Session A

Progress, policies and legislation

Chairpersons

Ingvar Andersson (UNDP, USA)
Xiangjun Yao (Ministry of Agriculture, China)

Lectures

The EU water initiative, its research component and ecosan
Zissimos Vergos (European Commission, Belgium)

The BMBF programme “decentralised (alternative) water systems” - international projects
Rüdiger Furrer (Research Center Karlsruhe, Project Agency for Water Technology and Waste Management, Germany)

Demand on and difficulties for implementation of ecosan concepts in China
Jiang Zhang (Institute for Sustainable Technology, Zhejiang University, China), Jun Chen

New legislation for on-site sanitation in Finland*
Harri Mattila (Häme Polytechnic, Environmental Engineering, Finland)

Key-activities, services and current pilot projects of the international ecosan programme of GTZ*
Christine Werner, Heinz-Peter Mang, Ve Kessen (GTZ, Germany)

EcoSanRes - a Swedish international ecosan-programme
Arno Rosemarin (Stockholm Environment Institute, Sweden)

Guidelines for the implementation of the Bellagio Principles and the household centred environmental sanitation approach (HCES) *

Tentative guidelines for agricultural use of urine and faeces*
Björn Vinnerás, Håkan Jönsson (Swedish University of Agricultural Sciences, Sweden), Eva Salomon, Anna Richert-Stenzing

Oral poster presentations

Ecosan - clean production mechanism under the Kyoto-protocol
Gert de Bruijne, Nadine Dulac (WASTE, Netherlands)

Rainwater harvesting, water re-utilisation and ecological sanitation - further developments
Dietmar Sperfeld, Erwin Nolde (Fachvereinigung Betriebs- und Regenwassernutzung e.V., Germany)

*This paper has been peer reviewed by the symposium scientific committee
The EU water initiative, its research component and ecosan

Zissimos Vergos

European Commission
Directorate General for Research
Directorate Environment
e-mail: zissimos.vergos@cec.eu.int

EU water initiative - A quick overview

World Summit for Sustainable Development

Geographical Components

- Africa (sub-Saharan)
- EECCA
- Mediterranean
- (North Africa and Middle East)
- Latin America

Thematic Components

- Water Supply and Sanitation (WSS)
- Integrated Water Resources Management (WRM...including trans-boundary resources)

Horizontal Components

Financing
Research

EU water initiative – organization

Multistakeholder Forum
(EU and Partner Governments and Organizations, NGOs, Private Sector...)
chained by the Commission

Existing components (WG’s)

Africa
EECCA
Mediterranean
Latin America
Financing
Research

Design phase (end 2003)

Denmark (WSS)
France (WRM)

Implementation Phase (starting 2004)

Spain and Portugal

United Kingdom
European Commission
EU water initiative - research component: aims and expected contribution to the water initiative

- Co-ordination, coherence and complementarities of European efforts
- Higher impact, critical mass and strategic partnerships
- Support and Feedback for policy formulation and integrated water research approaches
- Awareness, proactive participation, human resources and better knowledge and innovation management in developing countries
- Integration and operational feedback between development co-operation and research

EU water initiative - research component: the mapping of European efforts

- Policy frameworks
- Major Organisations and Institutions
- Strategic Approaches
- Problems and best practices
- Targeted Water Research areas
- Beneficiary regions/countries

EU water initiative - research component
Preliminary conclusions from mapping exercise

- High profile of international water research at EU Member States and Community level
- Significant efforts taking place = systematic analysis is needed for capitalising on lessons and best practices
- Added-value, critical mass and higher impact can be derived from better co-ordination
- Diversity of strategic approaches of international co-operation in water research
- More integrated approaches are needed to tackle existing problems
- Planning should be demand orientated, based on stakeholders analysis and public participation
- Additional efforts shall be put into better streamlining and integration of water research in development co-operation efforts

EU water initiative - research component
The way forward

- Finalise mapping, assessment and dissemination of results and feedback from concerned stakeholders
- Operational links with the other Working Groups, promotion of strategic partnerships and integration with development co-operation programmes
- Identify target regions and thematic areas (pilot integrated water research activities)
• Intensify dissemination of Public Information and Awareness to institutions and stakeholders in European and Partner countries

**International research co-operation**

**6th research framework programme (2002-2006)**

---

**Potential interfaces for ecological sanitation**

**Specific measures in support of international co-operation (INCO)**

**Developing Countries** - Rational Use of Natural Resources

• Humid and semi-humid ecosystems (call 2003)
  - Ecosystem dynamics and use of renewable natural resources.
  - Integrated approach to natural and agro-resource use systems.

• Multiple Demands on Coastal Zones (call 2003)

• Food Security (future call)

• Arid and Semi-Arid Ecosystems (future call)

**Mediterranean** - Integrated Management of Limited Water Resources

• Policy for Integrated Water Planning (call 2003)

• Improving Water Consumption (call 2003)
  - Non-conventional water resources.
• Fertilisation and Plant Nutrition.
• Advanced Water Treatment, re-use and energy implications (call 2003)
  • Efficient use of treated water and multiple uses of water resources for a variety of uses.
  • Institutional and legal mechanisms for water purification and reuse

Potential interfaces for ecological sanitation
Specific measures in support of international co-operation (INCO)

Western Balkans - Environment (calls 2003)
• Development of waste water treatment and reuse technologies (including agricultural water use)
• Innovative cost-effective techniques for the efficient treatment of industrial and municipal waste and the use of recycled materials through bio-depuration and composting.

Russia and other NIS (EECCA) - Environment and Health Protection
• Stabilisation of research and development potential, changes in the industrial production system, environment and health protection and related safety aspects.

Potential interfaces for ecological sanitation

Thematic priority 6: Sustainable Development, Global Change and Ecosystems
Sub-priority: Global Change and Ecosystems
• Integrated water management at river basin level, African and EECCA countries
  • Twinning European/Third Countries river basins (call 2003)
  • Methodologies of IWRM and Transboundary Issues (IP or NoE - call 2004)
• Integrated urban water management, problems of African, Asian and South American mega-cities and peri-urban areas
  • Wastewater reuse (call 2004)
  • Integrated Urban Water Management (IP or NoE - future calls)
  • Strategies, technologies and Management Practices for Drinking Water supply (future calls)

Potential interfaces for ecological sanitation

Thematic priority 6: Sustainable Development, Global Change and Ecosystems
Sub-priority: Global Change and Ecosystems
• Management of water under scarcity, focussed on South Mediterranean countries
  • Technologies for monitoring and mitigating the impact of water scarcity (call 2003)
  • New approaches to water stress (IP or NoE - call 2004)
• Development of scenarios of water demand and availability at 25-50 years, with focus on South and East Mediterranean and EECCA countries
  • Water Scenarios for Europe and neighbouring countries (IP or NoE - call 2004)
Potential interfaces for ecological sanitation

### Community Development Co-operation - Water Sector

- **Cross-cutting focus area**
  - Water resources assessment and planning (WARP)
  - Three specific societal functions
  - Basic water supply and sanitation services (BWSS)
  - Municipal water and wastewater services (MWWS)
  - Agricultural water use and management (AWUM)

- **Local Participation & Ownership**
  - Decentralised & Community based management
  - NGOs
  - Appropriate Technology
  - Public & Private Sector

### Research work related to ecological sanitation

#### 5th research framework programme

In Europe and Third Countries
- Water Conservation and Water Saving
- Wastewater treatment, recycling and re-use in agriculture
- Economic, social and environmental sustainability
- Water Contamination and Pollution Control
- Cost-Effective Reclamation Technologies for domestic wastewater
- Groundwater and Soil Interactions
- Public Health, Sanitation and Hygiene
- Cost-effective rehabilitation of water supply and sewer networks
- Private sector involvement in water supply and sanitation

#### Member states - international research - focal points

**Austria:** Federal Ministry of Finance and BOKU - University of Natural Resources and Applied Life Sciences, Vienna - Austrian Development Co-operation.

**Belgium:** Directorate General for International Co-operation in the Ministry of Foreign Affairs
Some concluding remarks

- Ecological Sanitation is a **concept perfectly in line with the sustainable development perspective and major orientations of the Community Research Framework Programmes** in the water and sanitation sector.

- The **EU Water Initiative** includes sanitation as one of its focal areas providing a fertile ground for extending **environmental sanitation into ecological sanitation** in developing countries.

- Existing **strategic partnerships and field work in ecosan are of particular relevance to the EU Water Initiative**, and vice versa, and **effective linkages shall be established.**
The BMBF programme “decentralized (alternative) water systems” - international projects

Rüdiger Furrer
Forschungszentrum Karlsruhe
Project Agency for Water Technology and Waste Management acting on behalf of the BMBF (German Federal Ministry of Education and Research) and BMWA (German Federal Ministry of Economics and Labour)
Mailbox 36 40, 76 021 Karlsruhe, Germany
internet: http://www.fzk.de/ptwte/
e-mail: ruediger.furrer@ptwte.fzk.de

Introduction

The projects funded by the BMBF/PTWT+E concerning decentralized (alternative) water systems are based on an announcement in the “Bundesgesetzblatt” (Federal Law Gazette) of June 27, 2001.

All the drafts (112 in total) were surveyed on behalf of the BMBF by an external committee consisting of experts in water management, associations, universities, and members of industry. The announcement itself was made in accordance with the BMZ/GTZ project “ecosan”. The levels of international development, technical feasibility, and administrative requirements were compiled from two studies carried out by the University of Witten-Herdecke and the University of Munich.

Especially with the international projects, we wish to contribute to a more conscious and sustainable use of water, a resource that cannot be replaced. Accordingly, these projects contribute to the ambitious aims of the Sustainability Summit of Johannesburg, which was to halve, by the year 2015, the proportion of people who are unable to reach or afford safe drinking water and do not have access to basic sanitation.

The BMBF research program is mainly designed to combine and to improve existing components. Apart from the reduction of the drinking water consumption key aspects are to decouple materials and water flows such that recovery of nutrients and energy will be possible and economically efficient.

Subjects of investigation are: Anaerobic waste water treatment, membrane filtration, processes close to nature, reuse of gray water and rainwater, separation vacuum and compost toilets, winning of biogas and decentralized power stations, production of compost and fertilizers, economic, sociocultural, and legal aspects.

Concerning the implementation and dissemination of the research results an adequate contribution from German private companies as well as from the foreign partners is required. (The system of project funding does not allow a direct funding of foreign partners.)

Current projects: Vietnam - (Dr. Clemens - University of Bonn)

Topic:
Closing of agricultural nutrient cycles via hygienically harmless substrates from decentralized water systems in the Mekong delta

University of Bonn:
working group materials flows
Dr. J. Clemens
working group hygiene  
working group sociology  
working group agricultural ecology  
working group agricultural water management  

University of Bochum:  
working group drinking water  
University of Can Tho  

Level of knowledge:  
About 17 million people are living in the Mekong delta (40,000 km²). The population density is twice as high as in Germany. The delta is mainly used for the growing of rice, vegetables, and fish farming. Less than 50% of the total population has access to fresh water, in rural areas less than 10%. Instead of drinking water, people use collected rainwater (pathogenic germs) or water from uncontrolled wells (chemicals for use in agriculture, seawater intrusion).

Main activities:  
In the first part of this project the soils, groundwater, water and materials flows, and the agricultural use of two different areas in the Mekong delta will be studied in detail. The varying demands of soils for fertilizer/sludge or humus/compost will form the basis on which the most suitable waste water concept will be worked out. Concerning drinking water, the disinfection with soil filtration, solar energy and the sustainable abstraction of groundwater will be examined.

Comment on project funding:  
The Mekong delta is considered typical for many territories of South Asia:
- alternation between flood and demand for irrigation
- pollution of the raw waters (groundwater, surface water)
- rural areas which are intensively used for agriculture

Construction and maintenance of drinking water treatment and waste water treatment plants are expensive, especially in areas with low average income. The idea of this project is to adapt the waste water treatment system directly to the demands of agriculture. This will increase the consumer acceptance and decrease the costs of the maintenance.
### Egypt (Prof. Hegemann - Technical University of Berlin)

**Topic:**
Improvement of the effluent quality of aerated lagoons (ponds) by membrane filtration

Institute for Technical Pollution Control  
National Research Center

**Level of knowledge:**
Lagoons are widely spread because of the simple and cost-saving construction and maintenance. However, the rate of degradation and the retention of bacteria and germs are limited compared to activated sludge plants. Strictly speaking, direct use of the effluents for irrigation purposes is not possible.

**Main activities:**
A pilot plant will be constructed and transferred to an existing waste water treatment plant in a village near Cairo. The pilot plant will serve for about 500 population equivalents.

The device will be optimized to reduce water evaporation, to increase retention of pathogenic germs, the operation safety, and to reduce the costs of maintenance.

After membrane filtration, the treated waste water is intended to be reused for irrigation or as industrial process water.

For applications in Germany or Eastern Europe, where lagoons are frequently met, operation conditions for N- and P-removal will be studied. The treated waste waters should then be discharged into receiving water bodies or infiltrated into the ground.

**Comment on project funding:**
In the case of success, this project will contribute to the improvement of existing simple waste water treatment plants. It is designed to save rare drinking water resources and reduce the costs for fertilizers. Egypt was chosen as location as it is considered typical for all semi-arid climates.

The operation conditions with N- und P-removal will allow to optimize existing lagoons (ponds) in Germany and Eastern Europe, respectively.

### Turkey (Dr. Theilen - AT-Association)

**Topic:**
MODULAARE - Integrated modules for high-efficient waste water treatment, waste treatment and recovery of energy in tourism resorts

**Level of knowledge:**
The materials flows in (tourist) hotels are extremely high:
Proper recycling management is generally not applied in hotels or tourist resorts. Sarigerme Park Hotel situated on the Turkish Aegean coast about 372 beds and was selected for the following reasons:

- there is sufficient place for pilot plants
- the hotel provides the necessary technical equipment to support the research program.
- the hotel is connected to a municipal waste water treatment plant. In the case of operation troubles or reconstruction measures there will not occur any problems.
- the hotel has been granted different environmental awards and was certified according to DIN EN ISO 14001. This shows the commitment of the hotel management to a sustainable tourism.

**Main activities:**

A large closed-loop recycling waste water and solid waste is intended to be achieved by the activated membrane reactor the fermentation module.

The membrane module will produce industrial process water. Its suitability for irrigation, fertilization, and the hotel laundry will be investigated.

Cut grass, kitchen garbage and the surplus sludge will be treated in the fermentation reactor. This module will be optimized in terms of amount of produced biogas, quality of compost, and pre-treatment of the input materials.

A concept to make use of the biogas (i.e. decentralized power station) will not be realized at the moment.

**Comment on project funding:**

Since the tourism industry is an important economic factor in Germany, we are particularly responsible for supporting sustainable tourism. In a lot of touristic areas the situation is quite similar.

Due to the modular concept, an adaptation to various places and climatic zones seems to be easily realizable.

