When sanitation alternatives are being considered, it should be ensured that women are involved in all decision-making processes, even if traditionally they are excluded from decisions seen as being outside of the family, connected with the allocation of finances or concerned with "technical measures." It should be remembered that if these systems fail, women would usually be the group most severely affected.

Addressing gender issues implies taking a closer look at social structure and relationships between women and men and between girls and boys and examining the different roles of community members. Considering gender is therefore not just a matter of involving women in a sanitation project; the first goal is to make gender roles and interdependencies visible and to include this in the implementation process. The roles of men and women with regard to decision-making, choice of technology, hygiene, food security, financial security, crop production and health issues should be determined in order to involve the correct groups in an appropriate, participatory manner (Werner et al., 2003).

8
ENVIRONMENTAL ASPECTS

The use of excreta and greywater in agriculture has the potential for both positive and negative environmental impacts. The resource value of excreta and greywater has been largely described in chapter 1. The present chapter reviews the potential environmental impacts associated with the use of urine, faeces and greywater, which will differ depending on local conditions.

It is important to minimize the environmental impact associated with the direct use of excreta and greywater in agriculture in both the local and global context. For large-scale implementation, environmental impact assessment is a useful tool for the analysis. A procedure for measuring the environmental impacts of different sanitation approaches involves the analysis of material flows (see case study in Box 8.1) or a life cycle analysis for the production of different crops, which may also lead to a better understanding of the environmental impacts of different agricultural practices (see case study in Box 8.2).

Box 8.1 Example of environmental assessment through material flow analysis

A case study conducted in Viet Tri, Viet Nam, allowed an estimation of nitrogen flows related to excreta and organic solid waste management in Viet Tri by applying the method of material flow analysis (Montangero, Nguyen & Belevi, 2004). The results indicate that 60% of the nitrogen delivered to the households in the form of food is finally discharged with the excreta in surface water, in fish ponds or on the soil, resulting in water pollution. The impact of potential control measures — including increasing the proportion of households using urine diversion latrines from 5% to 25%, treating 25% of the effluent from on-site sanitation systems in duckweed ponds and treating 25% of the sludge from on-site systems in constructed wetlands — was quantified. The proposed measures led to a 30% reduction of the nitrogen load into soil and surface water.

Box 8.2 Life cycle analysis of wheat production using human urine as fertilizer

Life cycle analysis is another tool for monitoring environmental sustainability. The environmental consequences of introducing urine as a fertilizer for cereals were studied by Tidåker (2003). Conventional production of spring barley with a chemical fertilizer was compared with the same production using urine as fertilizer. If the collection system and handling were optimized and well functioning, the energy use decreased by 27% when urine was used as fertilizer. Eutrophication of surface waters was substantially lowered due to lower discharge of nitrogen and phosphorus, but a higher release of ammonia to the atmosphere occurred. The environmental impact depended on decisions made at the farm level, highlighting the need for monitoring the reuse system from the toilet all the way to the field.

The environmental impact of different sanitation systems can be measured in terms of the use of natural resources, discharges to water bodies, air emissions and impacts on soils. Table 8.1 summarizes the types of impacts that may be considered in an environmental impact assessment (Kvarnström et al., 2004). Most relevant in relation to the use of excreta and greywater are the potential environmental impacts on soil and water bodies.

8.1 Impacts on soil

Relevant substances to consider in terms of environmental impacts on soil are salts, heavy metals, persistent organic compounds, hormones and nutrients.

8.1.1 Metals

The content of heavy metals in excreta is generally low or very low, compared with other sources with potential impacts on soil, and depends on the amounts present in consumed food products. The contents of urine reflect metabolism, and the levels of heavy metals in urine are very low (Jönsson et al., 1999; Vinnerås, 2002; Palmquist, 2004). Concentrations of heavy metals are relatively higher in faeces than in urine, but the concentrations are lower than in chemical fertilizers (e.g. cadmium) and farmyard manure (e.g. chromium and lead). The main proportion of the micronutrients and other heavy metals passes through the intestine unaffected (Fraústo da Silva & Williams, 1997). Of all the liquid household effluents, greywater may have the highest heavy metal content.

Table 8.1 Criteria for measuring environmental impacts of sanitation systems

Criteria	Unit
Use of natural resources, construction, operation and maintenance	
Land	m^2/person
Energy	MJ/person
Construction materials	Type and volume
Chemicals	Type and volume
Fresh water	m^3/person per year
Discharge to water bodies	
BOD/COD	g/person per year
Impact on eutrophication	g/person per year of nitrogen and phosphorus
Hazardous substances: heavy metals, persistent organic compounds, pharmaceutical residues, hormones, pathogens	mg/person per year; number/unit
Air emissions	
Contribution to global warming	kg of carbon dioxide equivalents
Resources recovered	
Nutrients	% into the system
Energy	% consumption within the system
Organic materials	% into the system
Water	% into the system
Quality of recycled product released to soil	
Hazardous substances: heavy metals, persistent organic compounds, pharmaceutical residues, hormones, pathogens	mg/unit; number/unit

Source: Kvarnström et al. (2004).

Regardless of the metal content of the excreta and greywater, a metal will not impact plant uptake unless it first reaches a threshold concentration in the soil and the metal is in a mobile phase (i.e. dissolved in the soil solution and not adsorbed to soil particles). Metals are bound to soils at a pH above 6.5 and/or with high organic matter content. If the pH is below this value, organic matter is consumed or all feasible soil adsorption sites are saturated, metals become mobile and can be absorbed by crops and contaminate water bodies. The plant roots act as an efficient barrier against uptake of non-essential metals. Therefore, impacts on soils from heavy metals are usually noted on soil microbiology before they are observed in plants or ultimately humans (or animals). Impacts of heavy metals on crops are complex, because there humans (or animals). Impacts of heavy metals on crops are complex, because there may be antagonistic interactions that affect their uptake by plants (Drakatos et al., 2002).

One important heavy metal is cadmium, which is a non-essential element that can pass through the root barrier, due to its resemblance to zinc. Cadmium is toxic to humans and needs to be limited in the inflow to agricultural land. Heavy metal concentrations in excreta and greywater generated at the household or small community level will rarely be high enough, however, to threaten the environment.

Table 8.2 Concentrations of heavy metals in urine, faeces, wastewater and source-diverted kitchen waste, compared with farmyard manure

	Unit	Cu	Zn	Cr	Ni	Pb	Cd
Urine	µg/kg ww	67	30	7	5	1	0
Faeces	µg/kg ww	6 667	65 000	122	450	122	62
Blackwater	µg/kg ww	716	6 420	18	49	13	7
Kitchen waste	µg/kg ww	6 837	8 717	1 706	1 025	3 425	34
Cattle organic farmyard manure	µg/kg ww	5 220	26 640	684	630	184	23
Urine	mg/kg P	101	45	10	7	2	1
Faeces	mg/kg P	2 186	21 312	40	148	40	20
Blackwater	mg/kg P	797	7 146	20	54	15	7
Kitchen waste	mg/kg P	5 279	6 731	1 317	791	2 644	26
Sewage sludge	mg/kg P	13 360	19 793	1 072	617	1 108	46.9
Cattle organic farmyard manure	mg/kg P	3 537	18 049	463	427	124	16

ww: wet weight
Sources: Steineck et al. (1999); Vinnerås (2002).

8.1.2 Persistent organic compounds

Excreta and greywater normally have low contents of persistent organic compounds. However, depending on the household use, greywater may contain as many as 900 different organic compounds; nevertheless, most of these substances will be found at very low concentrations (Eriksson et al., 2002). Collected faecal sludge may also contain a range of different organic chemicals used in the household if they have been dumped in the toilet. Information to system users regarding the importance of correct handling of household chemicals is vital.

If excreta and greywater are treated prior to use in agriculture, the concentration of many of these compounds will be reduced by adsorption, volatilization and biodegradation. Absorption of these substances by plants through their root system is not likely to occur due to their usually large size and high molecular weight, which reduces their mobility in soil and water (Pahren et al., 1979). It is possible that these chemicals can be transferred to the edible surfaces of crops, but concentrations are likely to be low. These substances may be associated with soil that remains on the crops after harvest. Washing produce thoroughly prior to consumption will remove a large percentage of this contamination.

Synthetic organic compounds are adsorbed and biodegraded with time in soil. Cordy et al. (2003) studied the removal of 34 organic compounds that can be found in excreta and greywater and did not detect any of them after 3 m of infiltration through desert soils with a retention time of 21 days. Removal of endocrine disruptors such as steroidal hormones detected in treated and non-treated wastewater through infiltration in soils has been demonstrated (Mansell, Drewes & Rauch, 2004).

A variety of pharmaceutical residues or their metabolic by-products can be detected in excreta and sometimes greywater. Most of these substances are at the highest concentrations in urine. A number of biologically active pharmaceuticals and their metabolites have been identified in groundwater and drinking-water samples (Heberer, Schmidt-Bäumler & Stan, 1998; Heberer, 2002). The effects of these substances on the ecosystem and animals are not known, but negative effects on the quantity or quality of crops are assumed to be negligible. Furthermore, the amount of hormones in manure from domestic animals is far greater than the amount found in human urine or faeces. Thus, even though theoretical estimates based on effects on fish have indicated an ecotoxicological effect from estradiol, comparative assessments with manure strongly indicate that the risk is very limited (Hanselman, Graetz & Wilkie, 2003).

Urine and faecal fertilizers are mixed into the topsoil, where there is a high level of biological activity. Usually the substances are retained there for months. The dominant removal mechanism for these substances is adsorption. Removal efficiencies are greater in soils containing higher contents of silt, clay and organic matter. Some may be transported through the soil matrix to groundwater, and two drugs (carbamazepine and primidone) did not show significant reductions even after six years of passage through the soil aquifer treatment system (Drewes, Heberer & Reddersen, 2002). Additional attenuation, to below the detection limit, occurs by biodegradation, regardless of aerobic or anoxic conditions or the type of organic carbon matrix present (hydrophobic acids, hydrophilic carbon vs colloidal carbon). A variety of pharmaceutical residues or their metabolic by-products in low concentrations can be detected in wastewater, which may reflect either that they are excreted in urine and faeces or that they are flushed away in the toilet.

Endocrine disruptors (which interfere with hormone functions) have also been found in greywater and may not degrade quickly in the environment. Mansell, Drewes & Rauch (2004) found that 17-α-estradiol, estriol and testosterone are not sensitive to photodegradation (i.e. less than 10% destruction after 24-h exposure to ultraviolet light). Thus, these compounds could remain on the surface of crops irrigated with greywater that contains them. The concentrations of these compounds are usually extremely low, and to date only effects on animals in direct contact with polluted water have been demonstrated. Effects on humans have not been shown.

Regarding excreta, some substances with endocrine disrupting properties, such as hormones (from humans, e.g. 7-ethinylestradiol, or from plants, e.g. 17-α-estradiol estriol) and pharmaceuticals, may be present in low concentrations, especially in diverted urine. It should be noted that animal manure also contains residues of pharmaceuticals used, in many cases preventive medication, resulting in high amounts of, especially, antibiotics. The soil system is generally better equipped than watercourses for degradation of the pharmaceutical residues present in the fertilizers.

8.1.3 Salinization

Salinity effects are, in general, of concern only in arid and semi-arid regions, where accumulated salts are not flushed regularly from the soil profile by rainfall. The use of urine and greywater can accelerate the process of soil salinization due to its higher salt content. However, fertilizers containing organic materials will help to buffer the negative effects of the salts in the soil profile.

There are four ways in which salinity affects soil productivity:

1) It changes the osmotic pressure at the root zone.
2) It provokes specific ion (sodium, boron or chloride) toxicity.
3) It may interfere with plant uptake of essential nutrients (e.g. potassium and nitrate) due to antagonism with sodium, chloride and sulfates.
4) It may destroy the soil structure by causing soil dispersion and clogging of pore spaces. This results in an increased lateral drainage, but may also affect the oxygenation. Both low-salinity waters and high sodium concentrations in the water in relation to calcium and magnesium concentrations in the soil exacerbate the effects.

Salinization is measured through a combination of parameters. Depending on the type of soils and the washing and drainage conditions, salinity problems can occur with conductivities of >3 mS/m, dissolved solids concentrations of >500 mg/l (being severe if >2000 mg/l) and sodium adsorption ratios of >3–9 (Ayers & Westcott, 1985). Soil salinization is also affected by inefficient drainage, climate and type of soil. Practices to limit salinization include soil washing and appropriate soil drainage.

8.2 Impacts on water bodies

Application of excreta and greywater to agricultural land will reduce the direct impacts on water bodies. However, as for any type of fertilizer, the nutrients may percolate to groundwater if applied in excess or be flushed into surface water after excessive rainfall. This impact will always be less compared with that of the direct use of water bodies as the primary recipient.

The impact of reuse of human excreta and greywater in agriculture on groundwater quality depends on factors such as agricultural application rate, the type of irrigation water, the soil type, aquifer vulnerability, the agricultural practices and the type of crops, as well as the recharge and groundwater use (Foster et al., 2004).

In order to avoid negative effects of using excreta and greywater as agricultural fertilizers, the following should be considered (Foster et al., 2004):

- improve agricultural practices;
- establish criteria to operate wells used to supply water for human consumption in the surroundings (establish safe distances to the agricultural site, depth of extraction and appropriate construction);
- routinely monitor groundwater.

Surface water bodies are affected by agricultural drainage and runoff. Impacts depend on the type of water body (rivers, agricultural channels, lakes or dams) and their use, as well as the hydraulic retention time and their function within the ecosystem.

A high organic load will, independently of the source, affect the dissolved oxygen levels, thus impacting aquatic organisms. Additionally, the nitrogen or phosphorus washed into water bodies will lead to eutrophication and subsequent oxygen depletion and will facilitate the growth of toxin-producing algae (Chorus & Bartram, 1999).

Organic chemicals originating from excreta and greywater will only minimally impact surface water bodies due to their adsorption to soil particles after application. The soil will act as a filter before the respective pollutants reach groundwater and surface waters.

Nitrogen can contaminate groundwater and surface water bodies by infiltration and agricultural runoff. The amount of nitrogen leached depends on crop demand, hydraulic load due to rain and agricultural water, soil permeability and nitrogen content in soils. Agricultural runoff containing phosphorus can cause eutrophication in surface water bodies (reservoirs and lakes). High concentrations of biodegradable organic matter in agricultural runoff water can lead to the consumption of dissolved oxygen in lakes and rivers.

