EcoSan Research Workshop in Stockholm
August 19-21, 2002

Report compiled by

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Content

1. Brief summary of the discussion

Monday 19 August (Day 1)

The presentation of the participant showed that they cover disciplines from microbiology to anthropology and have working experiences ranging from institutional aspects to biogas and agricultural application of human waste. The group is therefore well positioned to tackle the wide range of research issues pertaining to EcoSan.

Discussion about requirements for an ecosan system

The group commenced with a discussion on what requirements an EcoSan system should fulfil (no priority):

- adapted management system (municipal monitoring)
- regulations allowing alternatives
- easy to use and maintain (self-instructive)
- indoors
- no smell, no flies, no rats

- affordability (individual vs joint treatment)
- efficient collection of fees – institutional organisation
- acceptability – residents, professionals and local authorities
- saving resources (H_2O, energy, nutrients)
- number of users (public/private)

- "no" environmental contamination
- low environmental cost
- cost-efficiency of reuse
- "non-contaminated" rest products – where to discharge them (robustness)
- short recirculation of "all" substances with no accumulation
- fair quality of groundwater
- disease control

- interface with nature (floodings etc.)
- locally feasible (adapted)
- continuous vs intermittent use
- sanitary system required
- robust – taking care of special groups (handicapped etc.) but also

- few breakdowns and controllable effects

These requirements are needed in the EcoSan process of converting our resources nutrients, water, and energy to the intended output of food production, resource protection (surface water, groundwater, ecosystems) and better health.

The group agreed that a cost-effective system is a strong driving force. It is difficult to obtain good comparison of costs since existing systems have received major subsidies and utilities themselves are rarely in a position to give data. Cost calculations are mostly made by consultants, and there are few independent research done at universities. A PhD-student in the Swedish Urban Water programme is currently working on comparing the economics of conventional and alternative systems. The biggest cost item in Sweden relates to laying pipes. Future toilet systems may be without piped networks, making it possible to place them anywhere. In recirculation systems and alternative systems the cost-effectiveness of collection, transport and reuse needs to be considered.

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Presentations by the participants

Presentations of projects and/or specific aspects of EcoSan systems in various parts of the world.

1. ***Aidan Cronin*** presented the case of groundwater protection in Kampala, Uganda and in Lichinga, Mocambique. Local variety whether well-water pollution is from above or via groundwater. Impact of dug latrines is less than expected, and poor wellheads is sometimes the main problem. To fully understand the impact of any form of sanitation on groundwater quality we need to get a handle on the interaction between wells and latrines from a number of aspects such as: population density, geology, number of well and latrine users, well abstraction volume, depth of wells and latrines, water table depth, latrine type, climate, socio-economic status, sanitary protection of wells etc. Use of a portable kit for analysing water quality.

Comments: Also in Norway, poor wellheads have proven to cause groundwater contamination (nitrate and chlorine only at background levels) rather than infiltration units. Better results than expected for the infiltration (PJ). Wellheads are often not constructed properly – too fast and cheap. NA would like to discuss the methods used in the kits further. If a chromogenic agar is used, temperature is less important (can vary 30-38°C). Important to improve wellheads, but latrines should not be forgotten. In Argentina latrines have been reported to cause problems (AC referred to Guy Howard). From Australia NA reports less virus transport than expected, 4-5 log reduction in 10 m sand. The risks depend much on type of soil and it is very difficult to model. The soil is a barrier but we often do not know how efficient it is.

2. ***Petter Jenssen*** presented a case study from Cuba with “zero emission” apartment buildings (blackwater collection by vacuum and low flush gravity toilet, biogas). Case study from Bangalore, India, toilet centres, transport, central composting, recommended for silviculture, parks (not vegetable crops yet).

Comments: Discussion on whether men can/should sit or stand when urinating in urine-diverting toilets. Recently there was an article about that is better (healthier) to sit. According to the participants most men actually sit during the night – behaviour should not be so difficult to change. Later on a discussion on different types of vacuum systems took place (see below). Energy need to be considered when installing vacuum systems. It might be possible to combine with solar energy.

3. ***Jutta Niederste-Hollenberg*** presented single household approach to reuse all fractions (membranes, RO, sand filters), concentration of urine (evaporation, vacuum, freezing) for industrial uses, pharmaceuticals (which ones?) in urine.

Comments: What is the cost for urine treatment? How much energy is needed? According to HJ (and Stockholm Water Company) cost could be motivated by a decrease in cost for storage (less volume/weight). Also a hygienisation will be obtained e.g. from heat treatment. The nutrient content in the filtrated faeces was discussed and considered, as it probably would be low.

