European Research Tour Summary

Ecological Sanitation in Europe : a pathway for Quebec (Canada)

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October 7th 2008

STEPPE

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Research Tour Goals

1. To get “on the edge” knowledge and identify knowledge gaps;
2. Identify the main research institutions involved in Ecosan and their focus of research;
3. Meet people and establish contact.

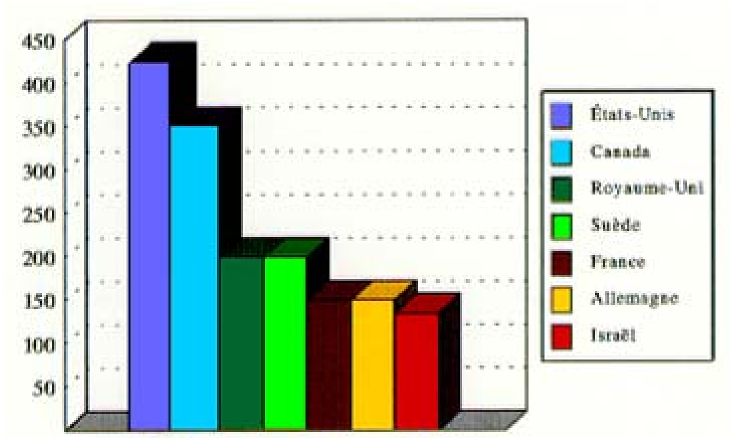
Thesis context, goals and methodology

Quebec's context (23% of Canada's population)

- Daily home production per person

Wastewater				Residual organic matter	
Urine	Faecal matter	Toilet flush water	Grey water	Food residues	Green residues
1,36 L [1]	**0,14 kg [2]**	**90 L [4-5]**	**180 L [4-5]**	**220 g [3]**	**270 g [3]**
• Physico-chemical treatment (for most of sewage) • Most houses don't have water meter				• 8 % reuse (central composting) [6]	

Total daily consumed water per person (litres)



http://services.ville.montreal.qc.ca/station (2002)

(1) Otterpohl (2000)
(2) Remy & Ruhland (2006)
(3) Recyc-Québec (2004)
(4) Ville de Montréal (2002)
(5) Ministère enviro Qc (2002)
(6) Recyc-Québec (2007)

Quebec's context (23% of Canada's population)

- Ecological sanitation (Ecosan) concept is unknown
- Low electricity price (~4 cents Euro/kWh)
- 94% of our electricity comes from hydro-electricity
- Micro-production of electricity begins to be encouraged (experimental)

Photo : www.hydroquebec.com/professeurs/visites-scolaires/cote_nord.html

Conclusions from my literature review

1. Central anaerobic digestion of organic waste would be more environment friendly, but central composting is less costly (~20% less);
2. Transportation can have a medium to a significant impacts in system life on both cost and environment (conclusions differ from different studies);
3. Ecosan projects work in urban context and have great potential (Conclusions from the Ecosan project at the Stahndorf's WWTP in Berlin [(1)]);
4. A LCA study concludes that new sanitation concepts have many ecological advantages on conventional systems [(2)];
5. New sanitation concepts are not more or much more expensive than conventional systems [(3)];
6. No optimum scale for an Ecosan project has been determined in a western society context yet;
7. No Ecosan design has been considered for Canada yet.

(1) Peter-Fröhlich, A. et Al. (2006) Sanitation Concepts for Separate treatment of Urine, Faeces and Greywater (SCST) – Results. EU-Demonstration project, Berlin, http://www.kompetenz-wasser.de/SCST-Downloads.295.0.html?&L=2
(2) Remy C.& Ruhland, A. 2006. Ecological assessment of alternative sanitation concepts with Life Cycle Assessment, TU-Berlin, Germany, http://www.kompetenz-wasser.de/SCST-Downloads.295.0.html?&L=2
(3) Oldenburg, M. 2007. Final cost calculation report for the demonstration project “Sanitation Concepts for Separate Treatment of Urine, Faeces and Greywater “ (SCST), Germany, http://www.kompetenz-wasser.de/SCST-Downloads.295.0.html?&L=2

Research objectives

1. To determine the optimum scale for an ecological sanitation project (could be in the city of Montreal);
2. To compare the performance of different alternatives (ecosan project) with the reference system;
3. To compare anaerobic digestion and composting of combined organic waste and brown/blackwater;
4. To provide crucial information to city planners, legislators and real estate developers.

Research hypothesis

An optimum scale of an ecological sanitation project exists based on environmental, technical, economical and social criteria in an urban context (See notes 1 and 2).