Phosphorus is an essential element for plant growth, and mined phosphates are a common input into agricultural production in order to increase crop productivity. Soil phosphorus content varies with parent material, texture and management factors, such as rate of application, type of phosphorus applied and soil cultivation (Sharpley, 1995). It is usually present in soils in relatively important quantities. World supplies of accessible mined phosphate are diminishing. It is predicted that phosphate-carrying rocks/mineral reserves will run out in 60–130 years. The mining of phosphate causes environmental damage because it is often removed close to the surface in large open mines, leaving behind scarred land. Moreover, phosphate-carrying rocks/minerals also contain varying amounts of non-desired elements, such as cadmium. Approximately 25% of the mined phosphorus ends up in aquatic environments or buried in landfills or other sinks (Tiessen, 1995). The discharge into aquatic environments causes eutrophication of water bodies, leading to more environmental damage. To reduce the phenomenon of eutrophication, wastewater treatment plants require additional phosphorus removal treatment capacity, which adds to the costs and complexity of the treatment process.

Urine alone contains more than 50% of the phosphorus excreted by humans. Thus, the diversion of urine and its use in agriculture can aid crop production and reduce the need for costly, advanced wastewater treatment processes to remove phosphorus from the effluents (EcoSanRes, 2005).

9
ECONOMIC AND FINANCIAL CONSIDERATIONS

Economic factors are especially important when the viability of a new scheme for the use of excreta and greywater in agriculture is assessed, but even an economically worthwhile project can fail without careful financial planning.

Economic analysis and financial considerations are critical underpinnings for the promotion of the safe use of excreta and greywater. Economic analysis seeks to establish the economic feasibility of a proposed project in a broad macroeconomic context and allows economic comparisons between different options to implement the project. The costs transferred to other sectors — for example, as a result of health and environmental impacts on downstream communities — also should be included as distinct components in a cost analysis. This can be achieved through multiple-objective decision-making processes.

Financial planning looks at how the project is to be paid for. In establishing the financial feasibility of a project, it is important to determine the sources and flows of revenue and to clarify who will pay for what. The ability to profitably market the treated greywater and excreta or the products grown with them also needs analysis. Market feasibility assessment is discussed in section 9.3.

9.1 Economic feasibility

Economics looks at the optimal use of limited resources and at opportunities foregone by their use. In the context of excreta and greywater use for agriculture, economic analyses seek to establish whether resources invested in such projects have optimal returns, bearing in mind the resource value of excreta and greywater themselves. There are a number of methods that can be used to economically analyse projects, with cost-effectiveness analysis and cost–benefit analysis being the most important. The availability of reliable data sets and the setting of realistic and meaningful boundaries critically determine the quality of economic evaluations.

9.1.1 Cost–benefit analysis

Cost-effectiveness analysis has been frequently used for the economic evaluation of different health intervention options, offsetting costs against agreed, meaningful health indicators. Outside the health sector, planners are accustomed to cost–benefit analysis. Within the framework of a cost–benefit analysis, monetary values are assigned to all expected costs and benefits of a project. This allows decisions on whether and how to do projects, based on the internal rate of return. The introduction of the DALY as a composite measure of community health has made it possible to apply cost–benefit analyses to health interventions in an intersectoral context, such as is the case for the safe use of excreta and greywater in agriculture. The economic appraisal of an excreta and greywater use project is undertaken to determine the efficiency of the project, as a basis to decide whether it is worthwhile to proceed with it (Squire & van der Tak, 1975; Gittinger, 1982). This requires a calculation of the marginal costs and benefits of the project — that is, the differences between the costs and benefits of the project and the costs and benefits of the alternative. For any scheme to be economically viable, its marginal benefits should exceed its marginal costs.

The strength of cost–benefit analyses of sanitation schemes lies in the production of comparable data for a range of different sanitation options as a basis for decision-making. The comprehensiveness of the cost analysis component is critical, and it should therefore explicitly include direct costs related to the system hardware and software components, but also indirect costs incurred by other components, such as planning, administration, hygiene promotion campaigns and the health and environmental impacts on downstream communities.

9.1.2 Costs and benefits

Traditional economic evaluations of sanitation systems tend to face an important hurdle: the definition of the system boundaries often leads to substantial costs and/or benefits being completely overlooked. How substantial these costs can actually be becomes apparent from the example of a centralized wastewater treatment plant that discharges treated effluent to a surface water body. In addition to the investment, reinvestment and operation and maintenance costs of the sewer network and treatment plant, costs incurred by the environmental problems arising in the receiving water should be considered, as should those of the social loss of a recreational area, of the possible effect on subsequent drinking-water treatment, of the loss of natural habitats, of effects on coastal areas and of using drinking-water to flush the system. Each one of these indirect costs may in turn incur further costs.

For systems using excreta and greywater, the indirect costs may include those of the necessary transformation to adapt the existing sanitary infrastructure, additional awareness-raising activities to ensure its proper use and the need for continued research and development of the system.

For a centralized wastewater treatment facility, the expected health benefits for those connected to the system are obvious. The safe use of excreta and greywater has a number of indirect benefits to be considered, including:

- preserving high-quality water sources for priority uses, such as drinking-water supply (through the possible use of treated greywater for irrigation water and by not discharging effluents to water sources);
- an improvement of soil structure and fertility;
- increased access to fertilizer, particularly for poor subsistence farmers (thus increasing harvests and food security);
- reduced energy consumption (both in the treatment works and for fertilizer production);
- possible energy production and resource conservation;
- creation of small- and medium-sized businesses, selling technologies or services associated with the collection, treatment and/or marketing of the products.

It is therefore essential that economic evaluations comparing these two options be of a sufficiently strategic nature and that they take into account economies of scale in decentralized systems.

Further economic and financial considerations guiding the choice of sanitation systems for the safe use of excreta and greywater include the following:

- Sewerage systems are expensive to build, operate and maintain — systems that can reduce the infrastructure needs (e.g. on-site dry sanitation, with or without urine diversion) may be much less expensive.
- The cost of pumping greywater or transporting excreta can be substantial — greywater and excreta treatment facilities should be planned where the greywater and excreta can be efficiently used with minimal transport (e.g. neighbourhood biogas digestors could be used to treat excreta from on-site systems in urban areas).
- Effective low-cost greywater and excreta treatment technologies are available.
- Combinations of different treatment technologies (e.g. composting toilets plus post-composting with organic material) may increase pathogen removal

efficiencies at low cost and provide flexibility for upgrading treatment facilities.

- Users of greywater and excreta may be willing to pay for the greywater and excreta.
- Greywater and excreta tariffs may help to foster cost recovery, and the sale of crops at a central facility may also raise revenues.
- Differential prices for treated greywater and excreta and freshwater or agricultural inputs may entice farmers to use greywater and excreta instead of high-quality freshwater sources or expensive imported fertilizers.

Excreta and greywater use systems can influence the economic status at the household level and at the national level. If excreta and greywater are treated and managed properly, health risks are significantly reduced. At the household level, the resources spent on caring for or curing a sick person may be allocated to other tasks, and time gained through reduced illness can be used for education or income-generating activities. At the national level, the burden on scarce financial and human resources in the health sector may be reduced and can be realloted to other areas.

9.1.3 Multiple-objective decision-making processes

The information produced by economic evaluations helps support decision-making processes, but it should be combined with information that allows other factors and externalities to be taken into account. To be able to objectively compare different sanitation systems, there is a need for fully integrated cost–benefit or multiple-criteria analyses of all types of sanitation systems, performed over system life cycles or planning periods. This can be achieved using multiple-objective decision-making approaches. These involve establishing criteria that consider all key aspects of the system (e.g. health, environmental, sociocultural, economic and technical aspects) and using these to form a basis for decision-making.

A range of different quantification methods can be used in multiple-criteria approaches outside of estimated monetary values, with DALYs as a measure of health effects and various measurable indicators (e.g. the use of natural resources, discharge to water bodies, etc.) for the environment. Sociocultural aspects, such as the appropriateness of the system or its legal acceptability, can be qualitatively assessed, as can technical issues, such as system robustness or its compatibility with existing systems. The analysis of a specific proposed project should involve not only a comparison of one system with another, but also a comparison of the options to implement one particular scheme — for instance, the use of greywater for different purposes (irrigation, industrial, non-potable uses).

9.1.4 Empirical examples of cost analyses for reuse systems

One of the difficulties in the economic evaluation of sanitation systems that promote the use of excreta and greywater is that very few studies have so far been carried out and that when information is available, it is mainly from pilot or demonstration projects, which have additional expenses (e.g. for technology introduction costs, limited, small-scale fabrication of system elements, awareness-raising activities, etc.). Such studies have also tended to consider only a particular aspect of the system rather than adopt a holistic view. Studies that have considered only investment, reinvestment and operation and maintenance costs have shown, however, that systems designed to use excreta and greywater have a financial advantage over more conventional systems (see Box 9.1).

Box 9.1 Examples of investment and operation and maintenance cost comparisons

Germany

In Brandenburg, near Berlin, Germany, cost comparisons have been made for three different sanitation concepts for a planned new housing estate, where the population is expected to increase from 672 to 5000 inhabitants within 10 years. The three systems analysed were:

1) *Conventional*: Gravity sewer system, consisting of flush toilets, conventional gravity sewer system, pumping station with transport sewer to the existing sewer network, system operated by the public supplier.
2) *Gravity*: Source separation concept I (gravity, composting of faeces), consisting of gravity separation toilets, collection and storage of urine, transport and agricultural use on a nearby farm, faeces transported in gravity sewer with aerobic treatment in a compost separator, utilization of compost in horticulture, transport of greywater in gravity sewer system, treatment in a constructed wetland, transport to the receiving water body.
3) *Vacuum*: Source separation concept II (vacuum, digestion of faeces), consisting of vacuum separation toilets, gravity urine transport, storage of the urine and agricultural use on a nearby farm, faeces transported by vacuum sewerage, common treatment with organic waste in a biogas plant, biogas used to produce energy, transport of the digested sludge to nearby farms and utilization in agriculture, transport of greywater in gravity sewer system, treatment in a constructed wetland, transport to the receiving water.

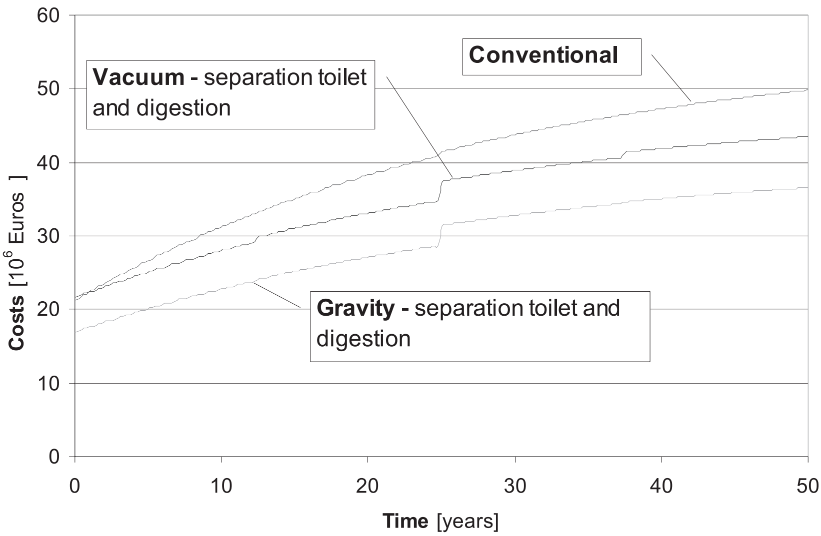

Figure 9.1
Cost comparison for the installation, operation and maintenance of the three systems for a population of 5000 in Brandenburg, Germany

The costs associated with the three systems were calculated over a lifetime of 50 years, with an annual interest rate of 3.5% per annum. The results of this cost comparison can be clearly seen in Figure 9.1, for the situation where 5000 inhabitants are served and the local Berlin water company is responsible for the operation of the system. Other service scenarios have been calculated with different population numbers and operational models, which also revealed a significant price advantage for the use-oriented systems over the system's lifetime.

Box 9.1 (continued)

Uganda

In Kalungu Girls Secondary School in Uganda, existing sanitation facilities were posing a risk to groundwater quality, the main source of potable water. In 2003, a project was implemented to renew and improve both water supply and sanitation facilities at the school. Additionally, a training programme aimed at ensuring an understanding and proper use of the new facilities was implemented.

Prior to deciding on the sanitation scheme, a detailed cost comparison was conducted and served as one instrument in the decision-making progress. Two alternative sanitary solutions were compared:

1) *Option 1: Source separation concept*: Dry urine diversion toilets, sewer line for greywater and a horizontal subsurface flow constructed wetland. The treated products from the toilets are to be used to water gardens within the school grounds.
2) *Option 2: Conventional concept*: Flush toilets for the students, separate sewer system for wastewater, mechanical pretreatment, pumping station and a vertical subsurface flow constructed wetland.

The comparison considered investment and reinvestment and operating costs. The calculation was carried out over a 50-year time frame, with reinvestments depending on individual system parts and an interest rate of 8% per annum.

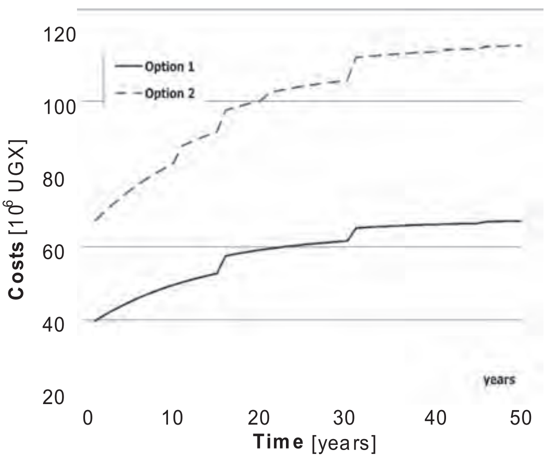

Figure 9.2
Cost comparison for the installation, operation and maintenance of the two systems for the school (exchange rate as of 22 September 2004: 1€ = 2060 UGX).

The cost comparison in Figure 9.2 shows that the safe use option is significantly less expensive. The main difference results from the significantly smaller wastewater treatment system for this option and the pumping station required for the conventional option.

