

# Proceedings of an Awareness Raising Workshop on Ecological Sanitation

September 2nd to 4th 2003

Gaborone, Botswana



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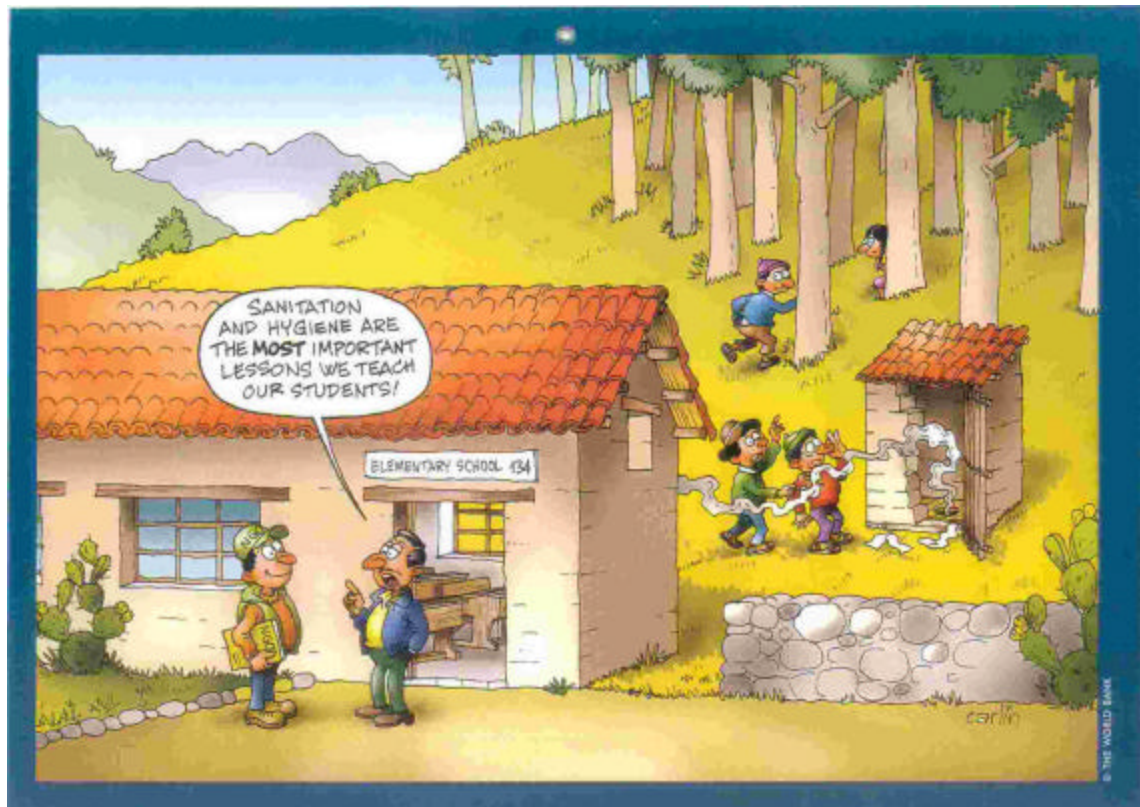
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Available from:

IUCN Botswana  
Private Bag 00300  
Gaborone  
Botswana  
Tel/Fax: (267) 3971 584  
E-mail: [iucnbotswana@iucn.org](mailto:iucnbotswana@iucn.org)  
<http://www.iucnbot.bw>

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## Abbreviations

B	Boron
BGR	Federal Institute for Geosciences and Natural Resources
BOBS	Botswana Bureau of Standards
BOD	Biological Oxygen Demand
BORDA	Bremen Overseas Research and Development Association
Ca	Calcium
CBNRM	Community -based Natural Resources Management
CEAP	Community Environmental Action Plan
CEU	Commission of the European Union
Cl	Chloride
COD	Chemical Oxygen Demand
CPG	Civil & Planning Group
Cu	Copper
DED	German Development Services
DSWM	Department of Sanitation and Waste Management
DWA	Department of Water Affairs
EHO	Environmental Health Officers
EU	European Union
Fe	Iron
GO	Government Organisations
GoB	Government of Botswana
GONGO	Government Oriented Non Government Organisations
GTZ	German Technical Cooperation Agency
HCES	Household Centred Environmental Sanitation
IUCN	The World Conservation Union
K	Potassium
KDC	Kweneng District Council
MEWT	Ministry of Environment, Wildlife and Tourism
Mg	Magnesium
MLGLH	Ministry of Local Government, Lands and Housing
Mn	Manganese
Mo	Molybdenum
N	Nitrogen
MDG	Millennium Development Goals
NDP9	National Development Plan 9
NGO	Non Government Organisations
NNAS	National Needs Assessment Survey
NO <sub>3</sub>	Nitrate
NOSSP	National On Site Sanitation Programme
NRM	Natural Resources Management
NRSP	National Rural Sanitation Programme
NSP	National Settlement Policy
OECD	Organisation for Economic Development and Cooperation
P	Phosphorus
PTB	Permaculture Trust of Botswana
R&D	Research and Development
RIIC	Rural Industries Innovations Centre
S	Sulphur
SADC	Southern African Development Community
SHHA	Self Help Housing Authority

SMEC	Snowy Mountains Engineering Corporation
UD	Urine Diversion
UNDP	United Nations Development Programme
UNICEF	United Nations International Children Educational Fund
USAID	United States Agency for International Development
UESS	Urban Environmental Sanitation Service
UV	Ultra Violate
VIDP	Ventilated Improved Double Vault Pit latrine
VIP	Ventilated Improved Pit latrine
WC	Water Closet
WHO	World Health Organisation
WSSD	World Summit on Sustainable Development
Zn	Zinc

## **Acknowledgements**

IUCN would like to acknowledge the DSWM for its contributions in organising the site visit to Kweneng District as well as for its interest in Ecological Sanitation; the Kweneng District for its availability to host and lead the site visits on Ecological Sanitation; all the presenters that made themselves available to share lessons learnt from Botswana but also from the region and beyond; all the participants who showed a sincere interest in learning about Ecological Sanitation and taking it a step further; and last but certainly not least we would like to thank GTZ-Eco-San for its financial and organisational contributions to the workshop and for requesting that such a workshop be organised in Botswana.

We are very grateful to all of you as your inputs have been a key contribution towards the success of the workshop and hopefully more than a “drop of water in the sea” towards increased Ecological Sanitation in Botswana.

## **Foreword**

During two and a half days stakeholders from Botswana, community members, government officials, NGOs, private companies and others gathered together to share their knowledge and experiences on sanitation in an attempt to increase awareness on specifically Ecological Sanitation.

The workshop has been an opportunity to learn to know more about the specific concept of Ecological Sanitation, systems that are used to implement it (waterborne and non-waterborne systems), as well as perspectives and requirements for the implementation of Ecological Sanitation in both rural and urban areas. Lessons learnt in Botswana and in other parts of the world were shared in an effort to reduce problems and increase acceptance of Ecological Sanitation in this country. One of the very key aspects that was learnt was the importance of informing stakeholders about options available and advantages as well as drawbacks of each system so to allow them to make informed choices. The importance of dissemination of information and education was highlighted throughout the workshop and should remain at the core of activities. Last but not least an emphasis was put on the relevance of health and safety aspects to be kept in mind when implementing Ecological Sanitation. Health is an issue that should be at the centre of attention of all practitioners as it influences activities from the very start (choice of a system) to the very end (use of the by-products from the toilets for gardening and agriculture).

In Botswana Ecological Sanitation is still at its first steps and it is our thrust that this workshop has only been the first of a series of awareness raising and information sharing activities throughout the country. Important challenges still lie ahead of us, to make it become a reality all stakeholders should join efforts and collaborate towards Ecological Sanitation: towards improved water quality, improved health, improved sanitation, and improved food security in Botswana.

*Cathrine Wirbelauer  
Project Coordinator  
IUCN/DED Botswana*



**Proceedings of an Awareness Raising  
Workshop on Ecological Sanitation**

**2<sup>nd</sup> – 4<sup>th</sup> of September 2003  
Gaborone, Botswana**



## **Proceedings, Awareness Raising Workshop on Ecological Sanitation**

**Day 1, September 2<sup>nd</sup> 2003**

### **Opening Remarks**

*By K.A. Selotlegeng, Director of the Department of Sanitation and Waste Management*

The Director of the Department of Sanitation and Waste Management (DSWM) began his remarks by welcoming participants to the three-days workshop on Ecological Sanitation organised by IUCN in collaboration with the DSWM and GTZ.

He continued by noting that sanitation is in a crisis worldwide as well as in Botswana. WHO figures show that there are at least 2.4 billion people in the world without improved sanitation and that those in need primarily reside in rural Asia and Africa. Improved sanitation (e.g. public sewer, septic systems, simple pit latrines or VIP) does not solve the problems, though. From the experiences within Botswana, some lessons have already been learnt, such as that of conventional pit latrines failing to sanitise and contributing to groundwater pollution, and septic systems and sewage treatment plants often discharging into the environment to the total exclusion of any nutrient recovery.

Uncontained and untreated human excreta pollute groundwater tables and streams, helping to perpetuate the cycle of human diseases and upsetting fragile ecosystems by nutrient overloading. UNICEF identified Botswana as being one of those countries with a medium coverage with improved sanitation (51-75%), and some of the latest data from Botswana mention 200,000 households using improved sanitation. Nevertheless, nitrate pollution of groundwater remains a major problem in this country.

During the World Summit on Sustainable Development held in Johannesburg in 2002, several targets for the coming decade were set. Among these was the intention to “halve, by year 2015, the proportion of people who do not have access to basic sanitation.” The need to find sustainable alternatives to conventional approaches remains enormous. Sanitation should no longer be a process whereby excreta is contained in deep pits or improperly treated and flushed downstream. Sustainable and ecological sanitation requires a holistic approach and consideration.

Ecological sanitation provides alternative solutions with or without water, while providing containment, treatment and recycling of excreta. It involves composting toilets in shallow reinforced pits; dry urine-diverting toilets with storage vaults; urine diverting mini-flush toilets; and even high-tech vacuum systems.

Ecological Sanitation is a three-step process: containment, sanitisation and recycling/recovery of human excreta. These three steps constitute three main aims that should be of greatest interest to all as they relate to the protection of human health and the environment reducing the use of water in sanitation systems and recycling/recovering nutrients to be used as conditioners and fertilizers in agriculture.

What makes Ecological Sanitation even more important? Is it the fact that Ecological Sanitation cannot be seen as a sanitation process of choice on its own, and that to be effective, it has to be seen as part of a broader process for rural and urban areas. The differences between rural and urban sanitation tend to increase, with high urban sanitation coverage and very low rural sanitation coverage. In a scenario with rapidly increasing urban environments we have to also think of sustainable options; resource-separation and recycling should become standard practice.

Mr Selotlegeng continued by mentioning the example of phosphorus, being one of the essential nutrients to living organisms. Most of the phosphorus consumed by animals and humans is excreted. By safely recovering the nutrients found in human excreta through ecological sanitation it is possible to reduce the depletion of mineral phosphorus reserves worldwide. Ecological sanitation also offers options to generally make excreta hygienic and thus creates opportunities to have valuable and effective organic fertiliser that recycles nitrogen, phosphorus, potassium and other nutrients contained in urine and faeces back into the productive environment, back into agriculture.

At a time where Botswana is preparing its Master Plan for Wastewater and Sanitation it becomes even more imperative to join forces within the country and the Southern African Region towards improved sanitation. It also becomes more important that stakeholders realise the linkages between sanitation, the water cycle and the recycling of organic waste.

Under current policy Botswana is committed to achieving the goals of Agenda 21, which calls for sustainable and environmentally sound development and seeks to:

- Preserve, protect and improve the quality of the environment;
- Contribute towards protecting public health; and
- Ensure a prudent and rational utilisation of natural resources.

Ecological Sanitation will contribute to all three of these cardinal principles.

Conservation of the environment stands out as a long-term commitment, and participants were called upon to ensure that this new initiative is linked with people's changing lifestyles and attitudes. This aspect should not be underestimated and participants were encouraged to keep it in mind when discussing Ecological Sanitation options suitable for the nation.

Finally all participants and Ecological Sanitation stakeholders, users (households and agriculturalist), service providers (NGOs and private sector) as well as government representatives from different sections, were encouraged to take advantage of the unique opportunity to determine strengths and weaknesses of ecological sanitation and chart a sound way forward for Botswana.

The director concluded by mentioning that good health conditions provide the basis for improved social and economic conditions, and this guarantees development.

## **Closed-loop oriented wastewater and waste management**

*By H-P. Mang, GTZ -Ecological Sanitation Project Team*

The presenter started by illustrating some of the main aspects of the world water and sanitation crisis. He noted that there is increasing scarcity and degrading quality of the world's freshwater and that about 1.1 billion people around the world have no access to safe drinking water. 2.4 billion people have inadequate sanitation and/or no means of wastewater disposal. Furthermore he mentioned that the global population is expected to increase by 2 billion people within the next 25 years (mostly in urban areas in developing and emerging market economies). This will be an enormous challenge to all those who work towards concerted efforts in resolving the water crisis. In fact figures already show that, at discharge, 90% of the wastewater worldwide is either only poorly treated or not treated at all, and that 80% of all diseases as well as 25% of all deaths in developing countries can be attributed to polluted water (WHO).

Under the United Nation's Millennium Development Goals (MDGs), some of the targeted achievements towards poverty eradication and sustainable development comprise rapid increase in access to: clean water, sanitation, energy, health care, food security and the protection of biodiversity. Specific targets in the water and sanitation sector include increasing by half the proportion of people with access to safe drinking water and to adequate sanitation by 2015.

The presenter continued by listing some of the shortcomings of conventional "flush and discharge" sanitation (Annex 4), such as:

- Pollution of waters by organics, nutrients, hazardous substances, pathogens, pharmaceutical residues, hormones, etc.;
- Unbearable health risks and spread of diseases;
- Severe environmental damage and eutrophication of the water cycle;
- Consumption of precious water for transport of waste (water carriage waste disposal systems);
- High investment: energy, operating and maintenance costs;
- Frequent subsidisation of "richer" areas and neglect of poorer settlements;
- Loss of valuable nutrients and trace elements contained in excreta due to discharge into waters;
- Impoverishment of agricultural soils and increased dependency on chemical fertilizers;
- Combined central systems are predominant in organised wastewater disposal resulting in problems with contaminated sewage sludge; and
- Linear end-of-pipe technology.

The main shortcomings of conventional "drop and store" sanitation can be summarised by noting that solids are retained while liquids seep into the ground; these liquids, loaded with pathogens, nitrates and viruses, pollute the ground water.

Both lists of shortcomings clearly identify the need for alternative solutions that provide more appropriate technologies and the recycling of precious nutrients.

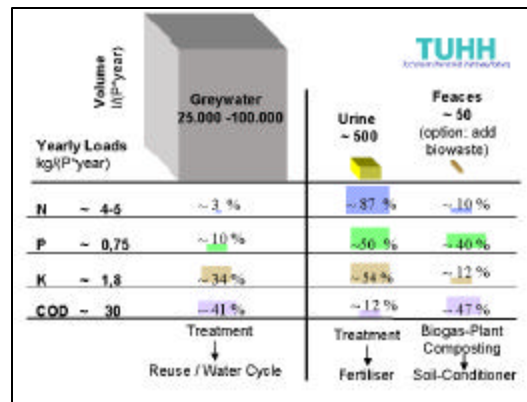
One of the alternative approaches is Ecological Sanitation (Eco San), but what exactly does it mean?

The basic principle of EcoSan systems is to close the loop between sanitation and agriculture. EcoSan is not a specific technology but a new philosophy based on an overall view of material flows dealing with what is presently regarded as waste and wastewater for disposal.

The main advantages of Ecological Sanitation (Annex 5) are the:

- **Improvement of health** by minimizing the introduction of pathogens from human excreta into the water cycle;
- **Promotion of recycling** by safe, hygienic recovery and use of nutrients, organics, trace elements, water and energy;
- **Conservation of resources** through lower water consumption, substitution of chemical fertilisers, minimization of water pollution; and
- **Material flow cycle instead of disposal.**

The composition of household wastewater (as per table below) helps in understanding the importance and need to identify treatment options that allow for a safe recovery of water and nutrients. In fact grey water if treated correctly can be safely reintroduced into the water cycle, urine can also be treated and used as fertiliser and finally faecal matter can be composted and used as a soil conditioner.



**Composition of household wastewater**

The presenter continued by illustrating the characteristics of the substances contained in wastewater and by mentioning some of the possible options for their separation.

Fraction	Characteristic
1. Faeces	<ul style="list-style-type: none"> <li>• Hygienically critical</li> <li>• Consists of organics, nutrients and trace elements</li> <li>• Improves soil quality and increases its water retention capacity</li> </ul>
2. Urine	<ul style="list-style-type: none"> <li>• Less hygienically critical</li> <li>• Contains the largest proportion of nutrients available to plants</li> <li>• May contain hormones or medical residues</li> </ul>

3. Grey water	<ul style="list-style-type: none"> <li>• Of no major hygienic concern</li> <li>• Volumetrically the largest portion of wastewater</li> <li>• Contains almost no nutrients (simplified treatment)</li> <li>• May contain washing powders etc.</li> </ul>
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<b>Substances</b>	<b>Urine (Yellow water)</b>	<b>Faeces (black water)</b>	<b>Grey water (shower, washing etc)</b>	<b>Rainwater</b>	<b>Organic waste</b>
<b>Treatment</b>	Hygienization by storage or drying	Anaerobic digestion, drying, composting	Constructed wetlands, gardening, wastewater ponds, biological treatment, membrane technology	Filtration, biological treatment	Composting, anaerobic digestion
<b>Utilisation</b>	Liquid or dry fertiliser	Biogas, soil improvement	Irrigation, groundwater recharge or direct use	Water supply, groundwater recharge	Soil improvement, biogas

Human faeces and urine can be utilised in agriculture under the following conditions:

- Proper pre-treatment (storage, drying, composting, anaerobic fermentation, heating, filtration, irradiation with UV etc.);
- Suitable “handling” (with security measures);
- Limitation to specific vegetables and field crops, and to specific vegetation periods, depending on pre-treatment;
- Regular sampling and hygiene control; and
- Respect of the crop’s nutrient needs (no over-fertilisation).

