NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF SCIENCE AND TECHNOLOGY

COURSE CODE: EHS 302

COURSE TITLE: ECOLOGICAL SANITATION

COURSE GUIDE

EHS 302

ECOLOGICAL SANITATION

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INTRODUCTION

Ecological sanitation is a 2-credit unit course. It is offered in 300 level (1st semester) of the B.Sc. Environmental Health Programme. This course provides an overview of what makes urine diversion a sustainable alternative to be considered by stakeholders, especially decision makers in both developed and the developing countries like Nigeria as an option to help reach the Millennium Development Goals (MDGs). The approach to sanitation that we are exploring in this course is based on three main fundamental aspects: rendering human excreta safe, prevention of pollution rather than controlling it after we pollute it and using the safe product of sanitised human excreta for agricultural purposes. This approach is called ecological sanitation.

WHAT YOU WILL LEARN IN THIS COURSE

The course content consists of a unit of the Course Guide which explains to you briefly what the course is about, what course materials you need and how to work with such materials. It also gives you some guideline for the time you are expected to spend on each unit in order to complete it successfully.

It guides you concerning your tutor-marked assignment which will be placed in the assignment file. Regular tutorial classes related to the course will be conducted and it is advisable for you to attend these sessions. It is expected that the course will prepare you for challenges you are likely to meet in the field of environmental health.

COURSE AIMS

The course aim is to provide you with an understanding of ecological sanitation as a new technology in waste disposal and waste recovery. It is intended to let you appreciate human waste as a resource that can be utilised in both developing countries like Nigeria and developed countries to improve agricultural production. It also intends to make you understand that not only human waste can be recovered and used but also wastewater.

COURSE OBJECTIVES

To achieve the aim set out, the course has a set of objectives. Each unit has specified objectives which are stated at the beginning of the units. You are advised to read the objectives before you study the unit because you may need to make reference to them during your study to check on your own progress. It is also good that you endeavour to check the unit objectives after completion of each unit to know the level of accomplishment. After going through the course, you should be able to:

- explain definition and concept of ecological sanitation
- describe excreta disposal technologies in ecological sanitation
- enumerate criteria in judging an ecological sanitation system
- list some available technologies in ecological sanitation
- describe types of toilets in ecological sanitation
- understand nutrient recovery and recycling methods in ecological sanitation.

WORKING THROUGH THIS COURSE

To complete this course you are expected to read each study unit, read the textbooks and other materials which may be provided by the National Open University of Nigeria. Each unit contains self-assessment exercises. In the course, you would be required to submit assignment for assessment. At the end of the course, there is final examination. The course should take about 15 weeks to complete. Listed below are the components of the course, what you have to do and how to allocate your time to each unit, in order to complete the course successfully and timely.

The course demands that you should spend good time to read and my advice for you is that you should endeavour to attend tutorial sessions where you will have the opportunity of comparing knowledge with colleagues.

COURSE MATERIALS

The main components of the course material are:

1. The Course Guide
2. Course units
3. References/further reading
4. Assignments
5. Presentation schedule

COURSE UNITS

The units in this course are as follows:

MODULE 1

Unit 1 Definition and Concept of Ecological Sanitation

Unit 2 Excreta Disposal Technologies in Ecological Sanitation

Unit 3 Design and Management of Ecological Sanitation

Unit 4 The Basic Types of Ecological Sanitation Options

Unit 5 Ecosan Promotion and Support

MODULE 2

MODULE 3

SUMMARY OF THE MODULES

In module 1, the first unit focuses on the meaning, and concepts of ecological sanitation. The second unit deals with the excreta disposal technologies in ecological sanitation; unit three is on design and management of ecological sanitation. Unit four is on the basic types of ecological sanitation options, while unit five is on Ecosan promotion and support. Unit one to four which are contained in module 2 described various examples of ecological sanitation toilets. Other units included in module 3 are; unit one which is on treatment of human faeces and urine, unit two which is on greywater, unit three which deals on biogas and finally unit four which examines the financial considerations, advantages and arguments for the use of ecological sanitation.

Each unit consists of one or two weeks works and include an introduction, objectives, main content, reading materials, exercises, conclusion, summary, tutor-marked assignments (TMAs), references and other resources. The various units direct you to work on exercises related to the required reading. In general, the exercises test you on the materials you have just covered or require you to apply it in a way that will assist you to evaluate your own progress and to reinforce your understanding of the material. Alongside the TMAs, these exercises will help you achieve the stated learning objectives of the individual units and course as a whole.

COURSE OVERVIEW

PRESENTATION SCHEDULE

Your course materials have important dates for the early and timely completion and submission of your TMAS and attending tutorials. You are expected to submit all your assignments by the stipulated time and date and guard against falling behind in your work.

ASSESSMENT

There are three parts to the course assessment and these include self-assessment exercises, tutor-marked assessments and the written examination or end-of-course examination. It is advisable that you do all the exercises. In tackling the assignments, you are expected to use the information, knowledge and techniques gathered during the course. The assignments must be submitted to your facilitator for formal assessment in line with the deadlines stated in the presentation schedule and assignment file. The work you submit to your tutor for assessment will count for 30% of your total course work. At the end of the course, you will need to sit for a final end-of-course examination of about the 2 hours duration. This examination will count for 70% of your total course mark.

TUTOR-MARKED ASSIGNMENT

The TMA is a continuous component of your course. It accounts for 30% of the total score. You will be given four (4) TMAs to answer. Three of this must be answered before you are allowed to sit for the end- of-course examination. The TMAs would be given to you by your facilitator and returned after you have done the assignment. Assignment questions for the units in this course are contained in the assignment file.

You will be able to complete your assignment from the information and material contained in your reading, references and study units. However, it is desirable in all degree level of education to demonstrate that you have read and researched more into your references, which will give you a wider view point of the subject.

Make sure that each assignment reaches your facilitator on or before the deadline given in the presentation schedule and assignment file. If for any reason you cannot complete your work on time, contact your facilitator before the assignment is due to discuss the possibility of an extension. Extension will not be granted after the due date unless there are exceptional circumstances.

FINAL EXAMINATION AND GRADING

The end-of-course examination for non-communicable and chronic diseases will be for about 3 hours and it has a value of 70% of the total course work. The examination will consist of questions, which will reflect the type of self-testing, practice exercise and tutor-marked assignment problems you have previously encountered. All area of the course will be assessed.

You should use the time between finishing the last unit and sitting for the examination to revise the whole course. You might find it useful to review your self-test, TMAs and comments on them before the examination. The end-of-course examination covers information from all parts of the course.

COURSE MARKING SCHEME

ASSIGNMENT	MARKS
Assignments 1 – 4	Four assignments, best three marks of the four count 10% each

	of the 30% course marks.
End-of-course examination	70%
Total	100%

FACILITATORS/TUTORS AND TUTORIALS

There are 15 hours of tutorial provided in support of this course. You will be notified of the dates, times and location of the tutorials as well as the name and the phone number of your facilitator, as soon as you are allocated a tutorial group.

Your facilitator will mark and comment on your assignments, keep a close watch on your progress and any difficulties you might face and provide assistance to you during the course. You are expected to mail your tutor-marked assignment to your facilitator before the schedule date (at least two working days are required). They will be marked by your tutor and returned to you as soon as possible.

Do not delay to contact your facilitator by telephone or e-mail if you need assistance.

The following might be circumstances in which you would find assistance necessary, hence you would have to contact your facilitator if:

- You do not understand any part of the study or the assigned readings.
- You have difficulty with self-tests.
- You have a question or problem with an assignment or with the grading of an assignment.

You should endeavour to attend the tutorials. This is the only chance to have face-to-face contact with your course facilitator and to ask question which are answered instantly. You can raise any problem encountered in the course of your study.

To gain more benefit from course tutorials, prepare a question list before attending them. You will learn a lot from participating actively in discussions.

SUMMARY

This course provides an overview of what makes urine diversion a sustainable alternative to be considered by stakeholders, especially decision makers in both developed and the developing countries like Nigeria as an option to help reach Millennium Development Goals (MDGs). Upon completing this course, you will be equipped with the meaning, and concepts of ecological sanitation. You will also understand the excreta disposal technologies in ecological sanitation, the design and management of ecological sanitation. You will know the basic types of ecological sanitation options, and be equipped on Ecosan promotion and support. Also at the end of the course, you will know the various ecological sanitation toilets. Other areas you will be equipped includes treatment of human faeces and urine, greywater, biogas and finally the financial considerations, advantages and arguments for the use of ecological sanitation. There are some questions which are built in-between the units that you are expected to answer such as the following;

- List five diseases that spread due to improper disposal of excreta and suggest some ways of preventing their spread.
- Define the following:

  i) Urine diversion

  ii) Toilet

  iii) Pathogens.

  iv) Grey water

- What are the available technologies in ecological sanitation?
- State the advantages of Ecosan dehydrating toilets over the conventional and improved pit latrine.
- State three differences between the composting system and dehydrating system in Ecosan.

The above list is just a few of the questions expected and is by no means exhaustive.