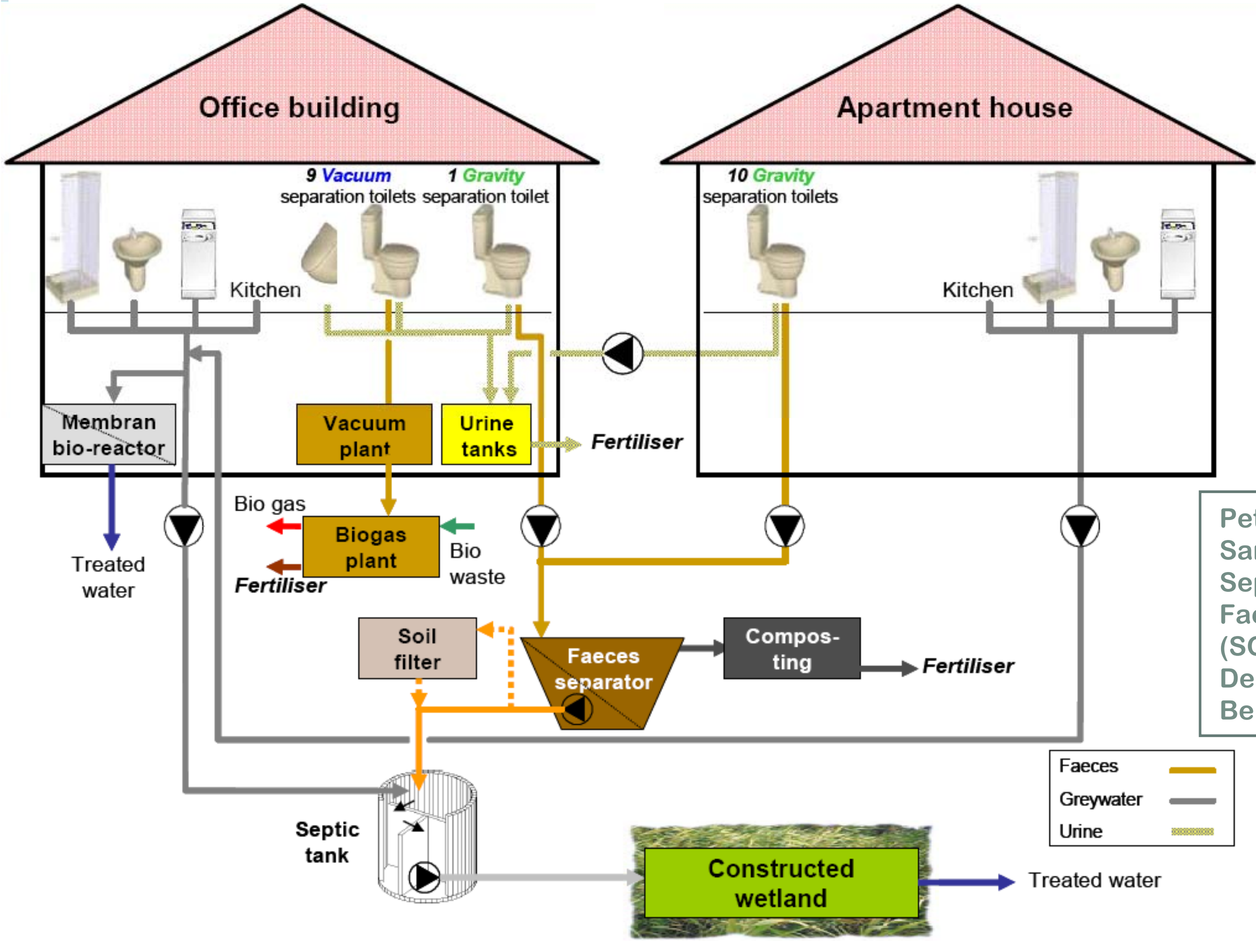
Note 1: In other words : Using a sustainable perspective, is it better to implement an Ecosan project for 250 people, 1000, 5 000, 25 000 or 100 000 ?

Note 2: The assessment could be applied for a quarter in the city of Montreal, Quebec (Canada)

Technical concepts considered (A)

1. Two Ecosan approaches

1. Vacuum toilet+biogas   2. Gravity toilet+composting



Peter-Fröhlich et Al. (2006) Sanitation Concepts for Separate treatment of Urine, Faeces and Greywater (SCST) – Results. EU-Demonstration project, Berlin

Technical concepts considered (B)

2. Technological systems details

Sub-functions	*Technologies*
1. Toilets	Urine diversion or not (to be determined)
2. Collection systems	Vacuum and gravity
3. Treatment systems	
- Faeces and org. matter	Digestion and composting
- Urine	Storage or nutrients extraction
- Greywater	Constructed wetland or Activated sludge process (SBR or MBR)
(Biogas usage)	Thermal energy or bio-methane
4. Storage	Tank (urine, digestate, compost)
5. Transport and spreading	Cistern / equipment for spreading