**Brazil (Dr. Sternad - Fraunhofer Gesellschaft, Institute for Interfacial Engineering and Biotechnology)**

**Topic:**

Decentralized water supply and waste water treatment combined with recovery of nutrients and energy under consideration of hygienic aspects for Piracicaba

**Partner**

Universidade Metodista de Piracicaba

**Level of knowledge:**

Only 9.6% of all South American bigger cities (> 50,000 inhabitants) treat their waste waters. In the city of Piracicaba (320,000 inhabitants) about 35% of the waste waters are treated in 45
usually smaller treatment plants. The waste water is frequently treated in open ponds, so that the dengue fever and other tropical diseases have spread.

Solid waste is deposited on unsuitable dumps, no recycling has been applied up to now.

**Main activities:**

- **Waste Water:**
  - Improvement of waste water treatment in Piracicaba.
  - A study will be carried out regarding the optimization of existing treatment plants. They will be evaluated concerning the production of biogas, production of N-, P-fertilizers, disinfection of the effluents.
  - Most of the existing waste water treatment plants start with an anaerobic stage. (target: optimization of the anaerobic reactor.)
  - Most of the plants apply an aerobic reactor as second step. At the biggest waste water treatment plant (Piracicamirim) it is intended to install a closed pilot reactor developed in Germany.

- **Waste:**
  - A concept for the separation, recycling of waste, and production of biogas will be worked out. A pilot plant for the production of biogas will be constructed on the campus.

**Comment on project funding:**

The city of Piracicaba is considered a promising location in Latin America. The region has a good reputation regarding its commitment to environmental protection. The first environmental associations were founded in Piracicaba. So we are looking forward to finding highly motivated local authorities.

The concept developed by FhG strongly considers the local infrastructure which is characterized by a lot of small (decentralized!) plants, no space for enlargement, and frequently the above mentioned two-stage construction.

With the help of two pilot plants it is intended to show an economically efficient way to improve existing plants.

**Ghana (Dr. Geller - Ingenieurökologische Vereinigung e.V.)**

**Topic:**

Ecological recycling management at the Valley View University in Accra

**Partners:**

- Bauhaus University of Weimar/ ecological engineering
  - Prof. Dr. D. Glücklich
- University of Hohenheim/ Tropics center
  - Prof. Dr. J. Sauerborn
- Valley View University
  - Dr. S. Laryea

**Level of knowledge:**

- biggest private university of Ghana (about 710 students, 50 lecturers/administration)
- water supply is mainly managed by trucks because of the inefficient public supply
- no utilization of rainwater or water-saving technologies
- old-fashioned waste water treatment
- the university will be enlarged (2005: about 1300 students)
Main activities:
- The present concept for the enlargement of the university will be extended to an ecological master plan (subjects: urban development, transport; energy, water, and waste; social and cultural activities).
- Reconstruction of a building with water saving toilets, construction of a new building with water saving toilets, compost toilets, and utilization of gray water.
- Storage of rainwater in a cistern for irrigation
- Recycling of biowaste, compost, urine, in agriculture, production of biogas.

Comment on project funding:
This project addresses to a target group that is highly interested in new technologies. We expect this to be of great advantage to the implementation of the joint research results, because the graduates of the university will spread their acquired knowledge to their home countries.

It will be interesting to study the social acceptance and the technical advantages or disadvantages of different techniques (water-saving toilets, compost toilets etc.) applied at the same place.

The results of this cooperation will be incorporated into a new study course called “Community and International Development Studies” at the Valley View University.

Projects in preparation

Four more projects are in preparation, which are briefly introduced in the following:

China:
This project is designed for rapidly growing urban areas. The most effective size of waste and waste water treatment plants will be determined regarding the recovery of energy and raw materials.

Algeria:
Waste water without or with little pretreatment will be reused to irrigate municipal areas to improve the air quality of the city of Algiers (i.e. along the main roads). The waste water will be taken directly from the sewer system. (GTZ cooperation).

China/Tanzania:
A new concept to obtain drinking water from the humidity of the air will be studied. The problem of the energy need will be solved by the exchange of radiation with the atmosphere.

South Africa:
Construction of a so-called “water house” designed for all water-related activities to improve the hygienic conditions in villages of developing countries.
Demand on and difficulties for implementation of ecosan concepts in China

Jian Zhang
Institute for Sustainable Technology, Zheda-Water - Zhejiang University Water Technology Co., Ltd.
E-mail: zhang@t-online.de

Jun Chen
Zheda - Zhejiang University Enterprise Group

Urbanisation and water pollution in China

The delayed family planning policy has resulted in a continuous population increase over one hundred years, and the social and economic development results in urbanisation. China is undergoing a precedent-less quick urbanisation process.

Summarizing various data sources the urbanisation in China can be reflected in the following figures.

<table>
<thead>
<tr>
<th>Year</th>
<th>1980</th>
<th>1995</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urbanisation grade</td>
<td>19.39%</td>
<td>28.85%</td>
<td>Ca. 40 %</td>
</tr>
<tr>
<td>Urbanised population</td>
<td>191 mio.</td>
<td>352 mio.</td>
<td>Ca. 520 mio.</td>
</tr>
<tr>
<td>Cities</td>
<td>223 cities</td>
<td>640 cities</td>
<td>?</td>
</tr>
</tbody>
</table>

Table 1: Urbanisation in China

Uncontrolled exaction of groundwater resulted in significant decline of groundwater level. Municipal and industrial wastewater as well as runoff from farmland pollute the insufficiently available water resource. The shortage of clean water has become to an essential limiting factor for the social and economical development.

Currently in more than 70 % of the Chinese cities the clean water resource is scare. Most Chinese lakes in and near cities are overloaded by nutrients phosphor and nitrogen.

According to the official source the treatment rate of the wastewater in China nowadays is only 7 %. At the same time the urbanisation speed is 8.3 % with an increasing trend.

Analysis of the countermeasures currently being implemented in China

In order to solve the problems China is undertaking the following measures in the field of urban construction:

1. Increasing the wastewater treatment rate with conventional European sanitation concept and centralised wastewater plants
2. Increasing reuse rate of effluents from the centralised wastewater treatment plants
3. South-water to northern projects

These measures are analysed and evaluated based on concrete examples. The results reveal the following problems:

1. According to both Chinese and European experiences the water pollution problem, particularly eutrophication problems in Chinese lakes cannot be sufficiently solved by the central-
ised wastewater plants, because of the very limited dilution possibilities and the huge difference between the nutrients concentration in effluents of wastewater plants and the requirement for surface water bodies.

2. Case studies showed that the possibility of reutilisation of effluents of wastewater plants is very limited in the praxis.

3. “South-Water to northern” can improve the water quantity situation in the northern cities but not the water quality situation. On another side, comparing the precipitation in northern Chinese cities with some European cities, for example with Berlin, it can be concluded that many northern cities are not absolutely water-“poor”. A comprehensive water management including rainwater harvesting is much more necessary.

4. Ecological sanitation and source control of wastewater (Otterpohl, 2000 etc.) can be regarded as very sustainable solutions for Chinese urban areas, particularly for construction of the new settlement areas and sanitation of old downtowns.

Comparison of South Control Measures with Traditional Sanitation Concepts with Preliminary Model Analysis

One of the typical pattern of urbanisation in China is the development of suburban area to urban area. A preliminary model analysis has been made for a new settlement with a total area of 10 km² and a projected population of 100,000.

The water consumption is divided into: drinking water, kitchen and shower water, washing water, toilette flushing water, water use in summer for green areas/facilities, road and street cleaning, water demand for scenery water bodies for compensation of evaporation loss, water used for construction, car washing etc.

Alternatives for water supply and treatment are compared with each other with cost estimates. The result shows the advantage of the source control concepts in ecological and economic terms.

Implementation Conditions

The acceptance in Chinese circles, particularly politicians for such as source control measures in urban construction is still very low. Reasons are many. One of the typical questions is that “we are learning European well proved experiences and concepts, these are centralised plants with thick pipelines”.

Current regulations and financing systems in China for urban construction are analysed, suggestions for research and development works as well as possibilities for application of ecosan concepts are made.

References

New legislation for on-site sanitation in Finland

Harri Mattila
Häme Polytechnic
Environmental Engineering
Visamäentie 35 B, FIN-13100 Hämeenlinna, Finland
e-mail: harri.mattila@hamk.fi

Keywords
Legislation, on-site sanitation, wastewater management

Abstract
Decentralised sanitation is very prominent in Finland at the moment. New legislation has caused and will cause further, number of changes in existing practices. These changes will cost billions of euros over the coming years.

The magnitude and speed of the development in the sector of decentralised sanitation is causing much confusion among authorities, manufacturers and other entrepreneurs and house owners.

Municipal authorities should now take a firm hold of the new tools (laws, decrees, municipal ordinances, etc.) and start requiring an improved standard of wastewater treatment also in rural areas. If they are not strict enough, they might lose the power of the new tools. It is easier to loosen one’s grip in the future (if necessary) than to tighten it.

Workable solutions will require totally new thinking as regards services. There will be new types of companies, co-operatives and entrepreneurs producing wastewater services.

Composting toilets should be promoted more forcefully as an alternative in the process of selecting proper sanitation management. But the reputation of dry toilets must first be improved. We all have mental pictures of old earth toilets that were cold, dark, smelly and had flies. That is why dry toilets are not very much appreciated in Finland today.

The need for on-site sanitation in Finland

The Finns have loaded their watercourses relatively heavily with different pollutants during the past decades. From about 1950 onwards, industrial development began, and the pulp and paper industry polluted badly certain rivers and lakes. At the same time, cities grew and the expansion of water distribution networks resulted in an extra load of wastewater on the same receiving waters. The use of artificial fertilisers in agriculture and forestry and subsequent leaching and runoffs into receiving waters has also increased. All these causes of pollution are now controlled to some extent. (Mattila, 2001)

Successive governments have supported rural areas in constructing drinking water supplies up to now, but wastewater treatment has been largely neglected. Now developers are working to keep the countryside alive, by trying to slow down migration from rural areas to cities. That is why farmers are supported in their efforts to process their products locally. And that is why there are projects aiming to improve the standard of the summer cottages to make them suitable for year-round living. The downside of these activities is that they increase the wastewater load on the watercourses.[LHL1].
Wastewater treatment by industry, cities, and even villages, developed rapidly from the late 1960s to the early 1980s (see Figure 1). Today, diffuse pollution is the major concern in water protection. Watercourses downstream of big cities and industries are improving, but other waters are in danger of becoming contaminated, because they are receiving more nutrients, solids and even bacteria, than they can tolerate.

Figure 1: Number of wastewater treatment plants in cities in Finland (1900–1993) (Katko and Lehtonen 1999).

Because of the major sources of pollution mentioned above, the wastewater load from individual households outside of sewer networks has so far been neglected. Even the Finnish Water Act has become outdated in this regard. Until February 2000, it was only acceptable to treat wastewater in septic tanks. Yet, it is known that even properly working septic tanks can only remove a maximum of 70% of the solid matter in wastewater (Mäkinen 1983; Santala 1990). Dissolved impurities flow freely into the environment, often directly into a ditch or a river.

National targets for water protection in Finland until 2005 were set in 1998. The targets for scattered settlements are ambitious. The BOD load should be reduced by 60% and the phosphorus load by 30% (Ministry of the Environment 1999).

There is also a real need of on-site sanitation in Finland for technical and economical reasons. With a population density of about 17.3 /km² for the whole country and only about 11.7 /km² outside of the capital area, it is clear that the centralised systems would be either too complicated, too expensive, or both in many areas.
### The changed on-site sanitation legislation

The **Environmental Protection Act** was amended on 1 March 2000 to meet the targets for 2005. The new act states that wastewater in rural areas must be treated to the extent that it cannot have a negative impact on the environment. The treatment technology, or even the methodology, is not specified in the law, but municipalities are given the right to issue local ordinances on these matters based on local circumstances. On the other hand, municipalities are also responsible for controlling the quality of wastewater treatment in their areas.

The Environmental Protection Act also has some other important sections dealing with on-site sanitation.

The general principles of the Environmental Protection Act are:

- environmental damages must be prevented beforehand
- environmental damages must be minimised
- people must exercise caution in their actions
- BAT (Best Available Technology) must be applied
- BEP (Best Environmental Practices) must be applied
- the one causing environmental damages must also pay for the rehabilitation.

The Environmental Protection Act gives the Ministry of the Environment the right to issue a decree on wastewater treatment in rural areas. Such a decree was ratified on the 11th of June 2003 and it will come into force on the 1st of January 2004.

According to the decree (Committee of Ministry of the Environment 2001):

- Wastewater must be treated so that
  - BOD load is diminished by 90 %,
  - total phosphorous content by 85 % and
  - total nitrogen content by 40 %.

  The measured effluent quality will be compared with the so-called house-specific wastewater load. It can be calculated by multiplying the number of occupants of a house by the average wastewater load per person and day which is equivalent to 50 g of BOD, and 2.2 g of total phosphorous plus 14 g of total nitrogen.

- A municipality can lower the percentages to 80 % (BOD), 70 % (P) and 30 % (N) in an area which is not very sensible as to environmental damages.

- Each and every household without a sewer connection must have a written (and drawn) description of its wastewater treatment system.

- Each wastewater treatment system must be designed according to the guidelines given in the decree.

- Sludges from septic tanks, other treatment units and containers must be collected from the properties like solid wastes. Thus, the municipality must organise centralised collection if the house owner cannot show he has made a contract concerning the collection with a company or an entrepreneur.

- The decree must be followed immediately from the beginning of 2004 with regard to new houses and within ten years with regard to existing houses.
The Environmental Protection Act gives municipalities the right to issue local environmental ordinances according to local circumstances. This means that a municipality can, for example, deny water closets in a certain area where water or groundwater pollution could seriously contaminate water supplies or, for example, nature.

Further, the Environmental Protection Act gives the municipal environmental authority the right to make inspections on site. If there is sufficient reason, the authority can demand improvements, for example, to the wastewater treatment system.

According to the Environmental Protection Act, it is not permissible to spoil the quality of groundwater or the soil. This is a quite important fact to remember when designing soil treatment systems for wastewaters.

The Water Supply Act is another new law affecting the sanitary solutions in rural areas. The act states that municipalities must have a Development Plan for Water Supply Services approved by the end of February 2004. This is the most essential section of the act. In the development plan municipalities are to present time schedules for the expansion of water and wastewater supply networks in the near future. This will provide the properties now outside of the networks valuable information the kind of technology and the size of investment reasonable for them.

According to the Water Supply Act, all the properties within the operational area of a water supply company have, on the one hand, the right to be served by the supply and, on the other, the responsibility to connect themselves to the network.

The Land Use and Building Act is a new act as well. It has the aim of improved quality of planning and construction. A design of a new house with a design of an on-site sanitation system must be approved by the municipal authority before the construction. Some of the sections of the act deal with the qualifications of persons involved in the construction business.

Quite an interesting and valuable section of the Land Use and Building Act is the one requiring that all new houses must have operation and maintenance guidelines in written form. These would be beneficial in the case of old houses and their equipment as well.