To gain most from this course you are advised to consult relevant books to widen your knowledge on the topic.

I wish you success in the course. It is my hope you will find it both illuminating and useful.

REFERENCES/FURTHER READING

Amadi, A.N. (2009). *Modern Environmental Sanitation*. Nationwide, Owerri: Printers and Publications Co. Ltd.

Esrey, S. A, Gough, J., Paport, D., Sawyer, R., Hebert, M.S., Vargas, J. (1998*). Ecological Sanitation,* Stockholm: Swedish International Development Agency.

Esrey, S. A., Andersson, & Ingvar. (2003). "Closing the Loop – Ecological Sanitation for Food Security".

Feachem, R. McHarry, M.& Mara, D. (1980). *Water, Waste and Health in Hot* ClimateS. London: J. Wiley.

Harmer, M. J. (1986). *Water and Waste Water Technology, SI Version.* (2nd ed.). New York: John Eily and Sons.

Okoroda, M. O. (1990). 'Training the Trainers on Ecological Alternatives Sanitation' .http://www.ecosan.co.za/product_info.html Open Source Encyclopedia.com 14 July, 2012. www 2.gtz.de/ecosan/English/16.

http://www.saching.com/Articles/The-Various-Causes-ofWaterScarcity in-the-World-254.html.

http://www.ruaf.org/system/files?file='Ecological Sanitation - Closing the Loop' .pdfhttp://www.lboro.ac.uk/well/resources/fact Sheets/factsheets tm/ Ecological%20sanitation.htm.

http://www.lboro.ac.uk/well/resources/Publications/Briefing%20Notes/ BN27%20Ecological%20sanitation.htm.

MAIN COURSE

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MODULE 1

UNIT 1 DEFINITION AND CONCEPT OF ECOLOGICAL SANITATION

CONTENTS

1.0 INTRODUCTION

Every human being that is alive is required by nature to excrete some waste products through the various openings in the body. If you can think back, you may remember how many times you urinated or how many times you defecated within the last two days. The urine and faeces are some of the waste products from your body. As soon as they are discharged into the environment, they become dangerous, especially if they contain pathogenic organism and they get back to our body either directly or indirectly. This is because of these disease causing organisms that can be found in them. It is because of this that urine and faeces should be handled with care and sanitised before discharging finally into the environment or re-used

As you read down the line, you will enjoy this course as you will learn more about the wastes from your body and how to dispose them.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain the meaning of ecological sanitation
- define some terms used in ecological sanitation
- mention some diseases related to disposal of excreta
- outline some preventive measures of the diseases in (iii) above.

3.0 MAIN CONTENT

3.1 Definition and Concept of Ecological Sanitation

Ecological sanitation (Eco-san) is based on an overall view of material flows as part of an ecologically and economically sustainable waste water management system tailored to the needs of the users and to the respective local conditions. It does not favour a specific sanitation technology, but is rather a new philosophy in handling substances that have so far been seen simply as waste water and water-carried waste for disposal.

According to Esrey *et al*. (2003), ecological sanitation can be defined as a system that prevents disease and promotes health, protects the environment and conserve water, recovers and recycles nutrients and organic matter.

Ecological sanitation (Ecosan) viewpoint sees human waste and wastewater as an opportunity. When properly designed and operated, eco-san systems provide a hygienically safe, economical, and closed-loop system to convert human wastes into nutrients to be returned to the soil, and water to be returned to the land. Alternatively, solid wastes are converted into a biofuel. The primary application for eco-san systems has been in rural areas where connection to a sanitary sewer system is not possible, or where water supplies are very limited.

Ecological sanitation also known as eco-san has passed through several stages of conceptual definitions and understanding by practitioners. The basic ones since 1980's till date are given below:

1980s- It is said to concern with urine diversion, dehydrating toilet, and reuse of faeces and urine.

1990s - It is said be a system that contains, sanitises and reuses faeces and urine.

2000 to date - It is said to be any sanitation system whose ultimate objective is to achieve practical sustainability and still maintain human dignity. (Amadi, 2009).

3.2 Concepts in Ecological Sanitation

There are some words /terms which you may not be familiar with. You are therefore encouraged to study their meaning in this unit to help you understand what the course is all about. You will meet these words in the various units under the study of ecological sanitation

3.2.1 Excreta

Waste matter from the body such as urine and faeces.

3.2.2 Urine

Is a typically stale liquid by product of the body secreted by the kidneys through processes called urination.

3.2.3 Faeces

Waste product from digestive tract expelled through the anus.

3.2.4 Toilet

Facility for urinating and defecation including the housing required for such facility.

3.2.5 Susceptible Host

A person who has no immunity against disease attack.

3.2.6 Pathogens

Disease causing micro-organism.

3.2.7 Urine Diversion

Separation of urine from faeces and water at the point of production.

3.2.8 Ecology

This connotes with the environment.

3.2.9 Eco-san

Another term used in place of ecological sanitation.

3.2.10 Grey Water

Grey water is domestic waste water other than that which comes from the toilet. It results from food preparation, washing of cooking utensils, cloths and body.

3.2.11 Black water

This is wastewater that contains excreta (urine and fecal matter).

3.2.12 Yellow water

Urine

3.2.13 Night soil

This connotes with faeces.

3.2.14 Vault

A water tight container that receives excreta from toilets.

3.3 History of Reuse-Oriented Sanitation Approaches

The recovery and use of urine and feces has been practiced by almost all cultures. The reuse was not limited to agricultural production. The Romans, for example, were aware of the bleaching attribute of the ammonia within urine and used it to whiten clothing. The most widely known reuse in agriculture has occurred in China. Reportedly, the Chinese were aware of the benefits of using excreta in crop production before 500 B.C., enabling them to sustain more people at a higher density than any other system of agriculture.

The value of "night_soil" as a fertiliser was recognised with well-developed systems in place to enable the collection of excreta from cities and its transportation to fields. However, its use promoted disease to such an extent that in Chinese cuisine almost all vegetables are thoroughly cooked. Elaborate systems were developed in urban centres of Yemen enabling the separation of urine and excreta even in multi-story buildings. Feces were collected from toilets via vertical drop shafts, while urine did not enter the shaft but passed instead along a channel leading through the wall to the outside where it evaporated. Here, feces were not used in agriculture but were dried and burnt as a biofuel. In Mexico and Peru, both the Aztec and Inca cultures collected human excreta for agricultural use. In Peru, the Incas had a high regard for excreta as a fertiliser, which was stored, dried and pulverised to be utilised when planting maize.

In the Middle_ages, the use of excreta and greywater was the norm. European cities were rapidly urbanising and sanitation was becoming an increasingly serious problem, whilst at the same time the cities themselves were becoming an increasingly important source of agricultural nutrients. The practice of using the nutrients in excreta and wastewater for agriculture therefore continued in Europe into the middle of the 19th Century. Farmers, recognising the value of excreta, were eager to get these fertilisers to increase production and urban sanitation benefited.

The increasing number of research and demonstration projects for excreta reuse carried out in Sweden from the 1980s to the early 21st century aimed at developing hygienically safe closed loop sanitation systems. Similar lines of research began elsewhere, for example in Zimbabwe, Netherlands, Norway and Germany. These closed-loop sanitation systems became popular under the name "eco-san", "dewats", "desar", and other abbreviations. They placed their emphasis on the hygeinisation of the contaminated flow streams, and shifted the concept from waste disposal to resource conservation and safe reuse. (Open Source Encyclopedia.com)

3.4 Urine and Feaces Related Diseases

Human excreta contain some pathogens. Some organisms live at the expense of man. These organisms are called parasites. The pathogenic organisms are found often in human faeces and when they get into the human body, they cause various forms of diseases.

The urine and faeces related diseases include:

i. Typhoid
ii. Paratyphoid
iii. Bilharzias
iv. Diarrhea
v. Poliomyelitis

vi. Dysentery
vii. Teniasis
viii. Giardiasis

When a person excretes pathogen into the environment, the environment becomes contaminated. Through this means, the organism reaches the hand, water, food, and finally into the mouth of a susceptible host. If nothing is done to stop the organisms from reaching the mouth of a susceptible host, he or she may contract any of the above mentioned diseases. See figure 1 below.

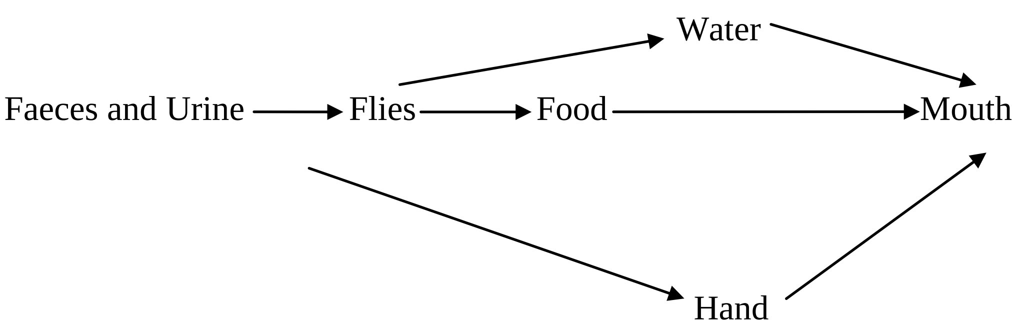

Fig. 1: Disease Transmission Cycle from Faeces and Urine to Mouth (Nwachukwu, 2008)

Figure1 shows how micro-organism can get to the mouth from faeces and urine, through the hand or water or food to mouth. In some cases, it will first be carried by a mechanical vector such as flies and other objects to the food before reaching the mouth.

