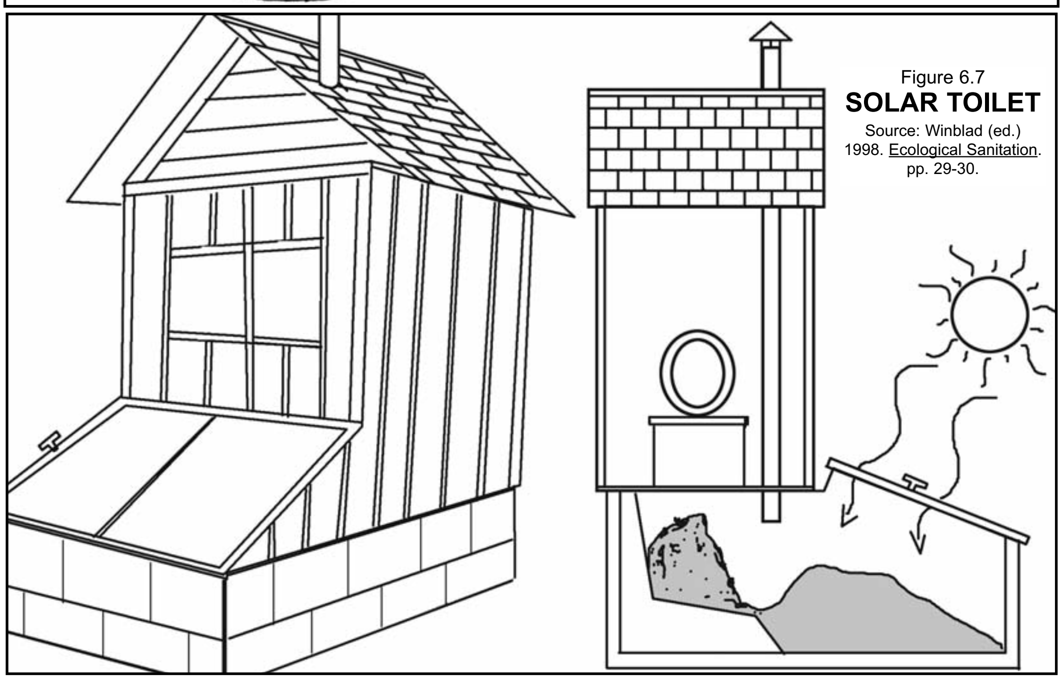


Figure 6.7
SOLAR TOILET
Source: Winblad (ed.) 1998. Ecological Sanitation. pp. 29-30.

phosphorous, and 3.9% potassium, reportedly higher than composted sewage sludge, municipal compost, or ordinary garden compost. Suitable concentrations of trace nutrients were also found. Toxic metals were found to exist in concentrations far below recommended safe levels.[12]

If a multrum toilet is managed properly, it should easily be odor and worry-free. As always, a good understanding of the basic concepts of composting helps anyone who wishes to use a composting toilet. Nevertheless, the multrum toilets, when used properly, should provide a suitable alternative to flush toilets for people who want to stop defecating in their drinking water. You can probably grow a heck of a rose garden with the compost, too.

Inexpensive versions of multrum toilets were introduced into the Philippines, Argentina, Botswana, and Tanzania, but were not successful. According to one source, *"Compost units I inspected in Africa were the most unpleasant and foul-smelling household latrines I have experienced. The trouble was that the mixture of excreta and vegetable matter was too wet, and insufficient vegetable matter was added, especially during the dry season."* [13] Poor management and a lack of understanding of how composting works will create problems with any compost toilet. Too much liquid will create anaerobic conditions with consequent odors. The aerobic nature of the organic mass can be improved by the *regular* addition of carbonaceous bulking materials. Compost toilets are not pit latrines. You cannot just defecate in a hole and walk away. If you do, your nose will let you know that you're doing something wrong.

Besides the Scandinavian multrum toilets, a variety of other composting toilets are available on the market today. One manufacturer claims that over 200,000 of their composting toilets have been sold worldwide. The same manufacturer produces a fiberglass and stainless steel toilet which consists of a drum under the toilet seat or under the bathroom floor into which the feces and urine are deposited. The drum is rotated by hand in order to blend the ingredients, which should include food scraps and a carbon material such as peat moss. The toilet can come equipped with an electric heating system and an electrical fan ventilation system. The compost, produced in small quantities which are removed by pulling out a drawer beneath the drum, is said to be suitable for garden purposes. Some of the models require water as well as electricity (although some require no electricity or water).[14]

Other composting toilets cost upwards of $10,000 or more, and can be equipped with insulated tanks, conveyers, motor-driven agitators, pumps, sprayers, and exhaust fans.[15] According to a composting toilet manufacturer, waterless composting toilets can reduce household water consumption by 40,000 gallons (151,423 liters) per year.[16] This is significant when one considers that only 3% of the Earth's water is not salt water, and two-thirds of that freshwater is locked up in ice. That means that less than one percent of the Earth's water is available as drinking water. Why shit in it?

COMPOSTING TOILETS AND RELATED PRODUCTS: MANUFACTURERS AND SUPPLIERS

(Special Thanks to the World of Composting Toilets Web Site at http://www.nwnet.co.uk/earthwise)

This list is provided for informational purposes only. Inclusion on the list does not constitute an endorsement by the author.

AUSTRALIA

CLIVUS MULTRUM AUSTRALIA
115 Railway Avenue, Strathpine, Qld 4500
Australia; Phone: 61 7 3889 6144
Fax: 61 7 3889 6149; Mobile phone: 0419 657851
web site address: www.earthlink.com.au/clivus
e-mail address: www.ats.com.au; Contact: Tony Rapson; Sells the Clivus Multrum range of toilets and graywater systems as well as toilet buildings for use in National Parks and Public areas. Also acts as agent for Separett and EnviroLet composting toilets.

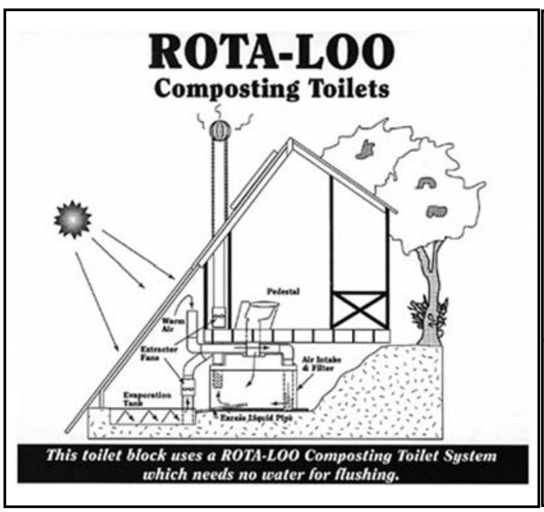
CLIVUS MULTRUM TOILET SYSTEMS (Agent)
9 Holland Street, Fremantle 6160, Western Australia
Australia; Phone: (08) 9430 7777
Fax: 61 8 9430 4305
Email: gaianet@cygnus.uwa.edu.au
Agent for Clivus Multrum composting toilets in western Australia.

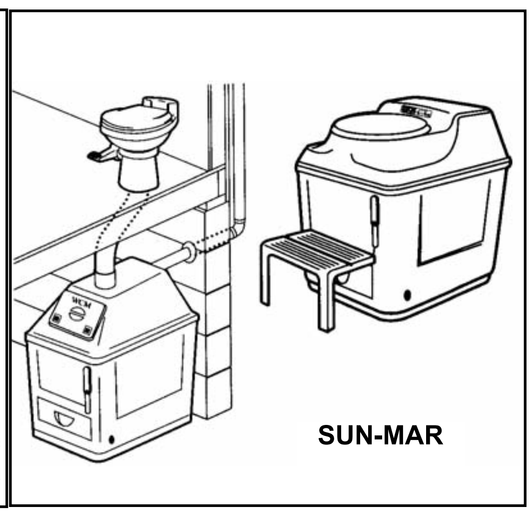
CLOSET DEPOSIT
3 Redash Place, Cabarita Beach, NSW 2488
Australia; Contact: Graham Clements; Supplies own design, inclined base, fibreglass composting chamber. Improved ventilation system for reduced tank size. Also supplies artificial wetlands graywater system in ferro-cement or HDPE plastic with flowform water conditioners.

DOWMUS Pty Ltd
PO Box 400, Mapleton Qld, 4552, Australia
Phone: 61 7 5499 9828; Fax: 61 7 5499 9688
Email: dowmus@ozemail.com.au
Web page: http://www.dowmus.com
Supply and install single batch tank system with compost extortion auger. Emphasis on worm and compost fauna treatment. Also incorporating graywater treatment.

GARRY SCOTT COMPOST TOILET SYSTEMS
Mullumbimby NSW, 2482, Australia
Phone: 61 2 6684 3468; FAX: 61 2 6684 4567
Email: enquires@composttoilets.com.au
Web page www.composttoilets.com.au
Design, manufacture, supply and service of a wide range of waterless compost toilets. Independent agent for systems manufactured by Clivus Multrum, Natureloo, Envirolet, Separett and selected others. Manufacture of lowcost PBD and Wheelie Batch systems. Ownerbuilder assistance with consultation, components, plans and books. Agent for the Hybrid toilet system, a septic system, with no flush, secondary treatment and excellent performance.

NATURE-LOO
Savannah Environmental Pty Ltd, 74 Brisbane Street, Bulimba, QLD 4171, Australia; Postal address: P.O. Box 150,Bulimba, Queensland, Australia 4171; PH: 61 7 3395 6800; FAX: 61 7 3395 5322





Email: info@nature-loo.com.au
Web site: www.nature-loo.com.au; Contact: Carla Gregg; Patented market-leader in domestic composting toilets: inexpensive, aerated tank, odour-free, batch system. Classic model easily owner-installed in space under floor. Self-contained Compact model can be installed on slab floor, and is suitable for temporary accommodation, holiday cabins, building sites, camp grounds, etc. Also markets toilet buildings suitable for golf courses, building sites, etc.

ROTA-LOO COMPOSTING TOILET
41A Jarrah Drive or PO Box 988,Braeside, Victoria 3195 AUSTRALIA; Phone: 61 3 9587 2447
Fax: 61 3 9587 5622; http://www.rotaloo.com
email: buzzburrows@rotaloo.com
General info: enquiry@rotaloo.com; Contact: Buzz Burrows (General Manager); Products: Domestic models, Mini 650, Standard 950 all with removable compost bins. Commercial models, Maxi 1200 (Fiberglass) Maxi 2000, all with removable compost bins. Soltran buildings, remote location Public Toilet Facilities, supplied in kit form in any configuration with combinations of two cubicles either standard or disabled. Graywater systems, plans available for passive systems or electropurification system will clean graywater to potable standard. Other products:Bacterial agents to speed up the decomposition rate.Bacterial agents that terminate odour problems in bad installations. Full range of accessories, fiberglass and ceramic pedestals. Urinals that don't need water for cleaning.

BELGIUM

ECOSAVE SEPARETT (AGENT)
Flierenbos 67, 2370 Arendonk, Belgium
Ph/Fax: 32 14 67 20 04; Agent for Septum and Separett urine separating composting toilets.

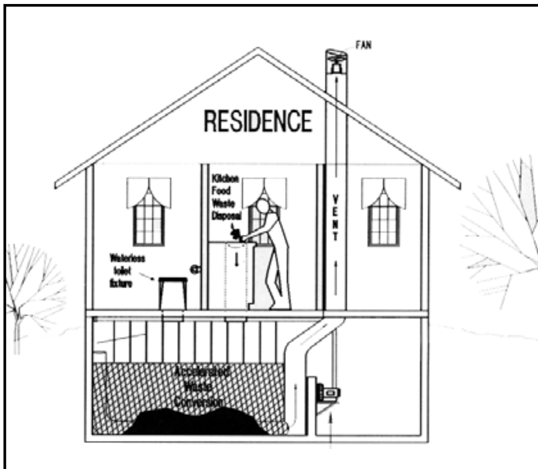
CANADA

CLIVUS MULTRUM CANADA LIAISON OFFICE
1911 Lorraine Place, Ann Arbor, MI 48104-3607
Contact: Laurence Scott ; Tel:734-995-4767; Fax: 734-994-1292 ;Email: naylorscott@compuserve.com

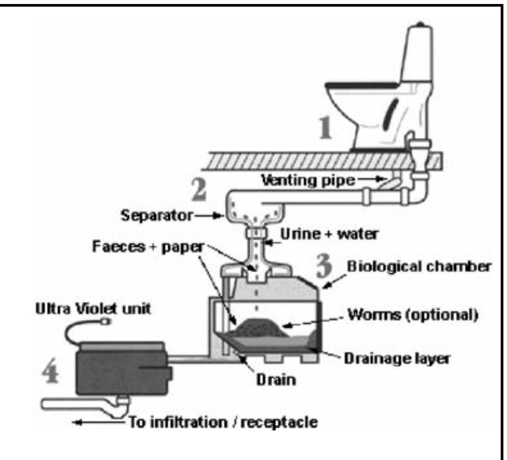
CLIVUS MULTRUM CANADA LTD.
1558 Queen Street, East Toronto, Ontario, M4L 1E8 or P.O.Box 783 - Station A, Windsor, Ontatio, N9A 6N8; Tel: 800-645-4767; Fax: 416-466-0635
Attn: L H Scott; Email: naylorscott@compuserve.com
Canada-USA Liaison; Tel: 734 995 4767
Fax: 734 994 1292

COMPOSTING TOILETS WESTERN (Agent)
1278 Inglewood Avenue, West Vancouver, B.C. B7T 1Y6, Canada; Phone: 1 604-926-3748
Fax: 1 604-926-4854; Contact: Bob Tapp

COMPOSTING TOILETS WESTERN
23646 16th Avenue, Langley B.C.V2Z 1K9, Canada;
Tel/Fax: 1 604-533-5207; Contact: J. Rockandel;
Supply and install Clivus Multrum composting toilets and Sum-mar composting toilets.



BIO-SUN



AQUATRON

SANCOR
140-30 Milner Ave., Toronto, Ontario M1S 3R3
Canada; USA Toll-Free: 1-800-387-5126
CDA Toll-Free: 1-800-387-5245
International: 1-416-299-4818; Fax: 1-416-299-3124
Email: info@envirolet.com
Web Site: http://www.envirolet.com
Online Store: http://www.sancor.net
Manufacturer of Envirolet Composting Toilet Systems. The systems include Waterless Self-Contained, Waterless Remote and Low Water Remote models. Available in Non-Electric, 12v Battery, Solar and 110v Electric. Available for purchase online.

SUNERGY SYSTEMS LTD
Box 70, Cremona, AB T0M 0R0, Canada
Phone: 403-637-3973
Email: sunergy@telusplanet.net
www.compostingtoilet.com; Contact: Michael Kerfoot
Also at: Sunergy's B.C. Office: 2945 Haliday Crescent, Nanaimo, B.C. V9T 1B2 Canada
Phone: 250-751-0053; Fax: 250-751-0063
Sunergy distributes Phoenix composting toilet systems in Canada for residential and public facility applications. Installations from coast to coast include National Parks, Provincial Parks, roadside rest areas, golf courses, responsible housing, etc. Design integrates solar/energy/resource efficiency with a natural whimsy.

SUN-MAR CORPORATION
5035 N Service Rd C9, Burlington Ontario
L7L 5V2 Canada; Phone: 1 905 332 1314
Fax: 1 905 332 1315; For a Free Catalogue Call: 1-800-461-2461; Email:compost@sun-mar.com;
Web page: http://www.sun-mar.com
Long time successful suppliers of bathroom installed composting toilets. Large range of models available for differing situations; both residential and cottage use toilets available.

CHILE

MINIMET S.A.
Av. 11 de Septiembre 1860, Of. 106 , Santiago, Chile
Contact: Jaime Arancibia; Tel: 56-2-233-53 69
Fax: 56-2-232-11 95
e-mail address: ggminimet@entelchile.net
Manufactures and sells Clivus Multrum products under license from Clivus Multrum, USA.

DENMARK

A & B BACKLUND APS (Agent)
Ordrupvej 101, DK-2920 Charlottenlund, Denmark;
Phone: 45 39 63 33 64; Fax: 45 39 63 64 55
Email: backlund@backlund.dk
We work with ecological environmental engineering and waste to energy subjects. We sell no-mixing composting toilets in plastic, pine wood, metal or china. Our big composting units are made of stainless steel or glassfiber with geotextile sacks. The toilets are either without flushing, with single flushing for urine, double flushing for both urine and feces (but separate), or with vacuum for feces and gravitation for urine. Agent for Separett, Septum, Mullis, WM-Ekologen.

B & O BYGGEINDUSTRI A/S
Pakhus 12, Sdr. Frihavn, Dampfaergevej 8, 2100
Kobenhaun 0, Denmark; Contact: Dany Vandy
Tel: 45 35 43 01 01; Fax: 45 35 43 25 22
Web site address: www.bobyg.dk
E-mail address: www.info@bobyg.dk
Sells and markets Clivus Multrum products as agent for Clivus AB, Sweden.

FINLAND

EKOLET (BIOLETT)
Estetie 3, FIN-00430 Helsinki, Finland
Phone: +358 40 546 4775, Fax: +358 9 563 5056
Email: eko@dystopia.fi
Web page: http://www.dystopia.fi/ekolet
The Ekolet composting toilet is the manufacturer's own design for domestic and cottage use. Good experience and test results for over 10 years. Requires no water, no additives, low or no el. requirements, cleans the liquid biologically so it can be piped along with graywater. Consists of a toilet seat and a 4 chamber rotating composting tank (polyethene, stainless steel) under the floor. The end-product is ready-to-use odorless fertilizer.

LUONTO-LAITE OY
Kasiniemenraitti 229, FIN-17740 KASINIEMI
FINLAND; Tel +358 (0)3 556 8132;
Fax +358 (0)3 556 8133; Email luontola@sci.fi
MARKETING: **NEXET OY**, Ravurinkatu 11
FIN-20380 TURKU, FINLAND
Tel +358 (0)2 276 0250; Fax +358 (0)2 276 0251
Email nexet@nexet.fi;
Web site: http://www.saunalahti.fi/luontola
The Composting Naturum Toilet. Bathroom installed, urine separating, rotary drum, composting toilet. Stylish design toilet in non-PVC plastic.

GERMANY

BIOTECHNIK (Agent)
Sigrid Habel, Lessingstr.6, D-04109 Leipzig
Germany; Phone:+49 342 234 8657
Fax: +49 341 980 3391
Agent for Biolett (Ekolet) composting toilets.

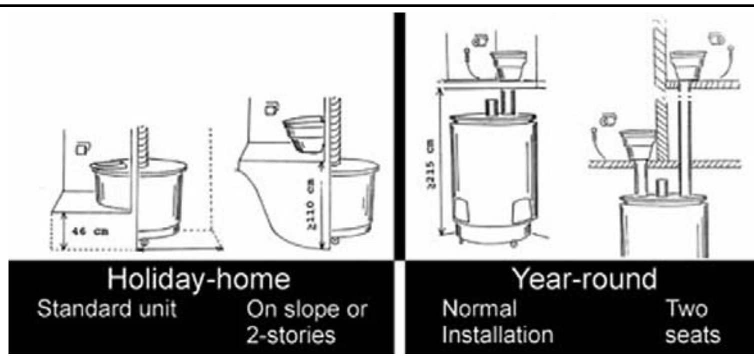
PEUSER GMBH (Agent)
Siloweg 1, D-56479 Neunkirchen/Ww
Germany; Phone: 49 6436 35 45
Fax: 49 6436 64 99
Agent for Septum toilets and products.

PEUSER GMBH (Agent)
Stollberger Strasse 31
D-09221 Neunkirchen/bei Chemnitz, Germany
Phone: 49 371 281 21 ?0; Fax: 49 371 281 21 50
Agent for Septum and Separett composting toilets and products.

SANITÄR U. HEIZUNG (Agent)
Uwe Reimer, Hallesche Strasse 9, D-04509
Delitzsch, Germany
Ph: 49 342 025 9281; Fax: 49 177 275 0928
Agent for Biolett (Ekolet) composting toilets.

C. & M. SCHÖNBERGER GBR (AGENT)
Blumenstrasse 11; D-61239 Langenhain
Tel +49 6002-92990; Fax +49 6002-92980
Agent for Separett Toilets

SOLTEC GMBH (Agent)
Wichmannstrasse 4, Bldg. 10, D-22607 Hamburg,
Germany; Email: soltec@enbil.de
Phone: +49 40 89 50-25; Fax: +49 40 89 50-28
Agent for Biolett (Ekolet) composting toilets.



EKOLET

IRELAND

THE OLD RECTORY
Robert Forrester, Easkey, Co. Sligo
Republic of Ireland; Tel/Fax +353 96 49 181
Email: adlib@tinet.ie; Agent for Septum and Separett servicing both UK and Ireland.

ISRAEL

ECONET ENVIRONMENTAL TECHNOLOGIES & PROJECTS LTD
Dr. Amram Pruginin, 11 Bialik St, Jerusalem, Israel; Tel/Fax: (972)-2-653 61 71
Email: msamram@pluto.mscc.huji.ac.il
Agent for Clivus Multrum in Israel.

KOREA

CLIVUS KOREA, INC.
701 Marco Polo Building, 720-20 Yeoksam-Dong, Kangnam-Ku, Seoul, 135-080 Korea; Tel: 82-2-501-4794/5; Fax: 82-2-568-4631; Contact: J.H. Um; Manufacture and market Clivus Multrum under license from Clivus Multrum USA.

LATVIA

SIA APRITE (Agent)
Gaujas iela 56, Cesis LV-4101, Latvia
Phone/Fax: 371 41 25 033
Agent for Septum toilets and products.

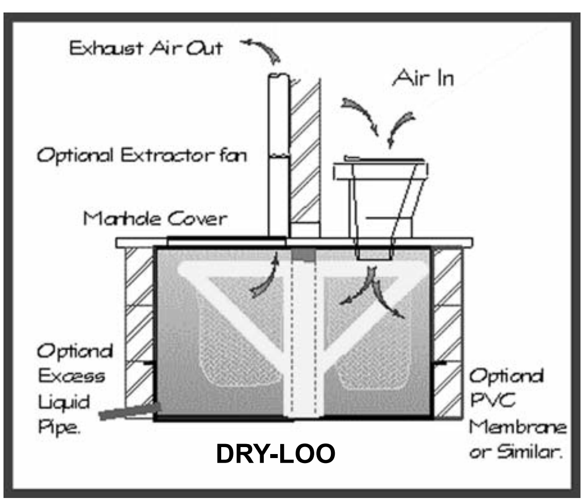
NETHERLANDS (HOLLAND)

CLIVUS MULTRUM
ECOSAVE - Mr. Danny Vandy;
Noorderbaan 25, 8256 PP Biddinghuizen, Holland;
Tel: (31)-321-332-038; Fax: (31)-321-330-975
Agent for Clivus Multrum composting toilets, Septum and Separett.

TECHNISCH BUREAU HAMAR
Heykampsweg 6, 7642 LP Wierden,Netherlands; Phone: 31 546 575697; Email: tbhamar@xs4all.nl; Web page: http://www.xs4all.nl/~tbhamar; Contact: Hans Baarslag; Makes and sells composting toilets for camping, temporary dwellings and replacement in normal houses. The designs are simple and utilize common materials in their manufacture. They are designed for economic treatment of toilet deposits and some household organic material.

NEW ZEALAND

ECOTECH (Agent)
RD 1 Masters Access Rd., Kaitaia, 0500 New Zealand; Ph/Fax: 64 9 409 4993; Website: http://www.ecotech.co.nzed
Email: ecotech/nzed@xtra.co.nzed
Contact: J. Douglas Donnell. Distributors of Sun-Mar composting toilets.



NORWAY

IMPERIAL ENGOS AS
Langgaten 71 A, Postboks 98
N 4301 Sandnes, Norway; Tel: 47 51 66 44 92
Fax: 47 51 62 36 07; Agent for Separett.

VERA
Vera Miljo A/S, Postboks 2036, N-3239 Sandefyord
Norway

SOUTH AFRICA

DRYLOO
PO Box 75619, Gardenview 2047, South Africa
Tel/Fax: 2711 615 5328, Mobile: 2782 463 0674
Email: theboys@netactive.co.za
Website: www.housingsupport.co.za
DRYLOO waterless collapsible low cost composting toilets. Six catchment bags on rotatable piping carousel. No mechanical parts. Suitable for hot conditions. Prov. Pat. 99/1278. Also solar toilet extraction fans. Available from Michael Mayers and Associates. The specialist in African non-flush toilets.

ENVIROLOO
Enviro options (Pty) Ltd, P.O. Box 27356, Benrose, 2011, South Africa
Tel: 27 11 6181350; Fax: 27 11 6181838
Established composting toilet maker/installer.

SPAIN

CLIVUS MULTRUM
Willi Knackstedt, Tel/Fax: (34)-95-266 60 25
Mobile: 989 82 22 30; Email: Carl@websida.com

SWEDEN

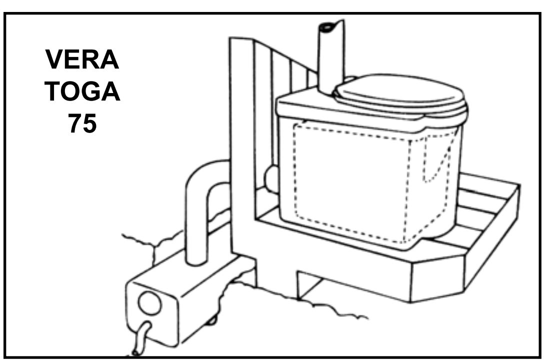
AQUATRON INTERNATIONAL
Bjornnasvagen 21, S-113 47 Stockholm, Sweden
Phone: 46-8-790 9895; Fax: 46-8-15 7504
Email: info@aquatron.se
Website: http://www.aquatron.se
Contact: Rolf Kornemark or Torgny Sundin.
Systems that use standard flush toilets connected to composting chambers via a centrifugal separator. The composting chamber is either inclined base, single batch or 4 chamber carousel. Graywater is treated with UV prior to drainage to a Graywater infiltration bed..

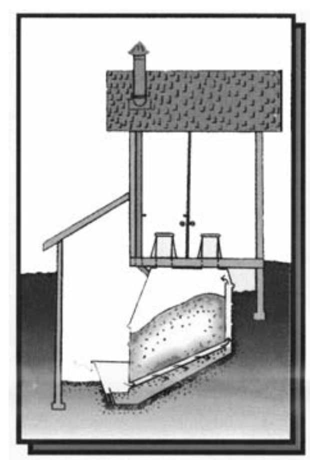
CLIVUS MULTRUM AB
Ålberga Boställe, 61050 Jönåker, Sweden
Phone: (46)-155-72310; Fax: (46)-155-72390
Email: torb@clivus-multrum.se
Main office in Europe for Clivus Multrum Composting Toilets

EKOLOGEN AB
Box 11162 - 10061, Stockholm, Sweden
Phone: 46 8 641 4250; Fax: 46 8 798 5650
Urine separating composting toilet systems.

MULLIS - THE BIOLOGICAL TOILET
Luxgatan 1, 119 69 Stockholm, Sweden
Phone: +46 8 656 54 56; Fax (?): +46 8 184 71 8
E-mail: mullis@hem3.passagen.se
Web site: http://hem3.passagen.se/mullis/
Contact: Uno Finnstrom; Supplies an inclined base composting toilet with 4 air tracks, built in rustfree sheet metal. Can be ordered made in desired length for capacity required.

SERVATOR SEPARETT AB
Skinnebo, S-330 10 Bredaryd, Sweden
Phone: +46 371 712 20 ; Fax: +46 371 712 60





COMPOST TOILET SYSTEMS

Email:servator@mbox200.swipnet.se
Web site: http://www.separett.com/
Suppliers of Lectrolav and Separett toilets, and now Septum composting toilets.

SVEN LINDEN AB
Ludvigsborg, 24394 Hoor, Sweden
Phone: 46-415-51335; Fax: 46-415-51115
Mobile phone: 070 584 76 52; Contact: Sven Linden
Produce a number of capacity tanks based on the single batch system with or without inclined base. Also a wheeled bin system is available.

SWEDISH ECOLOGY AB
Klippan 1A, S-414 51 Goteborg, Sweden
Phone: 46 31 42 29 30; Fax: 46 31 42 49 08
Contact: Harry Lejgren; Agent for the MullToa and Separera systems. These are the equivalent Scandinavian names for the Biolet and UFA toilets supplied by Biolet International.

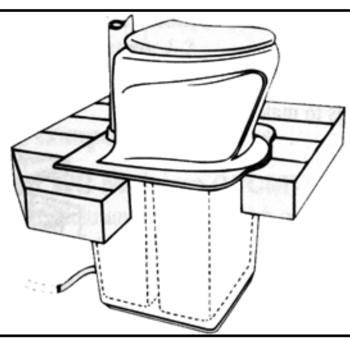
SWITZERLAND

BIOLET INTERNATIONAL
Weidstrasse 18a, 6300 Zug, Switzerland
Tel: ++41-41-710-4728; Fax: ++41-41-710-4683
Web page: http://www.biolet.com
E-mail: info@biolet.com; Established, world-wide suppliers of 9 models of unit compost toilets for bathroom and under-house installation.

UK

BARTON ACCESSORIES
Morleigh Road, Harbertonford, Totnes, Devon
TQ9 7TS, England
Phone/Fax: 44 1803 732878; Supplies the WEB toilet, a waterless electronic/biological toilet unit that fits in bathroom. In-built heat treatment in composting cycle. Is able to supply world-wide. New model: 12/24v DC, small enough for recreational vehicles, boats, motor coaches, domestic; can be run from solar cells, batteries, or wind generator.

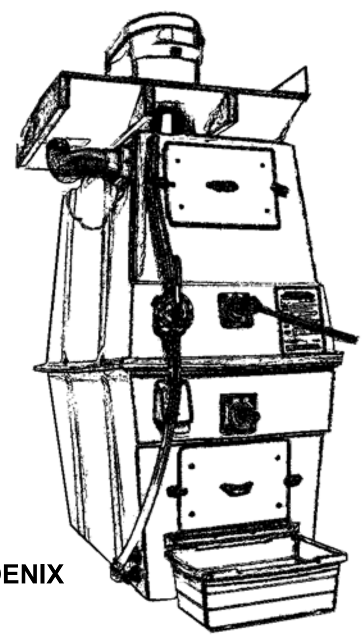
VERA TOGA LUX



EASTWOOD SERVICES
Kitty Mill, Wash Lane, Wenhaston, Halesworth, Suffolk, IP19 9DX, England
Phone/Fax: 44 1502 478165
Contact: Adam East. UK agent for Sun-Mar composting toilets and low flush systems. Supplier of gray and rain water recycling systems.

EKOLOGEN/NATRUM/SEPTUM
EASTWOOD SERVICES , c/o Kitty Mill, Wash Lane
Wenhaston Halesworth, Suffolk IP19 9DX England
Phone: 44 1502 478249, Fax: 44 1502 478165

ELEMENTAL SOLUTIONS
Oaklands Park, Newnham-on-Severn
Gloucestershire, GL14 1EF, UK
Phone: 01594 516063, Fax: 01594 516821
Email mark.es@aecb.net
Contact: Mark Moodie. Incorporates 'Camphill Water' and 'Nick Grant Ecological Engineering'; responsible for over 100 reed bed sites and compost toilet installations. Ceramic composting toilet pedestals. Own design and site specific composting toilet kits. UK and Ireland agents for 'Aquatron' toilet systems. Co writers of "Sewage Solutions; Answering the Call of Nature" and "Septic Tanks." Low water use fittings. Sewage courses, and rainwater harvesting. Genuine enquiries only please.



PHOENIX

KINGSLEY CLIVUS ENVIRONMENTAL PRODUCTS LTD.
Kingsley House, Woodside Road, Boyatt Wood Trading Estate, Eastleigh, Hampshire S050 4ET Great Britain; Tel: 44-01703-615680; Fax: 44-01703-642613; Contact: Viv Murley; Sells and markets Clivus Multrum products as agent for Clivus Multrum USA.

MAURICE MOORE
26 St Mary's Rd, Long Ditton, Surrey KT6, England
Phone: 44 181 398 7951
Agent for Soltrna/ Rota-loo in United Kingdom.

WENDAGE POLLUTION CONTROL LTD (Agent)
Rangeways Farm, Conford, Liphook, Hants UK
GU30 7QP; Phone: 44 1428 751296
Fax: 44 1428 751541
Contact: Nigel Mansfield. Agent for Biolet self-contained electrical compost toilets, in several varieties for home, caravans and portacabins. Also consultants in water, sewage and pollution control.

USA

ADVANCED COMPOSTING SYSTEMS
195 Meadows Road, Whitefish, MT, 59937, USA
Phone: 1 406 862 3855; Fax: 1 406 862 3855
Email: phoenix@compostingtoilet.com
Web site: www.compostingtoilet.com; Contacts: Glenn Nelson, James Conner. Manufactures the Phoenix Composting Toilet, a continuous throughput system featuring odorless, waterless operation, and built-in liquid respray of the composting pile. Very low energy requirements (five watts). Options include microflush toilets, auxillary evaporators, and photovoltaic systems for off-grid installations. Residential and public facility models available.

ALASCAN CLEARWATER SYSTEM
3498 St. Albans Road, Cleveland Heights, OH 44121 USA; Ph: 1 216 382 4151; Contact: David Kern; Email: Drewid@star21.com; Originally developed, tested and supplied in Alaska. The system uses either one cup per flush, or foam flush toilets, and a basement system comprised of one composting tank, one graywater treatment tank, & optional recycling system. System effluents are topsoil & potable water.

English/Welsh sign at the Center for Alternative Technology, Machynlleth, Powys, Wales

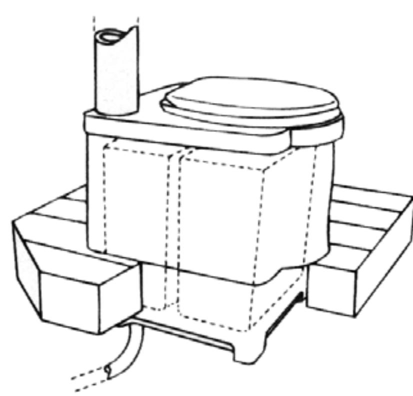
ALASCAN CLEARWATER SYSTEM (CONT.)
They have a 15 minute video about the system, available for $15 US including S&H.

ALASCAN OF MINNESOTA, INC.
8271 - 90th Lane, Clear Lake, MN 55319 USA
Marketing Manager: Jerry L. Carter
Phone: (320) 743-2909; Fax: (320) 743-3509
Email: mail@alascanofmn.com
Web Page: www.alascanofmn.com

ARCHITERRA ENTERPRISES, INC
0186 SCR 1400, BRR, Silverthorne, CO 80498 USA
PH/FAX: 970-262-6727
EMAIL: natural@colorado.net
WEBSITE: http://thenaturalhome.com
CATALOG: The Natural Home Building Source (24 pages); We sell and install graywater system packages, and Clivus Multrum and Sun-Mar composting toilet systems.

BIOLET U.S.A.
45 Newbury Street, Boston, MA 02116 USA
Tel: (617) 578-0435; Fax: (617) 578-0465
http://www.biolet.com; E-mail: info@biolet.com
Established manufacturer (since 1972) and worldwide supplier of BioLet composting toilets. Self contained, remote and non electric units are available.

BIO-RECYCLER CORP.
5308 Emerald Drive, Sykesville, MD 21784 USA
Phone: 1 410 795-2607; Fax: 1 410 549 1445
Contact: Jeremy Criss; Vermiculture based remote processing unit to which toilet deposits are delivered, using minimal water, by vacuum assisted toilet units. The resultant product is high nutrient worm castings used for soil amendment.



VERA TOGA 50

BIO-SUN SYSTEMS INC.
RR#2 Box 134A, Route 549, Jobs Corners, Millerton, PA 16936, USA; Email: bio-sun@ix.netcom.com
(Toll free): (800) 847-8840; Phone:1-717 537 2200; Fax: 1 717 537 6200
Email: bio-sun@ix.netcom.com; Contact: Becky Heffner, Al White; Composting toilet system based on the use of in-situ built tank and intermittent compressed air blown through composting pile.

CENTRE FOR ECOLOGICAL POLLUTION PREVENTION
P.O. Box 1330, Concord, MA 01742-1330 USA
Phone 978/369-9440; Email:CEPP@hotmail.com
The CEPP develops, promotes and demonstrates innovative lower-impact technologies and systems, with an emphasis on utilization and zero-discharge approaches. Their most important successes have been the development of low cost net composting systems that are suitable for developing countries and the development of planted treatment systems for graywater utilization.

CLIVUS MULTRUM US
15 Union Street, Lawrence MA, 01840, USA
Phone: 1 978 725 5591; 1 800 4 CLIVUS
Fax: 1 978 557 9658
Email: forinfo@clivusmultrum.com
Webpage:http://clivusmultrum.com/ Contact: Don Mills; Sole manufacturer of the Clivus Multrum, original design of inclined base composting toilet. Residential models as well as commercial systems. Also sell toilet buildings and graywater treatment systems.

CLIVUS NEW ENGLAND
P.O. BOX 127, North Andover, MA 01845 USA
Tel: 978-794-9400; Fax: 978-794-9444


ENVIROLET

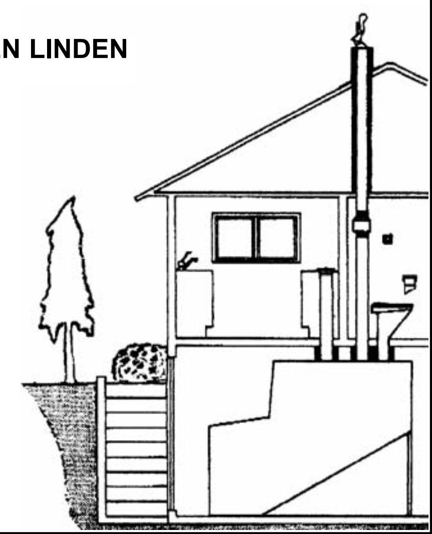
CLIVUS MULTRUM GREAT LAKES, INC
P.O. Box 1025, Ann Arbor, MI 48106 USA
Tel: 734-995-4767; Fax: 734-994-1292

COTUIT DRY TOILET
Conrad Geyser, PO Box 89, Cotuit, Massachusetts 02635 USA; Phone: 1-508-428-8442
Email: Conradg@Cape.com
Web site: http://www.cape.com/cdt

"CTS" TOILET
Composting Toilet Systems, PO Box 1928, Newport, Washington 99156-1928, USA
Phone: 1 509 447 3708; Toll free: 888 786 4538
Fax: 1 509 447 3708; Email: cts@povn.com
Contact: Joel Jacobsen; Inclined base composting toilet system built from fibreglass. 5 models offered with NSF International certification. Also offer pre-engineered toilet buildings and agent for Sun-Mar composting toilets.

ECOLOGY SERVICES
PO Box 76, Delafield, WI 53018 USA; Ph/Fax: 414-646-4664 (area code after 1/1/2000 = 262); Contact Mike Mangan. Sell and install composting toilets, graywater systems, and rainwater collection systems. Sunmar and Phoenix toilets.

ECO-TECH/VERA
ECOS, INC., P.O. Box 1313, Concord, MA 01742-1313 USA; Phone: 1-978-369-3951
Fax: 1-978 369 2484; Email: watercon@igc.org
http://www.ecologicalengineering.com/ecotech.html
"Tools for low-water living since 1972."
Sell a range of products: EcoTech Carousel compost

SVEN LINDEN


ECO-TECH/VERA (cont.)
ing toilet system, as well as composting toilet models from Vera Toga, BioLet, CTS and Sun-Mar; plans for site-built composting toilets; the Septic Protector, vacuum and micro-flush toilets; Washwater Garden graywater system; and related low-water products. Catalog $2.

JADE MOUNTAIN INC (Agent)
P.O. Box 4616, 717 Poplar, Boulder, CO 80306, USA
Phone: 1 800 442 1972 or 303 449 6601
Fax: 1 303 449 8266
Email: info@jademountain.com
Web site: http://www.jademountain.com; You can now download the complete catalog and order online. Supplies a wide range of appropriate technology products (over 6000) and information which includes composting toilets and graywater treatment systems.

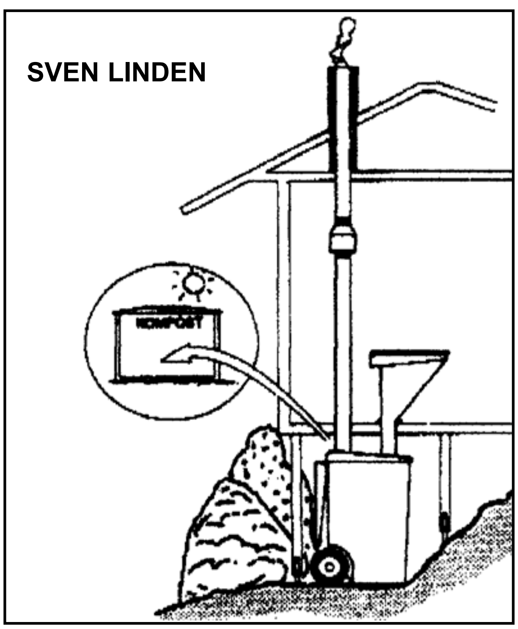
LEHMANS HARDWARE AND APPLIANCES (Agent)
One Lehman Circle, P.O. Box 41, Kidron, Ohio 44636, USA.
Phone: 1 330 857 5757; Fax: 1 330 857 5785
Email: info@lehmans.com
Web page: http://www.lehmans.com
Agent for Sunmar, Biolet and Alascan systems. Store and catalogue mail order sales of products for self-sufficiency. "Serving the Amish and others without electricity with products for simple, self sufficient living since 1955."

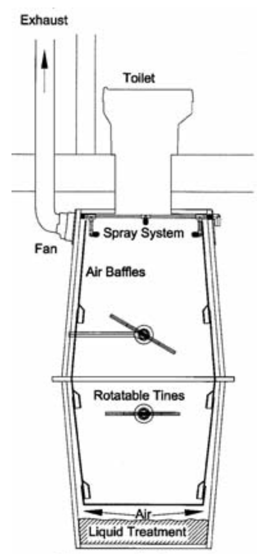
MOUNTAIN LION TRADING CO. (Agent)
Sales office: 2404 North Columbus Street
Spokane, WA 99207-2126, USA
Phone: 1 509-487-0765 (Voice or Fax)
Email: cj@mtlion.com
Web page: http://www.mtlion.com/sunmar.htm
Sell a range of products including Sunmar composting toilets.

REAL GOODS TRADING CO. (Agent)
555 Leslie St, Ukiah, CA. 95482, USA
Phone: 1 707 468 9292, Fax: 1 707 468 9394
Email: realgoods@realgoods.com
Web page: http://www.realgoods.com
Sun-mar and Biolet composting toilet agents. Stores in Hopland, CA, Eugene, OR and Amherst, WI.

SMARTER WATER COMPANY
Atlanta, GA USA
Email:email@smarterwater.com
Web page: http://www.smarterwater.com
Southeastern U.S. distributor of composting toilet systems. Agents for Sunmar composting toilet systems.

SOILTECH (Agent)
607 East Canal St, Newcomerstown, Ohio, 43832-1207, USA; Phone: 1 614 498 5929
Email: soiltech@tusco.net
Webpage: http://web.tusco.net/soiltech/
Contact: Kevin Mills; Distributors of Biolet composting toilets. Also have related products including a mulch starter.





PHOENIX SECTION

SOLAR COMPOSTING ADVANCED TOILET (S.C.A.T.) Larry Warnberg, PO Box 43, Nahcotta, WA 98637 USA; Ph: 360-665-2926: Email:warnberg@pacifier.com. The Solar Composting Advanced Toilet — S.C.A.T. — is a freestanding complete toilet facility designed to recycle human excrement and urine into a relatively dry and deodorized compost which can be safely and easily applied to the immediately surrounding landscape. The S.C.A.T. is suitable for recreational campsites, vacation cabins, construction sites, agricultural and nursery settings.

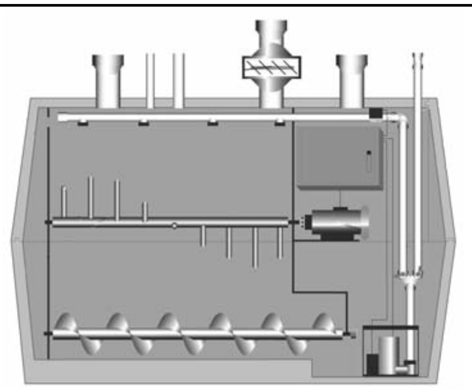
SUN-MAR CORPORATION
600 Main St., Tonawanda, NY 14150-0888 USA; For a Free Catalogue Call: 1 800 461 2461
Email:compost@sun-mar.com
Web page: http://www.sun-mar.com

SUPER TOILETS USA
John Flaherty, 10 Seaside Place, Norwalk, CT 06855 USA; Ph. and Fax: 203-831-9810.

OWNER BUILT

APPALACHIA SCIENCE IN THE PUBLIC INTEREST
50 Lair St., Mt. Vernon, KY 40456 USA. Ph: 606 256 0077 (main office); Fax: 606 256 2779; Website: http://www.kih.net/aspi; Email: aspi@kih.net; Contact: Jack Kiefer. ASPI has technical bulletins on composting toilets and constructed wetlands including schematics for a compost toilet which ASPI designed, and for a constructed wetland.

BIG BATCH COMPOSTING TOILET
EKAT (East Kentucky Appropriate Technologies) Executive Director, 150 Gravel Lick Branch Road Dreyfus, KY 40385, USA; Phone: 1 606 986-6146 Contact: Robert J. Fairchild; Another owner-build system that utilizes readily available materials. It is designed around a large rolling polyethylene dump cart with air pipes of PVC placed into it. Two are used, one 'resting' while the other is filled. EKAT is a non-profit organization which provides engineering assistance with appropriate technology projects to families and groups in central Appalachia. The 'Big batch composting toilet' plans are $7.


ALASCAN

ECO-TECH/VERA
ECOS, INC., P.O. Box 1313, Concord, MA 01742-1313 USA; Phone: 1-978-369-3951
Fax: 1-978 369 2484; Email: watercon@igc.org
http://www.ecologicalengineering.com/ecotech.html
Plans for site-built composting toilets (see previous US listing).

ELEMENTAL SOLUTIONS
Oaklands Park, Newnham-on-Severn
Gloucestershire, GL14 1EF, UK
Phone: 01594 516063, Fax: 01594 516821
Email mark.es@aecb.net
Contact: Mark Moodie. Kits include plans of the chamber recommended for a domestic situation in the UK climate. Includes ceramic pedestal, internal fittings of the tank, water proof 12V or 230V fan (uses ~3W) and power supply where necessary, construction and maintenance manual.


S.C.A.T.

GARRY SCOTT COMPOST TOILET SYSTEMS
Mullumbimby NSW, 2482, Australia; Phone/Fax: 61 2 6684 3468; Email: compost@mullum.com.au
Ownerbuilder assistance with consultation, components, plans and books.

LONG BRANCH ENVIRONMENTAL ED. CENTER
Big Sandy Mush Creek; POB 369; Leicester, NC 28748 USA; Contact: Paul Gallimore, Director
Tel: 828/683-3662; Fax: 828/683-9211
Website: http://main.nc.us/LBEEC/
E-mail: paulg@buncombe.main.nc.us

SOLAR COMPOSTING ADVANCED TOILET (S.C.A.T.) Larry Warnberg, PO Box 43, Nahcotta, WA 98637; Ph: 360 665 2926
Email: warnberg@pacifier.com. Solar composting toilet plans (see previous US listing).

STAN SLAUGHTER
55 Gallon Drum Compost Toilet - Guidebook and Plans. Stan Slaughter, Tall Oak Productions, Pilar Route, Box 11B, Embudo, NM 87531USA;
Ph: 888 484 4477; Fax: 505 758 0201
Website: www.stanslaughter.com. Also has a great audio tape: Rot N' Roll. Offers music/educational programs and a new card game, "Compost Gin."

"SUNNY JOHN" SOLAR MOLDERING TOILET
Construction Plans - $20/postpaid.
John Cruickshank, 5569 North County Road 29, Loveland CO 80538;
Email: hobbithouse@compuserve.com
http://ourworld.compuserve.com/homepages/hobbit-house

COMPOST THERMOMETERS

REOTEMP
11568 Sorrento Valley Road, Suite 10
San Diego, CA 92121 USA; Ph: 1 619 481 7737 (Toll free: 1-800-648-7737); Fax: 1 619 481 7415
email: reotemp@reotemp.com; www.reotemp.com

BACKYARD COMPOST BINS

COVERED BRIDGE ORGANIC
PO Box 91, Jefferson, OH 44047 USA
Ph: 440 576 5515

GARDNER EQUIPMENT
PO Box 106, Juneau, WI 53039 USA
Ph: 800 393 0333

GEDYE COMPOST BINS
555 S. Sunrise Way, Ste. 200, Palm Springs, CA 92262 USA
Ph: 760 325 1035; Fax: 760 778 5383

HARMONIOUS TECHNOLOGIES
PO Box 1716, Sebastopol, CA 95437 USA
Ph: 707 823 1999; Fax: 707 823 2424
Website: http://www.homecompost.com
Bins made from 100% recycled plastic.

PALMOR PRODUCTS
PO Box 38, Thorntown, IN 46071 USA
Ph: 800 872 2822; Fax: 765 436 2490
Website: http://www.trac-vac.com

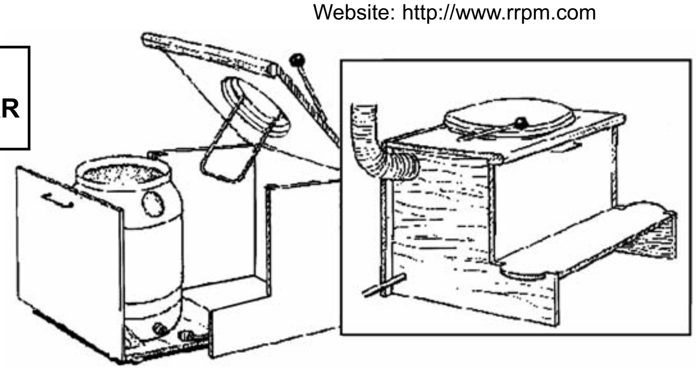
PLASTOPAN NORTH AMERICA, INC.
812 E 59th St., Los Angeles, CA 90001 USA
Ph: 323 231 2225; Fax: 323 231 2068
Website: http://www.plastopan.com

PRECISION-HUSKY
Equipment Division POD 507, Leeds, AL 35094 USA;
Ph: 205 640 5181; Fax: 205 640 1147
Website: http://www.precisionhusky.com

PRESTO PRODUCTS CO.
PO Box 2399, Appleton, WI 54913 USA
Ph: 920 738 0986; Fax: 920 738 1458

RECYCLED PLASTICS MARKETING, INC.
2829 152nd Ave. NE, Redmond, WA 98052 USA
Ph: 800 867 3201; Fax: 425 867 3282
Website: http://www.rrpm.com

TECHNISCH BUREAU HAMAR



C.E. SHEPHERD CO., INC.
PO Box 9445, Houston, TX 77261 USA
Ph: 713 928 3763; Fax: 713 928 2324
Website: http://www.ceshepherd.com

SMITH AND HAWKEN
117 East Strawberry Dr., Mill Valley, CA 94941 USA
Ph: 415 383 4415; Fax 415 383 8010
Website: http://www.smithandhawken.com

SWING AND SLIDE CORPORATION (SHAPE PRODUCTS)
1212 Barberry Dr., Janesville, WI 53545 USA
Ph: 800 888 1232; Fax: 608 755 4763

THE WILMARC CO.
225 W Grant St., Thorntown, IN 46071 USA
Ph: 765 436 7089; Fax: 765 436 2634
Website: http://www.wilmarcco.com

COMPOST TESTING LABS

WOODS END AGRICULTURAL INSTITUTE, INC.
PO Box 297, Mt. Vernon, ME 04352 USA
Ph: 207 293 2457 or 800 451 0337
FAX: 207 293 2488; email: info@woodsend.org
website: http://www.woodsend.org
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Website: www.stanslaughter.com

SONGS FOR THE COMPOST PILE
Dreams and Bones Performance Company, Jake Weinstein, Rainbow Recycling, 810 State St., New Haven, CT 06511 USA; Ph: 203 865 6507

INTERNET

EARTHWISE PUBLICATIONS; High Walk House, Kirkby Malzeard, Ripon HG4 3RY England; Phone + 44 01765 658786; Fax on request.
Email: earthwise@earthwise.nwnet.co.uk

WORLD OF COMPOSTING TOILETS:
http://www.nwnet.co.uk/earthwise/

INTERNATIONAL COMPOSTING TOILET NEWS:
http://www.nwnet.co.uk/earthwise/journal1/

ROT WEB:
http://net.indra.com/~topsoil/Compost_Menu.html

COMPOST RESOURCE PAGE:
http://www.oldgrowth.org/compost/humanure.html

HUMANURE FORUM:
http//:www.oldgrowth.org/compost/forum_humanure1/

CANADIAN COMPOSTING TOILET WEB SITE:
http://www.cityfarmer.org/comptoilet64.html#toilet

COMPOSTING COUNCIL:
http://www.compostingcouncil.org/

OTHERS OF INTEREST:

http://www.cals.cornell.edu/dept/compost/

http://www.composter.com/

http://www.history.rochester.edu/class/compost/compost.html

VERMICOMPOSTING:

http://www.humic.com/

http://www.wormdigest.org

http://www.wormwoman.com

http://www.vermint.com.au

http://www.wormpage.com

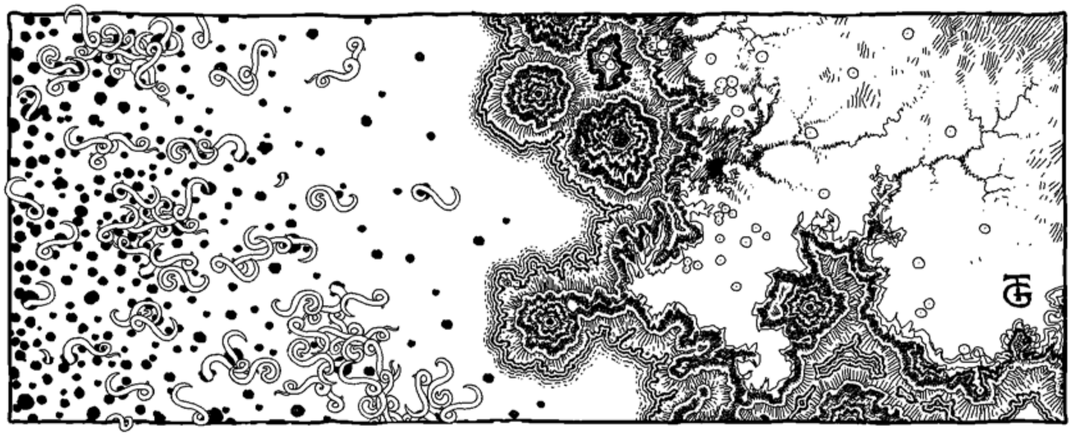
http://www.allthingsorganic.com

http://www.worm-publications.com

http://www.wormworld.com

http://www.vermitechnology.com

WORMS AND DISEASE



"A well-made compost heap steams like a tea kettle and gets hot enough to destroy all pathogens that may be present when one uses human sewage. An extraordinary device when one thinks about it. Thermophilic bacteria. Bacteria that can live and flourish in temperatures hot enough to cook an egg. How can they survive in such heat? Truly the tricks of nature are extraordinary!"
Robert S. deRopp

I well remember in early 1979 when I first informed a friend that I intended to compost my own manure and grow my own food with it. "*Oh my God, you can't do that!*" she cried.

"Why not?"

"Worms and disease!"

Of course. What else would a fecophobe think of when one mentions using humanure as a fertilizer?

A young English couple was visiting me one summer after I had been composting humanure for about six years. One evening, as dinner was being prepared, the couple suddenly understood the horrible reality of their situation: the food they were about to eat was *recycled shit*. When this "fact" dawned upon them, it seemed to set off some kind of instinctive alarm in their minds, possibly inherited directly from Queen Victoria. *"We don't want to eat shit!"* they informed me (that's an exact quote), as if in preparing dinner I was simply defecating on plates and setting them on the table. Never mind that the food was delicious. It was the *thought* of it that mattered.

Fecophobia is alive and well and currently afflicting about a billion westerners. One common misconception is that fecal material, when composted, remains fecal material. *It does not.* Humanure comes from the earth, and through the miraculous process of composting, is converted back into earth. When the composting process is finished, the end product is humus, not crap, and it is useful in growing food. My friends didn't understand this; despite my attempts to clarify the matter for their benefit, they chose to cling to their misconceptions. Apparently, some fecophobes will always remain fecophobes.

Allow me to make a radical suggestion: humanure is not dangerous. More specifically, it is not any more dangerous than the body from which it is excreted. The danger lies in what we *do* with humanure, not in the material itself. To use an analogy, a glass jar is not dangerous either. However, if we smash it on the kitchen floor and walk on it with bare feet, we will be harmed. If we use a glass jar improperly and dangerously, we will suffer for it, but that's no reason to condemn glass jars. When we discard humanure as a waste material and pollute our soil and water supplies with it, we are using it improperly, and *that* is where the danger lies. When we constructively recycle humanure by composting, it enriches our soil, and, like a glass jar, actually makes life easier for us.

Not all cultures think of human excrement in a negative way. For example, swear-words meaning excrement do not seem to exist in the Chinese language. The Tokyo bureau chief for the New York Times explains why: *"I realized why people [in China] did not use words for excrement in a negative way. Traditionally, there was nothing more valuable to a peasant than human waste."* [1] Calling someone a "humanure head" just doesn't sound like an insult. "Humanure for brains" doesn't work either. If you told someone they were "full of humanure," they'd probably agree with you. "Shit," on the other hand, is a substance that is widely denounced and has a long history of excoriation in the western world. Our ancestor's historical failure to responsibly recycle the substance caused monumental public health headaches. Consequently, the attitude that humanure *itself* is terribly dangerous has been embraced and promulgated up to the present day.

For example, a recently published book on the topic of recycling "human waste" *begins* with the following disclaimer: *"Recycling human waste can be extremely dangerous to your health, the health of your community and the health of the soil. Because of the current limits to general public knowledge, [we] strongly discourage the recycling of human waste on an individual or community basis at this time and cannot assume responsibility for the results that occur from practicing any of the methods described in this publication."* The author adds, *"Before experimenting, obtain permission from your local health authority since the health risks are great."* The author then elaborates upon a human "waste" composting methodology which includes segregating urine from feces, collecting the manure in 30 gallon plastic containers, and using straw rather than sawdust as a cover material in the toilet.[2] All three of these procedures are ones I would discourage based on my 20 years of humanure composting experience (no need to go to the bother of segregating urine; a 30 gallon container is way too big and heavy to be able to easily handle; and *sawmill* sawdust does, in fact, work beautifully in a composting toilet. These issues will be thoroughly discussed in the next chapter).