The Health Care Act gives the municipal health authority the right to make inspections on site. If some defects that could possibly cause health problems are found, the authority can demand improvements, for example, to the wastewater treatment system.

Will the new legislation be followed?

The mentioned acts as well as some lesser acts will lead to quite an improvement in on-site sanitation in Finland in the near future, especially if the municipal authorities are willing to use the available tools.

Figure 2 shows the changed situation with respect to the legislation concerning of on-site sanitation in Finland. The practical application of the new acts might be difficult in those Finnish rural areas where municipalities have few inhabitants. Thus, it may not always be easy for local politicians to set strict enough requirements: on-site wastewater treatment always means extra costs to households.
Figure 2: The changes in legislation for on-site sanitation in Finland

However difficult it will be to apply the new legal tools to achieve better on-site sanitation in municipalities, the authorities should be quite strict when doing so. If even the weakest tool is broken the stronger ones can also become useless.
New services are required

As long as on-site sanitation means wastewater (especially black wastewater) treatment on the property, house owners themselves cannot assume responsibility for designing, constructing, operating and maintaining the treatment units. In many cases even the septic tanks have proven too difficult to them to take care of, not to speak of more complicated systems.

Thus, successful on-site sanitation requires new actors to be involved. There are some 350,000 houses and 450,000 summer cottages outside of sewer networks in Finland (Committee of Ministry of the Environment 2001). Even though the sites are many, it is obvious that the big consultancy and construction companies are not very interested in tendering for this type of work where the unit prices are minimal.

Due to the new legislation on wastewater treatment in rural areas, product development work is very intensive in companies manufacturing treatment units. The BAT principle of the Environmental Protection Act requires that a person maintaining on-site sanitation systems must be a professional. Only a person involved in the sector daily knows always what is the newest and best technology for the property in question.

There are so many properties with on-site sanitation systems in municipalities that the municipal environmental protection authority cannot visit all of them to exert control. That is why control of the type in Figure 3 is suggested. The professional performing the maintenance on the on-site system reports major needs for repairs and other bigger undertakings not only to the house owner but also to the municipal authority. The authority can then make a control visit to the properties time allowing.

![Diagram](image-url)

**Figure 3:** Proposed control system for on-site sanitation (proposal by the author)

In future, the Finnish Environmental Authority (FEA) is to keep a register of the on-site sanitation systems which meet the requirements of the decree on wastewater treatment in rural areas (Committee of Ministry of the Environment 2001). That will ensure that BAT is used as far as possible.

The Regional Environmental Authorities (REA) are given an advisory role in the process. They have the latest information on, for example, the legal and financial aspects.

Of course, all the parties can consult FEA when-ever necessary. And the houseowner can contact REA to check, for example, the possibilities of getting financial aid for investments.
The dry toilet could solve water protection problems

Most of the nutrients, especially in black wastewaters, come from urine and faeces (Table 1).

<table>
<thead>
<tr>
<th></th>
<th>BOD</th>
<th></th>
<th>P</th>
<th></th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g/pc</td>
<td>%</td>
<td>g/pd</td>
<td>%</td>
<td>g/pc</td>
</tr>
<tr>
<td>faeces</td>
<td>15</td>
<td>30</td>
<td>0.6</td>
<td>30</td>
<td>1.5</td>
</tr>
<tr>
<td>urine</td>
<td>5</td>
<td>10</td>
<td>1.2</td>
<td>50</td>
<td>11.5</td>
</tr>
<tr>
<td>grey water</td>
<td>30</td>
<td>60</td>
<td>0.4</td>
<td>20</td>
<td>1.0</td>
</tr>
<tr>
<td>total</td>
<td>50</td>
<td>100</td>
<td>2.2</td>
<td>100</td>
<td>14</td>
</tr>
</tbody>
</table>

Table 1: Content of black wastewater (Committee of Ministry of the Environment 2001)

Considering the requirements of the decree on wastewater treatment in rural areas (page 3), it becomes obvious that the utilisation of dry toilet technology could help meeting the targets of water protection.

Treatment of grey wastewater is much easier than that of black wastewater. In most cases grey water infiltration would be successful, and if not, there are several rather simple treatment units for sale purifying them.

There is dire need to promote the use of dry toilets in Finland. In this country of tens of thousands of lakes the recreational use of water courses is quite popular during the summer. The problem is the very low discharge of smaller streams and rivers in midsummer which is the season for their recreational usage. When there is little natural flow, the bigger portion of the flow consists of wastewaters. This means that the bacteriological quality of waters is not satisfactory. If black wastewater is not led into ditches and rivers the situation improves significantly.

Yet, it is not too easy to promote the use of dry toilets in Finland. The time people still used traditional earth toilets is not too far behind. Their use in the cold climate with the associated smell and flies do not bring back fond memories. Thus, we should develop the existing composting toilets to bring them up to a level where they can truly compete with the comfort of water toilets. But even this is not enough: powerful marketing efforts are also required to make the new toilet technology popular.

Conclusions

The existing acts and other legal tools are sufficient for solving the wastewater problems of Finnish rural areas. It is more a question of common will and appropriate management solutions than inadequate tools. Municipal authorities should now take a firm hold of these new tools and start insisting on an improved standard of wastewater treatment in their areas.

The design, construction, operation and maintenance of on-site sanitation systems cannot be made the sole duty of homeowners. The appropriate solutions will require totally new thinking as regards services. There will be new types of companies, co-operatives and entrepreneurs producing wastewater services for consumers.

Until now, the sanitation of rural areas has not been controlled carefully enough. The new tools also make control of the work possible, if so desired.

We should promote composting toilets more forcefully as an alternative in proper wastewater management. There is no sense in mixing pure tap water with faeces and trying to separate them some 10 meters away on the other side of the wall. But the reputation of dry toilets must
first be improved. We all have mental pictures of old earth toilets that were cold, dark, smelly and had flies. That is why dry toilets are not very much appreciated in Finland today.

References


Mäkinen, K.: Structure and operation of septic tanks - A literature review and experiments, Publication no. 227, National Board of Waters, Helsinki (In Finnish, abstract in English).


Key-activities, services and current pilot projects of the international ecosan programme of GTZ*

Christine Werner,
Heinz-Peter Mang,
Ve Kessen

GTZ ecosan project
Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH
Dag-Hammarskjöld-Weg 1-5, 65726 Eschborn, Germany
internet: http://www.gtz.de/ecosan
e-mail: christine.werner@gtz.de

Keywords
Ecological sanitation programme activities, knowledge management, advocacy and networking, ecological sanitation pilot projects

Abstract
The GTZ started its international ecosan research and development project in May 2001 and is financed by the German Federal Ministry for Economic Cooperation and Development (BMZ). The aim of this project lies in promoting the development and pilot application of integral ecologically, economically and socially sustainable recycling-based wastewater and sanitation concepts in developing countries. Furthermore it aims at contributing to the global dissemination and application of ecosan approaches and establishing these internationally as state-of-the-art techniques – in both developing and in industrial nations.

Introduction
German development co-operation considers ecosan, including rainwater harvesting, as a new approach representing a series of technologies that are important in order to resolve the increasingly urgent problems related to the global water crisis. These approaches should serve as a key element in finding the necessary solutions if we are realistically to have any hope of achieving the Millennium Development Goals (MDG) in water supply and sanitation of halving the proportion of poor people without access to safe water and sanitation by 2015, and to contribute tremendously to environmental protection, sustainable natural resources management and safeguarding our future food security on earth.

The GTZ started its international ecosan research and development project in May 2001, with the project being financed by the German Federal Ministry for Economic Cooperation and Development (BMZ). The aim of the project is to promote the development and pilot application of integrated ecologically, economically and socially sustainable recycling-based wastewater and sanitation concepts in developing countries. Furthermore it aims at contributing to the global dissemination and application of ecosan approaches and establish these internationally as state-of-the-art techniques, in both developing and industrial nations, and at mainstreaming ecosan-approaches into technical and financial German development co-operation.

Ideally, ecosan systems enable an almost complete recovery of all organic nutrients and trace elements contained in domestic wastewater. Appropriately treated, such raw materials can be returned to agricultural processes, where they help maintain soil fertility and ensure long-term food security. At the same time, ecosan systems contribute to the conservation of our water resources and to reducing water-related environmental pollution and health risks.

*This paper has been peer reviewed by the symposium scientific committee
Key activities of the GTZ ecosan project

Know how management and networking

In co-operation with international and local partners, the ecosan project collates existing know-how so that existing experience on ecological sanitation can be used and further developed. This knowledge may include publications and practical know-how from users and experts on established as well as new ecosan specific developments, the problems encountered, news of successful projects, research findings and much more.

The ecosan project promotes the systematic development of a global sector-specific network of people, institutions and projects. It addresses experts, potential users and decision-makers who are looking for information, seeking concrete answers to specific questions, in need of decision-making tools or looking for contacts.

The GTZ ecosan project supports this network in several ways:

- e-newsletter
  Since June 2001, the ecosan project has been producing a multilingual electronic newsletter (in English, German, Spanish and French); it contains news of interesting new developments in ecological sanitation, information on, and downloading options for, current publications, details of upcoming events, contacts and interesting links, plus a sector forum for communicating with a readership of several thousand. The electronic GTZ ecosan newsletter appears quarterly. You can subscribe to the newsletter by sending an e-mail containing the words “subscribe ecosan” to majordomo@mailserv.gtz.de

- ecosan website
  Current information on closed-loop wastewater management and sanitation is available in German and English at: www.gtz.de/ecosan.

- ecosan project data sheets
  In cooperation with the SIDA (Swedish International Development Cooperation Agency) funded EcoSanRes-Programme of the SEI (Stockholm Environment Institute) and other partners, the GTZ-ecosan-project is compiling and constantly extending an overview list of existing pilot and research projects. Additionally, information concerning interesting and exemplary projects will be realised in the form of project data sheets.

- ecosan technologies data sheets
  With the support of the technical working group, the gtz-ecosan-project is elaborating technology data sheets on various ecosan-components.

- other publications on ecosan
  Ecosan-experiences and know-how are published by the ecosan-project along with brochures, posters, magazines, technical publications, films and other media

- conferences and workshops
  Organization of, and participation in, international events and workshops.
  (The 1st and 2nd international symposia on ecological sanitation Bonn 2000 and Lübeck 2003, 1st international conference on ecological sanitation, Nanning, China 2001, and many others.)

- co-operation in the field
  To advance ecosan ideas and to ensure that practical applications of ecosan result in good practise, a close co-operation between the experts working in the new field of ecosan and a
constant exchange of views and experiences between them is needed. The GTZ supports this co-operation through the exchange of experts between projects, through common evaluations, local workshops, and through the joint development and implementation of pilot projects.

- national and international working groups

This involves the initiation and coordination of expert working groups as project think-tanks, to establish basic materials and develop model ecosan concepts. So far a German-speaking technology working group has been established to compile, discuss and further develop various ecosan suitable technologies. Another international working-group for the subject of participation, awareness raising and education in the field of ecosan-promotion is in preparation in order to develop strategies, guidelines and tools for application in ecosan-projects.

**Design and implementation of pilot projects**

The design and implementation of research and demonstration projects with a focus on urban areas is the second main focus of the GTZ’s ecosan project. The aim of such pilot projects is to arrive at cost-effective, user-needs-oriented, practical ecosan solutions, which benefit users. In addition to addressing sanitation technology issues, another essential component of ecosan pilot projects are the concepts needed for the safe agricultural and horticultural application of the recovered products. Market analyses and suitable marketing strategies for the recovered recylcates are also necessary. Cost comparisons with conventional systems are just as important as the development of training modules for users, service enterprises and farmers, and health education measures.

At present, pilot demonstration projects are being prepared or implemented with the support of the GTZ-ecosan project in more than 20 countries. As the overall budget of the international GTZ ecosan project is limited, the main activities lie in laying the foundations for projects by researching, preparing and elaborating a financing concept as well as supporting the elaboration of baseline-studies, feasibility studies and project proposals which may be submitted to financing agencies or investors. Also ecosan-consultancy and knowledge management during the project implementation phase is offered.

Implementation on a larger scale and particularly in urban areas demands larger investments, as well as additional financing for the planning and development of innovative solutions, awareness raising and community participation. More funds are necessary if scientific research also forms a part of the project along with the promotion of agricultural use. Therefore, a commitment and budget is needed from local communities, bilateral German technical or financial cooperation, research programmes, other donor agencies or private investors.

**Ecosan pilot projects supported by German Development Cooperation**

**Botswana - ecological sanitation as an element of sustainable natural resources management**

In many African countries, including Botswana, conventional forms of wastewater disposal have drawbacks for the general population. Most households located outside the major urban centres are not connected to any existing waste management and sanitation system. Droughts and inadequate water resources make an already unsatisfactory situation even worse.
Over the next five years, a project devoted to sustainable regional resource management will be co-operating with local authorities, the International Union for the Conservation of Nature (IUCN) and the German Development Service (DED) to develop, test and demonstrate sustainable, decentralized wastewater management and sanitation systems and methods. Initially, private households in the districts of Ghanzi, Gaborone and Serowe are to be tied into the research activities. Later, the approach will be extended to the municipal level. One of the aims of this GTZ-project is to recover nutrients and trace elements from domestic wastewater, faeces and urine for use in agriculture. This not only contributes toward long-term food security, but also provides the people with an opportunity to earn extra money.

Egypt – Soilization of sewage sludge

In many countries, the use of sewage sludge in agriculture is thwarted either by the complexity of the processing technology or by the poor quality of the sludge, which arouses very little interest among farmers for its use as a soil conditioner. In Egypt, the GTZ has therefore supported a large scale field test, carried out by IPP Consult, of a process of sewage and faecal sludge upgrading, or soilization, by means of sewage sludge polders with grass or common reed. The results are promising and the process will be introduced in other ongoing ecosan pilot projects of GTZ in Kafr el Sheikh in Egypt and in Mali:

- process technology is easy to manage and economical
- structural, aesthetic and hygienic attributes of the soilised sludge are superior to those of dried sludge
- soilised products find more acceptance and the market potential is improved

Mali - On-plot ecosan systems for the treatment of faeces, urine and greywater

Koulikoro has a central potable water supply system dating from the 1970s, but as yet no sewage system. In an arid sub-Saharan country like Mali, where financial and water resources are scarce, a water-carried sewage system resembling those used in Europe would be inappropriate and too expensive. Mali is also faced with the steadily worsening problem of soil degradation, including desertification, chiefly as a result of agricultural overuse and an insufficient return of nutrients.
An affordable means of proper wastewater disposal is needed. The GTZ has therefore developed an on-plot household ecosan system in which faeces, urine and greywater are separately collected and treated. This offers major advantages over conventional latrine-based systems, as it enables the hygienic recovery of soil amending substances from faeces and of nutrients from urine and purified greywater. The ecosan system is also in harmony with local traditions. In 2002, the National sewage and Solid Waste Department at the Malian Ministry of the Environment incorporated the grey-water gardens and separating toilets developed by the ecosan initiative into its program. Together with the GTZ, the department is now examining their suitability for a widespread introduction. Ultimately, however, the success of grey-water gardens depends solely on the degree to which they are accepted by women for growing vegetables, bananas and papayas. At present, preparations are being made within a GTZ-supported decentralisation programme in a 2nd region, for a further development of this ecosan concept and its dissemination in 19 densely populated urban areas with between 2,000 to 130,000 inhabitants.