3.5 How to Prevent Urine and Faeces Related Diseases

i) Proper personal hygiene by washing hands after visiting toilet.
ii) Drinking water from non contaminated sources.
iii) Proper cooking of food.
iv Prevent flies from having access to food.
v) Immunisation of persons against the immunisable diseases such as poliomyelitis.
vi) Proper handling and sanitising of urine and faeces before discharging into the environment or re-use.

4.0 CONCLUSION

In conclusion, ecological sanitation has to do with three main fundamental principles which include: preventing pollution rather than attempting to control it after we pollute, sanitising the urine and the faeces to avoid diseases spread and using the safe product for other purposes. The eco-san approach treats human excreta as a resource; therefore it is a sustainable approach.

5.0 SUMMARY

In this unit, you were able to understand that ecological sanitation is said to be any sanitation system whose ultimate objective is to achieve practical sustainability and still maintain human dignity. You also discovered that there are various key words that are often used when discussing ecological sanitation such as excreta, urine, faeces, urine diversion, and toilets etc. Again, various diseases can be contacted from human excreta such as poliomyelitis, dysentery, typhoid and paratyphoid, and these diseases can be prevented through personal hygiene, food hygiene, water sanitation and through proper handling and sanitization of urine and faeces before re-use or disposal.

6.0 TUTOR-MARKED ASSIGNMENT

1. List five diseases that spread due to improper disposal of excreta and suggest some ways of preventing their spread.
2. Define the following:
   i) Urine diversion
   ii) Toilet
   iii) Pathogens
   iv) Grey water.

7.0 REFERENCES/FURTHER READING

Amadi, A.N. (2009). *Modern Environmental Sanitation*. Owerri: Nationwide Printers and Publications Co. Ltd.

Esrey, S. A., Anderson, & Ingvar (2003). “Closing the Loop – Ecological Sanitation for Food Security”.

Feachem, R. McHarry, M. & Mara, D. (1980). *Water, Waste and Health in Ho*t *Climates*. London: J. Wiley.

Nwachukwu, M. C. (2008). *Tropical Diseases, Prevention and Control. Enugu*: Peegat Ventures.

Open Source Encyclopedia.com 14 July, 2012.
www 2.gtz.de/eco-san/English/16.

UNIT 2 EXCRETA DISPOSAL TECHNOLOGIES IN ECOLOGICAL SANITATION

CONTENTS

1.0 INTRODUCTION

In unit 1, we discussed the definition and concept of ecological sanitation and we discovered in the unit that human excreta can be dangerous to our health if not properly handled. In this unit, we are going to discuss the excreta disposal technologies in ecological sanitation.

Therefore, different approaches that we can use to handle human excreta will be discussed. You will also understand the sources of excreta and waste water, their characteristics, and so on.

2.0 OBJECTIVES

At the end of this unit, you should be able to

- explain the sources and characteristics of excreta and grey water
- list some available technologies in ecological sanitation
- list criteria in judging an ecological sanitation system.

3.0 MAIN CONTENT

3.1 Sources of Excreta and Grey Water

The sources of excreta and grey water are homes, schools, churches, mosque, markets, hostels, hospitals, industries, airport, and offices and so on. Source includes all places man carries out his daily activities.

3.2 Characteristics of Grey Water, Faeces and Urine

There are various characteristics of grey water faeces and urine. These are discussed below.

3.2.1 Grey Water

Grey water is usually of no major hygienic concern. It contains almost no nutrient but contains a vast range of various amounts of substances such as oil, detergents and so on. Average production is about 25 – 100m^3 per capita per day.

3.2.2 Faeces

Faeces contain potentially a series of array of pathogens which cause many of the faeces mouth diseases. The pathogens may include protozoa, bacteria, viruses and helminthes. Faeces also consist of organics, nutrients and trace elements. The organics are decomposable and improves soil quality and water retention capacity. Average production capacity is 50kg capita.per day (Amadi, 2009).

3.2.3 Urine

Urine is hygienically not critical. It contains largest proportion of nutrient. These nutrients are found to be very important for the growth of plants and therefore very useful in agriculture. It contains very little organics and may also contain hormones and medical residues

3.3 Available Technologies

Many alternative ways of constructing dehydration toilet exist. Generally double – vault toilet with urine diversion have shown the most successful result and the highest popularity. Several modifications have been applied to enhance the dehydration process and to suit each region's condition. The main distinguishing features are listed below.

3.3.1 Urine Diversion or Non – Urine

Most dehydrating toilets require prior separation of urine to allow sufficient drying of faeces. Systems where urine and faeces are mixed only work properly in very dry climates. Some installations provide a drainage system for the chamber to improve dehydration of the solids.

Urine diversion systems not only allow the separate collection of nutrient rich and virtually sterile urine, but also greatly reduce the odour problems associated with dry mixed systems.

3.3.2 Use or Disposal of Urine

The use of separately collected urine as a fertiliser after appropriate storage is strongly recommended, due to its high nutrient concentration and the low associated health risks. However in certain circumstances, urine use may not be acceptable or immediately possible and urine is infiltrated directly to the soil via a soak – away pit.

3.3.3 Single Vault or Double Vault

Dehydration toilets can be built with a single or a double chamber for collection of faeces. By using a double – vault, handling of fresh excreta can be avoid, as the vaults are using alternately, with sufficient time allowed for the faeces to sanitise. Most dehydration toilets therefore use double – vault technology. Single – vault systems may be less expensive to build, but need more labour to guarantee the same hygienic safety as double – vault systems.

3.3.4 Ventilated Vault or not

Ventilation is generally recommended to prevent odour and flies and to enhance the drying process. In some cases it can be omitted (e.g. in extremely dry climates, or if the toilet is far from housing). However, if the toilet is constructed within the house, vent pipe is strongly recommended due to the reduced smell and flies problems. Ventilation through installed pipes can be natural or enforced by wind propelled or electrical fans.

3.3.5 Squatting or Sitting

There are numerous technologies that suit both defecation style (squatting or sitting) with simple drop holes or specially designed urine diversion squatting pans for squatting culture (e.g. Vietnamese toilets and Chinese squatting pan) or urine diversion seat risers for sitting cultures (Central America, Europe and parts of Africa).

3.3.6 Dry or Wet Anal Cleansing

Dehydration toilets can receive dry cleaning materials such as toilet paper (which however, will not decompose completely). Dehydration toilets can also be used for wet cleaning cultures, water from anal cleaning then has to be drained in a separate pipe so that no liquid is led into the vault.

3.3.7 Self – Built or Prefabricated

Most systems can be self-built by the users totally or partially using commercially available squatting pans or toilet seats. In some areas, complete systems including the toilet cabin and the substructure are available on the market.

3.4 Applicability

Dehydration toilets have been applied variously, mostly in developing countries, including China, Vietnam, India, Nepal, Mexico, Ecuador, El Salvador, South Africa, Zimbabwe and many others.

3.4.1 Climates

Dehydration toilets are mainly suitable for regions with high average temperatures, long dry and short rainy seasons or arid climatic conditions with high evaporation rates. Nevertheless, with simple solar heaters, they can also work in a more humid climate. Dehydration toilets are waterless systems that are particularly suitable for conditions where water is scarce.

3.4.2 Rural and Urban Areas

Dehydration toilets can be placed outside the house, attached or even inside the house. Dehydration toilets are therefore suitable both for rural and densely populated urban areas.

3.4.3 Different Cultural Settings

As already stated, dehydration toilets are suitable for different cultural settings. They can be designed to suit both sitting and squatting cultures and to cope with the use of water for wet anal cleaning culture as well.

3.5 Advantages of Dehydrating Toilet over Pit and Composting Toilets

The dehydrating toilet has some advantages over the pit toilets and also over the composting toilets. The advantages are discussed below.

3.5.1 Advantages Compared to Pit Toilets

Pit and Ventilated Improved Pit (VIP) toilets cannot be used in many areas due to high water tables and groundwater pollution potential, seasonal flooding, a hard, rocky surface, lack of space, and potential for groundwater infiltration. This is not the case with dehydration toilets. If pit and VIP toilets are to be used for longer than the period it takes the pit to fill, regular, expensive, and often unhygienic emptying is required, whereas the removal of the small, dehydrated volume of faeces from the dehydration toilet is much easier and more hygienic. If only used until the pit fills, the structure of pit and VIP toilets cannot be permanent and a new pit has to be dug, comparing unfavorably to the permanent structure of dehydration toilet.

Dehydration toilets are also more resource-efficient due to the reuse potential of the product.