9.2 Financial feasibility

To ensure sustainable services and cost recovery of excreta and greywater use systems, appropriate financing mechanisms are needed. A financial cost analysis should consider not only the investment, reinvestment and operation and maintenance requirements of the system, but also the indirect costs as well as the system's impacts on the environment, individuals and communities (Cardone & Fonseca, 2003).

Funds will be needed to ensure institutional capacity building and skills development, assessment and monitoring, policy formulation and the creation of an enabling environment for sanitation. The latter includes awareness-raising campaigns, hygiene promotion, public consultations and hearings, and informing policy- and decision-makers. Most of these activities are of a public nature, for the benefit of the community at large and individual households. Financing for sanitation mainly originates from two sources: the household and the public sector (Evans, 2001). Trying to mobilize individual household financial resources for activities targeted at the broader community has, however, proven difficult. This raises one of the main challenges of developing financing mechanisms for sanitation: How can the needs, interests and finances of individuals and households be effectively coordinated and reconciled with those at the community/national level? Ideally, this should be achieved in a way to recover costs, but also to ensure equitable access to sanitation, particularly for poorer members of society.

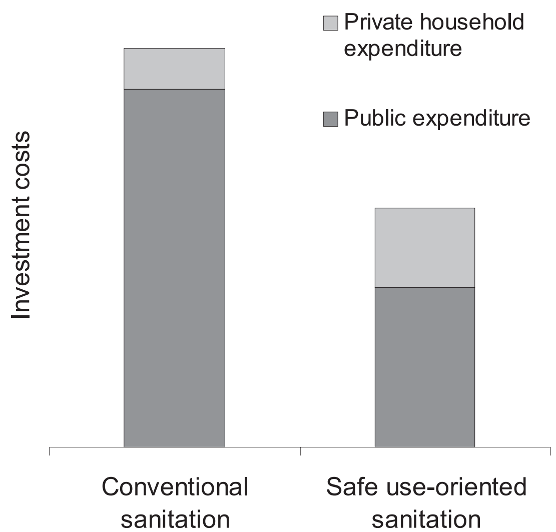

Figure 9.3
The cost structures of conventional and safe use-oriented sanitation systems (Werner et al., 2004)

Sanitation systems that recover excreta and greywater for use in agriculture generally have a different cost structure, and appropriate financing mechanisms may be needed to support private households in their decision to install them. As shown in Figure 9.3, the total costs to install such systems tend to be lower than for more conventional sanitation systems. In comparison with traditional decentralized sanitation (such as pit latrines or VIPs), they normally provide permanent solutions and thus do not have to be replaced when full, representing an incremental saving over an extended period of time. However, although the overall costs are lower, the initial costs to be covered by the private household may be higher as a result of having to replace or transform domestic sanitary facilities (e.g. by installing a urine diversion toilet).

Innovative financing alternatives, including start-up funds, community-based finance programmes, micro-credit programmes or targeted subsidies, which are easily understood by households, may therefore be required. These should put particular emphasis on the possibility of financing the users' investment for on-site and neighbourhood systems. Unlike rural areas, the systems for densely populated urban areas often cannot be left to the individual choice of the households. A common acceptable solution must be found, which may even be stipulated in legislation. Financial mechanisms will also be necessary in such cases to ensure that a uniform system can be adopted. Financing mechanisms should explicitly target the poorest, as they often pay higher costs for services than middle-class families (Mehta & Knapp, 2004). A sensitive use of these mechanisms is essential to ensure that proper support is given with maximum effect.

Experience from projects around the world has shown that subsidized installation of sanitation facilities does not guarantee their proper use and maintenance. Often the opposite is true, and toilets are converted into storerooms, households do not connect to sewers and wastewater treatment plants fail to work properly (Mehta & Knapp, 2004). Subsidies should therefore be focused on assisting households to obtain sanitation facilities that meet their needs, that they will use and whose maintenance they can afford. It is frequently more sustainable to spend financial resources on promotional efforts (including hygiene promotion) than to spend them on subsidies for sanitation hardware (WSSCC, 2005).

Households may be willing to pay up to 3% of household income for improved sanitary services, assuming that the household sees the service as necessary and that it actually does represent an improvement in the current situation (Rogerson, 1996). This expenditure also depends on other factors, such as who controls the household finances, ownership of the property where the family lives and the range of sanitary facilities on offer. Understanding what conditions encourage households to invest in sanitation and designing a range of options that respond to their wants and needs may help mobilize finances at the household level. It is clear from experience that household interest in sanitation is unlikely to be driven by health concerns. Comfort and convenience, prestige, permanence of the structure and, of course, costs are much greater motivating factors in the choice of a sanition system. The additional benefits accruing from the safe use of excreta and greywater have also proven attractive to families engaged in agriculture or horticulture. Adopting a demand-driven approach to sanitation should therefore assist households in choosing the system that they want and can afford.

Distribution of excreta and greywater may be a separate operation from their collection and treatment. Separate charges may be applied to individuals or communities using them. The level of these charges should be agreed at the planning stage. The responsible authorities must decide whether they should cover only the operation and maintenance costs or whether the capital costs of the scheme should be recovered as well. There are trade-offs between the desirability of maximum cost recovery and maintaining incentives for the use of excreta and greywater. Some prior investigation of the willingness and ability to pay is therefore essential in determining not only the level of charges, but also the frequency, timing and means of payment. For instance, in many rural settings, an annual charge payable after the harvest season may be the easiest to collect.

Farmers intent on using excreta and greywater in their agricultural production system may be willing to share in the investment in treatment works that are a prerequisite to obtaining use permits. Their contribution may be in cash or in the form of land for treatment and storage facilities.

The possibilities for private sector participation in sanitation systems that safely recover and use excreta and greywater are considerable (see Boxes 9.2 and 9.3). These range from construction of facilities and providing specific elements for them (e.g. urine-separating toilets) to the logistics of safely collecting, transporting and treating excreta and greywater through to their marketing and use. These market openings can also be stimulated and thus create business opportunities, particularly for small- and medium-sized enterprises.

Municipalities may also be able to operate profitable service providers for the management and treatment of faecal sludge in urban centres (see Boxes 9.2 and 9.3).

Box 9.2 Private sector providers of sanitation services

Factors influencing emptying service delivery for pit latrines and septic tanks

When the pits of on-site sanitation systems are full, they are emptied by cesspit trucks or manually. The financial, institutional and regulatory framework determines largely where and how the faecal sludges are deposited. To reduce cost, the truck drivers in many places sell the sludge to local farmers or dump the product on open spaces or into the drainage systems at the shortest possible distance.

Private cesspit emptying companies are often not legally recognized by the local authorities, even though they may constitute the only initiative catering for faecal sludge collection and disposal. In most cases, a fee structure and money flow procedures have become established without any legal control, resulting in emptying fees affordable to only a few and in indiscriminate dumping of faecal sludge. Experiences in the field show that the emptying service is cost-effective. Proper regulatory mechanisms, private sector competition and the development of economic incentives could help ensure that the collected sludge is delivered to a designated treatment site.

Faecal sludge emptying and haulage: a private sector "stewardship" business

Where the business opportunity exists, the faecal sludge emptying and haulage service is dominated by small-scale private entrepreneurs owning one or a few cesspit trucks. They often hold a share of >70% of this business, in spite of the lack of legal status. Table 9.1 highlights the importance of small-scale sanitation stewardship entrepreneurs, with examples from Ghana, Nepal, Senegal and Viet Nam, respectively, and illustrates the profit potential for faecal sludge removal services. The potential for strengthening the roles of private entrepreneurs in the safe management of faecal sludge exists. The policy framework should facilitate their role in providing safe services.

Table 9.1 Importance of small-scale private sanitation stewardship in faecal sludge management

	Kumasi	Dakar	Hanoi City	Kathmandu
Population (millions)	1.5	2.1	1.5	0.8
Share of population on on-site sanitation	60	60	90	–
Share of installations emptied mechanically (%)	90	70	90	64
Number of cesspit trucks in operation	25	± 100	40	8
Share of private business (%)	80	75	66	70
Total volume of faecal sludge hauled per day (m^3)	200–300	550	300–400	30–50
Average emptying cost per trip (€)	30–40	30–40	20–30	16–22
Yearly turnover/truck (k€)	30–60	20–30	10–20	10–15

Source: Data compiled from a field survey by Department of Water and Sanitation in Developing Countries (SANDEC) and its partners (Centre Régional pour l'eau Potable et l'Assainissement a faible coût (CREPA), Burkina Faso, Center for Environmental Engineering for Towns and Industrial Areas (CEETIA), Viet Nam, Environment and Public Health Organization (ENPHO), Nepal); prepared by Doulaye Koné and Martin Strauss, SANDEC / Swiss Federal Institute for Environmental Science and Technology (EAWAG); Strauss et al., 2003.

Box 9.3 Innovative money flows for improved faecal sludge management

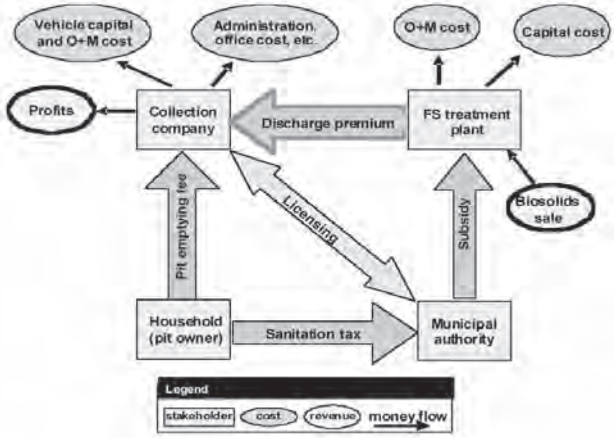

Figure 9.4
Scheme of innovative money flows in faecal sludge management
(O+M = operation and maintenance; FS = faecal sludge)

Sustainable environmental sanitation may be achieved or enhanced only by applying appropriate financial incentives and sanctions (Wright, 1997). Hence, municipalities must devise an effective sanctioning system (e.g. by imposing fines or non-renewal of faecal sludge collection contracts with entrepreneurs) and an incentive-based policy by, among others, paying entrepreneurs for delivering faecal sludge to the legally designated treatment or disposal site.

The potential business opportunity is shown in Figure 9.4. It is based on a rigorous economic analysis of the business opportunities and potential of existing and expected future key players. It analyses conditions under which each player can make a profit, based on their operation and maintenance costs, capital costs, margins of profit and potential for improving the service delivery. The development of the money flow model presented in Figure 9.4 implies a participatory consultation with key stakeholders (households, entrepreneurs, authority representatives, technical services, farmers, etc.). Hence, the project development process should be guided by a thorough stakeholder analysis study and stakeholder involvement process study.

Figure 9.4 illustrates such a financial scheme, the most crucial element of which is the payment to collectors for faecal sludge brought to the treatment site (discharge premiums). The flux reversal principle is about to be introduced in the city of Danang, Viet Nam. The city of Ouagadougou, Burkina Faso, is planning to pay collectors the equivalent of €3.70 per standard truck load on delivery of faecal sludge to the new wastewater/faecal sludge treatment scheme to reduce illegal and illicit dumping of faecal sludge or use of untreated faecal sludge in agriculture. For faecal sludge management to function on a sustainable basis, national or municipal governments must consider providing subsidies, recoverable partly by a tax on water, wastewater or sanitation charged to households. The rationale for such a policy is to render pit emptying affordable to all urban dwellers, to enable entrepreneurs to operate faecal sludge services with adequate profit margins and to keep prices for biosolids usable in agriculture competitive. Intensive information, awareness raising and social/commercial marketing campaigns are needed to render new money flow procedures acceptable to the urban customers and to induce the demand of farmers for biosolids.

Sources: Wright (1997); CREPA-Senegal (2002); Strauss et al. (2003).

9.3 Market feasibility

In planning for greywater and excreta use, it is important that the market feasibility be assessed. Market feasibility may refer to the ability to sell (treated) greywater and excreta to producers, or it can refer to the marketability of agricultural products grown with the use of excreta and greywater (see Table 9.2). For selling treated greywater and excreta, it is important to have an idea of how much people are willing and able to pay. Assessing the marketability is particularly important when crop restriction in agriculture is being considered as a partial health protection measure. Producers should be consulted as to which crops can be restricted. If farmers or market gardeners cannot make a suitable return on their products, then produce or waste application restrictions are likely to fail. Equally, if the excreta are to be used for gas or energy generation, it should also be ascertained if this could be achieved at a competitive price compared with that of other sources of energy.

Table 9.2 Market feasibility: planning questions

Product for sale	Key questions
Greywater and excreta	- What is the price for the treated greywater and excreta that people are willing and able to pay?
	- What is the demand in the project area for treated greywater and excreta?
	- Are there extra costs required to get the treated greywater and excreta to where it will be used (e.g. pumping costs, transport, etc.)?
Produce	- Are products (e.g. plants, biogas) acceptable to consumers?
	- Can producers earn acceptable returns with restricted application and produce?
	- Is the project capable of supplying products that meet market quality criteria (e.g. microbial standards for products to be exported)?

Any agricultural product grown with the use of treated greywater and excreta must be acceptable to the consumers. If the public perception of these products is negative, even if the quality meets WHO or national performance criteria, then farmers still may be unable to sell their produce. If agricultural products require post-harvesting processing, the cost and availability of these services need to be considered. In some cases, it will be necessary to actively market products to increase demand and profit potential. Currently, however, the management and use of most treated excreta and greywater are decentralized, often at household level, and they are used in subsistence rather than commercial agriculture and horticulture.

10
POLICY ASPECTS

The safe management and use of excreta and greywater in agriculture are facilitated by the appropriate policies, legislation, institutional framework and regulation at the international, national and local levels. In many countries, these frameworks are lacking or are insufficiently developed. This chapter looks at different policy and institutional aspects that will help promote the safe use of excreta and greywater. It also gives some country-specific policy/legal/regulatory examples. A policy framework should be based on a holistic approach that maximizes the public health protection and environmental benefits from the point of excreta and greywater generation through application to final product consumption.

Policy is the overall framework that sets national development priorities. It can be influenced by international policy decisions, by international treaties or commitments or by the policies of multilateral development institutions. Policy leads to the creation of relevant legislation. Legislation establishes the responsibilities and rights of different stakeholders. The institutional framework determines which agency has the lead responsibility for creating regulations (often as part of a consultative process) and who has the authority to implement and enforce the regulations (Figure 10.1).