Methodology (A)

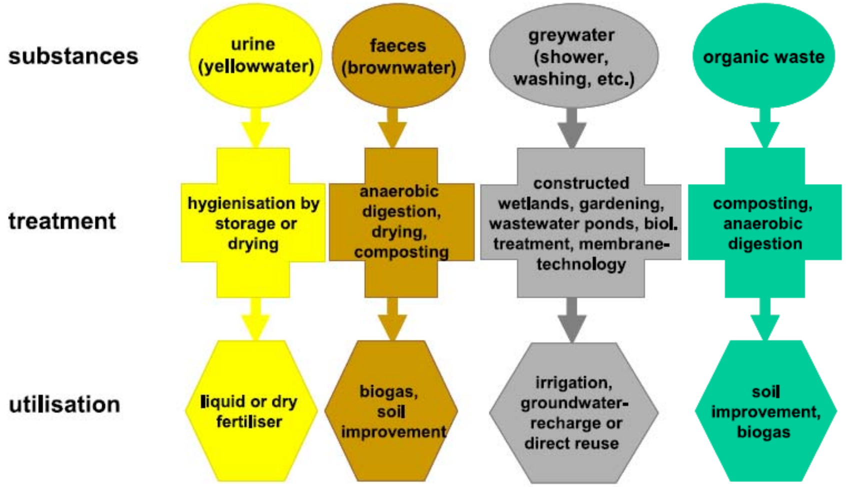
1. System's functions

Primary : To collect, transport, treat and dispose of the organic matter and wastewater

Secondary : To produce energy and nutrients

2. Functional unit

To realise these functions for one person on a one-year period



Adapted from Langergraber, G. & Muellegger, E. (2005)
Ecological Sanitation – a way to solve global sanitation problems?
Environmental International, vol. 31, nº3, p.433-444

Methodology (B)

Implementation scenarios*

Scenario nº 1 :	250 inhabitants
Scenario nº 2 :	1 000 inhabitants
Scenario nº 3 :	5 000 inhabitants**
Scenario nº 4 :	25 000 inhabitants
Scenario nº 5 :	100 000 inhabitants
Scenario nº 6 :	400 000 inhabitants*** (reference system A)
Scenario nº 7 :	1 800 000 inhabitants**** (reference system B)

* Systems modeling considers that systems are implemented in new buildings
** System nº3 : based on the LCA made in the frame of new sanitation concepts at Stahndorf's WWTP (Remy, 2006)
*** System nº6 (reference system A) : organic waste system analysis by a research group in Montreal (CIRAIG)
**** System nº7 (reference system B) : combined sewer management in Montreal, Quebec (Canada)

Methodology (C)

Two research phases

Phase 1 : Technical, economical and social analysis

Technical criteria

- Flexibility
- Feasibility
- Durability (robustness)
- Quantity and quality of biogas and nutrients

Social criteria

- Acceptability by inhabitants/farmers
- Health impact
- Law conformity

Economical criteria

- Construction/operation/maintenance costs
- Sales from products (biogas and nutrient)

Phase 2 : Environmental analysis (lifecycle assessment)

Resources consumption

Water, materials, energy and nutrients

Output management

Air, water and soil

Research Tour Summary


Credit: Charles Thibodeau

Arno Rosemarin & an ecosan building model,
Stockholm Environment Institute

Research institutions involved in ecological sanitation (that I visited or contacted)

The Netherlands

1. UNESCO-IHE
2. Wageningen University
3. WETSUS
4. TU-Delft

Germany

1. Tech. Univ. of Hamburg-Harburg
2. University of Bonn
3. Berlin Cent. of Competence for Water
4. Techn. Univ. of Kaiserslautern
5. Huber Technology
6. Fraunhofer - ISI
7. GTZ

Sweden

1. SEI – EcoSanRes
2. Royal Institute of Technology
3. University of Agricultural Science
4. Institute of Agricultural and Environmental Engineering
5. Urban Water
6. Ecoloop

Other countries

1. Eawag/Sandec (Switzerland)
2. UMB (Norway)
3. University of Natural Resources and Applied Life Sciences (Austria)
4. California University (USA)

Ecological sanitation's context (A)

1. Factors catalyzing adoption

« Resources costs increase and environmental awareness diffusion »

- Increasing fertilizer costs [(1)];
- Increasing costs for the public facilities refurbishment;
- Increasing costs for collecting and transporting the waste (fuel costs);
- Increasing energy cost (biogas produced is really interesting);
- Increasing drinking water cost;
- Increasing costs for the treatment of wastewater sludge;
- Climate change and environmental quality awareness;
- Concerns about pharmaceuticals and hormones in the water bodies [(2)].