4. ***Björn Vinnerås*** presented his study of faecal separation. The process needs to be rapid, otherwise nutrients in water phase, collectable amounts of nutrients, design of system for optimal collection, energy (see Appendix).

Comments: Discussion on robustness and possible causes of problems when systems don't work. Results in two polluted streams from the house. PJ: The greywater treatment could be scaled down, NA: The greywater treatment should be able to handle faecal contamination. The Aquatron is an option to vacuum, it is a less complex system, no noise and more robust. With soft bends a better separation is obtained. it would be good to be able to store urine and faeces together. Zeolites for concentration of ammonia in urine, Probably too low absorption capacity and thereby large mass to handle.

5***. Jan-Olof Drangert*** presented a case of a decentralised dry ecosan system in central Kimberly, South Africa. Residents can choose to reuse urine and faecal matter in the home gardens or have a central collection. Smell residents´ only worry. Communal water supply and greywater treated in small constructed soilbeds. Stormwater collected in communal pond.

Comments: Discussion on compost. If it gets too dry rainwater or urine can be added (HPM). HJ think it is a pity to waste the urine (most nitrogen will be lost). Problems with flies need to be addressed.

Tuesday 20 August (Day 2)

6. ***Håkan Jönsson*** presented facts and figures on the nutritional value of excreta and its possible use in agriculture. Results from fertilising experiments using various types of waste products were presented. A recommendation for human urine is to first add urine in amounts that is needed for nutrients <u>then</u> add water in amounts needed.

7. ***Heinz-Peter Mang*** presented several case studies – China (4 in 1), Afghanistan, Mali (Otterwasser, Lübeck and GTZ), Senegal (Gembloux University, Belgium, possible contamination of banana and papaya fruits by using wastewater for irrigation and fertilisation). GTZ understands that for treatment/preparation of concentrated blackwater or

faecal sludge biogas technology as integral part of communal ecosan-strategies is prioritised in many cases (China, Ethiopia, Netherlands, Tanzania, Germany, India, Indonesia), GTZ have long experience on this. They try to introduce ecosan as part of different types of projects/programmes (without explicitly calling it ecosan). There is a high value put on excreta in many places.

8. ***Caroline Schönning*** presented the method of quantitative microbial risk assessment (QMRA) and gave as an example results from an assessment of urine-diverting systems. Qualitative risk assessments can also be used to give recommendations in order to minimise risks. Guidelines for reusing urine have been established by the Swedish ecosan research team.

General discussion after the presentations

In Afghanistan they pay for excreta products (dry faeces) but are not aware of the nutritional value of urine. We need simple systems for collection and fertilising – how to apply, how much, different crops, different soils (HJ).

There are a lot of old research on mineral fertilisers applied to different countries. This research and recommendations need to be translated to excreta (HJ, HPM).

One problem is that there is no co-operation between institutions dealing with sanitation and agriculture, respectively.

Universities are often islands in developing countries. HPM does not think the universities are good collaborating partners. PJ has experience from Sri Lanka where they participate in a course for merit reasons rather than for the purpose of implementing the ideas (e.g. did not want to go out in the field). Local research institutes on the other hand, are often more keen to action as they in many cases work with local issues and thereby close to the society.

HPM thinks the pathogen risk using untreated faecal matters is not a major problem for the farmer, since changed behaviour is required. According to HPM a lot of research on soil improvement with organic material is done and information is available on the needs for most type of crops in relation to N, P, K, water and for some trace elements. Dissemination is what is needed.

According to HJ priorities of further research are collection, transport and treatment of faeces and concentration of urine to reach commercial N-concentration values in the liquid. Treatment need to be related to type of reuse. A fairly good hygienisation of feaces should be obtained before transport, and after that secondary treatment should be conducted.

PJ: Many alternatives for greywater treatment and reuse need to be studied. One example is reed beds, they work well in Norway and Denmark. In one year (?) the accumulation (of what?) is 0.5-1 m, so they last for long time.

TAS: Problems with green house gas emissions (NOx, CH_4, etc) during simple composting of feaces.

We have information about:

- fertilisation results
- pathogen control

and can use this to see what is missing. Integrated research is needed.