China - Municipal ecosan concepts in a Beijing suburb

Located in one of Beijing’s three river basins, Yang Song covers a little more than three square kilometres and is home to some 21,000 people. With its intensive livestock farming and grain and vegetable production, the region is a major source of food for the city of Beijing. The community currently produces roughly 15 tonnes of solid waste each day. Less than 10% of the town's wastewater is treated prior to being discharged into the rivers or groundwater. Within the scope of a local ecosan project, the community is to be provided with a modern, material-separating disposal and recycling concept for wastewater and organic wastes that is in line with the...
principles of closed-loop wastewater management and sanitation. The GTZ, Chinese and German scientists and companies are working together to analyse and compare different sanitation, wastewater treatment and recycling options in various harmonized systems. The cost-effective recovery of useful materials and energy is the main objective.

There are also plans to use water-saving vacuum technology and urine separation systems. Organic waste from kitchens and markets will be collected, shredded and, finally, fermented in a bioreactor system. The resultant fertilizer and hygienized urine will be suitable for use in growing flowers and vegetables. Greywater will be used for watering public parks and gardens.

**Cuba – ecosan research into non centralized applications**

Throughout Cuba, and particularly in urban areas, the wastewater management and sanitation systems lack capacity and are in urgent need of rehabilitation. Most notably in peri-urban areas with considerable agricultural activity, the soil, groundwater and watercourses are heavily polluted. As a result, health conditions and odour nuisance levels are critical in many places.

Moreover, many households do not have access to electricity. This forces many people to use ecologically questionable forms of fuel for their everyday needs.

To address the situation, a GTZ-supported ecosan research project is conducting field tests on various household sanitation systems and looking for appropriate-technology solutions that may generate cooking energy. For example, on several city farms in two different project regions, the utilization of household sewage and organic waste is being integrated into the in-house production of fertilizer and cooking energy. In a third region, pre-fabricated components are being designed and developed for diverse decentralized disposal systems, and in a fourth region, different ecosan systems are being implemented in urban centres. The four regions in question are located in different parts of the island to ensure the study of the representative of the island’s diverse climatic, structural and social conditions.
Ecological sanitation concept in Lesotho, water borne closed loop

Lesotho is selling drinking water to South Africa, but in their capital Maseru, high quality drinking water is scarce. Groundwater and lake water pollution in the city area was measured and pit latrines and septic tank overflows have been identified as contaminating source. The rocky underground is impermeable. At the other side, the large urban housing plots could be more efficiently used for urban agriculture and gardening, a need in a land where the arable space is under pressure. The central sewage treatment system is under loaded, because only a small part of Maseru city is connected and even half this sewer-connected area does not reach the treatment plant, as the pumping station has not been functioning for several years due to high operation costs and technical difficulties, which has resulted in a shortcut of the used untreated water to the border river.

Supported by the German Embassy, the German Development Service (DED) is realising some training and demonstration measures for household centred and community based closed loop on plot reuse of all wastewater and nutrients, driven by a market oriented sanitation approach.

The first system consists of a small bore sewer grid for eight houses (40 persons), a biogas-septic tank unit, an upflow filter based on recycled plastic bottles, a wetland, 800m² vegetable and fruit garden, and two household connections for the biogas as a full cooking energy source (for two families), has been installed and has been in service for one year. Moreover, the organic waste of the whole neighbourhood is composted in the garden area. The demonstration has shown, that year round gardening is possible, with higher yields and quality than only rainwater dependent agriculture and much cheaper than the use of piped fresh water for irrigation with additional fertilizer use. Driven by private demand and investment, an extension of similar systems for individual households and neighbourhoods (3-10 houses) is ongoing. Due to the German support, each site is actually used for training of private constructors and engineers, even from South Africa.

As the non-separation of streams results in a potential over-fertilisation of the garden area, and as first results of the pilot unit show that the biogas-septic tank unit could be smaller with the same energy efficiency if the hydraulic charge is lowered, the next steps planned are the stream separation of grey water and black water and the subsequent introduction of urine diversion. However, this last step will only be taken, when the gardening and urban agricultural demand is established and the liquid fertiliser demand is stabilised.

Further projects in preparation

Other projects are presently being prepared with the support of GTZ-ecosan in several other countries, where advocacy workshops, baseline and feasibility-studies are currently running or being organised:
Conclusion

The joint development and implementation of, mainly urban, pilot projects with other international and local partners in developing countries are a major pillar of the GTZ ecosan project. Pilot projects are indispensable, firstly because a great deal of research and development is still necessary to develop economical, workable and replicable ecosan solutions geared to user needs in urban areas and, secondly, because successful demonstration projects are the best publicity for recycling-based strategies.

Public relations, also via functioning demonstration projects, are enormously important for the successful and sustainable application of new eco-sanitation systems and their acceptance by the actors concerned. These actors include, on the one hand, the users, whose awareness, habits, convenience standards, finances and technical ability must be catered for in developing and implementing ecosan strategies, but also the private sector, public institutions and political decision-makers. The basic idea is to alter perception and concepts: Solid waste and wastewater should be seen primarily as resources containing nutrients rather than waste loads or pollutants.

In addition to addressing technological issues in wastewater disposal, the development work still needs to underpin new integral wastewater and sanitation strategies tailored to various framework conditions by way of pilot projects, including a range of investigations into the hygienic application of recyclates in agriculture and horticulture. There is also a need to prepare market analyses and develop suitable marketing strategies for the recovered recyclates. It is equally necessary to make economic comparisons with conventional systems, as it is to develop training modules for users, service enterprises and farmers as well as measures in health and hygiene education.

References

GTZ-ecosan project (August 2002) recycling beats disposal – flyer
Internal information of GTZ
EcoSanRes – a Swedish international ecosan programme

Arno Rosemarin
Stockholm Environment Institute
Box 2142, 103 14 Stockholm, Sweden
internet: http://www.sei.se/
internet: www.ecosanres.org
e-mail: arno.rosemarin@sei.se

Keywords
Ecosan, ecological sanitation, EcoSanRes, Sweden, global, pilot projects

Abstract
Now that sanitation has made it to the global agenda and that it is one of the Millenium Development Goals, sustainable alternatives to conventional practice need to be brought forward. Up to now the sector has not benefited from the 15-year learning curve on sustainable development. Ecological sanitation provides a battery of choices to communities both rich and poor and features source-separation and containment of human excreta, sanitization and recycling, all of which conventional approaches fail to do. Most of the world practices unsafe, and unsustainable sanitation and only an elite group of countries can afford to build and maintain sewage collection and treatment systems. The EcoSanRes programme has been set up by Sida in Sweden to develop ecological sanitation methods and promote these through full-scale pilot projects in selected developing countries. The outcome of this work will help meet the global needs for improved sanitation using safe, environment-friendly approaches that everyone can afford.

The sanitation crisis and the ecosan challenge
There are at least 2.4 billion people in the world without improved sanitation (defined by the World Health Organization as connection to a public sewer, connection to a septic system, a pour-flush latrine, a simple pit latrine or a ventilated improved pit latrine), primarily residing in rural Asia and Africa. But technically, even access to “improved” sanitation does not solve the problem because conventional pit latrines usually fail to sanitize and they contribute to groundwater pollution. Also, septic systems and sewage treatment plants often discharge into the environment with little or no sanitization or nutrient removal. So in actuality, far more than 2.4 billion people need to gain access to effective and sustainable sanitation.

Taking a somewhat radical view and considering that conventional solutions like pit latrines serving some 2.8 billion people, are often both health and environmental hazards, and that 70% of the sewage systems in the world, serving about 1 billion people, are often dysfunctional, the global sanitation crisis involves most of humanity (Matsui, 2002). Sanitation has somehow escaped entirely the debate on sustainable development. Thus the ecosan challenge is really of global proportion.

Reaching the WSSD target
The UN World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa in autumn 2002, articulated several targets for the coming decade. Among them, “halve, by the year 2015, the proportion of people that do not have access to basic sanitation”. This has been built into the UN Millennium Development Goals project within the Task Force on Water and
Sanitation. An initial background document has been released (Millenium Project, 2003). An action plan will be produced in 2005.

The World Summit for Children in 1990 called for universal sanitation by 2000. With significant effort, the 1990s saw a ten percent increase in global sanitation coverage, rising from 51%-61%, meaning an additional one billion people gained access to improved sanitation. However, the discrepancy between rural and urban sanitation improvement is high, with urban sanitation coverage consistently eclipsing rural sanitation coverage, where 80% of the people without sanitation live. Realizing that population growth is increasing, and that in addition to ensuring the 1.2 billion people in need of sanitation gain access, we must also secure sanitation for the expanding population – projected growth is about 20% by 2015 – the WSSD targets are less idealistic than the World Summit for Children goals, calling for universal sanitation coverage by the year 2025. Still, the consistent delay in reaching international sanitation goals should not be overlooked. The present timeline has already been pushed back 25 years since the status of sanitation in the world reached a crisis level almost 15 years ago. More than 4 billion people will need to gain access to basic sanitation to meet the 2025 target for universal coverage, according to the Global Water Supply and Sanitation Assessment 2000 Report (WHO, UNICEF, WSSCC, 2000).

No sanitation is dangerous

The health risks of a lack of, or inadequate, sanitation are mortal. The Framework for Action on Water and Sanitation, produced in conjunction with the WSSD, indicates close to 6,000 children die each day from diseases related to inadequate sanitation and hygiene, and a lack of access to safe drinking water. “In China, India and Indonesia, twice as many people are dying from diarrhoeal diseases as from HIV/AIDS” (WEHAB, 2002).

“Approximately 4 billion cases of diarrhoea each year cause 2.2 million deaths, mostly among children under the age of five. This is equivalent to one child dying every 15 seconds, or 20 jumbo jets crashing every day”, states the Global Assessment on Water and Sanitation 2000 Report. Other indicators of health risks associated with poor sanitation are the frequency of related parasites that have human faecal origin – about 1 billion people are infected with roundworm and 700 million with hookworm.

Uncontained and untreated human excreta pollute groundwater, streams, lakes and coastal zones, helping to perpetuate the cycle of human disease and upsetting fragile aquatic ecosystems by nutrient overloading and eutrophication. Just the need to “close the loop” on nutrients dictates the necessary paradigm shift toward sustainable sanitation. The health risks of conventional approaches are calling for immediate global action.

Inadequate sewage treatment creates problems downstream

The United States operates close to 100 million flush toilets, averaging 15-19 litres of freshwater per flush as a means to transport human excreta. Conventional sewerage is not a sustainable sanitation system, even for wealthy countries. Sweden, with a population of less than 9 million, produces about 1 million tons of wet sludge each year, most of which cannot be recycled to forests or agriculture due to heavy metal contamination. Of 540 major European Union cities, only 79 have advanced sewage treatment and 45% have either no treatment or incomplete primary or secondary treatment (EU, 2001). In February 2002, the European Commission took legal action against France, Greece, Germany, Ireland, Luxembourg, Belgium, Spain and the United Kingdom for alleged failure to implement various environmental laws for water quality protection. Of the 1 billion people that have flush toilets in the world, only 30% receive advanced sewage treatment (Matsui, 2002).
For developing countries attempting to use conventional flush sewerage systems, the situation is worsened by the resulting surface and groundwater pollution, resulting in an estimated 1 billion people left without access to clean drinking water.

**Socio-economic impact**

According to the Water Supply and Sanitation Collaborative Council’s Vision 21, “recognition of water and sanitation as basic human rights, and of hygiene as a prerequisite…form a major component in poverty reduction”.

Hygiene, safe water and sanitation are fundamental human rights. Ecological sanitation can improve social and economic conditions for all, especially for impoverished communities. Ecosan offers empowerment and safety, particularly to women and girls in urban and peri-urban areas that are often without sanitation, by providing a private and dignified environment for urinating and defecating. The use of sanitized human excreta as a fertilizer stimulates crop growth and, as a result, increases nutrition for those who depend on subsistence farming, or helps to generate or supplement income for those who sell the products they grow.

**The challenges**

Because 80% of the people without adequate sanitation (2 billion) live in rural areas – 1.3 billion of those in China and India – the barriers to communication present a significant impediment to informing these people about ecological sanitation. Television advertising, newspapers or printed material do not reach most of these people. Government services make infrequent calls to remote areas and NGOs serve a small segment of this population. Instead, most information is exchanged through face-to-face communication. How can we spread the message about sanitation alternatives and improved hygiene behaviour to such a large number of people living outside the reach of familiar communication channels?

**Need for alternatives**

Even if the sanitation crisis can be communicated to and understood by more people, the need to find sustainable alternatives to conventional approaches for both developed and developing countries remains. Sustainable and ecological sanitation requires a holistic approach, building on the intimate relationship between people and soil. Sanitation cannot be a linear process where excreta is hidden in deep pits or flushed untreated downstream to other communities and ecosystems.

**Ecological sanitation**

Ecological sanitation provides alternative solutions with or without water, while providing containment, treatment and recycling of excreta. It can involve soil-based composting toilets in shallow reinforced pits, dry urine-diverting toilets with storage vaults, urine-diverting mini-flush toilets and even high-tech vacuum systems. Cost-effective ecosan can be adapted for developing and developed countries. In arid zones, water resources can be saved for more important needs like personal hygiene and growing food. In humid areas with high water tables, above-ground and shallow ecosan systems can remain functional during seasonal floods. Ecosan provides human health and environmental protection using affordable and appropriate technologies to match the needs of the entire world. Figure 1 illustrates the ideal ecosan model.
The need for safe sanitation

Pathogens and parasites found in human excreta, if ingested, can result in a variety of illnesses, including diarrhea leading to malnutrition. If left untreated these illnesses can result in poor growth, iron deficiency (anemia), vitamin A deficiency, and leave the body’s immune system weakened and susceptible to more serious infections. Not all pathogens and parasites result in death, but the resulting malnutrition creates poor health and a predisposition to continual disease and death from other causes.

The limitations of present day sanitation

Conventional sanitation is currently offered by two models: pitsan (pit toilets) or flushsan (flush toilets). Although conventional sewage systems transport excreta away from the toilet user, they fail to contain and sanitize, instead releasing pathogens and nutrients into the downstream environment. This is considered the “linear pathogen flow” (Esrey et al., 1998). These systems mix faeces, urine, flush water and toilet paper with grey water, storm water and industrial effluents, usually overtaxing the design capacity of the treatment plants, if such a facility exists, as very few communities in the world are able to afford fully functional sewage systems. Simply put, flushsan has a dismal track record because all sewage systems contaminate the environment. Far more common than flush sanitation is the pit toilet, primarily because it is inexpensive and requires no infrastructure. This method fails to contain and sanitize excreta since pathogens and nutrients seep into the groundwater. Deep pit latrines also fail to recycle since the excreta is too deep for plants to make use of the nutrients. Pits are prone to periodic flooding, causing them to spill their contents. In general, pits are smelly, are often infested with flies, and in most parts of the world, are poorly maintained and continue to be a source of disease and pollution.