Finally the presenter noted that one person can provide enough nutrients to fertilise/condition from 200m<sup>2</sup> to 400m<sup>2</sup> of agricultural production area per year, depending on soil and plant type.

EcoSan can thus be summarised in a “triple win” situation of Water, Agriculture and Hygiene. In fact it allows for the protection of water resources through their reduced consumption and contamination; it allows for higher agricultural yields through the recovery of nutrients; and it allows for increased hygienic conditions through the minimization of water-based infections.

The presenter concluded by giving some information on the GTZ “EcoSan Research and development project”, its timeframe, activities, objectives and main aim over its three-year period (Annex 6).

One of the participants commented that the reuse of waste products from human beings as fertilizers in some cultures is a taboo and asked what the experiences in dealing with taboos worldwide were.

The presenter replied that one of the ways of dealing with these situations could be to look at local historical facts on the utilisation of human excreta and to use these data when introducing the concept to the people. Another solution could be to conduct research and development to understand the various taboos and to find appropriate solutions to face peoples' fears from the very start.

## **National Master Plan For Wastewater and Sanitation, the need for integrated sanitation services**

*By N. Mudge, SMEC International*

The presenter started by linking the need for integrated sanitation services in Botswana with Agenda 21. Agenda 21 strives to achieve three main aims towards “sustainable and environmentally sound development” in all countries:

- To preserve, protect and improve the quality of the environment;
- To contribute towards protecting public health; and
- To ensure a prudent and rational utilization of natural resources.

These three main aims have also been incorporated into the National Wastewater and Sanitation Policy finalised by the Government of Botswana in 2001, thus creating direct links between the developments that are guided by Agenda 21 and those that are to guide the implementation of activities in Botswana.

In an attempt to set up guidelines for implementation of the policy, the National Master Plan aims to:

1. evaluate the existing situation on wastewater and sanitation and their impact on the environment;
2. develop planning and implementation strategies for the long-term sustainable growth; and
3. enhance the living and working environment of the people of Botswana.

The terms of reference for the development of the national master plan also recommended that a range of products be included into the final document, such as an inventory of national assets, specific recommendations on “on-site sanitation”, and strategies for the development of wastewater and sanitation services for centres.

The Botswana 2001 census was an invaluable source of information on the situation of sanitation in the country and was used for the development of the Master Plan. The census gave a breakdown and figures on the number of sanitary facilities in the country, those owned by individuals and others. These figures were instrumental in identifying that a large percentage of the population (23%) did not have any toilet facility at all, that 21% owned flush facilities, 18% owned VIPs and 24% owned pit latrines. Besides several other type of sanitation facilities used by less than 10% of the population (e.g. own Enviro-Loo, communal flush toilets, communal VIP etc), 6% still use neighbours toilet and 5% communal pit latrines.

The tables below give a more detailed breakdown and analysis of the information gathered on the status of sanitation through the Census 2001.

	African Continent (WHO Definition)	Botswana (WHO Definition)	Botswana (GoB Definition)
Urban	81	95	53
Rural	41	51	18
Total	51	77	39

**Comparison of Adequacy of Sanitation services in Botswana (in %)**

NSP	Total Population (n.)	Households (n.)	Sewerage Cover	Adequate On- Site Sanitation Coverage	Not Adequate On-Site Sanitation Coverage
Primary	652,864	171,196	24%	33%	43%
Secondary	224,764	57,827	17%	29%	54%
Tertiary 1	55,616	11,786	2%	34%	64%
Total	933,244	240,809	21%	32%	47%

**Settlement pattern for urban and peri-urban/coverage**

NSP	Total Population (n.)	Households (n.)	Sewerage Cover	Adequate On- Site Sanitation Coverage	Not Adequate On-Site Sanitation Coverage
Tertiary 2	332,273	71,561	0.2%	26%	74%
Tertiary 3	94,449	19,299	0.2%	18%	82%
Tertiary 4	41,095	8,487	0%	14%	86%
Associated L	279,802	64,550	0%	10%	90%
Total	747,619	163,897	0.1%	18%	82%

**Settlement pattern for rural areas**

Area	Total household on-site sanitation needs	% of Total	Upgrade pit latrines	New installation needed
Urban/peri-urban	113,000	46	84,000	29,000
Rural	134,00	54	40,000	94,000
Total	247,000		124,000	123,000

**Summary of on-site sanitation needs**

The team working on the master plan development also reported on other findings on on-site options. A thorough study across the country showed that:

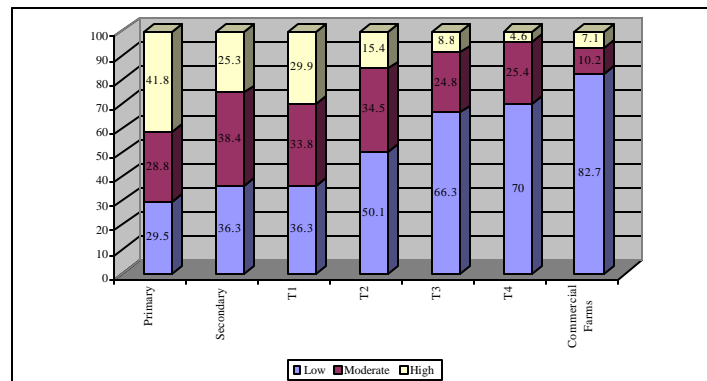
1. VIP technology is working well and is an adequate technology;
2. Septic tanks are a good way of dealing with waste, but there are problems with the design of soak-aways. The master plan has developed a planning and design manual with recommendations on various construction standards;
3. Dry composting has not been working well; and
4. High cost and complex technology is not the solution.

In Botswana, besides the 70% of on-site sanitation units being owned directly by private households, a number of projects and programmes contribute towards expanding and providing on-site sanitation:

1. NRSP (Government);
2. SHHA programmes (Government);
3. Institutional facilities (Government);
4. Red Cross (NGO);
5. USAID/UNICEF (NGO); and
6. IUCN/PTB, CBNRM-Missing Link Project (NGO).

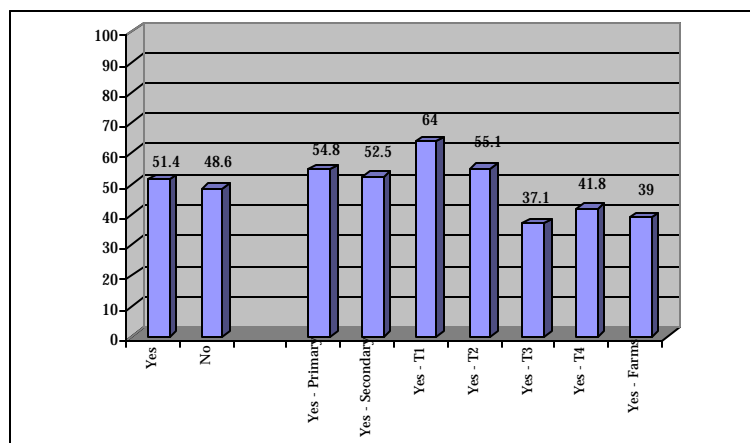
The speaker continued by mentioning that no matter which type of sanitation facility and no matter where in the country, the communities should remain at the core of any sanitation programme and activity. An in-depth analysis of the relation between communities and their involvement in sanitation was presented:

a) Communities ability to pay depending on their monthly income

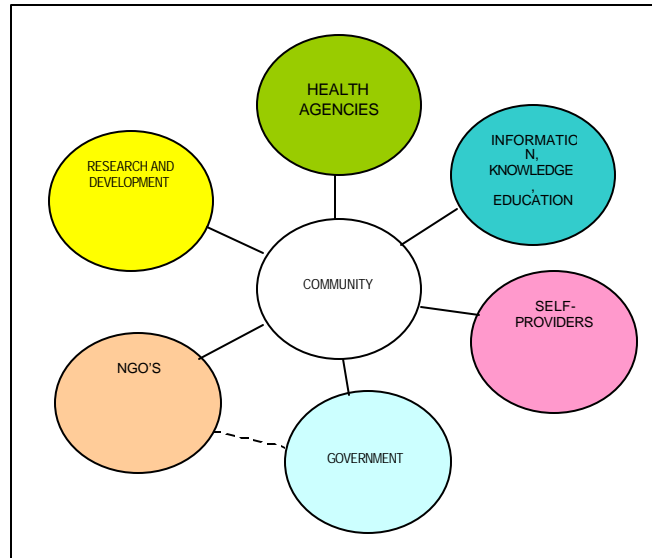


(Income averages used: low: <P500; medium P501-P1500; high: >P1501)

b) Communities willingness to upgrade pits to VIPs (based on up-grade cost of P600)



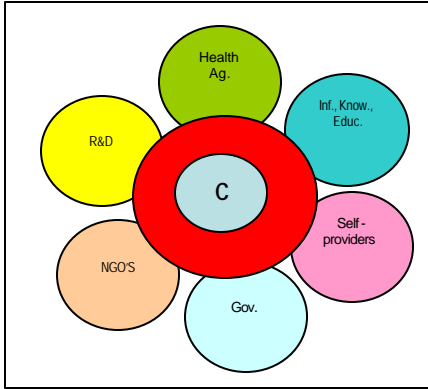
c) the need for integration based on the current relationships



The presenter highlighted that communities, being at the centre of sanitation, also have a direct link to groundwater contamination, and that generally on-site sanitation should be associated with improved health of the communities rather than increased pollution and hazards. Unfortunately it was noticed that the disposal practices of sewage and sludge was poor, that services for the de-sludging of pits were slow, that toilet paper and hand washing facilities were generally lacking, and that people thought pit latrines were okay but desired something better.

But communities, although they are at the centre of sanitation, cannot be held solely responsible for the above problems. Most of the sanitation problems in the country are a consequence of the current lack of integration:

- Communities are often confused about “who does what” in sanitation;
- Each stakeholder group develops its own interlinks with communities and some other groups (see figure above);
- The quality of the work is disabled by the fact that implementation is done in isolation;
- Local authorities are uncertain about who is coordinating what;
- There is no synergy with wastewater proposals;
- On-site sanitation is not considered in relation to future wastewater schemes;
- There is no coordination of information, education, and communication with the community; and
- There is little understanding about the range of technologies available, especially the cost implications of such technologies.



The integration that is desired would keep communities at the centre and improve the links to/between all other stakeholders towards increased synergies.

Integration would not only improve and raise the level of services provided to the communities, it would also assist in protecting the environment and implementing sustainable development in line with Agenda 21. The process of integration and coordination between agencies is a core function of the Department of Sanitation and Waste

Management and should be urgently improved. The main task would be that of implementing the recommendations of the Master Plan, which include establishing a regular network of communications, establishing integrated wastewater and sanitation management plans for centres, and launching the NOSSP (National On-Site Sanitation Programme).

In conclusion, the objectives of the Master Plan are consistent with meeting the requirements of Agenda 21. At this stage the levels of services and needs related to on-site sanitation are known and well defined. A number of technologies already in use have been assessed and recommendations have been made towards improved sanitation in Botswana. The integration of on-site sanitation services has been identified as being one of the key issues and elements for successful implementation of sanitation, and the integration between wastewater and on-site sanitation is also essential for sustainable development. Finally a conducive communication with the communities that are being served is mandatory.

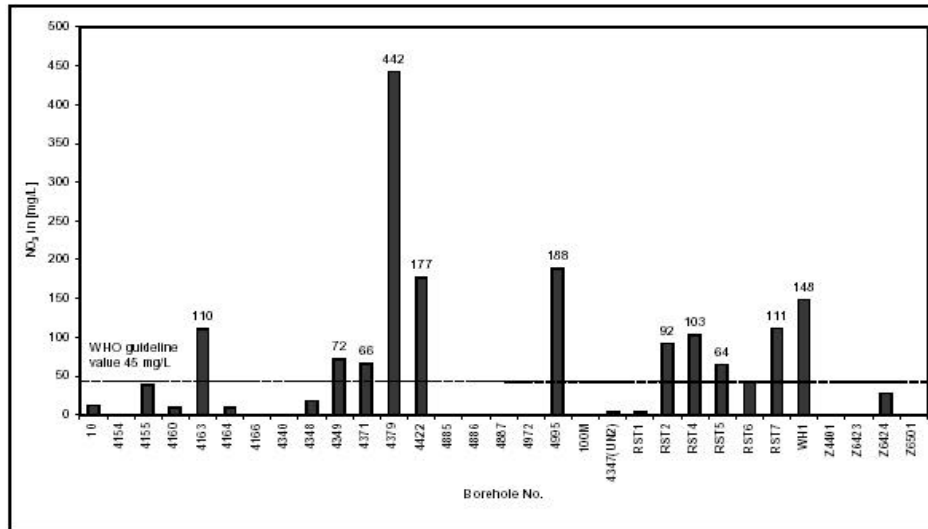
After the presentation the discussion started with issues related to general information on groundwater depth and pollution in Botswana. In response the presenter mentioned that the Department of Geological Surveys and the Department of Water Affairs have a lot of information on groundwater and referred to presentations by the Department of Geological Surveys that were to follow during the workshop. He continued by mentioning that there is a direct relationship between nitrates contamination and presence of pit latrines, especially in areas where the groundwater table is relatively high (as for instance in Ramotswa). A further point related to the important efforts made by the Government of Botswana on infrastructure development and less efforts made in assisting the population to connect and use available sanitation systems was raised. The presenter replied by informing participants that water treatment plants should not be built unless there is a real need. In fact technically for a plant to work effectively there needs to be at least 30% to 40% usage. The discussion was concluded by mentioning that the government has decided to operate on a cost recovery basis mainly recovering operating/maintenance costs and by emphasising an even greater need for community education towards adequate use and maintenance of any sanitation facility.

## Effects of urban expansion on groundwater quality in Ramotswa

By H. Vogel, BGR /Botswana Geological Survey

The presenter started by mentioning the background that motivated the research on the effects of urban expansion on groundwater quality. In fact, in the 1990s Ramotswa experienced one of Botswana's worst cases of groundwater pollution. One of the first hypotheses linked the pollution to the successful promotion of pit latrines and the location of Ramotswa (just above Botswana's most productive dolomite aquifer). It struck disaster as human wastewaters polluted the shallow aquifer in no time. Since the aquifer in Ramotswa is the most productive aquifer in Botswana and due to the scarce overall water availability in the country in late 2001, the Environmental Geology Division at the Department of Geological Services decided to carry out a groundwater investigation.

During the investigation, groundwater samples were taken from a total of 31 boreholes. Amongst these, 11 featured elevated nitrate levels. The maximum recorded nitrate concentration was 442 mg L<sup>-1</sup> at borehole 4379 (see figure below).



Nitrate concentration per borehole (Ramotswa)

It was assumed that these concentrations were mainly caused by human waste. In fact the spatial distribution of the boreholes featuring elevated nitrate levels and the prevailing groundwater flow direction revealed that unpolluted water entered the study area from the south and the southern well field showed no nitrate contamination.

In Ramotswa groundwater flows in a northerly direction and carries polluted water to the Ngotwane River. Nitrate levels in the boreholes along the river plain ranged from 65.5-188 mg/L and a maximum of 442 mg/l at borehole 4379. The first borehole in the northern direction, which displayed a critically high nitrate level, was borehole 4349 with 72 mg L<sup>-1</sup> of NO<sub>3</sub>. This borehole is located within the village.

Nitrate contamination has been suggested as an indicator of overall groundwater quality. Nitrate (NO<sub>3</sub>) pollution in groundwater has become a global problem. Most nitrogenous materials in natural waters tend to be converted to nitrate, so that all

sources of combined nitrogen (in particular organic nitrogen and ammonia) should be considered as potential nitrate sources (in the presence of oxygen, bacteria chemically oxidize (nitrify) ammonia to nitrate).

Primary sources of organic nitrates include human sewage and livestock manure (especially from feedlots). Since nitrates are very soluble and do not bind to soils, they have a high potential to migrate to groundwater. Because they do not evaporate, nitrates/nitrites are likely to remain in water until consumed by plants or other organisms.

The primary health hazard from drinking water with nitrate-nitrogen occurs when taken into the body where nitrate ( $\text{NO}_3$ ) is converted to nitrite ( $\text{NO}_2$ ) in the digestive system. The nitrite oxidizes iron in the haemoglobin of the red blood cells and forms methemoglobin, which lacks the oxygen-carrying ability of haemoglobin. Most humans above one year of age have the ability to rapidly convert methemoglobin back to oxyhemoglobin; hence, the total amount of methemoglobin within red blood cells remains low in spite of relatively high levels of nitrate/nitrite uptake. However in infants below 6 months of age the enzyme systems for reducing methemoglobin to oxyhemoglobin are not completely developed and methemoglobinemia ("blue baby syndrome") can occur. In this case blood lacks the ability to carry sufficient oxygen to the individual body cells causing the veins and skin to appear blue. Water with nitrate levels exceeding  $1.0 \text{ mg L}^{-1}$  should not be used for feeding babies.

Nitrate toxicity does occur in livestock, but the nitrate concentrations that produce toxicity are much higher than those for humans.