We also need more information about the following aspects:

- economic
- socio-culture
- transport

<u>Discussion about ecosan systems in general</u>

The format of the discussion was to follow the flow of nutrients in human waste. This time we started from the end-use in agriculture and for energy purposes, and then going backwards towards the toilet in the household. As seen in Table 1 we did not reach all the way to household aspects. However, usually discussions have started with the household and rarely reached agriculture and energy. Therefore this time we managed to discuss reuse issues at some length.

In order to make the discussion more focussed we related to four kinds of urban settings; high density areas with high-rise buildings, squatter areas, middle-income peri-urban areas, and exclusive residential areas with single houses. The outcome of the discussion resulted in a table (table 1).

Table 1 Suggested use, treatment and requirements of excreta and wastewater products in different type of settings in urban areas

	High density, high rise, no/little space	**Squatter areas, little/no space**	**"Periurban", some space, ordinary wage earners**	**Exclusive areas, wealthy residents, large gardens**
End use	agri/horti/silvi/aqua culture, landfill, bioenergy, green belt, recreational	roof/wall cultivation, small scale local + same as high density	street-side cultivation, biogas (evaporation of urine) <u>or</u> export, feed for animals	horti/silviculture, recreational, collection for export
Stakeholders (receiving and using)	professionals, private & public sector (e.g. farmers, municipal staff)	house owner + same as high density	house owner <u>or</u> public & private (farmers, staff)	house owners
Requirements: -usability -promotion -treatment/ handling	high (direct) nutritional value, cheap, delivered to site (other company not necessary), no odour, esthetical, safe for use, show cases for promotion	no odour, esthetical, adequate water resources	same as high rise (export) or same as squatter (local use)	same as squatter + easy to use
Blackwater/organic household waste or Urine and faeces/organic household waste	see table 2	aquaculture local: dehydration of faecal matter (add ash) + evaporation of urine + vermiculture urine need to be collected in humid areas.	dehydration of faeces + use of urine, compost + vermiculture, use of urine, biogas	<u>wet collection of faeces</u> dehydration of faeces + use of urine, compost + vermiculture + use of urine, biogas production if enough material + subsurface/drip irrigation (septic tank first), chemical treatment (e.g. PAA (para-acetic acid))
Solid waste	collection, central compost, biogas	part of compost or collected	part of compost, separate compost, direct use in garden, biogas	biogas (need additional material) + same as peri-urban,
Greywater	particle removal + partial reuse (flush, irrigation, cleansing), recharge, recreational or discharge through old sewer, (evaporating cooling tower)	small volume (~20-40 L/ppd). Infiltration in soakaway pit (larger area is preferred), reuse (washing, irrigation of roof cultivation)	volume >50 L/ppd, form part for irrigation, aquaculture, wetlands after settling tank, infiltrate	same as high rise or peri-urban

Comments to table 1
Horticulture = vegetables, flowers etc., need plenty of fertiliser in order to give high economic returns.
Ashes contain a lot of nutrients but these do not have a direct effect on the crop.
Example from Beijing: wooden pillars filled with soil are planted with seeds and irrigated with wastewater, the result will be "green walls" used for noise protection.

There was a question whether the waste produced in peri-urban areas contain too much nutrients or not, i.e. can all the waste be used within the housing area? Probably it could, but we assumed that some of it will be sent away from the site as well.

Recharge of groundwater is a possible option in cities. HPM: In some German cities people are given subsidies to change from asphalt/concrete to gravel on their own yard. AC: Recharge of groundwater is not always beneficial as many cities are suffering severe problems from rising groundwater levels. The quality of groundwater may also be variable and the suitability of infiltrating it into the subsurface need to be evaluated for each area.

Treatments need to be 1) pathogen reducing and 2) degrading faeces
HJ thinks that the issue of waste to be hygienically safe for use apply more to home gardeners than to farmers.

PJ: For retrofitting it is easier with systems that use a little water.
Vacuum systems, either for in-house transport or central collection and then vacuum transport.
Reuse in Cuba? They were deprived of 80% of their mineral fertilisers imported from Russia so they are much aware of the value of plant nutrients in excreta/wastewater. Had to switch to organic farming from one day to the next!

Sediment remains from biogas production (fertiliser) does not smell. Central collection possible (like septic tank sludge).

Humid areas – infiltrate urine? Can harm groundwater, many shallow dug wells.
Greywater mix with urine, how much space is needed for its application?

Compost – no compost toilet work thermophilic.