Ecosan is a real option
An essential step in the process of sanitation is the containment of that can cause disease. Human faeces contain bacteria, viruses and parasites, which, if not properly treated, can result in spreading of disease. Ecological sanitation systems are designed around true containment and provide two ways to render human excreta innocuous: dehydration and decomposition. The preferred method will depend on climate, groundwater tables, amount of space and intended purpose for the sanitized excreta.

Dehydration is the chemical process of destroying pathogens by eliminating moisture from the immediate (containing) environment. Some drying materials, like wood ash, lime and soil are added to cover the fresh deposit. Ash and lime increase pH which acts as an additional toxic factor to pathogens if the pH can be raised to over 9.5. The less moisture the better, and in most climates it is better to divert the urine and treat it separately.

Figure 2 shows a dry, double-vault urine diversion toilet, a model being used in China, India, Vietnam and Mexico. It takes an average family 6 months to fill one of the vaults. Then the second vault is used. The first vault is emptied following an additional 6 months of sanitation and the material is taken to a soil compost. Urine is never mixed in this toilet but continuously diverted into a separate container and later used in diluted form as plant fertilizer. The dry ecotoilet meets all necessary health and environmental protection criteria and goes well beyond what conventional approaches can offer (Stenström 2002), saving water and preventing water pollution. It produces no smell, does not attract flies and is an affordable solution inside and outside of dwellings throughout the world.

Soil-composting toilets make use of the process of decomposition, a biological process carried out by bacteria, worms and other organisms to break down organic substances. In a composting environment, the competition between organisms for available carbon and nutrients continues until the pathogens are defeated by the dominant soil bacteria. Soil-composting toilets are constructed using shallow, reinforced pits where soil and ash are added after each use. Toilets such as the Fossa Alterna (Figure 3) and Arbour Loo (Morgan 2001) have been successfully tested in Mozambique and Zimbabwe. The Fossa Alterna uses two alternating pits with a similar frequency of alternation as the double-vault dry toilet. Once sanitized and composted, the contents are removed and used in agriculture. The Arbour Loo is a single shallow pit which receives soil additions after each use and a tree is planted in the pit when it is full.
The recycling of nutrients in urine and faeces is one of the key benefits of ecological sanitation. The nitrogen and phosphorus found in urine is a valuable fertilizer and the high organic content of faeces makes the composted product — humus — an excellent soil conditioner. In addition, it is important to recover and reuse these nutrients toward sustainable ecosystems to reduce the drain on natural reserves and lessen the dependence on artificial chemical fertilizers. Some countries and cultures have been recycling human excreta for agricultural purposes for thousands of years, especially in China and Southeast Asia, but often excreta have not been properly sanitized therefore perpetuating disease. By implementing ecosan, we can safely recycle nutrients without risking people’s health and polluting the environment.

Urine contains 75-80% of the nutrients leaving the human body and 80% of the volume of excreta as well (Table 1). By using urine diversion we can reduce the nutrient load in sewage systems – thus eliminating the need for tertiary treatment. By using low-water or dry toilet systems we can reduce further the size of the sewage problem. Containment of dry faecal material and secondary treatment in eco-stations ensures that enteric pathogens are not released into the environment as is the case today with conventional sewage and pit systems.

<table>
<thead>
<tr>
<th></th>
<th>Urine</th>
<th>Faeces</th>
</tr>
</thead>
<tbody>
<tr>
<td>volume (L/p/d)</td>
<td>1.2 litres</td>
<td>0.15</td>
</tr>
<tr>
<td>Nitrogen (g/p/d)</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Phosphorus (g/p/d)</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>Potassium (g/p/d)</td>
<td>2.5</td>
<td>0.6</td>
</tr>
</tbody>
</table>


Table 1: Average production of urine and faeces and nutrient content

By year ca 2100, economical sources of mined phosphorus will be nearing depletion (Steen 1998). A global program for phosphorus recycling from agriculture and humans must be in place within a few decades. The geopolitics of phosphorus are more delicate than oil due to skewed distribution (60% of the resource is in one location, Morocco). World fertilizer consumption (ref. IFA) is about 85 million tons of nitrogen and 14 million tons of phosphorus per year. Recycling of urine and faeces applied globally could answer for at least a third of the nitrogen and a quarter of the phosphorus we use in agriculture.

**Ecosan for grey water treatment and composting of household organics**

The ecological sanitation approach can be broadened to cover all organic material generated in households (kitchen and food wastes). If these organic materials are sorted within the home, rather than mixed with solid waste and dumped, they become valuable recyclable materials once composted. Grey water can be treated using biological systems, such as evapotranspiration beds and constructed wetlands, and rainwater harvesting can be implemented to harness water for personal hygiene and irrigation (Figure 1).

**The EcoSanRes programme**

In 1993, the Swedish International Development Cooperation Agency (Sida) launched a sanitation research programme called SanRes, under the direction of Uno Winblad. The objectives of the programme were to:

- promote affordable and reproducible ecological sanitation systems
• establish pilot projects in various countries (China, Vietnam, Mexico, Bolivia, Chile, El Salvador and Guatemala)
• help build local capacity for research and development
• and to facilitate collaboration between developing nations in the field of applied sanitation research.

The eight-year mandate for the SanRes programme was fulfilled in 2001 and proved so successful it has evolved into a full-scale initiative sponsored by Sida and managed by the Stockholm Environment Institute, Akkadia Environment and SwedEnviro – the EcoSanRes Programme. The EcoSanRes Programme consists of three components: outreach, capacity and implementation.

Guidelines development

The EcoSanRes Programme is researching and testing methods of sanitation, primarily focusing on the safe removal of pathogens from human excreta and its subsequent optimal uses in agriculture as a fertilizer and soil conditioner. The end results of these investigations are guidelines to aid professionals, people and communities in implementing ecological sanitation systems. Guidelines are being written for safe handling of urine and faeces, agricultural reuse of human excreta, grey water treatment and management, and implementation and planning of ecosan projects.

Studies

Sanitation is usually heavily regulated at all levels of government, due to its impact on public health and safety, and it is also a subject traditionally approached with discomfort and inhibition. But, the need for sanitation is so basic it affects humans indiscriminately. Realizing the sensitivity of this issue and the reluctance of governments to embrace change, the EcoSanRes Programme has undertaken studies to explore the more elusive and social aspects of sanitation, such as regulatory frameworks, a review of alternative sanitation systems and legislation and norms and attitudes.

Implementation

The EcoSanRes Programme has established itself, and the concept of ecological sanitation, as legitimate by promoting local input to and adaptation of sanitation systems. Sida is implementing pilot projects in West Africa (eight countries), East and Southern Africa (Uganda, Mozambique and Zimbabwe), South Africa, China, India, Latin America (Bolivia, Guatemala and Mexico) and the Middle East (Palestine).

Efforts are in progress to provide new methods to help meet the Millennium Development Goals. Since the SanRes Programme was introduced in southern China in 1997, more than 100,000 urine diversion double vault toilets have been built in the Guangxi Region (Wei Bo, 2002), and ecological sanitation activities are increasing in half of the Chinese provinces.

Eco-Town projects

The full-scale ecological sanitation projects being initiated by EcoSanRes are efforts to generate the necessary data, technology and policies required to affect a major change in the way human settlements relate to the environment. The objective of one such project is to build a small eco-town in Inner Mongolia, China, with about 1,000 households, with an emphasis on testing, research and development and social marketing, as well as cultural, financial, legal and institu-
tional issues. This pilot project represents an evolutionary advancement in the implementation of ecological sanitation. It includes the management of grey water and solid waste, and the agricultural reuse of household residues. The incorporation of secondary treatment for faeces and solid waste in eco-stations differentiates this project from others because it is extending the concept of ecosan into a comprehensive sanitation system. It marks a shift from concentrating on small-scale household implementation to embracing a holistic approach to sanitation on a larger, urban scale. The goal is to provide the world with an example of a sustainable eco-town. Similar projects are being set up in Mexico and South Africa during the period 2003 to 2007.

Capacity building and training

One of the keys to successful implementation of ecosan is education. By funding training programs the supporters of ecological sanitation, including Sida and the EcoSanRes Programme, help to create a knowledgeable base of people who can promote the concept and act as a resource pool for others interested in ecological alternatives to conventional sanitation. Training courses gather experts from a variety of disciplines to strengthen capacity for planning, managing and implementing ecological sanitation systems. In particular, the focus of the courses is on how ecological alternatives to sanitation can be affordable and contribute to health and personal security, improve nutrition and protect drinking water and the surrounding ecosystems from pollution. Training courses were held in Uganda and South Africa in 2002, and courses are planned for India, China and Tanzania.

Organisations involved with EcoSanRes (www.ecosanres.org)

- Stockholm Environment Institute
- Akkadia Environment Management Consultants
- SwedEnviro Consulting Group
- Linköping University
- WKAB Consulting
- Swedish Institute for Infectious Disease Control
- Swedish University of Agricultural Sciences
- Aquamor – Zimbabwe
- Eco-Solutions – India
- Espacio de Salud – Mexico
- REDSECO – Latin America
- City of Kampala – Uganda
- CSIR – South Africa
- Mvula Trust – South Africa
- WaterAid – Mozambique
- Palestinian Hydrology Group – Palestine
- CREPA – Burkina Faso and West Africa
- Municipality of Erdos, Dong Sheng District, Inner Mongolia, China
- Ministry of Health – China
- Government of Bolivia
- Government of Guatemala
- Unicef
- UNDP
- World Bank (WSP)

References


Guidelines for the implementation of the Bellagio-Principles and the household centred environmental sanitation approach (HCES)*

Roland Schertenleib, Antoine Morel
EAWAG, Swiss Federal Institute for Environmental Science and Technology; Dept. Water and Sanitation in Developing Countries (SANDEC)
Ueberlandstrasse 133, P.O.Box 611, 8600 Duebendorf, Switzerland
e-mail: schertenleib@eawag.ch
e-mail: antoine.morel@eawag.ch

John Kalbermatten
3630 Garfield St. N.W.: Washington D.C. 20007. USA
e-mail: jmkkainc@aol.com

Darren Saywell
Water Supply and Sanitation Collaborative Council (WSSCC)
1219 Geneva, Switzerland
e-mail: saywell@who.int

Keywords
Environmental sanitation, household-centered approach, nutrient recycling, sanitation planning

Abstract
In response to the fact that almost half of the world population still lack access to adequate sanitation and in recognition that the conventional approaches to Environmental Sanitation are unable to make a significant change in this appalling situation, an Environmental Sanitation Working Group of the Water Supply and Sanitation Collaborative Council (WSSCC) developed in 1999 the Household-Centred Environmental Sanitation (HCES) approach. The HCES approach is a radical departure from past central planning approaches as it places the household at the core of the planning process. The approach responds directly to needs and demands of the user and attempts to avoid the problems resulting from either “top-down” or “bottom-up” approaches. Successful implementation of the HCES approach requires the dissemination of information and assistance to those responsible for improving environmental services, such as municipal officials, urban planners, and policy makers responsible for creating an enabling environment. Based on these considerations, provisional guidelines were prepared. They provide specific guidance for (a) creating an enabling environment for the use of the HCES approach and (b) undertaking a 10-STEP-process for its development and implementation.

Introduction
Since the earliest urban settlements, it has been recognized that some services have to be provided to ensure that the inhabitants are healthy and able to live in decent conditions. These services are: provision of safe water supply; the sanitary disposal of wastewater and human wastes; the proper management of solid wastes; and effective storm water drainage. In this paper these services are referred to as Urban Environmental Sanitation Services (UESS). Throughout the past few decades, efforts to improve living conditions among those lacking basic amenities have emphasized the provision of potable water. The other, equally vital, UESS

*This paper has been peer reviewed by the symposium scientific committee
components have invariably been considered less important. As a result, 2.4 billion people still do not have access to proper sanitation (WHO/UNICEF/WSSCC, 2000), less than 50% of municipal solid wastes are collected (WRI et al., 1996) and no one knows how many people are flooded out each year.

Although there are several reasons for the neglect of these other components and especially for the failure to achieve satisfactory sanitation coverage (Simpson-Hebert and Wood, 1998), the WSSCC Working Group on Environmental Sanitation came to the conclusion that poor planning lies at the heart of current shortcomings in environmental sanitation interventions (EAWAG/SANDEC and WSSCC, 1999). Too often only lip-service is given by environmental sanitation professionals to environmental management issues and services are not conceived in an integrated way. For example, provision of a water supply without allowing for the removal of wastewater may create standing water, thereby producing health hazards and poor living conditions. Nor is sufficient attention paid to the fact that the reduction of waste and the more efficient use and reuse of water and materials is the most effective way to reduce demand for waste treatment and disposal.

There has also been a tendency to develop systems that respond to problems of environmental waste management as perceived by policy makers and professionals, rather than to households’ and communities’ perceptions of their actual needs. Conventional UESS planning usually consists of what became to be known as a "Top-Down" approach. Needs are determined by well-meaning officials at central, regional and even municipal levels, based on their own perceptions. Those to be provided with services are "Target Beneficiaries" without much, if any, say in matters of service level or determination of priorities.

The Bellagio Principles for sustainable environmental sanitation

A representative group of experts drawn from a wide range of international organisations involved in environmental sanitation accepted the need to challenge conventional thinking and called in the Bellagio Statement for a radical overhaul of conventional policies and practices world-wide based on the following lessons learned from past efforts to improve UESS:

(a) “Business as usual” is not sustainable even in the industrialized countries; (b) the under-utilization of organic residues is economically wasteful; (c) the pressure of humanity on a fragile water resource base, and the corresponding need for environmental protection and freshwater savings, require that wastewater and wastes be recycled and considered as resources; (d) sanitation systems designed and implemented without consultation with stakeholders at all levels, and without their participation, are ineffective; (e) there is a lack of integration between the provision of water supply and arrangements for disposal of wastewater, and between excreta and wastewater management, solid waste management, and storm water drainage; (f) without sanitation and hygiene education, the health impacts expected from water supply are greatly diminished; and (g) the export of industrialized-world models of sanitation to environments characterized by water and resource scarcity is inappropriate.

In the light of these compelling arguments for radical re-thinking, the following principles were proposed as the underpinning basis for a new approach in environmental sanitation:

1. Human dignity, quality of life and environmental security at 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.

2. In line with good governance principles, decision-making should involve participation of all stakeholders, especially the consumers and providers of services.