3.5.2 Advantages Compared to Composting Toilet

Compared to composting toilets, another dry toilet type suitable for Eco-san concepts, dehydration toilets have some advantages. The main advantage is that the dehydration process is less sensitive than the composting process, resulting in lower maintenance needs.

This, of course, is only valid if design and climates, allow a good functioning of the drying process. In a cool and dry climate composting process might be easier to maintain than dehydration.

3.6 Criteria for Judging Eco-san System

There are five basic criteria for judging ecological sanitation system. These are:

a. **Prevent disease** – A sanitation system must be capable of destroying or isolating disease causing organisms called pathogens
b. **Affordability** – A sanitation system must be cheap so that it can be accessible to the world's poorest peoples
c. **Protect the environment -** A good sanitation system must prevent pollution of the environment return nutrients to the soil and conserve water resources
d. **Acceptable** – A sanitation system must be aesthetically in offensive and has respect for cultural and social values
e. **Simple** – A sanitation system must be simple and easily maintained with available local technical capacity (Akoroda, 1990).

3.7 Factors to be considered in Designing and Management of Eco-san Toilets

Many local conditions and variables influence the choice of Eco-san toilets. These are:

a. **Climate.** The climatic factors such as temperature, humidity and rainfall are to be considered in choice of toilets to be used. This is so because in dry areas it will be easier to sanitise faeces through dehydration whereas composting may be more successful in humid area
b. **Socio – cultural factors.** The acceptability of a particular design has to do with the customs and belief of the community. Therefore this factor is to be considered in design and management of ecological sanitation system to be adopted
c. Landscape and soil formation
d. **Population density and settlement pattern** – the availability of space for on-site/ off site processing storage and local recycling.
e. **Economic** – the financial resources of both individuals and the community as a whole to support a sanitation system is to be considered
f. **Technical capacity** – the level of technology that can be supported and maintained by local skills and tools
g. **Agriculture** – the characteristics of local agriculture and homestead gardening.

h. **Institutional support** – legal framework, extent of support for the eco-san concept in government, industry, financial institutions, universities and NGOs (Akoroda, 1990).

4.0 CONCLUSION

In conclusion, all the features of this unit have been designed to introduce you to the available excreta disposal technology in ecological sanitation. The unit discussed sources of excreta and grey water and their characteristics, criteria for judging a sanitation system and factors to be considered in designing and management of eco-san toilet.

5.0 SUMMARY

In summary, ecological sanitation technologies provide different approaches to handle excreta disposals considering the factors that influence the design and management of the technological option and the criteria the option must meet before it is accepted as a good sanitation system. Having gone through the unit, you are expected to be able to list some of the technologies available in ecological sanitation, know the sources of excreta and grey water including their characteristics and be able to list the criteria for judging eco-san toilet.

6.0 TUTOR-MARKED ASSIGNMENT

1. What are the available technologies in ecological sanitation?
2. State the advantages of Ecosan dehydrating toilets over the conventional and improved pit latrine.
3. What are the criteria for judging eco-san system?
4 List 3 advantages of eco-san toilets over the conventional pit toilets.

7.0 REFERENCES/ FURTHER READING

Amadi A.N. (2009). *Modern Environmental Sanitation*. Owerri: Nationwide Printers and Publications Co. Ltd.

Harmer M.J (1986). *Water and Waste Water Technology, SI Version.* (ed.). New York: John Eily and sons.

Okoroda, M. O. (1990). ‘Training the Trainers on Ecological Alternatives in Sanitation’ .http://www.eco-san.co.za/product_info.html.

http://www.saching.com/Articles/The-Various-Causes-of-Water-Scarcity-in-the-World- 254.html.

UNIT 3 DESIGN AND MANAGEMENT OF ECOLOGICAL SANITATION

CONTENTS

1.0 INTRODUCTION

In the last unit, we discussed excreta disposal technologies in ecological sanitation. In this unit we are to discuss design and management features of eco-san. The unit will provide an overview of possibilities in dealing with liquids and in sanitising solids and also urine recovery processes.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain urine diversion
- explain dehydration and composting systems
- list some examples of sanitation toilets based on dehydration and composting.

3.0 MAIN CONTENT

3.1 Dealing with Liquids

A basic question when designing an eco-san system is whether to divert urine or to receive combine urine and faeces in a single receptacle. If the urine and faeces are collected together, they will later be separated for effective management. But with few exceptions they can be combined and yet be processed well. In dealing with liquids therefore, we have three options: urine diversion, liquid separation and combined processing.

3.1.1 Urine Diversion

The idea of how to separate urine and faeces is simple. The defecating person is to sit or squat over some kind of dividing wall. So that faeces drop down behind the wall and urine passes in front of the wall. This idea of not mixing urine and faeces is not new as it has been in practice in some parts of China, Latin Ameraca and Scandinavia. Urine separation from faeces has five main advantages:

(a) It provides a good opportunity for the removal of excess wetness and humidity in the processing vault.
(b) The urine remains relatively hygienic and free from disease causing organisms.
(c) Such urine can be applied as fertiliser to enrich the soil.
(d) It keeps the volume of potentially dangerous materials small.
(e) It simplifies treatment of faeces.
(f) It reduces odour nuisance as obtained in combined system.

In some cases, once the urine is collected, it can either be infiltrated into a soak pit or an evapo-transpiration bed. The urine can also be used the same day for irrigation or stored on site for later use.

3.1.2 Liquid Separation

In this system, urine, faeces and at times a small amount of water go down the same hole. This system therefore does not require special design of seat-riser or squatting plate like in urine diversion. Here the liquids and solids are separated in an ‘Aquatron’, fixed on top of the processing vault .This device is developed in Sweden. It has no moving parts and simply uses the velocity of the flush to send the liquid around the inner wall of a doughnut-like arrangement while the solids fall through a hole in the middle.

The separation is placed on top of a processing composting chamber. Here the liquids are sanitised with ultraviolet radiation. Another alternative is to drain the vault through a net or a false floor of wire mesh. Because the liquids have been in contact with faeces they must be treated before they can be recycled as fertiliser.

3.1.3 Combined Processing

It is always a difficult task to process the liquid and solids together. However, under extremely dry climatic conditions or where large quantities of absorbent materials are added it may be easier to combine them during processing. Like the liquid separation option, the urine, faeces and in some systems a small amount of water, go down the same hole. This combined processing option is not recommended because of its associated odour nuisance and other insanitary conditions.

3.2 Dehydration

There are sanitation systems based on dehydration when something is dehydrated, all the water is removed from it. In dehydrating toilet the content of the processing vaults are dried with the help of heat, ventilation and addition of dry materials. The moisture content should as quickly as possible be brought down to below 25%. At this level, there is rapid pathogens destruction, no smell so as to attract flies breeding.

The use of specialised collection devices such as squatting pans and seta-risers which divert urine for storage in a separate in a separate container allows the faeces to be dehydrated fairly. Since urine contains most of the nutrients but generally no pathogens as pointed out earlier, it may be used directly as fertiliser without the need for further treatment.

Some Ecosan toilets based on dehydration are: Double Vault Dehydrating Toilet, Eklogen dehydrating toilet, Teepan solar heated toilet, Double Vault solar heater toilet and Indoor long drop dehydrating toilet, the arborloo**,** Fossa Alterna, and Skyloo. These eco-toilets will be dicussed in the subsequent modules.

3.3 Composting

There are ecological sanitation systems based on decomposition otherwise known as composting. Composting is a biological process in which, under controlled conditions bacteria, worms and other types of organisms' breakdown organic substances to make humus. In a composting toilet human excreta, along with additional bulking agents such as vegetable scraps, straw, coconut husks, sawdust, kitchen refuse, toilet paper and weeds are deposited into a processing chamber. In the chamber, soil micro-organism breakdown the materials inside. Most pathogenic organisms in a compact chamber are destroyed with 3-4 months as a result of completion with the soil based organisms and unfavourable environmental condition. The material in the compacting chamber can then be removed and subject to another treatment such as long storage, addition of line or treatment with higher temperature before final used as fertiliser. Examples of composting toilets includes; Clivus Multrum Single Vault Composting Toilet, Caroused multiple Vault composting toilet, Sirdo Seco solar heated toilet, Moveable Bin toilet, and Centre for Clean Development (CCD) toilet. The next module will feature discussion on some of these composting toilets.

4.0 CONCLUSION

In conclusion, there is need for appropriate design and management of ecological sanitation systems. This is to ensure high efficiency of the system and to achieve the desired results. In dealing with the liquids urine diversion and liquid separation are recommended but not combined system which is associated with odour nuisance. Different types of toilets are useful in ecological sanitation and are designed either as composting toilet or dehydrating toilet systems. Any of them can be very effective if well managed.

5.0 SUMMARY

In this unit, we discussed the design and management of ecological sanitation systems. The liquids can be dealt with in three ways viz: urine diversion, liquid separation, and combined processing. We also saw list of various types of toilets useful in ecological sanitation that will be discussed later in the future modules. These toilets are categorised into composting toilets and dehydrating toilets. Both composting and dehydrating options are good in eco-san if properly managed.