I had to ask myself why an author writing a book on recycling humanure would *"strongly discourage the recycling of human waste,"* which seems counterproductive, to say the least. If I didn't already know that recycling humanure was easy and simple, I might be totally petrified at the thought of attempting such an *"extremely dangerous"* undertaking after reading that book. And the last thing anyone wants to do is get the local health authorities involved. If there is anyone who knows nothing about composting humanure, it's probably the local health authority, who receives no such training. I had to read between the lines of the book to find an explanation.

It seems that the author was somehow associated with the "Bio-Dynamic" agricultural movement, founded by Dr. Rudolf Steiner. Dr. Steiner has quite some following around the world, and many of his teachings are followed almost religiously by his disciples. The Austrian scientist and spiritual leader had his own opinions about the recycling of humanure, based as it were on intuition rather than on experience or science. He insisted that humanure must only be used to fertilize soil used to grow plants to feed animals *other* than humans. The manure from those animals can then be used to fertilize soil to grow plants for human consumption. According to Steiner, humans must *never* get any closer to a direct human nutrient cycle than that. Otherwise, they will suffer "brain damage and nervous disorders." Steiner further warned against using "lavatory fluid," including human urine, which "should never be used as a fertilizer, no matter how well-processed or aged it is." [3] Steiner, quite frankly, was ill-informed, incorrect, and severely fecophobic, and that fecophobia has, unfortunately, rubbed off on some of his followers. It is unfortunate that sensational, fear-motivated warnings regarding humanure recycling continue to be published.

But, it's nothing new, and it has historically been based upon ignorance, which is a widespread problem. At one time, for example, doctors insisted that human excrement should be an important and necessary part of one's personal environment. They argued that, *"Fatal illness may result from not allowing a certain amount of filth to remain in [street] gutters to attract those putrescent particles of disease which are ever present in the air."* At that time, toilet contents were simply dumped in the street. Doctors believed that the germs in the air would be drawn to the filth in the street and therefore away from people. This line of reasoning so influenced the population that many homeowners built their outhouses attached to their kitchens in order to keep their food germ-free and wholesome.[4] The results were just the opposite — flies made frequent trips between the toilet contents and the food table.

By the early 1900s, the US government was condemning the use of humanure for agricultural purposes, warning of dire consequences, including death, to those who would dare to do otherwise. A 1928 US Department of Agriculture bulletin made the risks crystal clear: *"Any spitoon, slop pail, sink drain, urinal, privy, cesspool, sewage tank, or sewage distribution field is a potential danger. A bit of spit, urine, or feces the size of a pin head may contain many hundred germs, all invisible to the naked* *eye and each one capable of producing disease. These discharges should be kept away from the food and drink of [humans] and animals. From specific germs that may be carried in sewage at any time, there may result typhoid fever, tuberculosis, cholera, dysentery, diarrhea, and other dangerous ailments, and it is probable that other maladies may be traced to human waste. From certain animal parasites or their eggs that may be carried in sewage there may result intestinal worms, of which the more common are the hookworm, roundworm, whipworm, eelworm, tapeworm, and seat worm.*

Disease germs are carried by many agencies and unsuspectingly received by devious routes into the human body. Infection may come from the swirling dust of the railway roadbed, from contact with transitory or chronic carriers of disease, from green truck [vegetables] grown in gardens fertilized with night soil or sewage, from food prepared or touched by unclean hands or visited by flies or vermin, from milk handled by sick or careless dairymen, from milk cans or utensils washed with contaminated water, or from cisterns, wells, springs, reservoirs, irrigation ditches, brooks, or lakes receiving the surface wash or the underground drainage from sewage-polluted soil."

The bulletin continues, *"In September and October, 1899, 63 cases of typhoid fever, resulting in five deaths, occurred at the Northampton (Mass.) insane hospital. This epidemic was conclusively traced to celery, which was eaten freely in August and was grown and banked in a plot that had been fertilized in the late winter or early spring with the solid residue and scrapings from a sewage filter bed situated on the hospital grounds."*

And to drive home the point that human waste is highly dangerous, the bulletin adds, *"Probably no epidemic in American history better illustrates the dire results that may follow one thoughtless act than the outbreak of typhoid fever at Plymouth, Pa., in 1885. In January and February of that year the night discharges of one typhoid fever patient were thrown out upon the snow near his home. These, carried by spring thaws into the public water supply, caused an epidemic running from April to September. In a total population of about 8,000, 1,104 persons were attacked by the disease and 114 died."*

The government bulletin insisted that the use of human excrement as fertilizer was both "dangerous" and "disgusting." It warned that, *"under no circumstances should such wastes be used on land devoted to celery, lettuce, radishes, cucumbers, cabbages, tomatoes, melons, or other vegetables, berries, or low-growing fruits that are eaten raw. Disease germs or particles of soil containing such germs may adhere to the skins of vegetables or fruits and infect the eater."* The bulletin summed it up by stating, *"Never use [human] waste to fertilize or irrigate vegetable gardens."* The fear of human excrement was so severe it was advised that the contents of bucket toilets be burned, boiled, or chemically disinfected, then buried in a trench.[5]

This degree of fecophobia, fostered and spread by authoritative government publications and by spiritual leaders who knew of no constructive alternatives to waste disposal, still maintains a firm grip on the western psyche. It may take a long time to eliminate. A more constructive attitude is displayed by scientists with a broader knowledge of the subject of recycling humanure for agricultural purposes. They realize that the benefits of proper humanure recycling "far outweigh any disadvantages from the health point of view." [6]

THE HUNZAS

It's already been mentioned that entire civilizations have recycled humanure for thousands of years. That should provide a fairly convincing testimony about the usefulness of humanure as an agricultural resource. Many people have heard of the "Healthy Hunzas," a people in what is now a part of Pakistan who reside among the Himalayan peaks, and routinely live to be 120 years old. The Hunzas gained fame in the United States during the 1960s health food era, at which time several books were written about the fantastic longevity of this ancient people. Their extraordinary health has been attributed to the quality of their overall lifestyle, including the quality of the natural food they eat and the soil it's grown on. Few people, however, realize that the Hunzas also compost their humanure and use it to grow their food. They're said to have virtually no disease, no cancer, no heart or intestinal trouble, and they regularly live to be over a hundred years old while *"singing, dancing and making love all the way to the grave."*

According to Tompkins (1989), *"In their manuring, the Hunzakuts return everything they can to the soil: all vegetable parts and pieces that will not serve as food for humans or beast, including such fallen leaves as the cattle will not eat, <u>mixed with their own seasoned excrement</u>, plus dung and urine from their barns. Like their Chinese neighbors, the Hunzakuts save their own manure in special underground vats, clear of any contaminable streams, there to be seasoned for a good six months. Everything that once had life is given new to life through loving hands."* [7] (emphasis mine)

Sir Albert Howard wrote in 1947, *"The Hunzas are described as far surpassing in health and strength the inhabitants of most other countries; a Hunza can walk across the mountains to Gilgit sixty miles away, transact his business, and return forthwith without feeling unduly fatigued."* Sir Howard maintains that this is illustrative of the vital connection between a sound agriculture and good health, insisting that the Hunzas have evolved a system of farming which is perfect. He adds, *"To provide the essential humus, every kind of waste [sic], vegetable, animal and human, is mixed and decayed together by the cultivators and incorporated into the soil; the law of return is obeyed, the unseen part of the revolution of the great Wheel is faithfully accomplished."* [8] Sir Howard's view is that soil fertility is the real basis of public health.

A medical professional associated with the Hunzas claimed, *"During the period of my association with these people I never saw a case of asthenic dyspepsia, of gastric or duodenal ulcer, of appendicitis, of mucous colitis, of cancer . . . Among these people the abdomen over-sensitive to nerve impressions, to fatigue, anxiety, or cold was unknown. Indeed their buoyant abdominal health has, since my return to the West, provided a remarkable contrast with the dyspeptic and colonic lamentations of our highly civilized communities."*

Sir Howard adds, *"The remarkable health of these people is one of the conse-*

quences of their agriculture, in which the law of return is scrupulously obeyed. All their vegetable, animal and human wastes [sic] are carefully returned to the soil of the irrigated terraces which produce the grain, fruit, and vegetables which feed them." [9]

The Hunzas composted their organic material, thereby recycling all of it. This actually enhanced their personal health and the health of their community. The US Department of Agriculture was apparently unaware of the effective natural process of composting in 1928 when they described the recycling of humanure as "dangerous and disgusting." No doubt the USDA would have confused the Hunzas, who had for centuries safely and constructively engaged in such recycling.

PATHOGENS

[Much of the following information is adapted from Appropriate Technology for Water Supply and Sanitation, by Feachem et al., World Bank, 1980.[10] This comprehensive work cites 394 references from throughout the world, and was carried out as part of the World Bank's research project on appropriate technology for water supply and sanitation.]

Clearly, even the primitive composting of humanure for agricultural purposes does not necessarily pose a threat to human health, as evidenced by the Hunzas. Yet, fecal *contamination* of the environment certainly *can* pose a threat to human health. Feces can harbor a host of disease organisms which can contaminate the environment to infect innocent people when human excrement is discarded as a waste material. In fact, even a healthy person apparently free of disease can pass potentially dangerous pathogens through their fecal material, simply by being a carrier. The World Health Organization estimates that 80% of all diseases are related to inadequate sanitation and polluted water, and that half of the world's hospital beds are occupied by patients who suffer from water-related diseases.[11] As such, the composting of humanure would certainly seem like a worthwhile undertaking worldwide.

The following information is not meant to be alarming. It's included for the sake of thoroughness, and to illustrate the need to *compost* humanure, rather than to try to use it raw for agricultural purposes. When the composting process is sidestepped and pathogenic waste is issued into the environment, various diseases and worms can infect the population living in the contaminated area. This fact has been widely documented.

For example, consider the following quote from Jervis (1990): *"The use of night soil [raw human fecal material and urine] as fertilizer is not without its health hazards. Hepatitis B is prevalent in Dacaiyuan [China], as it is in the rest of China. Some effort is being made to chemically treat [humanure] or at least to mix it with other ingredients before it is applied to the fields. But chemicals are expensive, and old ways die hard. Night soil is one reason why urban Chinese are so scrupulous about peeling fruit, and why raw vegetables are not part of the diet. Negative features aside, one has only to look at satellite photos of the green belt that surrounds China's cities to understand the value of night soil."*[12]

On the other hand, "worms and disease" are not spread by properly prepared compost, nor by healthy people. There is no reason to believe that the manure of a healthy person is dangerous unless left to accumulate, pollute water with intestinal bacteria, or breed flies and/or rats, all of which are the results of negligence or bad customary habits. It should be understood that the breath one exhales can also be the carrier of dangerous pathogens, as can one's saliva and sputum. The issue is confused by the notion that if something is potentially dangerous, then it is always dangerous, which is not true. Furthermore, it is generally not understood that the carefully managed thermophilic composting of humanure converts it into a sanitized agricultural resource. No other system of fecal material and urine recycling or disposal can achieve this without the use of dangerous chemical poisons or a high level of technology and energy consumption.

Even urine, usually considered sterile, can contain disease germs (see Table 7.1). Urine, like humanure, is valuable for its soil nutrients. It is estimated that one person's annual urine output contains enough soil nutrients to grow grain to feed that person for a year.[13] Therefore, it is just as important to recycle urine as it is to recycle humanure, and composting provides an excellent means for doing so.

The pathogens that can exist in human feces can be divided into four general categories: *viruses, bacteria, protozoa,* and *worms (helminths).*

VIRUSES

First discovered in the 1890s by a Russian scientist, viruses are among the simplest and smallest of life forms. Many scientists don't even consider them to be

Table 7.1

POTENTIAL PATHOGENS IN URINE

Healthy urine on its way out of the human body may contain up to 1,000 bacteria, of several types, per milliliter. More than 100,000 bacteria of a single type per milliliter signals a urinary tract infection. Infected individuals will pass pathogens in the urine that may include:

Bacteria	Disease
Salmonella typhi	Typhoid
Salmonella paratyphi	Paratyphoid fever
Leptospira	Leptospirosis
Yersinia	Yersiniosis
Escherichia coli	Diarrhea

Worms	Disease
Schistosoma haematobium	schistosomiasis

Source: Feachem et al., 1980; and Franceys, et al. 1992; and Lewis, Ricki. (1992). *FDA Consumer*, September 1992. p. 41.

Table 7.2

MINIMAL INFECTIVE DOSES
For Some Pathogens and Parasites

Pathogen	Minimal Infective Dose
Ascaris	1-10 eggs
Cryptosporidium	10 cysts
Entamoeba coli	10 cysts
Escherichia coli	1,000,000-100,000,000
Giardia lamblia	10-100 cysts
Hepatitis A virus	1-10 PFU
Salmonella spp.	10,000-10,000,000
Shigella spp.	10-100
Streptococcus fecalis	10,000,000,000
Vibrio cholerae	1,000

Pathogens have various degrees of *virulence*, which is their potential for causing disease in humans. The minimal infective dose is the number of organisms needed to establish infection.

Source: Bitton, Gabriel. (1994). Wastewater Microbiology. New York: Wiley-Liss, Inc., p. 77-78. and *Biocycle*, September 1998, p. 62.

Table 7.3

POTENTIAL VIRAL PATHOGENS IN FECES

Virus	Disease	Can Carrier Be Symptomless?
Adenoviruses	varies	yes
Coxsackievirus	varies	yes
Echoviruses	varies	yes
Hepatitis A	Infectious hepatitis	yes
Polioviruses	Poliomyelitis	yes
Reoviruses	varies	yes
Rotaviruses	Diarrhea	yes

Rotaviruses may be responsible for the majority of infant diarrheas. Hepatitis A causes infectious hepatitis, often without symptoms, especially in children. Coxsackievirus infection can lead to meningitis, fevers, respiratory diseases, paralysis, and myocarditis. Echovirus infection can cause simple fever, meningitis, diarrhea, or respiratory illness. Most poliovirus infections don't give rise to any clinical illness, although sometimes infection causes a mild, influenza-like illness which may lead to virus-meningitis, paralytic poliomyelitis, permanent disability, or death. It's estimated that almost everyone in developing countries becomes infected with poliovirus, and that one out of every thousand poliovirus infections leads to paralytic poliomyelitis.

Source: Feachem et al., 1980

Table 7.4

POTENTIAL BACTERIAL PATHOGENS IN FECES

Bacteria	Disease	Symptomless Carrier?
Campylobacter	Diarrhea	yes
E. coli	Diarrhea	yes
Salmonella typhi	Typhoid fever	yes
Salmonella paratyphi	Paratyphoid fever	yes
Other *Salmonellae*	Food poisoning	yes
Shigella	Dysentery	yes
Vibrio cholerae	Cholera	yes
Other *Vibrios*	Diarrhea	yes
Yersinia	Yersiniosis	yes

Source: Feachem et al., 1980

organisms. They are much smaller and simpler than bacteria (some viruses are parasitic to bacteria), and the simplest form may consist only of an RNA molecule. By definition, a virus is an entity which contains the information necessary for its own replication, but does not possess the physical elements for such replication — they have the software, but not the hardware. In order to reproduce, therefore, viruses rely on the hardware of the infected host cell, which is re-programmed by the virus in order to reproduce viral nucleic acid. As such, viruses cannot reproduce outside the host cell.[14]

There are more than 140 types of viruses worldwide that can be passed through human feces, including polioviruses, coxsackieviruses (causing meningitis and myocarditis), echoviruses (causing meningitis and enteritis), reovirus (causing enteritis), adenovirus (causing respiratory illness), infectious hepatitis (causing jaundice), and others (see Table 7.3). During periods of infection, one hundred million to one trillion viruses can be excreted with each gram of fecal material.[15]

Bacteria

Of the pathogenic bacteria, the genus *Salmonella* is significant because it contains species causing typhoid fever, paratyphoid, and gastrointestinal disturbances. Another genus of bacteria, *Shigella*, causes dysentery. Myobacteria cause tuberculosis (see Table 7.4). However, according to Gotaas, pathogenic bacteria *"are unable to survive temperatures of 55^0-60^{0}C for longer than 30 minutes to one hour."* [16]

Protozoa

The pathogenic protozoa include *Entamoeba histolytica* (causing amoebic dysentery), and members of the Hartmanella-Naegleria group (causing meningoencephalitis) (see Table 7.5). The cyst stage in the life cycle of protozoa is the primary means of dissemination as the amoeba die quickly once outside the human body. Cysts must be kept moist in order to remain viable for any extended period.[17]

Table 7.5
POTENTIAL PROTOZOAN PATHOGENS IN FECES

Protozoa	Disease	Symptomless Carrier?
Balantidium coli	Diarrhea	yes
Entamoeba histolytica	Dysentery, colonic ulceration, liver abscess	yes
Giardia lamblia	Diarrhea	yes

Source: Feachem et al., 1980

Parasitic Worms

Finally, a number of parasitic worms pass their eggs in feces, including hookworms, roundworms (*Ascaris*), and whipworms (see Table 7.6). Various researchers have reported 59 to 80 worm eggs in sampled liters of sewage. This suggests that billions of pathogenic worm eggs may reach an average wastewater treatment plant daily. These eggs tend to be resistant to environmental conditions due to a thick outer covering,[18] and they are extremely resistant to the sludge digestion process common in wastewater treatment plants. Three months exposure to anaerobic sludge digestion processes appears to have little effect on the viability of *Ascaris* eggs; after six months, 10% of the eggs may still be viable. Even after a year in sludge, some viable eggs may be found.[19] In 1949, an epidemic of roundworm infestation in Germany was directly traced to the use of raw sewage to fertilize gardens. The sewage contained 540 *Ascaris* eggs per 100 ml, and over 90% of the population became infected.[20]

If there are about 59 to 80 worm eggs in a liter sample of sewage, then we could reasonably estimate that there are 70 eggs per liter, or 280 eggs per gallon to get a rough average. That means approximately 280 pathogenic worm eggs per gallon of wastewater enter wastewater treatment plants. My local wastewater treatment plant serves a population of eight thousand people and collects about 1.5 million gallons of wastewater daily. That means there could be 420 million worm eggs entering the plant each day and settling into the sludge. In a year's time, over 153 *billion* parasitic eggs can pass through my local small-town wastewater facility. Let's look at the worst-case scenario: all the eggs survive in the sludge because they're resistant to the environmental conditions at the plant. During the year, 30 tractor-trailer loads of sludge are hauled out of the local facility. Each truckload of sludge could theoretically contain over *5 billion* pathogenic worm eggs, en route to maybe a farmer's field, but probably a landfill.

It is interesting to note that roundworms co-evolved over millennia as parasites of the human species by taking advantage of the long-standing human habit of defecating on soil. Since roundworms live in the human intestines, but require a period in the soil for their development, their species is perpetuated by our bad habits. If we humans never allowed our excrement to come in contact with soil, and if we instead thermophilically composted it, the parasitic species known as *Ascaris lumbricoide*s, a parasite that has plagued us for perhaps hundreds of thousands of years, would soon become extinct. The human species is finally evolving to the extent that we are beginning to understand compost and its ability to destroy parasites. We need to take that a step further and entirely prevent our excrement from polluting the environment. Otherwise, we will continue to be outsmarted by the parasitic worms that rely on our ignorance and carelessness for their own survival.

Table 7.6

POTENTIAL WORM PATHOGENS IN FECES

Common Name	Pathogen	Transmission	Distribution
1. Hookworm	*Ancylostoma doudenale* *Necator americanus*	Human -soil -human	Warm, wet climates
2. ----------	*Heterophyes heterophyes*	Dog/cat -snail -fish -human	Mid. East/S. Europe/Asia
3. ----------	*Gastrodiscoides*	Pig -snail - aquatic vegetation -human	India/Bangladesh/Vietnam/ Philippines
4. Giant intestinal fluke	*Fasciolopsis buski*	Human/pig -snail - aquatic vegetation -human	S.E. Asia/China
5. Sheep liver fluke	*Fasciola hepatica*	Sheep -snail - aquatic vegetation -human	Worldwide
6. Pinworm	*Enterobius vermicularis*	Human -human	Worldwide
7. Fish tapeworm	*Diphyllobothrium latum*	Human/animal -copepod - fish -human	Mainly temperate
8. Cat liver fluke	*Opisthorchis felineus* *O. viverrini*	Animal -aquatic snail - fish -human	USSR/Thailand
9. Chinese liver fluke	*Chlonorchis sinensi*	Animal/human -snail -fish - human	S.E. Asia
10. Roundworm	*Ascaris lumbricoides*	Human -soil - human	Worldwide
11. Dwarf tapeworm	*Hymenolepsis* spp.	Human/rodent -human	Worldwide
12. ----------	*Metagonimus yokogawai*	Dog/cat -snail -fish -human	Japan/Korea/China/ Taiwan/Siberia
13. Lung fluke	*Paragonimus westermani*	Animal/human -snail - crab/crayfish -human	S.E. Asia/Africa/ S. America
14. Schistosome, bilharzia	*Schistosoma haematobium*	Human -snail -human	Africa, M. East, India
-----------	*S. mansoni*	Human -snail -human	Africa, Arabia, Latin America
----------	*S. japonicum*	Animal/human -snail -human	S.E. Asia
15. Threadworm	*Strongyloides stercoralis*	Human -human (dog -human?)	Warm, wet climates
16. Beef tapeworm	*Taenia saginata*	Human -cow -human	Worldwide
Pork tapeworm	*T. solium*	Human -pig -human or human -human	Worldwide
17. Whipworm	*Trichuris trichiura*	Human -soil -human	Worldwide

Source: Feachem et al., 1980

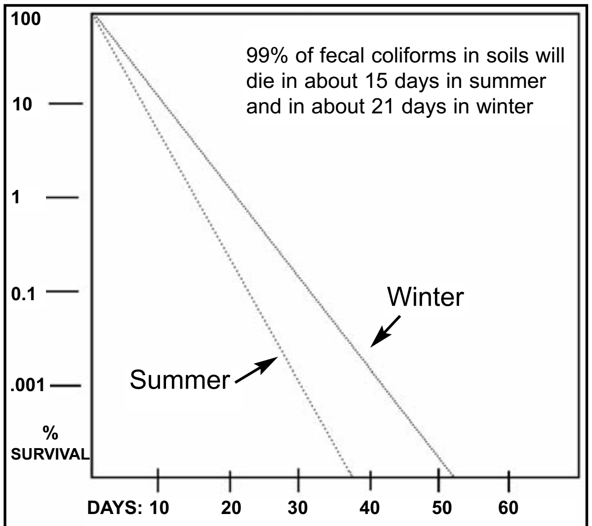


Figure 7.1
SURVIVAL TIMES
OF FECAL COLIFORMS IN SOIL

Source: Recycling Treated Municipal Wastewater and Sludge Through Forest and Cropland. Edited by William E. Sopper and Louis T. Kardos. 1973. p. 82.
Based on the work of Van Donsel, et al., 1967.

Table 7.7
AVERAGE DENSITY OF FECAL COLIFORMS EXCRETED IN 24 HOURS
(million/100ml)

Human	13.0
Duck	33.0
Sheep	16.0
Pig	3.3
Chicken	1.3
Cow	0.23
Turkey	0.29

INDICATOR PATHOGENS

Indicator pathogens are pathogens whose detectable occurrence in soil or water serves as evidence that fecal contamination exists.

The astute reader will have noticed that many of the pathogenic worms listed in Table 7.6 are not found in the United States. Of those that are, the *Ascaris lumbricoides* (roundworm) is the most persistent, and can serve as an indicator for the presence of pathogenic helminths in the environment.

A single female roundworm may lay as many as 27 million eggs in her lifetime.[21] These eggs are protected by an outer covering that is resistant to chemicals and enables the eggs to remain viable in soil for long periods of time. The egg shell is made of five separate layers: an outer and inner membrane, with three tough layers in between. The outer membrane may become partially hardened by hostile environmental influences.[22] The reported viability of roundworm eggs (*Ascaris* ova) in soil ranges from a couple of weeks under sunny, sandy conditions,[23] to two and a half years,[24] four years,[25] five and a half years,[26] or even ten years[27] in soil, depending on the source of the information. Consequently, the *eggs* of the roundworm seem to be the best indicator for determining if parasitic worm pathogens are present in compost. In China, current standards for the agricultural reuse of humanure require an *Ascaris* mortality of greater than 95%.

Ascaris eggs develop at temperatures between 15.5^0C (59.90° F) and 35^0C (95^0 F), but the eggs disintegrate at temperatures above 38^0C (100.40° F).[28] The temperatures generated during thermophilic composting can easily exceed levels necessary to destroy roundworm eggs.

One way to determine if the compost you're using is contaminated with viable roundworm eggs is to have a stool analysis done at a local hospital. If your compost is contaminated and you're using the compost to grow your own food, then there will be a chance that you've contaminated yourself. A stool analysis will reveal whether that is the case or not. Such an analysis cost about $41.00 in Pennsylvania (USA) in 1993, and $33 in 1999. I subjected myself to two stool examinations over a period of two years as part of the research for this book. I had been composting humanure for fifteen years at the time of the testings, and I had used all of the compost in my food gardens. Hundreds of other people had also used my toilet over the years, potentially contaminating it with *Ascaris*. Yet, both stool examinations were completely negative.

Indicator bacteria include fecal coliforms, which reproduce in the intestinal systems of warm blooded animals (see Table 7.7). If one wants to test a water supply for fecal contamination, then one looks for fecal coliforms, usually *Escherichia coli*. *E. coli* is one of the most abundant intestinal bacteria in humans; over 200 specific types exist. Although some of them can cause disease, most are harmless.[29] The absence of *E. coli* in water indicates that the water is free from fecal contamination.

Water tests often determine the level of *total coliforms* in the water, reported as the number of coliforms per 100 ml. Such a test measures *all* species of the coliform group and is not limited to species originating in warm-blooded animals. Since some coliform species come from the soil, the results of this test are not always indicative of fecal contamination in a stream analysis. However, this test can be used for ground water supplies, as no coliforms should be present in ground water unless it has been contaminated by a warm-blooded animal.

Fecal coliforms do not multiply outside the intestines of warm-blooded animals, and their presence in water is unlikely unless there is fecal pollution. They survive for a shorter time in natural waters than the coliform group as a whole, therefore their presence indicates relatively recent pollution. In domestic sewage, the fecal coliform count is usually 90% or more of the total coliform count, but in natural streams, fecal coliforms may contribute 10-30% of the total coliform density. Almost all natural waters have a presence of fecal coliforms, since all warm-blooded animals excrete them. Most states in the U.S. limit the fecal coliform concentration allowable in waters used for water sports to 200 fecal coliforms per 100 ml.

Bacterial analyses of drinking water supplies are routinely provided for a small fee (in 1994 around $20.00) by agricultural supply firms, water treatment companies, or private labs.

PERSISTENCE OF PATHOGENS IN SOIL, CROPS, MANURE, AND SLUDGE

According to Feachem et al. (1980), the persistence of fecal pathogens in the environment can be summarized as follows:

In Soil

Survival times of pathogens in soil are affected by soil moisture, pH, type of soil, temperature, sunlight, and organic matter. Although fecal coliforms can survive for several years under optimum conditions, a 99% reduction is likely within 25 days in warm climates (see Figure 7.1). *Salmonella* bacteria may survive for a year in rich, moist, organic soil, although 50 days would be a more typical survival time. Viruses can survive up to three months in warm weather, and up to six months in cold. Protozoan cysts are unlikely to survive for more than ten days. Roundworm eggs can survive for several years.

The viruses, bacteria, protozoa, and worms that can be passed in human excrement all have limited survival times outside of the human body. Let's take a look at their survival times when deposited raw into soil (refer to Tables 7.8 through 7.12).

Survival of Pathogens On Crops

Bacteria and viruses cannot penetrate undamaged vegetable skins. Furthermore, pathogens are not taken up in the roots of plants and transported to other portions of the plant.[30] However, pathogens can survive on the surfaces of vegetables, especially root vegetables. Sunshine and low air humidity will promote the death of pathogens. Viruses can survive up to two months on crops but usually live less than one month. Indicator bacteria may persist several months, but usually only last less than one month. Protozoan cysts usually survive less than two days, and worm eggs usually last less than one month. In studies of the survival of *Ascaris* eggs on lettuce and tomatoes during a hot, dry summer, all eggs degenerated enough after 27 to 35 days to be incapable of infection.[31]

Lettuce and radishes in Ohio sprayed with sewage inoculated with Poliovirus I showed a 99% reduction in pathogens after six days; 100% were eliminated after 36 days. Radishes grown outdoors in soil fertilized with fresh typhoid-contaminated feces four days after planting showed a pathogen survival period of less than 24 days. Tomatoes and lettuce contaminated with a suspension of roundworm eggs showed a 99% reduction in eggs in 19 days and a 100% reduction in four weeks. These tests indicate that if there is any doubt about pathogen contamination of compost, the compost should be applied to long-season crops at the time of planting so that sufficient time ensues for the pathogens to die before harvest.

Pathogen Survival In Sludge and Feces/Urine

Viruses can survive up to five months, but usually less than three months in sludge and night soil. Indicator bacteria can survive up to five months, but usually less than four months. Salmonellae survive up to five months, but usually less than

Table 7.8

SURVIVAL OF ENTEROVIRUSES IN SOIL

Viruses - These parasites, which are smaller than bacteria, can only reproduce inside the animal or plant they parasitize. However, some can survive for long periods outside of their host.

Enteroviruses - Enteroviruses are those that reproduce in the intestinal tract. They have been found to survive in soil for periods ranging between 15 and 170 days. The following chart shows the survival times of enteroviruses in various types of soil and soil conditions.

Soil Type	pH	% Moisture	Temp. (°C)	Days of Survival (less than)
Sterile, sandy	7.5	10-20%	3-10	130-170
		10-20%	18-23	90-110
	5.0	10-20%	3-10	110-150
		10-20%	18-23	40-90
Non-sterile, sandy	7.5	10-20%	3-10	110-170
		10-20%	18-23	40-110
	5.0	0-20%	3-10	90-150
		10-20%	18-23	25-60
Sterile, loamy	7.5	10-20%	3-10	70-150
		10-20%	18-23	70-110
	5.0	10-20%	3-10	90-150
		10-20%	18-23	25-60
Non-sterile, loamy	7.5	10-20%	3-10	110-150
		10-20%	18-23	70-110
	5.0	10-20%	10	90-130
		10-20%	18-23	25-60
Non-sterile, sandy	7.5	10-20%	18-23	15-25

Source: Feachem et al., 1980

Table 7.9

SURVIVAL TIME OF *E. HISTOLYTICA* PROTOZOA IN SOIL

Protozoa	Soil	Moisture	Temp (°C)	Survival
E. histolytica	loam/sand	Damp	28-34	8-10 days
E. histolytica	soil	Moist	?	42-72 hrs.
E. histolytica	soil	Dry	?	18-42 hrs.

Source: Feachem et al., 1980

Table 7.10

SURVIVAL TIMES OF SOME BACTERIA IN SOIL

Bacteria	Soil	Moisture	Temp.(°C)	Survival
Streptococci	Loam	?	?	9-11 weeks
Streptococci	Sandy loam	?	?	5-6 weeks
S. typhi	various soils	?	22	2 days-400 days
Bovine tubercule bacilli	soil & dung	?	?	less than 178 days
Leptospires	varied	varied	summer	12 hrs-15 days

Source: Feachem et al., 1980

Table 7.11

SURVIVAL OF POLIOVIRUSES IN SOIL

Soil Type	Virus	Moisture	Temp. (°C)	Days of Survival
Sand dunes	Poliovirus	dry	?	Less than 77
Sand dunes	Poliovirus	moist	?	Less than 91
Loamy fine sand	Poliovirus I	moist	4	90% reduction in 84
Loamy fine sand	Poliovirus I	moist	20	99.999% reduction in 84
Soil irrigated w/ effluent, pH=8.5	Polioviruses 1, 2 & 3	9-20%	12-33	Less than 8
Sludge or effluent, irrigated soil	Poliovirus I	180 mm total rain	-14-27	96-123 after sludge applied
			-14-27	89-96 after effluent applied
		190 mm total rain	15-33	less than 11 days after sludge or effluent applied

Source: Feachem et al., 1980

Table 7.12

SURVIVAL TIME OF SOME PATHOGENIC WORMS IN SOIL

Worm	Soil	Moisture	Temp. (ºC)	Survival
Hookworm larvae	Sand	?	room temp.	less than 4 months
	Soil	?	open shade, Sumatra	less than 6 months
	Soil	Moist	Dense shade	9-11 weeks
			Mod. shade	6-7.5 weeks
			Sunlight	5-10 days
	Soil	Water covered	varied	10-43 days
	Soil	Moist	0	less than 1 week
			16	14-17.5 weeks
			27	9-11 weeks
			35	less than 3 weeks
			40	less than 1 week
Hookworm ova (eggs)	Heated soil with night soil	water covered	15-27	9% survival after 2 weeks
	Unheated soil with night soil	water covered	15-27	3% survival after 2 weeks
Roundworm ova	Sandy, shaded		25-36	31% dead after 54 days
	Sandy, sun		24-38	99% dead after 15 days
	Loam, shade		25-36	3.5% dead after 21 days
	Loam, sun		24-38	4% dead after 21 days
	Clay, shade		25-36	2% dead after 21 days
	Clay, sun		24-38	12% dead after 21 days
	Humus, shade		25-36	1.5% dead after 22 days
	Clay, shade		22-35	more than 90 days
	Sandy, shade		22-35	less than 90 days
	Sandy, sun		22-35	less than 90 days
	Soil irrigated with sewage		?	less than 2.5 years
	Soil		?	2 years

Source: Feachem et al., 1980

Table 7.13

PARASITIC WORM EGG DEATH

Eggs	Temp.(ºC)	Survival
Schistosome	53.5	1 minute
Hookworm	55.0	1 minute
Roundworm	-30.0	24 hours
Roundworm	0.0	4 years
Roundworm	55.0	10 minutes
Roundworm	60.0	5 seconds

Source: Compost, Fertilizer, and Biogas Production from Human and Farm Wastes in the People's Republic of China, (1978), M. G. McGarry and J. Stainforth, editors, International Development Research Center, Ottawa, Canada. p. 43.

one month. Tubercle bacilli survive up to two years, but usually less than five months. Protozoan cysts survive up to one month, but usually less than ten days. Worm eggs vary depending on species, but roundworm eggs may survive for many months.

PATHOGEN TRANSMISSION THROUGH VARIOUS TOILET SYSTEMS

It is evident that human excrement possesses the capability to transmit various diseases. For this reason, it should also be evident that the composting of humanure is a serious undertaking and should not be done in a frivolous, careless, or haphazard manner. The pathogens that may be present in humanure have various survival periods outside the human body and maintain varied capacities for re-infecting people. This is why the *careful management* of a thermophilic compost system is important. Nevertheless, there is no proven, natural, low-tech method for destroying human pathogens in organic refuse that is as successful *and* accessible to the average human as well-managed thermophilic composting.

But what happens when the compost is not well-managed? How dangerous is the undertaking when those involved do not make an effort to ensure that the compost maintains thermophilic temperatures? In fact, this is normally what happens in most owner-built and commercial composting toilets. Thermophilic composting does not occur in owner-built toilets because the people responsible often make no effort to create the organic blend of ingredients and the environment needed for such a microbial response. In the case of most commercial composting toilets, thermophilic composting is not even intended, as the toilets are designed to be dehydrators rather than thermophilic composters.

On several occasions, I have seen simple collection toilet systems (sawdust toilets) in which the compost was simply dumped in an outdoor pile, not in a bin, lacking urine (and thereby moisture), and not layered with the coarse organic material needed for air entrapment. Although these piles of compost did not give off unpleasant odors (most people have enough sense to instinctively cover odorous organic material in a compost pile), they also did not necessarily become thermophilic (their temperatures were never checked). People who are not very concerned about working with and managing their compost are usually willing to let the compost sit for years before use, if they use it at all. Persons who are casual about their composting tend to be those who are comfortable with their own state of health and therefore do not fear their own excrement. As long as they are combining their humanure with a carbonaceous material and letting it compost, thermophilically or not, for at least a year (an additional year of aging is recommended), they are very unlikely to be creating any health problems, despite the rantings of fecophobes. What happens to these casually constructed compost piles? Incredibly, after a couple of years, they turn into quite lovely humus and, if left entirely alone, will simply become covered with vegetation and disappear back into the earth. I have seen it with my own eyes.

A different situation occurs when humanure from a highly pathogenic population is being composted. Such a population would be the residents of a hospital in an underdeveloped country, for example, or any residents in a community where certain diseases or parasites are endemic. In that situation, the composter must make every effort necessary to ensure thermophilic composting, adequate aging time, and total pathogen destruction.

The following information illustrates the various waste treatment methods and composting methods commonly used today and shows the transmission of pathogens through the individual systems.

Outhouses and Pit Latrines

Outhouses have odor problems, breed flies and possibly mosquitoes, and pollute groundwater. However, if the contents of a pit latrine have been filled over and left for a minimum of one year, there will be no surviving pathogens except for the possibility of roundworm eggs, according to Feachem. This risk is small enough that the contents of pit latrines, after twelve months burial, can be used agriculturally. Franceys et al. state, *"Solids from pit latrines are innocuous if the latrines have not been used for two years or so, as in alternating double pits."* [32]

Septic Tanks

It is safe to assume that septic tank effluents and sludge are highly pathogenic (see Figure 7.2). Viruses, parasitic worm eggs, bacteria, and protozoa can be emitted from septic tank systems in viable condition.

Conventional Sewage Treatment Plants

The only sewage digestion process producing a guaranteed pathogen-free sludge is batch thermophilic digestion in which all of the sludge is maintained at 50°C (122°F) for 13 days. Other sewage digestion processes will allow the survival of worm eggs and possibly pathogenic bacteria. Typical sewage treatment plants instead use a continuous process where wastewater is added daily or more frequently, thereby guaranteeing the survival of pathogens (see Figure 7.3).

I took an interest in my local wastewater treatment plant when I discovered that the water in our local creek below the wastewater discharge point had ten times the level of nitrates that unpolluted water has, and three times the level of nitrates acceptable for drinking water.[33] In other words, the water being discharged from the water treatment plant was polluted. We knew the pollution included high levels of nitrates, although we didn't test for pathogens or chlorine levels. Despite the pollution, the nitrate levels were within legal limits for wastewater discharges.

Figure 7.2

TRANSMISSION OF PATHOGENS THROUGH SEPTIC TANKS

Septic tanks are waste disposal systems and are not designed to destroy or eliminate pathogens. Four major pathogen groups can pass through septic systems and remain viable. Septic systems, therefore, are considered highly pathogenic. Source: Feachem et al., 1980

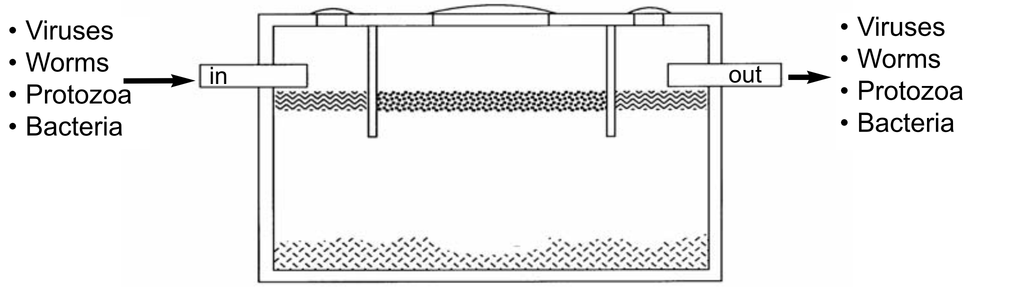
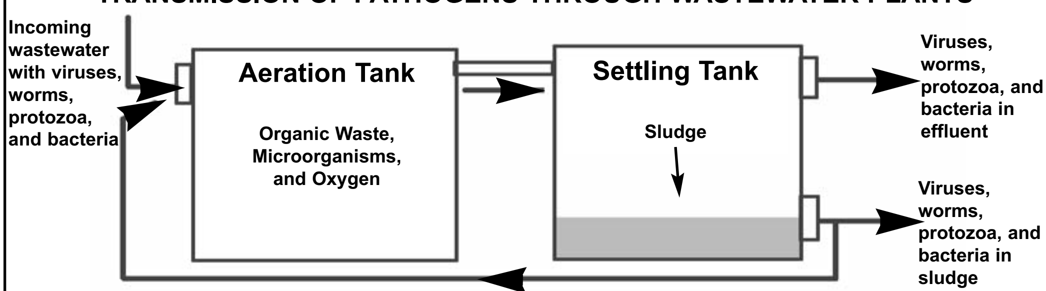


Figure 7.3

TRANSMISSION OF PATHOGENS THROUGH WASTEWATER PLANTS



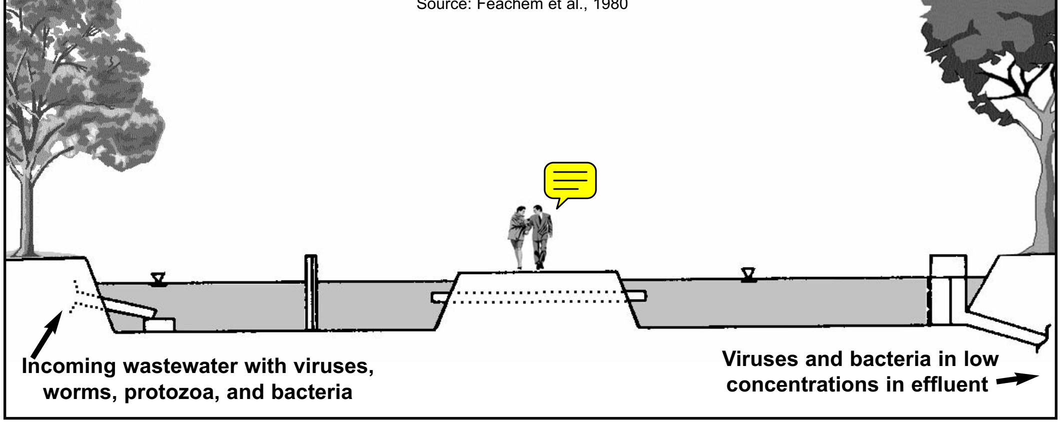
Conventional wastewater treatment plants allow the transmission of pathogens. Consequently, the effluent is commonly treated with chemical poisons such as chlorine, and the sludge is often buried in landfills.

Source: Feachem et al., 1980

Figure 7.4

TRANSMISSION OF PATHOGENS THROUGH WASTE STABILIZATION PONDS

Source: Feachem et al., 1980



Waste Stabilization Ponds

Waste stabilization ponds, or lagoons, large shallow ponds widely used in North America, Latin America, Africa and Asia, involve the use of both beneficial bacteria and algae in the decomposition of organic waste materials. Although they can breed mosquitoes, they can be designed and managed well enough to yield pathogen-free waste water. However, they typically yield water with low concentrations of both pathogenic viruses and bacteria (see Figure 7.4).

Composting Toilets and Mouldering Toilets

Most mouldering and commercial composting toilets are relatively anaerobic and compost at a low temperature. According to Feachem et al., a minimum retention time of three months produces a compost free of all pathogens except possibly some intestinal worm eggs. The compost obtained from these types of toilets can theoretically be composted again in a thermophilic pile and rendered suitable for food gardens (see Figure 7.5 and Table 7.14). Otherwise, the compost can be moved to an outdoor compost bin, layered and covered with straw (or other bulky organic material such as weeds or leaf mould), moistened, and left to age for an additional year or two in order to destroy any possible lingering pathogens. Microbial activity and earthworms will aid in the sanitation of the compost over time.

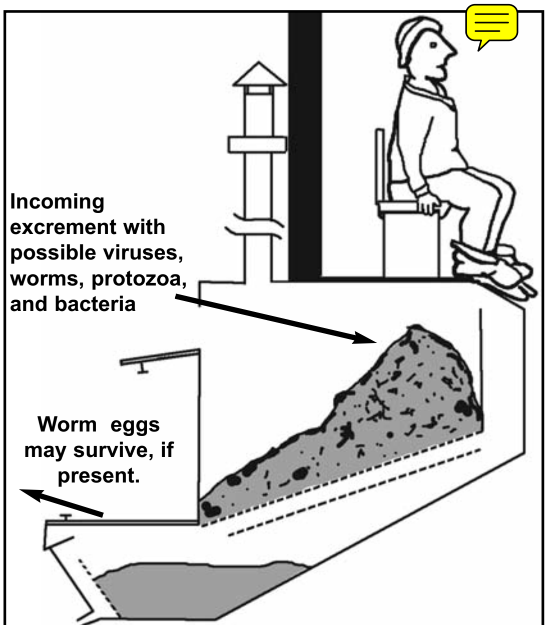


Figure 7.5
TRANSMISSION OF PATHOGENS THROUGH LOW-TEMPERATURE COMPOSTING TOILETS
Due to the low composting temperatures of most commercial composting and mouldering toilets, the eggs of some intestinal parasites, if present, may survive the composting process.

Source: Feachem et al., 1980

Well-managed Thermophilic Composting System

Complete pathogen destruction is guaranteed by arriving at a temperature of 62°C (143.6°F) for one hour, 50°C (122°F) for one day, 46°C (114.8°F) for one week, or 43°C (109.4°F) for one month. It appears that no excreted pathogen can survive a temperature of 65°C (149°F) for more than a few min-

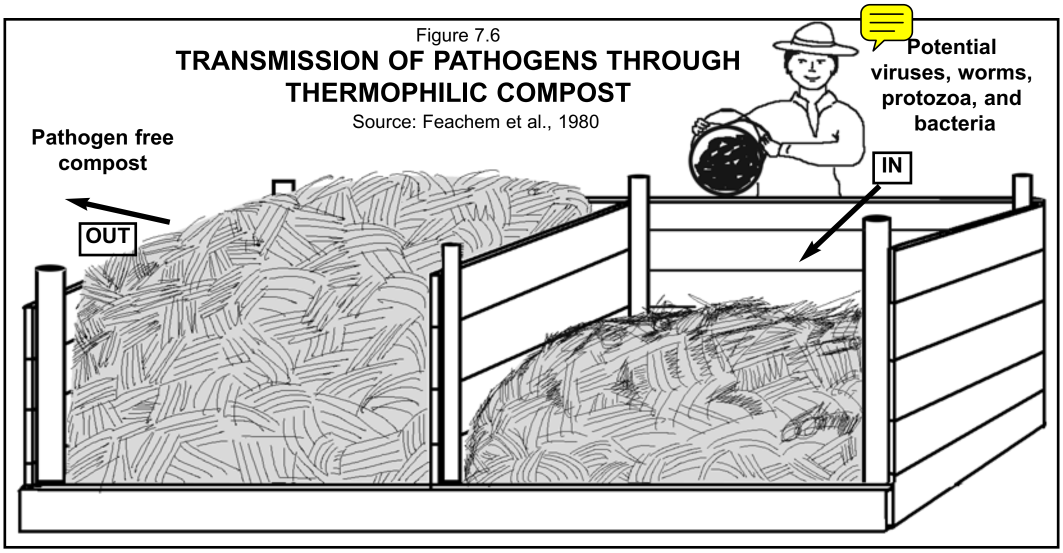


Figure 7.6
TRANSMISSION OF PATHOGENS THROUGH THERMOPHILIC COMPOST
Source: Feachem et al., 1980

utes. A compost pile containing entrapped oxygen may rapidly rise to a temperature of 55^{0}C (131^{0}F) or above, or will maintain a temperature hot enough for a long enough period of time to thoroughly destroy human pathogens that may be in the humanure (see Figure 7.6). Furthermore, pathogen destruction is aided by microbial diversity, as discussed in Chapter 3. Table 7.14 indicates survival times of pathogens in a) soil, b) anaerobic decomposition conditions, c) composting toilets, and d) thermophilic compost piles.

MORE ON PARASITIC WORMS

This is a good subject to discuss in greater detail as it is rarely a topic of conversation in social circles, yet it is important to those who are concerned about potential pathogens in compost. Therefore, let's look at the most common of human worm parasites: pinworms, hookworms, whipworms, and roundworms.

Pinworms

A couple of my kids had pinworms at one time during their childhood. I know exactly who they got them from (another kid), and getting rid of them was a simple matter. However, the rumor was circulated that they got them from our compost. We were also told to worm our cats to prevent pinworms in the kids (these rumors allegedly originated in a doctor's office). Yet, the pinworm life cycle does not include a stage in soil, compost, manure, or cats. These unpleasant parasites are spread from human to human by direct contact, and by *inhaling* eggs.

Pinworms (*Enterobius vermicularis*) lay microscopic eggs at the anus of a human being, its only known host. This causes itching at the anus which is the pri-

Table 7.14

PATHOGEN SURVIVAL BY COMPOSTING OR SOIL APPLICATION

Pathogen	Soil Application	Unheated Anaerobic Digestion	Composting Toilets (Three mo. min. retention time)	Thermophilic Composting
Enteric viruses	May survive 5 months	Over 3 months	Probably eliminated	Killed rapidly at 60ºC
Salmonellae	3 months to 1 year	Several weeks	A few may survive	Killed in 20 hrs. at 60ºC
Shigellae	Up to 3 months	A few days	Probably eliminated	Killed in 1 hr. at 55ºC or in 10 days at 40ºC
E. coli	Several months	Several weeks	Probably eliminated	Killed rapidly above 60ºC
Cholera vibrio	1 week or less	1 or 2 weeks	Probably eliminated	Killed rapidly above 55ºC
Leptospires	Up to 15 days	2 days or less	Eliminated	Killed in 10 min. at 55ºC
Entamoeba histolytica cysts	1 week or less	3 weeks or less	Eliminated	Killed in 5 min. at 50ºC or 1 day at 40º C
Hookworm eggs	20 weeks	Will survive	May survive	Killed in 5 min. at 50ºC or 1 hr. at 45ºC
Roundworm (*Ascaris*) eggs	Several years	Many months	Survive well	Killed in 2 hrs. at 55ºC, 20 hrs. at 50ºC, 200 hrs. at 45ºC
Schistosome eggs	One month	One month	Eliminated	Killed in 1 hr. at 50ºC
Taenia eggs	Over 1 year	A few months	May survive	Killed in 10 min. at 59ºC, over 4 hrs. at 45ºC

Source: Feachem et al., 1980

Table 7.15

THERMAL DEATH POINTS FOR SOME COMMON PARASITES AND PATHOGENS

PATHOGEN	THERMAL DEATH
Ascaris lumbricoides eggs	Within 1 hour at temperatures over 50ºC
Brucella abortus or *B. suis*	Within 1 hour at 55ºC
Corynebacterium diptheriae	Within 45 minutes at 55ºC
Entamoeba histolytica cysts	Within a few minutes at 45ºC
Escherichia coli	One hour at 55ºC or 15-20 minutes at 60ºC
Micrococcus pyogenes var. *aureus*	Within 10 minutes at 50ºC
Mycobacterium tuberculosis var. *hominis*	Within 15 to 20 minutes at 66ºC
Necator americanus	Within 50 minutes at 45ºC
Salmonella spp.	Within 1 hour at 55ºC; within 15-20 min. at 60ºC
Salmonella typhosa	No growth beyond 46ºC; death within 30 min. at 55ºC
Shigella spp.	Within one hour at 55ºC
Streptococcus pyogenes	Within 10 minutes at 54ºC
Taenia saginata	Within a few minutes at 55ºC
Trichinella spiralis larvae	Quickly killed at 55ºC

Source: Gotaas, Harold B. (1956). Composting - Sanitary Disposal and Reclamation of Organic Wastes . p.81. World Health Organization, Monograph Series Number 31. Geneva.

mary symptom of pinworm infestation. The eggs can be picked up almost anywhere; once in the human digestive system they develop into the tiny worms. Some estimate that pinworms infest or have infested 75% of all New York City children in the three to five year age group, and that similar figures exist for other cities.[34]

These worms have the widest geographic distribution of any of the worm parasites, and are estimated to infect 208.8 million people in the world (18 million in Canada and the U.S.). An Eskimo village was found to have a 66% infection rate; a 60% rate has been found in Brazil, and a 12% to 41% rate was reported in Washington D.C.

Infection is spread by the hand to mouth transmission of eggs resulting from scratching the anus, as well as from breathing airborne eggs. In households with several members infected with pinworms, 92% of dust samples contained the eggs. The dust samples were collected from tables, chairs, baseboards, floors, couches, dressers, shelves, window sills, picture frames, toilet seats, mattresses, bath tubs, wash basins and bed sheets. Pinworm eggs have also been found in the dust from school rooms and school cafeterias. Although dogs and cats do not harbor pinworms, the eggs can get on their fur and find their way back to their human hosts. In about one-third of infected children, eggs may be found under the fingernails.

Pregnant female pinworms contain 11,000 to 15,000 eggs. Fortunately, pinworm eggs don't survive long outside their host. Room temperature with 30% to 54% relative humidity will kill off more than 90% of the eggs within two days. At higher summer temperatures, 90% will die within three hours. Eggs survive longest (two to six days) under cool, humid conditions; in dry air, none will survive for more than 16 hours.

A worm's life span is 37-53 days; an infection would self-terminate in this period, without treatment, in the absence of reinfection. *The amount of time that passes from ingestion of eggs to new eggs being laid at the anus ranges from four to six weeks.*[35]

In 95% of infected persons, pinworm eggs aren't found in the feces. Transmission of eggs to feces and to soil is not part of the pinworm life cycle, which is one reason why the eggs aren't likely to end up in either feces or compost. Even if they do, they quickly die outside the human host.

One of the worst consequences of pinworm infestation in children is the trauma of the parents, whose feelings of guilt, no matter how clean and conscientious they may be, are understandable. However, if you're composting your manure, you can be sure that you are not thereby breeding or spreading pinworms. Quite the contrary, any pinworms or eggs getting into your compost are being destroyed.[36]

HOOKWORMS

Hookworm species in humans include *Necator americanus, Ancylostoma duodenale, A. braziliense, A. caninum,* and *A. ceylanicum.*

These small worms are about a centimeter long, and humans are almost the

Table 7.16

HOOKWORMS

Hookworm larvae develop outside the host and favor a temperature range of 23°C to 33°C (73°F to 91°F).

Temperature	Survival Time of: Eggs	Larvae
45°C (113°F)	Few hours	less than 1 hour
0°C (32°F)	7 days	less than 2 weeks
-11°C (12°F)	?	less than 24 hours

Both thermophilic composting and freezing weather will kill hookworms and eggs.

exclusive host of *A. duodenale* and *N. americanus.* A hookworm of cats and dogs, *A. caninum*, is an extremely rare intestinal parasite of humans.

The eggs are passed in the feces and mature into larvae outside the human host in favorable conditions. The larvae attach themselves to the human host usually at the bottom of the foot when they're walked on, and then enter their host through pores, hair follicles, or even unbroken skin. They tend to migrate to the upper small intestine where they suck their host's blood. Within five or six weeks, they'll mature enough to produce up to 20,000 eggs per day.

Hookworms are estimated to infect 500 million people throughout the world, causing a daily blood loss of more than 1 million liters, which is as much blood as can be found in all the people in the city of Erie, PA, or Austin, TX. An infection can last two to fourteen years. Light infections can produce no recognizable symptoms, while a moderate or heavy infection can produce an iron deficiency anemia. Infection can be determined by a stool analysis.

These worms tend to be found in tropical and semi-tropical areas and are spread by defecating on the soil. Both the high temperatures of composting and the freezing temperatures of winter will kill the eggs and larvae (see Table 7.16). Drying is also destructive.[37]

Whipworm

Whipworms (*Trichuris trichiura)* are usually found in humans, but also may be found in monkeys or hogs. They're usually under two inches long and the female can produce 3,000 to 10,000 eggs per day. Larval development occurs outside the host, and in a favorable environment (warm, moist, shaded soil), first stage larvae are produced from eggs in three weeks. The lifespan of the worm is usually considered to be four to six years.

Hundreds of millions of people worldwide, as much as 80% of the population in certain tropical countries, are infected by whipworms. In the US, whipworms are found in the south where heavy rainfall, a subtropical climate, and feces-contaminated soil provide a suitable habitat.

Persons handling soil that has been defecated on by an infected person risk infection by hand-to-mouth transmission. Infection results from ingestion of the eggs. Light infections may not show any symptoms. Heavy infections can result in anemia and death. A stool examination will determine if there is an infection.

Cold winter temperatures of -8°C to -12°C (17.6°F to 10.4°F) are fatal to the eggs, as are the high temperatures of thermophilic composting.[38]

Roundworms

Roundworms (*Ascaris lumbricoides)* are fairly large worms (10 inches in length) which parasitize the human host by eating semi-digested food in the small intestine. The females can lay 200,000 eggs per day for a lifetime total of 26 million or so. Larvae develop from the eggs *in soil* under favorable conditions (21°C to 30°C/69.8°F to 86°F). Above 37°C (98.6°F), they cannot fully develop.

Approximately 900 million people are infected with roundworms worldwide, one million in the US. The eggs are usually transmitted hand to mouth by people, usually children, who have come into contact with the eggs in their environment. Infected persons usually complain of a vague abdominal pain. Diagnosis is by stool analysis.[39] An analysis of 400,000 stool samples throughout the US by the Center for Disease Control found *Ascaris* in 2.3% of the samples, with a wide fluctuation in results depending on the geographical location of the person sampled. Puerto Rico had the highest positive sample frequency (9.3%), while samples from Wyoming, Arizona, and Nevada showed no incidence of *Ascaris* at all.[40] In moist tropical climates, roundworm infection may afflict 50% of the population.[41]

Eggs are destroyed by direct sunlight within 15 hours, and are killed by temperatures above 40°C (104°F), dying within an hour at 50°C (122°F). Roundworm eggs are resistant to freezing temperatures, chemical disinfectants, and other strong chemicals, but thermophilic composting will kill them.

Roundworms, like hookworms and whipworms, are spread by fecal contamination of soil. Much of this contamination is caused and spread by children who defecate outdoors within their living area. One sure way to eradicate fecal pathogens is to conscientiously collect and thermophilically compost *all* fecal material. Therefore, it is very important when composting humanure to be certain that *all* children use the toilet facility and do not defecate elsewhere. When changing soiled diapers, deposit the fecal material into the humanure receptacle with toilet paper or another biodegradable material. It's up to adults to keep an eye on kids and make sure they understand the importance of *always using a toilet facility.*

Fecal environmental contamination can also be caused by using raw fecal material for agricultural purposes. *Proper thermophilic composting of all fecal material is essential for the eradication of fecal pathogens.*

TEMPERATURE AND TIME

There are two primary factors leading to the death of pathogens in humanure. The first is *temperature*. A compost pile that is properly managed will destroy pathogens with the heat it generates.