As nitrate is a known toxin, the World Health Organization (WHO) has set a limit of  $45 \text{ mg L}^{-1}$  of total nitrate ( $\text{NO}_3^-$ ) for drinking water. The same maximum contaminant level for total nitrate applies in Botswana (BOBS).

## **Effects of urban expansion on groundwater quality in Francistown**

*By B. Mafa, Botswana Geological Survey*

Increasing industrialisation and the exploitation of raw materials and natural resources has led to an "environmental development" crisis in most developing countries. The ecological imbalances and projections for the future as well as the general shortage/pollution of drinking water, threatening the lives of many people worldwide, give reasons for alarm. It is therefore imperative that environmental protection encompasses investigation and assessment of natural resources, as well as an analysis of the processes that have an impact on the environment. Moreover, the results should be used for environmental planning, resources protection and resources management.

Elements that generally influence urban environmental pollution include:

- A trend in urbanization characterized by excessive migration. This often results in excessive pressure on urban land and the urban spatial system;
- The weakness of planning agencies responsible for the urban environment; and
- The lack of an environmentally conscious/responsible urban population.

Some of the major concerns identified in urban set-ups are:

- Uncleared refuse dumps at street junctions, market places, open spaces etc;
- Scraps of disused motorcars, oils;
- Open storm water drains blocked by non-biodegradable material; and
- Polluting developments such as kiosks, sheds of various sorts (e.g. Mechanic sheds), retail activities, food outlets, and to a smaller extent illegal squatters.

#### *The Case of Francistown*

The aim of the study was to determine the causes of groundwater contamination in Francistown. It was especially intended to follow up on the effects of urban expansion and mining within the Francistown city area on groundwater quality and to determine the contamination processes. The main output expected was to have recommendations on solutions/measures to be taken that could be used to facilitate urban planning in future developments of the city.

The geology of the area studied is characterised by rocks of a basement complex, including metavolcanics of the so-called Tati Schist Group. These underlie a significant portion of the Francistown area. The area is relatively flat, dipping gently towards the southeast and broken by small isolated hills and inselbergs. Exposure of the bedded strata is generally good though most of the granitoid rocks are poorly exposed.

Confining layers composed of sandy horizons contain water and contribute leakage into the underlying aquifer thereby acting as perched aquifers. Weathering of the rock complex appears to be confined to certain horizons within the Penhalonga Mixed Formation where it appears to be restricted to the easily weathered acid metavolcanics. The Tati River is an excellent outward expression of this feature as it also follows the geological strike of this formation within these acid metavolcanics. The river tends to change its course where it traverses more competent members of the Penhalonga Mixed Formation. This observation is very important in understanding which member of the Penhalonga Mixed Formation produces the best aquifer. Metavolcanics are generally hard brittle rocks that are less susceptible to weathering, and when fractured would have a moderate to high permeability. The steep dip of this formation to the southwest implies that deep boreholes may penetrate the acid metavolcanics and hence increase the yields.

Groundwater also occurs in sandy channels of the Tati and Ntshhe rivers, this perennial base flow component may also be regarded as an aquifer. In the upstream of the confluence with the Ntshhe River, the Tati River has a width of 35 – 40 m with the average thickness of the sand bed being 1.7m. However, sand pockets of up to 3m deep exist and increase the saturated storage of this aquifer. Downstream of this confluence, larger volumes of water can be stored since the river becomes wider with widths ranging from 20 – 100m and deeper sand beds of more than two metres in parts. The direction of groundwater flow is essentially towards the axis of the river suggesting that the river was influent over most of its course. The situation would probably have been different if the water levels had been measured at the beginning of the rainy season or the end of the dry season. In this case, the direction of flow would have been away from the axis of the river suggesting effluent conditions over most of the river course.

To understand the mechanism in place for groundwater recharge, daily rainfall totals have also been included. Although this data has been acquired over a relatively short time, it may be seen that there is a very small time lag (of 2-3 days) between the rainfall event and the rise in water levels that reflect recharge. This is because saturation of the river sand has to take place before the underlying aquifers recharge. The general trend is a progressively declining water table as the water further infiltrates downwards to the underlying deep fractured aquifer and possibly also towards the river (as effluent springs).

In light of what has been described the following deductions were made:

- Recharges only occur during the rainy season (from November, just after the beginning of the rainy season, to April, just after the end of the rainy season);
- The quantity of recharge depends on the total rainfall and runoff in the catchment zone;
- The “reservoir like” sands of the river beds that take water from the base flow must release this water (by gravity) into the underlying aquifer which is then recharged;
- Currently available data for the Francistown area cannot be used to establish the regional quantities of recharge. Previous studies by Australian groundwater consultants (1974) have estimated groundwater storage to be in the order of 3.5 million m<sup>3</sup>, assuming a storage coefficient of 0.05 on an area of 11km<sup>2</sup>. This only covered the area surrounding the city of Francistown and did not cover the entire aquifer; and
- Capacity of the Shashe Dam is 85 million m<sup>3</sup>!

The presenter continued by highlighting a number of specific hazards to groundwater in the Francistown city area.

*Pit latrines:* Faecal waste is composed of degraded organic matter, which is easily measurable by its N content mostly in the form of ammonium and nitrate (NO<sub>3</sub>, NO<sub>2</sub> and NH<sub>4</sub>, depending on the redox status of the environment). The World Health standard for highest permissible concentration of nitrate in groundwater/drinking water is 50mg/l.

*Waste Disposal Sites:* The city of Francistown is the first recipient of a modern landfill with groundwater quality monitoring wells in place. As long as the water quality monitoring is carried out proficiently the new landfill site should not contribute to groundwater pollution. The old dumpsite was closed and fenced to keep away scavenging animals from accessing and digging the old waste. Nonetheless, the dumpsite may still pose a threat to groundwater pollution and should also be monitored through wells. In fact the volume of potentially polluting leachate that is produced is linked to the amount of water percolating through the refuse (e.g. rainwater that is not kept away by a fence). When leachate from a landfill/dumpsite mix with groundwater the pollution flows in the same direction of the flowing water. Due to hydrodynamic dispersion and retardation the concentration decreases with distance from the landfill/dumpsite. In arid regions such as Botswana, the vadoze zone receives little or no water unlike in humid regions. This means that solid waste disposal is not likely to result in extensive groundwater contamination. However, it remains a hazard to water resources.

*Mining:* When mines are abandoned and the pumps used to keep the mine dry are switched off, water starts rising through the shafts and galleries. Contact with metallic salts and other substances that were deposited on the walls of those shafts and galleries can then pollute the water, which eventually flows back into the regional groundwater body. Furthermore, active mining related activities are also a hazard to groundwater. For example, when oxygenated water enters geological formations or sediments containing pyrite the oxidation process of pyrite by atmospheric oxygen is initiated:  $\text{FeS}_2 + 7/2\text{H}_2\text{O} + \text{H}_2\text{O} \rightarrow \text{Fe}^{2+} + 2\text{SO}_4^{2-} + 4\text{H}^+$ . Although the pH of the system may remain unchanged (through sediment buffering), iron ( $\text{Fe}^{2+}$ ) and sulphate ( $\text{SO}_4^{2-}$ ) particles are released into the groundwater. Sulphide mine tailings are notorious for causing heavy metal concentrations in groundwater. Besides reactions with pyrite, these tailings contain a range of sulphide minerals (such as sphalerite ( $\text{ZnS}$ ), chalcopyrite ( $\text{CuFeS}_2$ ) and arsenopyrite ( $\text{FeAsS}$ )) that are also source of heavy metal groundwater contamination. Localized groundwater arsenic contaminations due to mining activities, for example, are now being reported from an increasing number of countries and many new cases are likely to be discovered.

*Industries:* Most of the existing industries in Francistown are manufacturing industries in the textile and construction sector and do not pose much danger to groundwater reserves. The major threat to groundwater is linked to the motor industry/repair workshops that are scattered throughout the city. Although waste oil can be recycled through oil disposal tanks that are managed by major oil companies the efficiency of these is not clear.

*Construction and Urban Pollution:* Runoffs from the city can generally be highly polluting as they may carry a mix of polluting substances such as toxic metals, pesticides, oils, hydrocarbons, sediments and oxygen depleting substances. In the case of Francistown, surface water discharges often flow very rapidly and do not receive any treatment before entering the surrounding rivers and streams. Especially during the rainy seasons the potentially polluted surface water is only slightly diluted and not enough to reduce the impact of pollutants, leading to periods of poor water quality and ecological damage.

Following the very detailed description of factors potentially influencing the groundwater quality of the Francistown area, the presenter informed participants about the specific project results. The sampling was done on 47 boreholes and concentrated on field-testing of EC, pH,  $\text{HCO}_3$ ,  $\text{DO}_2$ , and  $\text{CO}_2$ , and the chemical analysis was conducted by the Geological Survey laboratory in Lobatse and the BGR laboratory in Hanover, Germany. It was tested against major ions, traces and heavy metals.

In order to confirm and better define the factors that could influence the quality of groundwater in the Francistown area, a groundwater pollution hazard map was created. The map showed the position of the different potential sources of pollution, and was further used for discussion of the data associating them with specific points of pollution input. Furthermore maps were developed on the distribution of groundwater pH values (with no sample showing acid conditions) and different concentrations of dissolved oxygen. This was the first step in order to distinguish zones with different aeration status. The latter map showed well the differentiation of the aerobic (oxygenated) and anaerobic (probably reduced) water samples. It was

the starting point towards the definition of possible pollution of the groundwater zones and also the prediction of the redox state of the area.

For a more detailed analysis it was necessary to analyse main redox state indicating species:  $\text{SO}_4^{2-}$ ,  $\text{Fe}^{2+}$ ,  $\text{Mn}^{2+}$ ,  $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{NH}_4^+$ . Through the comparison of these different species, it became evident that areas with high concentrations of  $\text{Fe}^{2+}$  and  $\text{Mn}^{2+}$  had at the same time low concentrations of  $\text{NO}_3^-$  and  $\text{SO}_4^{2-}$ . In addition, oxidative zones rich in sulphates and nitrates overlapped with zones with high concentrations of dissolved oxygen, and zones with high  $\text{Fe}^{2+}$  and  $\text{Mn}^{2+}$  overlapped with zones of very low dissolved oxygen. The change of one zone to another was gradual. Important data for identifying buffering systems was the presence of the  $\text{CO}_2$  and  $\text{HCO}_3^-$ . The distribution of these two species did not show significant connection to the redox state of the water. It was rather connected to the Ca and Mg. The next factor considered was the distribution of the Cl-ion. Due to its significant mobility, this was meant to point to possible input sites of pollutants. Few of the high concentration zones could be distinguished.

The next step was to search for possible pollutants, and therefore maps of the heavy metals and trace compounds concentration distribution were made. All heavy metals that were detected in the investigated area showed that distributions were quite different and possibly connected to the mine waste sites. Concentration distribution of Cd, Ni, Zn, Cu and Pb were presented on further maps. Zn was not connected to the mine dumps only; very strong concentrations of reduced Zn were spread much wider. Finally, out of the analysis of the trace elements, maps of distributions were constructed, and the distribution of the different pollutants showed zonal character. Therefore, after the identification of reduced and oxidized conditions, and the analysis of the distribution of pollutants, the assignment of different pollution zones was done.

According to the nature and spreading of pollution, three major pollutant sources were distinguished and confirmed for the Francistown area:

1. Landfills
2. Mine deposits
3. Pit latrines

Groundwater in these areas was considered unsuitable for human consumption as it exceeded World Health Organisation standards for drinking water quality. A significant aquifer system has been harmed over the years and it will take more than a generation to recover from damage caused by a decade of waste disposal.

The discussion on both presentations on ground-water pollution in Botswana started with a question related to the chemical analysis of the various boreholes and whether there was any correlation of the chemical concentrations and the hypothesis of the pollution being from human/animal waste. Both presenters agreed that not much research has been done, but that looking at the population distribution it would be safe to assume that most of the pollution comes from human waste. They also mentioned that nitrate may also be generated from other sources but that especially in the eastern part of the country it mainly comes from pit latrines. Generally though the presenters thought that although most of the pollution is done on-site some of it can also be transported through underground streams and would then be mainly due to cattle post activities.

## **“CBNRM - Missing Link” piloting Ecological Sanitation in Botswana**

*By C. Wirbelauer, IUCN/DED Botswana*

The presenter started the session by introducing the background and institutional arrangements for the CBNRM-Missing Link project. She informed participants that the project is coordinated by IUCN Botswana and that the field component is carried out by Permaculture Trust of Botswana, a local NGO based in Serowe and Ghanzi. The duration of the project is from June 2001-December 2004 (Phase 1 and 2) and it is funded by GTZ and DED.

The project's main goal is: “to develop, test and demonstrate a holistic/integrated approach to environmental management, sanitation and waste management at household and community level in selected communities.” It took on board “living” natural resources (e.g. veld products, forestry, agriculture, gardening, animal husbandry etc.), “non - living” natural resources (e.g. water, waste), and “Ecological sanitation” (conservation/reuse).

The project has four main areas of activity:

1. Assess past and present Natural Resource Management and environmental management practices and integrate them with Indigenous Knowledge Systems;
2. Pilot and develop environmental management approaches at household level;
3. Pilot and develop environmental management approaches at community level (CEAP-Community Environmental Action Plan); and
4. Document project approach, methodology and experiences, especially lessons learnt.

It is also divided in three phases:

Phase 1 (2001-2002) looked at mobilisation aspects and identification of suitable communities/households in Botswana (20 volunteering households in Paje, East and West Hanahai).

Phase 2 (2002-2004) is the main implementation and pilot period:

- a) Implementation of activities at household level (water, waste, sanitation, gardening and other NRM); and
- b) Extension of activities to a community level (CEAP or increase in number of households involved).

And finally phase 3 (2005-2006) concentrating on advocating the approach and sharing knowledge/lessons learnt on the EcoSan approach in Botswana.

The presenter then highlighted that one of the key elements of the CBNRM-Missing Link project (which was made clear to participating communities from the very start) was that it depends upon volunteer and self-sufficient participation. In fact, in an attempt to increase ownership, the project combined each implemented activity on the basis of labour and cash contributions, from the project and from the households, on an approximate 50:50 basis.

Project implementation started as planned and the villages were identified in both Central and Ghanzi District, respectively Paje and East and West Hanahai.

Although initially the aspect of Ecological Sanitation was new to Botswana and difficult to understand it very quickly received a place in the project, especially due to its potential contribution towards multiple benefits.

**Social/Economic benefit:** It improves the health and sanitation aspects within households and communities.

**Ecological benefit:** it avoids groundwater pollution and reduces the use of water (no flush in the toilets).

**Combination of benefits:** the sanitised by-products have a very competitive fertilization value and are re-usable for gardening and agriculture.

The pilot project developed progressively and went through different steps so to allow all project stakeholders to understand the process and own it. Some aspects turned out to be extremely important, such as the need to workshop and train in a continued and adaptive manner. Communities and households were from the very start made aware of all the projects components and informed about different options of EcoSan systems (urine diversion, Arborloos and composting toilets). Volunteering households had the space to choose the system they wanted (if they at all wanted to implement the EcoSan concept) and the structure they preferred for their homes. All chose the urine diverting system (as pictures above), some preferring to divert the urine into a soak-away (later agreeing that the collection would be more beneficial) others immediately collecting the urine in containers.



Urine diverting pedestal alone (left) and in the toilet with bucket of ash (right)

It was also clear from the start that just the choice of a system was not enough. Households had to understand and own the project, be willing/ready to invest in Eco-San, be ready to use the system as a toilet, and also be ready to use the by-products. Finally, when by-products are used, households also needed to have space (a garden/agriculture), water, and have protection against animals etc. Many aspects needed continuous support and exchange of information with participants.

Since mid-2001 and looking at all the different aspects of the CBNRM-Missing Link project (EcoSan, water, waste, gardening), a number of things have been achieved (see illustrations in Annex 7).

In August 2003, 20 EcoSan ground structures had been finalized (for the initial 20 participating households), 8 toilets were fully functional, and the by-products from 2 toilets were being sanitised (buckets with faecal matter emptied and urine containers set aside), and urine-diverting pedestals were being produced within the communities.

Most of the households had set up vegetable gardens, and the protection of these gardens had improved. Vegetables had already been sold in 2002 and 2003, fruit and shade trees were growing and the by-products from the first toilets had been used to grow paw-paws.

The availability of water was still a problem due to recurrent droughts and isolation. Households could easily understand the importance of conserving/harvesting water, and grey water was being used but mainly on trees. The concept of re-using waste (organic and non organic) was newer and more difficult to understand, nonetheless the first sanitised by-products from the toilets, formerly called “waste”, had been used to improve compost.

During implementation some other important issues had also been faced, especially related to financial problems at household level that gave little chance for households to actively participate and contribute to project implementation. Also the drought relief programme encouraged households to temporarily leave the villages for immediate cash income, frustrating the management of the EcoSan concept.

To date, some important lessons have been learned in particular that implementing the Ecological Sanitation concept affects people’s daily life, attitudes and mindset, and that there is a need for investment of time and resources in:

- Respecting individual needs;
- Training and learning-by-seeing;
- Information sharing;
- Adapting processes; and
- Technical support.

The project has now settled in the three communities and activities are being expanded. The number of participants is increasing and some activities might start in peri-urban areas (Serowe and Ghanzi). Generally the concept of Ecological Sanitation is being promoted throughout Botswana.

The presenter closed the session with a citation from one community member from Paje (2003) that summarises the Ecological Sanitation concept very well: “Conservation is the key concept of the “Missing Link”. Through the “Missing Link” we have learnt that there is nothing like waste - everything can be recycled. We are also taught how to sustain ourselves with things that we could be throwing away.”