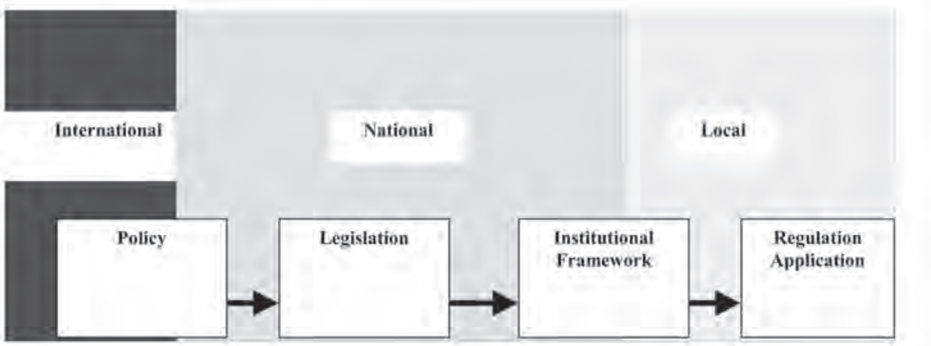

Figure 10.1
Policy framework

10.1 Policy

Policy is the set of procedures, rules and allocation mechanisms that provide the basis for programmes and services. Policies set priorities, and associated strategies allocate resources for their implementation. Policies are implemented through four types of policy instruments (Elledge, 2003):

1) *Laws and regulations:* Laws generally provide the overall framework. Regulations provide the more detailed guidance and may be developed at the national, regional or local level by different authorities as set out in legislation. Regulations are rules or governmental orders designed to control or govern behaviour and often have the force of law. Regulations for excreta and greywater use can cover a wide range of topics, including the practices of service providers, design standards, tariffs, treatment requirements, health-based targets and monitoring requirements, crop restrictions, environmental protection and contracts. These regulations, especially treatment and operational monitoring, have to be appropriate to local conditions.
2) *Economic measures:* Examples of economic measures are user charges, subsidies, incentives and fines. User charges, or tariffs, are charges that households and enterprises pay in exchange for the removal of human excreta

and greywater. Subsidies are allocations in cash or kind to communities and households for establishing recommended types of sanitation facilities or services and for the use of excreta and greywater in agriculture. Fines are monetary charges imposed on enterprises and people for unsafe disposal, emissions and/or risky hygienic behaviours and practices, which are a danger to people and the environment.

3) *Information and education programmes:* These programmes include public awareness campaigns and educational programmes designed to generate demand and public support for efforts to expand sanitation and hygiene services and encourage the safe use of excreta and greywater in agriculture.
4) *Assignment of rights and responsibilities for providing services:* National governments are responsible for determining the roles of national agencies and the appropriate roles of the public, private and non-profit sectors in programme development, implementation and service delivery.

The legislation resulting from policies for the safe use of excreta and greywater should establish a clear functional framework of how the sanitary system should operate. It should be directed explicitly at the correct level (household, district, municipality) and make clear provisions for all types of sanitation systems (from centralized to on-site systems). Local governments play a key role in implementing and enforcing such legislation.

10.1.1 International policy

International policy may affect the creation of national greywater and excreta use policies. National governments have numerous international obligations. They may originate from global treaties and conventions (such as the Basel, Rotterdam and Stockholm conventions). They may be linked to commitments made in the international arena (e.g. the Millennium Development Goals, or recommendations from the Commission on Sustainable Development). Or they may result from the conditions negotiated for loans and credits from international development banks and agencies. National policies for the safe use of excreta and greywater in agriculture will have to be in harmony with this international framework.

Another major issue is the international trade in food products. Those that are raised in compliance with the WHO *Guidelines for the safe use of wastewater, excreta and greywater* are internationally recognized as being developed within an appropriate risk management framework. This can help to facilitate international trade in agricultural products grown with the use of wastewater, excreta and greywater.

10.1.2 National greywater and excreta use policies

Policy priorities for each country are necessarily different to reflect local conditions. National policy on the use of excreta and greywater in agriculture needs to consider the following issues:

- health implications of excreta and greywater use in agriculture;
- requirements for a health impact assessment at the planning stage of proposed projects;
- water scarcity;
- wetland, coastal zone and biodiversity conservation;
- resource recovery and recycling;
- resource availability;
- sociocultural factors that influence practices and acceptability of excreta and greywater use;

- capacity to effectively treat excreta and greywater;
- capability and capacity to implement health protection measures to safely manage excreta and greywater use;
- impacts if excreta and greywater are not used in agriculture;
- impacts on household nutrition, food security and local economy;
- numbers of people dependent on excreta and/or greywater use in agriculture for their livelihoods;
- trade implications of growing crops with the use of treated excreta and/or greywater.

Responsibility for excreta and greywater use is often poorly anchored in existing policy and institutional structures. It may be divided arbitrarily between institutions working in public health, water resources management, agriculture and rural development or between town municipalities and regional and national governments. This may result in uncoordinated approaches and strategies, without an overall institutional responsibility. As most of the excreta and greywater management issues are likely to occur at the household or community level, policies should be clearly based on a local approach. Policies developed for sanitation also apply to the safe use of excreta and greywater and are best enforced by local governments and authorities.

In addition to public health aspects, environmental concerns are important in developing excreta and greywater use policies. National policies can strive to reduce environmental damage by requiring appropriate treatment chains and may also encourage the beneficial recycling of water and nutrient resources. This is apparent in relation to phosphorus, an important nutrient in excreta and greywater and indispensable in agriculture for crop development, but also a major cause of eutrophication if it ends up in freshwater bodies.

10.1.3 Greywater and excreta in integrated water resources management

In many arid and semi-arid countries, the renewable freshwater resources available are already heavily exploited. Integrated water resources management, as defined by the Global Water Partnership (GWP, 2000) is a process that promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.

Increasingly, the management of excreta and greywater is considered in the broad framework of integrated water resources management. Greywater may represent a reliable water source with constant flows even in the dry season, and excreta a constant source of organic material, nutrients and energy. Their productive use should figure prominently in water resources management, as it enables communities to reserve and preserve higher-quality water resources (i.e. uncontaminated groundwater or surface water), as well as to improve soil structure and fertility. Excreta and greywater use policies emphasize approaches that reduce environmental contamination and promote safe resource use. Of equal importance at the policy level is the fact that commercial fertilizers may not be an option for many farmers, due to high costs. Plant nutrients present in excreta and greywater are readily available, and their use helps to reduce reliance on commercial fertilizers for crop production.

10.2 Legislation

Legislation may facilitate technical incentives and financing mechanisms. In addition, legislation defines responsibilities and cooperation between relevant stakeholders, including the private sector, and appropriates financial resources for capacity building and training and for monitoring, implementation and maintenance. It provides a basis for enforcement of consistent standards for excreta and greywater collection, treatment and use to be complied with by other sectors (e.g. education, housing construction, workplace safety, etc.). Effective laws and regulations establish both incentives for complying and sanctions for not complying with the requirements (WHO, 2004a).

Often it may be sufficient to amend existing laws, but sometimes new legislation is required. The following areas deserve attention:

- define institutional responsibilities or allocate new powers to existing bodies;
- establish roles and relationships between national and local government levels;
- create rights of access to and ownership of greywater and excreta, including public regulation of its use;
- establish land tenure;
- develop public health and agricultural legislation concerning greywater and excreta quality standards, produce restrictions, application methods, occupational health, food hygiene and other preventive measures linked to health-based targets as deemed relevant.

An example of legal provisions conducive to the recycling of wastewater, excreta and greywater comes from Sweden and is presented in Box 10.1.

10.2.1 Institutional roles and responsibilities

Legislation may be required to establish a national coordinating body for excreta and greywater use and to set up local bodies to manage individual schemes. These will require a certain degree of autonomy from central government and the ability either to charge for the excreta and greywater they distribute or to sell any agricultural produce. Working within an existing institutional framework may be preferable to creating a new one.

At a national level, the safe use of excreta and greywater in agriculture is an activity that touches the responsibilities of several ministries or agencies. Normally, the development of policies to encourage the safe use of excreta and greywater would involve a consultative process between different agencies/institutions with overlapping responsibilities. Examples of ministries, authorities or agencies that have jurisdiction over the use of greywater and excreta in agriculture may include:

- *Ministry of Agriculture:* overall project planning; management of state-owned land; installation, operation and maintenance of irrigation infrastructure; agricultural research and extension, including training; control of product marketing.
- *Ministry of Environment:* sets excreta and greywater treatment and effluent quality standards based on environmental concerns, establishes practices for protecting water resources (both surface water and groundwater) and the environment; establishes monitoring and analytical testing protocols; manages and validates the environmental impact assessment process.
- *Ministry of Health:* health protection, particularly establishment of health-based targets (for treated excreta and greywater, products; health protection measures), monitoring procedures and methods and schedules for treated excreta and greywater; health education; disease surveillance and treatment; manages and validates the health impact assessment process.

- *Ministry of Water Resources:* incorporation of excreta and greywater use into integrated water resources planning and management.
- *Ministry of Energy:* integration of energy generation by the anaerobic treatment of excreta and greywater into national energy plans.
- *Ministry of Education:* develop school curricula concerning sanitation and personal and domestic hygiene and safe practices related to the use of excreta and greywater.
- *Ministry of Public Works/Local Government:* excreta and greywater collection, treatment and use.
- *Ministry of Finance and Economic Planning:* economic and financial appraisal of projects; import control; development of financing mechanisms for excreta and greywater conveyance and treatment and use infrastructure.

Box 10.1 Legislation: promoting or preventing?

The Swedish Environmental Code contains an example of legislation where the use and saving of resources are in focus. The objective states:

The purpose of this Code is to promote sustainable development, which will assure a healthy and sound environment for present and future generations....

The Environmental Code shall be applied in such a way as to ensure that: [...] 5. Reuse and recycling, as well as other management of materials, raw materials and energy are encouraged with a view to establishing and maintaining natural cycles. [...]

This aim is underlined in Chapter 2 of the Code, which states:

Persons who pursue an activity or take a measure shall conserve raw materials and energy and reuse and recycle them wherever possible. Reference shall be given to renewable energy sources.

This article ensures that the aim of conserving raw materials and resources is as important as the aim of minimizing emissions of pollutants, etc. Recycling of nutrients is now stipulated in the provisions, for example, for small wastewater plants for single-family houses.

Other ministries and government agencies, for example those concerned with land tenure, rural development, cooperatives and women's affairs, may also be involved.

Cooperation between the relevant agencies will require effective communications between the technical staff involved. Some countries, especially those facing water scarcity, may find it advantageous to establish an executive body, such as an interagency technical standing committee, under the aegis of a lead ministry (Agriculture or Water Resources) or possibly a separate organization (with both government and private funding sources), to be responsible for the development, planning and management of excreta and greywater use projects. Professionals involved in this will be required to develop skills in intersectoral negotiation and decision-making.

In many countries, the establishment of an ad hoc committee may be sufficient. Alternatively, existing organizations may be given responsibility for this intersectoral issue, or parts of it: for example, a National Water Board may be given responsibility for the safe use of wastewater, excreta and greywater in aquaculture/agriculture/energy generation. Such an organization should have the power to convene a committee of representatives from the different agencies with relevant responsibilities, which, in turn, will provide the interagency or interministerial mechanism to inform others of the challenges/opportunities in developing safe approaches in this connection.

For example, in Uganda, an Inter-Ministerial Steering Committee was set up as a policy- and strategy-making body to oversee activities related to water supply, sanitation and hygiene. It was made up of the permanent secretaries and directors from the ministries of Health, Water, Lands and Environment, Gender, Labour and Social Development, Local Government, Education and Sports, Finance Planning and Economic Development. The role of this committee was to review the overall water supply, sanitation and hygiene policy, coordinate and promote convergence between sectoral activities and promote appropriate changes in policies for sectoral programmes and projects.

In countries with a federal administration with a higher or lower degree of decentralization, such arrangements for interagency collaboration will be important at the appropriate levels. Whereas the general framework of greywater and excreta use policy and standards may be defined at the national level, the regional body will have to interpret and adapt these for effective implementation under local conditions.

Individuals collecting greywater and excreta and managing a scheme will often be under municipal control. If greywater and excreta use is to be promoted in the context of a national policy, this implies careful coordination and definition of the relationship between local and national government. On the one hand, it may be necessary for the national government to offer incentives to local authorities to promote safe use of greywater and excreta; on the other hand, sanctions of some sort may have to be applied to ensure that schemes are implemented without significant risk to public health.

Local governments usually have the authority to develop their own regulations within the national legal framework. For example, they should be able to collect fees for greywater and excreta treatment or other services, issue permits, conduct inspections, develop produce restrictions, inspect markets and develop decentralized greywater and excreta treatment and use facilities.

Permits may be issued by the local agriculture or water resources administration or by the body controlling the greywater and excreta distribution system for the use of excreta and greywater from a public conveyance network. Provision of such permits could be made conditional on the correct observance of sanitary practices regarding application methods, produce restriction and exposure control.

It is common for the agencies administering the distribution of greywater and excreta to deal with the landowners through users' associations, which may develop from traditional institutions. Permits to use greywater and excreta can then be issued to the associations, which simplifies the administrative task of dealing separately with a large number of small users. It also delegates to the associations the task of enforcing the regulations that must be complied with for a permit to be renewed.

A joint committee or management board, which may include representatives of these associations, any particularly large users, the authorities that collect and distribute the greywater and excreta, and also the local health authorities, is required. Even in small organizations, some form of arrangement, such as a committee with community representatives, is important for the users to participate in the management of the project. In some cases, farmers will be able to directly negotiate contracts for a specified supply of treated greywater and excreta with the treatment utility.

10.2.2 Other roles and responsibilities

The number of stakeholders that may be involved in the safe use of excreta and greywater can be quite large and may include individuals, groups, institutions or organizations with different needs and concerns. A detailed stakeholder analysis is normally carried out at the start of activities to identify those that will be of relevance and how large stakeholder groups may be effectively addressed and represented.