3. Waste should be considered a resource, and its management should be holistic and form part of integrated water resources, nutrient flows and waste management processes.
4. The domain in which environmental sanitation problems are resolved should be kept to the minimum practicable size (household, community, town, district, catchment, city) and wastes diluted as little as possible.

The Bellagio Principles were endorsed by the members of the Water Supply and Sanitation Collaborative during its 5th Global Forum in November 2000 in Iguacu (Brasil).

**The Household-Centred Environmental Sanitation Approach (HCES)**

The Household-Centred Environmental Sanitation Approach (HCES) developed by the WSSCC Environmental Sanitation Working Group is largely based on the Bellagio Principles (Schertenleib, 2000). There is consensus among the members of the Water Supply and Sanitation Collaborative Council that it offers the promise of overcoming the shortcomings of conventional approaches because its two main components correct existing unsustainable practices of planning and resource management. These components are:

- **The HCES approach makes the household the focal point of Environmental Sanitation Planning**, reversing the customary order of centralized top-down planning. It is based on the concept that the user of services should have a deciding voice in the design of the service, and that environmental sanitation problems should be solved as close as possible to the site where they occur. Only problems not manageable at the household level should be “exported” to the neighbourhood, town, city and so on up to larger jurisdiction. Making the household the key stakeholder also provides women with a strong voice in the planning process, and changes the government’s role from that of provider to that of enabler.

- **The Circular System of Resource Management (CSR M)** that, in contrast to the current linear system, emphasizes conservation, recycling and reuse of resources. The circular system practices what economists preach: waste is a misplaced resource. By applying this concept, the circular system reduces “downstream” pollution.

**Structure of decision making in the Household-centred approach**

The conventional approach to water supply and environmental sanitation is based on a highly centralized system of decision-making, usually under the control of the national government. In recent years, many governments have attempted to decentralize by delegating their functions to second- and third-tier governments (for example, to provinces and municipalities). However, the results of these efforts have been mixed. Delegation often leaves central policy-makers in charge and does little to encourage initiatives by local office-holders and managers. The problems with devolution generally result from the fact that only the new responsibilities, not the means of implementing them, are transferred to the local authorities.

The HCES Approach is a radical departure from past central planning approaches. As shown in the figure on the following page, it places the stakeholder at the core of the planning process. Therefore, the approach responds directly to the needs and demands of the user, rather than central planner’s often ill-informed opinions about them. It is based on the following principles:

- (a) Stakeholders are members of a “zone”, and act as members of that zone (“zones” range from households to the nation). Participation is in accordance with the manner in which those zones are organized; (b) zones may be defined by political boundaries (for example, city wards and towns) or reflect common interests (for example, watersheds or river basins); (c) decisions are reached through consultation with all stakeholders affected by the decision, in accordance with the methods selected by the zone in question (for example, votes at national level in a democratic system, town hall meetings at local level, or informal discussions at neighbourhood level); (d) problems are solved as close to their source as possible. Only if the affected zone is unable to solve the problem should the problem be “exported”, that is, referred to the zone at the next level.
The HCES approach attempts to avoid the problems resulting from either “top-down” or “bottom-up” approaches, by employing both within an integrated framework. The needs are determined in a bottom-up approach where decisions flow from the household to the community to the city and finally to the central government based on informed choices at all levels. The top-down part of the HCES approach consists then of fitting the proposed program within the municipality’s overall UESS strategy and ensuring support for its implementation.

Circular System of Resource Management

An important concept of the HCES approach is to minimise waste transfer across circle boundaries by minimising waste-generating inputs and maximum recycling/reuse activities in each circle. In contrast to the current linear system, the Circular System of Resource Management (CSRM) emphasizes conservation (reducing imports) of resources, and the recycling and reuse of resources used (minimizing exports). Resources in the case of environmental sanitation are water, goods used by households, commerce and industry, and rain water. The circular system practices what economists preach: waste is a misplaced resource. By applying this concept, the circular system reduces “downstream” pollution.

Strength and weakness of HCES

HCES is a multi-sector, multi-actor approach to delivering integrated urban environmental services. As already mentioned, it is designed to respond to household needs and priorities, since the household is the level at which decisions on investments are made and where behaviour change begins. Its main strength is that it offers the possibility of providing an integrated, affordable and sustainable package of services meeting the users’ priorities. Its potential weakness is that it requires collaboration and coordination between multiple agencies which may have different capabilities and little commitment to working together.

Guideline for implementing the HCES approach

Successful implementation of the HCES approach requires the dissemination of information and assistance to those responsible for improving environmental services. Therefore, preliminary guidelines were prepared which are mainly targeted at municipal planners (especially those responsible for planning urban environmental services) and civic officials, such as mayors and city managers. These are the people who will initially have to take the decisions on whether and how to apply HCES, who will implement and support the process, and who will be responsible to their citizens for the results. The guideline is intended to assist them to understand the HCES approach, to apply it in their own circumstances, and to be able to explain it to the user communities. Other potential users of the guideline are municipal/state/provincial and central government officials, whose support is essential once local authorities decide to undertake HCES-based programs. The provisional guideline provides specific guidance for:

a) Creating an Enabling Environment for the use of the HCES approach

b) Undertaking a 10-STEP Process for developing and implementing the HCES approach
Creating an enabling environment for implementing the HCES approach

An “enabling environment” is important for the success of any investment program, but it is especially vital when applying an innovative approach, such as HCES. Most of the critical elements should be identified or become evident during the program development process. Ideally, they should be identified, at least in broad terms, prior to the program launch so that the entire process does not start off with misunderstandings. It is essential that they are recognized before or during the identification and evaluation of options at the latest, since if these critical elements cannot be assured, then some of the options may not be feasible.

Government Support

Political support at all levels is essential. HCES involves departures from conventional methods, especially in its institutional approaches, and the program promoters should plan to devote considerable efforts to familiarizing elected officials, senior sector staff and advisers with the concepts. This will involve presentations, seminars, visits to demonstration projects in communities to learn about the possibilities offered by HCES.

Legal Framework

The most obvious immediate need for change in order to accommodate HCES is in the matter of standards. Many existing standards (national or municipal) are based on those developed in industrialized countries, under conditions totally different from those applying today in developing countries, and so they are often inappropriate. Even where they are in theory appropriate, they often cannot be applied (because they are too expensive), and enforcement is weak. Nevertheless, it is dangerous for a public sector official to reject the standards explicitly, because then the official may become personally liable for any resulting problems. Part of launching HCES should therefore be to secure a moratorium on the application of existing standards to the program area, and part of the overall exercise should be to try to identify standards which would be more appropriate.

Institutional Arrangements

Stakeholder service demand and delivery capacity will vary from zone to zone, and so will the need for support services. Local (neighbourhood) organizations will therefore require specific support inputs not only from similar organizations (that is, from similar zones), but from organizations in larger zones with greater responsibilities and (hopefully) greater capacities. The most significant change introduced by the HCES approach is the participation of stakeholders that previously have often had little opportunity to participate under the conventional system of project planning and implementation. Most UE SS organizations are unfamiliar with the concept of basing their program planning on responding to household demands and arriving at solutions acceptable to the household through a consultative process. Existing organizations will have to change their modus operandi from managing to supporting, requiring a good deal of reorientation and retraining of staff. For now, NGOs often bridge the gap between central organizations and stakeholders at the lower, community levels. This gap should eventually be eliminated, with more permanent arrangements between central organizations and organisms created by the community to satisfy its needs (which might still involve NGOs). Prior to program launch, a preliminary assessment should be conducted to determine the capacities of the various UE SS organizations and others who might become involved (including private sector and NGOs), and the existing status of collaborative planning activities. This knowledge will help planners to take quick action to remedy problems identified during the program launch meeting and throughout the HCES implementation.

Required Skills

Many groups and organizations will need training and orientation. For example householders will need to understand more about the implications of the options open to them, and will also have to be shown how to exert quality control over local builders and contractors, to make sure
that they are not being cheated. **Communities and their organisations (CBOs)** which will undertake construction, O&M and/or management of local UESS will need training on technical matters, accounting and simple financial management, basic contract procedures, and monitoring and reporting. **NGOs** that will become involved in the program need similar training, but at a more advanced level, as they are probably going to have to train the participating communities. They will also need to become familiar with the social factors affecting the selection and proper use of UESS, and with supporting communications strategies. **Municipal staff** will need to be reoriented away from their present perception, that UESS deficiencies are primarily due to lack of technical solutions developed in industrialized countries. Instead, they should be helped towards a better understanding of the social, institutional, financial and other factors that have to be addressed. All of these groups and individuals will need training in "commercializing" waste recycling and urban agriculture/horticulture activities (e.g., marketing) if the full potential that is offered by the application of the circular system is to be achieved. Only then can the simultaneous improvement of both the health and economic productivity of members of the participating households be achieved.

**Credit and other Financial Arrangements**

A major recurring problem encountered by low-income customers and small entrepreneurs is the lack of capital to finance investments or equipment, even when they are capable of paying small amounts for current expenses. Rather than to resort to grants or subsidies, governments and their agencies should consider the establishment of a line of credit, or the provision of equipment and materials against regular payments. The provision of grants and subsidies often has the unintended effect of encouraging users and organizations (at whatever level) to choose systems and technologies they are unable to sustain, which later leads to rapid deterioration of facilities and deficient services.

**10-STEP-process for developing and implementing the HCES approach**

The last section of the guideline describes ten typical steps involved in developing and implementing an HCES programme. These steps are presented here in sequence, but in practice they will usually overlap, some steps may need to be repeated more than once in an iteration to find acceptable solutions, and they will always need to be undertaken bearing in mind the concerns of the municipality as a whole.

**STEP 1: Request for assistance**

The HCES process should start in response to a request for assistance from the people who will benefit from the services: in the model used in the guideline, this request would be made to the mayor (or other professionals serving the mayor), by the users themselves, their political representatives or local community leaders.

**STEP 2: Launch of the planning and consultative process**

Once a request for assistance in developing an HCES-based programme has been received, it is important to check that all the participating stakeholders really understand and accept the implications, for example: intensive user involvement; close collaboration between various agencies; and the possibility that the integrated, balanced, multi-service solution finally adopted may not exactly correspond to what the individual sectoral agencies had envisaged.

**STEP 3: Assessment of current status**

The next step in the development of the programme is a comprehensive, participatory assessment of the current level of UESS service. This is a more complicated process than that carried out in typical conventional single-sector planning, which is often confined to trying to answer questions such as ‘What is needed in order for the water company to provide water through standpipes?’ An HCES assessment needs to cover all the services, must be participatory in its...
methodology, and understand how services are provided and used within a particular social context.

**STEP 4: Assessment of user priorities**

The results of the status assessment (STEP 3) should be reported to the community through a participatory process (i.e., meeting, focus group discussions) at which representatives of relevant agencies are also present - but as equal participants, not as leaders. The objectives of this part of the process are to (a) present the findings of the assessment, (b) correct possible factual errors, and (c) Establish, in broad terms, the ‘ground rules’ for the next, most intensive part of the study: deciding which deficiencies should be given priority, what levels of service should be considered, what institutional arrangements would be acceptable, etc. The setting of priorities is ultimately done by the householders, taking into account the Bellagio principles.

**STEP 5: Identification of options**

The identification of the various options for UESS services that are conducted using the HCES approach have to cover the same broad range of topics as those conducted for any feasibility analysis; they must examine the technical, institutional, financial and social feasibility of each option, and assess other factors such as its impact on the environment. The guideline does not discuss these techniques, which are covered by a number of standard texts. However, some special features are discussed which set the HCES analysis apart from conventional analyses.

**STEP 6: Evaluation of feasible service combinations**

Once the costs and implications of various options are known, at least approximately, work can begin on determining which combinations are likely to be feasible. The lowest desirable level of service should have been decided during the consultations in STEP 4. Above this lowest level, the task is primarily matching a particular level of service with the associated on- and off-site facilities (for example, flush toilets are not feasible without a high level of water supply and effective means of wastewater collection, treatment and disposal).

**STEP 7: Consolidated UESS plans for the study area**

The objective of this STEP is to develop a programme that will cover the entire study area (as defined in STEP 2). The various options identified during STEP 6 are likely to be suited to particular neighbourhoods or communities, depending on factors such as income level, housing type, soil conditions and topography. The challenge now is to assemble and integrate these into a broader UESS network.

**STEP 8: Finalising of consolidated UESS plans**

The consultation involves three stages: (a) planners present the options that appear feasible for individual neighbourhoods; (b) planners explain the interactions between neighbourhood choices; and (c) planners assist the community on reaching a consensus on a broader programme. It may be more efficient to conduct the first two stages separately, neighbourhood by neighbourhood, but if this approach is taken, each neighbourhood must clearly understand and accept that the final stage may lead to later adjustments and modifications.

**STEP 9: Monitoring, (internal) evaluation and feedback (MEF)**

MEF must be thought of as one integrated process, even though it consists of three separate elements. There is no point in collecting data (monitoring) unless the data is then analyzed critically (evaluation), and then the conclusions of the evaluation used to improve the process being monitored (feedback). Good MEF is absolutely essential to the success of HCES programmes.

**STEP 10: Implementation**

The final guideline will include a section on matters requiring attention during implementation, because programmes undertaken using the HCES approach are likely to require adjustment and fine-tuning during the implementation process, especially if new communities are added to
the programme as work proceeds. However, this section on implementation can only be prepared after the HCES approach has been applied to actual projects or programmes based on the preliminary guideline.

Conclusion

A new approach (HCES) has been suggested to overcome the shortcomings of conventional approaches in environmental sanitation planning by placing the household at the core of the planning process and by introducing a circular system of resource management. In order to implement the HCES approach, preliminary guidelines were prepared to give guidance how to create an enabling environment and how to apply the HCES approach. The provisional guideline should be tested on selected projects, which should be subjected to careful monitoring and evaluation. That process should not only test the provisional guideline and reveal areas which need to be improved, it should also bring out the topics which need to be particularly stressed during implementation, and the issues which are likely to arise.

Acknowledgement

The preliminary guideline presented in this paper has been developed in the context of an informal WSSCC partnership on environmental sanitation. The work is also part of the Swiss NCCR North-South and financially supported by SDC.

References

http://www.sandec.ch/env.san./downloadables.html

http://www.sandec.ch/env.san./downloadables.html


Tentative guidelines for agricultural use of urine and faeces*

Björn Vinnerås, Håkan Jönsson
Swedish Univ. of Agricultural Sciences, Dep. of Ag. Eng.
Box 7032, SE-750 07 Uppsala, Sweden
e-mail: bjorn.vinneras@lt.slu.se

Eva Salomon
JTI Box 7033, 750 07 Uppsala, Sweden

Anna Richert Stintzing
Verna Ekologi AB
Malmgårdsvägen 14, 116 38, Stockholm, Sweden

Keywords
Agriculture, faeces, fertilising, nutrient recycling, urine

Abstract
Plant nutrients are a necessary input in high-productive and sustainable crop production. The plant nutrients in both urine and faeces emanate from arable fields and thus should be recycled as fertilisers to support sustainability and to retain the fertility of the fields.