The second factor is *time*. The lower the temperature of the compost, the longer the subsequent retention time needed for the destruction of pathogens. Given enough time, the wide biodiversity of microorganisms in the compost will destroy pathogens by the antagonism, competition, consumption, and antibiotic inhibitors provided by the beneficial microorganisms. Feachem et al. state that three months retention time will kill all of the pathogens in a low-temperature composting toilet except worm eggs, although Table 7.14 (also from Feachem) indicates that some additional pathogen survival may occur.

A thermophilic compost pile will destroy pathogens, including worm eggs, quickly, possibly in a matter of minutes. Lower temperatures require longer periods of time, possibly hours, days, weeks, or months, to effectively destroy pathogens. One need not strive for extremely high temperatures such as 65°C (150°F) in a compost pile to feel confident about the destruction of pathogens. It may be more realistic to maintain lower temperatures in a compost pile for longer periods of time, such as 50°C (122°F) for 24 hours, or 46°C (115°F) for a week. According to one source, *"All fecal microorganisms, including enteric viruses and roundworm eggs, will die if the temperature exceeds 46°C (114.8°F) for one week."* [42] Other researchers have drawn similar conclusions, demonstrating pathogen destruction at 50°C (122°F), which produced compost "completely acceptable from the general hygienic point of view." [43]

A sound approach to pathogen destruction when composting humanure is to thermophilically compost the organic refuse, then allow the compost to sit, undisturbed, for a lengthy period of time after the thermophilic heating stage has ended. The biodiversity of the compost will aid in the destruction of pathogens as the compost ages. If one wants to be particularly cautious, one may allow the compost to age for two years after the pile has been built, instead of the one year that is normally recommended.

In the words of Feachem et al., *"The effectiveness of excreta treatment methods depends very much on their time-temperature characteristics. The effective processes are those that either make the excreta warm (55°C/131°F), hold it for a long time (one year), or feature some effective combination of time and temperature."* The time/temperature factor of pathogen destruction is illustrated in Figure 7.7.

In short, the combined factors of temperature and time will do the job of "turning turds into tomatoes."

CONCLUSIONS

Humanure is a valuable resource suitable for agricultural purposes and has been recycled for such purposes by large segments of the world's human population for thousands of years.

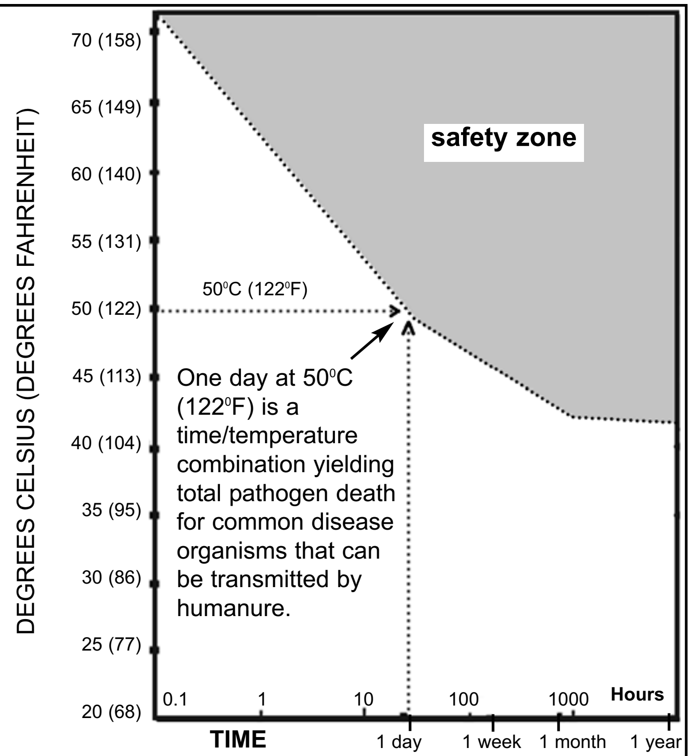
However, humanure contains the potential for harboring human pathogens,

Figure 7.7

SAFETY ZONE FOR PATHOGEN DEATH

Source: Feachem et al., 1980

The pathogen death boundaries shown at right include those for enteric (intestinal) viruses, *Shigella*, *Taenia* (tapeworm), *Vibrio cholera*, *Ascaris* (roundworm), *Salmonella*, and *Entamoebe histolytica*.

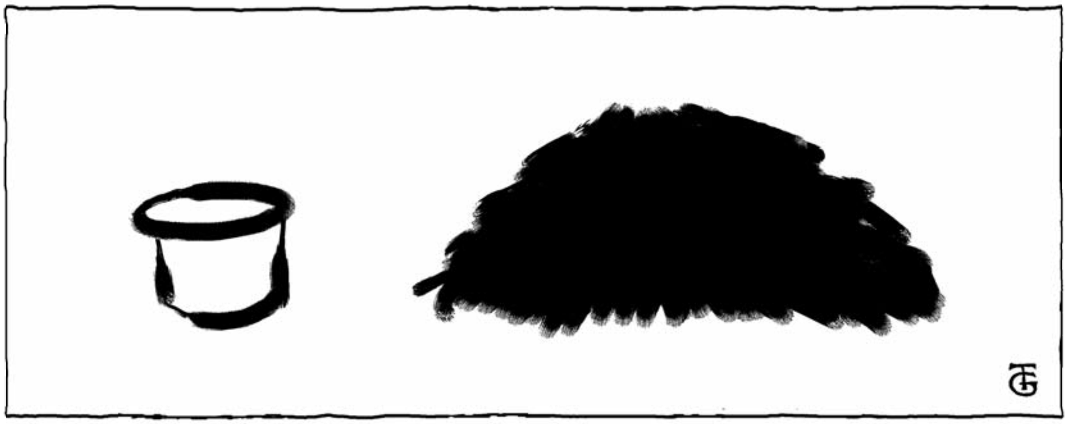


including bacteria, viruses, protozoa, and parasitic worms or their eggs, and thereby can contribute to the spread of disease when improperly managed or when discarded as a waste material. When pathogenic raw humanure is applied to soil, pathogenic bacteria may continue to survive in the soil for over a year, and roundworm eggs may survive for many years, thereby maintaining the possibility of human reinfection for lengthy periods of time.

However, when humanure is *thermophilically* composted, human pathogens are rapidly destroyed, and the humanure is thereby converted into a hygienically safe form, suitable for soil applications for the purpose of human food production.

Thermophilic composting requires no electricity and therefore no coal combustion, no acid rain, no nuclear power plants, no nuclear waste, no petrochemicals, and no consumption of fossil fuels. The composting process produces no waste, no pollutants, and no toxic by-products. Thermophilic composting of humanure can be carried out century after century, millennium after millennium, with no stress on our ecosystems, no unnecessary consumption of resources, and no garbage or sludge for our landfills. And all the while it will produce a valuable resource necessary for our survival while preventing the accumulation of dangerous and pathogenic waste. If that doesn't describe *sustainability*, nothing does.

THE TAO OF COMPOST



"Aspire to simple living? That means, aspire to fulfill the highest human destiny."
Charles Wagner

Organic material should be recycled by every person on the planet, and recycling should be as normal and integral to daily life as brushing teeth or bathing. Organic materials can be collected by municipalities and composted at central composting facilities. This is now done in many parts of the world where food scraps are composted for urban communities. Toilet materials are not yet being collected and centrally composted in very many places, although such collection will undoubtedly increase as time passes.

However, people can compost their own organic material in their own personal compost bins, in their own backyards. This is already becoming commonplace, and compost bins are now popping up in backyards everywhere like mushrooms after a rain. Composting need not cost money, and it can be practiced by anyone in the world at probably any location where plants can grow. Therefore, it is important that people everywhere learn to understand what compost is and how it can be made.

It is also important that we understand how to compost our toilet materials in a safe and simple manner. A low-cost composting toilet system can be very useful as a back-up toilet in an emergency situation when electrical or water services are disrupted, or when the water supply is diminished as during a drought, when flushing drinking water down toilets becomes especially ridiculous. It can also be very useful in any area where water or electricity is scarce or non-existent, as well as in developing countries where there may be many people with little or no money to buy commercial composting toilets. Finally, a simple, low-cost composting toilet system is attractive to anyone seeking a low-impact lifestyle, and who is willing to make the minimal effort to compost their organic materials. This chapter details how to compost toilet materials by using a simple, easy, low or no-cost method (a sawdust toilet) which my family and I have used for twenty years at the time of this writing.

The organic materials our bodies excrete can be composted much the same as any apple core or potato peel — by being added to a compost pile. There are essentially two ways to do this. The first is to construct or purchase a toilet which deposits directly into a composting chamber. This is discussed and illustrated in Chapter 6. Such toilets must be properly managed if thermophilic conditions are desired; most commercial composting toilets do not achieve such conditions, and are not meant to.

The second, less expensive, and simpler method is to use one's toilet as a collection device, much the same as any compost bucket, and then compost the contents in a separate compost pile on a regular basis. This simple technique can be done without unpleasant odors, and the toilet can be quite comfortably situated inside one's home. Moving toilet material to a compost bin, however, is an activity that many individuals have no interest in doing, usually not because it is a burdensome task (for a family of four it would involve a twenty minute trip to a compost bin about every three days), but because it's *shit*, for god's sake.

A friend of mine who wanted to use a compost toilet once told me she could never carry "a shit bucket" to a compost bin. She just could not do it, she said, shaking her head. I asked her how often she fed her dog, which was chained about a hundred yards from her house. "Every day," was her reply.

"How is it that you can carry a container of dog food out to your dog, every day, and not a container of soil nutrients to a compost pile once a week?" (A single person only needs to make a trip to a compost bin once a week.) No reply. "If the 'shit bucket,' as you call it, were full of roses, would you be able to carry it to a compost pile once a week?"

"Sure."

"Then why wouldn't you be able to carry a bucket of other organic material?"

Again, no reply. And none needed. The problem is not practical, it is psychological. I understand perfectly that many people consider the idea of composting their own excrement to be beneath them. In India, such a task was relegated to the "untouchables," the lowest caste of society. The act of carrying a container of one's own excrement to a recycling bin is an act of humility, and humility is sometimes in short supply. Eventually, toilets in general will be redesigned as collection devices and their contents will be collected and composted as a service by municipal workers. Until then, however, those of us who want to make compost rather than sewage must do it by our own humble selves.

I will never forget the day I introduced a close relative to my composting system. She came to visit me at my newly established homestead one spring day and I gave her a tour of my garden, which was already quite vibrant. A fresh pile of aged compost had been dumped from a wheelbarrow onto one of the raised garden beds and, as we passed, I reached down and scooped up a big handful, thrusting it toward her face. "Smell this," I said. So she put her nose right up to the black earth I held out before me and took a deep breath.

"Boy, that smells good!" she said, inhaling the rich, sweet-smelling aroma of fertile soil, and smiling.

"*This is my alternative to a septic system,*" I proudly informed her, still holding the compost out in front of me as I watched her smile freeze. I will always remember that shocked look on her face, cloaked behind a huge smile. My friend, although very open-minded, had not, prior to that moment, had the experience of so intimately communing with composted humanure. The compost did smell and look wonderful, if I have to say so myself, just like a rich soil from the woods, and I was *proud* of it.

People ask me when I'm going to install a septic system, as if composting is a phase you go through until you become mature and civilized enough to use a flush toilet. Others take one look at my compost toilet and say things like *"I respect the way you're living, but I could never do it."* Well, I could install a septic system, as I have running water and electricity (when I started using a composting toilet system I lived "off the grid," without electricity, and did so for a period of twelve years). However, a septic system would create environmental pollution and threaten the quality of my ground water, which I drink. It is a *waste disposal* system, collecting and storing waste and allowing the waste to slowly seep into the environment. I'd much rather engage in resource recovery instead of waste disposal, however unfashionable. My compost is my reward — it helps me to grow my food, and that's too valuable for me to be willing to sacrifice.

PRIMAL COMPOST

Try to imagine yourself in an extremely primitive setting, perhaps sometime around 10,000 B.C. Imagine that you're slightly more enlightened than your brutish companions and it dawns on you one day that your feces should be disposed of in a different manner. Everyone else is defecating in the back of the cave, creating a smelly, fly-infested mess, and you don't like it.

Your first revelation is that smelly refuse should be deposited in one place, not spread around for everyone to step in or smell, and it should be deposited away from one's living area. You watch the wild cats and see that they each go to a special spot to defecate. But the cats are still one step ahead of the humans, as you soon find out, because they cover their excrement.

When you've shat outside the cave on the ground in the same place several times, you see that you've still created a foul-smelling, fly-infested mess. Your second revelation is that the refuse you're depositing on the ground should be covered after each deposit. So you scrape up some leaves every time you defecate and throw them over the feces. Or you pull some tall grass out of the ground and use it for cover.

Soon your companions are also defecating in the same spot and covering their fecal material as well. They were encouraged to follow your example when they noticed that you had conveniently located the defecation spot between two large rocks, and positioned logs across the rocks to provide a convenient perch, allowing for care-free defecation above the material collecting underneath.

A pile of dead leaves is now being kept beside the toilet area in order to make the job of covering it more convenient. As a result, the offensive odors of human feces and urine no longer foul the air. Instead, it's food scraps that are generating odors and attracting flies. This is when you have your third revelation: food scraps should be deposited on the same spot and covered as well. Every stinky bit of refuse you create is now going to the same spot and is being covered with a natural material to eliminate odor. This hasn't been hard to figure out, it makes good sense, and it's easy to do.

You've succeeded in solving three problems at once: no more human waste scattered around your living area, no more garbage, and no more offensive odors assaulting your keen sense of smell and generally ruining your day. You also begin to realize that the illnesses that were prone to spread through the group have subsided, a fact that you don't understand, but you suspect may be due to the group's new found hygienic practices.

Quite by accident, you've succeeded in doing one very revolutionary thing: *you've created a compost pile.* You begin to wonder what's going on when the pile gets so hot it's letting off steam. What you don't know is that you've done exactly what nature intended you to do by piling all your organic refuse together, layered with natural, biodegradable cover materials. In fact, nature has "seeded" your excrement with microscopic animals that proliferate in and digest the pile you've created. In the process, they heat the compost to such an extent that disease-causing pathogens resident in the humanure are destroyed. The microscopic animals would not multiply rapidly in the discarded refuse unless you created the pile, and thereby the conditions, which favor their proliferation.

Finally, you have one more revelation, a big one. You see that the pile, after it gets old, sprouts all kind of vibrant plant growth. You put two and two together and realize that the stinking refuse you carefully disposed of has been transformed into rich earth, and ultimately into food. Thanks to you, humankind has just climbed another step up the ladder of evolution.

There is one basic problem with this scenario: it didn't take place 12,000 years ago. It's taking place now. Compost microorganisms are apparently very patient. Not much has changed since 10,000 B.C. in their eyes. The invisible animals that convert humanure into humus don't care what composting techniques are used today anymore than they cared what techniques may have been used eons ago, so long as their needs are met. And those needs haven't changed in human memory, nor are they likely to change as long as humans roam the earth. Those needs include: 1) *temperature* (compost microorganisms won't work if frozen); 2) *moisture* (they won't work if too dry or too wet); 3) *oxygen* (they won't work without it); and 4) *a balanced diet* (otherwise known as balanced carbon/nitrogen). In this sense, compost microorganisms are a lot like people. With a little imagination, we can see them as a working army of microscopic people who need the right food, water, air and warmth.

The art of composting, then, remains the simple and yet profound art of providing for the needs of invisible workers so that they work as vigorously as possible, season after season. And although those needs may be the same worldwide, the techniques used to arrive at them may differ from eon to eon and from place to place.

Composting differs from place to place because it is a bioregional phenomenon. There are thousands of geographic areas on the Earth each with its own unique human population, climatic conditions, and available organic materials, and there will also be potentially thousands of individual composting methods, techniques, and styles. What works in one place on the planet for one group of people may not work for another group in another geographic location (for example, we have lots of hardwood sawdust in Pennsylvania, but no rice hulls). Compost should be made in order to eliminate local waste and pollution as well as to recover resources, and a compost maker will strive to utilize in a wise and efficient manner whatever local organic resources are available.

THE SAWDUST TOILET

Simple methods of collecting humanure and composting it are sometimes called cartage systems or bucket systems, as the manure is carried to the compost bin, often in buckets or other waterproof vessels. People who utilize such simple techniques for composting humanure simply take it for granted that humanure recycling is one of the regular and necessary responsibilities for sustainable human life on this planet.

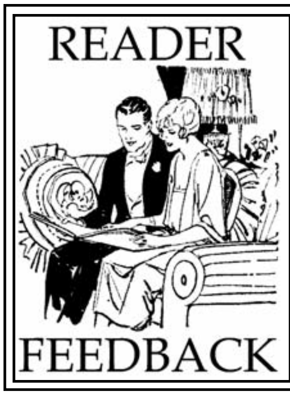
How it works is a model of simplicity. One begins by depositing one's organic refuse (feces and urine) into a plastic bucket, clay urn, or other non-corrodible waterproof receptacle with about a five gallon (20 liter) capacity. Food scraps may be collected in a separate receptacle, but can also be deposited into the toilet receptacle. A five gallon capacity is recommended because a larger size would be too heavy to carry when full. If five gallons is still too heavy for someone to carry, it can be emptied when half-full.

The contents of the toilet are kept covered with a clean, organic *cover material* such as rotted sawdust, peat moss, leaf mould, rice hulls, or grass clippings, in order to prevent odors, absorb urine, and eliminate any fly nuisance. Urine is deposited into the same receptacle, and as the liquid surface rises, more cover material is added so that a clean layer of organic material covers the toilet contents *at all times*.

A lid is kept on the toilet receptacle when not in use. The lid need not be airtight, and a standard, hinged toilet seat is quite suitable. The lid does not necessarily prevent odor from escaping, and it does not necessarily prevent flies from gaining access to the toilet contents. Instead, *the cover material does*. The cover material acts as an organic lid or a "biofilter"; the physical lid (toilet seat) is used primarily for convenience and aesthetics. Therefore, the choice of organic cover material is very important, and a material that has some moisture content, such as rotted sawdust, works beautifully. This is not kiln-dried sawdust from a carpenter shop. It is sawdust from a sawmill where trees are cut into boards. Such sawdust is both moist and biologically active and makes a very effective biofilter. Kiln-dried sawdust is too light and airy to be a 100% effective biofilter. Furthermore, sawdust from woodworking shops may contain hazardous chemical poisons if "pressure-treated" lumber is being used there. It seems that present-day carpenters are more than willing to expose themselves to the chemical hazards of poison-soaked lumber, which contains cancer-causing chemicals. There is no need for composters and gardeners to duplicate such unwise exposure.

I use rotted sawdust as a toilet cover material because it is a readily available, very inexpensive, local resource which works well. I used to haul a free load home from a local sawmill every so often in the back of my pick-up truck, but now I just have a fellow with a small dump truck deliver me a load every year or two. I have the sawdust dumped in a pile in a corner of my backyard adjacent to my compost bins where it can remain exposed to the elements and thereby slowly decompose on its own, as rotting sawdust makes compost more readily than fresh sawdust. The sawdust itself doesn't cost me anything, but I usually have to pay about five dollars to have it loaded onto the dump truck and another twenty-five to have it hauled. This is an expense I'm happy to pay every year or two in order to ensure for myself a functional compost toilet system. I would speculate that many other cellulose-based materials or combination of materials would work as a toilet cover material, including perhaps ground newsprint.

In the winter, an outdoor pile of sawdust will freeze solid. I have to layer some hay over mine and cover it with a tarp in order to be able to access it all winter. Otherwise, feedsacks filled with sawdust stored in a basement will work as an



"I found myself on an organic farm in Thailand...I and some other volunteers made handy use of your book. Instead of shitting in a pit and covering, we decided to make good use of 'the waste.' Could not have done it, however, without the information you provided. So yes, even in the remote parts of Thailand, your efforts have made their effects. We used easy-to-get rice husks instead of suggested sawdust — works brilliantly!" R.M. in Thailand

"I've been using lately well-rotted leaf mold to cover deposits in the five gallon bucket — and find this a fantastic cover for absorbing all odors — better than when I used sawdust." J.W. in CT alternative, as will peat moss and other cover materials stored indoors.

The system of using an organic cover material in a small receptacle works well enough in preventing odors to allow the toilet to be indoors, year round. In fact, a full bucket with adequate and appropriate cover material, and no lid, can be set on the kitchen table without emitting unpleasant odors (take my word for it). An indoor sawdust toilet should be designed to be as warm, cozy, pleasant, and comfortable as possible. A well-lit, private room with a window, a standard toilet seat, a container of cover material, and some reading material will suffice.

When the bucket is full, it is carried to the composting area and deposited on the pile. Since the material must be moved from the toilet room to an outdoor compost pile, the toilet room should be handy to an outside door. If you are designing a sawdust toilet in a new home, situate the toilet room near a door that allows direct access to the outside.

It is best to dig a slight depression in the top center of the compost pile and deposit the fresh material there, in order to keep the incoming humanure in the hotter center of the compost pile. This is easily achieved by raking aside the cover material on top of the pile, depositing the toilet contents in the resulting depression, and then raking the cover material back over the fresh deposit. The area is then immediately covered with additional clean, bulky, organic material such as straw, leaves, or weeds, in order to eliminate odors and to entrap air as the pile is built.

The bucket is then thoroughly scrubbed with a small quantity of water,

AMERICAN YARDS AND ENGLISH GARDENS

In the United States, a "yard" is a grassy area surrounding a house; the term is equivalent to the English term "garden." That grassy area may contain trees, shrubs, or flowers. If it is located in front of the house, it is called the "front yard." Behind the house, it is the "back yard." Beside the house, it is the "side yard." An American "garden" is a plot of vegetables, often located within the yard. An American garden can also be a flower garden or fruit garden; some American gardens contain flowers, fruits, and vegetables. In the UK, the green area around a house is called the "garden," whether it contains vegetables, flowers, or nothing but mowed grass. English homes do not have "yards." So the term "back yard composting," translated to UK English, would be "back garden composting."

SAWDUST TOILET VITAL STATISTICS

One hundred pounds of human body weight will fill approximately three gallons (.4 cubic feet, 693 cubic inches, or approximately 11 liters) in a sawdust toilet per week - this volume includes the sawdust cover material. One hundred pounds of human body weight will also require approximately 3 gallons of semi-dry, deciduous, rotting sawdust per week for use as a cover material in a toilet. This amounts to a requirement of approximately 20 cubic feet of sawdust cover material per one hundred pounds of body weight per year for the proper functioning of a sawdust toilet. Human excrement tends to add weight rather than volume to a sawdust toilet as it is primarily liquid and fills the air spaces in the sawdust. Therefore, for every gallon of sawdust-covered excrement collected in a sawdust toilet, nearly a gallon of cover material will need to be used.

which can be rain water or graywater, and biodegradable soap, if available or desired. A long-handled toilet brush works well for this purpose. Often, a simple but thorough rinsing will be adequate. Rain water or wastewater is ideal for this purpose as its collection requires no electricity or technology. The soiled water is then poured on the compost pile.

It is imperative that the rinse water not be allowed to pollute the environment. The best way to avoid this is to put the rinse water on the compost pile, as stated. However, the rinse water can be poured down a drain into a sewer or septic system, or drained into an artificial wetland. It can also be poured at the base of a tree or shrub that is designated for this purpose. Such a tree or shrub should have a thick layer of organic material (biological sponge) at its base and be staked or fenced to prevent access to children or pets. Under no circumstances should the rinse water be flung aside nonchalantly. This is the weak link in this simple humanure recycling chain, and it provides the most likely opportunity for environmental contamination. Such contamination is easy to avoid through considerate, responsible management of the system. Finally, never use chlorine to rinse a compost receptacle. Chlorine is a chemical poison that is detrimental to the environment and is totally unnecessary for use in any humanure recycling system. Simple soap and water is adequate.

After rinsing or washing, the bucket is then replaced in the toilet area. The inside of the bucket should then be dusted with sawdust, the bottom of the empty receptacle should be primed with an inch or two of sawdust, and it's once again ready for use. After about ten years, the plastic bucket may begin to develop an odor, even after a thorough washing. Replace odorous buckets with new ones in order to maintain an odor-free system. The old buckets will lose their odor if left to soak in clean, soapy water for a lengthy period (perhaps weeks), rinsed, sun-dried, and perhaps soaked again, after which they can be used for utility purposes (or, if you really have a shortage of buckets, they can be used in the toilet again).

Here's a helpful hint: when first establishing such a toilet system, it's a good idea to acquire at least *four* five gallon buckets, with lids, that are *exactly the same*, and more if you intend to compost for a large number of people. Use one under the toilet seat and two, with lids, set aside in the toilet room, empty and waiting (save the fourth as a back-up). When the first becomes full, take it out of the toilet, put a lid on it, set it aside, and replace it with one of the empty ones. When the second one fills, take it out, put the other lid on it, set it aside, and replace it with the other empty one. Now you have two full compost buckets, which can be emptied at your leisure, while the third is in place and ready to be used. This way, the time you spend emptying compost is almost cut in half, because it's just as easy to carry two buckets to the compost pile as one. Furthermore, you potentially have a 15 gallon toilet capacity at any one time (20 with the extra bucket), instead of just five gallons. You may find that extra capacity to come in very handy when inundated with visitors.

Why should all of the buckets be exactly the same? If you build a permanent toilet cabinet (seat), the top of the bucket should protrude through the cabinet to

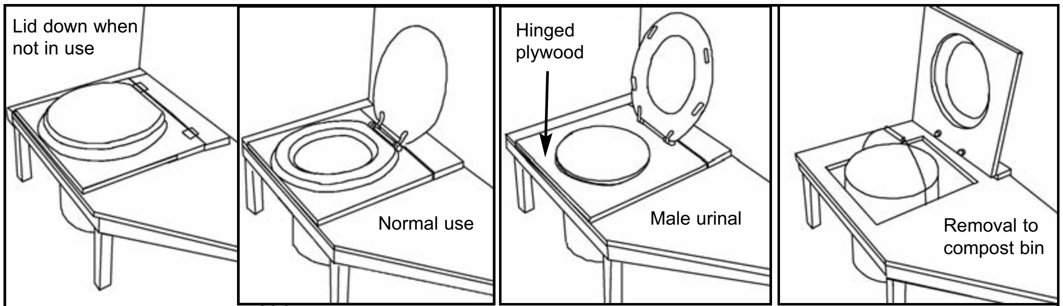


Figure 8.1

SAWDUST TOILET WITH HINGED SEAT

The above diagram shows a simple sawdust toilet permanently built into a toilet room. The compost receptacle (bucket) sits directly on the floor. A standard toilet seat is attached to an 18” square piece of plywood, which lifts up on hinges to allow easy access when removing the compost material. Bucket setback from the front edge of the plywood is 1&1/2”. Height of top surface of plywood is 1/2” lower than height of bucket. Bucket protrudes through cabinet to contact bottom of toilet seat ring. Plastic bumpers on bottom of toilet seat ring are swiveled sideways so as to fit around bucket. Actual toilet shown below.

Figure 8.2

SAWDUST TOILET WITH LIFT-OFF TOP

Toilet at left came with directions mounted on the wall.

contact the bottom of a standard toilet seat. This ensures that all organic material goes into the container, not over its edge. Although this is not usually a problem, it can be with young children who may urinate over the top of a bucket receptacle when sitting on a toilet. A good design will enable the bucket to fit tightly through the toilet cabinet as shown in Figures 8.1, 8.2, and 8.4. Since all plastic buckets are slightly different in height and diameter, you will have to build your toilet cabinet to fit one size bucket. You should have extra identical ones when backup capacity is needed to accommodate large numbers of people.

It is much better to set a full toilet receptacle aside, with a lid, and replace it immediately with an empty one, than to have to empty and replace a full one while someone is waiting to use the toilet. There are some things in life we would all like to avoid: you have no money in the bank, your gas tank is empty, you're out of firewood, your pantry is bare, the sun's not shining, the dog has died, and "nature calls," but the shit bucket's full. Put some harmonica music to that last sentence and you'd have *"The Shit Bucket Blues."* One can avoid singing that tune by properly planning and managing a sawdust toilet system.

Theoretically, with enough containers, a sawdust toilet system can be used for any number of people. For example, if you are using a sawdust toilet in your home, and you are suddenly visited by thirty people all at once, you will be very happy to have empty containers ready to replace the ones that fill up. You will also be very happy that you will not have to empty any compost containers until after your company leaves, because you can simply set them out of the way in the toilet room as they fill up, and then empty them the next day.

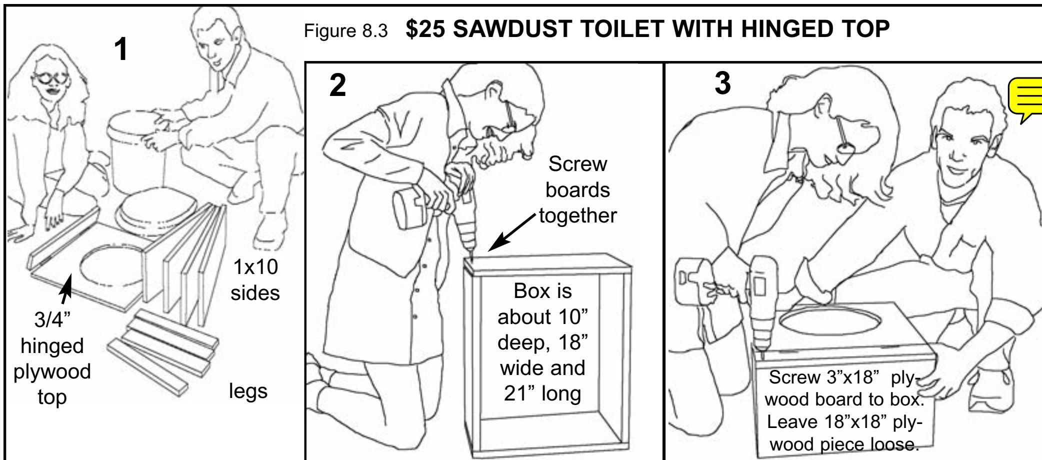
Experience has shown that 150 people will require four five gallon containers during a serious party. Therefore, always be prepared for the unexpected, and maintain a reserve toilet capacity at all times by having extra toilet receptacles available, as well as extra cover material. Incidentally, for every full container of compost material carried out of a toilet room, a full, same-sized container of cover material will need to be carried in.

Expecting five hundred people for a major gathering out in the woods? Sawdust toilets will work fine, as long as you keep enough buckets handy, as well as adequate cover materials, and some volunteers to manage it all. You will collect a lot of valuable soil nutrients. Which brings to mind a verse created by a friend and sung to the tune of "Old Joe Clark" at one of my own gatherings, here paraphrased:

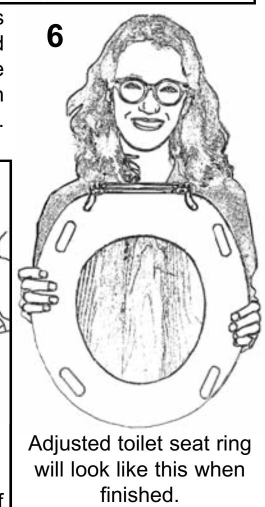
"He feeds us lots of party food,
and calls it appetizers.
But we know what he's going to do,
He'll make it fertilizer!"

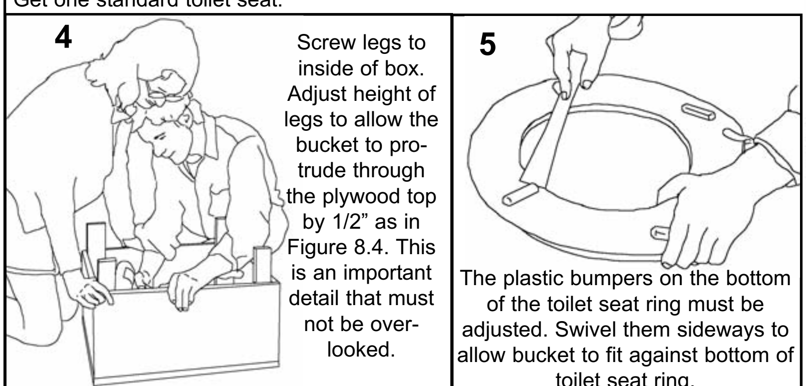
The advantages of a sawdust toilet system include low financial start-up cost in the creation of the facilities, and low, or no energy consumption in its operation.

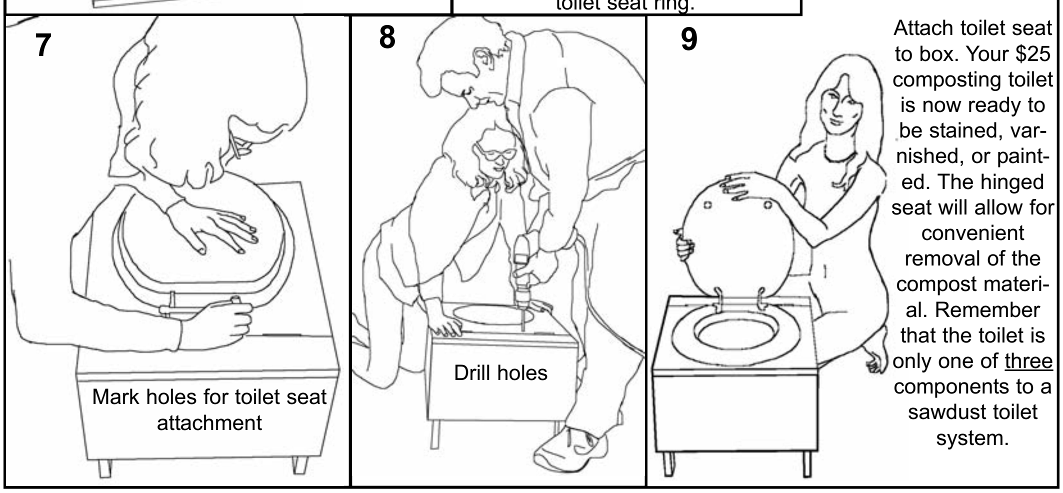
Figure 8.3 **$25 SAWDUST TOILET WITH HINGED TOP**



A hinged sawdust toilet box will be 18" wide by 21" long. Get (2) boards 3/4"x10"x18", (2) 3/4"x10"x19.5", (2) hinges, (1) piece of 3/4" plywood 18"x18" and another 18"x3" and hinge them together. Cut a hole in the larger plywood to fit the top of a five-gallon bucket, set back one and one half inches from the front (as in Figure 8.4). Get four five-gallon buckets that are identical. Get (4) 3/4"x3"x12" legs. Get one standard toilet seat.







Also, such a simple system, when the refuse is thermophilically composted, has a low environmental cost, as little or no technology is required for the system's operation, and the finished compost is as nice and benign a material as humanure can ever hope to be. No composting facilities are necessary in or near one's living space, although the toilet can and should be inside one's home and can be quite comfortably designed and totally odor-free. No electricity is needed, and no water is required except a small amount for cleaning purposes. The compost, if properly managed, will heat up sufficiently for sanitation to occur, thereby making it useful for gardening purposes. The composting process is fast, i.e., the humanure is converted quickly (within a few days if not frozen) into an inoffensive substance that will neither attract rodents nor flies. In cold winter months, the compost simply freezes until spring thaw, and then heats up. If the compost is unmanaged and does not become thermophilic, the compost can simply be left to age for a couple of years before horticultural use. In either case, a complete natural cycle is maintained, unbroken.

THE COMPOST BINS

A sawdust toilet requires three components: 1) the toilet receptacle; 2) cover materials; and 3) a compost bin system. The system will NOT work without all three of these components. The toilet is only the collection stage of the process. The composting takes place away from the toilet, and the compost bin system is important.

1) *Use at least a double-chambered, above-ground compost bin*. A three-chambered bin is recommended. Deposit in one chamber for a period of time (e.g., a year), then switch to another for an equal period of time.

2) *Deposit a good mix of organic material into the compost pile*, including kitchen scraps. It is a good idea to put all of your organic material into the same compost bin. Pay no attention to those people who insist that humanure compost should be segregated from other compost. They are people who do not compost humanure and don't know what they're talking about.

3) *Always cover humanure deposits in the toilet with an organic cover material* such as sawdust, leaf mould, peat moss, or rice hulls. *Always cover fresh deposits on the compost pile with coarser cover materials* such as hay, weeds, straw, or leaves. Make sure that enough cover is applied so that there is neither excess liquid build-up in the toilet nor offensive odors escaping either the toilet or the compost pile. The trick to using cover material is quite simple: *if it smells bad or looks bad, cover it until it does neither.*

4) *Keep good access to the pile* in order to rake the top flat, to apply bulky cover material when needed, to allow air to access the pile, and to monitor the temperature of the pile. The advantage of aerobic composting, as is typical of an above-ground pile, over relatively anaerobic composting typical of enclosed composting toilets, is that the aerobic compost will generate higher temperatures, thereby ensuring a more rapid and complete destruction of potential human pathogens.

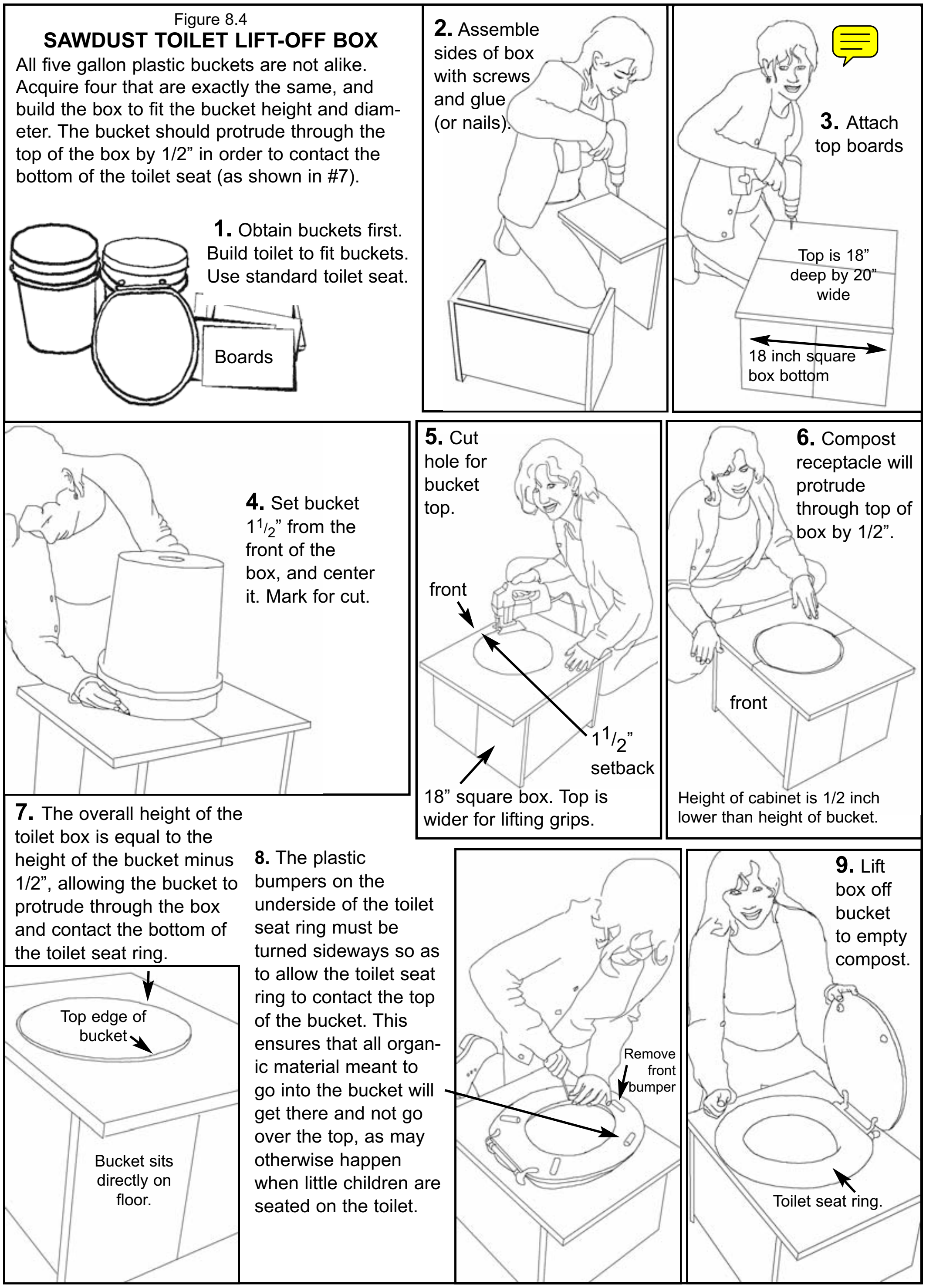


Figure 8.4
SAWDUST TOILET LIFT-OFF BOX

The disadvantages of a collection system requiring the regular transporting of humanure to a compost pile are obvious. They include the inconvenience of: 1) carrying the organic refuse to the compost pile; 2) keeping a supply of organic cover material available and handy to the toilet; 3) maintaining and managing the compost pile itself.

NORMAL COMPOSTING BIN SEQUENCE

It's very important to understand that *two* factors are involved in destroying potential pathogens in humanure. Along with heat, the *time* factor is important. Once the organic material in a compost pile has been heated by thermophilic microorganisms, it should be left to age or "season." This part of the process allows for the final decomposition to take place, decomposition that may be dominated by fungi and macroorganisms such as earthworms. Therefore, a good compost system will utilize at least two composting bins, one to fill and leave to age, and another to fill while the first is aging. A three-binned composting system is recommended, as the third bin provides a place to store cover materials, and separates the active bins so there is no possible accidental transfer of fresh material to an aging bin.

When composting humanure, fill one bin first. Start the compost pile by establishing a thick layer of coarse and absorbent organic material on the bottom of the bin. This is called a "biological sponge"; its purpose is to act as a leachate barrier. The sponge may be an 18 inch layer of hay or straw, grass clippings, leaves, and/or weeds. Place the first container of the humanure/sawdust mix from the toilet directly on the top center of the sponge. Cover immediately with more straw, hay, weeds, or leaves — the cover acts as a natural "biofilter" for odor prevention, and it causes air to become trapped in the developing compost pile, making physical turning of the pile for aeration unnecessary.

Continue in this manner until the bin is full, being sure to add to this bin *all* of the other organic material you produce. There is no need to have any other compost piles — one is enough for everything produced by the humans in your household. If you have small animals such as chickens or rabbits, their manure can go into the same compost pile. Presumably, pet manures can also go into the same compost pile as well (see Chapter 3), although pet manures, like human manures, can contain human pathogens, so thermophilic composting and/or adequate aging of the compost are essential. Small dead animals can also be added to the compost pile.

You need to do nothing special to prepare material for adding to the compost pile. You do not need to chop up vegetables, for example. Just chuck it all in there. Most of the things compost educators tell you cannot be composted *can,* in fact, be composted in your humanure compost pile (such as meat, fats, oils, etc.). Add it all to the same compost pile. Anything smelly that may attract flies should be dug into the top center of the pile. Keep a shovel or pitchfork handy for this purpose and use the tool *only* for the compost. Keep a clean cover material over the compost at all

SAWDUST TOILET IN NEW RURAL HOME ▲

PEAT TOILET (PEAT STORED ▲
UNDER LID WITH HANDLE)

HINGED TOP SAWDUST TOILET IN URBAN HOME ▲

LIFT-OFF SAWDUST TOILET IN RURAL HOME ▲

EMERGENCY SAWDUST TOILET ▲
IN BASEMENT OF NEW HOME WITH SEPTIC SYSTEM

SAWDUST TOILET IN "OUTHOUSE" ▲

times, and don't let your compost pile become shaped like the Matterhorn — keep it somewhat flattened so nothing rolls off.

When you have a sudden large quantity of cover material available, such as an influx of grass clippings when the lawn is mowed, weeds from the garden, or leaves in the fall, place them in the center bin for storage and use them to cover humanure deposits as you need them. It is assumed that you do not use any poisonous chemicals on your lawn. If you do, bag the lawn clippings, take them to a toxic waste dump, and on the way, reflect upon the folly of such toxic behavior. Do not put poisoned grass clippings on your compost pile.

Filling the first bin should take a year — that's how long it takes us, a family, usually of four, with a lot of visitors. We start to fill a compost bin every summer solstice or at some point near that time. Cover the finished compost pile with a thick layer of straw, leaves, grass clippings, or other clean material (without weed seeds) to insulate it and to act as a biofilter, then leave the pile alone. Start filling the second chamber, following the same procedure as the first (start with a biological sponge). When the second chamber is nearly full (a year later), the first one can begin to be emptied onto the garden, berries, orchard, or flower beds. The finished compost does not need to be dug deeply into the soil or buried in a trench on another planet, as the fecophobes insist. It can either be used as mulch, or it can be dug or tilled into the top layer of your garden soil. You can even roll naked in it if you want to (no, I haven't tried this — yet).

The author's triple chambered compost bins, in use for twenty years. The far bin is the active one, the near bin is the aging one, here being broken into for spring planting.

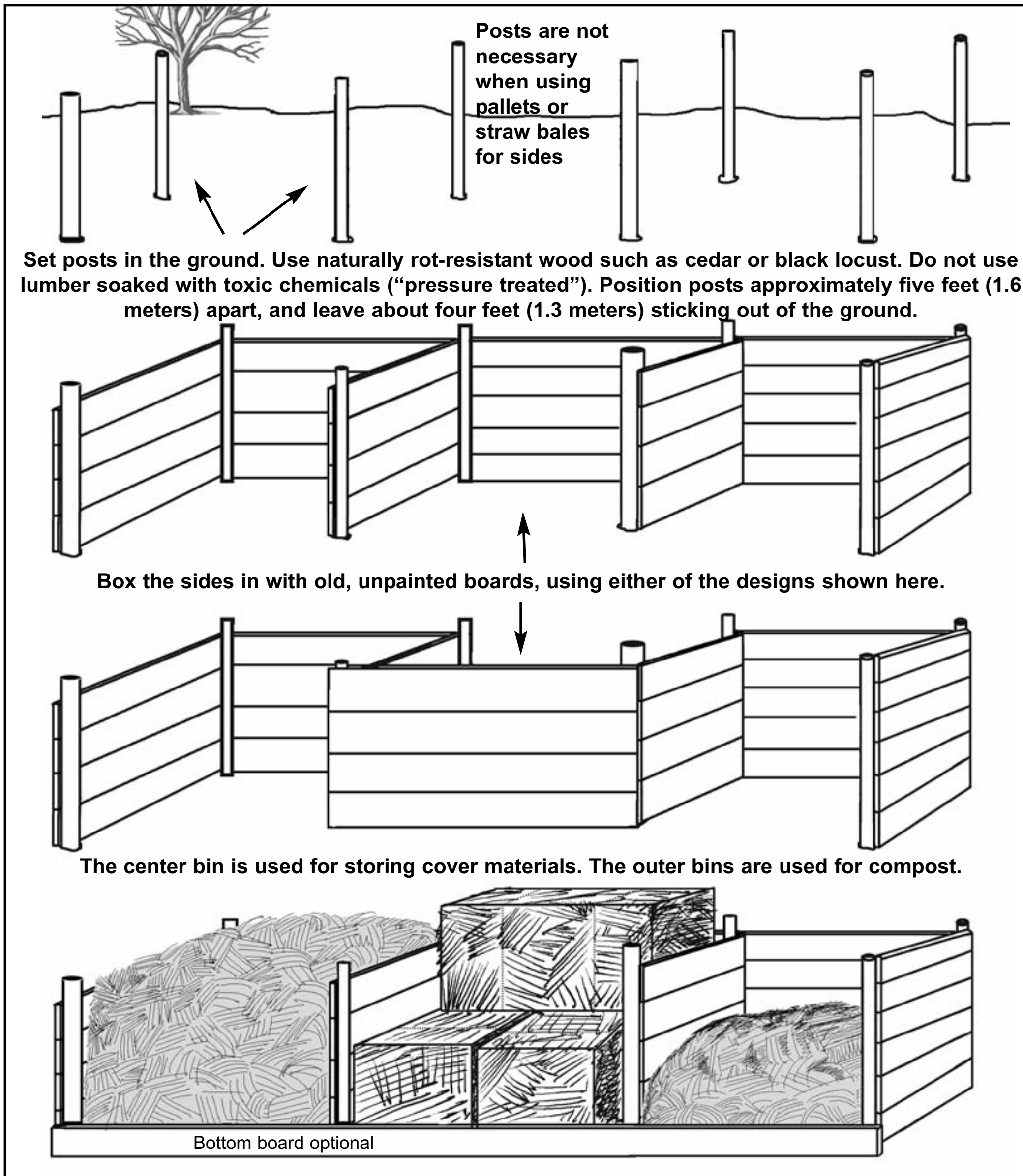


Figure 8.5

CONSTRUCTING A THREE-CHAMBERED COMPOSTING BIN

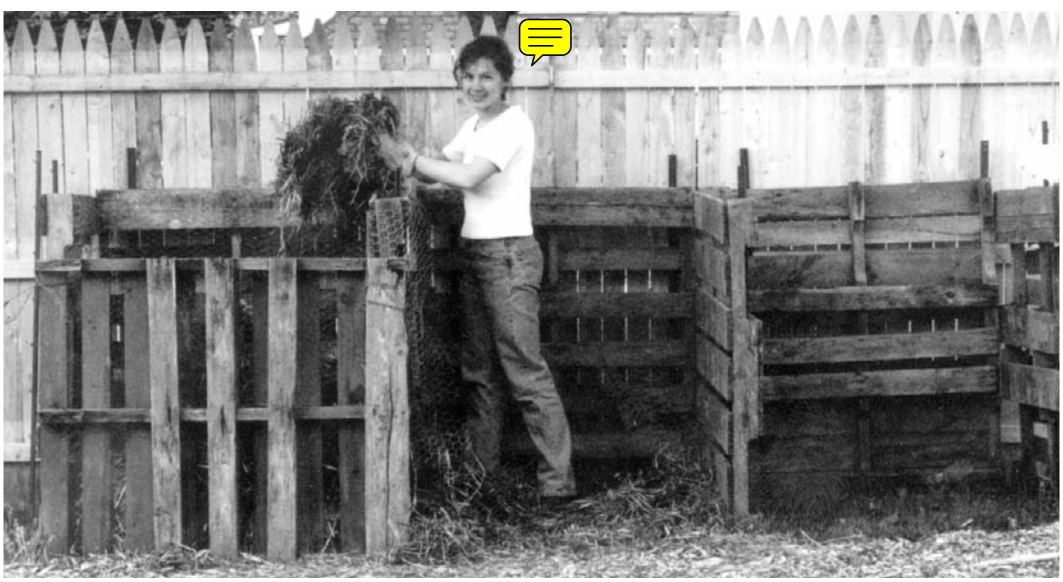
The three-chambered bin is ideally suited for humanure composting. The bin can be built of pallets wired, nailed, or screwed together instead of boards. Straw or hay bales (or pallets) can be used to close the open side when filling with compost. Later, the old straw can be used as a cover material. The center bin is used for storing excess cover materials such as garden weeds, lawn grass and leaves, or bales of hay or straw.

A compost pile can accept a huge amount of refuse, and even though the pile may seem to be full, as soon as you turn your back it will shrink down and leave room for more material. So when I say fill the first bin before filling the second, I mean *fill* it. A year is a good period of time for doing so in any area where there is an annual growing season. In the tropics, a shorter period may be necessary; I don't know. You readers who live in the tropics will have to figure that out. In the cold winters of the north, it is quite likely that the compost will freeze solid. You can, however, keep adding to the pile all winter. In the spring when it thaws out, the compost should work up a head of steam as if nothing happened.

Follow a natural timing cycle when making compost, one that is in tune to your agricultural cycle. A yearly cycle works best for me in Pennsylvania, where we have an annual growing cycle (one growing season per year). By late spring, the compost bin has been completely filled and it's time to let it sit until the next spring, when the finished compost will be ready to be removed and added to the garden.

The system outlined above will not yield any compost until two years after the process has started (one year to build the first pile and an additional year for it to age). However, after the initial two year start-up period, an ample amount of compost will be available on an annual basis.

A few people wrote to me wondering what happens to the leachate from the compost pile. Apparently they imagined that noxious fluids were draining into the soil under the pile, and they were concerned that this would constitute a violation of environmental regulations. Ironically, in most rural and many suburban areas, the



Newly constructed three-chambered compost bins made from pallets. The center chamber stores cover materials. This style compost bin costs practically nothing and can be erected in a short period of time. Photo by David Lott

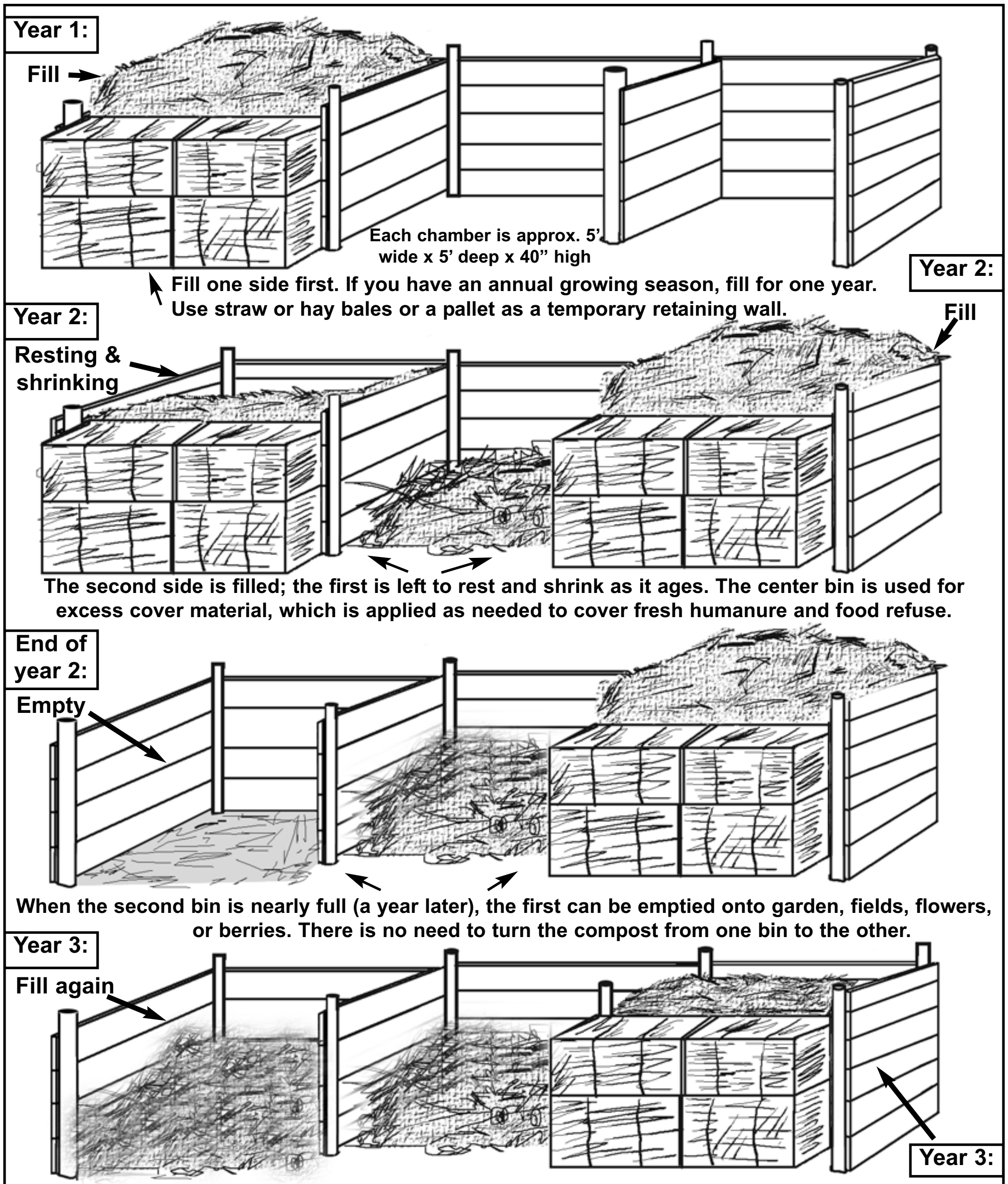


Figure 8.6

THE CEASELESS CYCLE OF COMPOST MAKING

Each compost bin should have a one year filling period and a one year retention (aging) period. At the end of the second year, the compost in the first bin will be ready for agricultural use. Turning from bin to bin is not necessary. In a diseased population, the compost should be aged for *two* years, and a third, separate, active bin will be required.

alternative would be to use a septic system for waste disposal. Septic systems are *designed* to leach waste into the soil. That makes me wonder why people are concerned about possible leaching into the soil from compost while they show no concern for the leaching from septic systems. The answer to the leaching question is two-fold. First, compost *requires* a lot of moisture; evaporated moisture is one of the main reasons why compost shrinks so much. Compost piles are not inclined to *drain* moisture unless during a very heavy rain. Most rainwater is absorbed by the compost, but in heavy rainfall areas a roof or cover can be placed over the compost pile at appropriate times in order to prevent leaching. Second, a thick biological sponge is layered under the compost before the pile is built. This acts as a leachate barrier. If these two factors aren't effective enough, it is a simple matter to place a layer of plastic underneath the compost pile, under the biological sponge, before the pile is built. Fold the plastic so that it collects any leachate and drains into a sunken five gallon bucket. If leachate collects in the bucket, pour it back over the compost pile. The plastic, however, will act as a biological barrier between the soil and the compost, and its use is therefore not recommended by the author. The interface between the compost pile and the soil acts as a corridor for soil organisms to enter the compost pile, and plastic will prevent that natural migration. However, the plastic *can* provide simple and effective leachate prevention, if needed.

PATHOGENIC POPULATIONS AND A TWO YEAR RETENTION TIME

Fecophobes, as we have seen throughout this book, believe that all human excrement is extremely dangerous, and will cause the end of the world as we know it if not immediately flushed down a toilet. Some insist that humanure compost piles must be turned frequently — to ensure that all parts of the pile are subjected to the internal high temperatures.

The only problem with that idea is that most people produce organic refuse a little at a time. For example, most people defecate once a day. A large amount of organic material suitable for thermophilic composting is therefore usually not available to the average person. As such, we who make compost a daily and normal part of our lives tend to be "continuous composters." We add organic material continuously to a compost pile, and almost never have a large "batch" that can be flipped and turned all at once. In fact, a continuous compost pile will have a thermophilic *layer*, which will be located usually in the top two feet or so of the pile. If you turn the compost pile under these conditions, that layer will become smothered by the thermophilically "spent" bottom of the pile, and all thermophilic activity will grind to a halt.