The stakeholder analysis given below provides a generic overview of the possible stakeholders in excreta and greywater use programmes:

- *Users of sanitation facilities:* These are most often the individual households. In rural areas, the households are usually the final decision-makers, responsible for the construction and maintenance of the sanitation facilities as well as the collection and treatment of the excreta and greywater; in urban areas, households may be marginally involved, with service providers collecting the excreta and greywater for further secondary off-site treatment, generally against payment. The households can help drive the process forward by adopting good sanitation and hygienic practices, innovating, taking action, talking to the neighbours about solving local problems and encouraging political representatives to support locally developed solutions.
- *Users of the treated excreta and/or greywater:* These may be the users of the sanitation facilities themselves, farmers in nearby areas or, in urban settings, market gardeners or communities involved in (peri-)urban agriculture.
- *Community-based organizations and self-help groups:* These support the households by organizing the delivery of the different services needed (e.g. maintenance of the facilities or the collection and treatment of the final treated products) and the use of the produced fertilizer at the level of the community-based organization or neighbourhood groups.
- *Nongovernmental organizations:* These provide information and raise awareness among potential users. They also often advise the households on the use of sanitation systems and support (poor) households in the contact with, for example, financing institutions and municipalities.
- *Service providers:* Service providers encompass a group of diverse stakeholders engaged in public or private market-oriented activities of service provision. These include planners, consultants, producers/suppliers, construction companies, utility providers and companies involved in excreta and greywater collection, transport and treatment. Farmers also act as service providers by collecting and treating excreta from the users of the sanitation facilities.
- *Developers and investors:* Developers and investors from either the private or public sector may initiate the construction of residential units. The decision of developers and investors to introduce systems for the safe use of excreta and/or greywater is often tightly related to the demand for the treated product. They are often actively involved in the planning and implementation process of an entire programme.
- *Financial institutions:* The introduction of new infrastructure generally requires that the investment and operation costs be secured.
- *Research institutions:* These may be universities or other research-oriented institutions or organizations that can provide evidence and advice to programme initiators, developers, municipalities and nongovernmental organizations.

- *International organizations:* International organizations can ensure that external funds for sanitation hardware are bundled with appropriate hygiene promotion and sanitation marketing activities; encourage governments to consider appropriate, cheaper and more sustainable sanitation systems; finance local sanitation research; develop guidance and tools for facilitating good practice; disseminate information; actively endorse the idea of flexible technical norms and standards to allow for innovation where excreta and greywater use is promoted; and offer support in adopting the legislative and regulatory framework to facilitate safe use and resource efficiency as part of sanitation systems.

Table 10.1 Different factors influencing stakeholders on the adoption of safe use systems

Principal stakeholders	Examples of motivating factors	Examples of constraints
I. Users of sanitation facilities: households, neighbourhoods, tourists, pupils, employees.	No odour, hygiene improvement, structural stability, local physical factors (high groundwater table, rocky ground, etc.), reduced costs, increased comfort, improvement of quality of life, greater security (in-house construction), interest in treated products, prestige, ecological reasons, water scarcity, unreliable water supply.	Habits, taboos, hygienic concerns, unfamiliarity, fear of loss of comfort, unavailability of structural elements, legislative restrictions, economic factors (e.g. for start-up, etc.).
II. Users of treated products.	Economic reasons, local and reliable availability of agricultural inputs (water, nutrients, organics), increase of crop yields for either the market or family needs, improvement of self-sufficiency, ecological reasons.	Habits, taboos, lack of logistics, fear of negative consumer perception, fear of negative long-term effects on soil.
III. Community-based organizations and self-help groups.	Failure of conventional/existing sanitation system, local improvement of quality of life, Agenda 21, MDGs, interest in treated products, reduced costs, local physical factors (high groundwater table, rocky ground, etc.).	Habits, taboos, lack of information, insufficient financing, inappropriate legislation, influence of interest groups, hygienic concerns.
IV. Nongovernmental organizations.	Failure of conventional/existing sanitation systems, economic reasons, ecological reasons, agricultural reuse of treated products, improve quality of life, etc.	Habits, taboos, lack of information, insufficient financing, inappropriate legislation, influence of interest groups, hygienic concerns.
V. Local authorities, government institutions.	Political reasons, economic reasons, ecological reasons, Agenda 21, MDGs, failure of conventional/existing sanitation system, possibility of financial support, sustainability of system, support regional self-sufficiency, promotion of (urban) agriculture, job (and income) creation, long-term security of social services (water supply, etc.).	Habits, taboos, lack of information, lack of start-up funds, insufficient financing, monitoring of treatment/ handling, etc., more difficult for decentralized system, distrust of alternative systems, not recognized as state of the art technology, reluctance to change status quo, contradiction of existing legal framework/long-term plans, powerful lobby from conventional centralized sanitation industry, corruption.

Table 10.1 (continued)

Principal stakeholders	Examples of motivating factors	Examples of constraints
VI. Service providers: planners/consultants, builders, maintenance service providers, producers of equipment, providers of collection, treatment, transport and marketing of the treated products.	Increased profit, opening up of a potentially huge new market, request/need for particular product, further develop their own know-how, ethical/ecological reasons.	Absence of technical knowledge, absence of products, inappropriate legislation, lack of suitable tools, economic interest of (waste) water monopolies, fear of failure (economic risk), not yet recognized as state of the art, reluctance to make the necessary increase in effort, lack of experience in decentralized planning/participation, lack of start-up funds, fear of reduced profit margins in smaller/decentralized projects, regulatory obstacles.
VII. Developers and investors.	Increase attractiveness of developments (eco-label), safe and secure "management" (especially in tourist areas), user satisfaction, economic reasons, legal requirements.	Absence of service logistic, habits, taboos, lack of information, lack of start-up funds, monitoring of treatment/handling, etc., more difficult for decentralized system, distrust of alternative systems, not recognized as state of the art technology, reluctance to change status quo, contradiction of existing legal framework / long-term plans, powerful lobby from conventional centralized sanitation industry, corruption, less "commission" for projects.
VIII. Financial institutions.	Economic reasons, failure of existing/conventional systems, improving sustainability, guarantee repayment of credit.	Absence of specific financing instruments, not recognized as state of the art technology, need for research and development.
IX. Research institutions.	Need for research and development, availability of research funds, ecological reasons.	Availability of research funds, prestige.
X. International organizations.	Political reasons, improvement of public health, pro-poor development goals, improvement of livelihood, social/economic/ecological sustainability, Agenda 21, MDGs, failure of conventional/existing sanitation system	Culture, habits, taboos, lack of information, monitoring of treatment/handling more difficult in a de-centralized system, distrust of innovative systems, reluctance to change, contradiction with existing legal framework, powerful lobby of conventional sanitation industry

Source: Adapted from GTZ (2003); UNESCO/GTZ (2006).

Table 10.1 presents some of the factors that may either motivate different stakeholders to adopt or discourage them from adopting safe use systems. A participatory approach is essential where the stakeholders have the possibility to voice their motivations and reservations. Equally important is dealing with the constraints raised. Mapping the motivations and constraints is a useful task, which should be adapted during the course of the project, becoming increasingly specific with time.

10.2.3 Rights of access

Farmers will be reluctant to install infrastructure or treatment facilities unless they have some confidence that they will continue to have access to the greywater and excreta. Permits dependent on efficient or sanitary practices by the farmers may regulate this access. Legislation may therefore be required to define the users' rights of access to the greywater and excreta and the powers of those entitled to allocate or regulate those rights.

10.2.4 Land tenure

Security of access to greywater and excreta is worth little without security of land or water tenure. Existing tenure legislation is likely to be adequate for most eventualities, although it may be necessary to define the ownership of virgin land newly brought under cultivation. If it is decided to amalgamate individual agricultural areas under a single management, powers of compulsory purchase may be needed.

10.2.5 Public health

The area of public health includes rules governing crop restrictions and methods of application, as well as quality standards for treated greywater and excreta, which may require an addition to existing regulations. It may include application requirements or required withholding periods between application and harvest. It also covers other aspects of health protection, such as the promotion of hygiene and other health issues, occupational health and food hygiene, which are unlikely to need any new measures. Consumers also have the right to expect safe products.

Legislation on the use of excreta and greywater, intended for the protection of public health, should be based on the health-based targets and health protection measures discussed in chapters 4 and 5 of this volume of the Guidelines.

10.3 Regulation

Regulations are the rules that specify actions that need to be performed by the users (can be individuals or communities, etc.) of excreta and greywater. Regulations are usually created through a consultative process led by an administrative authority, with a delegated responsibility in legislation. Regulations governing the use of excreta and greywater should be practical and focus on protecting public health (other issues will also be relevant, e.g. environmental protection). Regulations should also establish requirements to obtain permits, specify the risk management approaches that will be required in different settings, describe water quality/produce monitoring requirements, create disease surveillance requirements and develop financing mechanisms. Most importantly, regulations should be feasible to implement under local circumstances. Box 10.2 provides an example of regulations that affect the use of excreta and greywater in South Africa, and Box 10.3, the development of municipal regulations through consultation with various stakeholders in Tepoztlán, Mexico.

A framework of regulations could be set up around the different health protection measures (i.e. excreta and greywater treatment, use restriction, application, exposure

Box 10.2 National Building Regulations in South Africa

The National Building Regulations state that waterborne sewage and chemical closets are the only acceptable indoor toilets. The assumption is that municipalities will automatically be able to treat the sewage and safely discharge it to the environment. The safe use of excreta and greywater could be incorporated into the standards by allowing the choice of different technologies, e.g. different types of toilets or storage and treatment systems that facilitate the safe use of excreta and greywater. The National Building Regulations could allow the use of different systems if, for example, the owner of the building and/or the municipality can demonstrate that they can comply with system operation and treatment requirements.

Box 10.3 Developing a municipal regulation for the city of Tepoztlán in Mexico

The content of a regulatory framework for a municipality with regard to sanitation is being proposed for the municipality of Tepoztlán in Mexico. The regulation will be developed after extensive consultation with key local and national stakeholders and in parallel with proposals for appropriate institutional reforms to ensure their effective application. This municipal regulation will contain the following specifications:

a. Basic principles and rules taking into account particularities of the municipality.
b. Inclusion of rules for construction permits and new urban developments.
c. Policy and procedures regarding water management and sanitation, including assessment and monitoring.
d. Specify concrete measures and actions regarding sanitation that should be undertaken by the municipality.
e. Adapting local regulations to federal and regional legislation to avoid conflicting jurisdictions and to promote concurrent jurisdictions.
f. Institutional mechanisms of participation of the local population in the process of municipal management in specific affairs of importance such as sanitation, with specific emphasis on surveillance.
g. Definition of minimum norms of quality of the public services offered by the municipality.
h. Requirements for housing development to fulfil the regulation in relation to sanitation and other issues.
i. Establishing proper incentive systems for conversion and retrofitting of conventional technology towards alternative sanitation technologies that facilitate the safe use of excreta and greywater.
j. Implementation of registers and inventories of waters and soils.
k. Improving the tariff system collection.

A bottom-up strategy is thus proposed, where appropriate regulation for a municipality, in this case Tepoztlàn, could serve as a model for other municipalities and gradually influence regulation at other levels of government.

control). Regulations may already exist for some of the protective measures. Without some complementary measures, such as regulations that control market hygiene (e.g. availability of adequate sanitation and safe water supplies and market inspectors), safe food products grown in compliance with the excreta or greywater regulations could easily become recontaminated in the market, mitigating any impact of previous public health protective measures that have been implemented (see Table 10.2 for examples of activities that might require regulations).

10.4 Development of a national policy framework

In developing a national policy framework for the safe use of excreta and greywater in agriculture, it is important to define the objectives of the policy, assess the current policy environment and develop a national approach.

10.4.1 Defining objectives

The use of greywater and excreta can have one or more of several objectives. Defining these objectives can help to start the planning and implementation process (Mills & Asano, 1998). The main objectives might be:

- to increase national or local economic development;
- to increase crop production;
- to increase energy production;
- to augment freshwater supplies and otherwise take full advantage of the resource value of greywater and excreta;
- to manage greywater and excreta in a cost-effective, environmentally friendly manner;
- to improve household income, food security and/or nutrition.

Where greywater and excreta are already used, sub-objectives might be to incorporate health and environmental safeguards into management strategies or improve produce or yields through better practice.

Table 10.2 Examples of activities that might be covered in regulations

System components	Regulatory considerations
Greywater and excreta	Access rights; tariffs; management (e.g. municipalities; communities, user groups, etc.)
Conveyance	Responsibility for building infrastructure and operations and maintenance, pumping costs, delivery trucks
Treatment	Treatment requirements depending upon final use; process requirements
Monitoring	Types of monitoring (e.g. process monitoring, analytical, parameters), frequency, location, financial responsibilities
Greywater and excreta application	Fencing, need for buffer zones
Produce restrictions	Types of produce permitted, not permitted, enforcement, education of users/public
Exposure control	Access control for use areas (e.g. sign posting, fences), protective clothing requirements, provision of water and sanitation facilities for workers, hygiene education responsibilities
Market hygiene	Market inspection, provision of safe water and adequate sanitation facilities at markets
Financial authority	Mechanisms for charging tariffs, collecting fines
Enforcement	Mechanisms for ensuring regulatory compliance

10.4.2 Analysis of the existing policy framework

The right formal and informal policy framework can facilitate the safe use and management of excreta and greywater. Existing practices, habits and customs need to be integrated to understand what actions should be taken to reduce risks and maximize benefits.

An existing policy framework facilitates, impedes or is neutral towards the safe use of excreta and greywater. The most practical approach is from a "what is not strictly prohibited" rather than from a "what is specifically allowed?" perspective. This analysis should include the whole handling chain, from point of household generation through conveyance, storage, treatment, use and product consumption. Coordination of many authorities/agencies at the community level will be helpful, and the analysis of the existing framework should have that objective in focus.

As legal, institutional, cultural and religious contexts differ, it is not possible to prescribe a specific methodology for institutional analysis that functions globally. The questions in Table 10.3 should be seen as examples for a structured approach with the aim of identifying the system. Is the purpose to use the excreta and greywater at the household level and then to delegate responsibility to individual households? Or is the system to be operated by a municipality? What permits are necessary? Is it possible for local farmers to sell their crops after using these substances? The framework should not be prescribing specific technologies, but it should be based on the principles of maximizing public health and environmental protection and identifying the necessary changes within the existing institutional framework. Once an analysis is completed, it will be helpful to develop an action plan.