A few questions were raised, particularly related to health measures adopted within the project, the maturity period of the compost before it can be used, the general acceptance by the villagers of the use of human waste, and the type of vegetables that should be grown.

The presenter acknowledged that a lot of time needs to be invested in talking to people, and that initially it was difficult for people to accept certain aspects of the project. It took about a year to identify 20 households that were willing to implement the project, pilot the EcoSan concept and invest time and money in it. Education played a crucial role in creating acceptance, and after initial “fears” the rate of acceptance was very good. Regarding health safety measures and sanitisation of the by-products from the toilets, the project started by looking at research and measurement standards from South Africa and Zimbabwe whilst waiting to generate specific measurements on EcoSan here. Towards the end of Phase 2 and Phase 3 the CBNRM-Missing Link is planning to develop a manual with guidelines for the implementation of Ecological Sanitation (including all the above aspects) in Botswana.

## **Shoshong water supply and sewerage project**

*By M. Buxton-Tetteh, CPG Botswana*

The presenter started by giving participants a brief overview of the project. The Shoshong water supply and sewerage project was initiated by the Department of Water Affairs in collaboration with CGC/CCEC JV. It started in January 2002 in Shoshong, a village approximately 40 km from Mahalapye (Central District, Eastern Botswana). The project has a duration of 24 months and a contract budget of P58.216.631,61.

There are three primary project components:

1. Water supply: involves upgrading the existing supply from Mahalapye and improving the distribution;
2. Sewerage: concentrates on reticulation and treatment aspects; and
3. Solid waste: looks at developing a feasibility study for the collection and disposal of solid waste within the village.

The project started by using the gravity system only and plans were designed for the entire village. Tests conducted indicated that for the system to maintain the minimum required velocity for cleansing of the pipes, the pipes had in some points to be buried at about 100 meters depth.

Further studies showed the following primary factors characterising the area of intervention:

- The expected peak flows were about 0.05 – 15 l/s;
- The length of tertiary and secondary sewer lines was 300 – 1200m;
- The spatial pattern of residential development in the village was sporadic; and
- Poor soil conditions and hard material - with a depth of up to 2.8m - were found in several areas.

During the development and implementation of the project the consultants were thus very soon motivated to compare two alternative sewage reticulation systems: the gravity system and the vacuum system.

Generally, with conventional gravity systems, wastewater flows via gravity pipe from the houses to the collection chamber/sump. When a predetermined volume is collected, an interface valve opens and wastewater is evacuated into the vacuum pipe by atmospheric pressure. To effectively run the system several lift stations are required and excavation can be up to a depth of 5 – 8m. The minimum size of pipes required is 160mm and several manholes have to be built in the area. Finally in certain areas intermediate flush tanks might have to be installed to flush the system periodically.

The vacuum system operates using vacuum pumps. The vacuum pumps generate the necessary pressure in the vacuum tank. The air, which enters the system via collection chambers located underground (usually in convenient locations nearby the houses), is then evacuated from the system by these pumps. Two Vacuum stations that act as pumping stations are required, and excavations are usually minimal with a maximum depth of 1.5m. The maximum size of pipes required is 200mm and a collection chamber needs to be installed.



Example of excavation depths for both gravity (left) and vacuum systems (right) in Shoshong.

A simple comparison of the two systems as per experience in Shoshong shows that:

1. Two central vacuum stations would replace the 10 lifting stations required in the area;
2. Smaller diameter of PVC pipes is needed;
3. The trenches for the vacuum pipes are only 1.2 m deep and narrow;
4. More local employment is created;
5. Maintenance of two vacuum stations is less than that for 10 pumping stations;
6. No additional flush tanks are needed, thus no precious fresh water is wasted for just flushing gravity pipelines frequently; and
7. No dry sewers will appear.



Example of manhole for gravity systems (left) and inspection pipe for vacuum systems (right) in Shoshong

The presenter concluded by mentioning that it is anticipated that the vacuum system has economical, ecological and some technical advantages over the gravity system. In a country that has severe water problems, water conservation is very vital and it is important to use a system that requires less water. Finally the use of local manufacturers for collection chambers could reduce the maintenance cost and increase employment.

During discussions the presenter mentioned that the vacuum system originates from the Netherlands and that it has been in operation for about one hundred years. The Shoshong project is the first African pilot and the warranty on equipment and quality has thus been extended to five years. Implementation will have to be closely monitored and results appropriately interpreted.

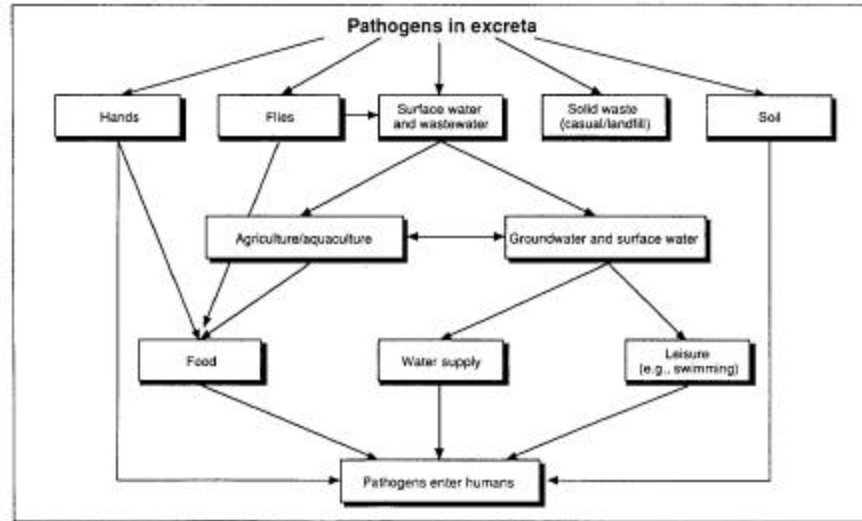
## **Health and safety aspects of EcoSan and excreta handling**

*By A. Austin, CSIR South Africa*

Sanitation, health and environment - how are these three areas linked? There are three fundamental issues to always keep in mind when dealing with EcoSan: Sanitation is not just a matter of building toilets; it goes hand in hand with an effective health care programme; and technology by itself cannot break the cycle of disease transmission, if hygiene awareness in a community is at a low level a safe disposal of human excreta alone will not necessarily mean the creation of a healthy environment.

The presenter then informed participants about water and sanitation related diseases, which are essentially caused by pathogenic (disease causing) organisms called pathogens. There are four groups of pathogens: Bacteria (e.g. salmonella, cholera, shigella), Viruses (e.g. polio, rotavirus), Protozoa (e.g. amoeba, cysts) and Helminths (e.g. worms, bilharzia). These are mainly found in faeces whereas urine is virtually sterile (see details in Annex 8: "Occurrence of some pathogens in urine, faeces and sullage").

Furthermore, pathogen transmission routes mostly involve food and hands. Generally poor domestic and personal hygiene are the major cause of disease transmission but there are also health hazards associated with excreta reuse: handling and the risk of contaminated food infecting humans and animals.

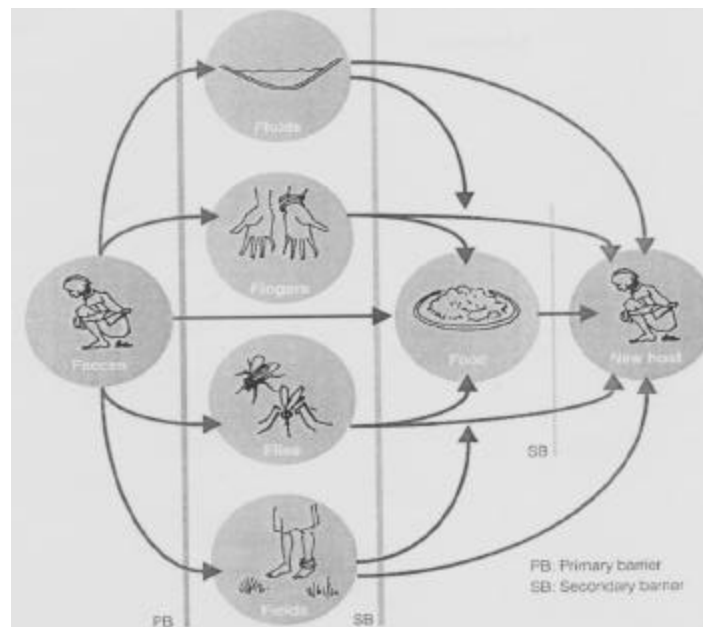


Infection Routes of Pathogens

The infective dose of pathogens required for creating disease in a human host varies:

- Helminths, protozoa and viruses: a low dose is sufficient (< 100)
- Bacteria: a medium to high dose is necessary (>1 million)

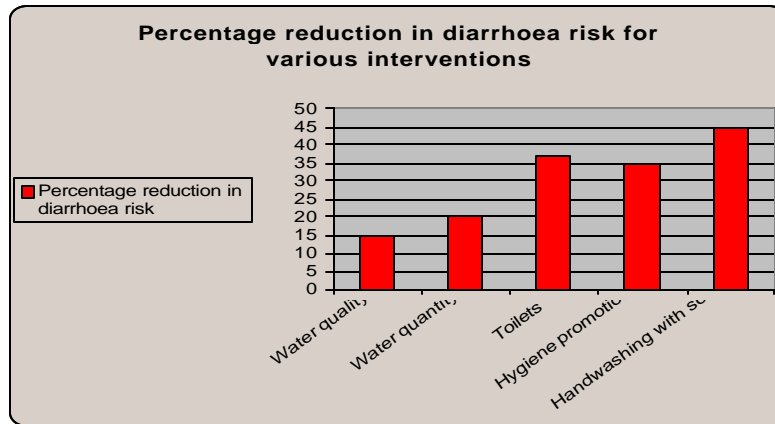
Generally 1g. of faeces can already contain millions of organisms, yet at the same time little but appropriate hygiene can avoid any transmission of diseases.



Pathogens Transmission Barriers

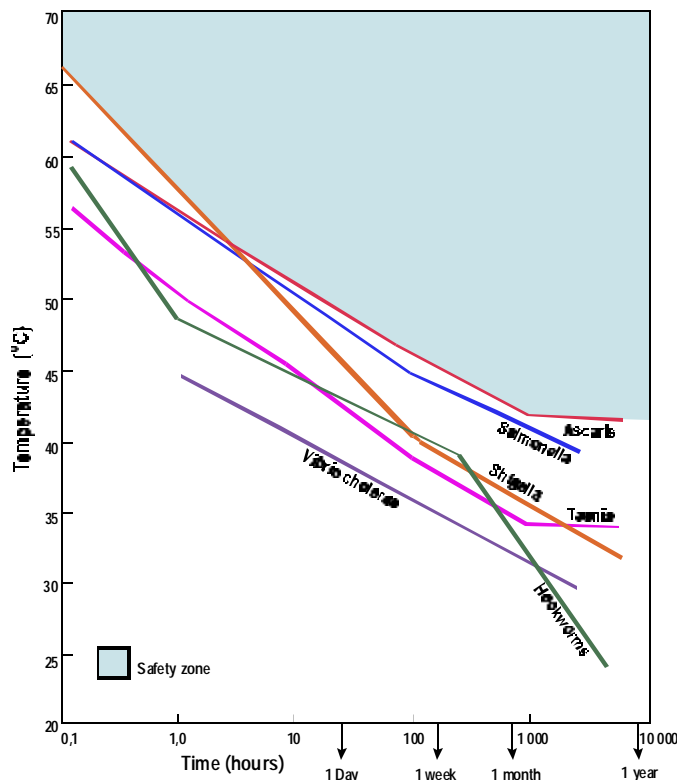
Good sanitation prevents excreta from entering the domestic environment and getting into water, and good hygiene prevents the transmission of microbes from the environment into the human body via the hands.

Adequate excreta disposal and safe hygiene practices together effectively prevent almost all gastro-intestinal infection.



Figures show that by combining interventions on water quality, water quantity, existence of toilets, hygiene promotion and hand washing the risk of diarrhoea can be reduced (above). One of the most important aspects to be highlighted is the need for rigorous and regular personal hygiene and hand washing with soap after each visit to the toilet and before handling any food.

Besides avoiding disease transmission through personal hygiene, the risk of transmission remains for as long as pathogens are not destroyed. The death/survival of pathogens is an important factor and pathogens should be destroyed or rendered harmless. Certain environmental conditions are favourable for the survival of pathogens, such as cool temperature, moisture and a neutral pH.



On the other hand, some experimental results in South Africa show that:

- Wood ash and its high pH assist in pathogen die-off;
- Heat and UV radiation assist in pathogen die-off;
- Many organisms are still active after 12 months; and
- Managed heaps are usually better than closed containers. Heap aeration reduces moisture, increases temperature, and assists dehydration, therefore pathogens die-off.

Generally time and temperature have shown to be two of the most important aspects in the destruction of pathogens (see figure on the left)

In conclusion the presenter highlighted that the appropriate treatment of faeces has an important impact on people's health. People need to be convinced that additional time and effort are warranted and an educational strategy must include awareness of health and hygiene issues.

One question was then raised on whether people in South Africa had opted for the closed container or for the heap. The presenter mentioned that it varies from culture to culture and that some cultures have a phobia towards handling excreta. Workshops had to be carried out with the communities and they had to be informed about the advantages and disadvantages of the various systems. Some opted for the closed container, others for the heap. In any case, he said, Ecological Sanitation is a learning process and projects should reasonably adapt to communities' needs.

### **Experience in piloting composting toilets in Botswana**

*By G. T. M. Moanakwa, RIIC*

Since 1996, RIIC, through the Civil Engineering Section, has been involved with research on sanitation technologies as a way of "positively contributing towards environmental protection with the aim of providing appropriate sanitation technologies at affordable costs to households countrywide". This was triggered when RIIC was commissioned (in 1996) by the then Ministry of Local Government, Lands and Housing (MLGLH) to undertake research and development of low cost Ventilated Improved Pit Latrines. The project was funded by UNICEF and covered three sub-districts: Chobe (Pandamatenge), Kweneng West (Diphuduhudu) and Bobirwa (Gobojango).

Three different superstructures for the VIP latrines were developed: one spiral shaped and without a door, one prefabricated (steel) and another square shaped with a door. They all had circular substructures not mortared at the joints so to allow effluents to seep into the surrounding ground, thus keeping the solids dry but also contributing significantly to groundwater pollution. Each of these three structures was constructed in each village (none have been constructed since).

In 1997 the RIIC Extension Team conducted their biannual National Needs Assessment Survey (NNAS) and one of the recommendations in the report was to: "carry out research into more appropriate technologies for human waste disposal, especially for areas with a high groundwater table". To address the above issue the ecological sanitation concept of 'sanitising-and-recycling' human waste was considered: human excreta are first rendered safe (processed) on site, and if necessary further processed off-site, the nutrients contained therein can then be recycled in agriculture. This is the process of composting human faeces in composting toilets.

The background to using composting toilets was that, as many cultures have already been doing for many years, sanitised faecal matter can be used as fertilizer. The Chinese, for example, have long been using human excreta as fertilizer. In 1952, they were using about 70% of all produced human excreta and about 90% in 1956 (Winblad and Kilama, 1986). Other countries that have been involved in

composting of human excreta include Vietnam, Guatemala, India, Mexico, Sweden and Algeria.

Composting is a biological process and under controlled conditions soil based microorganisms decompose the solids. The process is enhanced by a variety of organisms ranging from viruses, bacteria and fungi to earthworms and insects. Other influencing factors are temperature, moisture content and sufficient oxygen (aerobic).

The humus produced can then be used as a soil conditioner, free from any pathogens.

Before a composting toilet can be used for the first time organic material should be filled into the receptacle so to start off the composting process: grass, straw, husks, sawdust, weeds, leaves, yard sweepings or kitchen peelings. These absorb the liquids, provide carbon for decomposition, increase the variety of micro-organisms and prevent the pile from being too compact. During usage of the toilet the following should be fulfilled:

- The above materials should be regularly added to the heap inside the receptacle so that the whole process does not stop or slow down;
- Care should be taken that the toilet is not overfilled with leaves and others as it could affect the performance and lifetime of the toilet; and
- The addition of ashes to the faecal heap in the receptacle helps keeping odours out, absorbs moisture and makes the faecal matter less attractive to flies.

The objective of RIICs ecological programme was to do some research on composting toilets and identify/develop technologies that:

- Protect the environment;
- Are user friendly;
- Are easy to construct or install; and
- Are affordable to households.

The following systems were piloted and tested.

#### *Earth Mill Organic Toilet*

This dry compost toilet separates urine and faeces and uses worms for the decomposition of the faeces. It was acquired in 1998 from RSA and tested at one of the RIIC staff houses. It has a solids receptacle while the urine is directed to a small wetland or soak away drain. A separating flap allows the urine to flow past while the solids remain on top of the flap and after defecating a lever just behind the pedestal is pulled upwards to deposit the solids into the receptacle. The faeces compost in the receptacle and when filled up, the composted matter has to be taken out of the receptacle.

The results were not satisfactory as the faeces got stuck on the separating flap therefore could not be deposited into the receptacle as required. Another modified model was bought from the same supplier and was installed for communal use at Dikabeya village near Palapye. The same problem was encountered.

### *Eco Privy Toilet*

The concept was derived from the Earth Mill Organic toilet where the urine and faeces are separated at point of source. The toilet is constructed out of cement/sand blocks and the receptacle is plastered inside so to make it totally watertight and avoid seepages into the surrounding ground. The idea was that the urine would deposit into a small chamber that directs it to a small soak away or wetland while the solids are deposited into the receptacle where the composting of the faeces is enhanced by earthworms. The earthworms aerate the faeces by their movement and by creating vents. They also feed on the faeces, thus reducing its volume. The pile of faeces under the pedestal has to be moved to the processing chamber from time to time and once composted, the matter has to be removed from the chamber.