In healthy human populations, therefore, turning a continuous compost pile is not recommended. Instead, all humanure deposits should be deposited in the top center of the compost pile in order to feed it to the hot area of the compost, and a thick layer of insulating material (e.g., hay) should be maintained over the com-

DO'S AND DON'TS OF A THERMOPHILIC TOILET COMPOSTING SYSTEM

DO — Collect urine, feces, and toilet paper in the same toilet receptacle. Urine provides essential moisture and nitrogen.

DO — Keep a supply of clean, organic cover material handy to the toilet at all times. Rotting sawdust, peat moss, leaf mould, and other such cover materials prevent odor, absorb excess moisture, and balance the C/N ratio.

DO — Keep another supply of cover material handy to the compost bins for covering the compost pile itself. Coarser materials such as hay, straw, weeds, leaves, and grass clippings, prevent odor, trap air in the pile, and balance the C/N ratio.

DO — Deposit humanure into a depression in the top center of the compost pile, not around edges.

DO — Add a mix of organic materials to the humanure compost pile, including *all* food scraps.

DO — Keep the top of the compost pile somewhat flat. This allows the compost to absorb rainwater, and makes it easy to cover fresh material added to the pile.

DO — Use a compost thermometer to check for thermophilic activity. If your compost does not seem to be adequately heating, use the finished compost for berries, fruit trees, flowers, or ornamentals, rather than food crops. Or allow the constructed pile to age for two full years before garden use.

DON'T — Segregate urine or toilet paper from feces.

DON'T — Turn the compost pile if it is being continuously added to and a batch is not available. Allow the active thermophilic layer in the upper part of the pile to remain undisturbed.

DON'T — Use lime or wood ashes on the compost pile. Put these things directly on the soil.

DON'T — Expect thermophilic activity until a sufficient mass has accumulated.

DON'T — Deposit anything smelly into a toilet or onto a compost pile without covering it with a clean cover material.

DON'T — Allow dogs or other animals to disturb your compost pile. If you have problems with animals, install wire mesh or other suitable barriers around your compost, and underneath, if necessary.

DON'T — Segregate food items from your humanure compost pile. Add all organic materials to the same compost bin.

DON'T — Use the compost before it has fully aged. This means one year after the pile has been constructed, or two years if the humanure originated from a diseased population.

DON'T — Worry about your compost. If it does not heat to your satisfaction, let it age for a prolonged period, then use it for horticultural purposes.

A TIP FROM MR. TURDLEY

Sawdust works best in compost when it comes from logs, not kiln-dried lumber. Although kiln-dried sawdust (from a wood-working shop) will compost, it is a dehydrated material and will not decompose as quickly as sawdust from fresh logs, which are found at sawmills. Kiln-dried sawdust may originate from "pressure-treated" lumber, which usually is contaminated with chromated copper arsenate, a known cancer-causing agent, and a dangerous addition to any backyard compost pile. Sawdust from logs can be an inexpensive and plentiful local resource in forested areas. It should be stored outside where it will remain damp and continue to decompose. Although some think sawdust will make soil acidic, a comprehensive study between 1949 and 1954 by the Connecticut Experiment Station showed no instance of sawdust doing so.

Source: Rodale, The Complete Book of Composting, 1960, p. 192.

posting mass. Persons who have doubts about the hygienic safety of their finished humanure compost are urged to either use the compost for non-food crops or orchards, or have it tested at a lab before using on food crops.

On the other hand, one may have the need to compost humanure from a population with known disease problems. If the organic material is available in *batches*, then it can be turned frequently during the thermophilic stage in order to enhance pathogen death. After the thermophilic stage, the compost can be left to age for at least a year.

If the organic material is available only on a continuous basis, and turning the pile, therefore, is counterproductive, an *additional* year-long curing period is recommended. This will require one more composting bin in addition to the two already in use. After the first is filled (presumably for a year), it is left to rest *for two years*. The second is filled during the second year, then it is left to rest for two years. The third is filled during the third year. By the time the third is filled, the first has aged for two years and should be pathogen-free and ready for agricultural use. This system will create an initial lag-time of three years before compost is available for agricultural purposes (one year to build the first pile, and two more years retention time), but the extra year's retention time will provide added insurance against lingering pathogens. After the third year, finished compost will be available on a yearly basis. Again, if in doubt, either test the compost for pathogens in a laboratory, or use it agriculturally where it will not come in contact with food crops.

ANALYSES

After nearly 14 years of composting all of my family's and visitors' humanure on the same spot about 50 feet from my garden, and using all of the finished compost to grow the food in our single garden, I analyzed my garden soil, my yard soil (for comparison), and my compost, each for fertility and pH, using LaMotte test kits from the local university.[1] I also sent samples of my feces to a local hospital lab to be analyzed for indicator parasitic ova or worms.

The humanure compost proved to be adequate in nitrogen (N), and rich in phosphorus (P), and potassium (K), and higher than either the garden or the yard soil in these constituents as well as in various beneficial minerals. The pH of the compost was 7.4 (slightly alkaline), and no lime or wood ashes had been added during the composting process. This is one reason why I don't recommend adding lime (which raises the pH) to a compost pile. A finished compost would ideally have a pH around, or slightly above, 7 (neutral).

The garden soil was slightly lower in nutrients (N, P, K) than the compost, and the pH was also slightly lower at 7.2. I had added lime and wood ashes to my garden soil over the years, which may explain why it was slightly alkaline. The garden soil, however, was still significantly higher in nutrients and pH than the yard soil (pH of 6.2), which remained generally poor.

My stool sample was free of pathogenic ova or parasites. I used my own stool for analysis purposes because I had been exposed to the compost system and the garden soil longer than anyone else in my family by a number of years. I had freely han-

Adequately aged, thermophilically composted humanure is a pleasant-smelling, hygienic material. It can be freely handled and used as mulch in a food garden. The author's asparagus bed is shown here getting its 17th annual spring mulching.

dled the compost, with bare hands, year after year, with no reservations (my garden is mostly hand-worked). I repeated the stool analysis a year later (after 15 years of exposure) again with negative results (no ova or parasites observed). Hundreds of people had used my compost toilet over the years, prior to these tests.

These results indicate that humanure compost is a good soil builder, and that no intestinal parasites were transmitted from the compost to the compost handler. This wasn't a laboratory experiment; it was a real life situation conducted over a period of 15 years. The whole process, for me, has been quite successful.

Another five years have passed since I did those analyses, and over the entire 20 year period, all of the humanure compost my family has produced has been used in our food garden (see color photos following this chapter). We have raised a lot of food with that compost, and a crop of lovely and healthy children with that food.

One person commented that the Ova & Parasite lab analyses I had done at the local hospital were pointless. They didn't prove anything, or so the contention went, because there may not have been any contamination by intestinal parasites in the compost to begin with. If, after fifteen years and literally hundreds of users, no contaminants made their way into my compost, then why do people worry about them so much? Perhaps this proves that the fears are grossly overblown. The point is that my compost has not created any health problems for me or my family, and that's a very important point, one that the fecophobes should take note of.

MONITORING COMPOST TEMPERATURE

Figure 8.7 shows the rise in temperature of humanure compost piles (feces, urine, and food scraps) which had been frozen all winter. The compost consisted primarily of deposits from the sawdust toilet, which contained raw hardwood sawdust

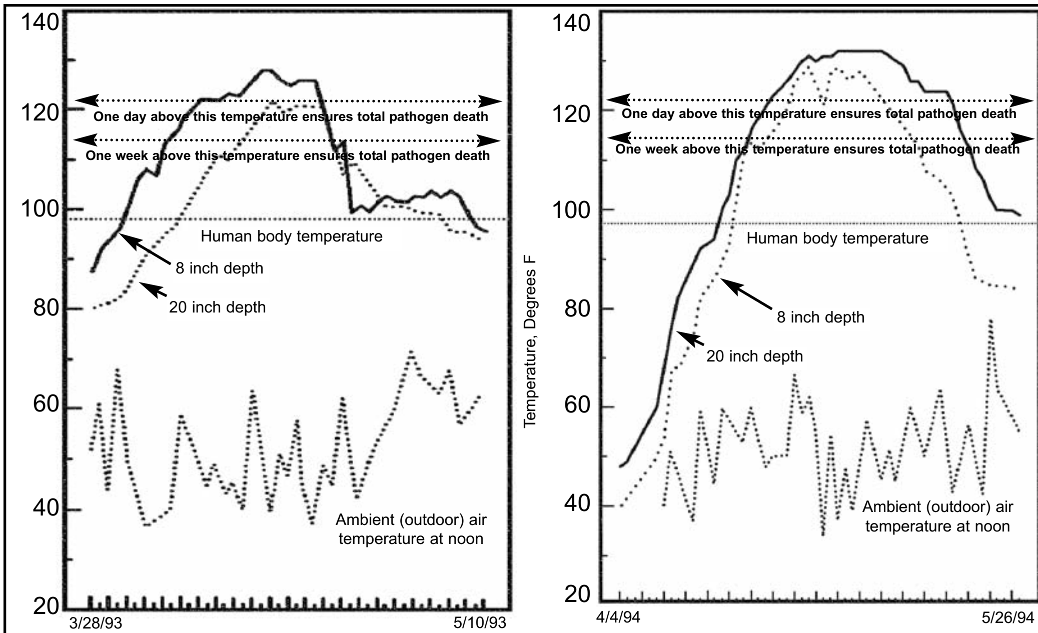
ANOTHER TIP FROM MR. TURDLEY

THE SECRET TO COMPOSTING HUMANURE IS TO KEEP IT COVERED.

Always thoroughly cover toilet deposits with a clean, organic cover material such as rotting sawdust, peat moss, leaf mould, rice hulls, or other suitable material to prevent odor, absorb urine, and balance the nitrogen.

Always cover toilet deposits again, after adding them to the compost pile, with a clean cover material such as hay, straw, weeds, grass clippings, leaves, or other suitable material in order to prevent odors and flies, to create air spaces in the compost pile, and to balance the nitrogen.

Such cover materials also add a blend of organic materials to the compost, and the variety supports a healthier microbial population.



Graph A: **Days 3/28/93 to 5/10/93** Figure 8.7 Graph B: **Days 4/4/94 to 5/26/94**

TEMPERATURE CURVE OF HUMANURE COMPOST PILES AFTER SPRING THAW

The above compost piles were situated outdoors, in wooden bins, on bare soil. The compost was unturned and no compost starters were used. Ingredients included humanure, urine, food scraps, hay, weeds, leaves, and some chicken manure (on right).The compost was frozen solid, but exhibited the above temperature climb after thawing. Fresh material was added to the compost pile regularly while these temperatures were being recorded on unmoved thermometers. The hot area of the compost pile remained in the upper section of the compost as the pile continued to be built during the following summer. In the fall, the compost cooled down, finally freezing and becoming dormant until the following spring. It is imperative that humanure compost rise above the temperature of the human body for an extended period of time. This is the "fever effect," which is necessary to destroy pathogens. A temperature exceeding 120^{0}F for at least one day is preferred, although lower temperatures for longer periods can be effective (see Chapter 7). The heating of the compost should be followed by a lengthy curing period (at least a year).

"Thank you for a wonderful book on a subject where little information is available. We started using our 'system' the day after receiving your book. It took about two hours to put together. I wish that more problems that at first seemed complicated and expensive could be solved as simply as this one has with your help." J.F. in NY

From a Christmas letter to friends and relatives:

"I am sorry to say that the solar toilet...never got off the ground. The plans from the book were sketchy and we weren't able to get it to work. It's sitting in the back of the property covered and waiting to be converted into a solar oven. But luckily we read another book [Humanure Handbook] which had an even better method suited for our household. With minimal fuss and expense we set up the system, and it's working great." J.S. in CA (just enough to cover the material in the toilet), humanure including urine, and toilet paper. In addition to this material, kitchen food scraps were added to the pile intermittently throughout the winter, and hay was used to cover the toilet deposits on the pile. Some weeds and leaves were added now and then.

The material was continuously collected over a period of about four months from a family of four, and added to an existing compost pile. Nothing special was done to the pile at any time. No unusual ingredients were added, no compost starters, no water, no animal manures other than human (although a little chicken manure was added to the pile charted on the right, which may explain the higher composting temperatures). No turning was done whatsoever. The compost piles were situated in a three-sided, open-topped wooden bin on bare soil, outdoors. The only imported materials (not from the home) were sawdust, a locally abundant resource, and hay from a neighboring farm (less than two bales were used during the entire winter).

Two thermometers were used to monitor the temperature of this compost, one having an 8" probe, the other having a 20" probe. The outside of the pile (8" depth) shown on Graph A was heated by thermophilic activity before the inside (20" depth). The outside thawed first, so it started to heat first. Soon thereafter, the inside thawed and also heated. By April 8th, the outer part of the pile had reached 50°C (122°F) and the temperature remained at that level or above until April 22nd (a two-week period). The inside of the pile reached 122°F on April 16th, over a week later than the outside, and remained there or above until April 23rd. The data suggest that the entire pile was at or above 122°F for a period of eight days before starting to cool. The pile shown in Graph B was above 122°C for 25 days.

According to Dr. T. Gibson, Head of the Department of Agricultural Biology at the Edinburgh and East of Scotland College of Agriculture, *"All the evidence shows that a few hours at 120 degrees Fahrenheit would eliminate [pathogenic microorganisms] completely. There should be a wide margin of safety if that temperature were maintained for 24 hours."* [2]

The significance of the previous graphs is that they show that the humanure compost required no coaxing to heat up sufficiently to be rendered hygienically safe. It just did it on its own, having been provided the simple requirements a compost pile needs.

READER

FEEDBACK

"The one alteration I'm going to make to the potty pictured in your book is a hinged door on the front and an attachable wagon handle, and, of course, large wheels on a shallow box the bucket rests in. That's only because I'm older (55), small and have arthritis. I can't pick up five gallons of anything wet and heavy. I could empty the bucket on a daily basis, but I don't know if that's a good idea or if it would screw up the working of the compost pile [author's note: it wouldn't]. Thank you for taking on the work and expense of sharing your experience with those of us who want to leave small or no footprints on our Mother Earth. (P.S. My children will be horrified! No doubt they will choose to stay at a motel and eat at restaurants.)" C.M. in AZ

THE SAWDUST TOILET ON CAMPING TRIPS

Humanure composters have tricks up their sleeves. Ever go on a week-long camping trip or to a camping music festival and hate using those awful portable chemical toilets that stink? If you have a humanure compost bin at home, simply take two five gallon buckets with you on the trip. Fill one with a cover material, such as rotted sawdust, and put a lid on it. Set it inside the empty bucket and pack it along with your other camping gear. Voila! One portable composting toilet! When you set up your camp, string up a tarp for privacy and set the two containers in the private space. Use the empty container as a toilet, and use the cover material to keep it covered. Place a lid on it when not is use. No standing in line, no odors, no chemicals, no pollution. This toilet will last several days for two people. When you leave the camp, take the "soil nutrients" home with you and add them to your compost pile. You will probably be the only campers there who didn't leave *anything* behind, a little detail that you can be proud of. And the organic material you collected will add another tomato plant or blueberry bush to your garden. You can improve on this system by taking a toilet seat that clamps on a five gallon bucket, or even taking along a home-made toilet box with seat (as shown in Figures 8.3 and 8.4).

A SIMPLE URINAL

Want to collect urine only? Maybe you want a urinal in a private office, bedroom, or shop. Simply fill a five gallon bucket with rotted sawdust or other suitable material, and put a tight lid on it. A bucket full of sawdust will still have enough air space in it to hold about a week's worth of urine from one adult. Urinate into the bucket, and replace the lid when not in use. For a fancy urinal, place the sawdust bucket in a toilet cabinet such as illustrated in Figures 8.1, 8.2, 8.3, and 8.4. When the bucket is full, deposit it on your compost pile. The sawdust inhibits odors, and balances the nitrogen in the urine. It sure beats the frequent trips to a central toilet that coffee drinkers are inclined to make, and no "soil nutrients" are going to waste down a drain.

WHY NOT PLACE THE COMPOST BINS DIRECTLY UNDERNEATH THE TOILET?

The thought of carrying buckets of humanure to a compost bin can deter even the most dedicated recycler. What if you could situate your toilet directly over your compost bins? Here's some reader feedback:

"I finally write back to you after 2 1/2 years of excitingly successful and inspiring use of humanure methods applied to a 'direct shitter' compost. We indeed built a beautiful humanure receptacle 10 feet long, 4 feet high and 5 feet wide, divided into two chambers. One chamber was used (sawdust after every shit, frequent green grass and regular dry hay applications) from May 1996 until June 1997, then nailed shut. We moved to the second chamber until June 1998 — when with excitement mounting, we unscrewed the boards at the back of the "Temple of Turds" (our local appellation) and sniffed the aroma...of the most gorgeous, chocolate brownie, crumbly compost ever SEEN. Yes, I thrust my hands fully into the heavenly honey pot of sweet soil, which soon thereafter graced the foundations of our new raspberry bed. Needless to say, the resulting berries knew no equal. Humanure and the potential for large-scale . . . even a city size composting collection (apartment building toilets into a central collection dumpster), along with the crimes of the so-called "septic system," has become one of my most favored topics of conversation and promotion. Often through direct exposition at our farm. Many thanks for your noble work of art and contribution to this stinky species of ape." R.T. in CT

MORE ON INSTALLING THE COMPOST BINS UNDER YOUR HOUSE

The **Straw Bale House** in Ship Harbor, Nova Scotia, Canada, built in 1993, employed an outhouse until 1998 when a composting toilet was built. The toilet allowed for the direct depositing of humanure into compost chambers underneath the house. Designer/builder Kim Thompson provides feedback:

"Having heard and experienced mixed success with commercial composting toilets, it was exciting to read the Humanure Handbook and have systems detailed which reinforced ideas that had only existed with me intuitively before. I did a lot of research on the subject, but as far as I could make out, the indoor system I wanted to try hadn't been done before. After several phone conversations with Joe Jenkins, his encouragement, and a sharing of plans, I went ahead with the project. Two concrete chambers, three feet high by five feet square, with four inch thick walls, were built on a six inch gravel base with a French drain, underneath the house. In the bathroom above, a wooden box was fitted with a standard toilet seat as well as a compartment for sawdust storage. All kitchen scraps, straw, and some garden compost were added regularly to the compost chambers, as well as the sawdust cover material. Red wriggler worms were added as well. Two and a half residents used the toilet, and the first chamber filled in six months.

Because there wasn't a good starter base of organic material, and because there was no drain (one was added later), the compost was, for many months, a sloppy, ineffectual mess. I now recommend layering the following materials in a composting chamber before it is used: one foot of straw, six inches of sawdust, a couple buckets of compost as a starter, one foot of leaf compost, and three inches of sawdust (or something like that depending on availability of local resources). Be sure to include a drainage system from the chambers to prevent a build-up of urine.

Make sure there are screens over the access doors to the chambers which can be easily removed, as easy access to the chambers makes it more likely that they will be maintained and monitored regularly. In a northern climate the chambers need to be constructed in such a way as to insure that they won't heave with the frost. It is important to insulate the chambers during the winter months to optimize conditions for thermophilic activity.

The learning curve on how to maintain and use the system efficiently has been steep. It is like learning how to make bread, easy when you know how. Smell has been the biggest problem so far. We have tried three different ways of venting and find that it still smells on occasion. Venting is currently done through a stove-pipe flue. I intend to install a small photovoltaic fan that will either draw air into the stove-pipe or directly outside through a vent. I injured myself over the winter and found that maintenance of the composting toilet system for a single person with a disability was difficult, especially hauling the bags of frozen sawdust cover material into the storage area. I had thought that establishing thermophilic activity in the second chamber over the winter months would be difficult, but a couple buckets of compost from the first chamber activated the new chamber almost immediately. The draft created by the toilet seat hole while in use, especially in the winter, has been variously described. A simple way of sealing the seat when not is use needs to be developed. We have been using a piece of polystyrene foam with a handle which sits in the box under the seat. It works, but isn't elegant.

I love the fact that I don't have to deal with a septic system and that the compost produced will help feed my family. The composting toilet complements well my work with low impact, natural building systems. Many people who contact Straw Bale Projects about construction are also interested in the compost toilet alternative."

For more information contact Kim Thompson, Straw Bale Projects, 13183 Hwy #7, Ship Harbor, NS Canada B0J 1Y0; EMail: shipharbor@ns.sympatico.ca

FECOFRIGGINFOBIA

There seems to be an irrational fear among fecophobes that if you don't die instantly from humanure compost, you'll die a slow, miserable, and wretched death, or you'll surely cause an epidemic of something like the plague and everyone within 200 miles of you will die, or you'll become so infested with parasitic worms that you'll no longer be recognized as human (your head will look like spaghetti).

These fears exist perhaps because much of the information in print concerning the recycling of humanure is confusing, erroneous, or incomplete. For example, when researching the literature during the preparation of this book, I found it surprising that almost no mention is ever made of the thermophilic composting of humanure as a viable alternative to other forms of on-site sanitation. When "bucket" systems are mentioned, they are also called "cartage" systems, and are universally decried as being the least desirable sanitation alternative. For example, in *A Guide to the Development of On-Site Sanitation* by Franceys et al., published by the World Health Organization in 1992, "bucket latrines" are described as *"malodorous, creating a fly nuisance, a danger to the health of those who collect or use the nightsoil, and the collection is environmentally and physically undesirable."* This sentiment is echoed in Rybczynski's (et al.) World Bank funded work on low-cost sanitation options, where it is stated that *"the limitations of the bucket latrine include the frequent collection visits required to empty the small container of [humanure], as well as the difficulty of restricting the passage of flies and odors from the bucket."*

I've personally used a sawdust toilet for 20 years and it has never caused odor problems, fly problems, health problems, or environmental problems. Quite the con-

YET ANOTHER TIP FROM THE INFAMOUS MR. TURDLEY

PRESSURE TREATED LUMBER SHOULD NEVER BE USED TO MAKE COMPOST BINS

Or for anything else, either, when the lumber is soaked with chromated copper arsenate. CCA saturated lumber would be more appropriately called "cancer-soaked" lumber rather than euphemistically referred to as "pressure treated."

Both arsenic and chromium have been classified as human carcinogens (causing cancer) and are suspected mutagens (causing mutations). The poisons in cancer-soaked lumber are widely documented to leach into the soil and rub off onto skin and clothing.

Such material has no place in organic gardens or compost bins. You can't even safely burn cancer-soaked lumber to get rid of it — it produces highly toxic fumes and ash. Be very careful when getting sawdust from a lumber yard. It may contain highly toxic cancer-soaked sawdust!

trary, it has actually *enhanced* my health, the health of my family, and the health of my environment by producing healthy, organic food in my garden, and by keeping human waste out of the water table. Nevertheless, Franceys et al. go on to say that *"[humanure] collection should never be considered as an option for sanitation improvement programmes, and all existing bucket latrines should be replaced as soon as possible."* Say what?

Obviously Franceys et al. are referring to the practice of collecting humanure in buckets without a cover material (which would surely stink to high heaven and attract flies) and without any intention of composting the humanure. Such buckets of feces and urine are presumably dumped raw into the environment. Naturally, such a practice should be decried and strongly discouraged, if not outlawed. However, rather than forcing people who use such crude waste disposal methods to switch to other more prohibitively costly waste disposal methods, perhaps it would be better to educate those people about *resource recovery*, about the *human nutrient cycle*, and about *thermophilic composting*. It would be more constructive to help them acquire adequate and appropriate *cover materials* for their toilets, assist them in constructing *compost bins*, and thereby eliminate waste, pollution, odor, flies, and health hazards altogether. I find it inconceivable that intelligent, educated scientists who observe bucket latrines and the odors and flies associated with them do not see that the simple addition of a clean organic cover material to the system would solve the aforementioned problems, and balance the nitrogen of the humanure with carbon.

Franceys et al. state, however, in their aforementioned book, that *"apart from storage in double pit latrines, the most appropriate treatment for on-site sanitation is composting."* I would agree that composting, when done properly, is the most appropriate method of on-site sanitation available to humans. I would not agree that double pit storage is more appropriate than thermophilic composting unless it could be proven that all human pathogens could be destroyed using such a double pit system, and that such a system would produce no unpleasant odor, and would not require the segregation of urine from feces. According to Rybczynski, the double pit latrine shows a reduction of *Ascaris* ova of 85% after two months, a statistic which does not impress me. When my compost is finished, I don't want *any* pathogens in it.

Ironically, the work of Franceys et al. further illustrates a "decision tree for selection of sanitation" that indicates the use of a "compost latrine" as being one of the least desirable sanitation methods, and one which can only be used if the user is willing to collect urine separately. Unfortunately, contemporary professional literature is rife with this sort of inconsistent and incomplete information which would surely lead a reader to believe that composting humanure just isn't worth the trouble.

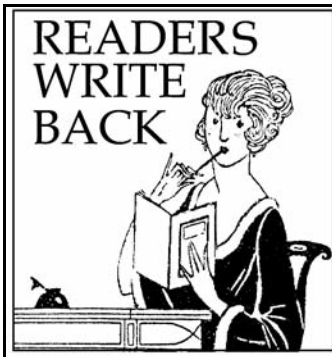
On the other hand, Hugh Flatt, who, I would guess, is a practitioner and not a scientist, in *Practical Self-Sufficiency* tells of a sawdust toilet system he had used for decades. He lived on a farm for more than 30 years which made use of "bucket lavatories." The lavatories serviced a number of visitors during the year and often two families in the farmhouse, but they used no chemicals. They used sawdust, which Mr. Flatt described as “absorbent and sweet-smelling.” The deciduous sawdust was added after each use of the toilet, and the toilet was emptied on the compost pile daily. The compost heap was located on a soil base, the deposits were covered each time they were added to the heap, and kitchen refuse was added to the pile (as was straw). The result was “*a fresh-smelling, friable, biologically active compost ready to be spread on the garden*.” [3]

Perhaps the "experts" will one day understand, accept, and advocate simple humanure composting techniques such as the sawdust toilet. However, we may have to wait until Composting 101 is taught at the university, which may occur shortly after hell freezes over.

In the meantime, those of us who use simple humanure composting methods must view the comments of today’s so-called experts with a mixture of amusement and chagrin. Consider, for example, the following comments posted on the World Wide Web by an “expert.” A reader posted a query on a compost toilet forum website wondering if anyone had any scientific criticism about the above mentioned sawdust toilet system. The expert replied that he was about to publish a new book on composting toilets, and he offered the following excerpt:

> *“Warning: Though powerfully appealing in its logic and simplicity, I’d expect this system to have an especially large spread between its theoretical and its practical effectiveness. If you don’t have a consistent track record of maintaining high temperatures in quick compost piles, I’d counsel against using this system. Even among gardeners, only a small minority assemble compost piles which consistently attain the necessary high temperatures . . . Health issues I’d be concerned about are 1) bugs and small critters fleeing the high-temperature areas of the pile and carrying a coat of pathogen laden feces out of the pile with them; 2) large critters (dog, raccoons, rats . . .) raiding the pile for food and tracking raw waste away; and 3) the inevitable direct exposure from carrying, emptying, and washing buckets.*
>
> *Some clever and open-minded folk have hit on the inspiration of composting feces . . . by adding them to their compost piles! What a revolutionary concept! . . . Sound too good to be true? Well, in theory it is true, though in practice I believe that few folks would pass all the little hurdles along the way to realizing these benefits. Not because any part of it is so difficult, just that, well, if you never ate sugar and brushed and flossed after every meal, you won’t get cavities either.”* [4]

Sound a bit cynical? The above comments are entirely lacking in scientific merit, and expose an “expert” who has no experience whatsoever about the subject on which he is commenting. It is disheartening that such opinions would actually be published, but not surprising. The writer hits upon certain knee-jerk fears of fecophobes. His comment on bugs and critters fleeing the compost pile coated with pathogen-laden feces is a perfect example. It would presumably be a bad idea to



From a Public Radio Commentary

"People are saying that the Year 2000 computer problem could foul up a lot of stuff we usually depend on, all at once. I thought I'd give this Y2K Practice Day a try. Turn off the heat, lights, water and phones. Just for 24 hours. The day before Practice Day, I complained to Larry, telling him that I was bitterly disappointed not to try out an emergency toilet. This complaining really paid off. Larry, who's also a writer researching Year 2000 emergency preparedness, phoned a man named Joe Jenkins, author of a book called the Humanure Handbook. Joe reassured my husband of the safe, sanitary, and uncomplicated method for composting human waste. His solution is based on 20 years of scholarly study. It turns out that the thermophilic bacteria in human waste, when mixed with organic material like peat moss or sawdust, creates temperatures over 120 degrees Fahrenheit, rapidly killing pathogens just as Mother Nature intended.

We grew bold and daring and decided to use our emergency five gallon bucket with the toilet seat, layering everything with peat moss. Larry spent maybe a half hour building a special compost bin. This was right up his alley, since he already composts all the kitchen scraps, yard, and dog wastes.

Surprisingly, I found myself liking that little toilet. It was comfortable, clean, with no odor, just a slightly earthy smell of peat moss. The soul-searching came when I contemplated going back to the flush toilet.

By coincidence, I recently heard a presentation by the director of the local waste treatment facility. He was asked to address the issue of Year 2000 disruptions and explain what preparations were being made. In a matter-of-fact voice, he described what a visitor from another planet would undoubtedly consider a barbaric custom. First, we defecate and urinate in our own clean drinking water. In our town, we have 800 miles of sewers that pipe this effluent to a treatment facility where they remove what are euphemistically called solids. Then they do a bunch more stuff to the water, I forget exactly what. But I do remember that at one point, they dose it with a potent poison — chlorine, of course — and then they do their best to remove the chlorine. When all this is done, the liquid gushes into the Spokane River.

At this meeting was a man named Keith who lives on the shores of Long Lake, down river from us. Keith was quite interested to know what might occur if our sewage treatment process was interrupted. The waste treatment official assured him that all would be well, but I couldn't help reflecting that Keith might end up drinking water that we had been flushing. I like Keith. So I decided to keep on using my camp toilet.

My husband is a passionate organic gardener, at his happiest with a shovel in his hand, and he's already coveting the new compost. He's even wondering if the neighbors might consider making a contribution. I'm just grateful the kids are grown and moved out, because they'd have a thing or two to say."

Judy Laddon in WA (excerpted with permission) inform this fellow that fecal material is a product of his body, and that if it is laden with pathogens, he's in very bad shape. Furthermore, there is some fecal material probably inside him at any given moment. Imagine that — pathogen-infested fecal material brimming with disease-causing organisms actually sitting in the man's bowels. How can he survive?

When one lives with a humanure composting system for an extended period of time, one understands that fecal material comes from one's body, and exists inside oneself at all times. With such an understanding, it would be hard to be fearful of one's own humanure, and impossible to see it as a substance brimming with disease organisms, unless, of course, one is diseased.

The writer hits upon another irrational fear — large animals, including rats, invading a compost pile and spreading disease all over creation. Compost bins are easily built to be animal-proof. If animals are a problem, the problem can be remedied by lining a compost bin with chicken wire, or surrounding the compost with pallets, straw bales, or similar barriers. In 20 years of humanure composting, we have never had a problem with animals, have never seen a rat in our compost, and our compost bins are not wire-lined. We have had dozens of skunks, possums, and raccoons in our chicken house, but never in our compost pile 50 feet away. It seems that the thermophilic composting process itself makes the organic material undesirable for larger animals, including dogs.

The writer warns that most gardeners do not have thermophilic compost. Most gardeners also leave critical ingredients out of their compost, thanks to the fear-mongering of the ill-informed. Those ingredients are humanure and urine, which are quite likely to make one's compost thermophilic. Commercial composting toilets almost never become thermophilic. Does the author also condemn those? As we have seen, it is not only the temperature of the compost that destroys pathogens, it is retention time. The sawdust toilet compost pile requires a year's construction time, and another year's undisturbed retention time. When a thermophilic phase is added to this process, I would challenge anyone to come up with a more effective, earth-friendly, simpler, low-cost system for pathogen destruction.

Finally, the writer warns of "the inevitable direct exposure from carrying, emptying and washing buckets." I'm not sure what he's getting at here, as I have car-

READER

FEEDBACK

"We've been joyfully composting for some time already, and adding our humanure since this spring. Your book was immensely informative, helping to dispel some of those culturally imposed myths of fecophobia! Please know that the book is being eagerly passed about and many of our friends have also begun composting humanure, too! Again, thank you for all the years and time you and your family have spent experimenting and actively composting! Your work has been a great asset to our path of a simpler, sustainable and self-reliant lifestyle. We believe we are the keys to changing the dominant paradigm and healing the Earth. Thank you, thank you for the book!" B.C. and J.S. in AK ried, emptied, and washed buckets for 20 years and never had a problem.

Other recent experts have thrown in their two cents worth on the sawdust toilet. A book on composting toilets (also about to be published as I write this), mentions the sawdust toilet system.[5] Although the comments are not at all cynical and are meant to be informative, a bit of misinformation manages to come through. For example, the suggestion to use "rubber gloves and perhaps a transparent face mask so you do not get anything splashed on you" when emptying a compost bucket onto a compost pile, caused groans, a lot of eyes to roll, and a few giggles when read aloud to seasoned humanure composters. Why not just wear an EPA approved moon suit and carry the compost bucket at the end of a ten-foot pole? How is it that what has just emerged from one's body can be considered so utterly toxic? More exaggeration and misinformation existed in the book regarding temperature levels and compost bin techniques. One warning to "bury finished compost in a shallow hole or trench around the roots of non-edible plants," was classic fecophobia. Apparently, humanure compost is to be banned from human food production, never mind the human nutrient cycle. The authors recommended that humanure compost be composted *again* in a non-humanure compost pile, or micro-waved for pasteurization, both bizarre suggestions. They add, "Your health agent and your neighbors may not care for this [sawdust toilet composting] method."

I have to scratch my head and wonder why the "experts" would say this sort of thing. Apparently, the act of *composting* one's own humanure is so radical and even revolutionary to the people who have spent their lives trying to *dispose* of the substance, that they can't quite come to grips with the idea. Ironically, a very simple sawdust toilet used by a physician and his family in Oregon is featured and illustrated in the above book. The physician states, *"There is no offensive odor. We've never had a complaint from the neighbors."* Their sawdust toilet system is also illustrated and posted on the internet, where a brief description sums it up: *"This simple composting toilet system is inexpensive both in construction and to operate and, when properly maintained, aesthetic and hygienic. It is a perfect complement to organic gardening. In many ways, it outperforms complicated systems costing hundreds of times as much."* Often, knowledge

"My wife and I have just finished reading your handbook and found it an inspiration in our pursuit of alternative living styles. Our system is up and functioning very well for us and already building our future garden bedding. We have discovered a certain level of 'alienation' when 'friends' have discovered our system. Although not particularly concerned about this 'friendship purification process,' we would like to network with other like-minded people to share ideas and experiences. If you have the fortune of knowing anyone using your technique in Eastern Washington-Northern Idaho area, would you please extend to them our invitation of friendship? Thank you for your book and your leadership into the rather solitary world of fecal familiarity." K.K. and A.K. in WA

"I line the solids bucket with newspapers so that I don't need to rinse it out." A.E. in Australia derived from real-life experiences can be diametrically opposed to the speculations of "experts." Sawdust toilet users find, through *experience*, that such a simple system can work remarkably well.

What about "health agents"? Health authorities can be misled by misinformation, such as that stated by the above authors. Health authorities, according to my experience, generally know very little, if anything, about thermophilic composting. Many have never even heard of it. The health authorities who have contacted me are very interested in getting more information, and seem very open to the idea of a natural, low-cost, effective, humanure recycling system. They know that human sewage is a dangerous pollutant and a serious environmental problem, and they seem to be surprised and impressed to find out that such sewage can be avoided altogether. Most intelligent people are willing and able to expand their awareness and change their attitudes based upon new information. Therefore, if you are using a sawdust toilet and are having a problem with any authority, please give the authority a copy of this book. I have a standing offer to donate, free of charge, a copy of the *Humanure Handbook* to any permitting agent or health authority, no questions asked, upon anyone's request — just send a name and address to the publisher at the front of this book.

Well-informed health professionals and environmental authorities are aware that "human waste" presents an environmental dilemma that is not going away. The problem, on the contrary, is getting worse. Too much water is being polluted by sewage and septic discharges, and there has to be a constructive alternative. Perhaps that is why, when health authorities learn about the thermophilic composting of humanure, they realize that there may very likely be no better solution to the human waste problem. That may be also why I received a letter from the US Department of Health and Human Services praising my book and wanting to know more about humanure composting, or why the US Environmental Protection Agency wrote to me to praise the *Humanure Handbook* and order ten copies (and re-order more later), or why the PA Department of Environmental Protection nominated *Humanure* for a public-awareness environmental award in 1998. Fecophobes think composting humanure is dangerous. I will patiently wait until they come up with a better solution to the problem of "human waste." I expect there will be a few cold days in hell before that happens.

"Just a note to thank you for sending the gratis copies of Humanure to our local supervisors and health director. A small but significant step forward is shown by the article on the reverse side and no doubt your book played a part [a newspaper article titled "Law Would Back Waterless Toilets" was copied on the back of the letter]. This victory may not seem like much but, believe me, getting these troglodytes to change their minds on anything is nothing less than a miracle!
R.W. in CA

LEGALITIES

This is an interesting topic. It seems that some people believe that if you do anything differently from the mainstream, if must be illegal. Certainly composting humanure must be illegal. Afterall, humanure is a dangerous pollutant and must be immediately disposed of in a professional and approved manner. Recycling it is foolish and hazardous to your health and to the health of your community and your environment. At least that's what the fecophobes think. Therefore, recycling humanure can not be an activity that is within the law, can it? Well, yes actually, the backyard composting of humanure is probably quite within the letter of the laws to which you are subjected.

Waste disposal is regulated, and it should be. Waste disposal is potentially very dangerous to the environment. Sewage disposal and recycling are also regulated, and they should be, too. Sewage includes a host of hazardous substances deposited into a waterborne waste stream. People who compost their humanure are neither disposing of waste, nor producing sewage — they are recycling. Furthermore, regarding the regulating of composting itself, both backyard composting and farm composting are exempt from regulations unless the compost is being sold, or unless the farm compost operation is unusually large.

To quote one source, *"The US Department of Environmental Protection (DEP) has established detailed regulations for the production and use of compost created from [organic material]. These regulations exclude compost obtained from backyard composting and normal farming operations. Compost from these activities is exempt from regulation only if it is used on the property where it was composted, as part of the farming operation. Any compost which is sold must meet the requirements of the regulations."* [6]

Composting toilets are also regulated in some states. However, composting toilets are usually defined as toilets inside which composting takes place. A sawdust toilet, by definition, is *not* a composting toilet because no composting occurs in the toilet itself. The composting occurs in the "backyard" and therefore is not regulated by composting *toilet* laws. Portable toilet laws may apply instead, although the backyard compost exemption will probably allow sawdust toilet users to continue their recycling undisturbed.

A review of composting toilet laws is both interesting and disconcerting. For example, in Maine, it is apparently illegal to put kitchen food scraps down the toilet chute in a commercial composting toilet, even though the food scraps and toilet materials must go to the exact same place in the composting chamber. Such a regulation makes no sense whatsoever. In Massachusetts, finished compost from composting toilets must be buried under six inches of soil, or hauled away and disposed of by a septage hauler. These laws are apparently written by people who are either lacking in knowledge and understanding, or are fecophobic, or, most likely, all of the above. Such laws can discourage the necessary and important recycling of humanure.

Ideally, laws are made to protect society. Laws requiring septic, waste, and sewage disposal systems are supposedly designed to protect the environment, the health of the citizens, and the water table. This is all to be commended, and conscientiously carried out by those who produce *sewage*, a waste material. If you don't produce sewage, you have no need for a sewage disposal system; laws pertaining to sewage disposal are not your concern. The number of people who produce backyard compost instead of sewage is so minimal, that few, if any, laws have been enacted to regulate the practice. The thermophilic composting of humanure is not a threat to society, it produces no pollution, does not threaten the health of humans, nor contaminate the groundwater or environment. Unfortunately, because this fact is not understood by many people, ignorance remains a problem.

It would be hard to intelligently argue that a person who produces no sewage must have a costly sewage treatment system. What would they do with it? That would be like requiring someone who doesn't own a car to have a garage. And it would be very difficult to prove that composting humanure is threatening to society, especially given the facts as presented in this book. It is much easier to prove that composting humanure is a *benefit* to society. On the other hand, Galileo, the astronomer, was arrested as a heretic and forced to renounce his theory that the Earth revolves around the sun. Yes, that was three hundred years ago, but sometimes it seems like the consciousness of our society as it relates to human manure is still back in the dark ages.

If you're concerned about your local laws, go to the library and see what you can find about regulations concerning backyard compost. Or inquire at your county seat or state agency as statutes, ordinances, and regulations vary from locality to locality. Where I live, septic system permits aren't required for new home construction, but the next county is two properties over and people there are required to have septic system permits before they can build a new dwelling. This is largely due to the fact that the water table tends to be high in my area, and septic systems don't always work, so sand mounds are required by law for sewage disposal. If you don't want to dispose of your manure but want to compost it instead (which will certainly keep it out of the water table, not to mention raise a few eyebrows at the local municipal office), you may have to stand up for your rights.

A reader called from a small state in New England to tell me his story. It seems the man had a sawdust toilet in his house, but the local municipal authorities decided he could only use an "approved" waterless toilet, meaning, in this case, an incinerating toilet. The man did not want an incinerating toilet because the sawdust toilet was working well for him and he liked making and using the compost. So he complained to the authorities, attended township meetings, and put up a fuss. To no avail. After months of "fighting city hall," he gave up and bought a very expensive and "approved" incinerating toilet. When it was delivered to his house, he had the delivery people set it in a back storage room. And that's where it remained, still in the packing box, never opened. The man continued to use his sawdust toilet for years after that. The authorities knew that he had bought the "approved" toilet, and thereafter left him alone. He never did use it, but the authorities didn't care. He *bought* the damn thing and had it in his house, and that's what they wanted. Those local authorities obviously weren't rocket scientists.

Another interesting story comes from a fellow in Tennessee. It seems that he bought a house which had a rather crude sewage system — the toilet flushed directly into a creek behind the house. The fellow was smart enough to know this was not good, so he installed a sawdust toilet. However, an unfriendly neighbor assumed he was still using the direct waste dump system, and the neighbor reported him to the authorities. But let him tell it in his own words:

> "Greetings from rural Tennessee.
>
> I'm a big fan of your book & our primitive outhouse employs a rotating 5-gallon bucket sawdust shitter that sits inside a 'throne.' Our system is simple & based largely on your book. We transport the poop to a compost pile where we mix the mess with straw & other organic materials. The resident in our cabin before we bought the farm used a flush toilet that sent all sewage directly to a creekbed. An un-informed neighbor complained to the state in 1998, assuming that we used the same system. The state people have visited us several times. We were forced to file a $100 application for a septic system but the experts agree that our hilly, rocky house site is not suitable for a traditional septic system even if we wanted one. They were concerned about our grey water as well as our composting outhouse. My rudimentary understanding of the law is that the state approves several alternative systems that are very complicated and at least as expensive as a traditional septic. The simple sawdust toilet is not included & the state does not seem to want any civilian to actually transport his own shit from the elimination site to a different decomposition site. The bureaucrats tentatively approved an experimental system where our sewage could feed a person-made aquatic wetlands type thingie & they agreed to help us design & implement that system. Currently, we cannot afford to do that on our own & continue to use our sawdust bucket latrine. The officials seem to want to leave us alone as long as our neighbors don't complain anymore. So, that's a summary of our situation here in Tennessee. I've read most of the state laws on the topic; like most legal texts, they are virtually unreadable. As far as I can tell, our system is not explicitly banned but it is not included in the list of "approved" alternative systems that run the gamut from high-tech, low volume, factory-produced composting gizmos to the old fashioned pit latrine. For a while now, I've wanted to write an article on our experience and your book. Unfortunately, grad school in English has seriously slowed down my freelance writing."
>
> Cheers, A.S. in Tennessee

Other than the above two situations, I have heard no details from other readers who may have had problems with authorities in relation to their sawdust toilets. Nevertheless, as part of the research for this second edition, I have undertaken a review of US state regulations pertaining to composting toilets, and that information is included in Appendix 3.

In Pennsylvania, the state legislature has enacted legislation *"encouraging the* *development of resources recovery as a means of managing solid waste, conserving resources, and supplying energy.*" Under such legislation the term "disposal" is defined as *"the incineration, dumping, spilling, leaking, or placing of solid waste into or on the land or water in a manner that the solid waste or a constituent of the solid waste enters the environment, is emitted into the air or is discharged to the waters of the Commonwealth."* [7] Further legislation has been enacted in Pennsylvania stating that *"waste reduction and recycling are preferable to the processing or disposal of municipal waste,"* and further stating *"pollution is the contamination of any air, water, land or other natural resources of this Commonwealth that will create or is likely to create a public nuisance or to render the air, water, land, or other natural resources harmful, detrimental or injurious to public health, safety or welfare. . ."* [8] In view of the fact that the thermophilic composting of humanure involves recovering a resource, requires no disposal of waste, and creates no environmental pollution, it is unlikely that anyone who *conscientiously* engages in such an activity would be unduly bothered by anyone. Don't be surprised if most people find such an activity commendable, because, in fact, it is.

If there aren't any regulations concerning backyard compost in your area, then be sure that when you're making your compost, you're doing a good job of it. It's not hard to do it right. The most likely problem you could have is an odor problem, and that would simply be due to not keeping your deposits adequately covered with clean, not-too-airy, organic "biofilter" material. If you keep it covered, it does not give off offensive odors. It's that simple. Perhaps shit stinks so people will be naturally compelled to cover it with something. That makes sense when you think that thermophilic bacteria are already in the feces waiting for the manure to be layered into a compost pile so they can get to work. Sometimes the simple ways of nature are really profound.

Few people understand that the composting of humanure is a benign method of recycling what would otherwise be a toxic waste material. For that reason, this book is recommended reading for people involved in municipal, county, or township waste treatment or permitting, or resource recovery. So when you're feeling especially benevolent, buy an extra copy of *Humanure* and give it to your local authority. Anonymously, if necessary.

What about flies — could they create a public nuisance or health hazard? I have never had problems with flies on my compost. Perhaps the compost heats up so fast that flies don't have a chance to enjoy it. Of course, a clean cover material is kept over the compost pile at all times. Concerning flies, F. H. King, who traveled through China, Korea, and Japan in the early 1900s when organic material, especially humanure, was the only source of soil fertilizer, stated, *"One fact which we do not fully understand is that, wherever we went, house flies were very few. We never spent a summer with so little annoyance from them as this one in China, Korea and Japan. If the scrupulous husbanding of [organic] refuse so universally practiced in these countries reduces the fly nuisance and this menace to health to the extent which our experience suggests, here is one great gain."* He added, *"We have adverted to the very small number of flies observed anywhere* *in the course of our travel, but its significance we did not realize until near the end of our stay. Indeed, for some reason, flies were more in evidence during the first two days on the steamship out from Yokohama on our return trip to America, than at any time before on our journey."* [9]

If an entire country the size of the United States, but with twice the population (at that time), could recycle all of its organic refuse without the benefit of electricity or automobiles and not have a fly problem, surely we in the United States can recycle a greater portion of our own organic refuse with similar success today.

ENVIRONMENTAL POTTY TRAINING 101

Simple, low-tech composting systems not only have a positive impact on the Earth's ecosystems, but are proven to be sustainable. Westerners may think that any system not requiring technology is too primitive to be worthy of respect. However, when western culture is nothing more than a distant and fading memory in the collective mind of humanity thousands (hundreds?) of years from now, the humans who will have learned how to survive on this planet in the long term will be those who have learned how to live in harmony with it. That will require much more than intelligence or technology — it will require a sensitive understanding of our place as humans in the web of life. That self-realization may be beyond the grasp of our egocentric intellects. Perhaps what is required of us in order to gain such an awareness is a sense of humility, and a renewed respect for that which is simple.

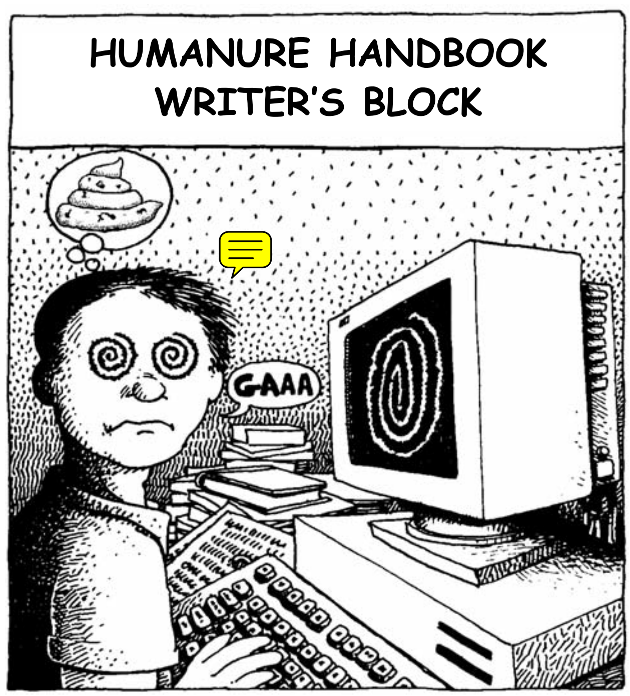
Some would argue that a simple system of humanure composting can also be the most advanced system known to humanity. It may be considered the most advanced because it works well while consuming little, if any, non-renewable resources, producing no pollution, and actually creating a resource vital to life.

Others may argue that in order for a system to be considered "advanced," it must display all the gadgets, doodads and technology normally associated with advancement. The argument is that something is advanced if it's been created by the scientific community, by humans, not by nature. That's like saying the most advanced method of drying one's hair is using a nuclear reaction in a nuclear power plant to produce heat in order to convert water to steam. The steam is then used to turn an electric generator in order to produce electricity. The electricity is used to power a plastic hair-drying gun to blow hot air on one's head. That's *technological* advancement. It reflects humanity's *intellectual* progress . . . (which is debatable).

True advancement, others would argue, instead requires the *balanced* development of humanity's intellect with physical and spiritual development. We must link what we know intellectually with the physical effects of our resultant behavior, and with the understanding of ourselves as small, interdependent, interrelated life forms relative to a greater sphere of existence. Otherwise, we create technology that excessively consumes non-renewable resources and creates toxic waste and pollution in order to do a simple task such as hair drying, which is easily done by hand with a towel. If that's advancement, we're in trouble.

Perhaps we're really advancing ourselves when we can function healthfully, peacefully, and sustainably without squandering resources and without creating pollution. That's not a matter of mastering the intellect or of mastering the environment with technology, it's a matter of mastering one's self, a much more difficult undertaking, but certainly a worthy goal.

Finally, I don't understand humans. We line up and make a lot of noise about big environmental problems like incinerators, waste dumps, acid rain, global warming, and pollution. But we don't understand that when we add up all the tiny environmental problems each of us creates, we end up with those big environmental dilemmas. Humans are content to blame someone else, like government or corporations, for the messes we create, and yet we each continue doing the same things, day in and day out, that have created the problems. Sure, corporations create pollution. If they do, don't buy their products. If you have to buy their products (gasoline for example), keep it to a minimum. Sure, municipal waste incinerators pollute the air. Stop throwing trash away. Minimize your production of waste. Recycle. Buy food in bulk and avoid packaging waste. Simplify. Turn off your TV. Grow your own food. Make compost. Plant a garden. Be part of the solution, not part of the problem. If you don't, who will?



FREQUENTLY ASKED QUESTIONS ABOUT SAWDUST TOILETS

Should a sawdust toilet be inside or outside?

Inside. It is much more comfortable during cold and wet weather. The contents of an outside toilet will freeze in the winter and will be very difficult to empty into the compost bin. Keep a clean layer of sawdust over the toilet contents at all times and you won't have any odor inside.

Can the sawdust toilet receptacle be left for long periods without emptying?

The toilet can sit for months without emptying. Just keep a clean layer of sawdust or other cover over the contents.

How full should the sawdust toilet receptacle be before it's emptied?

You know it's time to empty the toilet when you have to stand up to take a shit.

Should a compost pile be separated from the earth by a waterproof barrier to prevent leaching?

Put a sheet of plastic under your compost and arrange it to drain into a sunken bucket if leaching is a concern. Any leachate collected can be poured over the compost. Otherwise, use an earth bottom.

What sort of seal should I use around the toilet seat lid?

You don't need a seal around the toilet seat lid. The "seal" is created by the organic material that covers the humanure.

Can I use leaves as a cover material in my compost pile?

Leaves are great. Keep a bale of straw or hay around too, if you can. It will trap more air.

What about winter composting? How can I add to a compost pile when it's covered with snow?

Just deposit on top of the snow. The main problem in the winter is the cover material freezing. So you need to cover your leaves, sawdust, hay, or whatever you use to prevent them from freezing so you can use them all winter long. I just throw a tarp over my outdoor pile of sawdust then cover that with a thick layer of straw, and there always seems to be a section of the sawdust that I can dig out, unfrozen, in the winter.

Does a compost bin need to have an open side? Shouldn't a bin be enclosed in an urban situation?

You don't need an open side. Someone wrote to me from Manhattan who had installed sawdust toilets in a communal home, and he made a four sided bin (one side removable) with a heavy screen top to keep out anything that might want to try to get in (like flies, rats, skunks, snakes or politicians). That seemed like a good idea for a city situation (a screen bottom may be necessary too). I've also had people write to me from New Haven and Cincinnati telling me they're now using sawdust toilets in the city, with a backyard compost bin. Wrap your bins in chicken wire if animals are a problem.

Where do you keep your sawdust? I can't seem to decide where to store it.

I have lots of space (17 acres) and I just have a dump truck bring me a load of sawdust every year or two and dump it out by my compost bins. If I didn't have that option I might try using peat moss, which is handily packaged and could be kept indoors, or bag up sawdust in feed sacks (one of my neighbors did this), or use a three-chambered bin and put the sawdust in the center chamber.

How do I know the edges of the compost pile will get hot enough to kill all pathogens?

You will never be absolutely certain that every tiny bit of your compost has been subjected to certain temperatures, no matter what you do. If in doubt, let it age for an additional year, have it tested at a lab, or use the compost on non-food crops.

Can I build my compost bin under my house and defecate directly into it?

Yes.

What about building codes, septic permits, and other government regulations?

Some composters are inclined to believe that government bureaucrats are against composting toilets. This is more paranoia than truth. Alternative solutions are becoming more attractive as the sewage issue continues to get worse. Government agencies are looking for alternative solutions that work, and they are will-

FREQUENTLY ASKED QUESTIONS ABOUT SAWDUST TOILETS

ing to try new things. Their concerns are legitimate, and change comes slowly in government. If you work cooperatively with your local authority, you may both be satisfied in the end.

Have you had problems with flies and rats in your compost?

No, never. If you do, you will have to envelope your compost bin in screening.

Can I use softwood sawdust in my compost?

Yes. Make sure it's not from "pressure treated" lumber, cedar, or redwood. The sawdust can be moist, but shouldn't be wet.

What about using railroad ties to make compost bins?

The creosote is not good for your compost.

What about using dog doo in compost?

Either use a separate compost bin (I recommend this because many dogs are not healthy, and pass visible parasites, such as tapeworms, in their stools). Use a cover material, and let the compost age a long time (a year or two). Or add the dog doo to a properly managed thermophilic pile. Same for cats.

What about coffee filters and barbecue ashes?

Throw coffee filters in your compost. Grounds, too, and even old coffee. Barbeque ashes? Maybe throw them in with the dog doo. Use *that* compost for planting flowers.

If I don't want to start using humanure in my compost now, could I do it on short notice in the event of a municipal emergency?

In the event of a serious municipal emergency, yes, you could immediately begin composting humanure, as long as you had a source of clean cover material (sawdust, leaves, etc.) and a compost bin. Compost works much better when you feed it manure and urine or other nitrogen sources (grass clippings and other greenery, for example), so you may find that humanure greatly improves your compost if you haven't already been adding other animal manures.

What is the hottest temperature you have recorded in your compost? Can it get too hot?

About 65 degrees Celsius. Yes, it can get too hot (see Chapter 3). A cooler pile over a longer period is ideal. It's more likely your compost won't get hot enough. This is often due either to a dry pile (make sure you compost all urine), or to the use of wood chips (do not use wood *chips* — use sawdust).

Can you compost humanure with a large family? Would it be too labor intensive?

For a family of 6-10, depending on body weight, a five gallon compost toilet receptacle would fill daily. A bigger concern would be the supply of organic cover material, which would amount to about five gallons of volume daily also.

What about composting on a flood plain? Would a pit latrine work better?

Don't compost on a flood plain. Don't use a pit latrine.

What are some other compost bin designs?

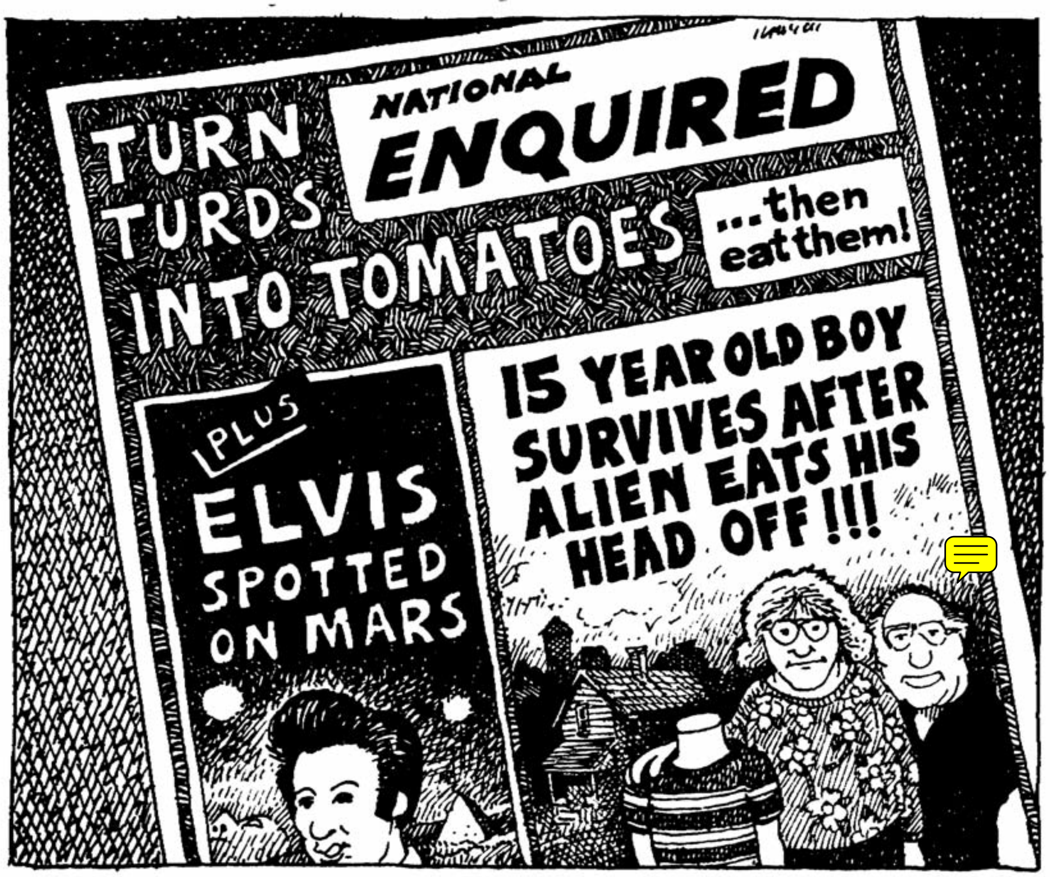
One design consists of two concentric wire bins with leaves stuffed in between and the humanure going into the center. Another is a bin composed entirely of straw or hay bales. Another design consists of three contiguous wooden bins with the middle one having a roof over it to collect water, and to keep the cover material stored in the middle bin dry.