(1) Presentation of Arno Rosemarin, EcoSanRes, Stockholm Environment Institute
(2) Many articles made by Eawag and Martina Winker

Ecological sanitation's context (B)

2. Adoption barriers

« Sanitation is not considered as a priority and Ecosan meets typical new technology obstacles »

- Wastewater facilities are well implemented. « The problem is solved, let's work on something else. » (Example of Germany) [(1)] ;
- Additional cost for the new sanitation concept appliances in a new home is about 3%. (cases in Sweden from urine diversion only) [(2)] ;
- New sanitation concept ignorance and public authorities [(3)], engineers and construction industry conservatism [(4)];
- Uncertainties about human excreta total innocuity when used as fertilizer [(5);]
- Human excreta is not accepted as a fertilizer in biological farming [(6)].

(1) Discussion with Ralf Otterpohl, TUHH, Germany
(2) Discussion with Mats Johansson, Sweden
(3) Discussion with Detlef Schwager, engineer, Germany
(4) Conseil de la construction du Quebec
(5) Many articles made by Eawag and Martina Winker
(6) Kvarnström, E. & Al. 2006. Urine diversion, one step towards sustainable sanitation. EcoSanRes publication.

Three approaches [1] (managing urine, faeces and org. matter)

Sanitation with water (high tech)

Approach 1

Vacuum toilet **without urine diversion** that sends blackwater in a digester with the addition of biowaste to produce **biogas**. Greywater is treated in a constructed wetland or in a SBR/MBR.

Approach 2

Urine diversion toilet that sends faeces (after filtration) in a **compost** bin to be treating with biowaste. Greywater treatment and brown water filtrate in a constructed wetland, a SBR or a MBR.

Sanitation without water (low tech)

Approach 3

Urine diversion toilet **without water** with reuse of faeces and biowaste after **composting**. Greywater treatment in a constructed wetland, a SBR or MBR.

* Although the compost is always reused on agricultural lands without any transformation (transportation by truck), urine and faeces digestate can be treated (compression for urine and nutrient recovery for urine and faeces).

(1) Otterpohl, R. (2008) Ecological sanitation, high, medium and low tech solutions, Powerpoint Presentation

Approach selection criteria

1. Water scarcity and prize;
2. System technological complexity level;
3. Technician skills (construction and maintenance);
4. User acceptance;
5. Treated matter reuse options;
6. Environmental goals and priorities;
7. Economic situation;
8. Implementation size.

Implementation scale for some case studies

Approach 1 (no urine diversion and biogas)

1. Flintenbreite, Germany (TUHH) — Nb of people: 250
2. Sneek, NL (Wageningen Univ.) — Nb of people: 300
3. Knittligen, Germ. (Fraunhofer - ISI) — Nb of people: 350 (potential)
4. Students residence, Norw. (UMB) — Nb of people: 45

Approach 2 (urine diversion and composting)

1. Eklandaskolan school, Sweden — Nb of students:~450
2. SolarCity Pichling, Austria (Otterwasser) — Nb of people: ~250
3. Lambertsmühle, Germany (TUHH) — Nb of people: ~8

Approach 3 (dry with urine diversion and composting)

1. Gebers, Sweden (Verna Ecology) — Nb of people: 80
2. Erdos, China (SEI – EcoSanRes) — Nb of people: 2900

Minimum implementation scale for approach 1

The minimum implementation scale for cost effectiveness differs from one expert to the other. Nevertheless, minimum scale converged to a range between **200 and 600 people**.

A doctorate student from TUHH (Germany) told me that the minimum scale to implement thermophilic anaerobic digester is around 20 000 people.

Anaerobic digester size has a major cost impact (energy consumption) on both capitalization and operation costs. Smaller is the anaerobic digester, higher will be the heat required per unit of mass of effluent treated.

Credit: Charles Thibodeau

Digester, Experimental lab, TUHH, Germany

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Urine diversion or not in approach 1 ?

Advantages of urine diversion

1. Treatment of urine and faeces more efficient;
2. pH variation in the digester can be more tolerated (less ammonia);
3. Potential to save more water;
4. Micro-pollutants (pharm.+hormones) from urine easier to remove;
5. Less water in the digestate (easier to handle).