One unit was constructed at the RIIC staff houses in 1999 and performed very well. Five more units were constructed in Gweta village in 2001, these failed to perform as the worms did not survive in the receptacle and it was very smelly. The decomposition process could not be achieved as required.

Two characteristics of this toilet are that even men have to sit when urinating and that its convenient design allows it to fill up after 2 years of normal usage by a family of eight. The construction costs are estimated at P2,500.

### *RIIC Eco Toilet*

The concept was adopted from El Salvador in South America where solar heated toilets have been used and have performed well. The design phase for this toilet has just been completed and construction will be started shortly. It is constructed the same way as the Eco Privy toilet with the receptacle also totally sealed to avoid any seepage into the surrounding ground. This toilet has urine diversion (solid and liquid waste do not mix) and a separate urinal is provided for men. A solar heater will be placed on the side of the receptacle to help dehydrate and treat the waste faster. The elimination of pathogens, bacteria and viruses can be speeded with heat treatment through the solar heater. A mild steel sheet that is painted black on the outside to absorb as much heat as possible and silver on the inside to reflect back into the receptacle any heat that could escape will further enhance the dehydration process. The solar heater will also act as manhole for the access into the receptacle. The single processing chamber will be receiving human excreta and toilet paper (or cleansing material). Urine is to be piped into a small soak pit near the toilet. Aquatic plants can be grown in the soak pit to combat odours. A vent pipe is also to be installed to allow for aeration inside the receptacle. Every 2 weeks the pile of excreta that will have accumulated below the seat will be shifted to the solar heating / composting side of the receptacle with a rake. Once every six months the dry and odour-free waste pile at the end of the vault will be shovelled into bags and dumped, buried or used in the garden as fertilizer (long term aim).

Several problems were encountered with the two already piloted systems:

#### Earth mill

1. Faeces stuck on the separating flap creating visual nuisance and attracting flies as well as other insects.

## Eco Privy

1. Users sometimes dumped water into the receptacle thus creating a very wet environment. It is not ideal for the survival of the earthworms and composting of faeces.
2. Men did not like the idea of sitting on the pedestal to urinate so they just urinated into the receptacle.
3. Users also had a problem with moving the solids from under the pedestal to the composting zone.

These problems were addressed and except for the death of the earthworms, the users complied. The death of the earthworms was never investigated so no solution to it was found.

Generally the main problem with composting toilets is culture. People are used to the drop and store (pit latrines) or flush and discharge (water systems) approaches and getting them to work on their faecal waste, which they normally do not get into contact with, is a major issue. The experience with the toilets installed in Gweta village proved that investing time and developing activities step-by-step can give positive results.

From the work that RIIC has been doing and the difficulties of the programme, interesting conclusions can be drawn. In fact, environmental protection has been achieved as there haven't been any seepages into the surrounding ground thus groundwater aquifers were not contaminated. We have also learnt that systems need to be user-friendly: men having to sit when urinating and handling of solids might discourage initially but if well informed users will learn, understand and accept the concept. A certain advantage of the system has been the ease of construction as well as affordability for a wide-range of households. The most important cost reducing factor is that the substructure are made out of simple materials such as plastic (Earth mill) or cement/sand bricks (Eco Privy and Eco Toilet) and that the superstructure can be made out of any locally available material reducing the costs of import.

A recommendation to all stakeholders was made by the presenter at the end of the session encouraging them to put more emphasis on undertaking research on composting toilets to come up with the most appropriate composting toilet that can serve the country to the best of its needs. He also highlighted the importance and need for education and awareness raising on the advantages and disadvantages of composting toilets.

## **Examples of water borne closed loop sanitation systems in Maseru**

*By A. Leuta, DED Lesotho*

The presenter started by explaining that the broader reasons for the introduction of closed loop sanitation systems in Maseru resulted from several problems, in particular: degraded landscapes, very little food production, unemployment and frequent droughts.

Narrowing down the problems to specifically sanitation, she then mentioned that some of the major concerns were linked to poorly constructed septic tanks, poorly

centralized sewer systems, insufficient capacity for emptying the cesspools, very limited capacity of trucks for emptying the septic tanks and high maintenance costs. These issues were relevant in Maseru whereas in rural areas of Lesotho there is no sanitation at all.

Regarding the closed-loop approach and the active utilisation of nutrients, participants were informed that in Lesotho, although some had noticed that pumpkins grow nicely around septic tanks and people generally plant fruit trees in abandoned pit latrines, there is very little or no active utilization of nutrients.

On the basis of the above, the objective of the project was to provide an appropriate technology for closed loop wastewater utilization and energy production with “self-propelling dissemination mechanisms”.



In August 2002 the first digester for wastewater treatment in Lesotho was constructed on Mr. Kellner's premises in Maseru (see picture).

Activities that immediately followed the installation of the digester concentrated on creating a specific demand within the area of Maseru and organizing demonstration visits to raise awareness amongst the people.

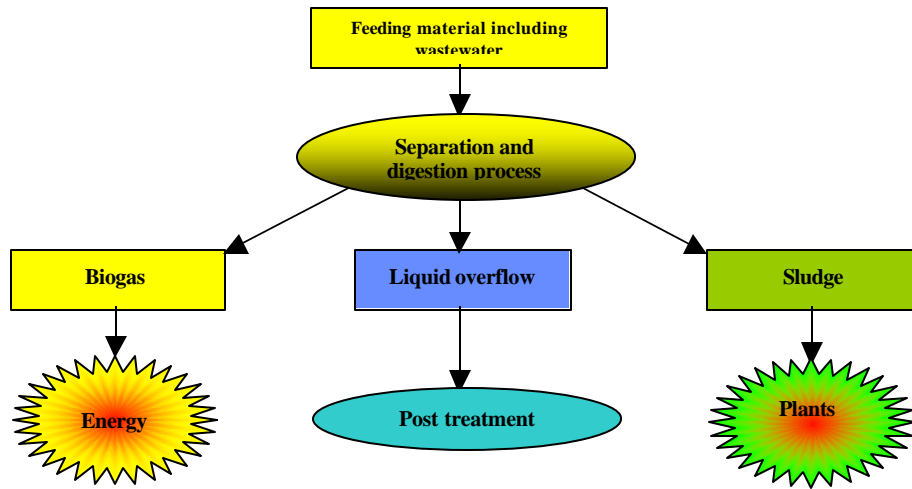
Training was also an important component and seven trainees from different disciplines received on-the-job training.

Finally further digesters were constructed on sites where the demand seemed sincere and effective.

Since then, several components of Ecological Sanitation were implemented:

- Biodigester: organic waste, kitchen waste and excreta are put in the digester as settlers;
- Root treatment system (horizontally operated): the system is attached “down-stream” of the biodigester (sedimenter) and filters the water, which can then be scooped out for irrigation;
- Fixed film aerobic and anaerobic units (experimental): three-dimensional plastic bottles are either shredded or cut and placed in the wastewater stream so to allow for the settling of bacteria. Plastic can be used in both aerobic or anaerobic systems;
- Mixed vegetable gardens are set up and french drains irrigate hedges etc.

The biodigester, as per diagram on opposite page, is made more stable through the use of chickenwire (preventing any breaks in the structure especially the dome), the application of hot wax inside the dome (allowing for a gastight sealing), and closing the dome with hocks.



Flowchart on the operation of a biodigester (above)

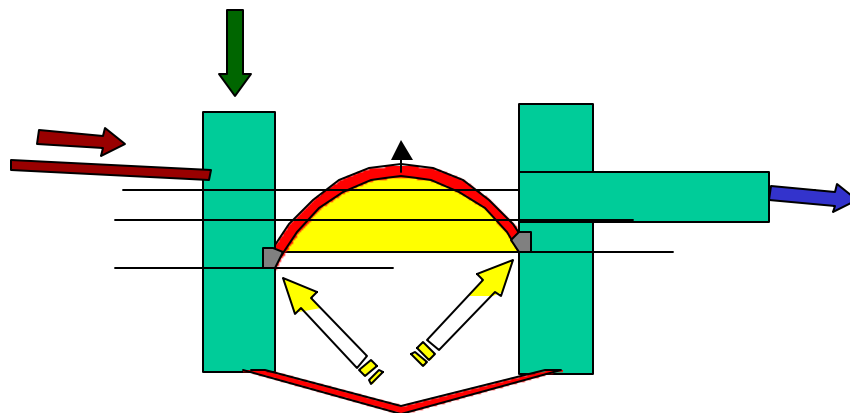


Diagram of a biodigester for wastewater treatment (above)

The presenter concluded by mentioning some of the main achievements of the project:

- Five persons earn their living by building biodigesters on a non-subsidized basis (as far as material, labour and transport are concerned);
- One person assists with administrative issues;
- 10 digesters have been completed within seven months and four digesters are under construction; and
- 13 customers are on a waiting list.

The presentation raised a lot of interest amongst participants and one of the main questions raised during discussions concerned the energy output of the biogas production. The presenter answered that “unfortunately” human faeces can only cover 15% of household cooking needs.

## **Water saving devices and low flush technology**

*By J. Selke, Orbit Pumps*

The presenter introduced participants to some general concerns on the importance of water in Botswana and the need for conservation. In Vision 2016, water conservation is emphasized and conservation measures are being addressed in detail in NDP 9.

The presentation continued with the specific example of water usage at the Shoshong Secondary School. The hostel at the Shoshong Senior Secondary School accommodates about 1300 students and each student staying in the hostel from Monday to Friday needs approximately 130 litres of water per day. On weekends, when laundry is done, each student uses about 350 litres. Assuming that each student uses the toilet five times a day with 13 litre flushes for each time, the use and waste of water and the school's water consumption reach sky-rocking figures. Furthermore the automatic flushing system toilets are the biggest "consumers" of water and work 24 hours a day; the showers, with cold and hot water, are also high consumers.

In the above case but also in other cases simple water savings could be implemented through the reuse of grey water from the washbasins, showers and laundry. The grey water could be used (after treatment) for flushing the toilets, gardening, cleaning etc. and the treatment could be done by using reed-beds on rotating disk systems. A further very simple water saving option could be that of using waterless urinals.

Some of the typical water saving applications that could be used include:

*Time Metering Taps:* These are self-closing taps with a button or a lever. The appliances are operated by applying pressure on the lever or the button for running water, and once the lever or button is released the water cuts off automatically. These appliances are perfect for conserving water in most public places such as commercial, industrial, institutional buildings and schools.

*The EcoSmellstop Fitting System* This is a non-return valve system that can fitted to almost any urinal on the market. It is a waterless and odorless urinal system that requires no flushing.

*Urine Separating Toilets:* Ecological sanitation concepts do contribute to water saving and help in the reduction of toilet flush water consumption (treated drinking water being much too valuable to be used for flushing). The separation of undiluted urine has two advantages: the urine is separated without water, thus no flushing is necessary, and, when collected in a container, it can be used as a fertilizer in agriculture. Faeces can also be collected without any addition of water and when processed and combined with other organic waste can be used as a soil conditioner. Nonetheless, even dry EcoSan systems should have comfort, be easy to handle and have a modern design.

## Community-based sanitation

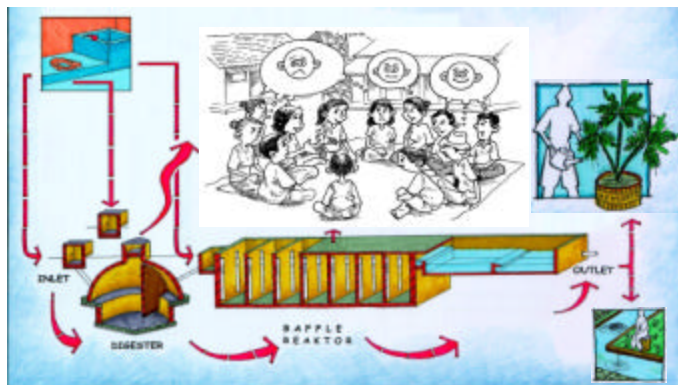
By C. Kellner, DED/FEDINA-BORDA

The presenter started by illustrating BORDA's mission and area of activities. BORDA's mission is to "ensure access to vital resources and fostering an intact environment" thus to contribute towards poverty alleviation and sustainable development. International activities and cooperation are mainly undertaken in Africa (Guinea and Namibia) and Asia (India, Peoples Republic of China, Indonesia and Vietnam). Projects are financed by external sources, such as the Federal Ministry for Economic Co-operation and Development - Germany (BMZ), the Commission of the European Union (CEU), the Free Hanseatic City of Bremen (LafEz), the WSP SEA (World Bank) and international project partners or private donors.

The concept of community based sanitation aims at providing public sanitation facilities and ensuring access to basic sanitation in densely populated poor urban communities.

Java and Bali, for example, are among the most densely populated areas in the world. About 125 million people discharge around 10 million m<sup>3</sup> wastewater per day into the environment. One of the major consequences of these highly polluted environments is that well and tap water in most Indonesian cities do not fit human consumption standards due to high contamination in *Escherischia coli*. Furthermore, centralized sewerage systems serve only 10-15 % of the population in six Indonesian cities and most of the on-site sewerage systems do not function efficiently. Finally, livelihoods and natural resources, especially in poor urban settlements, are increasingly threatened. This dramatic situation encouraged several countries and development organisation (including BORDA) into developing community-based sanitation schemes.

To start with, BORDA identified one project site in a workers' settlement in Tangerang, Indonesia. The site was characterised by a very densely populated area with inadequate sanitation facilities (average: 1 toilet per 100 inhabitants) being a major hazard to public health. Furthermore, the area was close to factories and industries, and the construction of any new infrastructure would be done in swamp/land fill areas.



The project adopted a three-step approach: information-analysis-implementation. A demand-responsive approach in connection with social-marketing was undertaken, whereby the communities participated in planning. This approach allowed target groups to choose the most adequate solution for themselves (informed choice). Finally

communities were asked to pay for these sanitation services, the project limiting its input to providing the communities with the sanitation facilities for 500 people (including toilets, bathrooms, community water points and washing facilities).

The facilities set up in Tangerang (picture previous page) also included a wastewater treatment plant (dewats-digester) located underneath the sanitation facility. The wastewater treatment is based on flow-separation of “grey” and “black” water and the structure consists of a bio-digester (settler) and a baffled anaerobic reactor.

Anaerobic treatment processes work without external energy inputs and have several other advantages:

- Low maintenance costs, no high - tech equipment nor movable parts required;
- Spare-parts are locally available;
- Wastewater pollution is reduced by up to 90% (BOD/COD), thus reducing surface water pollution caused by untreated wastewater emission; and
- Groundwater is not polluted, as the wastewater treatment plant is waterproof and airtight.

Furthermore the use of this technology allows for treated wastewater to be partly reused for low-scale gardening or fishponds (according to customer demand). Biogas is also captured and can be used for cooking in neighbouring houses, and the sludge is collected and treated by the municipality and reused for soil improvement in agriculture.

Finally, user fees between 0.05 and 0.1 US\$ cover costs of operation and maintenance and contribute to the development of local community self-help groups. The staff stays on-site and is responsible for cleanliness of the facilities and BEST Sanitation (NGO) experts ensure service and maintenance of the system components.

## **Design of EcoSan systems and the Urine Diversion component**

*By A. Austin, CSIR South Africa*

Five main criteria guide good sanitation, and unless these are followed there will be no proper sanitation system. These are:

- Reliability;
- Acceptability;
- Appropriateness;
- Affordability; and
- Sustainability.

The requirements for appropriate and sustainable sanitation systems are also manifold, and sanitation systems should:

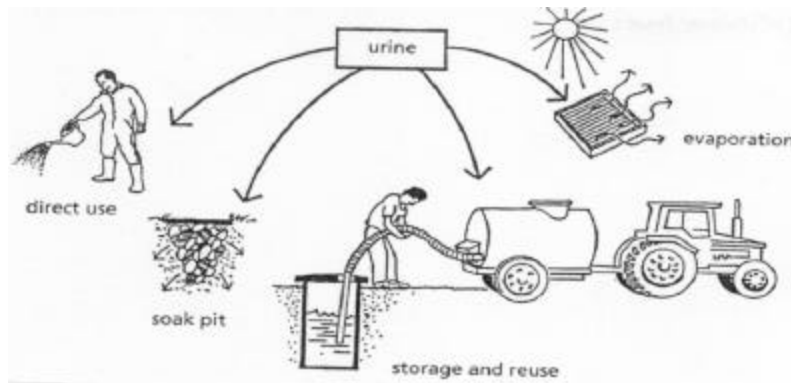
- Be compatible with the social, cultural and economic conditions of the target area/group;
- Be comprehensible to the users (need for creating awareness and helping the users to understand what they are using);
- Exploit locally available resources (both material and human resources); and
- Be simple and easy to operate and maintain (no moving parts).

Urine diversion toilets allow for dry source separation of urine and faeces, the first being diverted into a container whilst the second drops into a different receptacle or sealed floor.

Different models (details on designs and materials used may be seen in Annex 9) of urine-diverting pedestals are available on the market: plastic (SA), porcelain (Sweden) and mortar (Mexico, SA). The superstructures can vary in shape and material according to the user's needs. The material used should ideally be locally available and can range from bricks, to wood, thatch, wattle and daub, mud blocks, pre-cast concrete etc.