Do you recommend using chlorine bleach as a disinfectant?

I don't recommend it for anything. It's an environmental contaminant. Try hydrogen peroxide or something more environmentally friendly if you're looking for a germ killer. Or just use soap and water.

What about meat and dairy products in compost?

They'll compost. Dig them into the top center of the pile, and keep it all covered with a clean, organic material.


NATIONAL
ENQUIRED
TURN TURDS INTO TOMATOES
...then eat them!
PLUS
ELVIS SPOTTED ON MARS
15 YEAR OLD BOY SURVIVES AFTER ALIEN EATS HIS HEAD OFF !!!

A section of the author's organic garden in summer. This garden has been fortified with humanure compost for twenty continuous years at the time of this writing, making obvious the benefits of such composting. No synthetic fertilizers, pesticides, or chemicals have ever touched this garden. No additional fertilizers or manures are used here other than the manures from the few homestead chickens and rabbits. Although most of the world's humanure is quickly flushed down a drain, or discarded into the environment as a pollutant, it could instead be converted, through composting, into lush vegetative growth, and used to feed humanity.

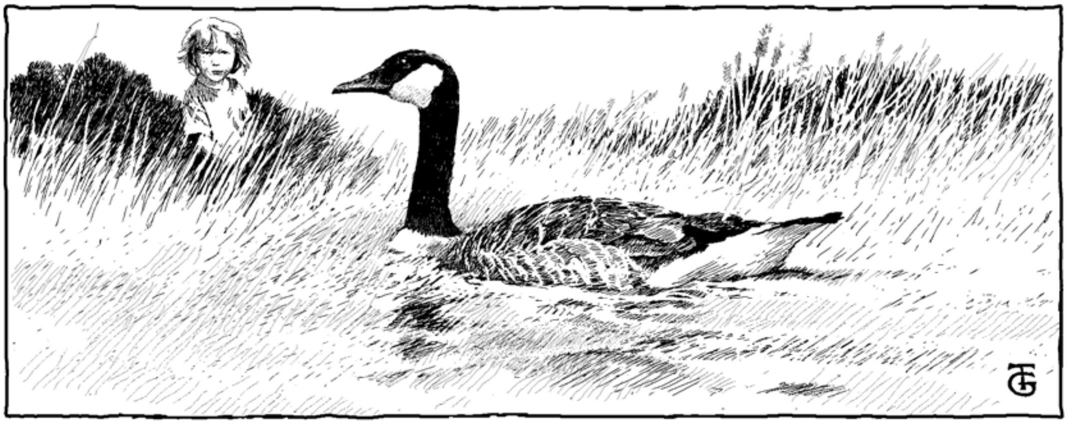
▲ The author in his garden. A closed human nutrient cycle preserves the fertility of the soil.
▼ Lush vegetation rewards humanure composters, some of whom prefer to garden by the moon, as shown in this late summer photo.

Top photo by Jeanine Jenkins, all others by author

Two decades of humanure compost allows this organic garden to produce crops without the need for additional fertilizers. The author's daughter and wife grace the spring broccoli, cabbage, pepper, onion, and potato crops.

Compost microorganisms help convert humanure into garden produce, as shown in this late-season photo of a tomato harvest from an organic garden fortified with humanure compost.

ALTERNATIVE GRAYWATER SYSTEMS



"When dealt with appropriately, graywater is a valuable resource which horticultural and agricultural growers, as well as home gardeners, will increasingly come to appreciate."
Carl Lindstrom

There are two concepts that sum up this book: 1) one organism's excretions are another organism's food, and 2) there is no waste in nature. We humans need to understand what organisms will consume our excretions if we are to live in greater harmony with the natural world. Our excretions include humanure, urine, and *other* organic materials that we discharge into the environment, such as "graywater," which is the water resulting from washing or bathing. Graywater should be distinguished from "blackwater," the water that comes from toilets. Graywater contains recyclable organic materials such as nitrogen, phosphorous, and potassium. These materials are pollutants when discarded into the environment. When responsibly recycled, however, they can be beneficial nutrients.

My first exposure to an "alternative" wastewater system occurred on the Yucatan Peninsula of Mexico in 1977. At that time, I was staying in a tent on a primitive, isolated, beach-front property lined with coconut palms and overlooking the turquoise waters and white sands of the Caribbean. My host operated a small restaurant with a rudimentary bathroom containing a toilet, sink, and shower, primarily reserved for tourists who paid to use the room. The wastewater from this room drained from a pipe, through the wall, and directly into the sandy soil outside, where it ran down an inclined slope out of sight behind the thatched pole building. I first noticed the drain not because of the odor (there wasn't any that I can remember), but because of the thick growth of tomato plants that cascaded down the slope where the drain was located. I asked the owner why he would plant a garden in such an unlikely location, and he replied that he didn't plant it at all — the tomatoes were volunteers; the seeds sprouted from human excretions. He admitted that whenever he needed a tomato, he didn't have to go far to get one. This is not an example of sanitary wastewater recycling, but it is an example of how wastewater can be put to constructive use, even by accident.

From there, I traveled to Guatemala, where I noticed a similar wastewater system, again at a crude restaurant at an isolated location in the Peten jungle. The restaurant's wastewater drain irrigated a small section of the property separate from the camp sites and other human activities, but plainly visible. That section had the most luxurious growth of banana plants I had ever seen. Again, the water proved to be a resource useful in food production, and in this case, the luxurious growth added an aesthetic quality to the property, appearing as a lush tropical garden. The restaurant owner liked to show off his "garden," admitting that it was largely self-planted and self-perpetuating. "That's the value of drain water," he was quick to point out, and its value was immediately apparent to anyone who looked.

All wastewater contains organic materials, such as food remnants and soap. Microorganisms, as well as plants and macroorganisms, consume these organic materials and convert them into beneficial nutrients. In a sustainable system, wastewater is made available to natural organisms for their benefit. Recycling organic materials through living organisms naturally purifies water.

In the US, the situation is quite different. Household wastewater typically contains all the water from toilet flushings (blackwater) as well as water from sink, bathtub, and washing machine drains (graywater). To complicate this, many households have in-sink garbage disposals. These contraptions grind up all of the organic food material that could otherwise be composted, then eject it out into the drain system. Government regulators assume the worst case scenario for household wastewater (lots of toilet flushings, lots of baby diapers in the wash, and lots of garbage in the disposal unit), then they draft regulations to accommodate this scenario. Wastewater is considered a public health hazard which must be quarantined from human contact. Typically, the wastewater is required to go directly into a sewage system, or, in suburban and rural locations, into a septic system.

A septic system generally consists of a concrete box buried underground into which household wastewater is discharged. When the box fills and overflows, the effluent drains into perforated pipes that allow the water to percolate into the soil. The drain field is usually located deep enough in the soil that surface plants cannot access the water supply.

In short, conventional drainage systems isolate wastewater from natural systems, making the organic material in the water unavailable for recycling. At wastewater treatment plants (sewage plants), the organic material in the wastewater is removed using complicated, expensive procedures. Despite the high cost of such separation processes, the organic material removed from the wastewater is often buried in a landfill.

The alternatives should be obvious. Albert Einstein once remarked that the human race will require an entirely new manner of thinking if it is to survive. I am inclined to agree. Our "waste disposal" systems must be rethought. As an alternative to our current throw-away mentality, we can understand that organic material is a resource, rather than a waste, that can be beneficially recycled using natural processes.

In pursuing this alternative, the first step is to *recycle* as much organic material as possible, keeping it *away* from waste disposal systems altogether. We can eliminate all blackwater from our drains by composting all human manure and urine. We can also eliminate almost all other organic material from our drains by composting food scraps. As such, one should *never* use an in-sink garbage disposal. As an indication of how much organic material typically goes down a household drain, consider the words of one composting toilet manufacturer, *"New regulations will soon demand that septic tanks receiving flush toilet and garbage disposal wastes be pumped out and documented by a state certified septage hauler every three years. When toilet and garbage solids and their associated flush water is removed from the septic system, and the septic tank is receiving only graywater, the septic tank needs pumping only every twenty years."* [1] According to the US EPA, household garbage disposals contribute 850% more organic matter and 777% more suspended solids to wastewater than do toilets.[2]

The second step is to understand that a drain is not a waste disposal site; it should *never* be used to dump something to "get rid of it." This has unfortunately become a bad habit for many Americans. As an example, a friend was helping me process some of my home-made wine. The process created five gallons of spent wine

FOUR STEPS TOWARD BENEFICIAL GRAYWATER REUSE

1) Keep as much organic material out of the water as possible. Use a compost toilet and have a compost pile for food scraps. Never use an in-sink garbage disposal. Compost grease, fats, and oils.

2) A household drain is not a waste disposal site. Consider the drain as a conduit to the natural world.

3) Do not allow any toxic chemicals to enter your drain system. Use biodegradable soaps and environmentally benign cleaning agents.

4) Use water sparingly and efficiently. If possible, collect rainwater and/or re-use graywater.

APPROXIMATE WATER USE OF STANDARD APPLIANCES

US top-loading washing machine	30 gallons
European front loading washing machine	10 gallons
Dishwasher	3-5 gallons
Low flow shower head, per shower	3-7 gallons
Other sink use (shaving, handwashing, etc.)	1-5 gallons

Source: Lindstrom, Carl (1992). *Graywater — Facts About Graywater — What it is, How to Treat it, When and Where to Use it.* www.greywater.com as a by-product. When I had my back turned, the fellow dumped the liquid down the sink drain. I found the empty bucket and asked what happened to the liquid that had been in it. "I dumped it down the sink," he said. I was speechless. Why would anyone dump five gallons of food-derived liquid down a sink drain? But I could see why. My friend considered a drain to be a waste disposal site, as do most Americans. This was compounded by the fact that he had *no idea* what to do with the liquid otherwise. My household effluent drains directly into a constructed wetland which consists of a graywater pond. Because anything that goes down that drain feeds a natural aquatic system, I am quite particular about what enters the system. I keep all organic material out of the system, except for the small amount that inevitably comes from dishwashing and bathing. All food scraps are composted, as are grease, fats, oils, and every other bit of organic food material our household produces (every food item compost educators tell you "not to compost" ends up down a drain or in a landfill otherwise, which is foolish; in our household, it all goes into the compost). This recycling of organic material allows for a relatively clean graywater that can be easily remediated by a constructed wetland, soilbed, or irrigation trench. The thought of dumping something down my drain simply to dispose of it just doesn't fit into my way of thinking. So I instructed my friend to pour any remaining organic liquids onto the compost pile. Which he did. I might add that this was in the middle of January when things were quite frozen, but the compost pile still absorbed the spent wine. In fact, that winter was the first one in which the active compost pile did not freeze. Apparently, the 30 gallons of liquid we doused it with kept it active enough to generate heat all winter long.


Phoebe demonstrating a simple rain water collection system used for watering chickens.

Step three is to eliminate the use of all toxic chemicals and non-biodegradable soaps in one's household. Chemicals could find their way down the drains and out into the environment as pollutants. The quantity and variety of toxic chemicals routinely dumped down drains in the US is both incredible and disturbing. We can eliminate a lot of our wastewater problems by simply being careful what we add to our water. Many Americans do not realize that most of the chemicals they use in their daily lives and believe to be necessary are not necessary at all. They can simply be eliminated. This is a fact that will not be promoted on TV or by the government (including schools), because the chemical industry might object. I am quite sure that you, the reader, don't care whether the chemical industry objects or not. Therefore, you willingly make the small effort necessary to find environmentally benign cleaning agents for home use.

Cleaning products that contain boron should not be used with graywater recycling systems because boron is reportedly toxic to most plants. Liquid detergents are better than powdered detergents because they contribute less salts to the system.[3] Water softeners may not be good for graywater recycling systems because softened water reportedly contains more sodium than unsoftened water, and the sodium may build up in the soil, to its detriment. Chlorine bleach or detergents containing chlorine should not be used, as chlorine is a potent poison. Drain cleaners, and products that clean porcelain without scrubbing should not be drained into a graywater recycling system.

Step four is to reduce our water consumption altogether, thereby reducing the amount of water issuing from our drains. This can be aided by collecting and using rainwater, and by recycling graywater through beneficial, natural systems.

The "old school" of wastewater treatment, still embraced by most government regulators and many academics, considers water to be a vehicle for the routine transfer of waste from one place to another. It also considers the accompanying organic material to be of little or no value. The "new school," on the other hand, sees water as a dwindling, precious resource that should not be polluted with waste; organic materials are seen as resources that should be constructively recycled. My research for this chapter included reviewing hundreds of research papers on alternative wastewater systems. I was amazed at the incredible amount of time and money that has gone into studying how to clean the water we have polluted with human excrement. In all of the research papers, without exception, the idea that we should simply stop defecating in water is never suggested.

The change from a water polluting, waste-disposal way of life to an environmentally benign, resource-recovery way of life will not occur from the "top down." Many government authorities and scientists take our wasteful, polluting way of life for granted, and even defend it. Those of us who are courageous enough to be different and who insist upon environmentally friendly lifestyles represent the first wave in the emerging lifestyle changes which we must all inevitably embrace. As our numbers increase, our cumulative impact will become more and more significant.

GRAYWATER

"The question of residential water conservation is not one of whether it will occur, but rather a question of how rapidly it will occur."
Martin M. Karpiscak et al.

It is estimated that 42 to 79% of household graywater comes from the bathtub and shower, 5 to 23% from laundry facilities, 10 to 17% from the kitchen sink or dishwasher, and 5 to 6% from the bathroom sink. [By comparison, the flushing of toilets (creating blackwater) constitutes 38 to 45% of all interior water use in the US, and is the single largest use of water indoors. On average, a person flushes a toilet six times a day.[4]]

Various studies have indicated that the amount of graywater generated per person per day varies from 25 to 45 gallons (96 to 172 liters), or 719 to 1,272 gallons (2,688 to 4,816 liters) per week for a typical family of four.[5] In California, a family of four may produce 1300 gallons of graywater in a week.[6] This amounts to nearly a 55 gallon drum filled with sink and bath water by every person every day, which is then drained into a septic or sewage system. This estimate does not include toilet water. Ironically, the graywater we dispose of can still be useful for such purposes as yard, garden, and greenhouse irrigation. Instead, we dump the graywater into the sewers and use drinking water to irrigate our lawns.

Reuse of graywater for landscape irrigation can greatly reduce the amount of drinkable water used during the summer months when landscape water may constitute 50-80% of the water used at a typical home. Even in an arid region, a three person household can generate enough graywater to meet all of their irrigation needs.[7] In Tucson, Arizona, for example, a typical family of three uses 123,400 gallons of municipal water per year.[8] It is estimated that 31 gallons of graywater can be collected per person, per day, amounting to almost 34,000 gallons of graywater per year for the same family.[9] An experimental home in Tucson, known as Casa del Aqua, reduced its municipal water use by 66% by recycling graywater and collecting rainwater. Graywater recycling amounted to 28,200 gallons per year, and rainwater collection amounted to 7,400 gallons per year.[10] In effect, recycled graywater constitutes a "new" water supply by allowing water that was previously wasted to be used beneficially. Water reuse also reduces energy and fossil fuel consumption by requiring less water to be purified and pumped, thereby helping to reduce the production of global warming gases such as carbon dioxide.

Because graywater can be contaminated with fecal bacteria and chemicals, its reuse is prohibited or severely restricted in many states. Since government regulatory agencies do not have complete information about graywater recycling, they assume the worst-case scenario and simply ban its reuse. This is grossly unfair to those who are conscientious about what they put down their drains and who are determined to conserve and recycle water. Graywater experts contend that the health threat from graywater is insignificant. One states, *"I know of no documented instance in which a person in the US became ill from graywater."* [11] Another adds, *"Note that although graywater has been used in California for about 20 years without permits, there has not been one documented case of disease transmission."* [12] The health risks from graywater reuse can be reduced first by keeping as much organic material and toxic chemicals out of your drains as possible, and second, by filtering the graywater into a constructed wetland, soilbed, or below the surface of the ground so that the graywater does not come into direct human contact, or in contact with the edible portions of fruits and vegetables.

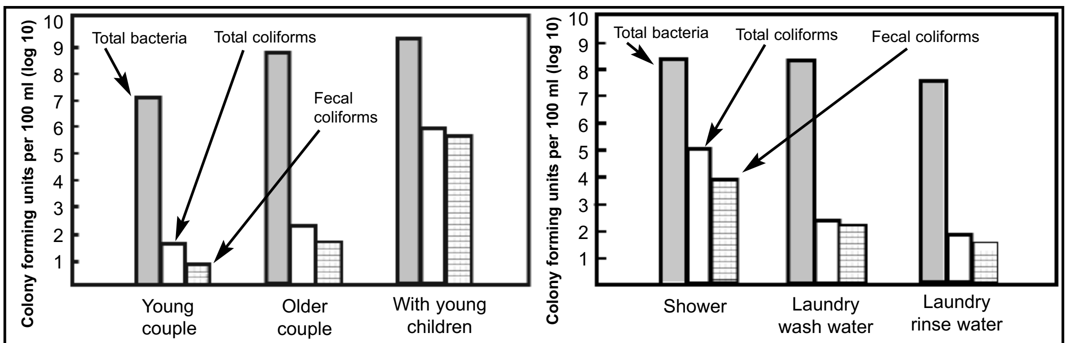
In November of 1994, legislation was passed in California that allowed the use of graywater in single family homes for subsurface landscape irrigation. Many other states do not currently have any legislation regulating graywater (see Appendix 3). However, many states are now realizing the value of alternative graywater systems and are pursuing research and development of such systems. The US EPA, for example, considers the use of wetlands to be an emerging alternative to conventional treatment processes.

PATHOGENS

Graywater can contain disease organisms which originate from fecal material or urine entering bath, wash, or laundry water. Potential pathogens in fecal material and urine, as well as infective doses, are listed in Chapter 7.

Indicator bacteria such as *E. coli* reveal fecal contamination of the water, as well as the possible presence of other intestinal disease-causing organisms. Fecal coliforms are a pollution indicator. A high count is undesirable and indicates a greater chance of human illness resulting from contact with the graywater. Plant material, soil, and food scraps can contribute to the *total* coliform population, but fecal coliforms indicate that fecal material is also entering the water system. This can come from baby diapers, or just from bathing or showering.

More microorganisms may come from shower and bath graywater than from



BACTERIA IN GRAYWATER FROM VARIOUS FAMILY GROUPS

The left column is the standard plate count (total bacteria), the middle column is total coliforms, the right column is fecal coliforms. This indicates that more fecal coliforms come from families with young children.

Figure 9.1

BACTERIA IN GRAYWATER FROM SHOWERS AND LAUNDRY

The left column is the standard plate count (total bacteria), the middle column is total coliforms, the right column is fecal coliforms. This indicates that more fecal coliforms come from shower water than laundry water.

Source: Rose, Joan B. et al. (1991). *Microbial Quality and Persistence of Enteric Pathogens in Graywater from Various Household Sources.* Water Resources, Vol. 25, No. 1, pp. 38, 39, 1991.

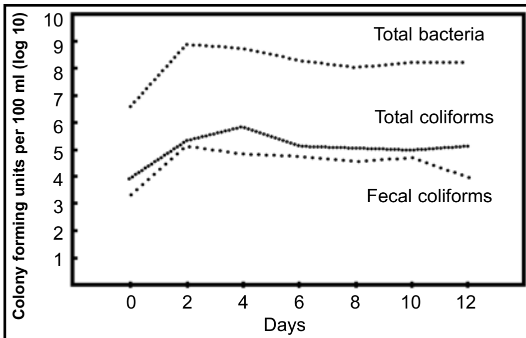


Figure 9.2

GROWTH AND SURVIVAL OF BACTERIA IN GRAYWATER

Source: Rose, Joan B. et al. (1991). *Microbial Quality and Persistence of Enteric Pathogens in Graywater from Various Household Sources.* Water Resources, Vol. 25, No. 1, p. 39, 1991.

other graywater sources. Studies have shown that total coliforms and fecal coliforms were approximately ten times greater in bathing water than in laundry water (see Figure 9.1).[13]

One study showed an average of 215 total coliforms per 100 ml and 107 fecal coliforms per 100 ml in laundry water; 1810 total coliforms and 1210 fecal coliforms per 100 ml in bath water; and 18,800,000 colony forming units of total coliforms per 100 ml in graywater containing household garbage (such as when a garbage disposal is used).[14] Obviously, grinding and dumping food waste down a drain greatly increases the bacterial population of the graywater.

Due to the undigested nature of the organic material in graywater, microorganisms can grow and reproduce in the water during storage. The numbers of bacteria can actually increase in graywater within the first 48 hours of storage, then remain stable for about 12 days, after which they slowly decline (see Figure 9.2).[15]

For maximum hygienic safety, follow these simple rules when using a graywater recycling system: don't drink graywater; don't come in physical contact with graywater (and wash promptly if you accidently do come in contact with it); don't allow graywater to come in contact with edible portions of food crops; don't allow graywater to pool on the surface of the ground; and don't allow graywater to run off your property.

PRACTICAL GRAYWATER SYSTEMS

The object of recycling graywater is to make the organic nutrients in the water available to plants and microorganisms, preferably on a continuous basis. The organisms will consume the organic material, thereby recycling it through the natural system.

It is estimated that 30 gallons of graywater per person per day will be produced from a water-conservative home. This graywater can be recycled either indoors or outdoors. Inside buildings, graywater can be filtered through deep soil beds, or shallow gravel beds, in a space where plants can be grown, such as in a greenhouse.

Outdoors, in colder climates, graywater can be drained into leaching trenches that are deep enough to resist freezing, but shallow enough to keep the nutrients within the root zones of surface plants. Freezing can be prevented by applying a mulch over the subsurface leaching trenches. Graywater can also be circulated through evapotranspiration trenches (Figure 9.3), constructed wetlands (Figures 9.4, 9.5, 9.6, and 9.7), mulch basins (Figure 9.10), and soilbeds (Figures 9.11, 9.12, 9.13, and 9.14).

EVAPOTRANSPIRATION

Plants can absorb graywater through their roots and then transpire the moisture into the air. A graywater system that relies on such transpiration is called an Evapotranspiration System. Such a system may consist of a tank to settle out the solids, with the effluent draining or being pumped into a shallow sand or gravel bed covered with vegetation. Canna lilies, iris, elephant ears, cattails, ginger lily, and umbrella tree, among others, have been used with these systems. An average two bedroom house may require an evapotranspiration trench that is three feet wide and 70 feet long. One style of evapotranspiration system consists of a shallow trench lined with clay or other waterproof lining (such as plastic), filled with an inch or two of standard gravel, and six inches of pea gravel. Plants are planted in the gravel, and no soil is used.

Other systems, such as the Watson Wick (Figure 9.3), may be deeper and may utilize topsoil.

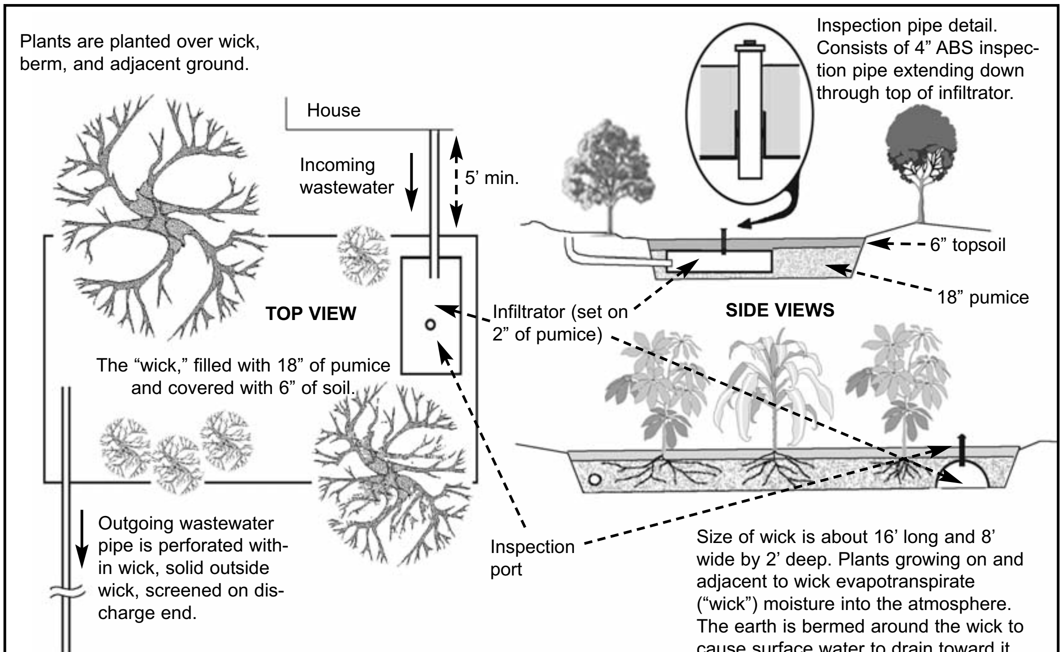


Figure 9.3

WATSON WICK OUTDOOR GRAYWATER/BLACKWATER EVAPOTRANSPIRATION SYSTEM

For more information about this system contact Tom Watson, PO Box 8, Embudo, NM 87531

NORWEGIAN CLEARWATER SYSTEM FOR BLACKWATER

A reader from Texas sent in the following information about a three-tank wastewater system: *"The system is called the Norwegian Clearwater System and has been used in Norway for about 20 years. The first tank is a standard septic tank which collects the blackwater and solids. The second tank is filled with one and a half feet of gravel on the bottom and one and a half feet of coarse sand on top, with a permeable membrane between them. This tank serves as a filter for the blackwater, removing the contaminants, and rendering the blackwater into graywater. The third tank is a collection tank which has a sump pump to pump the water into our raised bed gardens, thus the system is totally self-contained. The only maintenance required is to periodically have the solids pumped from the first tank, and to rake the top layer of sand in the middle tank. The sand should probably be replaced after two or three years depending on the volume of water handled by the system.*

A friend of ours installed this system in his bed and breakfast home. He had the county inspectors review the system, and they stated that it passed their codes, probably the most rigid in Texas. We have not had the graywater tested as it comes out of the third tank for pathogens, but we intend to do this."

R.E. in Texas

A SHORT GLOSSARY OF SCIENTIFIC WETLAND TERMS

BOD (BIOLOGICAL OXYGEN DEMAND) is the amount of oxygen in water that will be consumed by microorganisms in a certain period of time. The more organic nutrients in the water, the greater the BOD, because there will be more microorganisms feeding on the nutrients and consuming oxygen. BOD is measured by obtaining equal volumes of water from a source to be tested. Each specimen is diluted with a known volume of distilled water which has been thoroughly shaken to ensure oxygen saturation. One specimen is measured for dissolved oxygen; the other is set aside in a dark place for five days, then measured. BOD is determined by subtracting the second reading from the first. BOD5 is a measure of the oxygen depletion after five days. High BOD is an indicator of organic pollution.

COLIFORM BACTERIA - Bacteria occurring naturally in the intestines of warm-blooded animals. Most do not cause disease. Drinking water should have less than four coliform bacteria per 100 ml of water. Counts higher than 2,300/100 ml are considered unsafe for swimming, and waters with 10,000/100 ml are unsafe for boating.

CONSTRUCTED WETLAND - A human-made complex of saturated substrates (such as gravel), with emergent and submergent plants, animal life, and water at or near the surface, which simulates natural wetlands for human use and benefit.

HYDRIC SOIL - water-saturated soil

HYDROPHYTE - water-loving plant

CONSTRUCTED WETLANDS

The system of planting aquatic plants such as reeds or bulrushes in a wet (often gravel) substrate medium for graywater recycling is called a "constructed wetland" or "artificial wetland." The first artificial wetlands were built in the 1970s. By the early 1990s, there were more than 150 constructed wetlands treating municipal and industrial wastewater in the US.

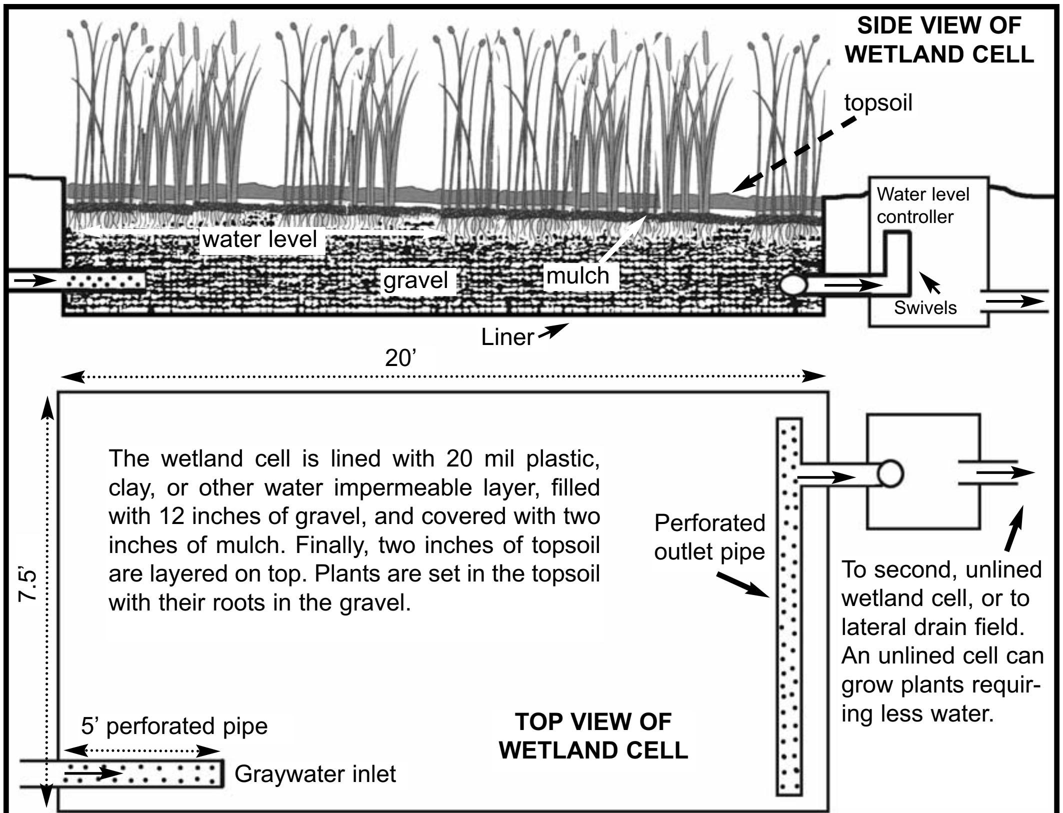
According to the US Environmental Protection Agency, *"Constructed wetlands treatment systems can be established almost anywhere, including on lands with limited alternative uses. This can be done relatively simply where wastewater treatment is the only function sought. They can be built in natural settings, or they may entail extensive earthmoving, construction of impermeable barriers, or building of containment such as tanks or trenches. Wetland vegetation has been established and maintained on substrates ranging from gravel or mine spoils to clay or peat . . . Some systems are set up to recharge at least a portion of the treated wastewater to underlying ground water. Others act as flow-through systems, discharging the final effluent to surface waters. Constructed wetlands have diverse applications and are found across the country and around the world. They can often be an environmentally acceptable, cost-effective treatment option, particularly for small communities."* [16]

A wetland, by definition, must maintain a level of water near the surface of the ground for a long enough time each year to support the growth of aquatic vegetation. Marshes, bogs, and swamps are examples of naturally occurring wetlands. Constructed wetlands are designed especially for pollution control, and exist in locations where natural wetlands do not.

Two types of constructed wetlands are in common use today. One type exposes the water's surface (Surface Flow Wetland, Figure 9.6), and the other maintains the water surface below the level of the gravel (Subsurface Flow Wetland, Figures 9.4, 9.5, and 9.7). Some designs combine elements of both. Subsurface flow wetlands are also referred to as Vegetated Submerged Bed, Root Zone Method, Rock Reed Filter, Microbial Rock Filter, Hydrobotanical Method, Soil Filter Trench, Biological-Macrophytic Marsh Bed, and Reed Bed Treatment.[17]

Subsurface flow wetlands are considered to be advantageous compared to open surface wetlands, and are more commonly used for individual households. By keeping the water below the surface of the gravel medium, there is less chance of odors escaping, less human contact, less chance of mosquito breeding, and faster "treatment" of the water (due to more of the water being exposed to the microbially populated gravel surfaces and plant roots). The subsurface water is also less inclined to freeze during cold weather.

Constructed wetlands generally consist of one or more lined beds, or cells. The gravel media in the cells should be as uniform in size as possible and should consist of small to medium size gravel or stone, from one foot to three feet in depth. A layer of sand may be used either at the top or the bottom of a gravel medium, or a



APPROXIMATE SIZES OF SINGLE CELL CONSTRUCTED WETLANDS WITH LEACH FIELD FOR INDIVIDUAL FAMILY HOMES

Bedrooms	Size of wetland cell	Length of lateral overflow drain field
1	120 sq. ft. (4'x30')	100 feet
2	240 sq. ft. (4'x60')	150 feet
3	360 sq. ft. (5'x72')	200 feet
4	480 sq. ft. (6'x80')	300 feet

Source: Kentucky State Guidelines as indicated in ASPI Technical Series TP-30, *Artificial or Constructed Wetlands.* ASPI Publications, 50 Lair St., Mt. Vernon, KY 40456 USA. Ph: 606 256 0077 (main office); Fax: 606 256 2779; Website: http://www.kih.net/aspi; Email: aspi@kih.net

Liners can be made from polyethylene, butyl rubber, PVC, natural clay, or other waterproof material. Washed 2B gravel or pea gravel, of uniform size, can be used as filler. Sand may be useful as a cushion to protect the liner from the gravel. The soil cover is optional; plants can be planted directly into the gravel. Mulch should be coarse enough to stay on top of the gravel. Connector pipes should be 2" to 4" in diameter. The holes in the perforated inlet and outlet pipes are 1/2" to 3/4" in diameter (depending on diameter of pipe).

Figure 9.4

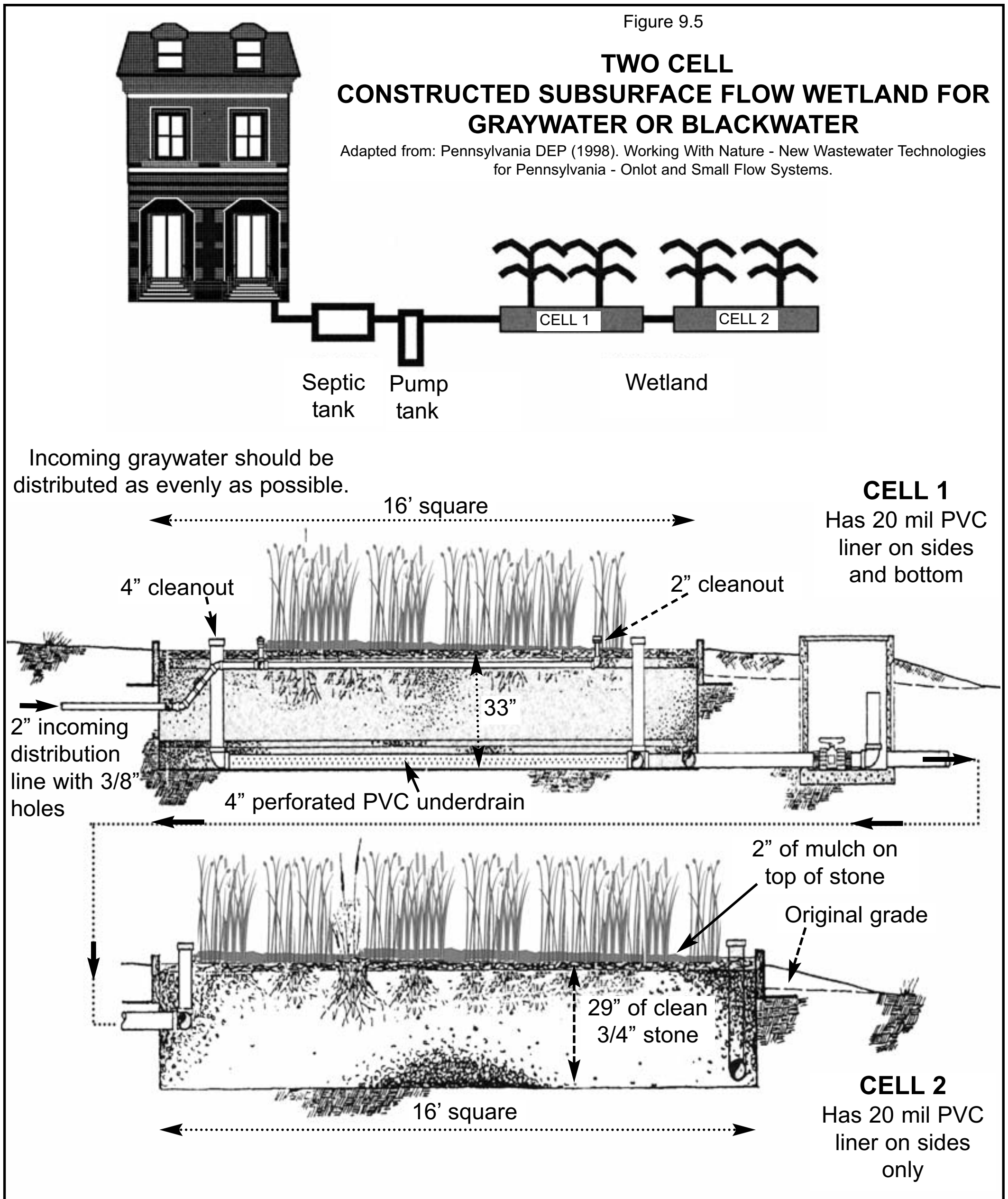
ASPI SINGLE CELL SUBSURFACE FLOW CONSTRUCTED WETLAND

Adapted from ASPI Technical Series TP-30, *Artificial or Constructed Wetlands.* ASPI Publications, 50 Lair St., Mt. Vernon, KY 40456 USA. Ph: 606 256 0077 (main office); Fax: 606 256 2779; Website: http://www.kih.net/aspi; Email: aspi@kih.net

Figure 9.5

TWO CELL CONSTRUCTED SUBSURFACE FLOW WETLAND FOR GRAYWATER OR BLACKWATER

Adapted from: Pennsylvania DEP (1998). Working With Nature - New Wastewater Technologies for Pennsylvania - Onlot and Small Flow Systems.



Most biological recycling of organic nutrients occurs in the upper layers of the soil, called the "bio-active zone." Typical wastewater systems thus far (such as typical septic systems and leach fields) have been placed below the bio-active zone, so little, if any, nutrient recycling takes place. A constructed wetland allows the nutrients in wastewater effluent to be beneficially used by aquatic plants and microorganisms.

layer of mulch and topsoil may be applied over the top of the gravel. In some cases, gravel alone will be used with no sand, mulch, or topsoil. The sides of the wetlands are bermed to prevent rainwater from flowing into them, and the bottom may be slightly sloped to aid in the flow of graywater through the system. A constructed wetland for a household, once established, requires some maintenance, mainly the annual harvesting of the plants (which can be composted).

In any case, the roots of aquatic plants will spread through the gravel as the plants grow. The most common species of plants used in the wetlands are the cattails, bulrushes, sedges, and reeds. Graywater is filtered through the gravel, thereby keeping the growing environment wet, and bits of organic material from the graywater become trapped in the filtering medium. Typical retention times for graywater in a subsurface flow wetland system range from two to six days. During this time, the organic material is broken down and utilized by microorganisms living in the medium and on the roots of the plants. A wide range of organic materials can also be taken up directly by the plants themselves.

Experimental constructed wetland in a greenhouse at Slippery Rock University, Slippery Rock, PA. Diagram of system is shown in Figure 9.7. Researchers Tony Liguori (rear) and Dr. Valentine Kefeli monitor the system.

Bacteria, both aerobic and anaerobic, are among the most plentiful microorganisms in wetlands and are thought to provide the majority of the wastewater treatment. Microorganisms and plants seem to work together symbiotically in constructed wetlands, as the population of microorganisms is much higher in the root areas of the plants than in the gravel alone. Dissolved organic materials are taken up by the roots of the plants, while oxygen and food are supplied to the underwater microorganisms through the same root system.[18]

Aquatic microorganisms have been reported to metabolize a wide range of organic contaminants in wastewater, including ben-

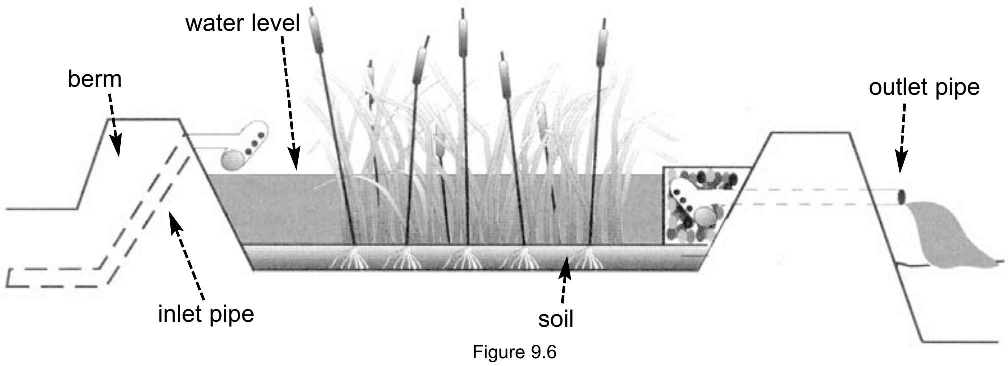


Figure 9.6

SURFACE FLOW WETLAND

Surface flow wetlands have a typical retention time for wastewater of five to ten days.

Source: Pipeline, Vol. 9, No. 3. National Small Flows Clearinghouse, WVU, PO Box 6064, Morgantown, WV 26506-6064

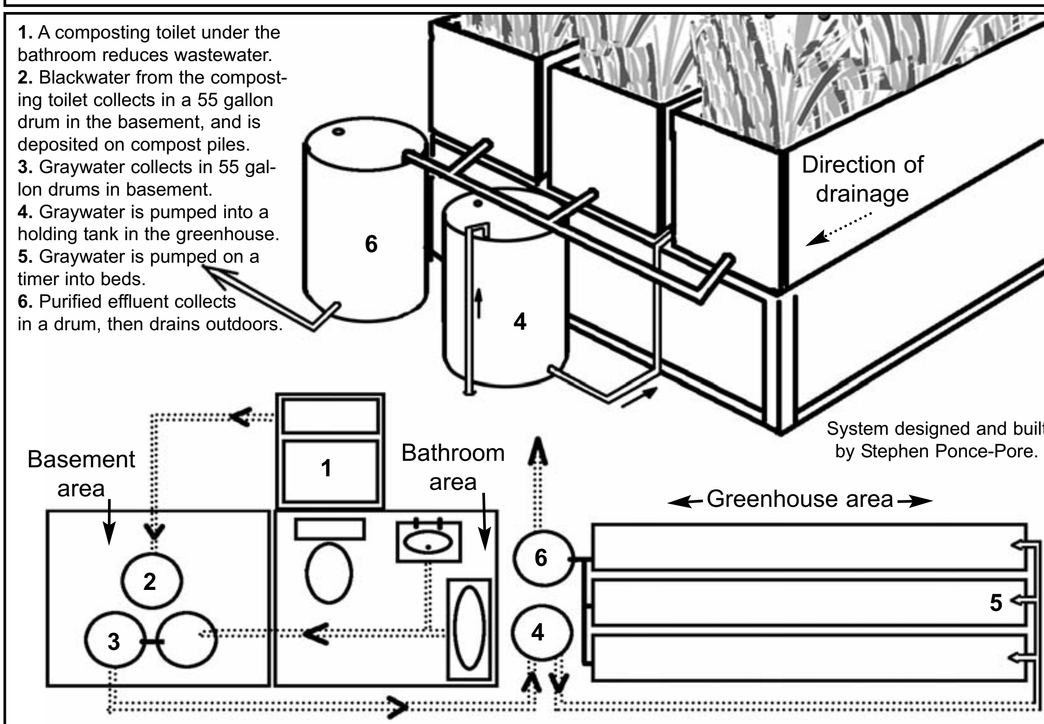


Figure 9.7

CONSTRUCTED WETLAND IN INDOOR GREENHOUSE

This experimental subsurface flow constructed wetland at Slippery Rock University's Macoskey Center for Sustainable Systems Education and Research is designed to purify graywater by filtering it through gravel-only beds planted with umbrella tree plants. It yields an effluent that is within state regulations for direct discharge to the environment. Each of the three cells has a volume that is 13' long, 16" wide, and 14" deep. The boxes are made of wood, and are lined with a heavy waterproof material. Graywater is pumped on a timer twice a day (9am and 5pm) at a low rate. For more information contact Slippery Rock University, Slippery Rock, PA 16057 USA; Phone: 724-738-0606 (see photo, previous page).

zene, napthalene, toluene, chlorinated aromatics, petroleum hydrocarbons, and pesticides. Aquatic plants can take up, and sometimes metabolize, water contaminants such as insecticides and benzene. The water hyacinth, for example, can remove phenols, algae, fecal coliforms, suspended particles, and heavy metals including lead, mercury, silver, nickel, cobalt, and cadmium from contaminated water. In the absence of heavy metals or toxins, water hyacinths can be harvested as a high-protein livestock feed. It can also be harvested as a feedstock for methane production. Reed-based wetlands can remove a wide range of toxic organic pollutants.[19] Duckweeds also remove organic and inorganic contaminants from water, especially nitrogen and phosphorous.[20]

When the outdoor air temperature drops below a certain point (during the winter months in cold climates), wetland plants will die and microbial activity will drop off. Therefore, constructed wetlands will not provide the same level of water treatment year round. Artificial wetlands systems constitute a relatively new approach to water purification, and the effects of variables such as temperature fluctuations are not completely understood. Nevertheless, wetlands are reported to perform many treatment functions efficiently in winter. One source reports that the removal rates of many contaminants are unaffected by water temperature, adding, *"The first two years of operation of a system in Norway showed a winter performance almost at the same level as the summer performance."* Some techniques have been developed to insulate wetland systems during the colder months. For example, in Canada, water levels in wetlands were raised during freezing periods, then lowered after a layer of ice had formed. The cattails held the ice in place, creating an air space over the water. Snow collected on top of the ice, further insulating the water underneath.[21]

It is estimated that one cubic foot of artificial wetland is required for every gallon per day of graywater produced. For an average single bedroom house, this amounts to about a 120 square foot system, one foot deep. However, it is better to overbuild a system than to underbuild. Some constructed wetland situations may not have enough drainage water from a residence to keep the system wet enough. In this case, extra water may be added from rain water collection or other sources.

WETLAND PLANTS

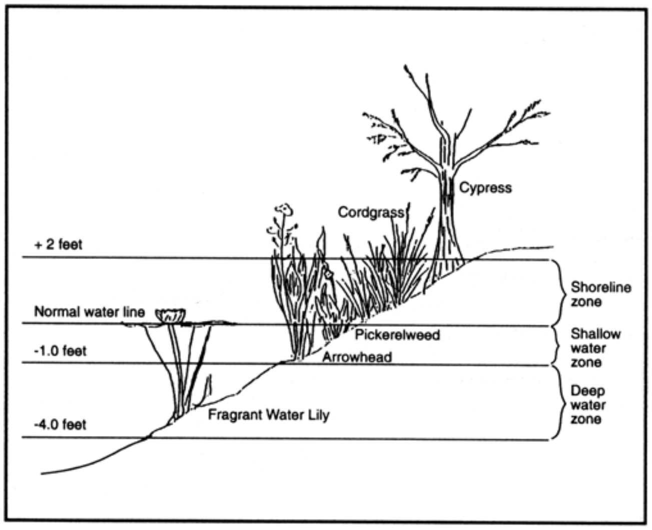
Aquatic plants used in constructed wetland systems can be divided into two general groups: microscopic and macroscopic. Most of the microscopic plants are algae, which can be either single cell (such as *Chlorella* or *Euglena*) or filamentous (such as *Spirulina* or *Spyrogyra*).

Macroscopic (larger) plants can grow under water (submergent) or above water (emergent). Some grow partially submerged and some partially emerged. Some examples of macroscopic aquatic plants are reeds, bulrushes, water hyacinths, and duckweeds (see Figure 9.8 and Table 9.1). Submerged plants can remove nutrients from wastewaters, but are best suited in water where there is plenty of oxygen

Figure 9.8

AQUATIC PLANTS

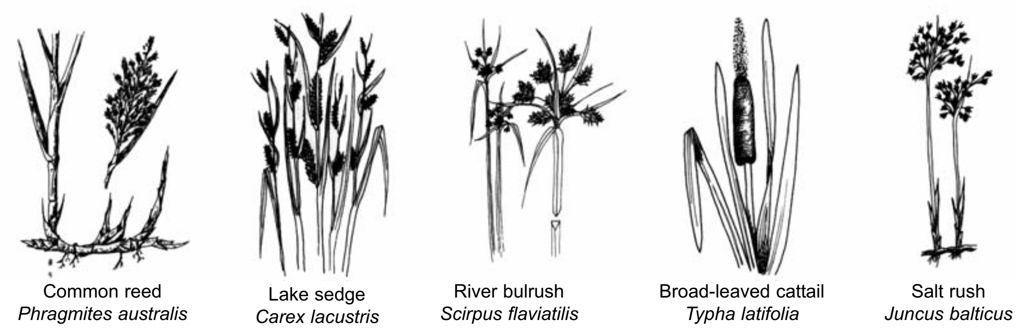
Two or more growing seasons may be necessary before plants are completely established.



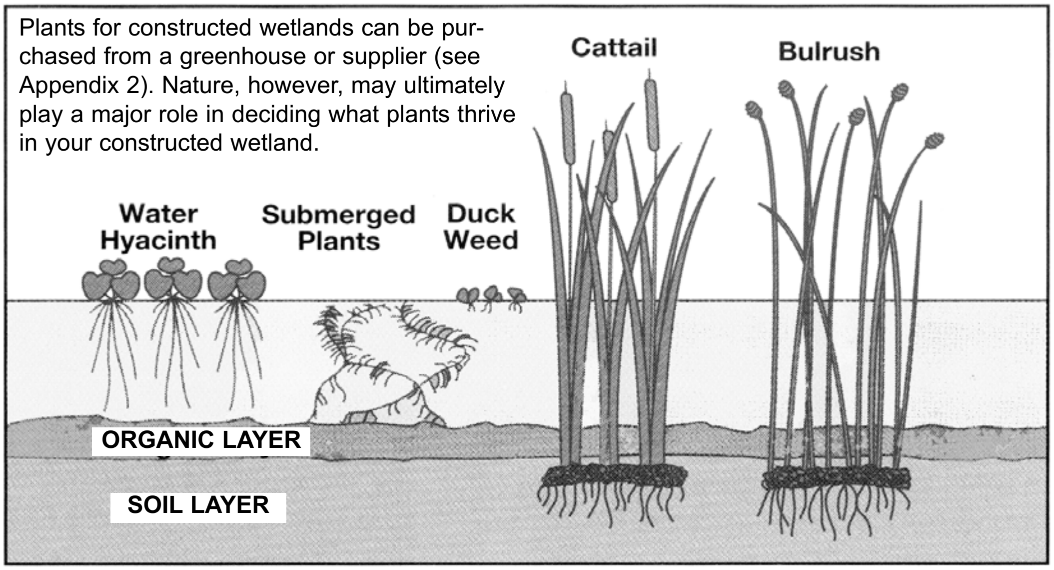
A CONSTRUCTED WETLAND REQUIRES FOUR COMPONENTS FOR FUNCTIONAL SUCCESS

1) A substrate (such as gravel)
2) Aquatic plants
3) Water
4) Naturally occurring microorganisms (both aerobic and anaerobic)

Sources: University of Florida, Institute of Food and Agricultural Sciences. Circular 912, *Aquascaping: Planting and Maintenance.* and National Small Flows Clearinghouse, Pipeline, Summer 1998, Vol. 9, No. 3: *Constructed Wetlands, A Natural Treatment Alternative.*



Plants for constructed wetlands can be purchased from a greenhouse or supplier (see Appendix 2). Nature, however, may ultimately play a major role in deciding what plants thrive in your constructed wetland.



(water with a high level of organic material tends to be low in oxygen due to extensive microbial activity).

Examples of floating plants are duckweeds and water hyacinths. Duckweeds can absorb large quantities of nutrients. Small ponds that are overloaded with nutrients such as farm fertilizer run-off can often be seen choked with duckweed, appearing as a green carpet on the pond's surface. In a two and a half acre pond, duckweed can absorb the nitrogen, phosphorous, and potassium from the excretions of 207 dairy cows. The duckweed can eventually be harvested, dried, and fed back to the livestock as a protein-rich feed. Livestock can even eat the plants directly from a water trough.[22]

Algae work in partnership with bacteria in aquatic systems. Bacteria break down complex nitrogen compounds and thereby make the nitrogen available to algae. Bacteria also produce carbon dioxide which is utilized by the algae.[23]

Soilboxes or Soilbeds

A soilbox is a box designed to allow graywater to filter through it while plants grow on top of it (Figure 9.14). Such boxes have been in use since the 1970s. Since the box must be well-drained, it is first layered with rocks, pea gravel, or other drainage material. This is covered with screening, then a layer of coarse sand is added, followed by finer sand; two feet of top soil is added to finish it off. Soilboxes can be located indoors or outdoors, either in a greenhouse, or as part of a raised-bed garden system.[24]

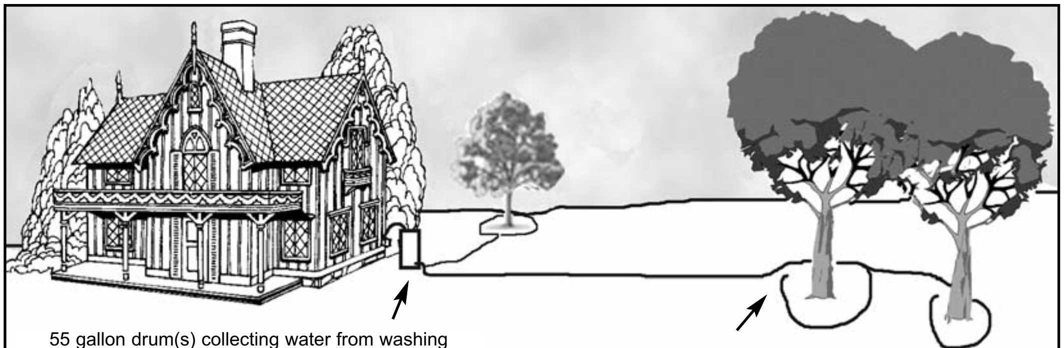
Soilboxes (soilbeds) located in indoor greenhouses are illustrated in Figures 9.11 and 9.13. An outdoor soilbed is illustrated in Figure 9.12.

PEEPERS

At one point in the development of my homestead, I had to decide what to do with my graywater. My household produced no blackwater or sewage, and we composted all of our organic material. We only had a hand pump at the kitchen sink, and we carried our drinking water from a spring out behind the house. Nevertheless, we still had a sink and bathtub with drains, and the water had to go somewhere.

The choices I had were pretty limited: install an underground septic tank and drain the graywater into it; run the graywater through some sort of biofilter (such as sawdust) and then compost the sawdust on occasion; or try some sort of constructed wetland. I decided to experiment with the last option, mainly because I had an acid-mine-drainage spring running past my house, and I thought the graywater, which tends to be alkaline because of soap, would help neutralize the acid water. I also thought a pond would provide insurance against a drought, when rain water collection for watering a garden isn't reliable.

The acid spring flowed past my house from an abandoned surface coal mine,



55 gallon drum(s) collecting water from washing machine or sink drains. Drum may be located in basement for year-round use, and regularly pumped to outdoor mulch basins.

Hose is perforated only around the trees, where it is buried in a shallow trench under a heavy mulch. Entire length of hose may be buried for frost protection.

Figure 9.10

SIMPLE GRAYWATER SYSTEM: SHALLOW IRRIGATION TO MULCH BASINS

Because of the alkaline nature of graywater, acid loving plants should not be used in graywater irrigation systems. Such plants include rhododendron, azalea, foxglove, hydrangea, fern, gardenia, primrose, begonia, hibiscus, violet, impatiens, and others.

When water under pressure is used for subsurface irrigation, a sleeve system over the irrigation hose, shown at right, will prevent erosion of the soil around the hose area.The sleeve will also prevent clogging of the irrigation hose by insects and roots.

For more information contact Carl Lindstrom at www.greywater.com.