Table 10.3 Structured questions providing input for an institutional analysis of excreta and greywater use

Questions regarding…	Examples of relevant questions
…the legal framework	Does the existing legal framework adequately govern excreta and greywater use?
	Are existing regulations appropriate? Or do existing regulations conflict with desired outcomes for the use?
	Are national policies within the sector based on appropriate levels of legality? Are there barriers or obstacles resulting from the legal basis of excreta or greywater use?
	Are these policies sufficiently comprehensive to allow institutions to develop strategies and action plans to act upon them?
	Are these national policies compatible with other relevant national policies and regulations, for example, environment, public health, education and decentralization?
	Are the policies more appropriate for one or more target groups or areas (e.g. urban areas, small towns, rural areas)?
	Do laws or by-laws cover responsibilities of landlords for providing adequate storage or treatment facilities for tenants?
	What challenges and possibilities exist within the spatial planning and building codes? How is construction permitted or restricted?
	What is stated in technical norms and standards?[a]
	To what extent can neighbours have opinions on land use? Do these rights pose challenges?
	Who has the right to use the resource (e.g. water)?
	Will the owner of the resource, such as the land and water, be entitled to compensation?
	What is stated in the health legislation?
	What is stated in the infectious disease protection legislation?
	Are there environmental quality standards regulating effluent quality?
	Are there legislative obstacles hindering the commercialization of products cultivated with human excreta?
	Is authorization or notification needed for different aspects of the recycling scheme?
	Is there legislation that, in practice, suppresses the development of recycling-oriented sanitation systems?
	Who enforces the rules?
	What is the legal status of excreta and greywater? Covered or excluded?
	How is the flow of different fractions regulated (keeping excreta and greywater separate throughout collection/transport/use)? Does the existing legal framework direct the excreta and greywater flow towards use or towards deposition/discharge?
	Who has a right of access to excreta and greywater?
	Are quality standards in place for excreta and greywater, restrictions on crop use, application methods, occupational health, food hygiene, etc?

Table 10.3 (continued)

Questions regarding…	Examples of relevant questions
…the relevant authorities	Who has the responsibility to make legislation/regulation on different levels?
	What are the appropriate standards for excreta and greywater use?
	Is there coordination between the relevant authorities in terms of resposnsibility?
	Is there a clear and proper division of powers/finances/competence?
	What supportive policies are there? Is there a coordination of water and sanitation policies with environmental and agricultural policies?
	Are there action plans connected to the policies?
	What are the roles and relationships between national and local governments?
	Do authorities comply with legislation/regulations? Does the national or state-level government intervene when national policies are not implemented?
…the informal institutions	What are the attitudes, human and organizational behaviour, codes of conduct and behavioural patterns from an excreta and greywater use perspective[b]
	Is there compliance with legislation/regulation[c]?
…other issues	Is there a potential for corruption?
	Are there any other competing interests with the excreta and greywater?

[a] Many existing standards (national or municipal) are based on those developed in industrialized countries, under conditions different from those applying in developing countries, and so they are often inappropriate. Part of launching a household-centred environmental sanitation approach should therefore be to secure a moratorium on the application of existing standards to the programme area, and part of the overall exercise should be to try to identify standards that would be more appropriate because they meet the basic purpose of standards, to ensure that everyone has a healthy life (WSSCC, 2005).

[b] It is important to remember that informal institutions are more resilient towards change than formal ones (Hukkinen, 1999).

[c] Many of the problems related to the legal field have to do with a strong dichotomy between legislation and reality. Some countries may have advanced legislation and comprehensive policy and planning instruments, but poor law enforcement and poor implementation of plans and policies. Any effort to build a different legal framework must tackle this issue in order to promote laws that are in accordance with the complexities that the different actors will have to deal with when applying or being affected by the legislation concerned (Johansson & Kvarström, 2005).

Source: Adapted from Elledge et al. (2002).

10.4.3 Development of action plans

Analysis of the existing legal framework may find that new institutions, laws or regulations are warranted or that existing frameworks should be modified to accommodate the safe use of excreta and greywater.[1] New tasks within the changed framework may be included in action plans. Action plans should be output oriented with monitoring mechanisms. Developing an action plan may include consideration of the following elements:

- **Institutional reform action**
  - adding sanitation and resource recycling into poverty reduction strategy papers
  - allocation of new or changed powers to existing bodies

[1] Institutional change is a complex process and depends on (i) the stability characteristics of institutions, (ii) the sources of change, (iii) the agent of change and (iv) the direction of change and path dependence (North, 1990). Institutions typically change incrementally rather than instantaneously, which means that short-term profitable opportunities cumulatively create the long-term path of change (Seppälä, 2002).

- the creation of new authorities or new tasks for old authorities
- development of new policies (see above for key features of sanitation policies)
- coordination of policies
- creation of economic incentives, removal of economic hindrances
- new/changed legislation/regulation[1]
    - e.g. identification of environmental quality standards, identification of time period to respect between excreta/greywater amendment event and harvest
    - One way to keep legislation modern for a longer time period is to make it less detailed and specific. For the sanitation case, one way of achieving this is to avoid mentioning technologies in legislation/ regulation, but rather focus on functions that the sanitation services should provide. A function, or performance or criteria, approach opens up for innovative technologies/systems as long as they comply with the criteria identified in the legislation/regulation.
- action plans to enforce existing/new regulations
    - Better compliance with existing laws and rules and in many cases also reformed legislation are needed, as both these issues are important and intimately related. Better rules may foster different policies and help, among other things, to get better compliance. However, new laws and rules have to be coupled with concrete and specific application and enforcement of the law.
- reallocation of financial resources
- creation of monitoring mechanisms
- creation of financial mechanisms allowing the safe use of excreta and greywater (e.g. microfinance, revolving funds, etc.)
- completed decentralization processes[2]

- **Change in ways of working**
    - continuous stakeholder involvement in order for legislation/regulation and institutions to be viable and accepted by the public
    - enhanced cooperation between existing authorities
    - execution of integrated planning approaches[3]
- **Piloting**
    - If the institutional framework does not embrace the safe use of excreta and greywater, identification of waiver possibilities in order to conduct use in pilot projects may be essential for decision-making. The programmes should be integrated, encompassing sanitation, health and hygiene, nutrient/resource recycling and food security.

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[1] Legislation/regulations should create conditions that favour innovation (in both technology and financing mechanisms); define cooperation between relevant stakeholders, including the private sector; and allocate financial resources to capacity building, training and monitoring implementation and maintenance (WHO, 2004a).

[2] If you apply the household-centred environmental sanitation approach to planning of urban environmental sanitation services, it is important to decentralize powers and functions, since it builds on both bottom-up and top-down approaches to service provision planning (WSSCC, 2005).

[3] Household-centred environmental sanitation is a multisector, multiactor approach to delivering urban environmental sanitation services, where urban environmental sanitation services comprise not only sanitation but also storm water and solid waste as well as water provision. In this way, the stakeholders have opportunities to participate in the planning, implementation and operation of urban environmental sanitation services, which is believed to increase their sustainability (WSSCC, 2005).

- **Information, education, communication**
  - awareness-raising campaigns at different levels[1]
  - development of local guidelines for the safe use of excreta and greywater in agriculture
  - capacity-building efforts (e.g. bringing together more resources, stronger institutions, better trained people and improving skills; WHO, 2004a)
    - training regulators so that they know how to support, regulate and control systems for the safe use
  - information sharing through conferences, workshops and other forums
  - information and education programmes (see, for example, WHO's sanitation and hygiene promotion programming guide; WHO, 2005b).

10.4.4 Research

Research on minimizing health impacts associated with use of excreta and greywater in agriculture should be conducted at national institutions, universities or other research centres. It is important to conduct research at the national level, because data concerning local conditions are the most important for developing effective health protection measures and may well vary considerably between countries. Pilot schemes can be developed to investigate feasible health protection measures and answer production-related questions. In situations where excreta and greywater use is practised in small-scale diffuse facilities, often at the household level, national research may be used to validate health protection measures and then develop guidelines and standards to be used by small-scale farmers. Research results should be disseminated to various groups of stakeholders in a form that is useful to them.

A pilot project is particularly useful in countries with little or no experience of managing excreta and greywater use in agriculture or when the introduction of new techniques is envisaged. Health protection is an important consideration, but there are other questions that are difficult to answer without local experience of the kind a pilot project can give. These questions are likely to include important technical, social and economic aspects. A pilot scheme can help to identify potential health risks and develop ways to control them.

Pilot projects should be planned — that is, a variety of crops (both old and new) should be investigated, with different application rates. Information is required not only on yields, but also on levels of toxic metals, organic chemicals and pathogens typically present in the region in local waste and their effects on the environment.

A pilot project should be carefully planned so that the work involved is not underestimated and can be carried out correctly; otherwise, repetition is required. After the experimental period, a successful pilot project may be translated into a demonstration project with training facilities for local operators and farmers.

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[1] The main reason for awareness raising, on a decision-maker level, with regard to the use of excreta and greywater is that the possibilities it entails are relatively unknown. However, extensive, unregulated use of wastewater occurs in many cities today (e.g. Dakar), even if the main reason for farmers to divert raw wastewater to agricultural or horticultural fields might be to capture water rather than nutrients. Awareness-raising campaigns geared towards farmers should thus address the health risks associated with the use of raw wastewater/excreta and highlight the nutrient value of treated excreta. Awareness raising for safe excreta and greywater use applies also to engineers, planners and even sanitation professionals. There is an overall need to broaden the nature of the debate concerning the role of sanitation and the aims of sanitation provision.

11
PLANNING AND IMPLEMENTATION

The safe use of greywater and excreta in agriculture requires adopting an appropriate planning approach at both the national level and the individual project level, with health as a first priority. Planning strategies, including communication with different groups of stakeholders, have been dealt with in chapter 10. The present chapter describes other planning and implementation issues, partly adapted to the local level.

11.1 Adopting an appropriate planning approach

Planning and development of sanitation programmes have been comprehensively addressed elsewhere (see, for example, WSSCC, 2005). This information can be used as a basis for the creation of new programmes. The planning of sanitary systems aimed to use excreta and greywater should take account of certain specific considerations responding to the needs of a safe use-oriented approach:

- *Integrate aspects of safe use in the assessment of the current sanitary situation and in all the planning activities and conceptual work:* When planning systems to safely use excreta and greywater, a broader spectrum of issues has to be considered. These include the assessment of the current agricultural situation, the type of crops cultivated and prevalent agricultural practices. These relate to the water and fertilizer needs, agricultural equipment and irrigation practices. The quality of the irrigation water used relates to the relative risks of contamination as well as livestock production, practices concerning the treatment and use of manure and current and traditional practices of fertilization and soil conservation. Productivity, costs and benefits, farmers' and consumers' perceptions of the use of artificial fertilizer, manure, treated wastewater, greywater and human excreta as well as other aspects should also be considered. In addition to traditional agriculture, excreta and greywater can be and have been applied as fertilizers in areas such as forestry, aquaculture (see Volume 3 of the Guidelines) and market gardening or for energy production.
- *Integrate aspects related to water supply:* As the source separation of excreta and greywater may reduce the amount of treated fresh water used in homes (e.g. to transport excreta in waterborne systems), water supply systems can often be reviewed and modified.
- *Integrate aspects of urban planning:* As excreta and greywater should be used as close to the source as possible to minimize transport requirements, coordination with urban planners may be required (e.g. in order to provide space for the integration of a constructed wetland in an urban park, to support urban agriculture or to provide small-scale service providers with an area for the treatment and storage of excreta in the neighbourhood).
- *Integrate aspects of solid waste management:* The collection, transport, treatment and use of, for example, composted or dehydrated faeces may be carried out as part of a solid waste management programme. In many countries, those responsible for solid waste management have a long experience with organizing the collection and use systems, as well as marketing know-how.
- *Consider a much wider variety of sanitation systems:* A wide array of technical and operational solutions supporting the use of excreta and greywater are available (see chapter 5). Planners may consider a range of different options for the local circumstances. From the users' perspective, the

ability to choose between different effective technology options to fit their household and budgetary needs is vital. Planners should consider the corresponding institutional and management arrangements needed for different excreta and greywater use options.

- *Apply new and wider-ranging decision-making and evaluation criteria for water supply and sanitation services:* Excreta and greywater use systems highlight the widened boundaries of sanitation systems (integrating aspects of agriculture, energy production, nutrition and public health). Traditionally used evaluation criteria (e.g. the limiting parameters for discharge into receiving water bodies) are insufficient to evaluate different sanitation options. Decision-making criteria should support the choice of sustainable systems and include consideration of resource conservation, health impact, economic, environmental and social aspects and the technical functionality of the system.
- *Provide stakeholders with the relevant information, enabling them to make an "informed choice":* The range of possibilities to recover and safely use excreta and greywater is often unknown to most stakeholders (including decision-makers), which limits their ability to make an informed choice of a sanitary system and its components. Suitable information and awareness raising are therefore needed.

In addition, it is valuable to:

- integrate educational, institutional and capacity-building aspects into planning instruments;
- focus on the assessment of the needs of the user of the sanitation, the end users of the treated excreta and greywater and the service providers;
- consider smaller planning units and a greater number of decentralized options.

To successfully integrate the additional considerations of safe use-oriented sanitation systems, an appropriate approach to the planning processes must be adopted. A sound basis for such an approach can be found in the Bellagio Principles (Box 11.1), drawn up by the Environmental Sanitation Working Group of the Water Supply and Sanitation Collaborative Council (WSSCC) and endorsed by the Council during its 5th Global Forum in November 2000 in Iguaçu, Brazil. The principles call for a change of conventional sanitation policies and practices worldwide (WSSCC/EAWAG/SANDEC, 2000).

The WSSCC (WSSCC/EAWAG/SANDEC, 2004) has published an implementation guide for the Bellagio Principles, promoting a household-centred environmental sanitation approach with two main components:

1) The focal point of environmental sanitation planning should be the household, reversing the customary order of centralized top-down planning. The users of the services should have a deciding voice in their design, and sanitation issues should be dealt with as close as possible to the site where they occur. With the household as the key stakeholder, women are provided with a strong voice in the planning process, and the government's role changes from that of provider to that of enabler.
2) A circular system of resource management should be used, emphasizing the conservation, recycling and reuse of resources, in contrast to the current linear sanitation service system.

Box 11.1 The Bellagio Principles

1) Human dignity, quality of life and environmental security at the household level should be at the centre of the new approach, which should be responsive and accountable to needs and demands in the local and national setting;
- Solutions should be tailored to the full spectrum of social, economic, health and environmental concerns;
- The household and community environment should be protected;
- The economic opportunities of waste recovery and use should be harnessed.