Advantages to collect and treat blackwater as a whole (using vacuum toilet)

1. Has only one pipe instead of two (less costly);
2. The vacuum toilet system is efficient (no struvite deposition problem);
3. The vacuum toilet is efficient as it is sold right now (there is no urine diversion vacuum toilet available and efficient);
4. Doesn't require westerner habit change;
5. Need only one truck to collect and transport the residual matter (digestate is only one fraction);
6. Toilet cleaning easy to perform;
7. Digestate reuse as a whole (only one fraction to handle).

Case study: Flintenbreite-Lübeck, Germany (A) [(1)]

1. 35 apartments now, but will increase to 117 (350 people).
2. Two vacuum toilets for each apartment;
3. Three constructed wetlands for greywater treatment 1) One metre deep 2) Five to six greywater feed per day 3) Even distribution of greywater 4) Surface: 2 m^2/pers;
4. For the project success, it is really important to educate and to raise user environment awareness. (Ex.: Use of phosphate-free detergent);
5. When the mesophilic digester will start, the biogas will be used for cogeneration (heat and electricity). Upon biogas shortage, natural gas will be used for backing;

Credit: Charles Thibodeau

Constructed wetland, Flintenbreite-Lübeck, Germany

(1) Ralf Otterpohl, professor, TUHH, Germany

Case study: Flintenbreite-Lübeck, Germany (B) (1)

6. Stabilisation digestate tank volume : 50 m^3;
7. Biogas storage tank volume : 20 m^3;
8. A maintenance employee is required full time to prevent and repair any system malfunctions and to collect organic matter;
9. The technical room didn't smell good! They will soon install a biofilter;
10. A MBR will perhaps be preferred to constructed wetland for the greywater treatment for the next housing units.

Credit: Charles Thibodeau

Digester (will run soon),
Flintenbreite-Lübeck, Germany

(1) Ralf Otterpohl, professor, TUHH, Germany

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Case study : Sneek, The Netherlands (A) (1)

1. 30 apartments now. Should built 200 more;
2. The system is equipped with an energy recovery unit (heat from the digestate);
3. The vacuum station is discharged six times a day in the digester for a short time (12 seconds) each time;
4. Biogas is burned in a sanitary waterheater. The system will soon be transformed to heat service water to heat buildings in winter (hot service water will be stored in an aquifer in summer);

Credit: Charles Thibodeau

Desar project, Sneek, The Netherlands

(1) Presentation of Brendo Meulman in Wageningen conference, May 2008, The Netherlands

Case study : Sneek, The Netherlands (B) (1)

5. System equipped with Anammox process for the removal of 70% of Nitrogen in N_2 form and Struvite precipitation (~80% of P removal);
6. Digester HRT: 33 days;
7. Food residue and paper don't cause any vacuum collection problem because the shredder is efficient;
8. MBR for greywater treatment;
9. One problem: corrosion of the facility's metal
10. They designed the biogas tank system with the collaboration of the firefighters department and everything went fine.

Credit: Charles Thibodeau

Brendo Meulman, Technical room
Desar project, Sneek, The Netherlands

(1) Presentation of Brendo Meulman in Wageningen conference, May 2008, The Netherlands

One dutch experience from urine diversion toilet use

Meeting with Arjen van der Mark (Reest & Wieden, The Netherlands)

1) Toilet paper can block the urine collection pipe;
2) People press on the big button (big flush) usually reserved for defecation, because the small and big buttons are not well differentiated.
3) Urine obtained is five to ten times more diluted than pure urine. Their goal is to get a two to five times dilution;
4) Maintenance issue: it is very important that people can go in stores buy the parts needed. This is not always the case right now;
5) Cost is 500 Euros for two urine diversion toilet (one house).

Credit: Charles Thibodeau

Urine diversion concept exhibition room
Reest & Wieden, Water public autority,
The Netherlands

Vacuum (toilet) collection: fact sheet (A)

1) Station can be located as far as 3 km from a collection inlet [1];
2) Vacuum pipe diameter: 90 mm [2];
3) Food can be vacuum-collected, but the maximum total solids concentration is unknown;
4) Nb of connected units [3]: 1) Min: 25 houses 2) Minimum cost effectiveness: 70-100 homes 3) Typical : 200 à 300 homes;
5) To prevent water consumption and operation technical problem, it would be preferable to collect the organic waste manually (wheel bin) [1]

(1) Hans-Christian Rüster, Director Vacuum Sanitation Systems, Roediger Vacuum, Germany
(2) Discussion with Brendo Meulman, Landustrie, The Netherlands
(3) Crites, R.W. & Tchobanoglous, G. 1998. Small & Decentralized Wastewater Management Systems, WCB/McGraw-Hill, 1084 pages.