6.0 TUTOR-MARKED ASSIGNMENT

1. State three differences between the composting system and dehydrating system in eco-san.
2. Write briefly on composting.

7.0 REFERENCES/ FURTHER READING

Amadi, A.N. (2009). *Modern Environmental Sanitation*. Owerri: Nationwide Printers and Publications Co. Ltd.

Esrey, S. A, Gough, J., Paport, D., Sawyer, R., Hebert, M.S., & Vargas, J. (1998). *Ecological Sanitation.* Stockholm: Swedish International Development Agency.

Pervy, H.S, Rowe, D. R & Tchobanoglous, G. (1985). *Environmental Engineering.* New York: McGraw Hill International Editions, Civil Engineering Series.

UNIT 4 THE BASIC TYPES OF ECOLOGICAL SANITATION OPTIONS

CONTENTS

1.0 INTRODUCTION

In the last unit, we discussed the design and management of ecological sanitation systems. In this unit, we are to discuss the basic eco-san options. There are four basic ecosan options. These are rural upgrade, urban upgrade, new development option and non residential option.

Each option suits a particular condition of housing development.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- list the basic eco-san options
- describe the rural upgrade option
- determine the best option in a particular situation
- state the differences in the options.

3.0 MAIN CONTENT

3.1 Rural Upgrade

This corresponds to what could be considered as the "classic" eco-san project. Farming households, in rural areas, receive support to establish ecological sanitation systems either on their compounds or in their houses. The farming households are usually responsible for the handling of the recyclates which most often comprises only urine and faeces, using them on their own fields as fertiliser and soil conditioners. Grey water treatment and reuse, rainwater harvesting, and organic waste management can be integrated into the system, although this is rarely practiced in this type of project.

The decision to implement eco-san may result from the initiative of a local None Governmental Organisation or Community Based Organisation engaged in ecological development. The organisation may start their activities by contacting local opinion leaders, informing them of the eco-san approach and asking for their support. It is hoped that once these people have accepted the system, a broader introduction among the farming households will be facilitated and accelerated.

The decision can be however be made at the political macro-level, for example within the framework of a rural development programme. This would involve a large number of farming households in the project, enabling economies of scale to be made, but possibly complicating the participation process.

In this case, information structures (public/private) and appropriate financing methods would generally be provided by the government.

3.2 Urban Upgrade

This corresponds of Eco-san projects implemented in all existing urban or peri-urban areas of cities and towns in the course of renovation or rehabilitation work. Here, more or less well functioning existing sanitation systems are converted to closed loop systems. This therefore applies to all areas, from informal settlements to luxury multi-story apartment or office blocks, where the existing infrastructure is to be upgraded to Eco-san systems. The implementation of such projects generally tends to be much more complex than those in areas of new development, for several reasons. The use of the existing infrastructure may still be foreseen in the project, which means that eco-san solutions must be built around this system, which may cause a considerable degree of technical difficulty. Private households may also only reluctantly agree to convert their sanitary facilities to Eco-san, as they will most likely have to foot the bill for the changeover. Private investors may also not be willing to participate in such project as there is a considerably smaller opportunity for them to make a profit.

Additionally, these built-up areas may have very little space for the installation of decentralised solutions. Projects in this context may therefore have to adopt a long term approach to the completion of an eco-san system, with innovations being over many years.

The ultimate handling and reuse of the recyclates (faeces, urine, grey water, rain water, storm water, organic waste and energy) is carried out, either only partially or for a particular recyclate, by the householders themselves in an urban context (in vegetable gardens, urban agriculture, for toilet flushing etc). More usually, however, the households may not have the opportunity, or the need, to use the recyclates themselves. In such cases external services providers, working either privately or for the municipality, can be charged with collecting, treating, storing and marketing the recyclates, eventually transporting them to a reuse site, for example in urban parks or to farmers cultivating on the outskirts of the town, for energy production or for producing service water for private or public users.

The initiative for projects of this type can come from a variety of sources. The households concerned may themselves initial the project on a local level, but it can also come from the macro-level, for example in the case of improvement projects for informal settlements implemented by the municipality or the government. The projects in this case address a large number of households, with the degree of support from the authorities such as government/municipality being considerably stronger (regulation, financial support) than from local micro-initiatives.

3.3 New Development Option

This option is to be planned when new dwellings or development areas are being constructed either by the authorities (national, regional or local government) or by private developers. These are normally private businesses, but may sometimes also include citizens groups who wish to build their own homes with provision of ecological sanitation facilities. The dwellings come equipped with Eco-san systems, and these systems are therefore considered from early stage of the planning, facilitating considerably the consideration of all relevant aspects of town planning, land use, (urban) agriculture, water management and so on, as well as their rapid and comprehensive introduction. They are often sold and rented to a relatively well-off section of the population, if the developers themselves do not occupy them. There is however also the possibility of new development areas with closed-loop ecological sanitation systems being constructed specifically for low-income households. Because of the urban location and the favourable planning conditions, all the treatable resources (urine, faeces, grey water, rain water, storm water and organic waste) may be integrated into these sanitation systems.

Depending on the social status and activities of the users of the sanitary facilities, the handling and reuse of the recyclates may proceed in two ways:

They could be collected and treated by a service provider (either private or from the municipality) at a certain cost to the users. The products are then used by a third party (e.g. farmers, city parts etc) who may have to buy and transport the products or The households themselves collects and reuse the recyclates on their own plots of land (gardens/urban agriculture).The initiative to opt for an eco-san system often comes directly from the investor i.e. the private developers or citizens groups or the local, regional or national government and their respective planners.

They should, at the latest, be informed at this point of the principles and operation of their Eco-san system (okoroda 1990) Non-residential.

This covers all Eco-san applications in buildings and areas that are not intended for normal residential use. Examples of these include public institutions, such as schools or hospitals, private establishments, such as banks or offices, as well as hotels or holidays lodges. Projects of this type may address the upgrading or rehabilitation of an existing conventional sanitation system to Eco-san or the construction of a new building with a closed-loop sanitation system. Depending on the circumstances, upgrade or new construct, different levels of technical difficulty may be encountered.

All recycling options are possible in such projects, with the integration of grey water, rainwater and organic waste into the system along with the use of faeces and urine. The handling of the recyclates can be carried out either by the users of the building (e.g. employees, public etc) or service providers are engaged, requiring a marketing and transport of the recyclates to the end users. The decision to use an Eco-san system in this case can be taken at the micro level, if the owners of an individual building, for example a hotel, voluntarily opt for closed-loop sanitation.

Alternatively, macro level decisions, for example that all schools should implement Eco-san or that certain natural resources in a region must be protected, can be taken at government level.

4.0 CONCLUSION

There are four basic ecological sanitation options namely the rural upgrade, urban upgrade, new development upgrade and the non-residential upgrade. Each option suits a particular condition of housing development. For the rural upgrade, farming households, in rural areas, receive support to establish ecological sanitation systems either on their compounds or in their houses. The decision to implement eco-san may result from the initiative of a local None-Governmental Organisation or Community Based Organisation engaged in ecological development.

5.0 SUMMARY

In this unit, we discussed the four basic ecological sanitation options which are the rural upgrade, urban upgrade, new development upgrade and the non-residential upgrade. The rural upgrade is for farming households, in rural areas, the urban upgrade applies to all areas, from informal settlements to luxury multi-story apartment or office blocks, where the existing infrastructure is to be upgraded to Eco-san systems.

New development option is to be planned when new dwellings or development areas are being constructed either by the authorities (national, regional or local government) or by private developers while non-residential option covers all Eco-san applications in buildings and areas that are not intended for normal residential use. Examples of these include public institutions, such as schools or hospitals, private establishments, such as banks or offices, as well as hotels or holidays lodges.

6.0 TUTOR-MARKED ASSIGNMENT

List the four ecological sanitation options and state the difference between the new development option and the non-residential option.

7.0 REFERECES/FURTHER READING

Amadi, A.N (2009). *Modern Environmental Sanitation*. Owerri: Nationwide Printers and Publishing Co Ltd.

Esrey, S. A, Gough, J., Paport, D., Sawyer, R., Hebert, M.S., & Vargas, J. (1998). 'Ecological http://www.eco-san.co.za/product_info.html'.

Okoroda, M.O. (1990). 'Training the Trainers on Ecological Alternatives in Sanitation'. http://www.eco-san.co.za/product_info.html.

UNIT 5 ECO-SAN PROMOTION AND SUPPORT

CONTENTS

1.0 INTRODUCTION

In the last unit, we discussed the basic types of eco-san options but in this unit we will examine some of the critical issues related to promoting and supporting eco-san systems on a large scale. The first two parts discuses the key elements of a participatory user –oriented promotion, education and training strategy. The last part cover the essential institutional arrangement required in developing and back up the community based system. It is important to move away from manipulation of public opinion towards citizen control by sharing knowledge, delegating responsibility and building partnership.

Eco-san systems are more complex than most conventional sanitation systems and usually place more responsibility for appropriate function on individual families and local communities. User must become aware that despite potential health benefits, improper use of any toilet may turn it into a nuisance, threaten public health and pollute environment. (Esrey, 2003).