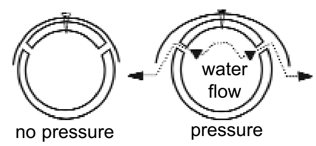
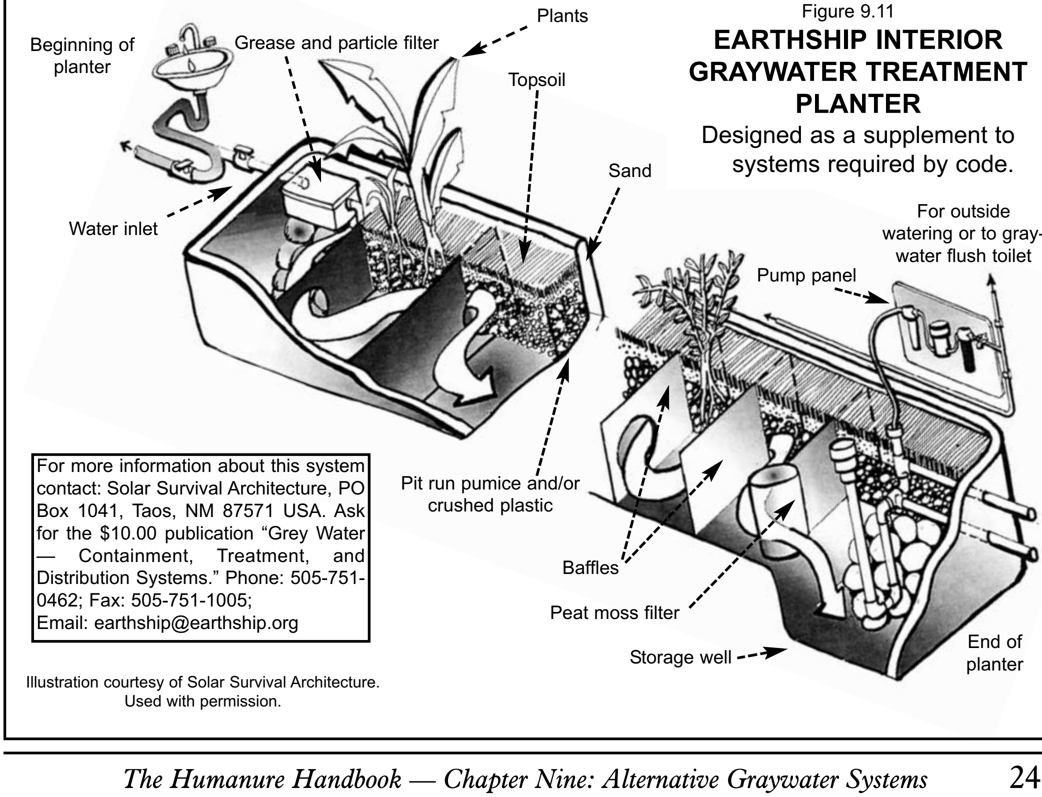


Figure 9.11

EARTHSHIP INTERIOR GRAYWATER TREATMENT PLANTER

Designed as a supplement to systems required by code.



For more information about this system contact: Solar Survival Architecture, PO Box 1041, Taos, NM 87571 USA. Ask for the $10.00 publication "Grey Water — Containment, Treatment, and Distribution Systems." Phone: 505-751-0462; Fax: 505-751-1005; Email: earthship@earthship.org

Illustration courtesy of Solar Survival Architecture. Used with permission.

and when I first started living beside it, it was choked with long, slimy, green algae. I introduced ducks to the algae-choked water, and quite by accident, I found that the algae disappeared as long as I kept ducks on the water. Whether the ducks were eating the algae or just breaking it up with their feet, I don't know. In any case, the water changed from ugly to beautiful, almost overnight, by the simple addition of another lifeform to the biological system. This indicated to me that profound changes could occur in ecological systems with proper (even accidental) management. Unfortunately, constructed wetland systems are still new and there is not much concrete information about them that is applicable to single family dwellings. Therefore, I was forced, as usual, to engage in experimentation.

I built a naturally clay-lined pond near my house about the size of a large swimming pool, then diverted some of the acid mine water to fill the pond. I directed my graywater into this "modified lagoon" wastewater system via a six inch diameter drain pipe with an outlet discharging the graywater below the surface of the pond water. I installed a large drainpipe to act as a pre-digestion chamber where organic material could collect and be broken down by anaerobic bacteria en route to the lagoon, like a mini septic tank. I add septic tank bacteria to the system annually by dumping it down the household drains. I assumed that the small amount of organic matter that entered the pond from the graywater drain would be consumed by the organisms in the water, thereby helping to biologically remediate an extensively damaged source of water. The organic material settles into the bottom of the pond, which is about five feet at the deepest point, thereby being retained in the constructed system indefinitely. I also lined the bottom of the pond with limestone to help neutralize the incoming acid mine water.

The ducks, of course, loved the new pond. They still spend countless hours poking their heads under the water, searching the pond bottom for things to eat. Our house is located between our garden and the pond, and the water is clearly visible from the kitchen sink, as well as from the dining room on the east side of the house, while the nearby garden is visible from the west windows. Shortly after we built the pond, my family was working in our garden. Soon we heard the loud honking of Canada geese in the sky overhead, and watched as a mating pair swooped down through the trees and landed on our new, tiny pond. This was quite exciting, as we realized that we now had a place for wild waterfowl, a bonus we hadn't really anticipated. We continued working in the garden, and were quite surprised to see the geese leave the pond and walk past our house toward the garden where we were busy digging. We continued to work, and they continued to walk toward us, eventually walking right past us through the yard, and on to the far end of the garden. When they reached the orchard, they turned around and marched right past us again, making their way back to the pond. To us, this was equivalent to an initiation for our new pond, a way that nature was telling us we had contributed something positive to the environment.

Of course, it didn't end with the two Canada Geese. Soon, a Great Blue

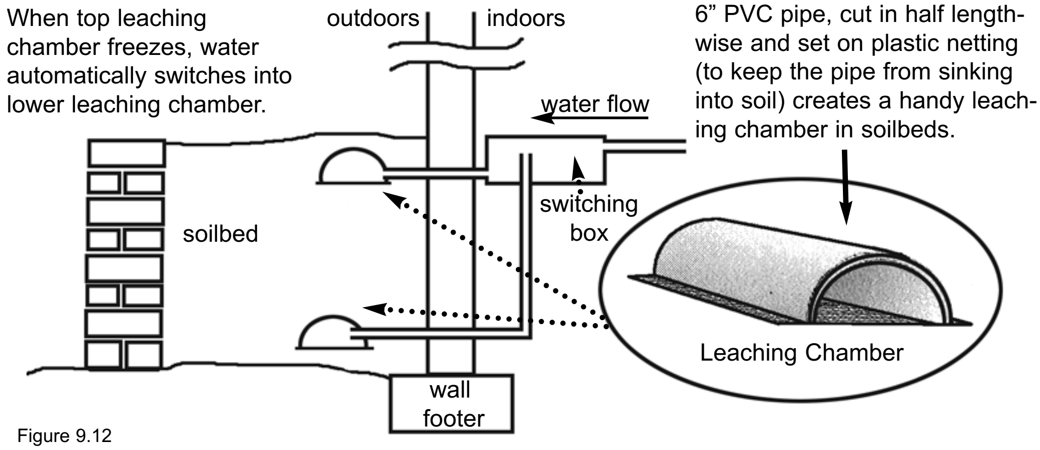


Figure 9.12

OUTDOOR SOILBED GRAVITY WATERLINE SWITCH FOR FROZEN CONDITIONS

Source: Carl Lindstrom, www.greywater.com

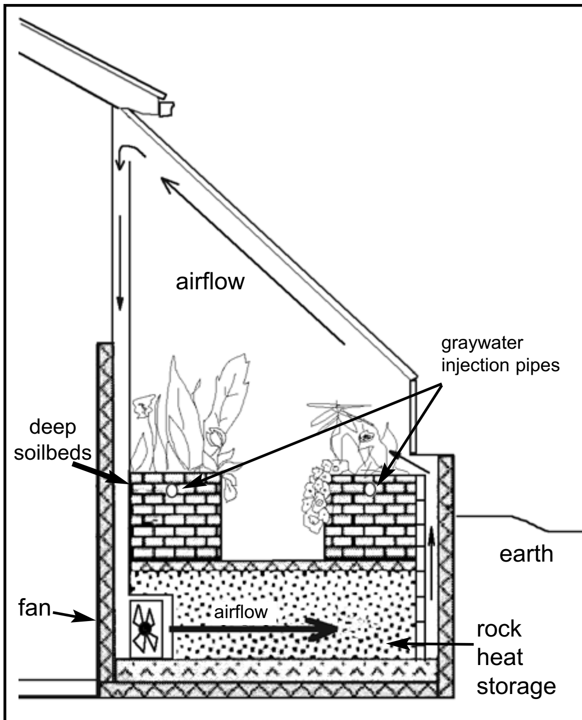


Figure 9.13

ATTACHED GREENHOUSE WITH GRAYWATER FILTERING SOILBEDS

Source: Carl Lindstrom, www.greywater.com

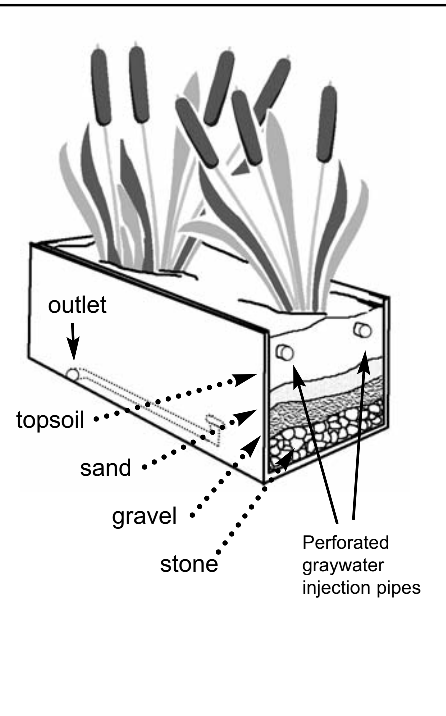


Figure 9.14

SIMPLE SOILBOX GRAYWATER FILTER

Source: Carl Lindstrom, www.greywater.com

Heron landed in the pond, wading around its shallow edges on stilt-like legs. It was spotted by one of the children during breakfast, a mere fifty feet from the dining room window. Then, a pair of colorful wood ducks spent an afternoon playing in the water. This was when I noticed that wood ducks can perch on a tree branch like a songbird. Recently, I counted 40 Canada geese on the little pond. They covered its surface like a feathery carpet, only to suddenly fly off in a great rush of wings.

We raise our own domesticated ducks for algae control, for eggs, and occasionally for meat. At one point we raised some Mallard ducks, only to find that this wild strain will fly away when they reach maturity. One of the female Mallards became injured somehow, and developed a limp. She was certainly a "lame duck," but the children liked her and took care of her. Then one day she completely disappeared. We thought a predator had killed the defenseless bird, and we never expected to see her again. To the children's delight, the following spring a pair of wild Mallard ducks landed on our little pond. We watched them swim around for quite some time, until the female came out of the water and walked toward us. Or, I should say, "limped" toward us. Our lame Mallard duck had flown away for the winter only to come back in the spring with a handsome boyfriend! Our new graywater pond was the point of reference for her migration.

My youngest daughter, Phoebe, was given a Canada goose to raise by one of the neighbors. The tiny gosling couldn't have been more than a day or two old when it was discovered wandering lost along the road. I'm not sure why Phoebe was asked to take care of the goose, other than she loves animals and she had a pond in her

Orion, Phoebe, and Cayli by our graywater pond.

Table 9.1

CONSTRUCTED WETLAND PLANT SPECIES POTENTIALLY SUITABLE FOR WASTEWATER TREATMENT IN THE US

COMMON NAME	LATIN NAME
Alligator weed	*Alternathera philoxeroides*
American cranberrybush	*Viburnum trilobum*
American lotus	*Nelumbo lutea*
American sloughgrass	*Beckmanaia syzigachne*
American sycamore	*Platanus occidentalis*
Arrow arum	*Peltandra virginica*
Arrowhead	*Sagittaria* spp.
Bald Cypress**	*Taxodium distichum*
Barnyard grass	*Echinochloa crus-galli*
Beggar ticks	*Bidens* spp.
Black-eyed susan	*Rudbeckia hirta*
Black gum**	*Nyssa sylvatica*
Black spruce	*Picea mariana*
Blueflag iris**	*Iris versicolor, I. hexagona*
Broadleaf arrowhead	*Sagittaria latifolia*
Broadleaf water plantain	*Alisma plantago-aquatica*
Bulrush	*Scirpus* spp.
Buttonbush**	*Cephalanthus occidentalis*
Bur marigold	*Bidens laevis*
Bur reed	*Sparganium* spp.
Calla lily	*Calla palustris*
Cardinal flower**	*Lobelia cardinalis*
Cattail*	*Typha* spp.
Chufa flatsedge	*Cyperus esculentus*
Cinnamon fern**	*Osmunda cinnamomea*
Columbine	*Aquilegia canadensis*
Cordgrass**	*Spartina bakeri*
Crooked stem aster	*Aster prenanthoides*
Culver's root	*Veronicastrum virginicum*
Dayflower	*Commelina* spp.
Duckweeds*	*Wolfia, Spirodella, Lemna*
Eastern yellow stargrass	*Hypoxix hirsute*
Elephant ear	*Colocasia* spp.
Elodea	*Elodea canadensis*
False indigo bush	Amorpha fruticosa
Fetterbush**	*Lyonia lucida*
Florida Elm**	*Ulmus floridana*
Fowl bluegrass	*Poa palustris*
Fowl manna grass	*Glyceria striate*
Fragrant water lily	*Nymphaea odorata*
Giant burreed	*Sparganium eurycarpum*
Ginger lily	*Hedychium* spp.
Golden canna**	*Canna flaccida*
Golden club	*Orontium aquaticum*
Hackberry**	*Celtis* spp.
Halberd leaved rosemallow	*Hibiscus lanvis*
Horsetail	*Equisetum* spp.
Lizard's tail	*Saurusus cernuus*
Loblolly bay**	*Gordonia lasianthus*
Manna grasses	*Glyceria* spp.
Marsh marigold	*Caltha palustris*
Marsh blue violet	*Violaceae cucullata*
Meadow beauty**	*Rhexia* spp.
Mist flower	*Eupatorium coelestinum*
Monkeyflower	*Mimulus* spp.
Nodding bur marigold	*Bidens* spp.
Northern white cedar	*Thuja occidentalis*
Pickerelweed	*Pontederia cordata*
Pop ash**	*Fraxinus caroliniana*
Prairie cordgrass	*Spartina pectinata*
Purple leaf willow herb	*Epilobium coloratum*
Red anise**	*Illicium floridanum*
Red cedar**	*Juniperus silicicola*
Red maple**	*Acer rubrum*
Redtop	*Agrostis alba*
Reedgrass	*Calamagrostis* spp.
Reeds	*Phragmites* spp.
Rice cutgrass	*Leersia oryzoides*
River birch	*Betula nigra*
Royal fern**	*Osmunda regalis*
Rush	*Juncus* spp.
Saw tooth sunflower	*Hellanthus grosseserratus*
Sedge	*Carex* spp.
Sensitive fern	*Onoclea sensibilis*
Silky dogwood	*Cornus amomum*
Sisklyou aster	*Aster hesperius*
Smartweeds	*Polygonum* spp.
Spatterdock	*Nuphar luteum*
Spearmint	*Mentha spicata*
Spikerush*	*Eleocharis* spp.
St. John's wort**	*Hypericum* spp.
Stout wood reedgrass	*Cinna arundinacea*
Swamp bay**	*Persea palustrus*
Swamp dogwood**	*Cornus foemina*
Swamp hibiscus**	*Hibiscus coccineus*
Swamp lily	*Crinum americanum*
Swamp milkweed	*Asclepias incamata*
Swamp rose	*Rosa palustris*
Swamp rosemallow	*Hibiscus moscheutos*
Sweetbay magnolia**	*Magnolia virginiana*
Sweet flag	*Aconus cabmus*
Sweet gum**	*Liquidambar styraciflua*
Tickseed**	*Coreopsis* spp.
Tiger lily	*Lilium tigrinum*
Tulip tree	*Liriodendron tulipfera*
Turtlehead	*Chelone glabra*
Umbrella tree	*Cyperus papyrus*
Virginia mallow	*Itea virginica*
Watercress	*Nasturtium officinale*
Water hyacinths*	*Eichhornia crassipes*
Water primrose	*Primulaceae pulverulenta*
Wax myrtle**	*Myrica cerifera*
White-top	*Scolochloa festucacea*
Willow	*Salix* spp.
Willow weed	*Polygonum lapathifolium*
Yellow cow lily	*Nuphar luteum*
Yellow iris	*Iris pseudacoras*

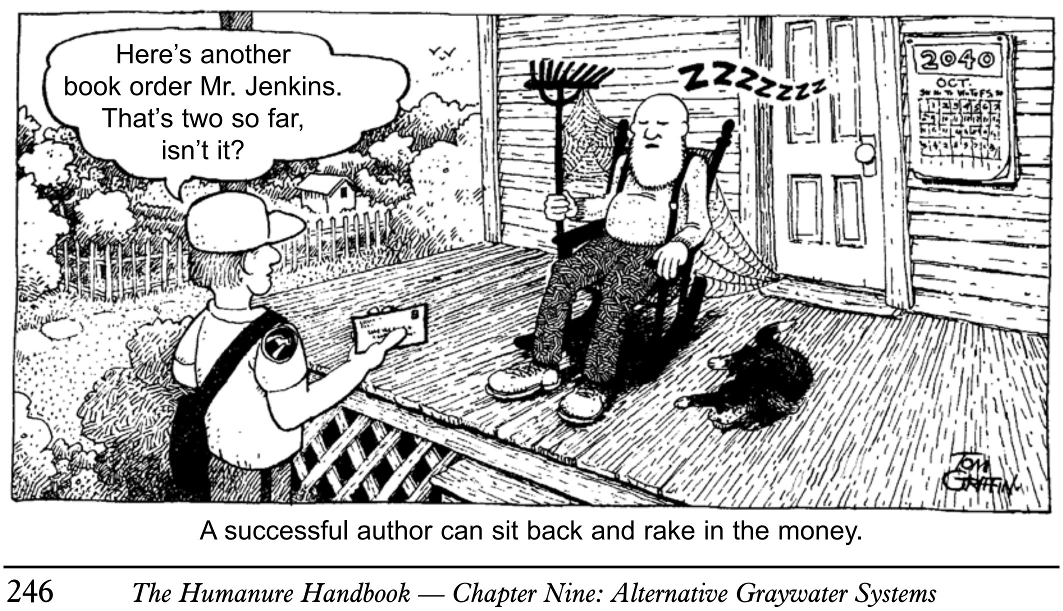
*May be invasive and difficult to control.
**Shoreline plants.

Sources: Golueke, Clarence G. (1977). *Using Plants for Wastewater Treatment.* Compost Science, September/October 1977, p. 16. and ASPI Technical Series TP-30, *Artificial or Constructed Wetlands.* ASPI Publications, Rt. 4, Box 298, Livingston, KY 40445. and Marburger, Joy E. (1992). *Wetland Plants - Plant Materials Technology Needs and Development for Wetland Enhancement, Restoration, and Creation in Cool Temperate Regions of the United States.* The Terrene Institute, 1717 K. Street, NW, Suite 801, Washington DC, 20006. and University of Florida, Institute of Food and Agricultural Sciences. Circular 912, *Aquascaping: Planting and Maintenance.*

backyard, but she enthusiastically accepted the responsibility. She named the goose "Peepers," and everywhere Phoebe went, Peepers followed. The two of them spent many a day at the graywater pond, Peepers splashing around in the water while Phoebe sat on the shore watching. Soon Peepers was a full grown goose, and everywhere Peepers went, large piles of goose droppings followed. The goose doo situation finally became so intolerable (to Dad, who renamed the goose "Poopers") that Peepers was furtively exported to the wild. Phoebe was heartbroken.

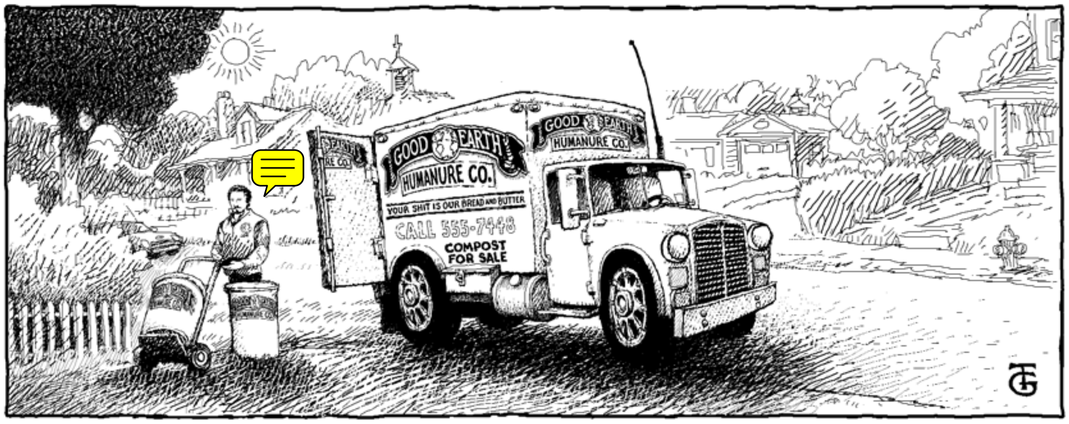
This spring, as I write this, ten years after our graywater pond was constructed, a pair of honking Canada geese once again flew overhead. Except this time, only the female landed in our little pond. Phoebe went running to the pond when she heard that familiar honking, yelling "Peepers! Peepers!" Peepers had come back to say hello to Phoebe. How did I know it was Peepers? I didn't. But somehow, Phoebe did. She stood on the pond bank for quite some time talking to the majestic goose, and the goose, also standing on the bank, talked back. They carried on a conversation that is rarely witnessed. Finally, Peepers flew off, and this time, Phoebe was happy.

I have more stories to tell about our graywater pond, and no doubt will have many more in the future. A buried, quarantined, septic tank for graywater, on the other hand, is pretty boring. I believe I made the right decision in deciding to construct a pond for our graywater. The benefits of such a system can go far beyond what one may imagine.



A successful author can sit back and rake in the money.

THE END IS NEAR



"If you want to be free, learn to live simply.
Use what you have and be content where you are."
J. Heider

Ladies and gentlemen, allow me to introduce you to a new and revolutionary literary device known as the *self-interview!* (Applause heard in background. Someone whoops.) Today I'll be interviewing myself. In fact, here I am now. (Myself walks in.)

Me: Good morning, sir. Haven't I seen you somewhere before?

Myself: Cut the crap. It's too early in the morning for this. You see me every time you look in the mirror, which isn't very often, thank god. What, for crying out loud, would possess you to interview yourself, anyway?

M: If I don't, who will?

MS: You do have a point there. In fact, that may be an issue worthy of contemplation.

M: Well, let's not get off the track. The topic of discussion today is a substance near and dear to us all. Shall we step right into it?

MS: What the hell are you talking about?

M: I'll give you a hint. It often can be seen with corn or peanuts on its back.

MS: Elephants?

M: Close, but no cigar. Actually, cigar would have been a better guess. We're going to talk about humanure.

MS: You dragged me out of bed and forced me to sit here in front of all these people to talk about CRAP?!

M: You wrote a book on it, didn't you?

MS: So what? OK, OK. Let's get on with it. I've had enough of your theatrics.

M: Well, first off, do you expect anyone to take the Humanure Handbook seriously?

MS: Why wouldn't they?

M: Because nobody gives a damn about humanure. The last thing anyone wants to think about is a turd, especially their own. Don't you think that by bringing the subject to the fore you're risking something?

MS: You mean like mass constipation? Not quite. I'm not going to put any toilet bowl manufacturers out of business. I'd estimate that one in a million people have any interest at all in the topic of resource recovery in relation to human excrement. Nobody thinks of human manure as a resource; the concept is just too bizarre.

M: Then what's the point?

MS: The point is that long-standing cultural prejudices and phobias need to be challenged once in a while by somebody, anybody, or they'll never change. Fecophobia is a deeply rooted fear in the American, and perhaps Western, psyche. But you can't run from what scares you. It just pops up somewhere else, where you least expect it. We've adopted the policy of defecating in our drinking water and then piping it off somewhere to let someone else deal with it. So now we're finding that our drinking water sources are dwindling *and* becoming increasingly contaminated. What goes around comes around.

M: Oh, come on. I drink water every day and it's never contaminated. We Americans probably have the most abundant supply of safe drinking water of any country on the planet.

MS: Yes and no. True, your water may not suffer from fecal contamination, meaning intestinal bacteria in water. But how much chlorine do you drink instead? Then there's water pollution from sewage in general, such as beach pollution. But I don't want to get into all this again. I've already discussed human waste pollution in Chapter Two.

M: Then you'll admit that American drinking water supplies are pretty safe?

MS: From disease-causing microorganisms, generally yes, they are. Even though we defecate in our water, we go to great lengths and expense to clean the pollutants back out of it. The chemical additives in our water, such as chlorine, on the other hand, are not good to drink. And let's not forget that drinking water supplies are dwindling all over the world, water tables are sinking, and water consumption is on the increase with no end in sight. That seems to be a good reason to not pollute water with our daily bowel movements. Yet, that's only *half* the equation.

M: What do you mean?

MS: Well, we're still throwing away the agricultural resources that humanure should be providing us. We're not maintaining an intact human nutrient cycle. By piping sewage into the sea, we're essentially dumping grain into the sea. By burying sludge, we're burying a source of food. That's a cultural practice that should be challenged. It's a practice that's not going to change overnight, but will change incrementally if we begin acknowledging it now.

M: So what're you saying? You think everybody should shit in a five-gallon bucket?

MS: God forbid. Then you *would* see mass constipation!

M: Well then, I don't understand. Where do we go from here?

MS: I'm not suggesting we have a mass cultural change in toilet habits. I'm suggesting that, for starters, we need to change the way we *understand* our habits. Most people have never heard of such a thing as a nutrient cycle. Many people don't even know about compost. Recycling humanure is just not something people think about. I'm simply suggesting that we begin considering new approaches to the age-old problem of what to do with human excrement. We also need to start thinking a bit more about how we live on this planet, because our survival as a species depends on our relationship with the Earth.

M: That's a beginning, but that's probably all we'll ever see in our lifetime, don't you think? Some people, like you for example, will think about these things, maybe write about them, maybe even give them some lip service. Most people, on the other hand, would rather have a bag of cheese puffs in one hand, a beer in the other, and a TV in front of them.

MS: Don't be so sure about that. Things are changing. There are more than a few people who will turn off their TVs, pick the orange crumbs out of their teeth, and get busy making the world a better place. I predict, for example, that composting toilets and toilet systems will continue to be designed and redesigned in our lifetimes. Eventually, entire housing developments or entire communities will utilize composting toilet systems. Some municipalities will eventually install composting toilets in all new homes.

M: You think so? What would that be like?

MS: Well, each home would have a removable container made of recycled plastic that would act as both a toilet receptacle and a garbage disposal.

M: How big a container?

MS: You'd need about five gallons of capacity per person per week. A container the size of a fifty gallon drum would be full in about two weeks for an average family. Every household would deposit all of its organic material except graywater into this receptacle, including maybe some grass clippings and yard leaves. The municipality could provide a cover material for odor prevention, consisting of ground leaves, rotted sawdust, or ground newsprint, neatly packaged for each household and possibly dispensed automatically into the toilet after each use. *This would eliminate the production of all organic garbage and all sewage,* as it would all be collected without water and composted at a municipal compost yard.

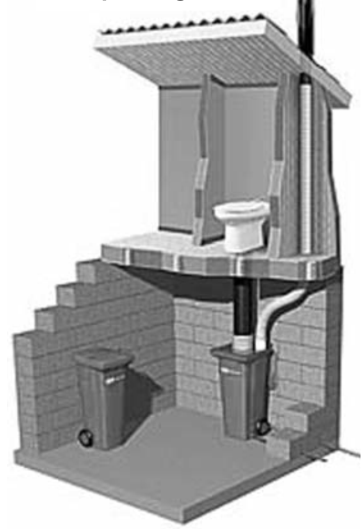
M: Who'd collect it?

MS: Once every couple of weeks or so, your municipality or a business under contract with your municipality would take the compost receptacle from your house. A new compost receptacle would then replace the old. This is already being done in the entire province of Nova Scotia, Canada, and in areas of Europe where organic kitchen materials are collected and composted.

Nova Scotia's "green cart" for household organic material collection (left) looks suspiciously similar to the Vera Toga composting toilet receptacle, shown at right. If municipalities can collect organic material on a large scale and compost it, why not humanure as well?

Nova Scotia's "green cart."

Vera Toga composting toilet.



Missoula, Montana, sewage sludge, prior to composting, pointed out by Rick Kruger, production manager of Eko-Kompost (bottom left). After composting, the material is bagged and sold for home gardens (bottom right). Walter Termeer, of Fundy Compost in Brookfield, Nova Scotia, inspecting his windrow sewage sludge composting operation (below).

When toilet material is added to the collection system, your manure, urine, and garbage, mixed together with ground leaves and other organic refuse or crop residues, would be collected regularly, just like your garbage is collected now. Except the destination would not be a landfill, it'd be the compost yard where the organic material would be converted, through thermophilic composting, into an agricultural resource and sold to farmers, gardeners, and landscapers who'd use it to grow things. The natural cycle would be complete, immense amounts of landfill space would be saved, a valuable resource would be recovered, pollution would be prevented, and soil fertility would be enhanced. So would our long-term survival as human beings on this planet.

M: I don't know . . . how long before people will be ready for that?

MS: In Japan today, a similar system is in use, except that rather than removing the container and replacing it with a clean one, the truck that comes to pick up the humanure suctions it out of a holding tank. Sort of like a truck sucking the contents out of a septic tank.

Such a truck system involves a capital outlay about a third of that for sewers. One study which compares the cost between manual humanure removal and waterborne sewage in Taiwan estimates manual collection costs to be less than one-fifth the cost of waterborne sewage treated by oxidation ponds. That takes into account the pasteurization of the humanure, as well as the market value of the resultant agricultural soil additive.[1]

M: But that's in the Far East. We don't do stuff like that in America.

MS: One of the most progressive large scale examples I have seen is in Nova Scotia, Canada. On November 30, 1998, Nova Scotia banned all organic material from entering its landfills. The municipality provides free receptacles for every household to deposit their food scraps into. So when a banana peel or burnt pop-tart gets pitched into the trash, it goes into the *green cart* along with egg shells, coffee grounds, and even cereal boxes, waxed paper, and file folders. Then, every two weeks, a truck comes around, just like the standard garbage trucks we're used to seeing, and picks up the organic material. From there, it goes to one of many central composting yards, where the material gets run through a grinder and shoved into a giant composting bin. Within 24 to 48 hours, the thermophilic microorganisms in the garbage have raised the temperature of the organic mass to 60-70^{0}C (140-158^{0}F). And it's a natural process.

The Netherlands was one of the first countries to mandate large scale source separation of organic material for composting, having done so since 1994; in at least five European countries, such separation is common.[2] Since 1993, in Germany, for example, discarded waste material must contain less than 5% organic matter, otherwise the material has to be recycled, mainly by composting.[3] In England and Wales, a target has been set to compost a million tonnes of organic household material by the year 2000.[4]

M: But those are not toilets.

MS: Can't you see? This is only one small step away from collecting toilet materials and composting them, too. Toilets will be redesigned as *collection* devices, not *disposal* devices. We've developed the art, science, and technology of composting enough to be able to constructively recycle our own excrement on a large scale.

M: So why don't we?

MS: Because humanure doesn't exist, as far as most compost professionals are concerned. It's not even on the radar screen. Human manure is seen as human *waste*, something to be disposed of, not recycled. When I was visiting composting operations in Nova Scotia, one compost educator told me there were 275,000 metric tonnes of animal manures produced annually in his county suitable for composting. He did not include human manure in his assessment. As far as he was concerned, humans are not animals and they don't produce manure.

To give you an example of how clueless Americans are about composting humanure, let me tell you about some missionaries in Central America.

M: Missionaries?

MS: That's right. A group of missionaries was visiting an indigenous group in El Salvador and they were appalled by the lack of sanitation. There were no flush toilets anywhere. The available toilet facilities were crude, smelly, pit latrines that bred flies. When the group returned to the United States, they were very concerned about the toilet problem they had seen, and decided they should help. But they didn't know what to do. So they shipped a dozen portable toilets down there, at great expense.

M: Portable toilets?

MS: Yeah, you know, those big, plastic outhouses you see at rest stops along the highways, at construction sites, and festivals. The ones that smell bad, and are filled with a blue liquid choked with floating turds and toilet paper.

M: Oh yeah.

MS: Well, the village in El Salvador got the portable toilets and the people there set them up. They even used them — until they filled up. The following year, the missionaries visited the village again to see how their new toilets were working.

M: And?

MS: And nothing. The toilets had filled up and the villagers stopped using them. They went back to their pit latrines. They had a dozen portable toilets sitting there filled to the brim with urine and crap, stinking to high heaven, and a fly heaven at that. The missionaries hadn't thought about what to do with the toilets when they were full. In the US, they're pumped out and the contents are taken to a sewage plant. In El Salvador, they were simply abandoned.

M: So what's your point?

MS: The point is that we don't have a clue about constructively recycling humanure. Most people in the US have never even had to think about it, let alone do it. If the missionaries had known about composting, they may have been able to help the destitute people in Central America in a meaningful and sustainable way.

But they had no idea that human manure is as recyclable as cow manure.

M: Let me get this straight. Now you're saying that humans are the same as cows?

MS: Well, all animals defecate. Many westerners simply won't admit it. But we're starting to. We Americans have a long way to go. The biggest obstacle is in understanding and accepting humanure and other organic materials as resource materials rather than waste materials. We have to stop thinking of human excrement and organic refuse as waste. When we do, then we'll stop defecating in our drinking water and stop sending our garbage to landfills.

It's critical that we separate water from humanure. As long as we keep defecating in water we'll have a problem that we can't solve. The solution is to stop fouling our water, not to find new ways to clean it up. Don't use water as a vehicle for transporting human excrement or other waste. Humanure must be collected and composted along with other solid (and liquid) organic refuse produced by human beings. We won't be able to do this as long as we insist upon defecating into water. Granted, we can dehydrate the waterborne sewage sludge and compost that. However, this is a complicated, expensive, energy-intensive process. Furthermore, the sludge can be contaminated with all sorts of bad stuff from our sewers which can become concentrated in the compost.[5]

M: Composting sewage sludge is bad?

MS: No. In fact, composting is probably the best thing you can do with sludge. It's certainly a step in the right direction. There are many sludge composting operations around the world, and when the sludge is composted, it makes a useful soil additive. I've visited sludge composting sites in Nova Scotia, Pennsylvania, Ohio, and Montana, and the finished compost at all of the sites is quite impressive.

M: It'll never happen (shaking his head). Face it. Americans, westerners, will never stop shitting in water. They'll never, as a society, compost their manure. It's unrealistic. It's against our cultural upbringing. We're a society of Howdy-Doody, hotdogs, hairspray, and Ho-Hos, not composted humanure, fer chrissake. We don't believe in balancing

SOURCE-SEPARATED ORGANIC MATERIALS PICKED UP BY MUNICIPALITIES AT HOMES IN NOVA SCOTIA

FOOD MATERIALS

Fruits
Vegetables
Meat
Shells
Dairy products
Oils, grease, fats
Breads
Pasta
Bones
Egg shells
Coffee grounds & filters
Tea leaves and bags

YARD MATERIALS

Grass
Leaves
Brush
House plants
Weeds

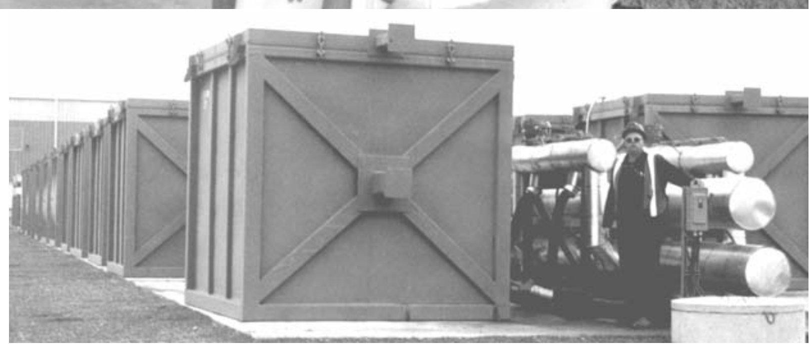
PAPER PRODUCTS

Boxes: cereal, shoe, tissue, detergent, cracker, cookie, baking product, and frozen food
Toilet paper and paper towel rolls
Napkins
Paper towels
Wax paper
File folders
Manila envelopes
Wrapping paper
Paper plates and cups
Newspapers
Bags: sugar, flour, and potato

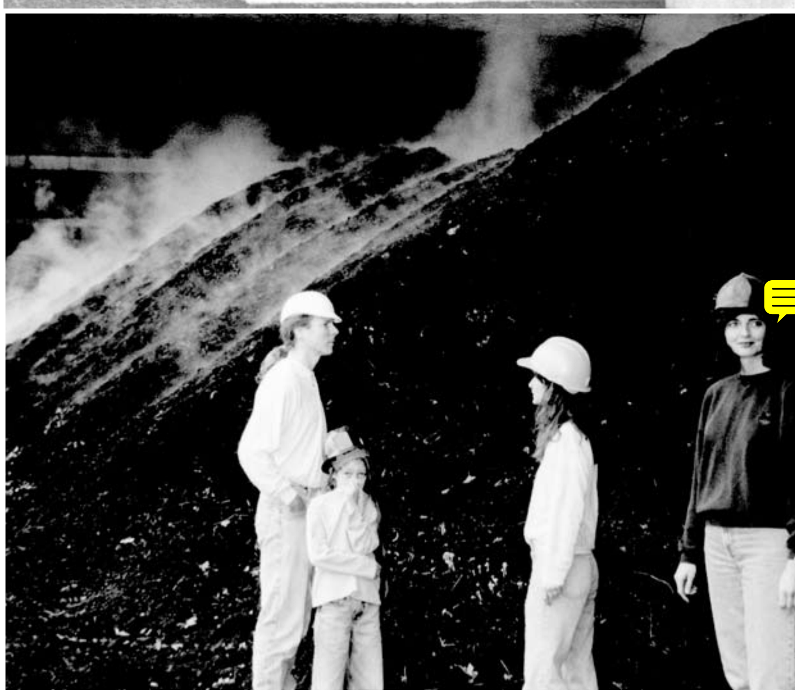
OTHER

Sawdust and wood shavings

▲ Butler, Pennsylvania, US, sewage sludge composting facility, steaming away. Compost operators Chris Arnold (left) and Dennis Kenyon (right) escort Humanure Handbook researcher Claire Anderson.



Balefill Composting Facility in Kemptown, Nova Scotia, Canada, uses a high-tech, in-vessel composting system to compost organic household materials. Shown with maintenance supervisor Glen Scott. ▶



The Akron, Ohio, US, ▶ sewage sludge composting facility composts the sludge produced by 328,000 people in one of the largest and oldest sludge composting facilities in the US. Visitors Michael Timmer (left) and Cynthia Hoffman (right) accompany the author's wife Jeanine and daughter Phoebe on a tour of the facility.

human nutrient cycles! We just don't give a damn. Compost making is unglamorous and you can't get rich doing it. So why bother?!

MS: You're right on one point — Americans will never stop shitting. But don't be so hasty. In 1988, in the United States alone, there were 49 operating municipal sludge composting facilities.[6] By 1997, there were over 200.[7] A solid waste composting plant in Oregon is designed to handle 800 tons of refuse daily.

In Duisberg, Germany, a decades-old plant composts 100 tons of domestic refuse daily. Another plant at Bad Kreuznach handles twice that amount. Many European composting plants compost a mixture of refuse and sewage sludge. There are at least three composting plants in Egypt. In Munich, a scheme was being developed in 1990 to provide 40,000 households with "biobins" for the collection of compostable refuse.[8]

It's only a matter of time before the biobin concept is advanced to collect humanure as well. In fact, some composting toilets already are designed so that the humanure can be wheeled away and composted at a separate site. Eventually, municipalities will assume the responsibility for collecting and composting all organic material from urban and suburban human populations, including toilet materials.

M: Yeah, right.

MS: And you are now revealing the main obstacle toward a sustainable society. Personal attitude. Everything we take for granted today — shoes, clothing, metal tools, electronic equipment, heck, even toilet paper, exists for one reason, and one reason only: because someone in the past cared about the future. You'd be running around naked today chasing rabbits with a stick if people in the past hadn't made things better for us in the present. We all have an obligation to our future generations. That's what evolution is, and that's what survival of the species requires. We have to think ahead. We have to care about our descendants too, and not just about ourselves. That means we have to understand that waste is not good for us, or for future generations. When we dump endless amounts of garbage into the environment with the attitude that someone in the future can deal with it, we are not evolving, we're *devolving*.

M: What's that supposed to mean?

MS: It's simple enough. OK, you have trash. You don't throw the trash "out." There is no "out." It has to go somewhere. So you simply sort the trash into separate receptacles in your home, and that makes it easy to recycle the stuff. When it's recycled, it's not wasted. A chimpanzee could figure that out. It's easy to understand and it's easy to do.

A lot of compost that's been produced by big composting plants has been contaminated with things like batteries, metal shards, bottle caps, paints, and heavy metals. As a result, much of it hasn't been useful for agriculture. Instead, it's been used for filler or for other non-agricultural applications, which, to me, is absurd. The way to keep junk out of compost is to value compostable material enough to collect it separately from other trash. A household biobin would do the trick. The biobin could be collected regularly, emptied, its contents composted, and the compost sold to farmers and gardeners as a financially self-supporting service provided by independent businesses.

The trick to successful large-scale compost production can be summed up in two words: *source separation*. The organic material must be separated at the source. This means that individual families will have to take some responsibility for the organic material they discard. They will no longer be permitted to throw it all in one garbage can with their plastic Ho-Ho wrappers, pop bottles, broken cell phones, and worn out toaster ovens. Organic material is too valuable to be wasted. The people in Nova Scotia have figured that out, as have many others throughout the world. Americans are a little slow.

M: But they're not composting toilet materials, are they?

MS: They're composting sewage sludge, which is a big step in the right direction. Some entrepreneurs are in the sewage composting business in the United States, too. In 1989, the town of Fairfield, Connecticut, contracted to have its yard material and sewage sludge composted. The town is said to have saved at least $100,000 in waste disposal costs in its first year of composting alone. The Fairfield operation is just a quarter mile from half million dollar homes and is reported to smell no worse than wet leaves from only a few yards away.[9]

In Missoula, Montana, all of the city's sewage sludge is composted, and the entire composting operation is funded by the tipping fees alone. All of the compost produced is pure profit, and all of it is sold. Composting is a profitable venture

AN INTERESTING TWIST TO NOVA SCOTIA'S COMPOSTING

As of November 30, 1998, in the Canadian province of Nova Scotia, one could no longer throw "away" organic material. By law, it had to be recycled. Composting took off in a big way in Nova Scotia as a result, and numerous composting operations have now sprung up throughout the province, each with their own way of making compost. Some are high-tech, some very low-tech.

Other materials, such as bottles, cans, and recyclable plastics are also banned from landfills there. By the time all municipal trash is sorted, separated, and recycled, the junk that ends up at the landfill disposal site looks pretty useless: old batteries, lots of ripped up old plastic bags, discarded pieces of hard plastic, old parts of electronic equipment, glass chards, old light bulbs, things like that. The stuff looks like such useless junk you could not imagine any use for it at all. But when the junk is shoved into a pile, guess what happens: incredibly, it *composts*.

All of this useless garbage is systematically composted in huge, manually aerated composting chambers. How can plastic and glass compost? Apparently, there is enough residual organic material in this junk (probably from disposable diapers), complete with thermophilic microorganisms, that when the stuff is piled together under controlled conditions, it heats up.

Why would anyone compost useless trash? For two very important reasons. First, because it reduces the mass of the trash by 50%, thereby cutting in half the amount of landfill space needed to dispose of this garbage. And second, because it renders the stuff biologically stable and not likely to undergo biochemical changes after burial.

Sometimes the magic of compost appears in very unlikely places.

when properly managed.

M: But still, there's the fear of humanure and its capability of causing disease and harboring parasites.

MS: That's right. But according to the literature, a biological temperature of 50°C (122°F) for a period of 24 hours is sufficient to kill the human pathogens potentially in humanure. EPA regulations require that a temperature of 55°C (131°F) be maintained for three days when composting sewage sludge in bins. Thermophilic microorganisms are everywhere, waiting to do what they do best — make compost. They're on grass, tree branches, leaves, banana peels, garbage, and humanure. Creating thermophilic compost is not difficult or complicated, and thermophilic composting is what we need to do in order to sanitize human excrement without excessive technology and energy consumption. Thermophilic composting is something humans all over the world can do whether or not they have money or technology.

There will always be people who will not be convinced that composted humanure is pathogen-free unless every tiny scrap of it is first analyzed in a laboratory, with negative results. On the other hand, there will always be people, like me, who conscientiously compost humanure by maintaining a well-managed compost pile, and who feel that their compost has been rendered hygienically safe as a result. A layer of straw covering the finished compost pile, for example, will insulate the pile and help keep the outer surfaces from cooling prematurely. It's common sense, really. The true test comes in living with the composting system for long periods of time. I don't know anyone else who has done so, but after twenty years, I've found that the simple system I use works well for me. And I don't do anything special or go to any great lengths to make compost, other than the simple things I've outlined in this book.

Perhaps Gotaas hits the nail on the head when he says, "*The farm, the garden, or the small village compost operator usually will not be concerned with detailed tests other than those to confirm that the material is safe from a health standpoint, which will be judged from the temperature, and that it is satisfactory for the soil, which will be judged by appearance. The temperature of the compost can be checked by: a) digging into the stack and feeling the temperature of the material; b) feeling the temperature of a rod after insertion into the material; or c) using a thermometer. Digging into the stack will give an approximate idea of the temperature. The material should feel very hot to the hand and be too hot to permit holding the hand in the pile for very long. Steam should emerge from the pile when opened. A metal or wooden rod inserted two feet (0.5 m) into the pile for a period of 5-10 minutes for metal and 10-15 minutes for wood should be quite hot to the touch, in fact, too hot to hold. These temperature testing techniques are satisfactory for the smaller village and farm composting operations.*" [10]

In other words, humanure composting can remain a simple process, achievable by anyone. It does not need to be a complicated, high-tech, expensive process controlled and regulated by nervous people in white coats bending over a compost pile, shaking their heads and wringing their hands while making nerdy clucking sounds.

I want to make it clear though, that I can't be responsible for what other people do with their compost. If some people who read this book go about composting humanure in an irresponsible manner, they could run into problems. My guess is the worst thing that could happen is they would end up with a mouldered compost pile instead of a thermophilic one (I see this happen a lot). The remedy for that would be to let the mouldered pile age for a couple years before using it agriculturally, or to use it horticulturally instead.

I can't fault someone for being fecophobic, and I believe that fecophobia lies at the root of most of the concerns about composting humanure. What fecophobes may not understand is that those of us who aren't fecophobes understand the human nutrient cycle and the importance of recycling organic materials. We recycle organic refuse because we know it's the right thing to do, and we aren't hampered by irrational fears. We also make compost because we need it for fortifying our food-producing soil, and we consequently exercise a high degree of responsibility when making the compost. It's for our own good.

Then, of course, there's the composter's challenge to fecophobes: *show us a better way to deal with human excrement.*

M: Sounds to me like you have the final word on the topic of humanure.

MS: Hardly. The *Humanure Handbook* is only a tiny beginning in the dialogue about human nutrient recycling.

M: Well, sir, this is starting to get boring and our time is running out, so we'll have to wrap up this interview. Besides, I've heard enough talk about the world's most notorious "end" product. So let's focus a little on the end itself, which has now arrived.

MS: And this is it. This is the end?

M: "This is the end." (Sung like Jim Morrison.) What d'ya say folks? (Wild applause, stamping of feet, frenzied whistling, audience jumping up and down, yanking at their hair, rolls of toilet paper thrown confetti-like through the air, clothes being torn off, cheering and screaming. Someone starts chanting "*Source separation, Source separation*!" What's this!? The audience is charging the stage! The interviewee is being carried out over the heads of the crowd! Hot dang and hallelujah!)

(scratch n' sniff)

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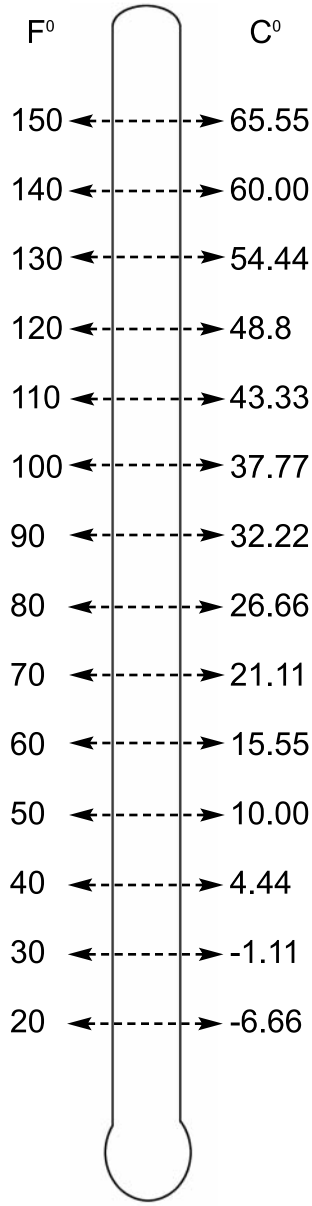
A behind-the-scenes look at the Humanure Handbook production staff, busy at work.

HUMANURE HANDBOOK -- APPENDICES

APPENDIX 1: TEMPERATURE CONVERSIONS

Fahrenheit	Celsius
-40	-40
-30	-34.44
-20	-28.88
-10	-23.33
0	-17.77
5	-15.00
10	-12.22
15	-9.44
20	-6.66
25	-3.88
30	-1.11
35	1.66
40	4.44
45	7.22
50	10.00
55	12.77
60	15.55
65	18.33
70	21.11
75	23.88
80	26.66
85	29.44
90	32.22
95	35.00
98.6	36.99
100	37.77
105	40.55
110	43.33
115	46.11
120	48.88
125	51.66
130	54.44
135	57.22
140	60.00
145	62.77
150	65.55
155	68.33
160	71.11
165	73.88



$F^0 = 9/5\ C^0 + 32$

Celsius	Fahrenheit
0	32.00°
5	41.00°
10	50.00°
15	59.00°
20	68.00°
25	77.00°
30	86.00°
35	95.00°
40	104.00°
45	113.00°
50	122.00°
55	131.00°
60	140.00°
65	149.00°
70	158.00°
75	167.00°
80	176.00°
85	185.00°
90	194.00°
95	203.00°
100	212.00°

APPENDIX 2
SOURCES OF WETLAND PLANTS

CONNECTICUT

Blackledge River Nursery, 155 Jerry Daniels Road, Marlborough, CT 06447; Ph. 860 295 1022; Plant price list available upon request.

ILLINOIS

LaFayette Home Nursery, Inc., RR 1 Box 1A, LaFayette, IL 61449; Ph. 309 995 3311; Fax 309 995 3909; email: tonyclhn@netins.net or dougilhn@netins.net

The Natural Garden, 38 West 443 Highway 64, St. Charles, IL 60175; Ph. 630 584 0185; Fax 630 584 0185

Synnestvedt Company
24550 W. Highway 12D, Round Lake, IL 60073
Ph: 847 546 4834; Free Catalog.

MARYLAND

Benedict Greenhouses, 1054 South Salisbury Boulevard, Salisbury, MD 21801; Ph. 410 742 2266

Environmental Concern, Inc., 201 Boundary Lane, PO Box P, St. Michaels, MD 21663; Ph. 410 745 9620; Fax 410 745 4066; http://www.wetland.org; email: order@wetland.org; Free catalog.

Kurt Bluemel, Inc., 2740 Greene Lane, Baldwin, MD 21013-9523; Ph. 410 557 7229; Fax 410 557 9785; http://www.bluemel.com; email: bluemels@aol.com; Catalog: $3.

Lilypons Water Gardens, 6800 Lilypons Road, PO Box 10, Buckeystown, MD 21717-0010; Ph. 410 874 5133; Toll free Ph: 800 999 5459; Fax: 800 879 5459; http://www.lilypons.com; email: info@lilypons.com; Free catalog.

Maryland Aquatic Nurseries, 3427 North Furnace Road, Jarrettsville, MD 21084; Ph. 410 557 7615; Fax 410 692 2837; http://www.marylandaquatic.com; email: info@marylandaquatic.com; Catalog: $5.

MASSACHUSETTS

Bigelow Nurseries, PO Box 718, Northborough, MA 01532; Ph. 508 845 2143; Fax 508 842 9245; Free catalog.

MINNESOTA

Prairie Moon Nursery, RR 3 Box 163, Winona, MN 55987; Ph. 507 452 1362; Fax 507 454 5238; http://www.prairiemoonnursery.com; email: pmnrsy@luminet.net; Free catalog.

MISSOURI

Gilberg Perennial Farms, 2906 Ossenfort Road, Glencoe, MO 63038; Ph. 314 458 2033; Fax 314 458 9640; http://www.gilbergfarms.com; Free catalog.

NEBRASKA

Stock Seed Farms, Inc., 28008 Mill Road, Murdock, NE 68407; Ph. 402 867 3771; Fax 402 867 2442; http://www.stockseed.com; email: stockseed@navix.net; Free catalog.

NEW JERSEY

Waterford Gardens, 74 East Allendale Road, Saddle River, NJ 07458; Ph. 201 327 0721; Fax 201 327 0684; http://www.waterford-gardens.com; email: splash@waterford-gardens.com; Catalog: $5.

Wild Earth Native Plant Nursery
PO Box 7258, Freehold, NJ 07728;
Ph/Fax 732 308 9777.

NEW YORK

Southern Tier Consulting, Inc., PO Box 30, West Clarksville, NY 14786; Ph. 716 968 3120; Fax 716 968 3122; email: froghome@eznet.net; Free catalog.

APPENDIX 2
SOURCES OF WETLAND PLANTS (CONTINUED)

NORTH CAROLINA

Gardens of the Blue Ridge, PO Box 10, Pineola, NC 28662; Ph. 828 733 2417; Fax 828 733 8894; http://www.gardensofthe-blueridge.com; email: gardensblueridge@boone.net; Color catalog, $3, deductible with first order.

Green Biz, PO Box 64995; Fayetteville, NC 28306; Toll free Ph. 800 848 6634; Ph. 910 323 8811; Fax 910 433 9052; http://www.green-biznursery.com; email: greenbiznursery@aol.com; Free catalog.

OHIO

William Tricker, Inc., 7125 Tanglewood Drive, Independence, OH 44131; Ph. 216 524 3491; Fax 216 524 6688; http://www.tricker.com; Catalog: $2.

PENNSYLVANIA

Buddies Nursery, PO Box 14, Birdsboro, PA 19508; Ph. 610 582 2410; Fax 610 582 0955; Free wholesale catalog.

Ecoscience, Inc., RR 4 Box 4294, Moscow, PA 18444; Ph. 570 842 7631; Fax 570 842 9976; http://www.ecoscnc.com; email: ecosc-nc@scranton.com; Free catalog.

Ernst Conservation Seeds, 9006 Mercer Pike, Meadville, PA 16335
Ph: 800-873-3321; Fax: 814-336-5191
Web site: http://www.ernstseed.com
email: ernst@ernstseed.com
Free information guide/price list.

North Creek Nurseries, 388 North Creek Road, Landenberg, PA 19350; Ph. 610 255 0100; Fax 610 255 4762
email: ncreek@dca.net
Free catalog, wholesale only.

TENNESSEE

Savage Nurseries Center, 6255 Beersheba Highway, McMinnville, TN 37110; Ph. 931 668 8902; Free catalog.

VIRGINIA

Naturescapes, 1581 Hosier Road; Suffolk, VA 23434; Ph./Fax 757 539 4833; Wholesaler; Phone or Fax for quote.

WISCONSIN

Applied Ecological Services, Inc./Taylor Creek Nurseries, Box 256, Brodhead, WI 53520; Ph. 608 897 8547; Fax 608 897 8486; http://www.appliedeco.com; email: appliede-co@brodnet.com; Free catalog.

Kester's Wild Game Food Nurseries, Inc., Box 516, Omro, WI 54963; Ph. 920 685 2929; Toll-free: 800 558 8815; http://www.kester-snursery.com; email: pkester@vbe.com; Free catalog.

Prairie Ridge Nursery, RR 2, 9728 Overland Road, Mt. Horeb, WI 53572-2832; Ph. 608 437 5245; Fax 608 437 8982; email: crmprairie@inxpress.net; Restoration Guide: $5; Free plant price list.

Wildlife Nurseries, PO Box 2724, Oshkosh, WI 54903; Ph. 920 231 3780; Fax 920 231 3554; 42 page color catalog: $3.

CONSTRUCTED WETLAND EQUIPMENT/SUPPLIES SOURCES

Forestry Suppliers, Inc., 205 West Rankin Street, Box 8397, Jackson, MS 39284-8397; Ph. 601 354 3565; Fax 601 355 5126; http://www.forestry-suppliers.com; email: fsi@forestry-suppliers.com; Free catalog.

Isco, Inc., PO Box 82531, Lincoln, NE 68501; Ph. 402 464 0231; Fax 402 465 3022; http://www.isco.com; email: rickd@isco.com; Free catalog.

Water Environment Federation, 601 Wythe Street, Alexandria, VA 22314; Ph. 703 684 2400; Toll-free: 800 666 0206; Fax 703 684 2492; http://www.wef.org; email: msc@wef.org; Free catalog.

APPENDIX 3

STATE REGULATIONS (US), COMPILED IN 1999:
COMPOSTING TOILETS, GRAYWATER SYSTEMS, AND CONSTRUCTED WETLANDS

NOTES: **1**. Although many states do not have formal design standards or regulations concerning composting toilets, graywater systems, and/or constructed wetlands as they pertain to on-site sewage management for residences, many of the rules and regulations do contain a section allowing "experimental" and/or "alternative" systems which may be permitted by individual application to the regulating agency. Individuals interested in these systems should check with their state agency for more information.
2. When the phrase "no existing regulations," is used it is not meant to imply that those systems may be used without prior approval from the local or state permitting agency. In all cases, check with your local or state permitting agency to see what their permitting requirements are.