Vacuum (toilet) collection: fact sheet (B)

6) Cost is a very important factor. Many customers don't call back after they read our first proposal [1];

7) This new approach surely has a future: water pipes refurbishment cost is rising and new waterpipe constructions are rare [1];

8) Case studies in Dubaï [1]:
   1) One vacuum station for 23 000 persons;
   2) Two vacuum stations for 40 000 persons;

9) Biofilters are required to treat methane emissions from the vacuum pipes [1].

Brendo Meulman, Vacuum station
Desar project, Sneek, The Netherlands

(1) Hans-Christian Rüster, Director Vacuum Sanitation Systems, Roediger Vacuum, Germany

Greywater treatment

Membrane bio-reactor (MBR)

1. Requires one maintenance employee (1);
2. Effluent respects the irrigation water standards (1).

Constructed wetland

1. Required surface: 2 m²/pers. (Germany);
2. Main management challenge: maintenance. Can't be left in users' hands (2);
3. Filter media (sand/gravel) must be kept unfrozen to maintain the treatment performance (3).

Credit: Charles Thibodeau

Constructed Wetland in a home front yard
Detlef Schwager and his daughter
Roeblingen am See, Germany

(1) Discussion with Ralf Otterpohl, Professor, TUHH, Germany
(2) Discussion with Detlef Schwager, Sanitation engineer, Germany
(3) Discussion with Tom Headley, Researcher, UFZ, Germany

Urine treatment (A)

1. Ozone disinfection is 7-fold less energy-consuming than UV [1];
2. Minimal conditions to use steam stripping process [2]:
   1) Feed of 100L of urine/h;
   2) High pH (odour);
   3) 10 meters high stripping column.
3. In Sweden, pharmaceuticals and human hormones are not really an issue, while in Switzerland and Germany they are real concerns;
4. If we consider urine micro-pollutants removal important, why nobody is considering micro-pollutants in faeces or digestate ?

Credit: GTZ, www.gtz.de

Urine tank, GTZ headquarter
Eschborn, Germany

(1) Discussion with Felix Tettentorn, Doctorate student, TUHH, Germany
(2) Discussion with Joachim Behrent, Professor, TUHH, Germany

Urine treatment (B)

5. Urine treatment functions [1] to be assessed before being included in the system under investigation:
   1) Hygienization;
   2) Volume reduction;
   3) Nutrients extraction;
   4) Stabilization.

6. Urine treatment functions [1] that won't be considered:
   1) Micro-pollutants (pharm. + hormones) removal or destruction treatment;
   2) Nutrients elimination.

7. Three technological paths possible (up to now for my research):
   1) Urine storage + Transport (towards agricultural lands);
   2) Urine acidification + Urine storage + Transport;
   3) Struvite precipitation + Zeolites adsorption + Transport of MAP and N from Zeolites and residual urine sent in the constructed wetland.

(1) Maurer, M. 2006. Treatment processes for source-separated urine. Water Research, vol.40, p.3151-3166

Urine treatment (C)

Reasons for not considering micro-pollutants (MP) elimination functions (ozonation) as part of the studied system :

1. Environmental impacts are not well understood [(1-4)];
2. Existing MP concentration is too low to be measurable. In addition, based on the case of ibuprofen for instance, MP concentration captured by plants doesn't follow a linear relationship with the exposed concentration [(2)];
3. Ozonation treatment produces 1) AOX 2) Metabolites. We don't know the environmental impacts of these by-products. [(2)]

Other related facts

1. In drinking water, we can find around 5 ng of MP/L [(2)]. We would have to take thousands of water glasses to take the equivalent dose of one control birth pill [(3)].
2. Many people try to frighten people about potentials effects of micro-pollutants even though these are not known yet [(2)].
3. Real question: can we tolerate this risk, as we tolerate to breath in benzene while we are filling up the fuel tank ?

(1) Maurer, M. 2006. Treatment processes for source-separated urine. Water Research, vol.40, p.3151-3166
(2) Discussion with Martina Winker, Doctorant student, TUHH, Germany
(3) Lecture of George Tchobanoglous (University of California) in UMB, Norway
(4) Remy C.& Ruhland, A. 2006. Ecological assessment of alternative sanitation concepts with Life Cycle Assessment, TU-Berlin, Germany, http://www.kompetenz-wasser.de/SCST-Downloads.295.0.html?&L=2

Anaerobic digestion facility, Freiburg, Germany

1. City's and surroundings' organic waste management (~460 000 people)
2. 30 000 tons/year
3. 8 500 000 kWh-electricity/year
4. 9 000 tons of compost
5. 11 employees
6. Collection every week (organic waste fraction)
7. Digester feeding: 2 times/day, 6 days/week
8. Control parameters: 1) VFA 2) Methane 3) NH_3 4) pH
9. Digestate reuse: 1) Before sowing and after harvesting, some farmers apply the digestate without further treatment 2) The rest of the year, the digestate is separated in a solid and a liquid fraction (solid part is composted)
10. Facility problems: 1) Corrosion (caused by acid emissions (H_2S) from the organic matter) 2) Getting rid of the plastic bags that are put in the organic waste collection bin.