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- list the basic elements that makes eco-san systems sustainable
- explain promotion strategies
- explain participatory learning
- describe how local and non-governmental organisations can promote ecological sanitation.

3.0 MAIN CONTENT

3.1 Community Empowerment and Promotion

At the house hold level, individuals and families must understand how the eco san system works: what can go wrong, and the commitment and skill to manage it correctly for large scale application. It is also essential that significant part of local community shares this understanding and commitment.

In urban areas, the fundamental issue of eco-san is how to establish a full scale operation. It is one thing to operate scattered eco- san devices spread over a large territory; it is another very different matter to make thousands of eco-san system work properly in densely populated squatter areas. In devising urban eco-san system, a number of critical issues surface. These relate to the safe handling transportation and recycling of the output of eco-san devices.

Ecosan toilets should not be promoted for their own sake, but rather as part of a deeper process of empowering poor, in particular to take charge of their own development. Greater awareness and transformation at individual, group and community levels are more important than improved sanitation- which in fact, will only be sustainable if more profound changes have also taken place.

In order to be sustainable, eco-san system must be based on an understanding of its basic elements and how they are interconnected. These elements were outlined.

The nature that influences and is affected by the system, such as the climate and seasonal variations, the possible impact on water availability and resources and risk of pollution as well as the cultural and behavioural implications of the society in which it operates. The basic characteristic and limits of the process selected, and how to maintain the appropriate condition in order to make it work. The principal characteristics of the device and how to design, build, use and care for it properly.

Where eco-san is an entirely new and unfamiliar concept or technology, a substantial amount of promotion and instruction will be required. Promoting eco-san will be easier when the system does not represent a radical break from the accepted cultural practices. For example, countries that have long standing traditions of using night soil as fertiliser provide strong precedents for improving or expanding eco-san in them.

It is particularly important that women are included in the empowerment and promotion process right from the beginning. Women are the ones responsible for the household's water supply sanitation, hygiene and food preparation. Their views and concern must be expressed and integrated into the programme design as well as in detailed design decisions.

3.1.1 Needs Based Approach

Sanitations programmes should be designed to meet the needs defined by communities and household, rather than promote specific solution as defined by outsiders, needs can vary tremendously. For example, there may be remarkably rapid spread of dehydrating toilets due to environment factors such as acute and low chronic water shortage.

Again where there is high water-table characteristic, the traditional pit toilets are not feasible. Conversely, poverty alleviation through the use of urine for food production has been a primary motivating factor. Water saving has been considered an important secondary benefit.

If a potential user has not identified alternative sanitation as a necessity, and has limited knowledge of how facilities are to be constructed and maintained, the project often fails. The new toilet might end up being used as a storage space; or, in a more serious scenario, a badly-managed toilet can become a serious health hazard.

3.1.2 Promotion Strategies

No matter how effective the eco-san system may seem, its long-term success will depend on the credibility it enjoys with potential users. For the system to become an integral part of local culture it must first be shown to work and it must be acceptable to respected local leaders and opinion makers.

Key families can be a valuable mechanism for introducing eco-san concepts into a community. If these key families are pleased with the toilet, word always spreads quickly. These families should be encouraged to work together and learn from each other by sharing experiences, success and failures. Initially, this mutual support can reduce the risk of ridicule and rejection from other community members.

It is generally best to work through local grassroots organisations that are successful and well-known within the community. Such organisations are usually committed to transforming their communities for the benefit of all the people, and the environment. They might also have begun to analyse problems on a local (and broader) level and to develop ways to overcome them collectively; and they are likely to have the necessary social and political skills to cope with resistance to change within the community.

3.1.3 Technology Selection and Adaptation

When promoting eco-san it is important to offer alternative approaches and encourages the user to select the option most appropriate for their community. To do so, they must have access to full information regarding advantages and disadvantages of each-including the long-term implications for health and the environment.

The dehydrating and composting eco-san toilets systems should be promoted as viable long-term alternatives to conventional water-borne systems, not as intermediate' technology. It is important to involve local users in a pilot phase through which the new system is tested and modified to fit local cultural practices and environmental conditions. Long-term success and sustainability of the program will depend upon the effectiveness of this usage.

Finally, setting up demonstration toilets in public spaces, as at a school or near a clinic, frequently leads to failure, as generally no one takes clear responsibility for public toilets. This risk is further magnified in the case of eco-san toilets, which require even more user awareness and maintenance than conventional pit toilets.

3.1.4 Phasing the Programme

The history of technology transfer has many example of programme that went wrong when planners or politicians tried to go too fast without

adequate attention to user participation and understanding. Eco-san is no exception.
It is advisable to begin with experimental small-scale pilot projects through which different eco-san devices may be assessed. During the demonstration phase the social aspects of the approach can be refined while demonstrating to a broader audience that the technology works.

Finally, there needs to be regular follow-up to monitor experimental aspects and to ensure that necessary adjustments and modifications are made.

3.2 Education and Training of Eco-san Facilitators and Communities

To ensure that the people involved acquire the necessary commitment and capacity to set up, operate and maintain an eco-san system, it is usually necessary to recruit and prepare a cadre of eco-san facilitators or promoters. These people can be either community or institutional based and voluntary or paid. Frequently, they will be attached to programmes that are primarily oriented towards other areas, such as water, health, agriculture or environment. In fact, multidisciplinary and inter-ministerial team can be most effective for establishing sustainable eco-san programs and should be encouraged.

To equip the team of eco-san facilitators adequately a balance of three complementary educational strategies should be considered: participatory learning, sharing information and skills training. The degree of emphasis towards one approach or another will depend upon the specific culture or circumstances. For example, the use of participatory learning methods will be essential where urine diversion and the concept of recycling are unfamiliar or unacceptable. On the other hand, highly motivated cultures, with few or no basic resistances or taboos related to urine diversion or recycling of human excreta, may simply require information on the options available and specific skills training on how to construct the units and monitor their operation. Whatever the combination, it is especially important to maintain a holistic, interdisciplinary approach which will permit the users to integrate eco-san into their local culture and lifestyle.

3.2.1 Participatory Learning

The effective use of participatory methods can be vitally important to the success of eco-san programmers, as well as to hygiene and sanitation programs in general. These methods involve users in the overall identification of problems and finding solution, and in monitoring health and environmental impact. User participation is essential to make necessary adjustments to the system.

Participatory methods can also improve communication both within and between the community and support agencies. Individuals and communities have unique identities and ways of functioning, which change agents must listen to, understand and respect. Effective implementation requires a balance between local, traditional knowledge and outside expertise. Another advantage of participatory approaches is their potential for stimulating the self-confidence and creativity of the community members.

An important output of this participatory leaning process can be the formation of the an inter-institutional team of trainers, who can take the lead in promoting participatory methods; train staff from other institutions, as well as other sectors; and adapt and produce innovative, participatory leaning materials.

3.2.2 Sharing Information

Informed, knowledgeable people adopt and sustain behavioural change. Also, access to relevant information leads to sound community decision. The exchange of the relevant information is accelerated through participatory process and social networks. Mass communication (e.g. radio) and social marketing methods can add to the information contained in traditional knowledge systems, public endorsement institution, NGOs and private entrepreneurs.

The name given to a device or system will influence its perception as desirable or undesirable. For example, it is important to use the word 'toilet' in referring to eco-san devices, since common usage equates 'latrine' with a smelly outhouse at the back of the garden. For similar reasons, the term 'waste' should also be avoided. The wise promoter will avoid using such negatively loaded words.

3.2.3 Skills Training

The successful implementation of an eco-san programme requires changes in users' sanitation-related beliefs and practices, as well as in public officials' way of thinking. Large-scale eco-san urban systems, in particular, require appropriate training at various levels:

i. Key local authorities and field staff must be properly trained in the principles, technical solutions, comparative advantages and limitations of eco-san systems.

ii. Field workers will require practical training concerning the construction and management of the eco-san system, as well as empowerment methods.

iii. Household and community members must require skills in building, operating and maintaining eco-san devices.

iv. The learning by-doing approach should include participatory seminars, workshops and meetings, as well as broader hands-on training.

The promotion of eco-san system provides a unique opportunity to increase hygiene awareness. Operation and maintenance of dehydrating toilets, in some countries, has been remarkable in communities where sanitation programmes combine information on healthy practices with demonstration projects, user's participation in choosing sanitary devices, and targeted actions to reinforce new habits. In communities where training of household members in the management of their sanitation facilities has been neglected, sanitation continues to be poor.

3.3 International Framework

Various types of instructions need to be involved in promoting and supporting, eco-san system. The specific arrangements vary a great deal depending upon the local and national context. In some countries, the programmes evolve almost entirely through the official government structures; in others, the commercial sector and/or NGOs tend to take the lead.

3.3.1 Local and Non-governmental Organisations

Decentralised eco-san systems frequently rely on local organisations to promote, build, monitor and evaluate facilities. Their knowledge of local conditions, particularly household habits, is essential for promotion and management. Moreover, these organisations have the power to bring in new practices, survey household performance, mobilise local resources and influence the conduct of community members.