Besides the pedestals and the superstructures, the design and material used for the vault are also very important. For purposes of user-friendly maintenance of both the vault and the faeces heap, the lids of the vault should be light and easy to fit/remove. Options on the design of the vault include double-vault toilets, which are similar to a VIDP and allow the exchange of vault between the full and the empty one. All EcoSan toilets and sanitation facilities generally should have a hand-washing facility and soap, which should be used after each visit to the toilet.

Once the Facility is fully functional and the faeces are being treated/sanitised in the vault, the urine also needs to be disposed of. In South Africa most people do not



reuse the urine and prefer to divert it into a soak away. However, the diagram (left) shows some alternative usage for urine. Ideally it is collected in tightly closed containers where it sanitises for about 2 weeks before being directly used in the fields or gardens. But it can also be collected in

bigger tanks that are emptied by municipal services; it can also be left to evaporation; or, the less advisable and more polluting option, it can be diverted into a soak pit.

## **Day 2, September 3<sup>rd</sup> 2003**

*By C. Wirbelauer, IUCN*

The second day, started with a brief summary reminding participants about the lessons learnt and sharing highlights from the presentations given during the previous day. The presenter mentioned the worldwide water crisis and the need for improved health, sanitation and conservation of resources. She also mentioned some of the shortcomings of conventional “flush and discharge” and “drop and store” sanitation that emphasised not only high-tech developments in the sanitation sector but also the reinforcement and need for expansion of the concept of Ecological Sanitation.

She further continued by reminding participants about the core ecological sanitation technologies and concepts, starting from the worldwide view and narrowing it down to Southern Africa, as per presentations. Interesting figures on the specific sanitation status in Botswana and settlement patterns in different areas of the country were highlighted as well as specific recommendations on the need for better integration and cooperation between all stakeholders. This was emphasised through cautionary data on the effects of urban expansion on groundwater pollution in some areas of Botswana.

The presenter also mentioned the case studies of experiences in piloting Eco-San in Botswana, including non-waterborne and waterborne systems such as urine diverting, composting and Vacuum/Gravity sewerage systems. Community-based sanitation projects in Indonesia and Biogas options for Lesotho were presented as interesting case-studies on Eco-San options in use and technologies available around the globe.

All the case-studies concentrated on presenting several options already available towards improved sanitation and water conservation, thus trying to raise awareness on the importance of Ecological Sanitation amongst participants.

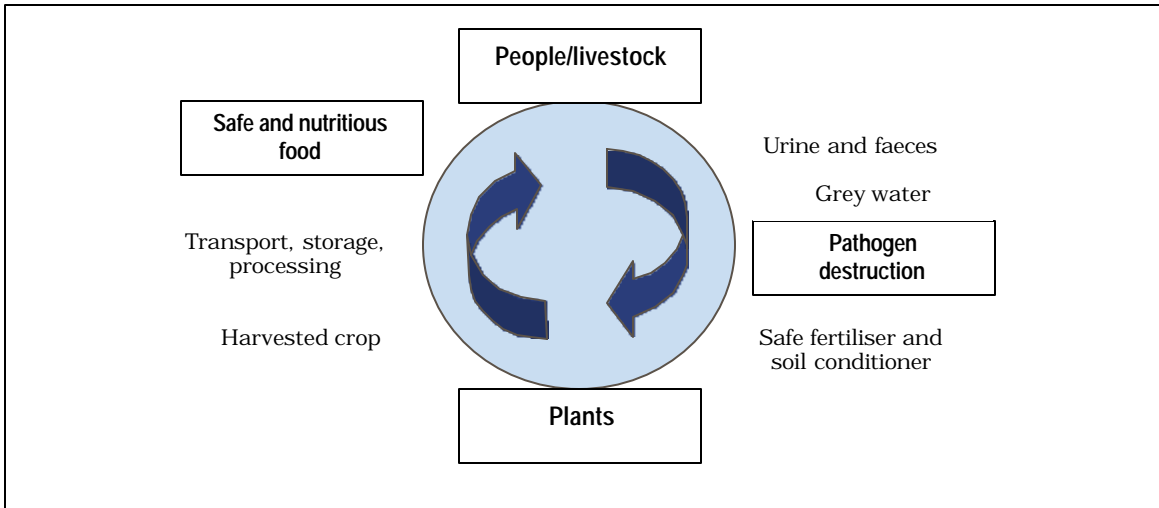
Finally participants were reminded of some design components of urine diversion toilets in Southern Africa, water saving devices and detailed health aspects to be kept in mind when implementing sanitation projects.

The second day continued with a series of presentations on the acceptance of the Eco-San concept and the application of by-products for agricultural purposes.

## Awareness, active participation and acceptance of Ecological Sanitation

By E-M. Huba-Mang, GTZ-EcoSan/FRUXOTIC

The presenter started with illustrating the meaning of “closing-the-loop” by showing participants a simple cycle-diagram (below).



The nutrient loop: from faeces to food

She continued by mentioning that, according to GTZ experience, some “ingredients” are compulsory for the successful implementation of ecological sanitation systems:

- Feasible and easy to handle technical solutions;
- Awareness of the decision-makers;
- Active participation of the users in the implementation and change process; and
- Acceptance of the systems by the users in their daily routine (including knowing and accepting food from plants fertilised with human excreta).

Motivations leading to a change and to ecological sanitation can vary from the interest in the recyclates for economical, ecological, agricultural and gardening reasons (as the fertilizers produced are high in nutrients), to water conservation issues (e.g. water scarcity) or other water related factors, to job and income generation etc. Further motivating aspects to adopt Ecological Sanitation were linked to local physical factors such as high groundwater table, rocky ground and the failure of conventional and existing sanitation systems to provide the required services.

Some of the major motivations to generally change sanitation systems included the failure of conventional/existing sanitation systems; the idea of having sustainable security of services, such as water supply, waste and wastewater management; the promotion of (urban) agriculture, assisting to food security in urban areas; and hygiene and health improvement, which would lead to increased comfort and quality of life.





But ecological sanitation requires changes in attitudes for everybody - users, suppliers as well as all other stakeholders. The change must go from a supply-driven, centralized approach to a demand-driven, decentralized household-centred approach. The community has to understand what it needs and what is beneficial to its own local situation. There must be realignment in the role of both public and private sectors.

Furthermore, the demand for EcoSan systems requires an informed choice by the consumer; the opportunity to know technical and economical alternatives is very important. There must also be a demand for soil conditioners and fertilizers these being some of the added values of these systems linking natural resources such as water and nutrients to sanitation.

Finally stakeholders must feel responsible for environmentally sound behaviour, which is a shared responsibility of households, neighbourhoods and community members and not only a government responsibility.

The stakeholder groups involved in ecological sanitation can be listed as follows:

- Users of sanitation facilities;
- Users of recyclates/final products;
- Community Based Organizations and self-help groups;
- NGOs and GONGOs;
- Local authorities and governmental institutions;
- Service providers;
- Developers and investors;
- Financial institutions; and
- Research institutions.

<b>Basic types of EcoSan projects</b>				
<b>Project-type</b>	<b>A</b> 	<b>B</b> 	<b>C</b> 	<b>D</b> 
<b>Characteristics</b>	<b>rural upgrading</b>	<b>urban upgrading</b>	<b>new urban development areas</b>	<b>non-residential (tourism, schools..)</b>
• User of sanitation facilities	household	household / neighbourhood	household / neighbourhood	tourists, employees, pupils ...
• User of the end products	household	household (partly) farmer, external user (partly)	household (partly) farmer, external user (partly)	user-institution (partly) farmer, external user (partly)
• Level of initiative / decision	micro macro	micro macro	macro	micro macro
• Considered resources (minimum / optimum)	faeces + urine only plus greywater, rainwater harvesting, organic waste	faeces + urine + greywater only plus rainwater harvesting, stormwater management, organic waste	faeces + urine + greywater + stormwater-management plus rainwater harvesting, organic waste	faeces + urine + greywater + stormwater-management plus rainwater harvesting, organic waste
• Service provision for operation, transport, treatment and marketing	household	household public/private service provider	household public/private service provider	user institution public/private service provider

The above illustration on types of EcoSan projects and characteristics was then presented, showing the differences that exist in the implementation of EcoSan in rural, urban, industrial and public areas.

*Examples of Constraints to Consider in Cases of “Rural Upgrading”*

When considering rural upgrading several constraints are likely to occur. One of the constraints that has often been observed is the lack of information amongst stakeholders leading to EcoSan not contributing to a positive social image of users. The lack of knowledge among users as well as consumers of possible food produced on the value of the recyclates can also negatively influence project implementation in these areas.

*Examples of constraints to consider in cases of “urban upgrading”*

- Distrust of the stakeholders towards alternative systems;
- EcoSan facilities are not considered to increase the social image of the user;
- Fear of loss of sanitation comfort;
- Influence of interest groups for more expensive conventional systems; and
- Lack of an adequate collection system for pre-treated recyclates.

*Examples of Constraints to Consider in Cases of “New Urban Development Areas”*

- In-house sanitation facilities are not considered in urban sanitation planning (“sewage is not ecological sanitation”);
- Regional demand for fertilizer and soil conditioner is not considered in urban sanitation planning (wastewater irrigation ≠ fertilization);
- Decentralization of service structure results in a more difficult supervision of treatment and handling; and
- Reluctance to change the status quo.

*Examples of Constraints to Consider in Cases of “Non Residential Buildings Like Tourist Resorts, Schools etc.”*

- Improper use of temporary users;
- Distrust of the responsible management towards alternative systems;
- Extreme hygienic concerns and fear of loss of comfort;
- Use of recyclates not considered during planning; and
- Required change in monitoring and maintenance of sanitation facilities.

In all the above cases the lack of respect of culture, attitudes, habits and taboos, as well as financial and legislative restrictions, may seriously impede on project implementation.

As can be generally observed from the above list of constraints, awareness raising is crucial and very much culture/context specific. Critical consideration on this issue is required before any outside experience can be adopted or adapted. Awareness raising should be seen as an interactive movement in which different parties are engaged, each with their own roles, responsibilities and ways to make their interests heard. Finally, awareness raising activities should focus on increased understanding of the problems and their solutions. It is important to make sure that the proposed changes are feasible and acceptable.

A further important pillar towards successful implementation of EcoSan is the active participation of stakeholders.

*Definitions of participation by different international and developmental agencies:*

Participation is the process through which stakeholders influence and share control over priority-setting, policy-making, resource allocations and access to public goods and services. (World Bank)

Participation means that people are involved in economic, social, cultural and political processes that influence their lives. (United Nations Development Programme UNDP)

Participatory development stands for a partnership based on dialogue between the different partners involved. This requires negotiations rather than an agenda which has been defined from outside. In this process people are no longer seen as recipients but rather as actors. (Organization for Economic Development and Cooperation OECD)

Participation in ecological sanitation is considered a collective action aimed at achieving a common objective; it implies that people take part and become involved. (GTZ)

Finally the EcoSan concept and its systems need to be accepted.

Well-informed users are usually most motivated to make ecological sanitation work. Proper installation helps by providing a healthy sanitation environment for the users. If the toilet system does not leak or produce odours it will be easier to accept than if there is a problem. It will also be easier for people to accept these new systems if the management of the recyclates is simple and safe. This is very important because we are not only talking of sanitation but of ecological sanitation and nutrient value.

Thus, before implementing ecological sanitation and in order to achieve acceptance, the following issues have to be addressed:

- Where and how can the recyclates be used?  
If the idea of using the recyclates is not included from the very beginning, it is not ecological sanitation. If the contents of the toilets would just go down to the river or the sewage plant, it would not be ecological sanitation but only sanitation.
- Which equipments can be used for the collection, transport and application of the recyclates?  
A lot of acceptance problems exist because people must handle the waste without adequate tools, this issue should be addressed before hand.
- What volumes of recyclates have to be collected to market them and make it economically feasible/interesting?  
It is not necessarily the household using the toilet itself that has to use the recyclates in its own garden or field, there should also be other solutions to implement ecological sanitation. If the solution is not at household level it must be at a broader level: at community level or outside the community. In both cases a relevant amount of recyclates needs to be available to make it viable from a marketing point of view.

Last but not least there has to be a clear agreement between the owner(s) of EcoSan facilities and the user(s) of the recyclates.

The presenter concluded with three recommendations:

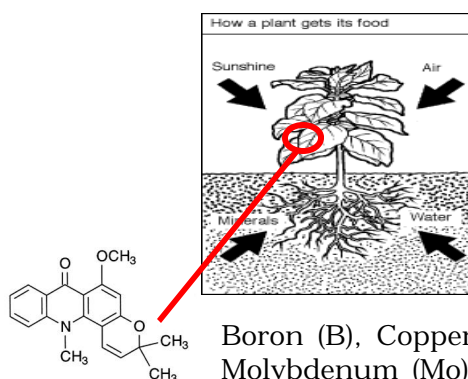
1. School children of today will be the users and decision-makers of tomorrow. Therefore topics related to ecological sanitation should be included in school curricula.
2. Visitors of tourist resorts are generally more open-minded to meet something unexpected. A clear explanation of the applied ecological sanitation system may help to disseminate the knowledge about environmentally sound sanitation, waste and wastewater management.
3. Worldwide, women play a key role in the in-house management of water, hygiene, health, sanitation, nutrition and children's education related to cultural attitudes. Because of this key role, women must be addressed in each programme related to ecological sanitation.

A general comment at the end of the presentation was made by one participant that raised the issue of gender equality and the need to involve both men and women living in the same households.

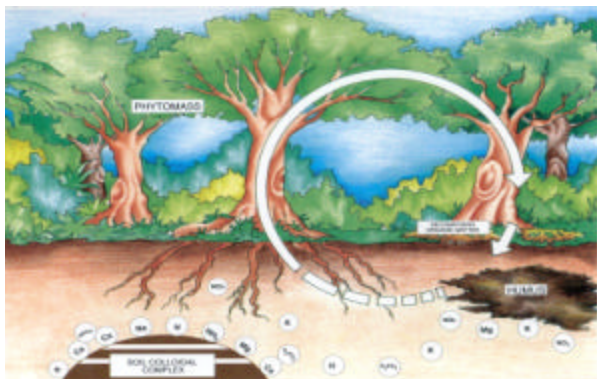
## Gardening and agriculture with EcoSan recyclates

By T. Hanke, GTZ EcoSan

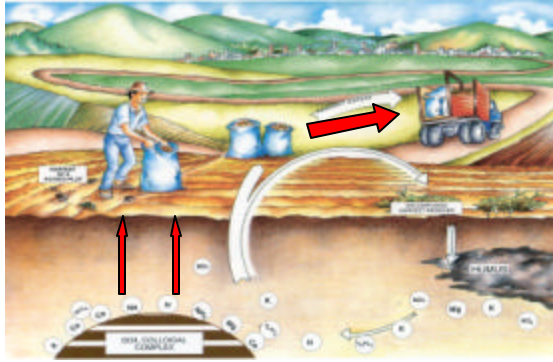
The speaker introduced his presentation by explaining that it would mainly look at the use of the by-products/recyclates from the EcoSan toilets in agriculture and gardening.



He continued by mentioning the key elements and minerals needed for plants to develop and grow: Energy (Light), Water (H<sub>2</sub>O), Carbon Dioxide (CO<sub>2</sub>), and Minerals. The macronutrients that a plant needs to grow can be summarised in: Nitrogen (N), Phosphorus (P), Potassium (K), Sulphur (S), Calcium (Ca), and Magnesium (Mg). Micronutrients such as: Boron (B), Copper (Cu), Iron (Fe), Chloride (Cl), Manganese (Mn), Molybdenum (Mo), and Zinc (Zn) occur in smaller concentrations but also have a very special function in the cell structure.



In a simplified natural ecosystem all minerals are part of a steady cycle. In the soil we have all the elements mentioned above which are absorbed by the plants. The plant grows, the leaves fall and dry up, decompose, are turned into humus and form again part of the soil structure. Once the decomposition of that organic matter is concluded minerals are released and can once again be re-absorbed by the growing plants, thus creating a cycle (left).



On the other hand, in a simplified agro ecosystem (left) minerals and organic matter are exported with the field products. They go to the city and to the consumers; the consumers eat and defecate. Most of what humans' take in is passed out of the body through urine, faeces or by sweating, and is often lost. At the same time, most of the minerals taken up with food will also be found in our excreta.

The value of minerals (mainly Nitrogen, Phosphorus and Potassium), contained in the excreta, faeces and urine, of an adult as well as other organic material in the household form an important part of the "household nutrient flow" (see table below).

Minerals	Grey water	Urine	Faeces
<b>N</b>	3%	87%	10%
<b>P</b>	10%	50%	40%
<b>K</b>	34	54%	12%
<b>COD</b>	41%	12%	47%

Nutrients and yearly averages of minerals found in grey water, urine and faeces

These minerals have an important value for agricultural production and should be used rather than lost forever. In fact agricultural chemical fertilisers contain the very same minerals, often extracted from fossil sources that are not being regenerated and thus will eventually be exhausted. The use of minerals contained in human excreta and organic household wastes is an excellent alternative to these fossil sources, and for as long as humans exist will not be exhausted. Systems that collect, process and reinsert these "wastes" into the nutrient cycle should be established to safely recover all the minerals needed for agricultural production, thus linking the fields to the consumers to the cities.

Generally biowaste, human faeces and urine can be utilised in agriculture under the following conditions:

- Proper pre-treatment (storage, drying, composting, anaerobic fermentation, heating, filtration, irradiation with UV etc.);
- Suitable "handling" (with security measures);
- Limitation with specified vegetables and crops, and to specified vegetation periods, depending on pre-treatment;
- Regular sampling and hygiene control, i.e. a structure for supervising the quality of the recyclates has to be developed; and
- Crop's needs for nutrients must be respected (no over-fertilization or ground water pollution).