Credit: Charles Thibodeau

Anaerobic digestion facility, Freiburg

Anaerobic digestion facility, Passau (Munich), Germany

1. City's and surroundings' organic waste management;
2. 15 000 tons/year;
3. 11 employees;
4. Collection: one week for organic waste fraction and one week for other waste;

Credit: Charles Thibodeau

Compost store house
Anaerobic digestion facility, Passau

5. Input impurities (mass): 3% (e.g. plastic bags, rocks, etc.);
6. Output impurities (mass): 0,3%;
7. Digester hydraulic retention time : 7 days;
8. The digester feeding matter is heated with the cogenerator engine cooling system;
9. The liquid fraction is collected by the farmers;
10. Two compost particles size:
    1) 7 mm (12 Euros/m^3);
    2) 12 mm (5 Euros/m^3).

Hygienization (A)

1. To guaranty complete hygienization, it would be better to heat the organic input before entering the digester instead of composting the digestate. The reason is that pile composting doesn't guaranty that the temperature rise is everywhere in the pile [(1)].
2. It appears that hygienization is mandatory when the reuse is made in agricultural soil. When reused is in silviculture or in ornamental plant horticulture, there is no need to do it;
3. Hygienization technique that is the most energy efficient: 70^{o}C for 1 hour [(2)];
4. While there is a concrete strategy to perform hygienization for mesophilic digester, the psychrophilic digester is lacking of such.

(1) Discussion with Franziska Meinzinger, Doctorate student, TUHH, Germany
(2) Discussion with Ake Nordberg, Researcher, Swedish Institute of agricultural and environmental engineering

Hygienization (B)

5. E. Coli is not a good bacteria indicator [1];
6. An alternative mean to achieve the hygienization of digestate: acidification with urea [2];
7. We shouldn't only consider hygienization as one "kill-everything-step" but as a series of steps that reduce enough the risk [2];
8. Goal to achieve in hygienization: log 6 reduction (if the initial concentration is not too high) [3].

(1) Lecture of Arve Alter, PhD Student in UMB, Norway
(2) Discussion with Thor Axel Stenström (Stockholm Environment Institute) in UMB, Norway
(3) Lecture of Thor Axel Stenström (Stockholm Environment Institute) in UMB, Norway

Legislation

1. It seems possible to perform ecological sanitation project as long as you get the « demonstrative label »;

2. In Sweden, Netherlands, Germany, Norway (and maybe others), it’s possible to get a permit to spread treated human excreta on fields for human food crops. In Quebec (Canada), it is only possible to use human excreta if applied 36 months before sowing crops for human food or 30 days before sowing crops for animal food;

3. The existing legislation is based on the maximum concentration of pollutants in the effluent, which is not adapted with current technology that has reduced water significantly, so increase the effluent pollutant concentration [1].

(1) Discussion with Merijn Picavet, Engineer, The Netherlands

Social acceptation

User/public

1. Vacuum toilet (high tech) is relatively well accepted, while dry toilet (low tech) is less [1-3];
2. Urine diversion toilet is better accepted at the office than at home [2];
3. Acceptance at home [2]:
   - 70% are open to consider having it at home;
   - 30% wouldn't accept one even if they agree with the advantages.
4. Some people are against anaerobic digester near their home because : [3]
   1. Biogas produces odour;
   2. Decrease of house value;
   3. More transport by truck around their home.

Farmers in Sweden

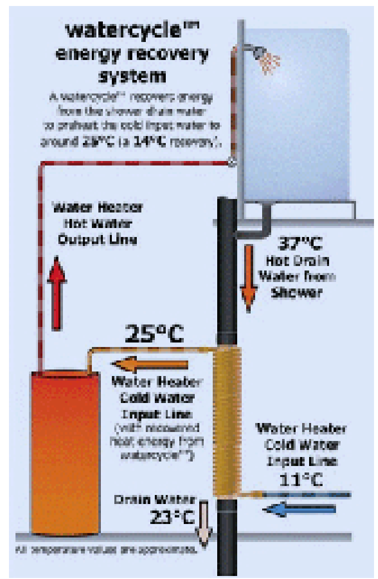
1. Appear to be in favour of spreading human excreta as fertilizers if the percentage of human excreta would account for a high portion of total land nutrient requirements[4].