2) In line with good governance principles, decision-making should involve participation of all stakeholders, especially the consumers and providers of services;
- Decision-making at all levels should be based on informed choices;
- Incentives for provision and consumption of services and facilities should be consistent with the overall goal and objective;
- Rights of consumer and providers should be balanced by responsibilities to the wider human community and environment.

3) Waste should be considered a resource, and its management should be holistic and form part of integrated water resources, nutrient flow and waste management;
- Inputs should be reduced so as to promote efficiency and water and environmental security;
- Exports of waste should be minimized to promote efficiency and reduce the spread of pollution;
- Wastewater should be recycled and added to the water budget.

4) The domain in which environmental sanitation problems are resolved should be kept to the minimum practical size (household, community, town, district, catchment, city) and wastes diluted as little as possible;
- Waste should be managed as close as possible to the source;
- Water should be minimally used to transport waste;
- Additional technologies for waste sanitization and reuse should be developed.

11.2 Local project planning: specific considerations

Individual project planning requires consideration of different issues, including the involvement of stakeholders through the use of participatory approaches, treatment, crop restriction, waste application, human exposure control, costs, technical aspects, support services and training.

11.2.1 Participatory approaches

Effective sanitation and hygiene programmes need to combine interventions to change behaviour with the selection of the right technology. Changing behaviour requires culturally sensitive and appropriate health education. People need to understand, in terms meaningful to their lifestyles and existing belief systems, why better health depends on the adoption of hygienic practices such as hand washing, the use of sanitation systems for the safe management of excreta and greywater, and safe storage and handling of drinking-water and food. Raising awareness about the importance of sanitation and hygiene may increase motivation to change harmful behaviours. Selecting the right sanitation technology is about having effective alternatives and making the right choice for the specific circumstances.

Making the right choice of technology requires an assessment of the costs (both for building the facility and for operation and maintenance) and its effectiveness in a specific setting. Participatory approaches such as Self-esteem, Associative strengths, Resourcefulness, Action-planning, and Responsibility (SARAR) and its focused application Participatory Hygiene and Sanitation Transformation (PHAST) have been effective in increasing sanitation coverage and good hygiene behaviours. SARAR has

Box 11.2 SARAR programme achievements in Mexico

Since its inception in 2003, the TepozEco Municipal Ecological Sanitation Project has used SARAR participatory tools to involve community groups in deepening their understanding of their environment and to develop strategies for improving water and sanitation services. TepozEco has worked closely with a local youth group in the periurban community of San Juan Tlacotenco. Members of this group have been trained as sanitation promoters and facilitators of the community decision-making process. In San Juan, the SARAR tools have been particularly valuable as a way to explore community perceptions of their problems and needs and to maintain the focus of decision-making within the community itself. For example:

- An adaptation of the extremely versatile *three-pile sorting* activity was used to involve the community in analysing and prioritizing various public services: not surprisingly, water and sanitation were at the top of the list.
- In a subsequent session, the *sanitation ladder* permitted the community to identify and compare the range of basic sanitation technologies available to them and to decide which options would be most appropriate given the particular local context (severe seasonal water shortages; absence of a central sewage system now and for the longer term; moderate to low income; need for inexpensive fertilizer for local crops; and a concern to avoid contamination of local streams at the top of the watershed).
- A *community mapping* exercise, the *story-with-a-gap* and a set of hygiene behaviour *sorting cards* helped the community to identify critical interventions, including greywater and solid waste management.

Sarar Transformación SC, responsible for coordinating the TepozEco, together with El Taller, a partner nongovernmental organization, have produced an Ecological Sanitation Educational Tool Kit, to facilitate the replication of the process in other programmes. The package includes a set of participatory materials as well as illustrated *technical guides* to provide information to the community in a timely and easily assimilated format with the aim to achieve better hygiene and sanitation behaviour as well as make use of accessible fertilizers in a safe way.

Source: Sarar Transformación SC, Mexico, 2005 (R. Sawyer, personal communication)

been used successfully as a core tool to start sanitation programmes in places as diverse as Mongolia, Kyrgyzstan, Mozambique, South Africa and El Salvador. Box 11.2 gives some examples of how SARAR tools have been used within the context of the TepozEco Municipal Ecological Sanitation Project in Tepoztlán, Mexico.

11.2.2 Treatment

The different characteristics of specific treatments available (see chapter 5) allow choices regarding the use of nutrients and soil conditioners from excreta or of water from greywater.

When excreta from many small sources are used, verification monitoring and assessment of the treatment efficiency of all the sources are impossible. Secondary off-site treatment is then an informed choice, especially in cities. The collection, treatment and reuse of the excreta can provide economic incentives to small entrepreneurs. In rural areas, however, farmers who have used raw excreta for years may not be easily persuaded to treat it. This should be dealt with by health educators and extension officers.

Whatever method is used for health protection when using excreta or greywater, its implementation is likely to demand a change in behaviour by a large number of individual users, which needs to be part of a sensitization process. One motivating factor might be the greater convenience and privacy of an in-house toilet, the waste from which can be treated, compared with open defecation.

11.2.3 Crop restriction

Crop restriction is relatively simple to implement where the treated excreta and greywater are used by a small number of large organizations, whether they are private firms, cooperatives, state farms or the municipal authority itself. However, the enforcement of crop restrictions on a large number of smaller farmers can be much more difficult. The products most likely to be excluded, such as vegetables for direct human consumption, are among those that would give higher cash yields than waste use to produce animal feed. Crop restriction is not impossible in such circumstances; it is most likely to succeed where local dietary habits limit the demand for uncooked vegetables and where there are profitable alternative crops for which a market exists.

In some countries, the existing planning structures and procedures allow a firm control of all produce grown, with regular inspection of farms and sanctions against those who deviate from agreed arrangements. Such mechanisms can be used at little extra cost to ensure that produce restrictions are followed.

If there is no local experience of the application of crop restrictions, their feasibility should be tested in a trial area before they are implemented on a wide scale. Such a trial will also give an initial estimate of the resources required for enforcement, as well as clarifying the most suitable institutional arrangements for the implementation of restrictions.

Enforcement may not always be as easy as might at first appear. Although a crop may take months to grow and can be inspected throughout this time, the excreta and greywater may need to be applied for only a few days each month, and this can be concealed, even from vigilant inspectors.

11.2.4 Application

The Agriculture Extension Service or the organization of Farmer Field Schools may be in the best position to promote hygienic practices relating to the application of excreta and greywater in agriculture/horticulture. Where a municipal body controls the source of treated excreta or faecal sludge, it may be able to encourage application before harvest periods by making it available only at certain times of the year. As stated in chapter 4, a withholding time should always apply, in addition to on-site/off-site treatment. Alternatively, the agency controlling distribution of the excreta or greywater may itself assume responsibility for the application of the treated products and charge for this service. The workers handling the excreta would then be the employees of a single entity, which would facilitate exposure control measures among them.

Source separation of urine and faeces may facilitate the application of excreta to a large degree, although if large amounts of nutrients are needed, the urine volume to be transported may prove impractical.

11.2.5 Human exposure control

Measures to reduce exposure to pathogens associated with water and sanitation and to promote good case management are well known components of primary health care. They include health education, particularly regarding domestic hygiene.

An obvious measure is to provide access to safe drinking-water and adequate sanitation. Controlling the exposure of users of excreta may have little effect if they continue to be exposed to infectious agents in their drinking-water and in their domestic environment through lack of these basic facilities. Particular care is required to ensure that the use of excreta or greywater does not cause contamination of nearby wells or other sources of drinking-water.

Where salaried workers are involved, their employers have a responsibility to protect them from exposure to pathogens, which in many countries is set down in existing legislation on occupational health. This may need to be brought to the employers' attention, together with guidance on the measures they should take, such as the issuing of protective clothing, particularly footwear and gloves, although these may not be comfortable in a tropical climate. Any effort to promote the issuing of protective clothing by employers must be accompanied by still greater efforts to convince their employees that they must wear it.

Measures to control the exposure of those who handle the produce can be implemented in much the same way as for farm workers. When produce handlers all work for a small number of employers, exposure control fits into a general programme of occupational health. On the other hand, when a large number of small traders are involved in selling or processing the produce, it will be difficult to implement exposure control measures unless they are all gathered together in a market. Most markets are subject to public health inspection, and basic exposure control measures may be a good thing, whether or not crops produced using wastes are being handled. In addition to protecting produce handlers from contamination, they may help to protect safe produce from becoming contaminated by the handlers. Markets are also good places to advise consumers about the hygienic precautions they should take with the food they purchase.

Residents who are not involved in the use of excreta or greywater are best placed to ensure that their health is not put at risk by those who are, once it has been explained to them what precautions are required and what risks they and their families may run if the precautions are not taken. Of course, a government inspector can ensure that fences are built and warning signs put up, but vigilant neighbours will be the first to notice when they need repair or replacement. The establishment of a residents' health committee can be a focus for a health education campaign, as well as providing a locally controlled institution to monitor the practice of waste use. The treatment and operational guidelines will in most instances safeguard the use.

With respect to intestinal helminth infections, treatment of farm workers, their families and other exposed groups through chemotherapy is relatively easy to administer in a formal programme, although additional health personnel may be required to treat a large population. It can be quite popular and provides an excellent opportunity for follow-up with hygiene education activities to publicize simple measures for personal protection. The employers may pay the cost of chemotherapy where salaried workers or sharecroppers work the fields.

If untreated excreta and greywater are used on many small and scattered fields, there are greater logistic problems. An additional problem arises where the excreta or greywater are used informally or illegally.

11.2.6 Costs

The choice of a sanitation and safe use system should also consider the overall costs — both the initial expense of the technology but also the ongoing costs of operation and maintenance. If the cost of those technologies chosen for implementation is likely to exceed the economic benefit of using the wastes, it is important to consider whether less expensive measures might suffice or whether it is worthwhile to use the wastes at all. In most cases, the benefits are likely to justify the costs, but some financial arrangement is needed to ensure that the costs are met from a suitable source. These aspects have been considered in chapter 8.

11.2.7 Technical aspects

Detailed planning for excreta and greywater use schemes should follow the usual national procedures for project planning, supplemented as necessary by the requirements of external funding agencies and by procedures specific to the nature of the project (excreta and/or greywater use and for the required health protection measures).

All relevant information needs to be collected to allow for decisions on the technical specifications of a new scheme. A checklist of these specifications is presented in Box 11.3.

Box 11.3 Technical information to be included in a project plan

- Current and projected generation rates of the wastes (excreta, sludge or greywater); proportion of industrial effluents; dilution by surface water
- Existing and required waste treatment facilities; pathogen removal efficiencies; physicochemical quality
- Existing and required land areas: size, location and soil types
- Energy requirements and energy potential of excreta/greywater (and possibility to combine with other organic waste)
- Evaporation (need for make-up water)
- Conveyance of treated wastes (collection of treated excreta and sludge by farmers or delivery by treatment authority)
- Storage requirements for the wastes
- Waste application rates and methods
- Types of crops and their requirements for waste quality and supplementary nutrients
- Estimated yields of crops per hectare per year
- Strategy for health protection

For each scheme, the planner should seek to maximize the net annual benefit in a manner consistent with labour constraints and the need to protect health and minimize costs. For this, cost estimates are valuable for the various activities, including major construction works for storage, treatment or transport of wastes, land preparation and necessary infrastructure, and also for staffing, treatment, pumping and maintenance as well as other inputs.

An assessment of the benefits requires a forecast not only of the probable yields of the crops grown but also of their anticipated prices. This, in turn, demands a survey to establish that an adequate market exists for the produce. This is particularly important where produce restriction is to be employed as a health protection measure and where the produce to be grown requires industrial processing; in the latter case, sufficient processing capacity must be available.

Projects for the use of treated excreta and faecal sludge are not static; they take time to be implemented and thereafter to evolve and grow. The plan should allow reasonable time scales for all its aspects: to obtain funding, to execute any necessary construction works and to prepare the ground for the scheme to begin. From then on, it should envisage the configuration of the project in each year of its future existence. For some projects, a long-term planning horizon will be needed.

A modest start is often advisable, followed by a phased expansion of the project in subsequent years. This will allow time to train farmers and staff in new methods and for lessons learnt in the early stages to influence later developments. It will also help to ensure that the level of production does not over-reach the current availability of excreta as fertilizers or the demand for the produce grown.

11.2.8 Support services

Various support services to farmers are particularly relevant to the implementation of health protection measures, and detailed consideration should be given to them at the planning stage in larger schemes. They include the following:

- machinery (sales and servicing, or hire);
- supplementary fertilizers or feed, pumps, nets, protective clothing, etc.;
- extension and training;
- marketing services, especially where new crops are introduced or new land brought into productive use;
- primary health care, possibly including regular health checks for workers and their families.

11.2.9 Training

Training requirements must be carefully evaluated at the planning stage, and often it may be necessary to start training programmes before the project begins.

The likely need for extension services must be assessed and provisions made for them to be available to producers after implementation of the project. Extension officers themselves will need training in the methods appropriate to health protection, as will the staff responsible for enforcing sanitary regulations regarding, among other things, produce restriction, occupational health and food hygiene.

Such training requirements are best met by local technical colleges and universities, but many countries may lack the specific expertise needed; overseas training may then be the only alternative in the short term until sufficient in-country experience is developed. This is an area in which cooperation between neighbouring countries can be especially fruitful.

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Annex 1
Glossary of terms used in Guidelines

This glossary does not aim to provide precise definitions of technical or scientific terms, but rather to explain in plain language the meaning of terms frequently used in these Guidelines.

Abattoir – Slaughterhouse where animals are killed and processed into food and other products.

Advanced or tertiary treatment – Treatment steps added after the secondary treatment stage to remove specific constituents, such as nutrients, suspended solids, organics, heavy metals or dissolved solids (e.g. salts).

Anaerobic pond – Treatment pond where anaerobic digestion and sedimentation of organic wastes occur; usually the first type of pond in a waste stabilization pond system; requires periodic removal of accumulated sludge formed as a result of sedimentation.

Aquaculture – Raising plants or animals in water (water farming).

Aquifer – A geological area that produces a quantity of water from permeable rock.

Arithmetic mean – The sum of the values of all samples divided by the number of samples; provides the average number per sample.

Biochemical oxygen demand (BOD) – The amount of oxygen that is required to biochemically convert organic matter into inert substances; an indirect measure of the amount of biodegradable organic matter present in the water or wastewater.

Blackwater – Source-separated wastewater from toilets, containing faeces, urine and flushing water (and eventually anal cleansing water in "washing" communities).