To ensure that the above aspects are followed and that the recovery of nutrients is efficient and safe, a number of structures would have to be set up, from the collection to the treatment, transport and finally marketing of the products.

*Collection:* the product (biowaste and excreta) has to be available; it has to have a certain quality and concentration; there should be a process of strict separation of all non-organic industrial wastes and wastewater (e.g. toxic and heavy metals) as these could be harmful for the agricultural production; and support services and discharge control at household-level should be in place.

Once the collection has been done all the products need to be treated (On- or Off-Site) according to international health standards. The products could be treated at household level, at specific collection points, or at bigger treatment sites. During treatment the mass needs to be minimised, i.e. the organic material has to be broken down into elements such as carbon whilst retaining the nutrients. There must be some guarantee for customers (farmers) that the product they get is of good quality; sampling must be done and regular control mechanisms must be in place. Finally during treatment the product has to be made hygienic and safe to handle.

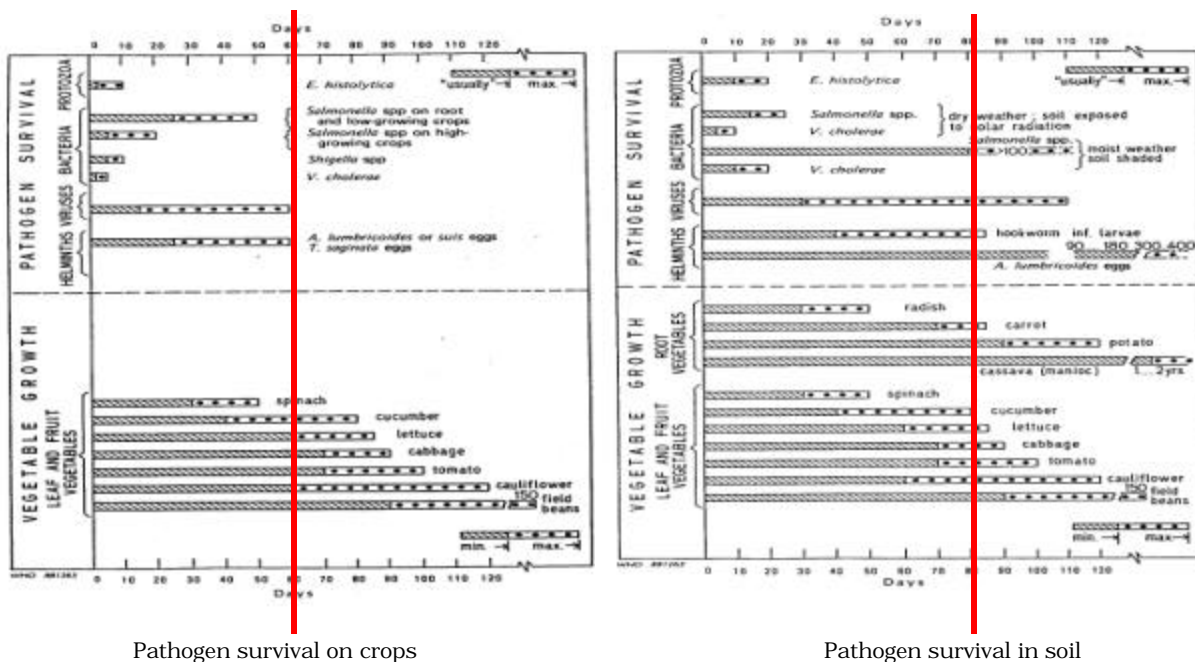
In order for the treated product to be useful for the consumers/users an important aspect has to be kept in mind - the distance between the treatment/packaging site and the fields - as this will influence the cost of the product: if too far it will also be too expensive.

Finally, the treated product has to be properly marketed, and for a marketing strategy to be successful the customers have to be aware of advantages/disadvantages of the product and have to be prepared to accept and use it. The product also has to be competitive in quality and cost to chemical fertilisers, thus acquiring an added value.

<b>Category</b>	<b>Use</b>	<b>Person / Group exposed</b>	<b>Nematodes [Eggs / kg]</b>	<b>Faecal coliforms [number / 100g]</b>
<b>A</b>	Application to field crop (used for raw food)	worker, consumer, public	$\leq 1$	$\leq 1000$
<b>B</b>	Application to field crop (for industrial use, feedstock, trees)	worker	$\leq 1$	no suggested standard
<b>C</b>	Local application to field crop of cat. B, without contact to persons	none	not relevant	not relevant

Hygiene quality standards for treated faeces (WHO)

The probability of infection or of transfer of diseases depends on several factors. Risks of infection and transmission only appear if a certain dose of pathogens is consumed. The risk can increase depending on the number of infected persons in a specific catchment area and if a sufficient amount of pathogens reaches the field, is later consumed by humans (hosts) and thus reintroduced into the transmission cycle.



Pathogen survival on crops

Pathogen survival in soil

In order to minimise the risk of infection through the use of treated faeces and faecal sludge the following steps of treatment for pathogen removal should be considered:

1. Storage/treatment (several days to 1 year);
2. Post treatment drying/composting, etc. (1-2 years); and
3. Time period from application until harvest (0.5-1 year)

Warm, dark, humid and oxygen free storage should be avoided by all means as these are “pathogen-friendly” factors that could lead to pathogen multiplication.

The treatment of urine is less time consuming as it has very low pathogen contents. Compliance with the recommended storage times and consideration of possible hormones/medical residues are sufficient, fresh urine can be used on trees.

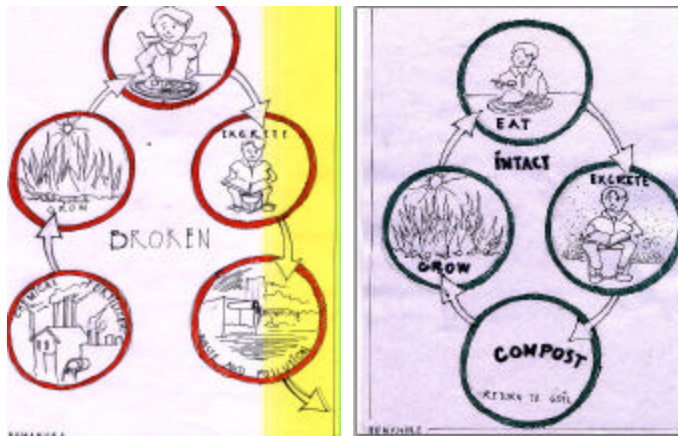
Industrial waste and wastewater have to be treated separately and monitored for hazardous substances.

The presenter concluded his session by informing participants that “one person can fertilize with its own EcoSan recycles an agricultural area of about 266-270m<sup>2</sup> - enough to grow and feed one person with vegetables, cereals and fruits during one year”.

Two questions came up regarding the reduction of smell in pit latrines (or EcoSan systems) and the reduction of risk of infection through vegetable production. The presenter replied that smell can be avoided without the application of chemicals (which would kill the bacterial flora needed for composting) by simply using source separating systems (e.g. urine-diversion) or by keeping the by-products as dry as possible (e.g. by adding ash/soil). He further referred to the pathogen survival diagrams (above) saying the risk of transmission of diseases would be reduced if the compost is stored for at least one year before application in the fields. If the safety measures mentioned during the presentation were followed the EcoSan compost could be safely used on any crop and vegetable.

## Multiple Strategies for Ecological Sanitation

By H-P. Mang, GTZ -Ecological Sanitation Project Team



What is EcoSan?

EcoSan means closing the “loop” in wastewater management and sanitation. It means moving from only sanitation (left) to sustainable and environmentally friendly sanitation (right).

In fact, EcoSan is a holistic and safe new concept for:

- Effective wastewater management and sanitation;
- Closing material cycles;
- Recovering and utilizing plant nutrients;
- Reducing the consumption of freshwater;
- Minimizing health risks;
- Minimizing environmental pollution; and
- Reducing energy consumption rates/better utilizing energy contents.

EcoSan is not a specific technology, but a new philosophy based on an overall view of material flows, of dealing with what is presently regarded as waste and wastewater for disposal. Ecological sanitation is different to water supply and is not equal to sewerage. It needs different solutions in different places. At the moment EcoSan has its own informal institution, but this urgently needs to be formalised and institutionalised. EcoSan has to be built on culture and has to be prioritised so to be able to positively contribute to combating the world water and sanitation crisis. EcoSan options must be provided.

The Household Centred Environmental Sanitation Approach (HCES-WSSCC, 2000) represents a new approach for planning environmental sanitation services, and offers the promise to correct existing unsustainable practices of planning and resource management by concentrating on two main components:

1. The focal point of environmental sanitation planning is the household, thus reversing the customary order of centralized top-down planning. The user of the services should have a deciding voice in their design, and sanitation issues should be dealt with as close as possible to the site where they occur.
2. Resource management should be seen as a circular system, emphasizing the conservation, recycling and reuse of resources, in contrast to the current linear sanitation service system.

*There are 10 steps to successfully implement EcoSan following the Bellagio Principles*

- |  |   |
|--|---|
| 1. Request for assistance;                       | 7. Development of consolidated Urban Environment Sanitation Service (UESS) plan for the area; |
| 2. Launch the planning and consultative process; | 8. Finalising the consolidated UESS plan;   |
| 3. Assessment of current status;                 | 9. Monitoring, evaluation and feedback; and   |
| 4. Assessment of user priority;                  | 10. Implementation  |
| 5. Identification of options;                    |   |
| 6. Evaluation of feasible service combinations;  |   |

(see Annex 10 “The Bellagio Principles and a household centred approach to environmental sanitation”).

Before illustrating some important gender aspects to be considered when embarking on EcoSan, the presenter also gave an overview of EcoSan projects that use different systems around the world (Annex 11, Illustrations and details on EcoSan systems and pilot projects).

Regarding gender issues, the presenter said that usually, when introducing conventional flush toilets, nobody considers them because “flushing is every user’s responsibility”. In most societies urine separation requires - especially for women - additional efforts to make children and other family members or guests use the toilet correctly. Dry toilets with or without urine separation mainly increase the workload of women as they are responsible for household matters as well as for the fields. Women are more frequently those who have to maintain the toilets by ensuring the supply and presence of ash or other mixing material; keeping toilets clean and ready for use without applying water or detergents; taking out the solids and using them as soil improver; and by also educating family members and children on how to use the toilets correctly.

Even in urban areas, women are generally the most involved in household gardening and food supply, and are thus responsible for closing the loop of nutrients. Although women have the burden of carrying out these difficult tasks, men still usually take decisions on housing and sanitary facilities. Finally, besides the women-men issue, elderly people very often have difficulties in maintaining dry toilets (compost and dehydration) by themselves.

In conclusion, the presenter encouraged all participants, EcoSan stakeholders and potential users to:

- Be convinced that eco-sanitation has an added value for communities;
- Be clear about the local barriers and obstacles to implementation;
- Pilot different strategies for well-off and for poorer communities, and combine implementation with market oriented measures;
- Promote tool guideline kits, especially for generating economic analyses of sustainable options; and finally
- Strengthen networking.

The presenter closed the session by citing a G8 meeting held in Evian, France on June 3, 2003, where leaders of the world's eight largest industrialized democracies wound up their annual three-day meeting with a joint statement that emphasized environmental responsibility and sustainable development. The statement said: "economically, major downside risks have receded and the conditions for a recovery are in place". The G8 leaders continued by calling for measures to prevent marine pollution and improve tanker safety, and adopted a plan of action to help halve the number of people without access to clean water and sanitation by 2015.

A comment from the floor referred to the social image of the users of EcoSan and the marketing strategies followed in Botswana. It was noticed that when talking about EcoSan it is too often linked to rural areas and/or poverty, thus reaching only a certain clientele. Furthermore it was noticed that especially when talking about urine diversion toilets men have difficulties in accepting to sit down when urinating and try to avoid using these facilities. Participants were reminded that there are simple urinals for men that should be used and introduced when implementing EcoSan projects. They were also informed that in rural communities the "men-sitting" issue had not really been an issue as men may just go to the bush to urinate.

## Site visit in the Kweneng District

During the afternoon participants were taken on a field visit to get first hand information as to how some of the EcoSan systems installed in Botswana work. Some of the EcoSan systems seen during the field visit included: VIPs, enviroloos, Calcamites, JoJos and also some double vault structures.

Enviroloo at the KDC offices



Jojo system



Open Enviroloo vault at the KDC offices



Closed Enviroloo Vault



A urine diversion toilet in use in a residential plot in Kweneng district



Disappointingly most of the systems were poorly maintained or not in use. Nevertheless one important lesson was learned, confirming what had already been said during the workshop: Education, information and training are crucial for any successful implementation of EcoSan. The installation of the toilet alone is not sufficient as EcoSan is a new concept, not a new technology or specific system.

## Day 3, September 4<sup>th</sup> 2003

*By C. Wirbelauer, IUCN*

The third and last day of the workshop also started with a brief summary and analysis of the previous day. The presenter reminded participants about the interesting lessons learnt on acceptance and awareness raising in EcoSan projects, as well as the safe use of by-products from the toilets for gardening and agriculture and some of the strategies used in other countries.

During the second part of the morning, participants had been split into three groups dealing with four themes that had been identified by them during the previous days' working cocktail:

- Technologies;
- Food Production;
- Acceptance/Awareness; and
- Health (Cross-cutting).

The main aim of these themes and the group discussions was the identification and agreement on a way forward for EcoSan in Botswana.

During the afternoon, participants went on a site visit in Kweneng District and were shown different sanitation systems:

- VIPs;
- Envirolloos;
- Calcamites; and
- JoJos.

Finally during the evening an Open-Market Space on EcoSan Components was set up. This gave an opportunity to display and explain different devices and technologies available in Botswana and neighbouring countries as well as in Europe and Asia. Some of the technologies displayed included:

- SolarSan;
- Envirloos;
- Cemforce; and
- Some systems presented during the previous days (E.g. Vacuum Sewerage System, Urine diversion and composting toilets).

The open-market space confirmed once again how manifold EcoSan can be, ranging from high technology to simple but effective systems (see list of Companies, Annex 2).

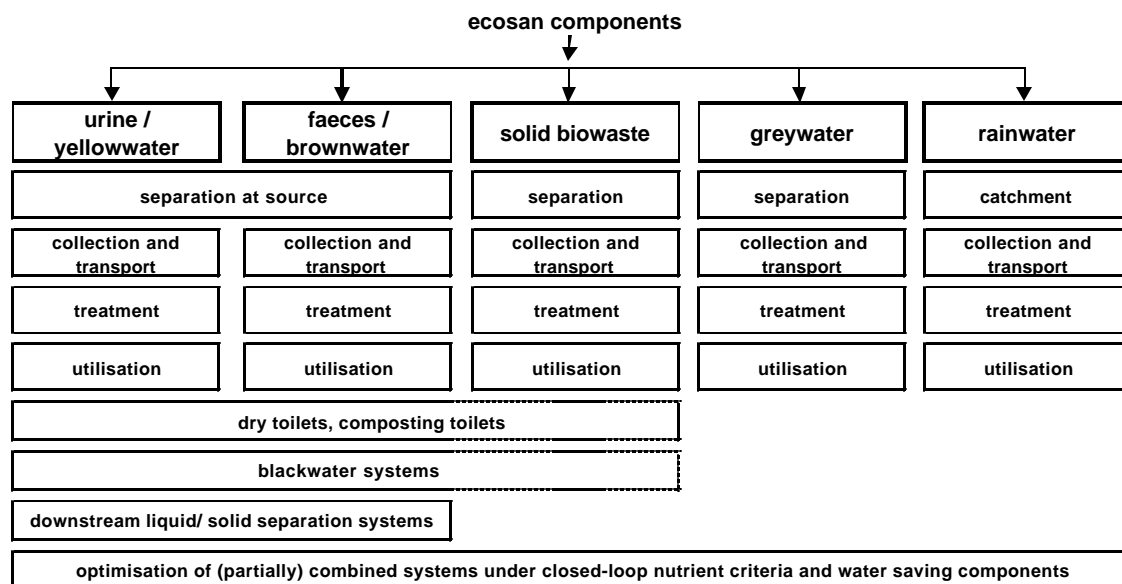
## Overview on technical EcoSan components, and worldwide strategies and planning procedures for EcoSan Projects,

By H-P. Mang, GTZ -Ecological Sanitation Project Team

The presenter started by reminding all those present that EcoSan is a concept and not a specific technology! The fundamental difference between the conventional concept and the EcoSan concept is that the first is linked to treatment that eliminates the nutrients and cleans the organic load, while the second is linked to one that recovers nutrients hygienically and conserves the organic material for reuse.

The Ecological Sanitation concept can be summarised and divided into three main steps: separation/collection, treatment and utilisation. Each step can be implemented through different technologies, processes and components as shown below:

Step	Solutions/Modules
1. Separated "in-house/on-site" collection (faeces / urine / grey water/organic solid waste)	<p>"High-tech" (waterborne)</p> <ul style="list-style-type: none"> <li>Double or triple sewer system in households</li> <li>Vacuum toilets/urine-separation toilets</li> </ul> <p>"Low-tech" (dry)</p> <ul style="list-style-type: none"> <li>Appropriate on site latrine systems (with faeces chamber and urine diversion)</li> </ul>
2. Treatment	<ul style="list-style-type: none"> <li>Anaerobic digestion (faeces/organic waste)</li> <li>Drying (faeces/urine)</li> <li>Storage (liquid urine)</li> <li>Composting (faeces/organic waste)</li> <li>Constructed wetlands/sand and gravel filtration; membrane filtration (grey water)/maturation ponds               <ul style="list-style-type: none"> <li>UV treatment</li> </ul> </li> </ul>
3. Utilisation	<ul style="list-style-type: none"> <li>Fertiliser in agriculture (faeces/organic waste)</li> <li>Irrigation (grey water)</li> <li>Groundwater recharge (purified grey water, rainwater)</li> </ul>



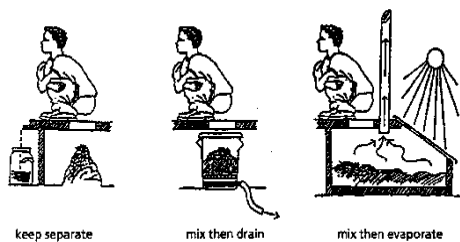
When introducing a new system, project implementers and practitioners should be informed with technical data sheets that include:

- process description;
- basic and general conditions;
- range of application;
- design and concept;
- function;
- evaluation under EcoSan-principles;
- economical data;
- conclusions and further development;
- producer / manufacturer; and
- references and further information.