Table 2. Possible treatment and use of blackwater, faeces, urine and solid waste (organic household waste) in high density areas (high rise buildings with no space available for local reuse)

Blackwater + organic matter	**Faeces + organic matter**	**Urine**
- vacuum/low flush (~1 L) - grinding - digestion - low flush urine diversion + faecal separation (mix urine + water for faeces; give less volume than vacuum) - chemical treatment - (stabilisation pond (reuse water or sludge), trials to cover ongoing	- *as blackwater + organic matter* - thermophilic composting - energy recovery	- collect + store - concentration (membrane, solar etc.)

- (drying) - aquaculture (=anything growing in water)		

Comments to table 2

When characterising toilets or toilet systems the following features can be combined in 12 different ways:

- vacuum or low-flush or dry
- urine diversion or non-diversion
- squatting or pedestal

Low-flush toilets need approx. 1 L flush in order for beneficial collection and reuse of the blackwater. If the flush is more than 3 L there is no use to collect it as "blackwater". Aquatron not "good" for ordinary toilets and urine diversion is a prerequisite.

Installation of urinals is an option. Too expensive sometimes, mainly because it requires more space. (In Changsha an additional 0.5 m^2 is required and 3 pipes (greywater, urine and blackwater) must be installed. Not much extra cost for new constructions according to HPM).

Is health always important? The farmers may not always care.

Important issues
- How the fertilising product is brought to the end-user
- Is the fertilising aspect (safely applying urine and organics based on feaces) a promoting selling argument of the agricultural product to the consumer?
- How we can guarantee:
    in house technology
    who decides, acceptability

Institutional issues (regulatory, actors, etc.)

Professionals (e.g. water department, health authorities), regulators, builders, housing co-operatives, suppliers, plumbers, manufacturers of in house sanitary technology products, advertisers, banks and lenders (financial), insurance, educators, etc. are involved in sanitation decisions. This list can be compared to the table where different techniques are listed and important aspects can be identified.

Users are rating the economics of the system, but also their environment awareness has an impact. Professionals may have mixed reactions to ecosan. It is crucial that regulators allow alternatives.

PJ: Example from Malaysia where they are prepared to go straight to decentralised systems in analogy with Cambodia that went straight to wireless telephone. Present ecosan as the future!

Involve public sector for promotion, regulation and monitoring. Not advisable to regulate what ecosan-technology should be used, but rather to offer options. Introduction through private sector and market channels.

(Renting residents have low influence on the in-house sanitary equipment choice in high rise buildings.) In this case builders or investors decide most facilities.
Government role: provide "subsidies" and frame regulations.

2. Proposed strategy for next step

Wednesday 21 August (Day 3)

A short recapitulation of the interests of the participants. Long lists of co-operating partners and field sites were given.

A systems analysis framework makes it possible to incorporate all aspects in the analysis.

A short discussion about key factors gave the following list:

- Smell (source, perception and countermeasures)
- Regulations (goal-oriented, rules of thumb, these rules should be based upon research), usage of human resources and, unintended outcomes
- Roles of private households and public sector (urban planning)
- Central vs. decentralised or semi-centralised collection and treatment (including hygiene aspects)
- Human resource use (staff, households, men and women expectations)
- Physical resource use (water, agriculture, hygiene)
- Technical improvements of existing systems (low maintenance)
- Unintended outcomes (leakage, health risks, climate change etc)

We need demonstration projects to be able to convince others about a system and its benefits and shortcomings (PJ). Demonstration systems also have to be included in the iterative process of improvement of the system to develop good functions (HJ). It is possible to evaluate present systems by impact assessment (e.g. Gebers in Stockholm). We should have in mind the difference of age between present system and the EcoSan system that is juvenile in comparison (PJ).

A matrix should be prepared for comparison of different system (AC). A 'gap analysis' to identify further research can be done by listing the projects (y) and fill in a form with different factors/key words (x) for comparison of the preformed projects (JNH). It is important that similar factors are compared (JOD).

For our future co-operation a framework has to be developed. An initial step the matrix about present projects should be produced, this will be done by PJ and JNH. Initially they will produce a proposal for how this should be done and within 1.5 months send out frames for the others to fill in. All participants should send keywords of the research topics to Petter and Jutta. PJ will arrange for a "secretary" producing a reference document (booklet) out of this that can be used as a joint basis for the further work within this group, both for references and also as basis for a joint future research applications.