ALABAMA: Alabama Department of Public Health, Division of Community Environmental Protection, RSA Tower, Suite 1250, PO Box 303017, Montgomery, AL 36130-3017; Ph. (334) 206-5373; Contact: John Paul O'Driscoll. **REGULATION(S)**: Chapter 420-3-1: Onsite Sewage Disposal and Subdivision-Onsite Sewage Systems, Water Supplies and Solid Waste Management (23 December 1998). **COMPOSTING TOILETS**: As of December 23, 1998, no regulations exist for composting toilets. Composting toilets are not expressly forbidden, but the homeowner does have to show adequate sewage disposal for graywater. Alabama is working on a set of new regulations, as the current rules have been overcome by time, and are not adequate for many of the situations that the regulated community faces today. The main shortcoming of the current regulations is that they do not adequately address the large systems and alternative technologies that are present today.[1] In the proposed regulations, composting toilets are discussed in Chapter 420-3-1-.59 under Non-Waterborne Systems: Pit Privies, Portable, Composting, and Incinerating Toilets. A composting toilet is defined as a dry closet which combines toilet and urinal waste with optional food waste in an aerobic vented environment. Decomposition of the waste is accomplished by the dehydration and digestion of organic matter, yielding a composted residue which is removed for sanitary disposal.[2] Conditions which justify the use of non-waterborne systems include when soil and site conditions are unsuitable for on-site sewage treatment and disposal systems (OSTDS) or when water under pressure is not available. Composting toilets must meet the standards of the National Sanitation Foundation (NSF), Canadian Standards Association (CSA), Underwriter's Laboratory, or Warnock Hershey. Other requirements call for continuous ventilation of the components for the storage or treatment of materials. Disposal of the compost must be in accordance with the guidance of EPA Part 503. Disposal of any liquids from the system must be to a sanitary sewer or to an approved OSTDS. **GRAYWATER**: Ch. 420-3-1-.03. Defined, graywater is that portion of sewage generated by a water-using fixture or appliance, excluding the toilet and possibly the garbage disposal.[3] References to graywater can be found under 402-3-1-.27 Effluent from Clothes Washing Machine and Residential Spa. Water from these systems can circumvent a septic tank and go into a separate effluent disposal field (EDF). In the current regulations, in the absence of water under pressure, graywater shall be disposed of by an effluent distribution line of 50 linear feet per dwelling. Graywater is also covered under the proposed draft of Ch. 420-3-1-.59. No new recommendations besides the EDF system are proposed. **CONSTRUCTED WETLANDS**: A constructed wetland is defined in the *proposed* rules as a human-made, engineered, marsh-like area which is designed, constructed, and operated to treat wastewater by attempting to optimize physical, chemical, and biological processes of natural ecosystems.[4] However, there are no existing regulations.

ALASKA: Alaska Department of Environmental Conservation, Domestic Wastewater Program, 410 West Willoughby Avenue, Suite 105, Juneau, AK 99801; Ph. (907) 465-5324; Fax (907) 465-5362; http://www.state.ak.us/dec. **REGULATION(S)**: 18 AAC 72 Wastewater Disposal (1 April 1999). **COMPOSTING TOILETS**: No existing regulations. **GRAYWATER**: 18 AAC 72.990. Graywater means wastewater a) from a laundry, kitchen, sink, shower, bath, or other domestic sources; and wastewater b) that does not contain excrement, urine, or combined stormwater. No existing regulations. **CONSTRUCTED WETLANDS**: No existing regulations.

ARIZONA: Arizona Department of Environmental Quality, 3033 North Central Avenue, Phoenix, AZ 85012-2809; Toll-free Ph. (800) 234-5677; Ph. (602) 207-4335; Fax (602) 207-4872; Contact: Nabil Anouti at (602) 207-4723; http://www.sosaz.com/public_services/Title_18/18-09.html. **REGULATION(S)**: Arizona Department of Environmental Quality (ADEQ) Bulletin No. 12, Minimum Requirements for the Design and Installation of Septic Tank Systems and Alternative On-site Disposal Systems (June 1989); Arizona Administrative Code Title 18, Ch. 9, Article 7: Regulations for the Reuse of Wastewater (30 September 1998); Arizona Guidance Manual for Constructed Wetlands for Water Quality Improvement (August 1996). **COMPOSTING TOILETS**: No regulations. Bulletin 12 suggests the use of composting toilets where conditions are such as to make it impossible or impractical to construct either a septic tank disposal or an earth-pit privy.[5] Provided they can be maintained and operated without endangering the public health or creating a nuisance, composting toilets may be permitted.[6] **GRAYWATER**: Defined under R18-9-701. Graywater means wastewater that originates from clothes washers, dishwashers, bathtubs, showers and sinks, except kitchen sinks and toilets. Under R18-9-703, section C6, graywater from single and multi-family residences may be used for surface irrigation. The design and construction of the system must be approved by the Department. Irrigation sites must be designed to contain a 10-year, 24-hour (i.e., maximum possible) rainfall event and the graywater must fall under the allowable limits of less than 25 colony forming units per 100 milliliters (CFU/ml) fecal coliform and less than 2.0 mg/l chlorine for surface irrigation. Under section 7, formation of a wetlands marsh is allowable reuse of reclaimed wastewater.[7] **CONSTRUCTED WETLANDS**: Bulletin 12 describes onsite alternatives to septic tank and drainfield disposal systems. The first general requirement of Bulletin No. 12 is that alternative onsite disposal systems are intended and will be approved for individual lots only where conventional septic tank systems are not suitable and cannot be approved.[8] Use of a septic tank with a minimum of two compartments for preliminary solids removal is necessary prior to a constructed wetland. Constructed subsurface flow wetlands are viewed as a beneficial augmenting step in the septic tank system, providing additional treatment between the septic tank and the soil absorption system.[9] The bulletin points out several benefits of segregating blackwater and graywater: 1) conservation of water resources; 2) potential of recycling valuable nutrients to the soil; 3) reuse potential of recycled graywater; and 4) prolonged life of the septic tank soil absorption system.[10] However, until further field data becomes available and is evaluated, graywater treatment and disposal systems shall be designed similarly for typical residential wastewater septic tank soil absorption systems. Under this scenario, it may be possible to reduce the septic tank system capacities, sometimes by one-third.[11]

ARKANSAS: Arkansas Department of Health, Sanitary Division, State Health Building, 4815 West Markham, Little Rock, AR 72201; Ph. (501) 661-2171. **REGULATION(S)**: Alternate Systems Manual published by Environmental Program Services, Division of Environmental Health Protection (April 1993). According to the Alternate Systems Manual, the Arkansas Department of Health encourages studies and submission of plans for alternative methods of treating and disposing of wastes generated by individual residences.[12] However, if site and soil conditions indicate that a standard septic tank and soil absorption system is feasible, no alternative or experimental system will be considered.[13] **COMPOSTING TOILETS:** are allowed as long as they are NSF approved. In fact, composting toilets are currently being used in state park systems.[14] A composting toilet is defined as a device specifically designed to retain and process body waste, and, in some cases, household garbage, by biological degradation. The process may be thermophilic or mesophilic, depending on the design of the toilet.[15] Some manufacturers claim the stabilized compost is safe and may be used as a soil additive in gardens. The actual health risks associated with this composted material have not been adequately assessed. The stabilized compost from a composting toilet must be buried onsite or deposited in an approved sanitary landfill. All composting devices must be evaluated by an ANSI approved laboratory under NSF Standard 41.[16] Approved composting toilets for the state of Arkansas include Clivus Multrum models 08, 08-0A, 08-A,202 and 205; and Sun-Mar Biological Composting Toilet and Sun-Mar-XL. Each application requesting approval of a composting toilet must also provide for the disposal of the home's graywater.[17] **GRAYWATER**: Essentially, graywater is treated the same as blackwater. The preferred method of handling graywater is through a conventional septic tank and absorption field. A 35% reduction in the absorption field size will be granted. Other methods of treating and/or disposing of graywater will be reviewed on a case by case basis.[18] **CONSTRUCTED WETLANDS (ROCK PLANT FILTERS)**: Rock plant filters (RPFs) provide secondary treatment to septic tank effluent. RPFs act as artificial marshes that rely on microorganisms and the roots of aquatic plants to achieve treatment. RPF systems may be considered on sites where low soil permeability prohibits use of a conventional septic system. Discharge from an RPF must be retained on site, which requires a lot size of at least three acres. This requirement may be waived on repairs to existing, failed septic systems. All off-site discharges must be undergo chlorination prior to discharge.[19]

CALIFORNIA: California Department of Water Resources, Water Conservation Office, 1020 9th Street, Sacramento, CA 95814; Ph. (916) 327-1655; Contact: Ed Craddock. For Composting Toilets and Constructed Wetlands Regulations, Contact: California Department of Health Services, 724 P Street, Room 1350, Sacramento, CA 95814; Ph. (916) 654 0584; Fax (916) 657-2996. **REGULATION(S)**: Appendix G. Graywater Systems. Uniform Plumbing Code, Title 24, Part 5, California Administrative Code (18 March 1997). **COMPOSTING TOILETS**: No existing regulations, check with your local or county agency. **GRAYWATER**: G-1. General. (b) The type of system shall be determined on the basis of location, soil type, and ground water level and shall be designed to accept all graywater connected to the system from the building. The system shall discharge into subsurface irrigation fields and may include surge tanks and appurtenances, as required by the Administrative Authority. (d) No permit for any graywater system shall be issued until a plot plan with appropriate data satisfactory to the Administrative Authority has been submitted and approved. When there is insufficient lot area or inappropriate soil conditions for adequate absorption of the graywater, as determined by the Administrative Authority, no graywater system shall be permitted. G2. Graywater is untreated wastewater which has not come into contact with toilet waste. Graywater includes used water from bathtubs, showers, bathroom wash basins, clothes washing machines and laundry tubs or an equivalent discharge as approved by the Administrative Authority. It does not include wastewater from kitchen sinks, photo lab sinks, dishwashers, or laundry water from soiled diapers. Surfacing of graywater means the ponding, running off, or other release of graywater from the land surface. G13 Health and Safety. (a) Graywater may contain fecal matter as a result of bathing and/or washing of diapers and undergarments. Water containing fecal matter, if swallowed, can cause illness in a susceptible person. (b) Graywater shall not include laundry water from soiled diapers. (c) Graywater shall not be applied above the land surface or allowed to surface and shall not be discharged directly into or reach any storm sewer system or any water of the United States. (d) Graywater shall not be contacted by humans, except as required to maintain the graywater treatment and distribution system. (e) Graywater shall not be used for vegetable gardens.[20] **CONSTRUCTED WETLANDS**: No existing regulations.

COLORADO: Colorado Department of Public Health and Environment, Water Quality Control Division, 4300 Cherry Creek Drive South, Denver, CO 80246-1530; Ph. (303) 692-3500. **REGULATION(S)**: Guidelines on Individual Sewage Disposal Systems, Chapter 25, Article 10 (1994). **COMPOSTING TOILETS**: Composting toilets, according to the Colorado Department of Health, are defined as unit(s) which consist of a toilet seat and cover over a riser which connects to a compartment or a vault that contains or will receive composting materials sufficient to reduce waste by aerobic decomposition.[21] Composting toilets receive deposits of feces, urine, and readily decomposable household garbage that are not diluted with water or other fluids.[22] These deposits are retained in a compartment in which aerobic composting will occur. The compartment may be located within a dwelling or building, provided that the unit complies with the applicable requirements of these guidelines and provided the installation will not result in conditions considered to be a health hazard as determined by the local health department. The effective volume of the receptacle must be sufficient to accommodate the number of persons served. When the receptacle is filled to 75% capacity, residue from the unit shall be disposed of by acceptable solid waste practices. Composting toilets must be NSF approved.[23]

GRAYWATER: Graywater systems collect, treat, and dispose of liquid wastes from sinks, lavatories, tubs, showers, and laundry or other approved plumbing fixtures, excluding toilet fixtures.[24] Graywater systems shall meet at least all minimum design and construction standards for septic tank systems based on the amount and character of wastes for the fixtures and the number of persons served.[25] **CONSTRUCTED WETLANDS:** are systems which utilize various wetland plants to provide secondary treatment of wastewater through biological, physical, and chemical processes.[26] Constructed wetland systems must be designed by a registered professional engineer. Designs have to be site-specific and must include estimates of effluent quality at the inlet and outlet. Periodic sampling is required at the owner's expense.[27]

CONNECTICUT: Connecticut Department of Public Health, 410 Capitol Avenue, MS #51 SEW, PO Box 340308, Hartford, CT 06134-0308; Ph. (860) 509-7296; http://www.dep.state.ct.us/dph. **REGULATION(S)**: Connecticut Public Health Code: Regulations and Technical Standards for Subsurface Sewage Disposal Systems, Section 19-13-B100 (Conversions, Changes in Use, Additions) (25 October 1976); Section 19-13-B103 (Discharges 5,000 Gallons Per Day or Less) (16 August 1982); and Technical Standards (Pursuant to Section 19-13-B103) (1 January 1997). **COMPOSTING TOILETS**: (b)(1) The local director of health may approve the use of a large capacity composting toilet or a heat-assisted composting toilet for replacing an existing privy or a failing subsurface sewage disposal system, or for any single-family residential building where application is made by the owner and occupant, and the lot on which the building will be located is tested by the local director of health and found suitable for a subsurface sewage disposal system meeting all the requirements of Section 19-13-B103d of these regulations. (2) All wastes removed from composting toilets shall be disposed of by burial or other methods approved by the local director of health.[28] 19-13-B103f XI. Non-Discharging Sewage Disposal Systems A. Large capacity composting toilets shall have separate receiving, composting, and storage compartments, arranged so that the contents are moved from one compartment to another without spillage or escape of odors within the dwelling. No large capacity composting toilets shall have an interior volume of less than 64 cubic feet. All toilet waste shall be deposited in the receiving chamber, which shall be furnished with a tight self-closing toilet lid. Food waste or other materials necessary to the composting action shall be deposited in the composting compartment through a separate opening with a tight fitting lid. The final composting material shall be removed from the storage compartment through a cleanout opening fitted with a tight door or lid. The cleanout shall not be located in a food storage or preparation area. The receiving and composting compartments shall be connected to the outside atmosphere by a screened vent. The vent shall be a minimum of six inches in diameter and shall extend at least 20 feet above the openings in the receiving and composting compartments, unless mechanical ventilation is provided. Air inlets shall be connected to the storage compartment only, and shall be screened. B. Heat assigned composting toilets shall have a single compartment furnished with a tight, self-closing toilet lid. The compartment shall be connected to the outside atmosphere by a screened vent. There shall be a mechanical ventilation fan arranged to control the humidity in the compartment and provide positive venting of odors to the outside atmosphere at all times. A heating unit shall be provided to maintain temperature in the optimum range for composting.[29] **GRAYWATER**: (n) Graywater means domestic sewage containing no fecal material or toilet wastes. Sec. 19-13-B103d. Minimum Requirements. (f) Gray Water Systems. Disposal systems for sinks, tubs, showers, laundries, and other graywater from residential buildings, where no water flush toilet fixtures are connected, shall be constructed with a septic tank and leaching system at least one-half the capacity specified for the required residential sewage disposal system.[30] Sec. 19-13-B103f. Non-discharging Sewage Disposal Systems (a) All non-discharging sewage disposal systems shall be designed, installed, and operated in accordance with the Technical Standards and the requirements of this section, unless an exception is granted by the Commissioner upon a determination that system shall provide for the proper and complete disposal and treatment of toilet wastes or graywater.[31] **CONSTRUCTED WETLANDS**: No existing regulations.

DELAWARE: Department of Natural Resources and Environmental Control, Division of Water Resources, 89 Kings Highway, Dover, DE 19901; Ph. (302) 739-4761. **REGULATION(S)**: Regulations Governing the Design, Installation and Operation of On-Site Wastewater Treatment and Disposal Systems (4 January 1984). **COMPOSTING TOILETS, GRAYWATER, CONSTRUCTED WETLANDS**: No existing regulations. However, a substantial portion of Delaware's population lives where centralized water supply or wastewater treatment services are limited. The Department's mission is to aid and assist the public in the installation of on-site sewage disposal systems, where possible, by utilizing the best information, techniques, and soil evaluations for the most suitable system that site and soil conditions permit. In the past, inadequately renovated wastewater has contaminated Delaware's groundwater and presented a threat to the public health, safety, and welfare. Corrective measures required the replacement of water supply and wastewater systems at a very high cost which was sometimes borne by the general public. In developing these Regulations, the Department operated under the philosophy that where soil and site conditions permit, *the least complex, easy to maintain, and most economical system should be used*. The Department's policy is to encourage development of systems, processes, and techniques which may benefit significant numbers of people in Delaware.[32]

FLORIDA: Florida Department of Health, Bureau of Water and On-Site Sewage Programs, 2020 Capital Circle SE, BIN #A08, Tallahassee, FL 32399-1713; Ph. (850) 488-4070; FAX (850) 922-6969; http://www.doh.state.fl.us; http://www.dep.state.fl.us/logc/documents/rules/ruleslistpa.htm#wastewater; Contact: David Hammonds; Email: David_Hammonds@doh.state.fl.us. **REGULATION(S)**: 381.0065 Florida Statutes Regulations: Chapter 64E-6, Florida Administrative Code, Standards for Onsite Sewage Treatment and Disposal Systems (3 March 1998). **COMPOSTING TOILETS**: Although they are not widely used, they are allowed, especially in floodprone areas. Florida encourages the use of composting toilets.[33] 64E-6.009 Alternative Systems. Upon approval by the DOH county health department, alternative systems may, at the applicant's discretion, be used in circumstances where standard subsurface systems are not suitable or where alternative systems are more feasible. Under this section, composting toilets may be approved for use if found in compliance with NSF Standard 41. Graywater and any other liquid and solid waste must be properly collected and disposed of in accordance with Chapter 64E.[34] 64E-6.010 Disposal of Sewage. No receptacle associated with an onsite sewage treatment and disposal system shall be cleaned or have its contents removed until the service person has obtained an annual written permit (form DH4013) from the DOH county health department in the county in which the service company is located.[35] **GRAYWATER**: as defined under Title XXIX, Public Health Chapter 381.0065 Onsite Sewage treatment and disposal systems, means that part of domestic sewage that is not blackwater, including the waste from the bath, lavatory, laundry, and sink, except kitchen sink waste.[36] Graywater systems are described in Rule 64E-6.013(4).[37] When a separate system is installed to dispose of graywater, the retention tank for such systems shall meet certain design standards as specified in Rule 64E-6.008(3): The minimum effective capacity of the graywater retention tank shall be 250 gallons, with such system receiving not more than 75 gallons of flow per day. Where separate graywater and blackwater systems are used, the size of the blackwater system can be reduced by not more than 25%. 10D-6.046 Location and Installation. (7) Onsite graywater tank and drainfield systems may, at the homeowner's discretion, be utilized in conjunction with an onsite blackwater system where a sewerage system is not available for blackwater disposal.[38] 10D-6.048 System Size Determination (4) A separate laundry waste tank and drainfield system may be utilized for residences and may be required by the county public health unit where building codes allow for separation of discharge pipes of the residence to separate stubouts and where lot sizes and setback allow system construction. (a) The minimum laundry waste trench drainfield absorption area for slightly limited soil shall be 75 square feet for a one or two bedroom residence with an additional 25 square feet for each additional bedroom. 10D-6.055 (k) All graywater tanks distributed by the state shall be approved for use by the department prior to being installed. Such approval shall be obtained only after the manufacturer of a specific model has submitted engineering designs of the tank. (4) Graywater retention tanks - when a separate system is installed to dispose of graywater, the retention tank for such system shall meet the following minimum design standards: a) the minimum effective capacity shall be as specified in Rule 10D-6.048(3). Liquid depth shall be at least 30 inches; and b) retention tanks shall be baffled and vented as specified in the septic tank construction standards found elsewhere in the section provided that an inlet tee, ell, or baffle shall be provided for graywater tanks.[39] **CONSTRUCTED WETLANDS**: No existing regulations.[40]

GEORGIA: Department of Human Resources, Division of Public Health, Environmental Health Section, 5th Floor-Annex, 2 Peachtree Street NW, Atlanta, GA 30303-3186; Ph. (404) 657-2700 or 6538; FAX (404) 657-6533; http://www.ph.dnr.state.ga.us/manuals/sewage/contents.html; Contact: Warren Abrahams, Program Consultant. **REGULATION(S)**: Rules of Department of Human Resources, Public Health, Chapter 290-5-26: Onsite Sewage Disposal Management Systems (20 February 1998). **COMPOSTING TOILETS**: Where the availability of land for installation of conventional septic tank systems is limited so as to allow for only a septic tank and a reduced size absorption system, composting toilets may be considered. Laundry, bath, and kitchen wastes must be disposed of in a conventional septic tank system, although the size of the absorption field may be reduced by 35% from that of a conventional system, provided water conservation devices are utilized. Composted wastes from the treatment unit shall be removed as per the manufacturer's recommendations and the residue shall be buried by covering with at least six inches of soil. Wastes should not be used as fertilizer for root or leaf crops which may be eaten raw. Composting toilets must be certified by the NSF as meeting the current standard 41 or certified by the manufacturer as meeting a nationally recognized standard for such purpose.[41] **GRAYWATER**: Graywater means wastewater generated by water-using fixtures and appliances, excluding water closets, urinals, bidets, kitchen sinks, and garbage disposals. Chapter 290-5-59, Special Onsite Sewage Management Systems, defines sewage as human excreta, all water-carried wastes, and/or liquid household waste including graywater from residences or similar wastes or by-products from commercial and industrial establishments.[42] Where a separate graywater system is to be used, the minimum effective capacity of the graywater retention tank shall be 500 gallons. The minimum absorption area for graywater or blackwater absorption systems serving residential properties shall be based on the number of bedrooms and the percolation rate. The blackwater portion of the total daily sewage flow shall be 35%; the graywater portion shall be 65%.[43] **CONSTRUCTED WETLANDS**: No existing regulations. Although no regulations are formally in place, an article in the Georgia Environmentalist gives design information and recommendations for both free water surface (FWS) and subsurface flow (SSF) constructed wetlands.[44]

HAWAII: Department Of Health, Wastewater Branch, Environmental Management Division, 919 Ala Moana Boulevard, Suite 309, Honolulu, HI 96814; Ph. (808) 586-4294. **REGULATION(S)**: Hawaii Administrative Rules, Chapter 11-62 (30 August 1991). **COMPOSTING TOILETS**: 11-62-03 Definitions. "Compost toilet" means a non-flush, waterless toilet that employs an aerobic composting process to treat toilet wastes.[45] Ch. 11-62-35 states that specific design requirements for composting (and other) toilets shall be reviewed and approved by the director on a case-by-case basis.[46] Products, if sold in Hawaii, are to be approved by the director, based on appropriate testing procedures and standards as set forth by the National Sanitation Foundation (NSF) Testing Laboratory.[47] The following toilets are approved the NSF Standard 041: Biolet XL; Clivus Multrum Model M-1, M-2, M-12, M-15, M-18, M-22, M-25, M-28, M-32, M-35, M54ADA; Ecotech Carousel; and Sun Mar Excel. **GRAYWATER**: means liquid waste from a dwelling or other establishment produced by bathing, washdown, minor laundry, and minor culinary operations, and specifically excluding toilet waste. [48] Chapter 11-62-31.1 states that individual wastewater systems may be used as a temporary on-site means of wastewater disposal in lieu of wastewater treatment works in residential developments when there is 10,000 square feet or more of land area for each individual wastewater system.[49] Section G covers graywater systems and their respective design characteristics.[50] Graywater conveyance systems include: sand filters, absorption trenches and beds, mounds or seepage pits, or when disinfected in accordance with 11-62-26(b) (which governs total coliform levels), used for irrigation.[51] 11-62-31.1 gives the general requirements for proposed individual wastewater systems. (g) A graywater system shall be designed in accordance with the following criteria: (1) design of graywater systems for dwelling units shall be based on a minimum graywater flow of 150 gallons per day per bedroom; and (2) graywater tanks, when required, shall be sized with no less than a 600 gallon capacity and shall conform to the requirements of section 11-62-33-1(a).[52] **CONSTRUCTED WETLANDS**: No existing regulations.

IDAHO: Division of Environmental Quality, 1410 North Hilton, Boise, ID 83706-1255; Ph. (208) 373-0502. Contact: Barry Burnell, Watershed Protection Supervisor. **REGULATION(S)**: IDAPA 16, Title 01, Chapter 03, Rules for Individual/Subsurface Sewage Disposal Systems (7 May 1993) and the Technical Guidance Manual (TGM) for Individual

Subsurface Sewage Disposal Systems. The TGM can be viewed at http://www.state.id.us/phd1/env/tgm/tgm.htm. Section 10 of the Idaho code covers Alternative Systems. If a standard system as described in the rules cannot be installed on a parcel of land, an alternative system may be permitted if that system is in accordance with the recommendations of the Technical Guidance Committee and is approved by the Director.[53] **COMPOSTING TOILETS:** are defined as toilets within the dwelling that store and treat non-water carried human urine and feces and small amounts of household garbage by bacterial decomposition. The resultant product is compost.[54] Composting toilets are allowed in residences that also have water under pressure, with the understanding that a public sewer or another acceptable method of on-site disposal is available. Permission must be obtained from the Idaho Health Department, as current plumbing code prohibits the use of composting toilets without their permission.[55] **GRAYWATER**: The Technical Guidance Manual contains a draft for graywater system guidelines and design requirements, but current Idaho rules permit graywater systems only as experimental systems.[56] The draft proposal describes graywater as untreated household wastewater that has not come into contact with toilet waste. Graywater includes used water from bathtubs, showers, bathroom wash basins, and water from clothes washing machines and laundry tubs. It shall not include wastewater from kitchen sinks, dishwashers, or laundry water from soiled diapers. A graywater system consists of a separate plumbing system from the blackwaste and kitchen plumbing, a surge tank to temporarily hold large drain flows, a filter to remove particles that could clog the irrigation system, a pump to move the graywater from the surge tank to the irrigation field, and an irrigation system to distribute the graywater. Graywater may not be used to irrigate vegetable gardens. Graywater systems may only be permitted for individual dwellings. The capacity of the septic tank and size of the blackwaste drainfield and replacement area shall not be reduced by the existence or proposed installation of a graywater system servicing the dwelling. Graywater shall not be applied on the land surface or be allowed to reach the land surface.[57] **CONSTRUCTED WETLANDS**: Constructed wetlands are only permitted under experimental systems. All experimental systems require a variance. Experimental systems also are required to be designed by a Idaho licensed professional engineer.[58]

ILLINOIS: Illinois Department of Public Health, Division of Environmental Health, 525-535 West Jefferson Street, Springfield, IL 62761-0001; Ph. (217) 782-5830; Contact: Elaine Beard or Doug Ebelherr. **REGULATION(S)**: Title 77: Public Health, Chapter I: Department of Public Health, Subchapter r: Water and Sewage, Part 905: Private Sewage Disposal Code, Section 905.30, Approved Private Sewage Disposal Systems (15 March 1996). **COMPOSTING TOILETS:** are approved for private sewage disposal of human wastes.[59] Compost toilets shall be designed in accordance with the manufacturer's recommendation to serve the anticipated number of persons. The owner of a compost toilet shall maintain the toilet and dispose of the contents in accordance with Section 905.170, which lists several methods of disposal: 1) discharge to a municipal sanitary sewer system; 2) discharge to sludge lagoons or sludge drying beds; 3) discharge to an incinerator device; or 4) discharge to a sanitary landfill.[60] Compost toilets shall comply with the requirement of the NSF Standard 41 and shall bear the NSF Seal.[61] **GRAYWATER, CONSTRUCTED WETLANDS**: No existing regulations (governed under experimental systems).

INDIANA: Indiana Department of Environmental Management, 100 North Senate Avenue, PO Box 6015, Indianapolis, IN 46206-6015; Ph. (317) 233-7179 or (317) 233-7188; Contact: Alan Dunn or Tim Decker; Email: adunn@ISDH.state.in.us. **REGULATION(S)**: Regulations, if they existed, would most likely be found under 401 Indiana Administrative Code 6-8.1. **COMPOSTING TOILETS, GRAYWATER**: No existing regulations. **CONSTRUCTED WETLANDS**: Constructed wetlands are approved only for experimental use in residential situations. Indiana outlines some basic design criteria for subsurface constructed wetlands, as follows: 1) The wetland is usually designed for five to seven days retention time; 2) Each wetland has one cell for residential projects, with each cell having a length to width ratio of no greater than 2:1; 3) The depth of gravel in the wetland is no greater than 24 inches; 4) There are three different gravel sizes in the wetland. The inlet and outlet ends of the wetland have coarse gravel in the range of 1 1/2 to 3 inches in size. The area between the ends has gravel in the range of 1/2 to 1 inch in size. The surface layer of gravel over the entire wetland is usually six inches in depth with a range of 3/8 to 1/2 inch size (pea gravel). All gravels are screened and washed to remove fines; 5) The water level in the wetland is set at a depth of two to three inches below the surface of the gravel by the outlet adjustable sump pipe. The outlet sump pipe is orificed with a 1 1/2 inch hole to regulate the flow from the wetland after a six inch rainfall event to spread the rainfall accumulation over a 24-hour period; 6) The wetlands are lined with at least a 20 mil liner for residential projects; 7) The wetland is tested for leaks over a 24-hour period with at least six inch depth of water above the inlet and outlet distribution and collection pipe; 8) The inlet distribution and outlet collection pipes for each cell of the wetland are placed at the bottom of the wetland gravel; 9) Some commonly used wetland plants are cattails (*Typha* sp.) and bulrushes (*Scirpus* sp.) along with other appropriate species. The shallower rooted plants are located near the inlet because of the higher influent temperatures and high nutrient levels, with deeper rooted plants located toward the end of the wetland; and 10) There is required monitoring at the inlet and outlet ends of the wetland for three to five years. Absorption field criteria: 1) Selection and sizing of the absorption field is always based upon the peak daily wastewater load and the on-site soil survey report that is done by an ARCPAC certified soil scientist, in the area of the absorption field; 2) There is an allowable reduction in the size of the absorption field associated with a subsurface constructed wetland based on the soil loading rate. For soil loading rates equal to or greater than 0.5 gallons per day (GPD) per square foot, but less than or equal to 1.2 GPD per square foot, the allowable reduction in field size is 50%. For soil loading rates of less than 0.5 GPD per square foot but greater than or equal to 0.25 GPD per square foot, the allowable reduction in the field is 33%; 3) There must be a 50 to 100% set aside area for the proposed absorption field associated with the subsurface constructed wetland because this combination is still considered experimental when there is an allowable absorption field size reduction; and 4) The septic tanks are sized for either a 36 or 48 hour detention time.[62]

IOWA: Iowa Department of Natural Resources, Wallace State Office Building, 502 East 9th Street, Des Moines, IA 50319-0034; Ph. (515) 281-7814; Contact: Brent Parker. **REGULATION(S)**: Chapter 69: On-Site Wastewater Treatment and Disposal Systems 567-69.11(455B). **COMPOSTING TOILETS, GRAYWATER**: No existing regulations. **CONSTRUCTED**

WETLANDS: are governed under 69.1(2). "On-site wastewater treatment and disposal system" means all equipment and devices necessary for proper conduction, collection, storage, treatment, and disposal of wastewater from four or fewer dwelling units or other facilities serving the equivalent of 15 persons (1,500 gpd) or less. This includes domestic waste, whether residential or non-residential, but does not include industrial waste of any flow rate. Included within the scope of this definition are building sewers, septic tanks, subsurface absorption systems, mound systems, sand filters, **constructed wetlands** and individual mechanical/aerobic wastewater treatment systems. 567---69.11(455B) Constructed wetlands. 69.11(1) Constructed wetlands shall only be used where soil percolation rates at the site exceed 120 minutes per inch. Because of the higher maintenance requirements of constructed wetland systems, preference should be given to sand filters, where conditions allow. b). The effluent from a constructed wetland shall receive additional treatment through the use of intermittent sand filters of a magnitude of half that prescribed in rule 69.9(455B). c) Effluent sampling of constructed wetlands shall be performed twice a year or as directed by the administrative authority. Tests shall be run on all parameters as required in 69.9(1). d). Specifications given in these rules for constructed wetlands are minimal and may not be sufficient for all applications. Technical specifications are changing with experience and research. Other design information beyond the scope of these rules may be necessary to properly design a constructed wetland system. 69.11(2) a). The wetland shall be of a subsurface flow construction with a rock depth of 18 inches and a liquid depth of 12 inches. b). Substrate shall be washed river gravel with a diameter of 3/4 inch to 2½ inches. If crushed quarried stone is used, it must meet the criteria listed in 69.6(4)"a." c). Detention time shall be a minimum of seven days. (1) This may be accomplished with trenches 16 to 18 inches deep (12 inches of liquid), three feet wide with 100 feet of length per bedroom. This may also be done with beds 16 to 18 inches deep, with at least 300 square feet of surface area per bedroom. The bottom of each trench or bed must be level within ±½ inch.
(2) Multiple trenches or beds in series should be used. Beds or trenches in series may be stepped down in elevation to fit a hillside application. If the system is on one elevation, it should still be divided into units by earthen berms at about 50 and 75% of the total length. (3) Each subunit shall be connected to the next with an overflow pipe (rigid sewer pipe) that maintains the water level in the first section. Protection from freezing may be necessary. d). Wetlands shall be lined with a synthetic PVC or PE plastic liner 20 to 30 mils thick. e). Effluent shall enter the wetland by a four inch pipe sealed into the liner. With beds, a header pipe shall be installed along the inlet side to distribute the waste. f). Wetland system sites shall be bermed to prevent surface water from entering the trenches or beds. 69.11(3) Vegetation shall be established on the wetlands at time of construction. Twelve inches of rock is placed in each unit, the plants are set, then the final four to six inches of rock is placed. b). Only indigenous plant species shall be used, preferably collected within a 100-mile radius of the site. Multiple species in each system are recommended. Preferred species include, but are not limited to: (1) *Typha latifolia* - Common cattail; (2) *Typha angustifolia* - Narrow leaf cattail; (3) *Scirpus* spp. - Bullrush; (4) *Phragmites communis* - Reed. Transplantation is the recommended method of vegetation establishment. For transplanting, the propagule should be transplanted, at a minimum, on a two-foot grid. The transplants should be fertilized, preferably with a controlled release fertilizer such as Osmocote 18-5-11 for fall and winter planting, 18-6-12 for spring planting, and 19-6-12 for summer planting. Trenches or beds should be filled with fresh water immediately. d). In the late fall, the vegetation shall be mown and the detritus left on the wetland surface as a temperature mulch. In the early spring, the mulch shall be removed and disposed of to allow for adequate bed aeration.[63]

KANSAS: Department of Health and Environment, Bureau of Water, Nonpoint Source Section, Forbes Field, Building 283, Topeka, KS 66620; Ph. (785) 296-4195 or 1683. **REGULATION(S)**: No existing regulations. If regulations existed, they should fall under the Kansas Administrative Regulations (KAR) Chapter 25, Article 5, Sewage and Excreta Disposal. **COMPOSTING TOILETS, GRAYWATER, CONSTRUCTED WETLANDS**: No existing regulations. Bulletin 4-2, Minimum Standards for Design and Construction of Onsite Wastewater Systems (March 1997) mentions alternative systems when conventional absorption fields or ponds are not suitable.[64] K.A.R. 28-5-9 gives authority to county health departments, in counties that have local codes, to grant variances for alternative onsite wastewater treatment and disposal systems. The variance request is filed with the county administrative agency.[65]

KENTUCKY: Department for Public Health, Division of Public Health Protection and Safety, Environmental Management Branch, Community Environment Section, 275 East Main Street, Frankfort, KY 40621; Ph. (502) 564-4856; FAX (502) 564-6533; Contact: Craig Sheehan, R.S., Health Inspection Program Evaluator; Email: Craig.sheehan@mail.state.ky.us. **REGULATION(S)**: 902 Kentucky Administrative Regulations 10:085 Kentucky Onsite Sewage Disposal Systems (September 1989). **COMPOSTING TOILETS**: are mentioned under 1b, 8. System Sizing Standards. When approved permanent non-water carriage water closet type devices (**composting toilets**, incinerator toilets, oil carriage toilets, etc.) are installed exclusively in any residence and no other blackwater type wastes are created, the daily design flow unit for that specific residence may be reduced.[66] **GRAYWATER**: in Section 2(13) means wastewater generated by water-using fixtures and appliances, excluding the toilet and the garbage disposal.[67] Graywater standards are mentioned under 13a-c, 8. When improved performance (of a septic system) may be attained by separating laundry graywater waste flows from other residential waste flow for new system installations, or as repair for existing systems, such separation shall be accomplished in the following manner: a) Graywater sewer for the washing machine shall be separated from the main house sewer; b) laundry graywater shall discharge into a lateral bed or trench(es) of a minimum of 100 square feet of bottom surface soil absorption area for a two bedroom residence and an additional 50 square feet for each additional bedroom; c) new system installations where laundry wasteflow separation exists are permitted a 15% reduction in the primary system lateral field requirements shall be allowed only for sites with soils in Soil Groups I-III. On sites with soils in Soil Group IV, such separation may be required, but no system size reduction will be granted.[68] **CONSTRUCTED WETLANDS**: or plant-rock filters generally consist of a primary treatment unit, usually a septic tank with two compartments or special filters, with a lined rock bed or cell containing approximately 12 inches of rock and a small overflow lateral field. Aquatic plants are planted in the rock media and treat the effluent to a very high degree. Any excess effluent is disposed of in the lateral field. Wetlands are sized based on 1.3 cubic feet of gravel area for each one gallon of total daily waste flow. A typical size for a three bedroom home would be 468 square feet of interior area. Various length to width ratios are acceptable with generally a relatively narrow width to longer length preferable. The system functions primarily by wastewater entering the treatment unit where some treatment occurs. The partially treated wastewater then enters the lined wetlands cell through solid piping where it is distributed across the cell. The plants within the system act to introduce oxygen into the wastewater through their roots. As the wastewater becomes oxygenated, beneficial microorganisms and fungi can thrive, where they in turn digest organic matter. In addition, fairly large amounts of water may be lost through evapotranspiration. Advantages of installing a constructed wetlands system are that they: 1) are space conservative (approximately 1/3 of conventional rock lateral); 2) can be placed on irregular or segmented lots; and 3) may be placed in areas with shallow water tables, high bedrock or restrictive horizons. Disadvantages include that constructed wetlands systems: 1) require a higher level of maintenance than other conventional systems; 2) may be more costly to install; and 3) have an unknown life span.[69]

LOUISIANA: Department of Health and Hospitals, Office of Public Health, Sanitation Services, 106 Canal Blvd., Thibodaux, LA 70301; Ph. (504) 449 5007; Contact: Teda Boudreaux. **COMPOSTING TOILETS, GRAYWATER SYSTEMS, CONSTRUCTED WETLANDS**: No existing regulations.[70]

MAINE: Department of Human Services, Bureau of Health, Division of Health Engineering, Wastewater and Plumbing Control Program, State House Station 10, Augusta, ME 04333-0010; Ph. (207) 287-5689. **REGULATION(S)**: Maine Subsurface Waste Water Disposal Rules 144A CMR 241(20 January 1998). **COMPOSTING TOILETS**: are regulated in Ch. 15, Section 1504.0. A composting toilet is designed to receive, store, and compost human wastes. Stabilized (that is, composted) wastes shall be removed for disposal when the toilet's capacity is reached. The minimum interior volume of a composting toilet shall be large enough to allow complete stabilization of all wastes when the toilet is used continuously at its proposed usage level. Toilet wastes shall be deposited into a receiving area with a self-closing, tightly fitting lid. There shall be a separate access, with a tightly fitting lid, through which food wastes, or other materials needed for the composting process, are routed to the composting compartment. Composted material shall be removed from the storage area through a cleanout opening fitted with a tight door or lid. Non cleanout may be located in a food storage or preparation area. Any liquid overflow shall be discharged to a primitive or conventional disposal field. The contents of an alternative toilet shall be removed and disposed of in a legal and sanitary manner whenever they reach recommended capacity of the alternative toilet.[71] **GRAYWATER**: 1509.0 Separated Laundry Disposal Systems. The plumbing inspector may approve a separate laundry system for single-family dwelling units. A separated laundry field requires an application for subsurface waste water disposal system completed by a licensed site evaluator and a permit to install the system. Only waste water from a washing machine may be discharged to the separate laundry disposal field designed for that purpose. Separate laundry disposal fields may be designed and used for hot tubs or backwash water. A separated laundry disposal field does not require a septic tank.[72] **CONSTRUCTED WETLANDS**: No existing regulations.

MARYLAND: Maryland Department of the Environment, Water Management Administration, 2500 Broening Highway, Baltimore, MD 21224; Ph. (410) 631-3778. **REGULATION(S)**: Regulations may be discussed under Chapter 9, Subtitle 14A. Waterless Toilets (1993). **COMPOSTING TOILETS**: Waterless toilets are covered in Chapter 9, Subtitle 14A-01. Waterless Toilets The Maryland Department of the Environment does not prohibit the use of any NSF approved composting toilet for use anywhere in the State. The Department's current regulation is to allow a 36% design flow reduction for residences when utilizing an NSF approved composting/waterless toilet.[73] **GRAYWATER**: Innovative graywater designs are currently allowed on a case-by-case basis under the Innovative and Alternative Program.[74] **CONSTRUCTED WETLANDS**: No existing regulations.

MASSACHUSETTS: Department of Environmental Protection, Division of Water Pollution Control, One Winter Street, 8th Floor, Boston, MA 02108; Ph. (617) 292-5500; http://www.magnet.state.ma.us/dep/brp/wwm/wwmhome.htm; Contact: Doug Roth; Email: douglas.roth@state.ma.us. For graywater, contact: Ruth Alfasso, graywater piloting coordinator; Email: Ruth.Alfasso@state.ma.us. **REGULATION(S)**: 310 CMR 15.000, Title 5: Innovative and Alternative Subsurface Sewage Disposal Technologies Approved for Use in Massachusetts (4 March 1998). **COMPOSTING TOILETS**: are certified for general use for new construction and for remedial use. Specific regulations concerning composting toilets follow: 1) compost temperature must be maintained above 131 degrees F (55 degrees C); 2) moisture must be maintained between 40-60% for best results; and 3) the system must be designed to store compostable and composted solids for at least two years, either inside the composting chamber or in a separate compost container. Compost must be disposed by one of two methods: 1) by on-site burial, covered with a minimum of six inches of clean compacted earth; or 2) by a licensed septage hauler. If any liquid by-product exists, it should be discharged through a graywater system that includes a septic tank and leaching system or removed by licensed septic hauler.[75] **GRAYWATER**: If the facility generates graywater (i.e, wastewater from sinks, showers, washing machines, etc.) a disposal system is still needed for the graywater. Title 5 has different requirements for remedial use and for new construction. Remedial use is for facilities which have a design flow of less than 10,000 gallons per day, are served by an existing system, and where there is no proposed increase in the design flow. An existing cesspool may be used as a leaching pit, provided that the cesspool is pumped and cleaned and is not located in groundwater, and meets the design criteria of 310 CMR 15.253 with respect to effective depth, separation between units, and inspection access. The cesspool may be replaced by a precast concrete leaching pit meeting those requirements, and the effluent loading requirements of Title 5. A septic tank should also be installed. Pertaining to graywater, a filter system specifically approved by the Department can be used instead of a septic tank.[76] Non-traditional graywater systems, such as those which use constructed wetlands or evapotranspiration beds, are approved on a piloting, site-specific basis.[77] **CONSTRUCTED WETLANDS**: No existing regulations, approved on a piloting basis only.[78]

MICHIGAN: Department of Environmental Quality, Environmental Health Section, Drinking Water and Radiological Protection Division, PO Box 30630, Lansing, MI 48909-8130; Toll-free Ph. (800) 662-9278; Ph. (517) 335-8284. **REGULATION(S)**: Michigan has one of the oldest existing guidelines for composting toilets and graywater systems. However, as there is no statewide sanitary code, the 46 local health departments define the criteria for onsite sewage disposal and "each county runs its own show."[79] The Michigan Department of Health publishes Guidelines for Acceptable Innovative or Alternative Waste Treatment Systems and Acceptable Alternative Graywater Systems under authority of Act 421, P.A. 1981 (1986). Under Act 421, an owner of a structure using an acceptable an innovative or alternative waste treatment system (heretoafter referred to as "alternative systems") in combination with an acceptable alternative graywater system (heretoafter referred to as "graywater systems") shall not be required to connect to an available public sanitary sewer system.[80] Alternative system means a decentralized or individual waste system which has been approved for use by a local health department and which is properly operated and maintained so as to not cause a health hazard or nuisance. An acceptable alternative system may include, but is not limited to, an organic waste treatment system or **COMPOSTING TOILET** which operates on the principle of decomposition of heterogenous organic materials by aerobic and facultative anaerobic organisms and utilizes an effectively aerobic composting process which produces a stabilized humus. Alternative systems do not include septic tank-drainfield systems or any other systems which are determined by the department to pose a similar threat to the public health, safety and welfare, and the quality of surface and subsurface waters of this state.[81] A person may install and use in a structure an alternative system or an alternative system in combination with an graywater system. The installation and use of an alternative system or an alternative system in combination with a graywater system in a structure shall be subject to regulations by the local health department in accordance with the ordinances and regulations of the local units of government in which the structure lies. A local health department may inspect each alternative system within its jurisdiction at least once each year to determine if it being properly operated and maintained. 1) A local health department may charge the owner of an alternative system a reasonable fee for such an inspection and for the plan review and installation inspection. 2) The department shall maintain a record of approved alternative systems and their maintenance and adoption. The department, after consultation with the state plumbing board, shall adopt guidelines to assist local health departments in determining what are graywater systems and what are alternative systems. The department shall advise local health departments regarding the appropriate installation and use of alternative systems and alternative systems in combination with graywater systems. 3) A person who installs and uses an alternative system or an alternative system in combination with a graywater system shall not be exempt from any special assessments levied by a local unit of government for the purpose of financing the construction of an available public sanitary sewer system. 4) An owner of a structure using an alternative in combination with a graywater system shall not be required to connect to an available public sanitary sewer system.[82] **GRAYWATER**: system means a system for the treatment and disposal of wastewater which does not receive human body wastes or industrial waste which has been approved for use by a local health department and which is properly operated and maintained so as not to cause a health hazard or nuisance.[83] Structures which utilize alternative systems and graywater systems which are self-contained systems that do not have an on-site discharge should not be required to connect to an available public sanitary sewer system.[84] Alternative systems must meet the requirements of Sections 5 (6) and 21 of the Michigan Construction Code, act 230, Public Acts of 1972 as amended. Structures using alternative systems must also meet the requirements of the Michigan Plumbing Code.[85] Alternative systems and graywater systems should be tested by the National Sanitation Foundation (NSF) under Standard 41 testing protocol or by an equivalent independent testing agency and procedure. Lacking this testing procedure, the local health department should require performance data prior to approval. When requested, the Michigan Department of Public Health will assist local health departments in evaluating performance data from the NSF and other sources. Each local health department should require appropriate methods for disposal of stored liquid or solid end products from alternative systems.[86] To the extent that funds are available, the department will provide training and technical field assistance to local health departments regarding the appropriate installation and use of alternative systems and graywater systems.[87] A person may petition, in writing, the commission to approve the use of a particular material, product, method of manufacture or method or manner of construction or installation. On receipt of the petition, the commission shall cause to be conducted testing and evaluation it deem desirable. After testing and evaluation, and an open public hearing, the commission may reject the petition in whole or in part, may amend the code in such matter as the commission deems appropriate, or may grant a certificate of acceptability.[88] **CONSTRUCTED WETLANDS**: The Department of Environmental Quality provides a document entitled Review of Subsurface Flow Constructed Wetlands Literature and Suggested Design and Construction Practices. Constructed wetlands are run through a primary septic tank and then through a subsurface disposal system.[89] In fact, this guide recommends that at least two septic tanks should be provided with a total volume of at least two times the design daily flow.[90]

MINNESOTA: Minnesota Pollution Control Agency, Water Quality Division, Nonpoint Source Compliance Section, 520 Layfayette Road, St. Paul, MN 55155-4194; Ph. (612) 296-7574; http://www.revisor.leg.state.mn.us/arule/7080/0910.html. **REGULATION(S)**: Chapter 7080.9010, Alternative and Experimental Systems (3 November 1998). **COMPOSTING TOILETS**: No regulations,[91] except in Subpart 3G which mentions that other toilet waste treatment devices may be used where reasonable assurance of performance is provided.[92] **GRAYWATER**: Use of alternative systems is allowed *only* in areas where a standard system cannot be installed or is not the most suitable treatment. Subpart 3E of Ch. 7080.9010 states that a toilet waste treatment device must be used in conjunction with a graywater system. Accordingly, toilets wastes shall be discharged only to toilet waste treatment devices. Graywater or garbage shall not be discharged to the device, except as specifically recommended by a manufacturer. Septic systems are required for graywater systems. The drainage system in new dwellings or other establishments shall be based on a pipe diameter of two inches to prevent installation of a water flush toilet. There shall be no openings or connections to the drainage system, including floor drains, larger than two inches in diameter. For repair or replacement of an existing system, the existing drainage system may be used. Toilets or urinals of any kind shall not be connected to the drainage system. Toilet waste or garbage shall not be discharged to the drainage system. Garbage grinders shall not be connected to the drainage system. The building sewer shall meet all requirements for part 7080.0120, except that the building sewer for a graywater system shall be no greater than two inches in diameter. Graywater septic tanks shall meet all requirements of 7080.0130, subpart 1, except that the liquid capacity of a graywater septic tank serving a dwelling shall be based on the number of bedrooms existing and anticipated in the dwelling served and shall be at least as large as the following given capacities: 2 bedrooms, 300 gallon capacity; 3 or 4 rooms, 500 gallons; 5 or 6 rooms, 750 gallons; 7, 8 or 9 rooms, 1000 gallons. 4) Sizing for the system can be 60% of the amount calculated for a standard septic system. For ten or more bedrooms or other establishments, the graywater septic tank shall be sized as for any other establishment, except the minimum liquid capacity shall be at least 300 gallons. Graywater aerobic tanks shall meet all requirements of part 7080.0130. 6) Distribution and dosing of graywater shall meet all requirements of parts 7000.0150 and 7080.0160. 7) A standard graywater system shall meet all requirements of part 7080.0170. Experimental systems are discussed in subpart 3a. They may be used in areas where a standard systems cannot be installed or if a system is considered new technology with limited data on reliability.[93] **CONSTRUCTED WETLANDS**: No existing regulations.

MISSISSIPPI: Mississippi State Department of Health, PO Box 1700, Jackson, MS 39215-1700; Ph. (601) 576-7689; Contact: Ralph Turnbo. **REGULATION(S)**: Mississippi Individual On-Site Wastewater Disposal System Law, Chapter 41-67 (1996). **COMPOSTING TOILETS**: 2.3 (28) Non-Waterborne Disposal System - any non-water carried system that treats and/or disposes of human excreta.[94] Non-Waterborne Wastewater Systems are covered under MSDH 300-Section 02A-XIII-01 (revised February 17, 1997). 1. In remote areas of the State or certain transient or temporary locations, the use of non-waterborne systems such as sanitary pit privies, portable toilets, incinerating toilets, **composting toilets** and related sewage systems may be approved. Due to their limited capacities, these systems are restricted to receive excreta only. Since such systems require regular service and maintenance to prevent their malfunction and overflow, they shall only be used where the local health department approves such use.[95] **GRAYWATER**: No existing regulations. **CONSTRUCTED WETLANDS**: Constructed wetlands are discussed in Design Standard VII: Plant Rock Filter System, MSDH 300-Section 021-VII. I. A plant rock filter (constructed wetlands) wastewater treatment system may be utilized as an overland/containment system on sites where soil and site conditions prohibit the installation of a conventional or modified subsurface disposal system. In suitable soils, a plant rock filter may utilize underground absorption to dispose of effluent. It may also be utilized to polish effluent from malfunctioning "seeping" absorption field lines on existing systems. II. The plant rock filter may consist of a single cell, two cells in series or multiple cells in series. The design will depend on the topography. Differences in individual design, construction materials and construction methods allow each of these types of plant/rock filter to vary widely in their application. Careful consideration should be made during the soil/site evaluation to ensure that the "best choice" is recommended for the particular site. Recommendations developed by the Tennessee Valley Authority's General Design, Construction, and Operation Guidelines Constructed Wetlands Wastewater Treatment Systems for Small Users Including Individual Residences, Second Edition, have been adopted by reference.[96]

MISSOURI: Missouri Department of Health, Bureau of Community Environmental Health, PO Box 570, Jefferson City, MO 65102-0570; Ph. (573) 751-6095; FAX (573) 526-6946 or 751-0247. **REGULATION(S)**: Missouri Laws for On-Site Disposal Systems, Chapter 701, Section 701.025 (28 August 1998). **COMPOSTING TOILETS**: No existing regulations. May be covered under "Other Systems." Where unusual conditions exist, special systems of treatment and disposal, other than those specifically mentioned in this rule, may be employed, provided: 1) reasonable assurance of performance of the system is presented to the administrative authority; 2) the engineering design of the system is first approved by the administrative authority; 3) adequate substantiating data indicate that the effluent will not contaminate any drinking water supply, groundwater used for drinking water or any surface water; 4) treatment and disposal of the waste will not deteriorate the public health and general welfare; and 5) discharge of effluent, if any, shall be within setback distances as described in the rules.[97] **GRAYWATER**: Under 701.025,12(b), graywater includes bath, lavatory, laundry, and sink waste, excepting human excreta, toilet waste, residential kitchen waste and other similar waste from household or establishment appurtenances.[98] Title 19, Division 20, Chapter 3, General Sanitation, defines graywater as liquid waste, specifically excluding toilet, hazardous, culinary and oily wastes, from a dwelling or other establishment which is produced by bathing, laundry, or discharges from floor drains.[99] There are no design recommendations or regulations governing graywater systems. **CONSTRUCTED WETLANDS**: provide secondary levels of treatment, which means that some form of pretreatment (septic tank, aeration tank, lagoon, etc.), must be used prior to the wetland, as wetlands cannot withstand large influxes of suspended solids. The pretreatment used must be capable of removing a large portion of these solids. Effluent from wetlands must be contained on the owner's property with the same set-back distances as required for lagoons. 1. Free water surface wetlands are shallow beds or channels with a depth less than 24 inches and filled with emergent aquatic plants. This type of wetland shall not be allowed. 2. Submerged flow wetlands are similar to free water surface wetlands except that the channels are filled with shallow depths of rock, gravel or sand. The depth of the porous media is usually less than 18 inches. The porous medium supports the root systems of the emergent aquatic vegetation. The water level is to be maintained below the top of the porous medium so that there is no open water surface. The configuration of a wetland for an individual home can be a one cell or two cells in a series, depending on the soil properties of the site.[100]

MONTANA: Montana Department of Environmental Quality, Lee Metcalf Building, 1520 E. Sixth Avenue, PO Box 200901, Helena, MT 59620-0901; Ph. (406) 444-4633; FAX (406) 444-1374; Contact: Mark M. Peterson, P.E., Environmental Engineering Specialist, Permitting and Compliance Division; Email: mkpeterson@mt.gov. **REGULATION(S)**: Circular WQB 5. Minimum Design Standards for On-Site Alternative Sewage Treatment and Disposal Systems (1992). **COMPOSTING TOILETS**: Under Chapter 70.1, waste segregation systems consist of dry disposal for human waste such as various chemical and incinerator type systems with separate disposal for graywater. However, regardless of the type of dry disposal system used, the graywater must be disposed of by primary (septic tank) and secondary (subsurface drainfield) treatment.[101] Waste segregation systems will only be considered for recreational type dwellings which receive seasonal use or commercial buildings.[102] **GRAYWATER**: No existing regulations. Graywater must be disposed of through a septic tank and drainfield system. **CONSTRUCTED WETLANDS**: No existing regulations.

NEBRASKA: Nebraska Department of Environmental Quality, Ground Water Section, PO Box 98922, Lincoln, NE 68509-8922; Ph. (402) 471-2580 or (505) 827-7541; http://www.deq.state.ne.us/RuleandR.nsf/; Contact: Brian Sohall. **REGULATION(S)**: If they existed, regulations would probably be found in Title 124, Rules and Regulations for Design, Operation and

Maintenance of Onsite Wastewater Treatment Systems. **COMPOSTING TOILETS, GRAYWATER, CONSTRUCTED WETLANDS**: No existing regulations. Graywater is defined, but no systems are necessarily allowed under Title 124.

NEVADA: Department of Human Resources, Health Division, Bureau of Health Protection Services, 1179 Fairview Drive, Suite 101, Carson City, NV 89701-5405; Ph. (702) 687-6615 (general number); Ph. (702) 687-4750 (direct line); Contact: Joe Pollack. **REGULATION(S)**: R129-98. Sewage disposal is regulated under Nevada Administrative Code 444.750 (February 1998). **COMPOSTING TOILETS**: Not approved. **GRAYWATER**: systems are governed under Regulation R129-98, Section 78. 1. Graywater may be used for underground irrigation if approved by the administrative authority. A homeowner must obtain a permit to construct, alter or install a system that uses graywater for underground irrigation from the administrative authority before such a system may be constructed, altered or installed. 2. A system that uses graywater for underground irrigation: a) may be used only for a single family dwelling; b) must not be used in soils which have a percolation rate that is greater than 120 minutes per inch; c) must consist of a three-way diversion valve, a holding tank for the graywater and an irrigation system; d) may be equipped with a pump or siphon, or may rely on gravity to cause the water to flow to the irrigation system; e) must not be connected to a system for potable water; and f) must not result in the surfacing of any graywater. 3. A system that uses graywater for underground irrigation, or any part thereof, must not be located on a lot other than the lot which is the site of the single-family dwelling that discharges the graywater to be used in the system. Section 79. 1. An application to construct, alter or install a system that uses graywater for underground irrigation must include: a) detailed plans of the system to be constructed, altered or installed; b) detailed plans of the existing and proposed sewage disposal system; and c) data from percolation tests conducted in accordance with NAC 444.796 and sections 40 to 43, inclusive, of this regulation. 2. A holding tank for graywater must: a) be watertight and constructed of solid, durable materials that are not subject to excessive corrosion or decay; b) have a minimum capacity of 50 gallons; c) have an overflow and an emergency drain. The overflow and emergency drain must not be equipped with a shutoff valve. 3. A three-way diversion valve, emergency drain and overflow must be permanently connected to the building drain or building sewer and must be located upstream from any septic tanks. The required size of an individual sewage disposal system must not be reduced solely because a system that uses graywater for underground irrigation is being used in conjunction with the individual sewage disposal system. 4. The piping for a system that uses graywater for underground irrigation which discharges into the holding tank or is directly connected to the building sewer must be downstream of any vented trap to protect the building from possible sewer gases. 5. The estimated discharge of a system that uses graywater for underground irrigation must be calculated based on the number of bedrooms in the building, as follows: a) for the first bedroom, the estimated discharge of graywater is 80 gallons per day; and b) for each additional bedroom, the estimated discharge of graywater is 40 gallons per day. 6. The absorption area for an irrigation system that includes a system that uses graywater for underground irrigation must be calculated in accordance with the following parameters: percolation rate of 0-20 minutes per inch, 20 square feet (minimum square feet per 100 gallons discharged per day); 21-40 minutes/inch, 40 gallons/day; 41-60 minutes/inch, 60 gallons/day.[103] **CONSTRUCTED WETLANDS**: No existing regulations.