(1) Discussion with Thorsten Shuetze, Professor, TU-Delft and R. Otterpohl, TUHH.
(2) Arjen van der Mark, Reest & Wieden, The Netherlands
(3) Discussion with Joachim Behrent, Professor, TUHH, Germany
(4) Jönsson, H., P. Tidaker and A. Richert Stintzing, 2008. Role of farmer in improving the sustainability of sanitation systems. Wageningen Conference proceedings.

Expansion of system under investigation

Thermal energy recovery from greywater

According to Ralf Otterpohl [(1)], the thermal energy that we can get from the greywater is more cost-effective than the energy from the biodigester. However, the greywater temperature reduction impact on the treatment would have to be considered.



One example of greywater thermal energy recovery system

www.watercycles.ca/why-watercycles.php

(1) Discussion with Ralf Otterpohl, Professor, TUHH, Germany

Interesting facts (A)

1. The city of Berlin charges private house owner according to their lot surface in compensation of the city's task to treat the rainwater. However, if an owner implements a rainwater management system on his lot, he could obtain a tax discount [(1)];
2. Water fee in the city of Hamburg [(1)]:
   Drinking water: 1,8 Euros/m^3, Wastewater: 2,1 Euros/$m^{3;}$
3. The existing cost for vacuum toilet (1000 to 2000 Euros) could fall to 200 Euros if mass production is set up [(2)];
4. A decentralized management of organic matter should be combined with the decentralized energy production [(2)];
5. A MBR consumes 50% more energy than a SBR, but the reuse of nutrients from greywater is made possible [(3)];
6. In Germany, 30% of sludge produced in wastewater treatment plant is reused in agriculture, while Switzerland and Austria have banned this practice [(3)].

(1) Discussion with Thorsten Shuetze, Professor, TU-Delft, The Nehterlands
(2) Discussion with Ralf Otterpohl, Professor, TUHH, Germany
(3) Discussion with Christian Remy, Doctorate student, TU-Berlin, Germany

Interesting facts (B)

7. Consequences of mixing grey and blackwater about micro-organisms fate:
   1) virus : no spreading (no multiplication), but can accumulate on/in a plant;
   2) bacteria : spreading (multiplication will occur), but can't accumulate on/in a plant [(1)];
8. Urine produced by one person in one year can fertilized 300 to 400 m^2 of agricultural lands [(2)];
9. Some farmers can sometimes over farmed their soils which leads to complete fertilizing capacity depletion in 5 years [(3)].

(1) Discussion with A. Cencic, Professor, Micro-biologist, University V of Marlboru, Slovenia
(2) Discussion with Arno Rosemarin, Research director, EcoSanRes, Sweden
(3) Discussion with Joachim Behrent, Professor, TUHH, Germany

Issues to clarify

1. **Is the no-mix toilet promising ?**
   Some researchers (Swiss, Swedish and Dutch) tend to agree.
   Some researchers think it's not viable using it in approach 1.

2. **Is the dry toilet ready in occidental context (public acceptance) ?**
   No, according to Ralf Otterpohl. I imagine that EcoSanRes researchers won't agree. Their Erdos project (with dry toilet), after some adjustments, seems to work. But the smell acceptance is probably not the same due to cultural context.

3. **Which type of anaerobic digester is best in a cold climate (psychro/meso/thermo) ?**
   Thermophilic digester seems to be not viable, while psychrophilic and mesophilic are both viable options.

Vacuum toilet

No-Mix toilet

Credit: Charles Thibodeau

Unresolved questions

1. Why an approach that combines dry or low flush diverting toilet with anaerobic digestion has not yet been implemented or assessed?
2. Could wastewater low temperature have an impact on constructed wetland or MBR performance ? If so, which and to what extent?
3. Do constructed wetland treatment data take into account plant harvest and export ?
4. Does urine contain too much salt for certain soil types ? Is it always convenient for agricultural soil ?
5. What is the minimum distance to which urine treatment/compression/ extraction processes become cost effective vs storage only ?
6. What is the most convenient way to reuse digestate ? With or without solid/liquid separation ?
7. Is the hygienization for one hour at 70 ^{o}C the best way to achieve hygienization with anaerobic digestion process ? Are there other means that consume less energy ?

Conclusions summary

1. My research goals make sense, but I should refine the number of implementation scales to assess;
2. Ecological sanitation has a potential here in Quebec (Canada) in the mid or long term;
3. The two “water-based” approaches are viable and ready to be assessed. The “dry” approach will perhaps be assessed. System expansion for thermal energy recovery from greywater will be considered;
4. The step of assessing all stakeholders ideas about an ecological sanitation project can’t be ignored.

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