A further very important aspect when introducing and implementing EcoSan (as well as any other type of project), is to give people the chance to make an informed choice. The choice should be innovative, sustainable, and appropriate to the social, cultural and physical context. There is a need for open and honest dialogue regarding the potential advantages and disadvantages of a range of alternative systems. Even though users might opt for a less ideal system or some sort of a mix, implementers should be aware of it and accept it.

A simple example of various types of systems that have developed differently depending on different cultures is that of “Washers and wipers,” “Sitters” or “Squatters”.

The presenter continued by giving a few examples of urine diverting and composting toilets (e.g. the picture below illustrating three options for a non-waterborne urine diverting system).



1. Keep separate (source separating UD-system);
2. Mix and drain;
- and 3. Mix then evaporate.

But many more examples and illustrations from all over the world, ranging from high-tech components to custom/homemade ones, from waterborne to non-waterborne systems, were also shown to give participants an idea on

the variety and “complexity” of EcoSan systems (Annex 12).

To give an even more complete range of options from which to choose when utilising EcoSan, the presenter informed participants about some options available for linking the actual toilet to the treatment/re-use “site”, such as urine-diversion systems linked to the use of grey water in the gardens, small-scale anaerobic plants, earthworm treatment systems, epuvalisation etc. (see details and illustrations in Annex 12).

Once EcoSan systems have been installed and are functional, the utilisation and re-use of the by-products needs to be guaranteed. The presenter closed his session by considering the term “Night soil” as being a euphemism for the global practice of depositing human excrement directly in the fields near someone’s home. Most

farmers are aware of the resource value of animal dung (especially in Asia) and most societies have practiced recycling of nutrients derived from faeces and urine for a very long time.

## **National Master Plan for Wastewater and Sanitation “On-site Sanitation: The Way Forward”**

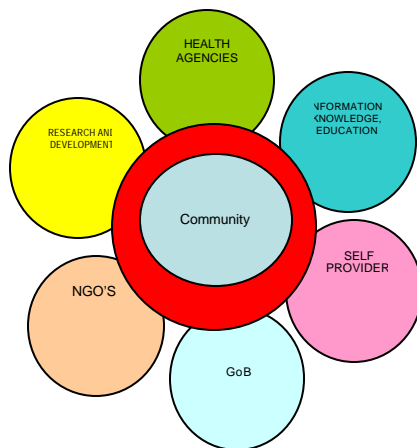
*By N. Mudge, SMEC International*

The last ‘formal’ presentation was to give participants an idea of the results from on-site sanitation in Botswana and the way forward as suggested in the National Master Plan for wastewater and sanitation.

The team working on the master plan had identified two main areas of government intervention:

1. Control of all on-site sanitation, as this allows complete integration through which the desired results can be achieved. This would include the integration of services, planning, stakeholder involvement and legislation.
2. The redesign of the National Rural Sanitation Programme into a National On-Site Sanitation Programme with clear goals, objectives, budgets, administrative structure, and appropriate resources.

Ideally, complete integration would allow for all major stakeholder groups to communicate, interact and contribute towards improved sanitation.



As already mentioned in a previous presentation, integration would allow for a number of government departments to collaborate more efficiently (circa eight Ministries and 20 Departments). It would also facilitate linkages between national activities/decisions and local needs by cooperating with all the local authorities, communities, NGO's etc.

Besides the DSWM (under MEWT), the Ministry of Health and the Ministry of Local Government and Lands are those ministries to be involved on the front-line.

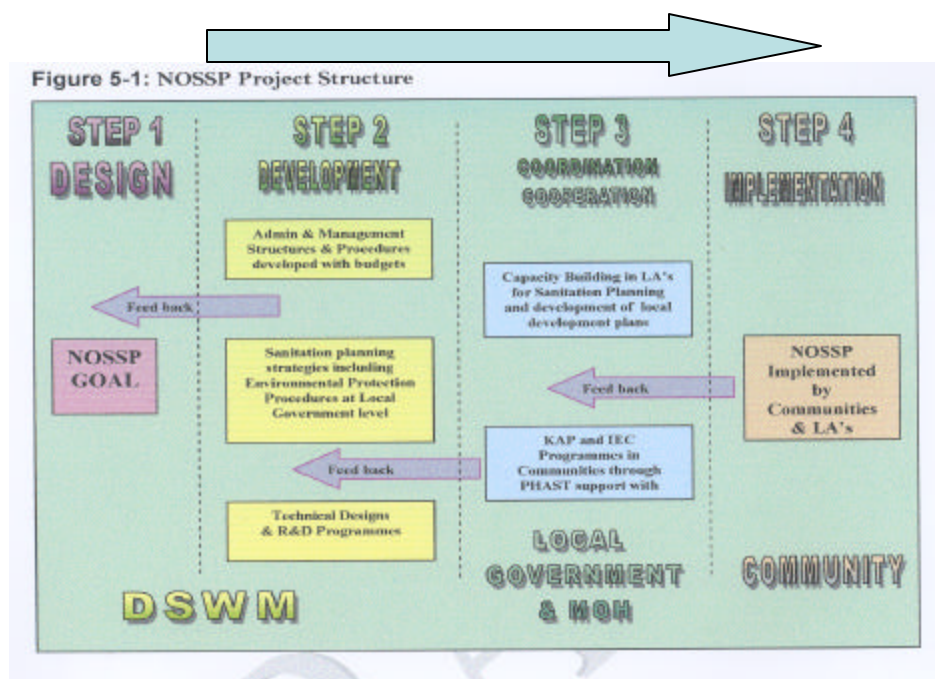
The reasoning behind the National On-Site Sanitation Programme (NOSSP) is that Government programmes represent approximately 20% or 1:5 of all on-site sanitation units installed, thus they represent a key component in national health and well being. Furthermore, the NRSP has served well and has fulfilled its purpose but is now in need of reshaping.

The Goal of NOSSP is “to ensure effective and efficient programmes for the delivery of appropriate, affordable, and environmentally sustainable on-site sanitation in rural and peri-urban areas of Botswana”.

Its main objectives and outputs are to:

- Establish NOSSP within DSWM: budget/mission/measurable outputs/monitoring;
- Develop capacity in EHO staff in LA's;
- Enhance sanitation culture in communities through participatory procedures;
- Develop National certification programme and R&D programmes for new technology;
- Ensure improved levels of appropriate and affordable on-site service to communities; and
- Provide environmental assessment and guidelines.

The National On-Site Sanitation programme structure, as suggested by the master plan, would include four main steps (design, development, coordination/cooperation and implementation), linking decisions made by central government to local government and NGOs and to the communities (see figure below).



Finally the aspect of research and development is a very relevant one, and a number of studies in different areas have already been carried out: Health risks; Knowledge, awareness and participation; Information, Education and Communication; Technology; International Practices; Emptying pits; and Geographical Information Systems.

In conclusion the presenter emphasised the need to start with integration, coordination, planning and legislation. He also highlighted the need to move away from the older NRSP and restructure it into the new national on-site sanitation programme (NOSSP) that would address a broader range of issues at both national and local levels.

In particular, he mentioned the need for a new direction so to be able to:

1. Create a national on-site sanitation strategy;
2. Control all on-site sanitation issues;
3. Focus on building knowledge rather than “holes in the ground”;
4. Build an improved communication web;
5. Establish auditable measures for success;
6. Establish a structured programme; and
7. Include research and development.

## **Main findings and recommendations from the group discussions**

*By groups (see Annex 13 – Issues to be discussed in groups)*

Participants acknowledged EcoSan as being a suitable **technical** option to sanitation in Botswana, especially due to the lack of water and poor soil conditions in the country. They also felt that in Botswana there is a need for **fertilizers** and soil conditioners as Sub-Saharan soils are generally poor.

The Urine-diverting and composting toilets were highlighted as being the most interesting **options** to address both the water and resource recovery issues.

It was also acknowledged that if properly implemented EcoSan can contribute towards ecological, economic and social benefits. The major **contributions** of EcoSan towards improvement of livelihoods in Botswana were identified as being:

- Improvement of soil conditions;
- Ground water protection/natural resource conservation;
- Health;
- Affordability;
- Income generation (fruits and fertilizers) and self-supply;
- Renewable energy (through biogas/biodigesters); and
- Increased social responsibility.

One of the suggestions raised was that of putting more emphasis on the ecological rather than the economic benefits of ecological sanitation, as the second could lead to businesses trying to invest for “quick money” only.

The groups thought that **guidelines** for EcoSan and the agricultural use of by-products should be developed to guarantee their safe and acceptable use.

Generally participants noted that a lot of **information** on EcoSan is already available in Botswana but that it should be disseminated in a more efficient way. Effective ways of dissemination and outreach suggested were:

- Workshops;
- Media;
- Improve networking between organisations/stakeholders involved;
- School Curriculum;
- Government (Department of Sanitation and Waste Management);

- Local community meetings;
- Fairs/exhibitions e.g. agricultural shows; and
- Set-up of a focal point for Botswana (with the suggestion that IUCN could take up this role).

But the groups also agreed that besides being a suitable option with many advantages, the implementation of EcoSan was linked to **acceptance and market development**. A very long list of possible barriers to the concept was presented:

- Agricultural (gardening) aspect;
- Approach used to present the idea/concept of eco-san;
- Cultural norms;
- Tribal differences, therefore we should not adopt a blanket approach;
- Education;
- Attitudes/perceptions of people towards waste - waste management perceived to be a dirty man's job, somebody else's responsibility;
- Poverty trap;
- Financial barriers;
- Gender and overall decision making; and
- Social status.

Some of the **actions** to be followed by stakeholders to get over the above barriers would thus need to include:

- Market surveys to determine the base of resistance;
- Reference to inexperience and "faults";
- Highlight income generation through the use of local resources;
- Elders should present the use of EcoSan systems to elders etc.;
- Involvement of farmers;
- Sensitisation of policy makers;
- Surveys on use and acceptance;
- Pilot projects with local demonstration sites and make use of the "learning-by-seeing" principle;
- Competitiveness;
- Sustained community based education and awareness raising;
- Use of efficient participatory approaches;
- Research on norms and culture of the people; and
- Appreciation of indigenous knowledge on sanitation and hygiene.

**Health** was considered being closely linked to sanitation and a very important aspect that requires more attention. More information should be shared amongst users, service/maintenance personnel and the community, especially on personnel hygiene, and how to safely handle the by-products from the toilets. But there is also need for the development and definition of:

- Appropriate plans for recyclables;
- Pre-determination of recycled matter; and
- Roles/responsibilities for maintenance.

The most pressing **issues to be addressed** for the expansion of Ecological Sanitation in Botswana were considered to be:

- Fund-raising;
- Coordination;
- Collection and compilation of relevant data for Botswana;
- Surveys;
- Evaluation of EcoSan challenges at a national level (needs assessment);
- Awareness campaigns directed towards policy makers;
- Pilot projects targeting schools and relevant institutions (e.g. agricultural college);
- Adoption and dissemination through a policy framework; and
- Implementation monitoring evaluation improvements.

Finally **Government**, and in particular the DSWM, should facilitate the process through the agenda set at the WSSD according to the timeframe of the WSSD millennium goal 2015.

At the end of group presentations and on a more general note, participants had picked out some specific issues of interest:

- Importance of linking EcoSan to **eco-tourism**: participants agreed that some tourists might be more open to innovation and willing to use the systems.
- The best way to influence **policy makers** identified by the groups was that of setting-up pilot projects and organising site visits so to provide them with first hand information.
- **Ownership** was also considered being a major ingredient for a successful implementation of EcoSan in Botswana and a recommendation to be taken on board by practitioners.
- **Capacity building** is an important issue and should be handled well. During some of the site visits to Kweneng District it was noticed that the projects had failed as the toilets were not properly used and maintained, mainly due to a lack of training, information and education.

## **Recommendations and Way Forward for Ecological Sanitation in Botswana**

*By K. Mokokwe, DSWM*

Through the inputs given by all participants and EcoSan stakeholders that had gathered during the two and a half day workshop, and especially through the outcomes from the group discussions, a way forward and a number of recommendations were identified.

As a result the main statement from the workshop was that:

**“Ecological Sanitation addresses not only sanitation but also enhances economic, environmental and social aspects:  
It provides further/new environmentally friendly approaches and options in the sanitation sector,  
Ecological sanitation also provides alternative options to chemical fertilizers and soil conditioners.”**

Five main recommendations could also be collectively developed:

### **Recommendation 1**

- a. There is a need for increased/improved dissemination of information and knowledge on Ecological Sanitation;
- b. There is a need to build capacity; and
- c. DSWM is recognised as lead agency to coordinate and mainstream issues related to Eco-San in other sectors.

### **Recommendation 2**

The concept/aspects of EcoSan should be included in all relevant policy frameworks and National Master Plans.

### **Recommendation 3**

The development of appropriate marketing strategies that address different target groups by emphasizing on the benefits of EcoSan is required.

### **Recommendation 4**

Research and development as well as piloting of the eco san concept (technologies, food production, health etc) is required in both rural and urban areas of Botswana.

### **Recommendation 5**

Awareness needs to be promoted in order to create political will.

The above recommendations and way forward were endorsed by all participants.

## **Closing Remarks**

*By R. Mojaphoko, UNDP*

In her closing remarks, Ms Mojaphoko noticed that we are currently facing a serious world water crisis. This threatens to affect all of humanity, with the poor set to suffer most from the decreasing quality and quantity of fresh water resources, resulting in increasing rates of water-related diseases and a damaged environment.

The problems raised by this water crisis are compounded by those caused by the sanitation crisis, which, while much less often discussed, is equally causing huge health and environmental problems around the world. The intricate interdependence of current sanitary systems with the water cycle require that both these issues be considered together, before we can consider how both these problems can be de-coupled from one another.

In order to address these problems in a concerted manner, the United Nations in a meeting in New York in September 2000, drew up a series of Millennium Development Goals. These goals aim to achieve poverty eradication and sustainable development by rapidly increasing access to basic requirements such as clean water, sanitation, energy, health care, food security and the protection of biodiversity. The United Nations Summit on Sustainable Development, held in Johannesburg, South Africa, in 2002, reassessed the goal with regard to water supply and extended it to the provision of sanitation. The current international target is therefore to halve the proportion of people without access to safe drinking water and adequate sanitation by 2015.

Sanitation is a critical intervention needed to improve living conditions among the world's poor and to reduce or prevent diarrhoea and other seriously debilitating conditions, especially among children. The absence of supportive policies to provide the basis for planning and implementing sanitation programmes is a missing link to improving coverage at a large scale.

Bringing ecological sanitation to the still unserved half of humanity, particularly those residing in urban settings where conventional approaches are neither available nor affordable, is one of the important tasks of the next years. As we heard in this workshop, the alternative systems are designed on the cyclical principles of natural ecosystems. Ecological toilets are designed to destroy pathogens close to where people excrete them, use no or very little water (and can use grey water), and recover and recycle nutrients.

Ecological sanitation helps to solve some of society's most pressing problems - infectious diseases, environmental degradation, water scarcity and the need to recover and recycle nutrients for plant growth. In doing so, it also helps to restore soil fertility, conserve fresh water and protect marine environments, all of which contribute toward food security.

Ecological sanitation approaches foster local initiatives and leadership, including the establishment of labour-intensive workplaces that manufacture urine-diverting toilets, community-based composting centres and home and community organic gardens.

UNDP already invited international experts in sanitation, public health, agriculture, nutrition and participatory development to come together in October 1999 for a workshop in Mexico, to address the ecosystem approach - Closing the loop - ecological sanitation for food security.

A book capturing first experiences from Mexico, other parts of Latin America and Zimbabwe in eco-toilet designs, safe reuse of excreta and prospects for urban agriculture and food security, was published by UNDP in 2001 and is available from the Internet: "Closing the loop - Ecological sanitation for food security" UNDP/SIDA [www.gwpforum.org/gwpef/wfmain.nsf/publications](http://www.gwpforum.org/gwpef/wfmain.nsf/publications)

It was very satisfying that this UNDP-initiative inspired other institutions to consider ecological sanitation in their activities related to health, water, sanitation, urban development and food security. One of the reasons why we are now here, in Botswana, discussing this topic.

Ecological sanitation, closing the loop between sanitation and agriculture, is the urgently needed new paradigm in sanitation. It is based on ecosystem approaches and the closure of material flow cycles rather than on the linear, expensive energy intensive end-of-pipe technologies. As we heard, eco san approaches have been adopted in a variety of contexts around the world, including densely populated urban areas.

On behalf of UNDP, Ms Mojaphoko expressed her sincere thanks to the organizers of this workshop -to the Department of Sanitation and Waste Management from the Government of Botswana, to IUCN, DED, GTZ - to have invited us to this event, giving the opportunity to gain broader awareness of the importance of environmental sound sanitation. And she also thanked all those attending for coming and participating actively in the discussions, sharing knowledge and information about national and international experiences.