Incentives and sanctions exerted by local religious or political Organisations can be vital assets in promoting and managing eco-san systems. If a large number of people belong to one particular religious sect endorsement a new approach to sanitation it can lead to a high level of acceptance and sustainable maintenance.

Trusted local organisations can help to encourage communities to adopt non-conventional approaches-even when those choices do not fit the households' initial aspirations. Appropriate long-term operation and maintenance of facilities require active involvement of community organisations.

Local and international NGOs are often ideal for promoting eco-san approaches, particularly during the early experimental and pilot phases. NGOs often enjoy ample contact and confidence with communities and have the flexibility to adapt their approaches and technologies to user needs.

3.3.2 Government and Official Bodies

Strong government commitment to eco-san is necessary, particularly in urban areas where the legal regulatory framework can be a decisive factor in the construction of sanitary systems. Although effective introduction and use of eco-san system depend to a great extent on community-based initiatives, central and local government involvement is needed to expand and sustain the approach. Community based solid waste management programmes prospects of sustainability and reliability will be greater if there is a high political will and government regulation that clearly supports community based efforts.

3.3.3 Commercial and Private Sector

Independent contractors and consulting groups have a straightforward economic incentive to see that their products or services are accepted and in demand. In fact, going a step further, people have suggested that one of the keys to longer term sustainability of eco-san systems is to strengthen the link that exists between the scale community oriented workshops that constructs the urine-diverted toilet seats and the masons.

3.3.4 International Development Organisation and Donors

In addition to their role as potential founders of innovative pilot sanitation programmes, international organisations can help to influence government officials and to formulate a favorable policy framework. UNICEF, for example, has played an important role as a channel for external funds and in aiding co-ordination between institutions, training and technical assistance. Similarly, Greenpeace has helped to bring about change in programme that has worked globally-particularly in starting and supporting technical research and development, and networking.

3.3.5 Technical Schools, Research Institutions and Professional Associations

Research institutions and technology centres can be vital in testing, adapting and monitoring the quality of new technologies and their operation. For example, Cemat in Guatemala played a central role in introducing and adapting the Vietnamese double-vault composting toilet to Central America.

As projects mature, more attention tends to be given to influencing sector policies and standards through training technical personnel and gaining support from professionals associations, e.g. architects, engineers, environmental health officers and agriculturalists. In urban programmes in particular, it is advisable to think out a strategy for involving these instructions early on.

3.3.6 Integrated Strategies and Partnerships

Some of the strongest eco-san programmes have developed strategies for involving several levels of institutions simultaneously. For example,

i. Local and international NGOs week at the urban and grassroots levels.

ii. The Ministry of Health can be at the forefront of research and development, training and promotion.

iii. UNICEF, funding has helped to bring about a change.

iv. Provision of technical guidance and co-funded international seminars and training courses.

v. In urban settings, in particular, responsibilities must be clearly defined. If necessary, a system of incentives and sanctions will have to be agreed upon and enforced.

4.0 CONCLUSION

In conclusion, we have discussed the promotion and support of ecological sanitation. There are various approaches and strategies that can be used in the support and promotion. Education and training of eco-san facilitators and communities as well as community empowerment are very crucial in eco-san promotion and support. We also identified that technical schools, research institutions and professional associations can be vital in testing, adapting and monitoring the quality of new technologies and their operations.

5.0 SUMMARY

In summary, this unit discussed the promotion and support of ecological sanitation. This was highlighted under, community empowerment, education and training of eco-san facilitators and communities, and international frame work. Issues like needs approach; promotion strategies, technology selection, and phasing the programme were discussed under community empowerment and promotion. Also, participatory learning, sharing information, and skills training were discussed under education and training and lastly local and non-governmental organisations, government and official bodies, commercial and private sectors, international development or donors, and technical schools, research institutions and professional associations are some of the issues raised under international framework.

6.0 TUTOR-MARKED ASSIGNMENT

Under ecological sanitation support and promotion, write short notes on:

1 Participatory learning
2 Phasing the programme.

7.0 REFERENCES/FURTHER READING

http://www.ruaf.org/system/files?file=Ecological Sanitation - Closing the Loop.pdf.

http://www.lboro.ac.uk/well/resources/fact-sheets/fact-sheetshtm/ Ecological%20sanitation.htm.

http://www.lboro.ac.uk/well/resources/Publications/Briefing%20Notes/ BN27%20Ecological%20sanitation.htm.

MODULE 2 TYPES OF TOILETS IN ECOLOGICAL SANITATION

UNIT 1 THE DOUBLE VAULT DEHYDRATING TOILET

1.0INTRODUCTION

In the last two units of module one, we discussed the basic types of eco-san options and examined some of the critical issues related to promoting and supporting eco-san systems on a large scale. In this unit, we are to discuss some Eco-san dehydrating toilets. When something is dehydrated all the water is removed from it, in a dehydrated toilet the contents of the processing vault are dried with the help of heat, ventilation and the addition of dry material. The moisture content should as quickly as possible be brought down to below 25%. At this level, there is a rapid pathogen destruction, no smell, and no fly breeding.

The use of specialised collection devices (squatting pans or seat risers), which divert urine for storage in a separate containers, allows the faeces to be dehydrated fairly easily as discussed previously. Since urine contains most of the nutrients but generally no pathogens, it may be used directly as a fertiliser without the need for further processing. It is generally difficult to dehydrate excreta without urine diversion, although in extremely dry climates this is possible. Very good examples of an ecological sanitation system based on dehydration are the double-vault dehydrating toilets designed in Vietnamese and also of Central American. These are discussed in this unit.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- describe double vault dehydrating toilet
- describe how the toilet work
- point out some advantages of these toilets
- sketch a double vault Vietnamese toilet processing chamber.

3.0 MAIN CONTENT

3.1 The Double Vault Dehydrating Toilet Designed in Vietnamese

This is one of the dehydrating toilets commonly found and designed in Vietnamese. When properly managed it is highly effective.

3.1.1 Design/Construction

The Vietnamese toilet consists of two processing chambers each with a volume of about 0.3 cubic metres.

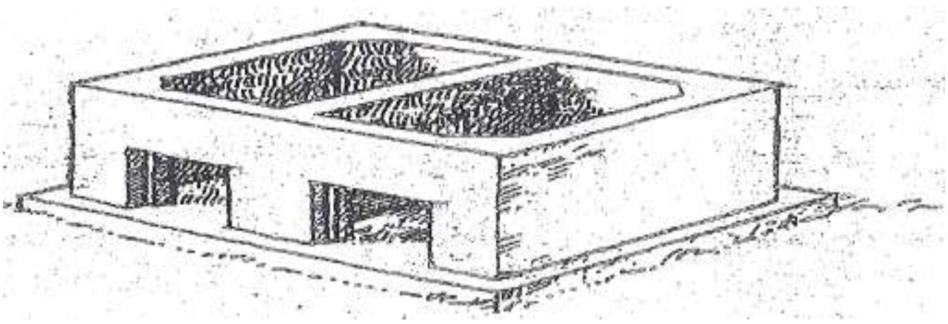

Fig.1: The Processing Chamber of the Vietnamese Double-vault Toilet (Esrey, *et al.*, 1998)

Each Vault is 0.8×0.8×0.5 meter. The picture also shows the two 0.3×0.3 meter openings for removal of dehydrated material.

SELF-ASSESSMENT EXERCISE

Look at figure 1 above and make a sketch of the processing chamber and indicate the dimensions of the vault and openings in your sketch.

The toilet is built entirely above ground with the processing chambers placed on a solid floor of concrete, bricks or clay. The floor is built up to at least 10 cm above ground so that heavy rains do not flood it.

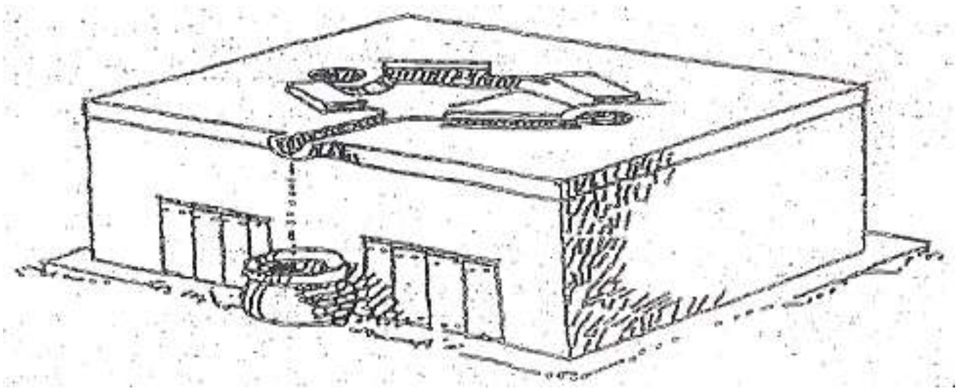

Fig.2: The Processing Chamber Provided with a Squatting Slab for Urine Diversion, a Pot for Collecting Urine and Lids for the Removal of Dehydrated Material (Esrey, *et al.*, 2003)

The drop hole not in use is closed with a stone and sealed with mud or mortar.