This paper presents tentative general guidelines for use of urine and faeces as fertiliser. Urine is a quick acting fertiliser rich in nitrogen, and with a composition of nutrients that well matches the needs of many crops. Urine and faecal matter well supplement each other, since faecal matter is slower acting and rich in phosphorous and potassium. It also contains organic matter and will increase the buffering capacity and the organic matter of the soil. Faecal matter should be sanitised before reuse, since it can contain high concentrations of pathogens.

More research on use of urine and faeces is needed in order to make the recommendations more detailed and to develop new ways to efficiently use human excreta in agriculture. The guidelines are developed by EcoSanRes, a programme supported by Sida.

Introduction
Many of the nutrients used today are either fossil resources or consume large amounts of fossil resources during their production. During food production, nutrients are removed from the soil and these nutrients have to be replaced by plant-available unpolluted nutrients. The main urban nutrient source is toilet waste and together with organic household waste, these fractions contain more or less the same amounts of nutrients removed from the field during food production.

The major proportion of the nutrients in wastewater originates from urine. Of the amounts consumed in food, about 70-90% of the nitrogen, 45-80% of the phosphorus and 70-95% of the potassium are found in this fraction while the rest is found in the faeces (Lentner et al., 1981; Guyton, 1992; Vinnerås 2002). The urine nutrients are water-soluble and relatively available for plants to take up or easily transformed into plant-available compounds (Kirchmann & Pettersson, 1995).

Plants take up nutrients in ionic form and the nutrients in urine are easily plant-available, since they are in ionic form, or rapidly degrade to this form. Most of the nitrogen in urine is excreted as urea, which is easily degraded to ammonium, often already during collection and storage.

---

*This paper has been peer reviewed by the symposium scientific committee
Otherwise, degradation takes place within hours of application. In the soil, ammonium is oxidised to nitrate and both ammonium and nitrate are plant-available. The phosphorus in the urine is in ionic form at excretion, but during storage some precipitates as calcium and magnesium phosphates and all of these forms are plant-available. The potassium and the sulphur are in ionic form and easily plant-available. Urine is a nitrogen-rich fertiliser with high plant availability.

Faeces are by weight the smallest of the biodegradable waste fractions. Between 30 and 110 kilograms, wet weight, of faeces are produced per person and year. This corresponds to 10-15 kilograms of dry matter (Lentner et al., 1981; Vinnerås 2002). The volume produced per person depends upon the composition of the food consumed. Meat and other foods low in fibre produce smaller volumes than food high in fibre (Guyton, 1992).

Faecal nitrogen is mainly found as organic nitrogen and has therefore to be mineralised before it becomes available for plants. Phosphorus is mainly found as small grains of calcium phosphates in the faeces (Frausto da Silva & Williams, 1997) and this phosphorus is available to plants. Potassium is mainly found in its water-soluble ionic form (Berger, 1960) and is therefore readily available. Faeces are high in phosphorous and potassium, but also contain slow release nitrogen.

The amount of nutrients found in the urine and the faeces depends on the nutrient content of the food consumed. This varies from person to person and region to region. Vinnerås & Jönsson (2003) present the estimated average composition of urine and faeces for different regions according to the average food consumption as given by the FAO.

The nutrient requirements of plants

Elements essential for the growth of plants are normally called nutrients. The nutrients used in the largest amounts are the non-mineral elements, i.e. carbon, hydrogen, and oxygen. These substances are mainly derived from carbon dioxide (CO₂) and water (H₂O). All other nutrients are mainly taken up from the soil by the roots. Increasing the supply of light, CO₂, water and mineral nutrients from the deficiency range increases the growth rate and crop yield. The yield response curves for a particular mineral nutrient can be illustrated as in Fig. 1. When the supply of one mineral nutrient or growth factor is increased, other mineral nutrients or growth factors then become important as limiting factors (Fig. 1).

Nutrients can be divided into the two categories macronutrients and micronutrients and the total uptake of macronutrients is about 100 times that of micronutrients. The macronutrients are the six elements nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca) and magnesium (Mg). Of these, yearly additions are usually needed of the first four (N, P, K, S), while the soil supply of Ca and Mg is usually sufficient provided that the pH is not too low. All over the world, nitrogen is frequently the most limiting nutrient for plant growth. The main natural sources of plant-available N are degradation of organic matter in the soil and N fixation by microorganisms living in symbiosis with the roots of legumes. The visible fertilising effect of using urine as a fertiliser usually comes from its N content. The natural supply of P comes from mineralisation of phosphates and from degradation of organic matter in the
In acidic soil the availability of P is often low, due to strong bonds between phosphates and metal ions at low pH. The high water solubility of K often results in a good supply of plant-available K. However, many crops such as vegetables need large amounts of potassium and therefore additional fertilisation improves plant growth. S is also highly water-soluble and most crops need it in somewhat smaller amounts than P. Even so, on many soils yearly additions of S are needed.

Micronutrients are also essential for plant growth, but the uptake of these elements is in small (micro) amounts. The elements normally considered to be micronutrients are boron, copper, iron, chloride, manganese, molybdenum and zinc (Frausto da Silva & Williams, 1997). Most micronutrients are needed for formation of different enzymes. These nutrients mainly come from degradation of organic material and erosion of soil particles. Only in special circumstances does scarcity of micronutrients limit plant growth. When human excreta are used as a fertiliser, the risk for such deficiency is minimal as excreta contain all the micronutrients.

### Application strategies for human excreta

Fertilisation only increases crop yield if the plant nutrient supply is one of the most limiting growth factors (Fig. 1). No yield increase is to be expected when fertilising crops that are mainly limited by factors other than nutrient supply, e.g., lack of water, too low or too high pH, etc.

Often when human excreta are used for fertilisation, the available amount is very limited in relation to the amount of plant nutrients needed. Therefore, it is important that the excreta are used in the most efficient way and this differs depending on the amount of available nutrients in relation to the available space.

There is enough space to utilise all of the nutrients to their full potential if the average application of available nitrogen is below dose A in Fig. 2. Dose A is the dose up to which the yield increases linearly with increasing application. Dose A differs between different crops, regions and climate. If its size is not known, then the application of the urine from one person during a full day per square metre (approx 1.5 litres of urine/m$^2$) can be used as a rule of thumb. This corresponds to application of approximately 40-80 kg N/ha.

When space is not a limiting factor, the full fertilising effect can easily be gained from urine, even if the urine is applied at different dosages in different places, as long as the dosage in all places is below dose A (Figure 2).

The best fertilising efficiency when space is so limited that the average dose has to be above A is obtained by keeping the dose even over the whole available space, if all the crops have the same nitrogen demand. The yield increases when the application is increased from dose A to dose B (Fig. 2). However, both the quantity and the quality of the yield are important and high doses of available nitrogen (i.e., urine) can also affect the quality. For example, the quality of wheat is generally improved by a high nitrogen dosage, while the quality of, for example, Irish potatoes may decrease since the tubers can become watery.
If no information is available on dose B, then a dose 5 times as high as dose A can be used as a rule of thumb, i.e. applying the urine from one person during one day on an area of 0.2 m².

If space is even more limited, i.e. so that the average dose would be above dose B, where additional amounts of urine become toxic, then the dose should be limited to dose B. The amount of urine that cannot be utilised as a fertiliser should be disposed of in some other way, i.e. as an accelerating agent when composting.

**Use of urine as a fertiliser**

The fertilising effect of urine is similar to that of a nitrogen-rich chemical fertiliser and urine should be used similarly. Therefore, urine is best utilised as a fertiliser to nitrogen-demanding crops and vegetables. If crop- and region-specific recommendations are available for the use of such a chemical fertiliser, a good starting point when using urine is to translate this recommendation to urine. This translation is simplified if the nitrogen concentration of the urine is known. If it is not, then as a rule of thumb, a concentration of 3-7 grams of nitrogen per litre of urine can be expected, or approximately half that concentration if flushed urine-diverting toilets are used (Vinnerås, 2002, Vinnerås & Jönsson, 2003).

Just prior to or during sowing/planting, the soil should normally be fertilised for the first and sometimes only time. The nutrient supply even at this early stage of plant life affects the yield. However, care should be taken to protect the seedlings from high concentrations of nutrients. In the early stages of cultivation, the availability of phosphorus and potassium is the most important factor. In large-scale crop production, the normal fertilisation strategy is application once or twice per growing season. If fertiliser is applied only once, this should be carried out prior to or at the time of sowing/planting. If the crop is fertilised twice, the second fertilisation should be performed after approximately 1/4 of the time between sowing and harvest. The crop can also be continuously fertilised, e.g. if the urine is collected in smaller cans and used more or less directly. However, the nutrients are not well-utilised after the crop enters its reproductive stage. An example is maize; fertiliser applied until the plants are setting ears is well-utilised, but after this stage the uptake of nutrients from the soil is negligible (Marschner, 1997).

Vegetables are normally harvested before they reach their reproductive stage and therefore fertilisation should stop after between 2/3 and 3/4 of the time between sowing and harvest. As a rule of thumb, fertilisation should stop after between 2/3 and 3/4 of the time between sowing and harvest. The amount of nutrients and the intervals depend mainly on nitrogen usage by the plant and root size. Root size varies between different crops (Fig. 3). Plants with inefficient or small root systems, e.g.
carrots or lettuce, could possibly benefit from several applications of nutrients throughout the cultivation time (Thorup-Kristensen, 2001.) In Swedish field trials with leeks fertilised with human urine, only small differences in yield were observed between leeks fertilised twice during the growing period and leeks fertilised every second week, i.e. eight times during the growing period, on clay soil. The total fertiliser dose was the same for both strategies. The yield was only slightly higher in plots fertilised every two weeks on the clay soil while on a sandy soil, there were no significant difference (Båth, 2003). However, as a hygiene safety measure, until hygiene guidelines have been developed, it is recommended that crops consumed raw are not fertilised with urine closer to harvest than one month (Schönning, 2003).

If the storage capacity during the non-cultivation period is insufficient, the urine can be utilised as a fertiliser for trees and bushes or it can be “stored” in the soil by application and incorporation of the urine in the field during the dry season, followed by normal crop cultivation when it is suitable according to rain and irrigation conditions. The main proportion of the nutrients will then remain in the soil and be available for the plants during the growing season, even if some nitrogen is lost. Further investigations are needed to determine the nitrogen loss during such storage.

**Application technique**

For best fertilising effect, the urine should be mixed into the soil as soon as possible after the application, instantly if possible. This can be done for example by applying it in small furrows that are covered after application. It can also be done by applying water after the urine, thereby washing the nutrients into the soil. When applying the urine, spraying of leaves with urine should be avoided as this can cause foliar burning due to high concentrations of salts if urine is left to dry on the leaves. Spraying urine in the air should also be avoided as the nitrogen in the urine is then partly lost as gaseous emissions of ammonia (Rodhe et al, 2003).

It is not necessary to dilute the urine before application. However, the whole root of the plants should not be thoroughly soaked with undiluted urine, as this might be toxic and even lethal, especially for small plants. Instead, the urine should be applied either prior to sowing/planting or at such a distance from the plants that the nutrients are within reach of the roots, but that they are not soaked.

**Use of faeces as a fertiliser**

The nutrient content in faecal matter is considerably lower than that in urine, especially the amount of plant-available nitrogen. The main contribution from the faecal matter is the content of phosphorus and potassium and the increase in buffering capacity of the soil.

The effect on soil pH and on its buffering capacity is important in areas with such a low soil pH that the growth potential of plants is affected. The importance of this effect, which is increased if ash is added to the faeces, has been shown in field trials in Uganda. The soil pH was low and the fertilising effect of urine and faeces+ash was better than that of urine only (Figure 4).

As faecal matter is one of the major sources of pathogenic microorganisms, this fraction has to be sanitised before usage. The faecal matter should preferably be treated on site at the point of collection to avoid handling of the pathogen-containing material, as one of the major transmission routes is direct contact with raw untreated faecal matter (Faechem et al., 1983). Alternatives for the sanitation of faecal matter are biological treatment, chemical treatment or incineration.

Composting is a traditional biological treatment of organic matter. To be sure that the microorganisms are inactivated, all of the material has to attain a high temperature for a period of time (Vinnerås et al., 2003). This method requires good technological skills to function well. Co-
posting reduces the amount of organic matter and therefore there is less left in the finished compost. Faecal matter to which ash or lime has been added seems to have too low a concentration of organic matter to attain temperatures high enough to sanitise the faecal matter (Vinnerås et al., 2003).

Traditionally chemical treatment of faecal matter has been performed by addition of ash and lime. More recent studies have also shown good effects from the addition of urea (Vinnerås et al., 2003). The advantage of chemical sanitisation of the faecal matter is that it can be performed at the collection site and it requires less technical skill than composting. It is important to use sufficient ash material to sanitise the faecal matter. An additional effect from chemical treatment with ash and lime is an increased buffering capacity and increased pH in the soil after application.

A third alternative is to incinerate the faecal matter. If the faeces are collected separately in a ventilated chamber, the dry matter content often becomes high enough to be combustable. When all the material is incinerated the risk of pathogens is small, as they are destroyed during the process. However, almost all of the nitrogen and carbon is lost during the process, although the amount of plant-available nitrogen is low in the faecal matter from the start. The other nutrients remain in the ash and become available to the plants when spread on soil. However, the nutrient concentration in this ash is high and therefore it should be carefully dusted out over a larger area.

As a hygiene safety measure until hygiene guidelines have been developed, we recommend that faecal matter, even if it is sanitised, should not be used as a fertiliser to vegetables that are eaten raw.

Faeces are rich in phosphorous and potassium and should therefore preferably be used on crops that have a high demand for potassium and phosphorous. The dose can be based on the recommended dose for use of phosphorous in chemical fertilisers. The risk of over-application is small, but toxic effects can occur at high application rates if the faeces are mixed with large amounts of ash.

**Application technique**

To gain the maximal effect from faecal matter it should, just as urine, be applied close to the roots of the plants, but not in such a way that it is the only growing medium available for the root. The easiest way to do this is by application in holes or furrows close to the plant. Faecal material should be cultivated into the ground and covered as soon as possible after application, to prevent unwanted contact with potential remaining pathogens. For best effect, it should be applied before sowing/planting. Care should be taken to prepare a proper seed bed.

**Figure 4:** The quality of the maize cobs varied between the treatments. Cob no. 1 from the left was fertilised with faeces + urine, Cob no. 2 with urine, while Cob no. 3 received no fertiliser.
Conclusions

The following tentative recommendations are based on our current knowledge of the use of urine and faeces in small- and large-scale cultivation.