The goal is an EU application. Next deadline is in March 2003. Other partners that have shown interest in a new EU application are Sandec/EAWAG, WSP, BRTC and IEEP in China, Makerere University in Uganda, pS-Eau and Toilette du Monde from France, University Gembloux from Belgium, Dutch groups (Waste, University of Wageningen and

IRC) and Senegal. In order to keep the costs down is it possible to split the old application in two or more parts.
Seed money and working capacity to prepare the new EU application will be sought from GTZ, Norad, and Sarec. The Swedish team is responsible for the draft application.

The participants agreed to proceed the work under the heading:
"Application and Assessment of Urban Resource-Recycling Sanitation Systems"

Preliminary schedule for the continuation of this cooperation*:

15/9 Keywords to Petter and Jutta
18/10 Review of application for seed money. The Swedish group will prepare a draft.
1/11 Submission of application for seed money to GTZ, Norad, and Sarec.
18/10 Matrix to be filled in and distributed

*Deadlines have been revised.

3. List of participants –
Ecological Sanitation Workshop
Stockholm 19-21 August, 2002

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4. Proposed programme for the EcoSan Research Workshop in Stockholm, August 19-21. 2002

Monday 19 August

10.00	Opening and presentations
11.00	Discussion of what requirements an EcoSan system should fulfill. A draft list of requirements will be prepared.
12.15	Lunch
13.30	Presentations (preliminary titles) of EcoSan systems followed by discussions
	Petter on Cuban project on vacuum system
	Heinz-Peter on Chinese projects with biogas in urban areas
	Jutta on reuse of different fractions and concentration of urine
	Aidan on groundwater protection in Kampala
	Björn on wet system in Norrkoping, Sweden
	Jan-Olof on self-contained housing project in Kimberley, SA
19.00	Dinner

Tuesday 20 August

09.00	Presentations continued
	Håkan on plant nutrients and composts
	Caroline and Thor Axel on barriers and risk management
11.00	Discussions on systems analysis and requirements
12.00	Lunch
13.30	General discussions about EcoSan (practical and theoretical) systems
19.00	Dinner

Wednesday 21 August

09.00	Development of research ideas
12.00	Lunch
13.00	Strategy for research proposals
15.0	End of Workshop

5. Appendices

Appendix A.

Urine diversion and faecal separation – content of presentation at Ecological Sanitation Workshop, Stockholm, August 19-21

Björn Vinnerås

As an alternative for blackwater systems is a combination of urine diversion and faecal separation. By using urine diversion is it possible to collect the major part of the household nutrients in a small and unpolluted fraction. The second most nutrient-containing fraction is the faeces. To collect these nutrients and still use a flushed toilet the faecal particles can be separated from the flushwater after a shorter transport. This is only possible if the nutrients remain in the particles that are separated. Degradation studies of faecal matter has shown that the degradation occurs relatively rapid and thereby will also the loss of nutrients increase with increase time of contact between the faeces and the water. The rapid degradation makes it hard to recover larger amounts of nutrients in separation systems where the faecal particles have a longer retention time, e.g. filters that are emptied every year or so.

Separation studies performed with faecal separation using a separator that uses surface tension, whirlpool effect and gravity for separation made it possible to collect up to 85% of the faecal nutrients in a small fraction after a pipe transport. These separators does not contain any movable parts and are thereby robust and as the water just goes through the separator the risk for contamination from other waters that are put into the toilet are small as also the dilution from water that just passes the separator.

With a well functioning system of urine diversion and faecal separation almost as much nutrients as in a blackwater system will be collected and at the same time is the system much mote robust towards outer condition, e.g. almost no dilution will occur from water used for anal cleansing as it just passes the separator.

As the faecal matter contains large amounts of microorganisms there will be a large risk for transmission of pathogens when handling this material. The risk for transmission of diseases can be lowered by disinfection of the faecal matter, which thereafter can be used as fertiliser. Two methods that we have looked closer to are the possibilities to use thermal composting for disinfection of faecal matter. Temperatures above 60°C were obtained during several days in a mixture of faeces, food waste and amendment, which was enough for hyginisation of the material. However, at tests on site in Ethiopia and Mexico no thermal composting was obtained. One of the main reasons for this was the usage of ash, lime and soil as additives to the faecal matter during the collection lowering the content of organic matter making thermal composting impossible.

Another way for attaining hygienic faecal matter for recirculation is by addition of urea before a shorter storage time. Studies in Sweden where urea have been added to faecal matter have shown that within 2 month of storage the risk for any viable pathogens are small. An additional effect from the treatment is an increased fertilising value as the urea after is has been used as disinfectant will be a readily plant available fertiliser upon application to soil, and urea should be easy to get as it is the most used fertiliser, world wide.