Buffer zone – Land that separates wastewater, excreta and/or greywater use areas from public access areas; used to prevent exposures to the public from hazards associated with wastewater, excreta and/or greywater.

Cartage – The process of manually transporting faecal material off site for disposal or treatment.

Coagulation – The clumping together of particles to increase the rate at which sedimentation occurs. Usually triggered by the addition of certain chemicals (e.g. lime, aluminium sulfate, ferric chloride).

Constructed wetlands – Engineered pond or tank-type units to treat faecal sludge or wastewater; consist of a filtering body planted with aquatic emergent plants.

Cost–benefit analysis – An analysis of all the costs of a project and all of the benefits. Projects that provide the most benefits at the least cost are the most desirable.

Cyst – Environmentally resistant infective parasitic life stage (e.g. *Giardia*, *Taenia*).

Cysticercosis – Infection with *Taenia solium* (pig tapeworm) sometimes leads to cysticerci (an infective life stage) encysting in the brain of humans, leading to neurological symptoms such as epilepsy.

Depuration – Transfer of fish to clean water prior to consumption in an attempt to purge their bodies of contamination, potentially including some pathogenic microorganisms.

Diarrhoea – Loose, watery and frequent bowel movements, often associated with an infection.

Disability adjusted life years (DALYs) – Population metric of life years lost to disease due to both morbidity and mortality.

Disease – Symptoms of illness in a host, e.g. diarrhoea, fever, vomiting, blood in urine, etc.

Disinfection – The inactivation of pathogenic organisms using chemicals, radiation, heat or physical separation processes (e.g. membranes).

Drain – A conduit or channel constructed to carry off stormwater runoff, wastewater or other surplus water. Drains can be open ditches or lined, unlined or buried pipes.

Drip irrigation – Irrigation delivery systems that deliver drips of water directly to plants through pipes. Small holes or emitters control the amount of water that is released to the plant. Drip irrigation does not contaminate aboveground plant surfaces.

Dual-media filtration – Filtration technique that uses two types of filter media to remove particulate matter with different chemical and physical properties (e.g. sand, anthracite, diatomaceous earth).

Effluent – Liquid (e.g. treated or untreated wastewater) that flows out of a process or confined space).

Encyst – The development of a protective cyst for the infective stage of different parasites (e.g. helminths such as foodborne trematodes, tapeworms, and some protozoa such as *Giardia*).

Epidemiology – The study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to the control of health problems.

***Escherichia coli* (*E. coli*)** – A bacterium found in the gut, used as an indicator of faecal contamination of water.

Excreta – Faeces and urine (see also faecal sludge, septage and nightsoil).

Exposure – Contact of a chemical, physical or biological agent with the outer boundary of an organism (e.g. through inhalation, ingestion or dermal contact).

Exposure assessment – The estimation (qualitative or quantitative) of the magnitude, frequency, duration, route and extent of exposure to one or more contaminated media.

Facultative pond – Aerobic pond used to degrade organic matter and inactivate pathogens; usually the second type of pond in a waste stabilization pond system.

Faecal sludge – Sludges of variable consistency collected from on-site sanitation systems, such as latrines, non-sewered public toilets, septic tanks and aqua privies. Septage, the faecal sludge collected from septic tanks, is included in this term (see also excreta and nightsoil).

Flocculation – The agglomeration of colloidal and finely divided suspended matter after coagulation by gentle stirring by either mechanical or hydraulic means.

Geometric mean – A measure of central tendency, just like a median. It is different from the traditional mean (which is called the arithmetic mean) because it uses multiplication rather than addition to summarize data values. The geometric mean is a useful summary when changes in the data occur in a relative fashion.

Greywater – Water from the kitchen, bath and/or laundry, which generally does not contain significant concentrations of excreta.

Groundwater – Water contained in rocks or subsoil.

Grow-out pond – Pond used to raise adult fish from fingerlings.

Hazard – A biological, chemical, physical or radiological agent that has the potential to cause harm.

Health-based target – A defined level of health protection for a given exposure. This can be based on a measure of disease, e.g. 10^{-6} DALY per person per year, or the absence of a specific disease related to that exposure.

Health impact assessment – The estimation of the effects of any specific action (plans, policies or programmes) in any given environment on the health of a defined population.

High-growing crops – Crops that grow above the ground and do not normally touch it (e.g. fruit trees).

High-rate treatment processes – Engineered treatment processes characterized by high flow rates and low hydraulic retention times. Usually include a primary treatment step to settle solids followed by a secondary treatment step to biodegrade organic substances.

Hydraulic retention time – Time the wastewater takes to pass through the system.

Hypochlorite – Chemical frequently used for disinfection (sodium or calcium hypochlorite).

Indicator organisms – Microorganisms whose presence is indicative of faecal contamination and possibly of the presence of more harmful microorganisms.

Infection – The entry and development or multiplication of an infectious agent in a host. Infection may or may not lead to disease symptoms (e.g. diarrhoea). Infection can be measured by detecting infectious agents in excreta or colonized areas or through measurement of a host immune response (i.e. the presence of antibodies against the infectious agent).

Intermediate host – The host occupied by juvenile stages of a parasite prior to the definitive host and in which asexual reproduction often occurs (e.g. for foodborne trematodes or schistosomes the intermediate hosts are specific species of snails).

Legislation – Law enacted by a legislative body or the act of making or enacting laws.

Localized irrigation – Irrigation application technologies that apply the water directly to the crop, either through drip irrigation or bubbler irrigation. Generally use less water and result in less crop contamination and reduce human contact with the wastewater.

Log reduction – Organism removal efficiencies: 1 log unit = 90%; 2 log units = 99%; 3 log units = 99.9%; and so on.

Low-growing crops – Crops that grow below, on or near the soil surface (e.g. carrots, lettuce).

Low-rate biological treatment systems – Use biological processes to treat wastewater in large basins, usually earthen ponds. Characterized by long hydraulic retention times. Examples of low-rate biological treatment processes include waste stabilization ponds, wastewater storage and treatment reservoirs and constructed wetlands.

Maturation pond – An aerobic pond with algal growth and high levels of bacterial removal; usually the final type of pond in a waste stabilization pond system.

Median – The middle value of a sample series (50% of the values in the sample are lower and 50% are greater than the median).

Membrane filtration – Filtration technique based on a physical barrier (a membrane) with specific pore sizes that traps contaminants larger than the pore size on the top surface of the membrane. Contaminants smaller than the specified pore size may pass through the membrane or may be captured within the membrane by some other mechanism.

Metacercariae (infective) – Life cycle stage of trematode parasites infective to humans. Metacercariae can form cysts in fish muscle tissue or on the surfaces of plants, depending on the type of trematode species.

Multiple barriers – Use of more than one preventive measure as a barrier against hazards.

Nightsoil – Untreated excreta transported without water, e.g. via containers or buckets; often used as a popular term in an unspecific manner to designate faecal matter of any origin; its technical use is therefore not recommended.

Off-site sanitation – System of sanitation where excreta are removed from the plot occupied by the dwelling and its immediate surroundings.

On-site sanitation – System of sanitation where the means of storage are contained within the plot occupied by the dwelling and its immediate surroundings. For some systems (e.g. double-pit or vault latrines), treatment of the faecal matter happens on site also, through extended in-pit consolidation and storage. With other systems (e.g. septic tanks, single-pit or vault installations), the sludge has to be collected and treated off site (see also faecal sludge).

Oocyst – A structure that is produced by some coccidian protozoa (i.e. *Cryptosporidium*) as a result of sexual reproduction during the life cycle. The oocyst is usually the infectious and environmental stage, and it contains sporozoites. For the enteric protozoa, the oocyst is excreted in the faeces.

Operational monitoring – The act of conducting a planned sequence of observations or measurements of control parameters to assess whether a control measure is operating within design specifications (e.g. for wastewater treatment turbidity). Emphasis is given to monitoring parameters that can be measured quickly and easily and that can indicate if a process is functioning properly. Operational monitoring data should help managers to make corrections that can prevent hazard break-through.

Overhanging latrine – A latrine that empties directly into a pond or other water body.

Pathogen – A disease-causing organism (e.g. bacteria, helminths, protozoa and viruses).

pH – An expression of the intensity of the basic or acid condition of a liquid.

Policy – The set of procedures, rules and allocation mechanisms that provide the basis for programmes and services. Policies set priorities and often allocate resources for their implementation. Policies are implemented through four types of policy instruments: laws and regulations; economic measures; information and education programmes; and assignment of rights and responsibilities for providing services.

Primary treatment – Initial treatment process used to remove settleable organic and inorganic solids by sedimentation and floating substances (scum) by skimming. Examples of primary treatment include primary sedimentation, chemically enhanced primary sedimentation and upflow anaerobic sludge blanket reactors.

Quantitative microbial risk assessment (QMRA) – Method for assessing risk from specific hazards through different exposure pathways. QMRA has four components: hazard identification; exposure assessment; dose–response assessment; and risk characterization.

Regulations – Rules created by an administrative agency or body that interpret the statute(s) setting out the agency's purpose and powers or the circumstances of applying the statute.

Restricted irrigation – Use of wastewater to grow crops that are not eaten raw by humans.

Risk – The likelihood of a hazard causing harm in exposed populations in a specified time frame, including the magnitude of that harm.

Risk assessment – The overall process of using available information to predict how often hazards or specified events may occur (likelihood) and the magnitude of their consequences.

Risk management – The systematic evaluation of the wastewater, excreta or greywater use system, the identification of hazards and hazardous events, the assessment of risks and the development and implementation of preventive strategies to manage the risks.

Secondary treatment – Wastewater treatment step that follows primary treatment. Involves the removal of biodegradable dissolved and colloidal organic matter using high-rate, engineered aerobic biological treatment processes. Examples of secondary treatment include activated sludge, trickling filters, aerated lagoons and oxidation ditches.

Septage – Sludge removed from septic tanks.

Septic tank – An underground tank that treats wastewater by a combination of solids settling and anaerobic digestion. The effluents may be discharged into soak pits or small-bore sewers.

Sewage – Mixture of human excreta and water used to flush the excreta from the toilet and through the pipes; may also contain water used for domestic purposes.

Sewer – A pipe or conduit that carries wastewater or drainage water.

Sewerage – A complete system of piping, pumps, basins, tanks, unit processes and infrastructure for the collection, transporting, treating and discharging of wastewater.

Sludge – A mixture of solids and water that settles to the bottom of latrines, septic tanks and ponds or is produced as a by-product of wastewater treatment (sludge produced from the treatment of municipal or industrial wastewater is not discussed in this volume).

Source separation – Diversion of urine, faeces, greywater or all, followed by separate collection (and treatment).

Subsurface irrigation – Irrigation below the soil surface; prevents contamination of aboveground parts of crops

Surface water – All water naturally open to the atmosphere (e.g. rivers, streams, lakes and reservoirs).

Thermotolerant coliforms – Group of bacteria whose presence in the environment usually indicates faecal contamination; previously called faecal coliforms.

Tolerable daily intake (TDI) – Amount of toxic substance that can be taken on a daily basis over a lifetime without exceeding a certain level of risk

Tolerable health risk – Defined level of health risk from a specific exposure or disease that is tolerated by society, used to set health-based targets.

Turbidity – The cloudiness of water caused by the presence of fine suspended matter.

Ultraviolet radiation (UV) – Light waves shorter than visible blue-violet waves of the spectrum (from 380 to 10 nanometres) used for pathogen inactivation (bacteria, protozoa and viruses).

Unrestricted irrigation – The use of treated wastewater to grow crops that are normally eaten raw.

Upflow anaerobic sludge blanket reactor – High-rate anaerobic unit used for the primary treatment of domestic wastewater. Wastewater is treated during its passage through a sludge layer (the sludge "blanket") composed of anaerobic bacteria. The treatment process is designed primarily for the removal of organic matter (biochemical oxygen demand).

Validation – Testing the system and its individual components to prove that it is capable of meeting the specified targets (i.e. microbial reduction targets). Should take place when a new system is developed or new processes are added.

Vector – Insect that carries disease from one animal or human to another (e.g. mosquitoes).

Vector-borne disease – Diseases that can be transmitted from human to human via insects (e.g. malaria).

Verification monitoring – The application of methods, procedures, tests and other evaluations, in addition to those used in operational monitoring, to determine compliance with the system design parameters and/or whether the system meets specified requirements (e.g. microbial water quality testing for *E. coli* or helminth eggs, microbial or chemical analysis of irrigated crops).

Waste-fed aquaculture – Use of wastewater, excreta and/or greywater as inputs to aquacultural systems.

Waste stabilization ponds (WSP) – Shallow basins that use natural factors such as sunlight, temperature, sedimentation, biodegradation, etc., to treat wastewater or faecal sludges. Waste stabilization pond treatment systems usually consist of anaerobic, facultative and maturation ponds linked in series.

Wastewater – Liquid waste discharged from homes, commercial premises and similar sources to individual disposal systems or to municipal sewer pipes, and which contains mainly human excreta and used water. When produced mainly by household and commercial activities, it is called domestic or municipal wastewater or domestic sewage. In this context, domestic sewage does not contain industrial effluents at levels that could pose threats to the functioning of the sewerage system, treatment plant, public health or the environment.

Withholding period – Time to allow pathogen die-off between waste application and harvest.

The third edition of the WHO ***Guidelines for the safe use of wastewater, excreta and greywater*** has been extensively updated to take account of new scientific evidence and contemporary approaches to risk management. The revised Guidelines reflect a strong focus on disease prevention and public health principles.

This new edition responds to a growing demand from WHO Member States for guidance on the safe use of wastewater, excreta and greywater in agriculture and aquaculture. Its target audience includes environmental and public health scientists, researchers, engineers, policy-makers and those responsible for developing standards and regulations.

The Guidelines are presented in four separate volumes: ***Volume 1: Policy and regulatory aspects; Volume 2:Wastewater use in agriculture; Volume 3: Wastewater and excreta use in aquaculture; and Volume 4: Excreta and greywater use in agriculture.***

Volume 4 of the Guidelines focuses exclusively on the safe use of excreta and greywater in agriculture. Recent trends in sanitation, including ecological sanitation, are driven by rapid urbanization. The momentum created by the Millennium Development Goals is resulting in dramatic changes in human waste handling and processing. New opportunities enable the use of human waste as a resource for pro-poor agricultural development, particularly in periurban areas. Best practice to minimize associated health risks is at the heart of this volume.

ISBN 92 4 154685 9

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