**Urine**

- If it has been collected and stored in a correct manner, urine is a quick-acting nitrogen fertiliser. Application of urine can beneficially take place from prior to sowing up to between 2/3 and 3/4 of the period between sowing and the harvest.
- The amount of urine that is used should be based on the amount of nitrogen that is recommended when fertilising with urea-based fertilisers. If no better knowledge exists, an estimate of the nitrogen concentration in urine of 3-7 g per litre can be used.
- If no recommendations can be obtained, a rule of thumb is to apply the urine collected from one person during one day to one square metre of land. The maximum dosage before risking toxic effects is approximately 5 times this dosage.
- Until further knowledge becomes available, the roots of plants should not be soaked with urine, in order to minimise possible risks of root toxic effects. Experience shows that while there is no risk with many crops, some are sensitive, especially as seedlings.
- Fertilisation with urine can be done once in the cultivation period, or repeatedly. Normally the effect on yield of repeatedly applications of urine is small if the total dosage remains the same.

**Faeces**

- Faecal matter is a fertiliser rich in phosphorous, potassium and organic matter. Faeces should be applied and mixed into the soil before cultivation starts.
- Faeces contain organic matter that improves soil fertility and increases the buffering capacity of the soil, especially when it has been mixed with ash. These effects are especially important on soils with low pH.
- The faeces should be placed within reach of the roots of plants in order to maximise the utilisation of the nutrients.
- The amount of faeces used should be based on the current recommendation for the use of phosphorous-based fertilisers. There is no risk of toxic effects even at higher dosage except when the faeces are mixed with large amounts of ash.
- For hygienic reasons, the faeces should be sanitised before usage. We also presently recommend that the faecal matter is covered after application and not used as fertiliser to vegetables that are consumed raw.

Lack of documented research in this area makes the development of definite guidelines difficult. Research on the use of urine and faeces as fertiliser is needed, especially in the following areas:

- Nutrient effects of excreta on crops and soil
- Fertilisation strategies when using excreta
- Efficiency of “storage” of urine in soil
- Simple and resource-efficient sanitation techniques for faeces
Acknowledgements

This study was financed by the Sida programme EcoSanRes.

We are grateful to the experts participating in the reference group for this project, George Anna Clark (Mexico), Sidiki Gabriel Dembele (Mali), Jan Olof Drangert (Sweden), Gunter Edström (Ethiopia), Bekithemba Gumbo (Zimbabwe/South Africa), Li Guoxue (China), Edward Guzha (Zimbabwe), Peter Morgan (Zimbabwe), Watana Pinsem (Thailand), Caroline Schönning (Sweden), Almaz Terefe (Ethiopia), Liao Zongwen (China).

References


Rodhe, L., Richert Stintzing, A., Steineck, S. 2003 Ammonia emissions after application of human urine to barley – application technique and application time. (Submitted to Nutrient Cycling in Agroecosystems.)

Schönning, C. 2003. Recommendations for the reuse of urine and faeces in order to minimise the risk for disease transmission, Conference proceedings “Ecosan – Closing the Loop” April 7-11, 2003 in Lübeck, Germany.


Jönssson, H. Vinnerås, B. 2003 Adapting the proposed Swedish default value for urine and faeces to other countries and regions. Conference proceedings "Ecosan -Closing the Loop" Lübeck 7-11 April 2003.
**EcoSan – clean production mechanism under the Kyoto-protocol**

Gert de Bruijne, Nadine Dulac

WASTE Advisers on urban environment and development
Nieuwehaven 201, 2801 CW, Gouda, The Netherlands

e-mail: gdebruijne@waste.nl

e-mail: ndulac@waste.nl

**Introduction**

The Kyoto-protocol provides instruments to reduce the greenhouse emissions that can be applicable for the development of EcoSan. The article will give arguments and supporting analysis that EcoSan must be regarded as clean production mechanism (article 12). Through support of EcoSan development in developing countries, industrialised countries must be allowed to claim the emission reduction that is achieved by these measurements. In a similar way joint implementation of EcoSan projects must be accounted for, and therefore become an option for investment.

The authors want to underline that EcoSan is a fundamental aspect of (urban) sustainable agriculture in the light climate change considerations, and should therefore be promoted according to article 2 of the Kyoto-protocol.

This would provide those countries extra means to invest in a sanitation approach that will avoid the introduction of sanitation system that itself also would contribute to global warming through the use of mineral energy for the construction (sewers) and operation (wastewater treatment) of the system. In addition, it will avoid the greenhouse gasses, such as methane (CH$_4$) will be released as a result of anaerobic digestion of wastewater.

**Methods**

The article will be a part of the C-N research under the UWEP-Plus programme of WASTE that studies the effects of ISWM on the use of energy and greenhouse emission.

The article will depart from the assumption that all people have the right to improve their standard of living. The economic growth that will be needed to realise this desire can be expressed, among others, in the need for energy and nutrients.

As a substitute for mineral fertiliser, the application of urine and faeces in agriculture will contribute to the reductions of greenhouse emissions (CO$_2$, CH$_4$ and N$_2$O). Illustrated with data of the Island on Tingloy in the Philippines, the article will present the argument that when human excreta are used as fertiliser, the standard of living of urban and rural farmers can be raised without an increase in the use of energy and exploitation of arable lands. The research will compare a develop strategy for a community in Tingloy based on the input of mineral fertilisers and of human nutrients. The model will distinguish between and based on the interrelated the C- and N cycle.

**Results**

The article wants to present a simple model through which one can start compare the effect of mineral fertiliser and human fertiliser on the global warming.

It is the intention of the authors that this *Tingloy model* can be used as tool by other communi-
ties to make strategic choices concerning the choice of sanitation approach. With the application of the model one should be able to make a rough estimate of the impact of sanitation choices in specific local context on global warming.

The article will present links between EcoSan and the Kyoto-protocol in the following sectors/source categories:

Energy; construction; transport; mineral products; agriculture; manure management; waste; wastewater handling.

Conclusions

The authors aspect to outline an argumentation and a supporting model that EcoSan practice must be certified under article 12 of the Kyoto-protocol, because it results in emission reduction as they are based on:

Voluntary participation

Real, measurable and long-term benefits related to the mitigation of climate change, and

Reduction in emissions that are additional to any that would occur in the absence of the certified project activity.
Rainwater harvesting, water re-utilisation and ecological sanitation – further developments

Dietmar Sperfeld, Erwin Nolde

Fachvereinigung Betriebs- und Regenwassernutzung e.V.
(Association of Rainwater Harvesting)
Havelstr. 7A, D-64295 Darmstadt, Germany
e-mail: info@fbr.de

Keywords
Greywater, rainwater harvesting, water re-utilisation

Introduction

Increasing anthropogenic environmental noxious, the change of soil exploitation and the climate change show a risk to the availability of water resources. Also the insufficient water resources in the single countries, various states of sophistication, social aspects and in many areas the low standard or a not even existing water and public sewage systems in different parts of the world are responsible for the mean supply of water. Experiences have shown that the water supply as well as the sewage water systems and clearings can not be treaten separately.

Even Germany with its high level of technology has to face many problems in this point.

The costs of preservation of the physical structures and systems for turning water into drinking water to such a standard which is requested in the German rules are very high. Main reason therefore is the increasing contamimation of groundwater and the resulting efforts for the cleaning of “rohwasser”.

The traditional water-carried waste disposal as a kind of transport medium for faeces- becomes a critical look in fact of the sustainability.

Comparing to the European countries which discuss the sanitary risk already at the point of using rainwater for toilet flushing and washing machine, most other countries will be content to dispose water in such a quality as the mentioned drinking water.

Based on these facts different technical innovations for a lasting water resource management and sewage systems have been developed.

Main aspects were the responsible commerce of water, which means a lower consumption and decrease of water contamination as well as a consistent partial flow management.

Whilst Europe focus mainly on technologies for saving water and efficiency of water recycling in all processes - biological, chemical and physical – different parts of the world are still in work for water and public sewage systems in general.

The constitution of new systems also means to renew all kinds of inspections and the modification to the already existing administrative guidelines. In Germany there exist e.g. the “Anschluss- und Benutzungszwang” for properties to the public infrastructure. Therefore many different administrative proceedings will have to be settled for any kind of technical innovations of the water resources management for communities.

So far main points in Germany were to reduce the consumption of drinking water. Technical installations as water saver fittings were a success in the sanitary area. A further important part is the rainwater harvesting and water re-utilisation. Through the substitution of drinking water by
Rainwater or different systems of grey water recycling, drinking water can be saved in one single household up to 50%.

Rainwater harvesting – state of the technology

Systems of rainwater harvesting were used all around the world with different technical efforts. Reservoirs and transport of water in mainly used in the agricultural area. The utilization of rainwater in the domestic area constantly increases.

While in developing countries the rainwater in general is collected on a low-technical standard for domestic applications and on the regional level also as drinking water and for personal hygiene, in other countries the collection of rainwater, predominantly to the industrial countries, becomes a substitution of drinking water, which then will be used for various ranges of application as toilet flushing, washer and garden irrigation. The technology of the rainwater harvesting offers numerous products for different application cases and installation sizes. A wide range of products are manufactured and are offered in the mean time.

This installation is essentially based on 2 modules. The illustration shows a central rainwater system in a domestic area, combining a pump, a supplemental feed module and the system control unit. It also shows reservoir modul, which integrates the reservoir, quiescent supply, removal line, overflow and filter completely.

The modular construction enables complete, industrially prefabricated arrangements parts finished in connection in different equipment variants and price ranges to produce.

So far the possibility is given to combine different components which are to be started if necessary with alternative sanitary systems meaningfully. Numerous physical-chemical and hygienic examinations/tests prove that the quality of the rainwater from these kinds of installations is suitable according to the state of the technology to use the water for the toilet flushing, washing machine, the garden irrigation and for cleaning purposes.

Turning rainwater into drinking water

With water treatment systems as e.g. of Aqua Sure, The Netherlands rainwater can be proceeded into drinking water quality. Through the storage of rainwater and subsequent proceeding, these systems offer possibilities to construct public drinking water systems to smaller communities and villages or at least at the domestic area.

These systems are mainly designed for regions, which do not dispose of a drinking water infrastructure. The following pictures show a water treat system, which works with the usual process of drinking water recycling as pre-infiltration, adsorption, ion exchange and disinfection. The tool is build up on a modulare basis an works on a 40 l/h capacity. This is equal to satisfy the daily supply of a family.

Whilst countries with sufficient water resources the supply with drinking water does not show the main problem, regions with less water resources rainwater these becomes an important aspect referring to the daily water supply. By using the new developed, dezentral Wasseraufbereitungsgeräten rainwater can be turned into drinking water.

The use of rainwater in addition /as a supplement to process water, for cool systems and cleaning purposes and other applications in the commercial or industrial areas is already implemented in a lot of cases. Here, first of all, economic reasons were the clincher.

Dependent on the fees for drinking water and the connection on the public sewage water systems these investments amortize themselves in relatively short intervals.
Grey water-reuse – state of the technology

An increasingly more important role is ascribed to the grey water reuse by the development of a sustainable water resource management. Water recycling in the domestic area is not basically new, but the comfort claims and the lifetime habits concerning water and body hygiene have strongly changed compared to the past times. The water-consumption has risen in this area definitely.

Today water recycling means to grasp and to treat slightly loaded domestic sewage water (grey water) and sewage contaminated with faeces (black water) separately. Typically grey water is such water as the drain of baths and shower sewage, washing table and the washing machine.

In a water-saving household in Europe approx. 50 to 55 l of grey water are consumed per day and person.

In fact of the low nutrient content a simple biological cleaning will satisfy the expectations. Based on the daily personal hygiene grey water continuous comes up not depending on any kind of weather influences.

The arising grey water can be grabbed to quality of process water, which gives the possibility to use this water for toilette flushing, washing machines as well as for watering demands.

Grey water systems can be implemented decentralized as well as centralized.

Decentralized grey water installations are, e.g. installations which process the grey water in the point of origin during central arrangements will bring the water from several housing units together and process them.

The grey water use assumes a functioning drinking water supply system to use the water by cycle guidance repeatedly.

The following image shows a grey water installation in a new built housing area with 120 units at Beijing, China.

Ecological sanitation

The ecosan concepts is based on a consistent separation of partial flow. The recycling of nutrients taken from the sewage of domestic areas is most important. Analyses of partial flow show, that the nutrients are from the human excretions urine and faeces. For the further use of these nutrients special technologies are necessary to reduce and avoid the dilution of the partial flow. By the use of special sanitary systems as separation toilets, vacuum toilets and compost toilets the separation of the partial flow can be guaranteed. In an optimal case a complete recovery/retrieval of nutrients in the sewage water taken from the domestic area will happen.

A further combination of systems for solids and also power generation under assistance of biogas reactors is also possible and have successful happened.

Furter-oriented combinations of rainwater harvesting, grey water utilization and ecosan technologies

Systems of process water and rainwater harvesting and grey water recycling are already in use and proceeded in different countries. Similar systems are already in use for the ecosan technologies. It is recommendable to avoid any kind of administrative restraints for the implementation and realisation of new and further oriented innovations in the denzentral solutions.
Actual there are multifaceted technologies, which can be accommodated to the individual financial situation of the particular country.

So far systems of rainwater and process water harvesting were successful used in main regions showing an existing drinking water infrastructure and public sewage system.

Possibilities of combinations of the suggested systems have to be proven accordingly to the different constraints. For countries with lower rainfall the question of the quantity of collected and stored rainwater has to be clarified. It will also be important to get further information about the annual spread of rainfall, roof and collecting areas/fields as well as about the possibilities to collect and store this water.

It has to be taken care in general that countries which will investigate ground for further communities or villages, especially the developing world with a low budget of water resources, should not work with any kind of Schwemmkanalisation.

The combination of ecosan technologies and grey water recycling should be preferred. The grey water can be drained in a dezentral soil filter and be trickled down or can be drained into the Vorfluter.

It other regions with other constraints it has to be proven which kind of combination of the single systems will be the most effective. Additional it should be considered that the installations should only use as less energy as possible so this may guarantee that regions without any infrastructure can use this installations dezentral by photovoltaic or biogas installations.

It is also possible that in the sense of economical aspects and in view of an already existing infrastructure, the combination with rainwater harvesting and grey water recyclingshould be continued. For the development of the responsible treat with water in municipalities in general, the elements of ecosan technologies as well as rainwater harvesting and water re-utilisation systems will become more and more important. The combination of both strategies will be a new task field referring to the planning, installation, operation and maintenance. Therefore further research projects and model test are required.

References

Fachvereinigung Betriebs- und Regenwassernutzung e.V.; Hrsg. (2002): Ökologische Sanitärkonzepte contra Betriebs- und Regenwassernutzung, fbr-Schriftenreihe Band 9; Darmstadt


Fachvereinigung Betriebs- und Regenwassernutzung e.V.; Hrsg. (2001): Regenwassernutzung und -bewirtschaftung im internationalen Kontext, fbr-Schriftenreihe Band 8; Darmstadt

Fachvereinigung Betriebs- und Regenwassernutzung e.V.; Hrsg. (1999): Grauwasser-Recycling, fbr-Schriftenreihe Band 5; Darmstadt
This page break is here because there was no way to move the footnote down in the page, we had to change the margin. The only way to change the margins in this page only is with a page break. DO NOT REMOVE IT!