NEW HAMPSHIRE: Department of Environmental Services, Bureau of Wastewater Treatment, 6 Hazen Drive, Concord, NH 03301; Ph. (603) 271-3711 or 3503; http://www.state.nh.us/gencourt/ols/rules/env-ws.html. **REGULATION(S)**: Chapter Env-Ws 1000 Subdivision and Individual Sewage Disposal System Design Rules. Env-Ws 1022 deals with Alternate Systems. **COMPOSTING TOILETS, GRAYWATER, CONSTRUCTED WETLANDS**: No existing regulations. New Hampshire, does, however, have extensive regulations pertaining to Alternate Systems, as follows. Part Env-Ws 1024 Innovative/Alternative Technology. The purpose of this part is to provide the methodology and review process for the approval of innovative/alternative individual sewage disposal systems, in compliance with RSA 485-A:29, I. b.This part shall apply to any proposed individual sewage disposal system technology not described elsewhere in Env-Ws 1000. a."Conventional system" means an individual sewage disposal system regulated under Env-Ws 1000 other than Env-Ws 1024. b."Innovative/Alternative waste treatment" as defined in RSA 485-A:2, XXI, includes individual sewage disposal systems. c."ITA" means innovative/alternative technology approval. Env-Ws 1024.03 a.If the system will require ongoing professional maintenance, a service contract for such maintenance shall be executed before operational approval is granted. b.In exchange for obtaining the benefit of an operational approval based on innovative/alternative technology, the owner shall covenant to replace the innovative/alternative system with a conventional system should the innovative/alternative system fail to operate lawfully. The covenant shall be recorded by the owner at the registry of deeds where the property is located. Env-Ws 1024.04 ITA Applications. a.Before an innovative/alternative waste treatment system may be used the technology shall be evaluated and approved in an ITA. b.To obtain an ITA, an owner, designer, or other person shall submit a letter of application that includes the following: 1).A written description of the proposed system; 2) All operational reports, patent information, technical reports, and laboratory reports published on the proposed system, even if the information might in whole or in part reflect negatively on the system; 3) A description of any advantages of the proposed system over conventional systems in the prevention of health hazards, surface and groundwater pollution, and any other environmental benefits; 4).A description of the possible risks to public health, surface or groundwaters, or other aspects of the environment of using the proposed system; 5).The names, addresses, and phone numbers of at least three individuals who have experience in the design operation of the same type of system; 6).The proposed system's effect on the area of land required for operation; 7).A list of any rules under Env-Ws 1000 for which waivers will be required; and 8).A list of site locations where the system has been used, whether successfully or not.[104]

NEW JERSEY: Department of Environmental Protection, Bureau of Nonpoint Pollution Control, PO Box 029, Trenton, NJ 08625-0029; Ph. (609) 292-0404 or 4543; http://www.state.nj.us/dep/dwq/rules.htm. **REGULATION(S)**: New .Jersey Administrative Code 7:9A Standards for Individual Subsurface Sewage Disposal Systems. **COMPOSTING TOILETS**: No existing regulations. **GRAYWATER**: 7:9A-2.1 "Graywater" means that portion of the sanitary sewage generated within a residential, commercial or institutional facility which does not include discharges from water closets or urinals.[105] 7:9A-1.8 (c) In cases where the actual volume of sanitary sewage discharged from a facility will be reduced by use of water-saving plumbing fixtures, recycling of renovated wastewater, incineration or composting of wastes, evaporation of sewage effluent or any other process, the requirement for obtaining a treatment works approval and a NJPDES permit shall be based upon the design volume of sanitary sewage, calculated as prescribed in N.J.A.C. 7:9A-7.4, rather than the actual discharge volume as modified by water conservation or special treatment processes.7:9A-7.3 (a) The system(s) shall be designed to receive all sanitary sewage from the building served except in the following cases: 1. Separate systems may be designed to receive only graywater, or only blackwater, as allowed in N.J.A.C. 7:9A-7.5. 7:9A-7.5 A graywater system may be approved by the administrative authority provided that all of the requirements of these standards are satisfied and provided that an acceptable means for disposal of the blackwater from the building served is indicated in the system design. When the blackwater from the building served by a graywater system is to be disposed of into a waterless toilet, a variance from the Uniform Construction Code, Plumbing sub-code, N.J.A.C. 5:23-3.5, must be obtained by the applicant prior to approval of the graywater system by the administrative authority and the volume of sanitary sewage to be used in the design of the graywater system shall be determined as prescribed in N.J.A.C. 7:9A-7.4. When the blackwater from the building served by a graywater system is to be disposed of into a separate subsurface sewage disposal system, the blackwater system shall meet all the requirements of this chapter and the volume of sanitary sewage used in the design of both the graywater system and the blackwater system shall be a minimum of 75 % of the volume of sanitary sewage determined as prescribed in N.J.A.C. 7:9A-7.4.[106] 7:9A-7.6 Each system approved by the administrative authority pursuant to this chapter shall consist of a septic tank which discharges effluent through a gravity flow, gravity dosing or pressure dosing network to a disposal field as hereafter described. Seepage pits shall not be approved for new installations except in the case of a graywater system as provided by in N.J.A.C. 7:9A-7.5. Installation of a seepage pit may be approved as an alteration for an existing system subject to the requirements of N.J.A.C. 7:9A-3.3.[107] **CONSTRUCTED WETLANDS**: No existing regulations.[108] 7:9A-3.11 Experimental systems The Department encourages the development and use of new technologies which may improve the treatment of sanitary sewage prior to discharge or allow environmentally safe disposal of sanitary sewage in areas where standard sewage disposal systems might not function adequately. Where the design, location, construction or installation of the system or any of its components does not conform to this chapter, the administrative authority shall direct the applicant to apply to the Department for a treatment works approval. Depending upon the volume and quality of the wastewater discharged, a NJPDES permit may also be required.[109]

NEW MEXICO: State of New Mexico Environment Department, 524 Camino De Los Marquez, Suite 4, Santa Fe, NM 87505; Ph. (505) 827-7545 or 7541 (direct number); FAX (505) 827-7545; Contact: R. Brian Schall, Water Resource Specialist/Community Services. **REGULATION(S)**: 20 NMAC 7.3, Liquid Waste Disposal Regulations (10 October 1997). **COMPOSTING TOILETS**: Composting toilets are allowed, although there is no mention of them in the regulations.[110] **GRAYWATER**: Subpart I, Part 107. AF. "graywater" means water carried waste from kitchen (excluding garbage disposal) and bathroom sinks, wet bar sinks, showers, bathtubs and washing machines. Graywater does not include water carried wastes from kitchen sinks equipped with a garbage disposal, utility sinks, any hazardous materials, or laundry water from the washing of material soiled with human excreta.[111] Revised regulations will have a separate section allowing graywater systems. However, the system will still have to run through a septic tank. Graywater can then be used for subsurface irrigation.[112] **CONSTRUCTED WETLANDS**: Constructed wetlands are considered an "alternative system."[113] Subpart II deals with ALTERNATIVE SYSTEMS. The Department may issue a permit, on an individual basis, for the installation of an alternative on-site liquid waste system, including a system employing new and innovative technology, if the permit applicant demonstrates that the proposed system, by itself or in combination with other on-site liquid waste systems, will neither cause a hazard to public health nor degrade a body of water, and that the proposed system will provide a level of treatment at least as effective as that provided by on-site liquid waste systems, except privies and holding tanks, that meet the requirements of this Part and the New Mexico Design Standards.[114]

NEW YORK: New York State Department of Health, Bureau of Community Sanitation and Food Protection, 2 University Place, Room 404, Albany, NY 12203-3399; Ph. (518) 458-6706; Contact: Ben Pierson. **REGULATION(S)**: Appendix 75-A, Wastewater Treatment Standards - Individual Household Systems, Statutory Authority: Public Health Law 201(1)(1) (1 December 1990). **COMPOSTING TOILETS**: 75-A. 10 Other Systems. (b) Non-Waterborne Systems. (1) In certain areas of the State where running water is not available or is too scarce to economically support flush toilets, or where there is a need or desire to conserve water, the installation of non-waterborne sewage systems may be considered, however, the treatment of wastewater from sinks, showers, and other facilities must be provided when non-flush toilets are installed. The Individual Residential Wastewater Treatment Systems Design Handbook gives more detail regarding composting toilets.[115] The State Uniform Fire Prevention and Building Code [9NYCRR Subtitle S Sections 900.1(a) and (b)] requires wet plumbing (i.e., potable water plus sewerage) for all new residences. In accordance with Section 900.2(b), minimal required plumbing fixtures may be omitted for owner occupied single family dwellings if approved by the authority having jurisdiction. Health Department approval for said omission(s) shall be fully protective of public health and be in general harmony with the intent of Section 900.1 (i.e., provide satisfactory sanitary facilities). In some areas of the state where available water becomes insufficient to economically use flush toilets (i.e., even those with only 1.6 gallons per flush) or where a need or desire exists to conserve water, use of non-waterborne systems may be justified.[116] Composters: These units accept human waste into a chamber where composting of the waste occurs.[117] Composters accept only toilet wastes and kitchen food scraps coupled with supplemental additions of carbon-rich bulking agents such as planar shavings or coarse sawdust. Household cleaning products should not be placed in the unit. Failure to add adequate bulking agents or maintain aerobic moisture can result in the pile becoming hard (and difficult to remove) or anaerobic. The composted humus contains numerous bacteria and may also contain viruses and cysts. Residual wastes (i.e., the composted humus) should be periodically removed by a professional septage hauler. If a homeowner chooses to personally remove the composted humus, it should be disposed of at a sanitary landfill or buried and well mixed into soil distant from food crops, water supply sources and watercourses. The humus comprises an admixture of recent additions and composted older additions and should be disposed of accordingly. Humus disposal sites shall meet Table 2 separation distances for sanitary privy pits.[118] These units shall be installed in accordance with the manufacturers instructions. The units shall have a label indicating compliance with the requirements of NSF Standard 41 or equivalent. Only units with a warranty of five years or more shall be installed.[119] **GRAYWATER**: systems shall be designed upon a flow of 75 gpd/bedroom and meet all the criteria previously discussed for treatment of household wastewater.[120] The treatment of household wastewater is regulated by 75-A.8. Subsurface Treatment. (a) General Information. All effluent from septic tanks or aerobic tanks shall be discharged to a subsurface treatment system. Surface discharge of septic tank or aerobic effluent shall not be approved by the Department of Health or a local health department acting as its agent.[121] **CONSTRUCTED WETLANDS**: There is no official state policy regarding constructed wetlands. It is doubtful that the state or county health departments would approve them.[122]

NORTH CAROLINA: Department of Environmental Health and Natural Resources, Division of Environmental Health, On-Site Wastewater Section, PO Box 27687, Raleigh, NC 27611-7687; Ph. (919) 733-2895 or 7015. **REGULATION(S)**: Sewage Treatment and Disposal Systems, Section .1900 (April 1993). **COMPOSTING TOILETS**: Section.1934. The rules contained in this Section shall govern the treatment and disposal of domestic type sewage from septic tank systems, privies, incinerating toilets, mechanical toilets, **composting toilets**, recycling toilets, or other such systems serving single or multiple family residences, places of business, or places of public assembly, the effluent from which is designed not to discharge to the land surface or surface waters. Section.1958 (a) Where an approved privy, an approved septic tank system, or a connection to an approved public or community sewage system is impossible or impractical, this Section shall not prohibit the state or local health department from permitting approved non-ground absorption treatment systems utilizing heat or other approved means for reducing the toilet contents to inert or stabilized residue or to an otherwise harmless condition, rendering such contents noninfectious or noncontaminating. Alternative systems shall be designed to comply with the purposes and intent of this Section. (c) Incinerating, composting, vault privies, and mechanical toilets shall be approved by the state agency or local health department only when all of the sewage will receive adequate treatment and disposal.[123] **GRAYWATER, CONSTRUCTED WETLANDS**: No existing regulations.[124]

NORTH DAKOTA: North Dakota Department of Health, Environmental Health Section, Division of Municipal Facilities, 1200 Missouri Avenue, Bismarck, ND 58504-5264; Ph. (701) 328-5211 or 5150; FAX (701) 328-5200; Contact: Jeff Hauge, P.E, Environmental Engineer. **REGULATION(S)**: Chapter 62-03-16. Individual Sewage Treatment Systems for Homes and Other Establishments Where Public Sewage Systems are not Available (1996). **COMPOSTING TOILETS**: 62-03-16-01. Where water under pressure is not available, all human body wastes shall be disposed of by depositing them in approved privies, chemical toilets or such other installations acceptable to the administrative authority.[125] **GRAYWATER**: 62-03-16-01. 6. Water-carried sewage from bathrooms, kitchens, laundry fixtures, and other household plumbing shall pass through a septic or other approved sedimentation tank prior to its discharge into the soil or into an alternative system. Where underground disposal for treatment is not feasible, consideration will be given to special methods of collection and disposal.[126] **CONSTRUCTED WETLANDS**: No existing regulations.

OHIO: Bureau of Local Services, Ohio Department of Health, 246 North High Street, Columbus, OH 43266-0588; Ph. (614) 466-5190 or 1390; Contact: Tom Grigsby, Program Specialist; Email: tgrigsby@gw.odh.state.oh.us. **REGULATION(S)**: O.A.C. Chapter 3701-29 Household Sewage Disposal Rules (1977). **COMPOSTING TOILETS, GRAYWATER, CONSTRUCTED WETLANDS**: No existing regulations. Chapter 3701-29-20. Variance. (C). Household sewage disposal system components or household sewage disposal systems differing in design or principle of operation from those set forth in rules 3701-29-01 to 3701-29-21, may qualify for approval as a special device or system provided, comprehensive tests and investigations show any such component or system produces results equivalent to those obtained by sewage disposal components or systems complying with such regulations. Such approval shall be obtained in writing from the director of health.[127]

OKLAHOMA : Department of Environmental Quality, 1000 Northeast 10th Street, Oklahoma City, OK 73177-1212; Ph. (405) 271-7363 or 702-8100 (Division of Water Quality); Contact: Donnie Johnson. **REGULATION(S)**: Chapter 640. Individual and Small Public Sewage Disposal (1998). **COMPOSTING TOILETS, GRAYWATER, CONSTRUCTED WETLANDS**: No existing regulations. Chapter 640-1-12 governs alternative/experimental disposal systems. Where unusual conditions exist, special systems of treatment and disposal, other than individual sewage disposal systems mentioned may be employed, provided that: 1) reasonable assurance is presented to the Department that the system will work properly; 2) the design of the system is approved by the Department prior to installation; 3) there is no discharge to the waters of the state; 4) treatment and disposal of waste are in such a manner as to protect public health and the environment; 5) such systems comply with all local codes and ordinances. (b) Special alternative systems or experimental systems shall be considered on a case-by-case basis, weighing heavily in the approval process. The plans for alternative systems shall be reviewed by the Department and approved or disapproved by the Area or Regional Supervisor. After construction, the installation of the alternative system shall be approved or disapproved by the local DEQ representative. (c) To apply for approval of such systems an applicant shall file two copies of test results based on OAC 252:640-1-9 and two copies of the design plan for the proposed system with the local representative of the Department for the area in which the property is located.[128]

OREGON: Department of Environmental Quality, Water Quality Division, 811 Southwest 6th Avenue, Portland, OR 97204-1390; Ph. (503) 229-6443; http://www.cbs.state.or.us (click on statute/rules and go to oar 918-770 (division 770); http://landru/leg.state.or.us/ors/447.html; http://arcweb.sos.state.or.us/rules/; Contact: Sherman Olson, Terry Swisher: Ph (503) 373-7488. **REGULATION(S)**: Oregon Administrative Rules, Chapter 918, Division 790, Composting Toilet Rules (1998); Oregon Revised Statutes 447.115 (1997); OAR Chapter 340, Divison 71 (1997). **COMPOSTING TOILETS**: As used in ORS 447.118 and 447.124, "compost toilet" means a permanent, sealed, water-impervious toilet receptacle screened from insects, used to receive and store only human wastes, urine and feces, toilet paper and biodegradable garbage, and ventilated to utilize aerobic composting for waste treatment. 447.118 (1) Nothing in ORS 447.010 to 447.160 shall prohibit the installation of a compost toilet for a dwelling by the occupant of the dwelling if the compost toilet complies with the minimum requirements established under this section. (2) Rules adopted under ORS 447.020 shall provide minimum requirements for the design, construction, installation and maintenance of compost toilets. (3) The Director of the Department of Consumer and Business Services with the approval of the State Plumbing Board may require by rule that, in addition to any other requirements provided by law, any manufacturer or distributor of a compost toilet and any person other than the owner of the dwelling in which the compost toilet is to be installed who proposes to install a compost toilet file with the Department of Consumer and Business Services a satisfactory bond, irrevocable letter of credit issued by an insured institution as defined in ORS 706.008 or other security in an amount to be fixed by the department with approval of the board but not to exceed $5,000, conditioned that such bond, letter of credit or security shall be forfeited in whole or in part to the department for the purpose of carrying out the provisions of ORS 447.124 by failure of such manufacturer, distributor or person to comply with the rules adopted under this section. 447.124 The Department of Consumer and Business Services, with the assistance of the Health Division: (1) May conduct periodic inspections of any compost toilet; (2) Upon making a finding that a compost toilet is in violation of the rules adopted pursuant to ORS 447.118 (2), may issue an order requiring the owner of the dwelling served by the compost toilet to take action necessary to correct the violation; and (3) Upon making a finding that a compost toilet presents or threatens to present a public health hazard creating an emergency requiring immediate action to protect the public health, safety or welfare, may issue an order requiring the owner of the dwelling served by the compost toilet to take any action necessary to remove such hazard or threat thereof. If such owner fails to take the actions required by such order, the department shall take such action, itself or by contract with outside parties, as necessary to remove the hazard or threat thereof. [129] More specific information regarding composting toilets is given under Chapter 918-718-0010. Composting toilets: 1) must be ventilated (electrical or mechanical); 2) shall have at least one cubic yard capacity for a one or two bedroom dwelling; 3) shall be limited to installation in areas where a graywater disposal system can be installed and used; 4) shall be installed in an insulated area to keep a biological balance of the materials therein; and 5) humus from composting toilets may be used around ornamental shrubs, flowers, trees, or fruit trees and shall be buried under at least 12 inches of soil cover. Deposit of humus from any compost toilet around any edible vegetation or vegetable shall be prohibited.[130] Composting toilets must be approved by the NSF Standard 41.[131] **GRAYWATER**: 447.140 (1) All waste water and sewage from plumbing fixtures shall be discharged into a sewer system or alternate sewage disposal system approved by the Environmental Quality Commission or department of Environmental Quality under ORS chapters 468, 468A and 468B. Graywater is technically defined as sewage and still requires a septic tank and drainfield, although the septic system can be reduced in size.[132] Chapter 340, Divisions 71 and 73: Under the “split-waste method,” blackwater sewage and graywater sewage from the same dwelling or building are disposed of by separate systems.[133] 340-71-320. Split Waste Method. In a split waste method, wastes may be disposed of as follows: (1) Black wastes may be disposed of by the use of State Building Codes Division approved non-water carried plumbing units such as recirculating oil flush toilets or compost toilets. (2) Graywater may be disposed of by discharge to: a) an existing on-site system which is not failing; or b) a new on-site system with a soil absorption facility 2/3 normal size. A full size initial disposal area and replacement disposal area of equal size are required; or c) a public sewerage system.[134] **CONSTRUCTED WETLANDS**: Performance based permits are issued for constructed wetlands. Several systems have been installed in Oregon, but not for single family homes.[135]

PENNSYLVANIA: Department of Environmental Protection, Bureau of Water Quality Protection, Division of Wastewater Management, Rachel Carson State Office Building, 11th Floor, 400 Market Street, Harrisburg, PA 17101-2301; Ph. (717) 787-8184. **REGULATION(S)**: Title 25. Environmental Protection, Chapter 73. Standards for Sewage Disposal Facilities, Current through 28 Pa.B. 348 (17 January 1998). **COMPOSTING TOILETS**: under Chapter 73.1 are defined as devices for holding and processing human and organic kitchen waste employing the process of biological degradation through the action of microorganisms to produce a stable, humus-like material.[136] Composting toilets are permitted under Ch. 73.65. Toilets must bear the seal of the NSF indicating testing and approval by that agency under Standard No. 41. (b) The device utilized shall meet the installation specifications of the manufacturer and shall be operated and maintained in a manner that will preclude any potential pollution or health hazards. (c) When the installations of a recycling toilet, incinerating toilet or composting toilets is proposed for a new residence or establishment, an onlot sewage system or other approved method of sewage disposal shall be provided for treatment of washwater or excess liquid from the unit. For existing residences, where no alteration of the on lot system is proposed, a permit is *not* required to install a composting toilet.[137] **GRAYWATER**: 73.11. (c) Liquid wastes, including kitchen and laundry wastes and water softener backwash, shall be discharged to a treatment tank.[138] **CONSTRUCTED WETLANDS**: No existing regulations. Ch. 73.71 governs Experimental Sewage Systems, which may be implemented upon submittal of a preliminary design plan. Experimental systems may be considered for individual or community systems in any of the following cases: 1) To solve existing pollution or public health problem; 2) To overcome specific site suitability deficiencies, or as a substitute for systems described in this chapter on suitable lots; 3) To overcome specific engineering problems related to the site or proposed uses; and 4) To evaluate new concepts or technologies applicable to onlot disposal.[139]

RHODE ISLAND: Department of Environmental Management, Division of Groundwater and Individual Sewage Disposal Systems, ISDS Section, 291 Promenade Street, Providence, RI 02908-5767; Ph. (401) 277-4700; http://www.state.ri.us/dem/regs/water/isds9-98.pdf or .doc. **REGULATION(S)**: Chapter 12-120-002, Individual Sewage Disposal Systems (September 1998). **COMPOSTING TOILETS**: Regulation 12-120-002, amended September 1998, governs composting toilet guidelines. SD 14.00 discusses the acceptability of composting, or humus, toilets, stating that a humus or incinerator type toilet may be approved for any use where a septic tank and leaching system can be installed. The regulation governs two types of composting toilets: 1) large capacity composting toilets; and 2) heat assisted composting toilets. Large capacity toilets must have an interior volume greater than or equal to 64 cubic feet. All waste removed from large capacity composting toilets shall be disposed of by burial or other means approved by the director. Separate subsurface sewage disposal facilities must be provided for disposal of any liquid wastes from sinks, tubs, showers and laundry facilities (SD 14.05).[140] **GRAYWATER**: The term, "graywater," shall be held to mean any wastewater discharge from a structure excluding the waste discharges from water closets and waste discharges containing human or animal excrement. The term, "sanitary sewage," shall be held to mean any human or animal excremental liquid or substance, any putrescible animal or vegetable matter and/or any garbage and filth, including, but not limited to, any graywater or blackwater discharged from toilets, laundry tubs, washing machines, sinks, and dishwashers as well as the content of septic tanks, cesspools, or privies.[141] **CONSTRUCTED WETLANDS**: No existing regulations. Section SD14.06 governs Innovative or Alternative Technology Approval Procedures (this is an extensive section on the procedures, that are required to install an alternative system).[142]

SOUTH CAROLINA: Onsite Wastewater Management Branch, Division of Environmental Health, Department of Health and Environmental Control, 2600 Bull Street, Columbia, SC 29201; Ph. (803) 935-7945; FAX (803) 935-7825; Contact: Richard Hatfield; Email: HATFIERL@columb72.dhec.state.sc.us. **REGULATION(S)**: Chapter 61-56, Individual Waste Disposal Systems (27 June 1986). **COMPOSTING TOILETS**: Composting toilets may be used in conjunction with an approved septic system, for facilities that are provided with water under pressure. If site and soil conditions are not acceptable for an approved septic system, an alternative toilet may be considered, but only if the facility is not connected to water under pressure. **GRAYWATER**: No existing regulations. Graywater is included within the Department's definition of sewage and must be managed appropriately. A permit applicant could elect to install separate systems to handle blackwater and graywater, but the same site and soil requirements apply for both systems. **CONSTRUCTED WETLANDS**: Constructed wetlands (rock/plant filter) may be installed by an owner, but only in conjunction with an approved pre-treatment system, such as a septic tank, and an approved disposal system, such as a drain field. A limited number of homeowners have elected to use constructed wetlands systems in an effort to mitigate failing conventional systems.[143] Regulation 61-56, Individual Waste Disposal Systems, grants authority to the Department of Health and Environmental Control to adopt standards for alternative onsite treatment and disposal systems. However, no technical standards have been developed for graywater systems, constructed wetlands or composting toilets.

SOUTH DAKOTA: Department of Environment and Natural Resources, Air and Surface Water Program, Joe Foss Building, 523 East Capitol, Pierre, SD 57501; Ph. (605) 773-3151; http://www.state.sd.us/state/legis/lrc/rules/7453.htm. **REGULATION(S)**: Chapter 74:53:01:10 (1 July 1996). **COMPOSTING TOILETS**: Unconventional systems are only to be used when water or electrical systems are unavailable. Vault privies, chemical toilets, incinerator toilets, or **composting units** shall be used when a water or electrical system is not available. With the exception of vault privies, all unconventional systems are considered experimental systems, and plans and specifications shall be submitted to the secretary for approval as an experimental system prior to installation.[144] **GRAYWATER**: Under Chapter 74:03: 01:38, graywater systems are wastewater systems designed to recycle or treat wastes from sinks, lavatories, tubs, showers, washers, or other devices which do not discharge garbage or urinary or fecal wastes. In areas where they will not create a public nuisance or enter any water of the state, graywater systems are exempt from the requirement that normally states that wastewater is not allowed to surface on, around, or enter state waters. 74-03:01:75. A graywater system shall be designed in accordance with the following criteria: 1) All graywater treatment and recycle systems shall be located in accordance of the distances specified in 74:03.01:56, Table 1; 2) Design of graywater systems shall be based on a minimum graywater flow of 25 gallons per day per person. Three days retention time shall be provided for each graywater tank; 3) Graywater tanks are septic tanks and shall conform to the requirements for septic tanks; and 4) Effluent from graywater systems may be recycled for toilet use, conveyed to absorption fields, mounds or seepage pits, or used for irrigation of lawns and areas not intended for food production. Percolation tests shall be conducted and the minimum size of absorption area shall be determined in accordance with 74:03:01:66 to 74:03:01:69, inclusive.[145] **CONSTRUCTED WETLANDS**: No existing regulations.

TENNESSEE: Tennessee Department of Environment and Conservation, Division of Ground Water Protection, L & C Tower, 10th Floor, 401 Church Street, Nashville, TN 37243-1540; Ph. (615) 532-0774; Contact: Stephen Morse, Environmental Manager. **REGULATION(S)**: Rules of Department of Environment and Conservation, Division of Ground Water Protection, Chapter 1200-1-6: Regulations to Govern Subsurface Sewage Disposal Systems (1997). **COMPOSTING TOILETS**: (2) Composting toilets must be certified by the NSF to be in compliance with NSF Standard 41, and be published in their Listing of Certified Wastewater Recycle/Reuse and Water Conservation Devices before they may be used for disposal of human excreta by non-water carriage methods. (c) A pit privy or composting toilet shall not be permitted for a facility where the facility has running water available unless there is an acceptable means to dispose of wastewater.[146] **GRAYWATER, CONSTRUCTED WETLANDS**: No existing regulations. However, the Tennessee Valley Authority does publish a set of guidelines for the design and construction of constructed wetlands: Tennessee Valley Authority's General Design, Construction, and Operation Guidelines — Constructed Wetlands Wastewater Treatment Systems for Small Users Including Individual Residences, Second Edition, by Steiner, et al., 1993.

TEXAS: Texas Natural Resource Conservation Commission, PO Box 13087, Austin, TX 78711-3087; Ph. (512) 239-4775; http://www.tnrcc.state.tx.us. **REGULATION(S)**: Chapter 285: On-Site Sewage Facilities (1999). **COMPOSTING TOILETS**: 285.2 (13) Composting toilet - A self-contained treatment and disposal facility constructed to decompose non-waterborne human wastes through bacterial action facilitated by aeration. 285.34 Other Requirements (e) Composting toilets will be approved by the executive director provided the system has been tested and certified under NSF Standard 41 [147] 285.2 (27) **GRAYWATER:** wastewater from clothes washing machines, showers, bathtubs, handwashing lavatories, and sinks not used for the disposal of hazardous or toxic ingredients or waste from food preparations. Subchapter H: 285.80. Treatment and Disposal of Graywater. New construction or modification to an existing graywater conveyance, treatment, storage or disposal system outside of a structure or building must be carried out in accordance with provisions of this chapter and any established requirements of the permitting authority. Any new construction or modification to an existing graywater reuse or reuse conveyance system associated with a structure or building must be carried out in accordance with the requirements of the State Board of Plumbing Examiners.[148] Graywater must be treated through a septic system first.[149] **CONSTRUCTED WETLANDS**: Permitted under 285.32C. Non-standard systems include, but are not limited to, all forms of the activated sludge process, rotating biological contactors, recirculating sand filters, and **submerged rock biological filters** (a fancy name for constructed wetlands). Non standard systems submitted for review will be analyzed on basic engineering principles and the criteria established in Chapter 285. These systems will be reviewed as one of a kind, site-specific installations. Whether blackwater or graywater, all domestic water-carried discharges have to go through a septic tank first before going through a wetland system. After passing through the wetland system, it must still go through a drainfield.[150]

UTAH: Department of Environmental Quality, Division of Water Quality, 288 North 1460 West, PO Box 144870, Salt Lake City, UT 84114-4870; Ph. (801) 538-6146; http://www.eq.state.ut.us/eqwq/wqrules.htm. **REGULATION(S)**: If they existed, they may be covered under R317-502-3, Individual Wastewater Disposal Systems (1993). **COMPOSTING TOILETS, GRAYWATER, CONSTRUCTED WETLANDS**: No existing regulations. R317-502-3. does speak to alternative systems. The drainage system of each dwelling, building or premises covered herein shall receive all wastewater (including but not limited to bathroom, kitchen, and laundry wastes) as required by the Uniform Plumbing Code and shall have a connection to a public sewer except when such sewer is not available or practicable for use, in which case connection shall be made as follows: 3.1 To an individual wastewater disposal system found to be adequate and constructed in accordance with requirements stated herein. 3.2 To any other type of wastewater disposal system acceptable under R317-1, R317-3, R317-5, or R317-560. R317-502-20. Experimental and Alternate Disposal Methods. 20.1 Where unusual conditions exist, experimental methods of wastewater disposal may be employed provided they are acceptable to the Division and to the local health department having jurisdiction. 20.2 When considering proposals for experimental individual wastewater disposal systems, the Division shall not be restricted by this rule provided that: A. The experimental system proposed is attempting to resolve an existing pollution or public health hazard, or when the experimental system proposal is for new construction, it has been predetermined that an acceptable back-up disposal system will be installed in event of failure of the experiment; B. The proposal for an experimental individual wastewater disposal system must be in the name of and bear the signature of the person who will own the system; and C. The person proposing to utilize an experimental system has the responsibility to maintain, correct, or replace the system in event of failure of the experiment. 20.3 When sufficient, successful experience is established with experimental individual wastewater disposal systems, the Division may designate them as approved alternate individual wastewater disposal systems. Following this approval of alternate individual wastewater disposal systems, the Division will adopt rules governing their use.[151]

VERMONT: Agency of Natural Resources, Department of Environmental Conservation, Wastewater Management Division,103 South Main Street, The Sewing Building, Waterbury, VT 05671-0401; Ph. (802) 241-3834; Contact: Bonnie J. Loomer-Hostelter; Email: bonniel@dec.anr.state.vt.us. **REGULATION(S)**: If they existed, they would most likely be found under Environmental Protection Rules, Chapter 1, Small Scale Wastewater Treatment and Disposal Rules (8 August 1996). **COMPOSTING TOILETS, GRAYWATER, CONSTRUCTED WETLANDS**: No existing regulations. Innovative systems are regulated under Chapter 1, Small Scale Wastewater Treatment and Disposal Rules. Innovative Systems are governed under subchapter 2, 1-203. Alternative systems are allowed in Vermont only if a back-up, in ground conventional (septic) system is installed.[152]
Constructed wetlands as treatment units could be approved if the design was sufficiently reliable given the extended winter season in Vermont. However, for all practical purposes, the discharge from a constructed wetland unit could not be discharged directly into surface waters under these regulations but would have to be discharged to a subsurface leachfield or possibly a sprayfield system.[153]

VIRGINIA: State of Virginia, Office of Environmental Health Services, Main Street Station, Suite 117, PO Box 2448, Richmond, VA 23218-2448; Ph. (804) 225-4030; http://www.vdh.state.va.us/onsite/regulations/sew-vac4.htm; Contact: Donald Alexander; Email: dalexander@vdh.state.va.us. **REGULATION(S)**: 12 VAC 5-610-980. **COMPOSTING TOILETS**: Article 6. 12 VAC 5-610-970. 3. Composting toilets are devices which incorporate an incline plane, baffles, or other suitable devices onto which human excreta is deposited for the purpose of allowing aerobic decomposition of the excreta. The decomposing material is allowed to accumulate to form a humus type material. These units serve as both toilet and disposal devices. Composting toilets are located interior to a dwelling. All materials removed from a composting privy shall be buried. Compost material shall not be placed in vegetable gardens or on the ground surface. All composting toilets must be certified by the National Sanitation Foundation as meeting the current Standard 41. **GRAYWATER**: No existing regulations. **CONSTRUCTED WETLANDS**: 12VAC5-640-370. Constructed wetlands are considered experimental and will be considered on a case by case basis by the department. All constructed wetland systems shall be designed to meet or exceed 10 mg/l BOD5 and 10 mg/l suspended solids. Experimental systems are exactly that: experimental. Only the results of testing will determine if they will become an approved method of treating wastewater. Some systems can solve site and soil problems that a conventional septic system cannot handle; however, no system can overcome all of the problems on some difficult sites. The Division is looking to find safe, sanitary and economical solutions for every site but some problems still lack a viable solution. In short, not every site "percs" and many, if not all, alternative technologies are more expensive than a conventional gravel system. The Department urges prospective buyers to get an approval letter or construction permit before buying property you wish to build on.[154]

WASHINGTON: Department of Health, Community Environmental Health Programs LD-11, Building 2, Airdustrial Center, PO Box 47826, Olympia, WA 47826; Ph. (360) 236-4501 or 3011 (Environmental Health Programs direct line); http://access.wa.gov/government/awlaws.asp; Contact: Jen Haywood. **REGULATION(S)**: WAC 246-272; Technical Review Committee, Guidelines for Composting Toilets (1994); Recommended Standards and Guidance for Water Conserving On-Site Wastewater Treatment Systems (1999). **COMPOSTING TOILETS**: I. The Technical Review Committee for On-Site Sewage Disposal, established under WAC 246-272-040, has reviewed the available literature on composting toilets. The committee has determined that composting toilets could be an approved method of sewage treatment if use is consistent with the guidelines herein. Composting toilets are not designed to handle the total wastewater volume generated in the home. The units are usually designed to accommodate fecal and urinary wastes together with small amounts of organic kitchen wastes. The remaining wastewater originating from bathing facilities, sinks and washing machines (graywater) must therefore be collected, treated and disposed of in an approved manner. Because there generally will be additional wastewater to dispose of, composting toilets are restricted. II. Composting toilets are any device designed to store and compost by aerobic bacterial digestion human urine and feces which are non-water carried, together with the necessary venting, piping, electrical and/or mechanical components.[155] Section A. Waterless Toilets/WLTs. Composting - Unit designed to store and compost (by microbial digestion) human urine and feces. These units are commonly designed to accommodate fecal and urinary wastes together with small amounts of organic material to assist their function. No water is used for transport of urine or feces within these units. They may be small enough to sit on the floor of a bathroom or large enough to require space below the floor to house the storage/composting chamber.[156] The units may be used to replace private privies or chemical toilets, including such applications as highway weigh stations, warehouses, port facilities, construction sites, residences, etc., may be used in dwellings where water supply is not available or provided (example: mountain cabins), or may be used in dwellings where an on-site sewage system is or can be provided for disposal of graywater. Where non-discharging blackwater treatment systems are used, a 50% reduction in septic tank volume and a 40% reduction in the daily hydraulic loading to be used in sizing the grey water disposal mechanism (drainfield, mound system, etc.) are recommended from standard design requirements. The units may be used in facilities where a public sewage system is provided for disposal of graywater.[157] The devices shall be capable of accommodating full or part-time usage without accumulating excess liquids when operated at the design rated capacity. Continuous forced ventilations (e.g., electric fan or wind-driven turbovent) of the storage or treatment chamber must be provided to the outside.[158] Components in which biological activity is intended to occur shall be insulated, heated, or otherwise protected from low temperature conditions, in order to maintain the stored wastes at temperatures conducive to aerobic biological decomposition: 20 to 50 degrees C (68 to 130 degrees F). The device shall be capable of maintaining wastes within a moisture range of 40 to 75%. The device shall be designed to prevent the deposition of inadequately treated wastes near parts used for the removal of stabilized end products. The solid end product (i.e., waste humus) shall be stabilized to meet NSF criteria when ready for removal at the clean out port.1. Performance Standards. 1.2.1.2. Toilets of proprietary design must be tested according to the NSF International Standard No. 41 (May 1983).[159] The maintenance of carbon-to-nitrogen ratios of approximately 20:1 are recommended. Consequently, additions of vegetable matter, wood chips, sawdust, etc., can be helpful. Removal of composted and liquid materials shall be done in a manner approved with the local health departments and as a minimum, shall comply with Guidelines for Sludge Disposal, Washington Department of Health, 1954. Persons finding it necessary to handle this material shall take adequate protective sanitation measures, and should wash their hands carefully with soap and hot water. Compost shall not be used directly on root crops or on low-growing vegetables, fruits or berries which are used for human consumption; however, this general restriction does not apply if stabilized compost is applied 12 months prior to planting. Where it can be shown that sludge will not come in direct contact with the food products, such as in orchards or where stabilized sludges are further treated for sterilization or pathogen reduction, less restrictive periods may be applicable. Performance monitoring shall be performed on composting toilets permitted under this guideline. Permits should include a statement indicating the permitter's right of entry and/or right to inspect. The frequency of monitoring shall be: 1) Two years after installation; 2) Four years after installation; and 3) in response to a complaint or problem. Non-water carried sewage treatment units are presently acknowledged to be a method of sewage disposal under the Uniform Plumbing Code, but variances to use the devices might be required by local administrative authorities. Variances must therefore be obtained from these departments together with approval of the local health department before the installation can be allowed. The Revised Code of Washington (RCW) 70.118 gives local boards of health the authority to waive applicable sections of local building/plumbing codes when they might prohibit the use of an alternative method for correcting a failure.[160] **GRAYWATER**: Section B. Graywater systems are virtually the same as combined-wastewater on-site sewage systems. Gravity flow graywater systems consist of a septic tank and subsurface drainfield. Pressurized graywater systems consist of a septic tank, a pump chamber or vault, and a subsurface drainfield. Other types of alternative systems, pre-treatment methods and drainfield design and materials options may also be incorporated in graywater systems. The primary distinction between a graywater system and a combined wastewater system is the lower volume of wastewater. As a result, the size of the septic tank and subsurface drainfield is smaller compared to a system that treats and disposes all the household wastewater (combined) through a septic tank and drainfield. In addition to the water conserving nature of waterless toilets/graywater systems, the graywater system drainfield can be designed and located to reuse graywater for subsurface irrigation. Drainfield designs (methods and materials) which place the distributed wastewater in close proximity to the root zone of turf grasses, plants, shrubs, and trees may be used to enhance the reuse potential of graywater as it is treated in the soil, assuring public health protection. When graywater systems are designed, installed, operated and maintained to maximize their potential as a graywater reuse irrigation system, various items should be considered. Among these are plant water and nutrient needs and limits, salt tolerances, depths of root zones, etc. The development of a landscape plan is recommended. Graywater treatment and disposal/reuse systems must provide treatment and disposal at least equal to that provided by on-site system. Graywater on-site systems may be used with new residential construction and existing dwellings. Internal household plumbing may be modified (consistent with local plumbing code) to route any portion of the household graywater to the graywater on-site sewage system. Graywater on-site sewage systems may be located anywhere conventional or alternative on-site sewage systems are allowed. Site conditions, vertical separation, pretreatment requirements, setbacks and other location requirements are the same as described in Chapter 246-272 WAC. 2.4 Graywater on-sites sewage systems must provide permanent, year-round treatment and disposal of graywater unless this is already provided by an approved on-site system or connection to public sewer. Graywater on-site systems must be installed with an approved waterless toilet or other means of sewage treatment for blackwater approved by the local health officer. Graywater systems are intended to treat and dispose "residential strength" graywater. Graywater exceeding residential strength must receive pre-treatment to at least residential strength levels. Design requirements for graywater on-site sewage systems, unless otherwise noted, are the same as requirements for combined wastewater systems presented in Chapter WAC 246-272. Graywater may be used for subsurface irrigation of trees (including fruit trees) shrubs, flowers, lawns and other ground covers but must not be used for watering of food crops of vegetable gardens, any type of surface or spray irrigation, to flush toilets/urinals or to wash wall, sidewalks or driveways. The disposal component of a graywater treatment system may be designed to enhance the potential for subsurface irrigation. The efficiency of graywater reuse via subsurface irrigation depends upon the proximity of the drainfield to the root-zone of plants, shrubs, trees or turf and the method of distribution. This may be enhanced by: Installing narrower-than-normal trenches shallow in the soil profile (state rules do not have a minimum trench width; minimum trench depth is six inches). Gravel and pipe size may limit how narrow a "conventional" trench may be. It is recommended that at least two inches of gravel be provided between the sides of the distribution pipe and trench sidewalls. Small gravel size (no less that 3/4 inch) is recommended for narrow trenches; using pressure distribution to reduce the height of the trench cross section to enable shallow trench placement and to assure even distribution; and using subsurface drip irrigation (SDS) technology for shallow system placement and equal distribution in close proximity to plant, shrub, turf and trees roots. Some agronomic issues that should be considered with graywater reuse are the water needs and salt tolerances of plants to be irrigated. In many cases, the volume of graywater generated may not meet the needs of the landscape plantings. If potable water is used to augment graywater for irrigation within the same distribution network, a method of backflow prevention approved by the local health officer is required. In some geographical and climatic areas, the frost-protection needs of an SDS or a conventional drainfield trench system may be counter-productive to effective graywater reuse via subsurface irrigation (distribution piping may be too deep for plant root systems). In these areas, local health officers may permit seasonal systems where year-round treatment and disposal is provided by an approved sewage system and seasonal subsurface irrigation with graywater is provided by a separate system with a shallow drainfield or SDS. Where seasonal systems are allowed, various administrative and design issues must be addressed. Both drainfields must meet state and local rule requirements, including soil application rates, to assure treatment and disposal at least equal to that provided by conventional gravity or pressure on-site sewage systems according to Chapter 246-272 WAC. 3.4.2 Municipal sewer systems may provide year-round sewage disposal in conjunction with seasonal graywater treatment and disposal systems designed to enhance graywater reuse via subsurface irrigation. Seasonal graywater treatment and disposal/reuse systems must include a three-way diverter valve to easily divert graywater to the year-round disposal field or sewer when needed (when freezing is a problem). Local health officers may permit "laundry wastewater only" graywater disposal or reuse systems for single family residences for either year-round or seasonal use. Graywater systems limited only to laundry wastewater (including laundry sinks) may differ from other graywater systems according to the following: A single compartment retention/pump tank, with a minimum liquid capacity of 40 gallons may be used in lieu of the tank recommendations. The tank must be warranted by the manufacturer for use with wastewater and meet requirements listed in Appendix G of the 1997 edition of the Uniform Plumbing Code (UPC). Minimum design flow for "laundry wastewater only" systems (for the purpose of drainfield sizing) must be based on the number of bedrooms in the residence and must be no less than 30% of the minimum graywater system design flows. A wastewater filter or screen (with a maximum size opening of 1/16 inch) must be provided in an accessible location conducive to routine maintenance. Homeowners are responsible for proper operation and maintenance of their graywater systems. Specific requirements will vary according to the county where the system is located and the specific type of system. See your local health jurisdiction for local system O & M requirements.[161] **CONSTRUCTED WETLANDS**: No existing regulations.

WEST VIRGINIA: Secretary of State, Administrative Law Division, State Capitol, 1900 Kanawha Boulevard East, Building 1, Suite 157K, Charleston, WV 25305-0770; Ph. (304) 558-6000; FAX (304) 558-0900; http://www.state.wv.us.sos; Email: WVSOS@Secretary.State.WV.US; Contact: Leah Powell. **REGULATION(S)**: Title 64, Interpretive Rules Board of Health, Series 47, Sewage Treatment and Collection System Design Standards (1983). **COMPOSTING TOILETS**: Interpretive Rule 16-1, Series VII, 10.1. Composting toilets may be utilized only in conjunction with an approved graywater treatment and disposal system. 10.2 The design and construction of a composting toilet must meet the requirements of NSF Standard 41. **GRAYWATER**: 12.1 Those houses served by a graywater disposal system must have a house sewer of not more than two inches in diameter. 12.2. Houses served by graywater disposal systems shall not have garbage disposal units. 12.3 Manufactured graywater disposal systems must be approved by the director. 12.4. Non-commercial graywater disposal systems shall consist of the following: 12.4.1. A soil absorption field designed on the basis of a 30% reduction in water usage, and constructed in accordance with the design requirements for the standard soil absorption fields. 12.4.2. A septic tank sized according to the following room sizes and minimum capacities: 2 rooms, 500 gallons; 3 to 4 rooms, 750 gallons; 5 or more rooms, add 210 gallons for each additional bedroom.[162] **CONSTRUCTED WETLANDS**: No existing regulations.

WISCONSIN: Department of Commerce, Bureau of Program Management, 715 Post Road, Stevens Point, WI 54481-6456; Ph. (715) 345-5334; FAX (715) 345-5269; http://www.commerce.state.wi.us/sb-comm83revisionsandarticles.html; http://www.legis.state.wi.us/rsb/code/comm/comm083.pdf; Contact: Jim Klass, Ph. (608) 266-9292 (Water Regulation). **REGULATION(S)**: If they existed, they may be found in Wisconsin Comm083. **COMPOSTING TOILETS, GRAYWATER SYSTEMS, CONSTRUCTED WETLANDS**: No existing regulations.

WYOMING: Department of Environmental Quality, Water Quality Division, Herschler Building, 122 West 25th Street, Cheyenne, WY 82002; Ph. (307) 777-7075; http://deq.state.wy.us/wqd/w&wwpage.htm; Contact: Larry Robinson; lharmo@missc.state.wy.us. **REGULATION(S)**: If they existed, regulations would most likely be found in Chapter XI, Part D, Septic Tank and/or Soil Absorption System, Water Quality Rules and Regulations in the Innovative and Alternative section. **COMPOSTING TOILETS, GRAYWATER SYSTEMS, CONSTRUCTED WETLANDS**: No existing regulations.

CANADA: Systems would be governed by the provincial Ministries of Health (municipal affairs and health, similar to our county government in the US). Check your local agency.

OTHER INFORMATION SOURCES: NATIONAL SMALL FLOWS CLEARINGHOUSE: West Virginia University, PO Box 6064, Morgantown, WV 26506-6064; Ph. (304) 294-4191; 1-800-624-8301; **NATIONAL SANITATION FOUNDATION: NSF STANDARD 41: NONLIQUID SATURATED TREATMENT SYSTEMS**: http://www.nsf.org

ENDNOTES (Appendix 3)

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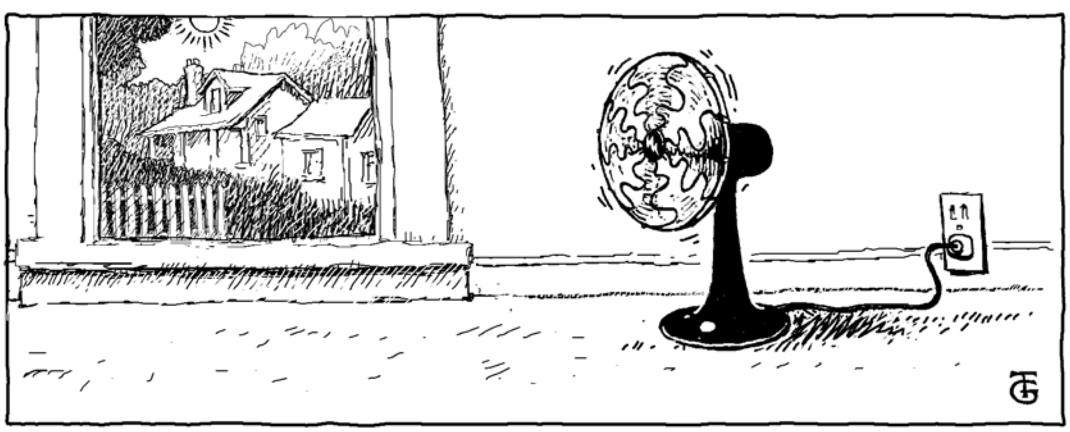

THE HUMANURE HANDBOOK — GLOSSARY

actinomycete
Bacteria resembling fungi because they usually produce a characteristic, branched mycelium.

activated sludge
Sewage sludge that is treated by forcing air through it in order to activate the beneficial microbial populations resident in the sludge.

aerobic
Able to live, grow, or take place only where free oxygen is present, such as *aerobic* bacteria.

algae
Small aquatic plants.

ambient air temperature
The temperature of the surrounding air, such as the outdoor air temperature in the vicinity of a compost pile.

amendment
See "bulking agent."

anaerobic
Able to live and grow where there is no oxygen.

Ascaris
A genus of roundworm parasitic to humans.

Aspergillus fumigatus
A spore-forming fungus that can cause allergic reactions in some people.

bacteria
One-celled microscopic organisms. Some are capable of causing disease in humans, others are capable of elevating the temperature of a pile of decomposing refuse sufficiently to destroy human pathogens.

biochemical oxygen demand (BOD)
The amount of oxygen used when organic matter undergoes decomposition by microorganisms.Testing for BOD is done to assess the amount of organic matter in water.

blackwater
Wastewater from a toilet.

bulking agent
An ingredient in compost, such as sawdust or straw, used to improve the structure, porosity, liquid absorption, odor, and carbon content. The terms "bulking agent" and "amendment" are often interchangeable.

carbonaceous
Consisting of or containing carbon.

carbon dioxide (CO_2)
An inorganic gas composed of carbon and oxygen produced during composting.

cellulose
The principal component of cell walls of plants, composed of a long chain of tightly bound sugar molecules.

C/N ratio
The ratio of carbon to nitrogen in an organic material.

combined sewers
Sewers that collect both sewage and rain water runoff.

compost
A mixture of decomposing vegetable refuse, manure, etc., for fertilizing and conditioning soil.

continuous composting
A system of composting in which organic refuse material is continuously or daily added to the compost bin or pit.

cryptosporidia
A pathogenic protozoa which causes diarrhea in humans.

curing
Final stage of composting. Also called aging, or maturing.

effluent
Wastewater flowing from a source.

enteric
Intestinal

evapotranspiration
The transfer of water from the soil into the atmosphere both by evaporation and by transpiration of the plants growing on the soil.

fecal coliforms
Generally harmless bacteria that are commonly found in the intestines of warm-blooded animals, used as an indicator of fecal contamination.

fecophobia
Fear of fecal material, especially in regard to the use of human fecal material for agricultural purposes.

fungi
Simple plants, often microscopic, that lack photosynthetic pigment.

graywater
Household drain water from sinks, tubs, and washing (not from toilets).

green manure
Vegetation grown to be used as fertilizer for the soil, either by direct application of the vegetation to the soil, by composting it before soil application, or by the leguminous fixing of nitrogen in the root nodules of the vegetation.

heavy metal
Metals such as lead, mercury, cadmium, etc., having more than five times the weight of water. When concentrated in the environment, can pose a significant health risk to humans.

helminth
A worm or worm-like animal, especially parasitic worms of the human digestive system, such as the roundworm or hookworm.

human nutrient cycle
The endlessly repeating cyclical movement of nutrients from soil to plants and animals, to humans, and back to soil.

humanure
Human feces and urine used for agriculture purposes.

humus
A dark, loamy, organic material resulting from the decay of plant and animal refuse.

hygiene
Sanitary practices, cleanliness.

indicator pathogen
A pathogen whose occurrence serves as evidence that certain environmental conditions, such as pollution, exist.

K
Chemical symbol for potassium.

latrine
A toilet, often for the use of a large number of people.

leachate
Any liquid draining from a source. Pertaining to compost, it is the liquid that drains from organic material, especially when rain water comes in contact with the compost.

lignin
A substance that forms the woody cell walls of plants and the "cement" between them. Lignin is found together with cellulose and is resistant to biological decomposition.

macroorganism
An organism which, unlike a microorganism, can be seen by the naked eye, such as an earthworm.

mesophile
Microorganisms which thrive at medium temperatures (20-37^{0}C or 68-99^{0}F).

metric tonne
A measure of weight equal to 1,000 kilograms or 2,204.62 pounds.

microhusbandry
The cultivation of microscopic organisms for the purpose of benefiting humanity, such as in the production of fermented foods, or in the decomposition of organic refuse materials.

microorganism
An organism that needs to be magnified in order to be seen by the human eye.

moulder (also molder)
To slowly decay, generally at temperatures below that of the human body.

mulch
Organic material, such as leaves or straw, spread on the ground around plants to hold in moisture, smother weeds, and feed the soil.

municipal solid waste (MSW)
Solid waste originating from homes, industries, businesses, demolition, land clearing, and construction.

mycelium
Fungus filaments or hyphae.

N
Chemical symbol for nitrogen.

naturalchemy
The transformation of seemingly valueless materials into materials of high value using only natural processes, such as the conversion of humanure into humus by means of microbial activity.

night soil
Human excrement used raw as a soil fertilizer.

nitrates
A salt or ester of nitric acid, such as potassium nitrate or sodium nitrate, both used as fertilizers, and which show up in water supplies as pollution.

organic
Referring to a material from an animal or vegetable source, such as refuse in the form of manure or food scraps; also a form of agriculture which employs fertilizers and soil conditioners that are primarily derived from animal or vegetable sources as opposed to mineral or petrochemical sources.

P
Chemical symbol for phosphorous.

pathogen
A disease-causing microorganism.

PCB
Polychlorinated biphenyl, a persistent and pervasive environmental contaminant.

peat moss
Organic matter that is under-decomposed or slightly decomposed originating under conditions of excessive moisture such as in a bog.

pH
A symbol for the degree of acidity or alkalinity in a solution, ranging in value from 1 to 14. Below 7 is acidic, above 7 is alkaline, 7 is neutral.

phytotoxic
Toxic to plants.

pit latrine
A hole or pit into which human excrement is deposited. Known as an outhouse or privy when sheltered by a small building.

protozoa
Tiny, mostly microscopic animals each consisting of a single cell or a group of more or less identical cells, and living primarily in water. Some are human pathogens.

psychrophile
Microorganism which thrives at low temperatures [as low as -10°C (14°F), but optimally above 20°C (68°F)].

schistosome
Any genus of flukes that live as parasites in the blood vessels of mammals, including humans.

septage
The organic material pumped from septic tanks.

septic
Causing or resulting from putrefaction (foul-smelling decomposition).

shigella
Rod-shaped bacteria, certain species of which cause dysentery.

sludge
The heavy sediment in a sewage or septic tank.

source separation
The separation of discarded material by specific material type at the point of generation.

sustainable
Able to be continued indefinitely without a significant negative impact on the environment or its inhabitants.

thermophilic
Characterized by having an affinity for high temperatures (above 40.5°C or 105°F), or for being able to generate high temperatures.

tipping fee
The fee charged to dispose of refuse material.

vector
A route of transmission of pathogens from a source to a victim. Vectors can be insects, birds, dogs, rodents, or vermin.

vermicomposting
The conversion of organic material into worm castings by earthworms.

vermin
Objectionable pests, usually of a small size, such as flies, mice, and rats, etc..

virus
Any group of submicroscopic pathogens which multiply only in connection with living cells.

waste
A substance or material with no inherent value or usefulness, or a substance or material discarded despite its inherent value or usefulness.

wastewater
Water discarded as waste, often polluted with human excrements or other human pollutants, and discharged into any of various wastewater treatment systems, if not directly into the environment.

Western
Of or pertaining to the Western hemisphere (which includes North and South America and Europe) or its human inhabitants.

windrow
A long, low, narrow pile, such as of compost.

worm castings
Earthworm excrement. Worm castings appear dark and granular like soil, and are rich in soil nutrients.

yard material
Leaves, grass clippings, garden materials, hedge clippings, and brush.

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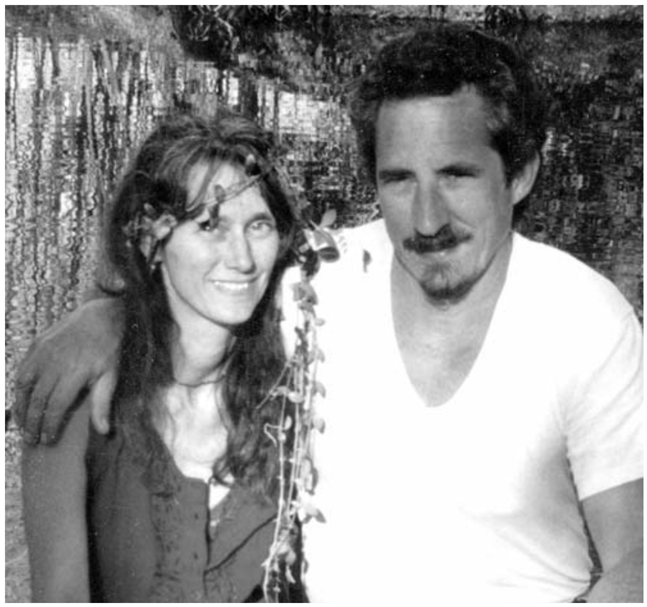

Joseph Jenkins lives with his wife, Jeanine, in western Pennsylvania on their owner-built 17 acre homestead. They have a blended family of six children. He has been an organic gardener since 1975, and a humanure composter since 1977. Self-employed six months of the year in the restoration of century-old stone roofs, the author carries on a trade he has practiced since 1967. The remaining six months of the year are spent researching, writing, and publishing. Jenkins was nominated by the Pennsylvania Department of Environmental Protection for the Three Rivers Environmental Award in 1998, in the "public awareness" category, in recognition of his work with the *Humanure Handbook*.

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