The processing chambers are covered with a squatting slab that has two drop holes, foot-rests and groove for urine. Both holes have tight-fitting lids. At the back there are two opening, 30×30cm, for the removal of the dehydrated materials. These openings are kept sealed until it is time to empty one of the chambers.

3.1.2 How the Toilet Works

People excrete in one of the chambers. Before the vault is used for the first time, the household members cover the floor with a layer of powdered earth. The purpose of this earth is to absorb moisture from the faeces and to prevent them from sticking to the floor. After each use, people sprinkle two bowls of ashes over the faeces. The ashes absorb moisture, neutralize bad odours and make the faeces less attractive to flies.

Urine drains away through the groove in the slab and collects in a jar behind the toilet. Paper used for anal cleaning is dropped in box or jar and burnt. Thus in the receptacle there are only faeces, ashes and soil. The content is therefore fairly dry and compact. The jar for collection of urine can be placed in position either empty or partly filled with water, lime or ashes. The urine or the urine-soaked ashes are used as a fertilizer.

The first vault can be used for about 2 months by a household of 5-10 persons. When it is two-thirds full, someone in the household levels the content with a stick. He or she then fills the vault to the brim with dried, powered earth, and seals the vault. All openings are tightly closed with lime mortar or clay. The other vault now comes into use instead. When after another two months the second vault is nearly full, he or she opens and empties the first vault. The dehydrated faeces, now odourless are used as fertiliser.

SELF-ASSESMENT EXERCISE

What do you think are the benefits of this toilet system? List them.

The Double-Vault Dehydrating Toilet designed in Central America is a slightly modified version of the Vietnamese toilet. It was introduced into Guatemala in 1978 by Cemat and over the past 20 years, thousands of units have been built in Central America, particularly in El Salvador. A similar development has taken place in Mexico where the system is also highly promoted.

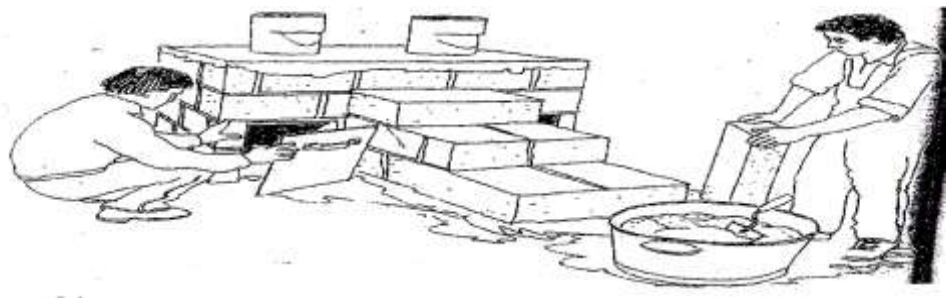

Fig.3: A Toilet Construction, on Top of Each Vault is a Seat Riser with a Urine Collector. The Seat Riser not in Use is usually covered with a Plastic Bag (Esrey, *et al.*, 2003)

3.2.1 Design and Construction

Like the Vietnamese original, the Lasf toilet consists of two chambers built above ground, each with a volume of about 0.6 cubic metres. From the collector the urine flows via a pipe in soakpit under the toilet chambers. The faeces fall straight down into the processing vault. After using the toilet the user sprinkles some dry mate like ashes, soil or a soil/lime or sawdust/lime mixture over the faeces. The paper used for anal cleaning is placed on special container next to the seat-riser and burnt. The vault thus receives only faeces and ashes (or whatever dry material is used). Every week the contents of the vault are stirred with a stick and more ashes added.

3.2.2 How the Toilet Works

When the first vault is nearly full it is topped up with soil and the seat closed. The second vault is now used. A year later or when the second is nearly full, the first one is opened. A household of 5-6 persons will produce almost half a cubic metre of dehydrated completely odourless material per year. The Lasf toilet is usually attached to house, sometimes even placed inside the house.

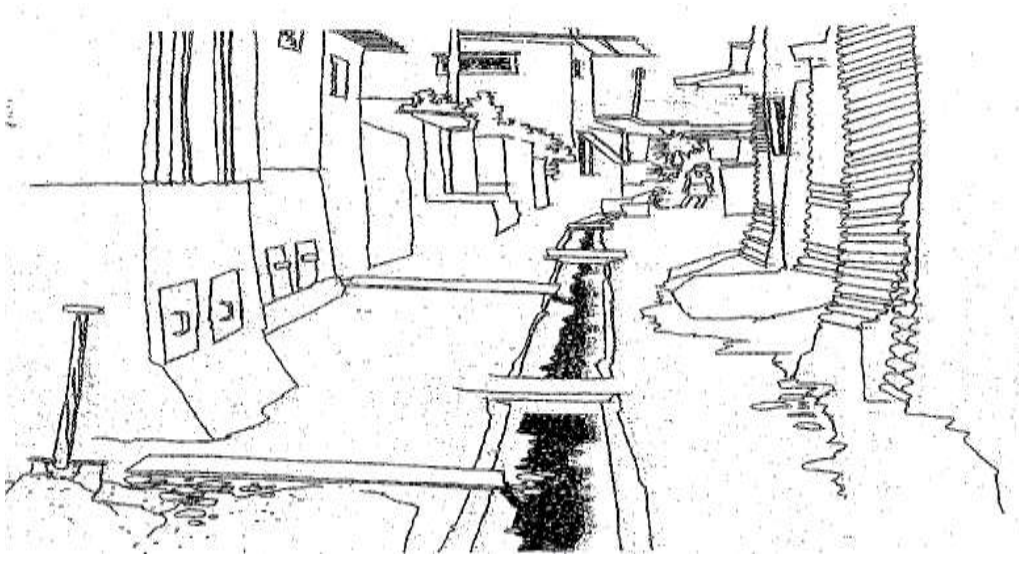

Fig.4: A High Density Squatter Area Showing Household Toilet Attached to, or Placed Inside the House (Esrey, *et al.,* 2003)

There are no bad odours from the toilets and no fly-breeding in the processing chambers. The dry mixture from the toilet is used to reclaim wasteland or put in bags and sold.

Fig.5: A Version of the Vietnamese Double Vault here Built into a Bathroom in a Modern High Standard House (Esrey, *et al*., 1998)

The toilet has a movable seat riser with urine collector. The processing chambers below the bathroom floor are accessible from outside the house. If properly managed there are no smell and no fly breeding in these toilets. They seem to work particularly well in the dry climate.

Where the system is not well managed there will be wetness in the processing chamber, odours, and fly breeding.

4.0 CONCLUSION

In conclusion, the Vietnamese double vault dehydrating toilet and the double-vault dehydrating toilet in Central America are ecological sanitation toilets based on dehydration. If properly managed they are highly effective, no smell no fly breeding and their end products can be used as fertilizer for some crop production. They are recommended in dry climate. A household of 5-6 persons will produce almost half a cubic metre of dehydrated completely odourless material per year.

5.0 SUMMARY

In this unit, we discussed the Vietnamese double vault dehydrating toilet and the double vault dehydrating toilet in Central America. The unit covered the design and construction of these toilets. Many sketches to illustrate the design were shown and the working mechanisms were discussed. This unit must have added something to your knowledge.

6.0 TUTOR-MARKED ASSIGNMENT

Sketch the processing chamber of Vietnamene double vault dehydrating toilet showing a squatting slab for urine diversion and a pot for collecting urine.

7.0 REFERENCES/FURTHER READING

Esrey, S. A., Anderson, & Ingvar. (2003). "Closing the Loop– Ecological Sanitation for Food Security."

Esrey, S. A, Gough, J., Paport, D., Sawyer, R., Hebert, M.S., & Vargas, J. (1998). *Ecological Sanitation*. Stockholm: Swedish International Development Agency.

UNIT 2 THE EKOLOGEN DEHYDRATING TOILET, TEEPAN SOLAR HEATED TOILET AND THE DOUBLE-VAULT SOLAR HEATED TOILET

CONTENTS

1.0 INTRODUCTION

In this unit, we are going further to discuss other types of dehydrating toilets. The use of specialised collection devices such as squatting pans or seat risers, which divert urine for storage in separate containers, allows the faeces to be dehydrated fairly easily as pointed out in unit 6. Since urine contains most of the nutrients but generally no pathogens, it may be used directly as a fertiliser without the need for further processing. It is generally difficult to dehydrate excreta without urine diversion, although in extremely dry climates this is possible. Here is the discussion on the Ekologen, Teepan solar heated and Double vault solar heated dehydrating toilets. The Ekologen, type of eco-san system was developed by professor Wolgast Mars, Karolinska Institute, Stockholm, Sweden, in the early 80s. The system is therefore called WM Ekologen, named after the founder.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- describe the WM Ekologen, Teepan solar heated, and Double vault solar heated dehydrating toilets
- describe how these toilets work
- point out some advantages of these toilets.

3.0 MAIN CONTENT

3.1 The WM Ekologen Dehydrating Toilet

Like the Vietnamese system it relies on a process of dehydration and is designed for urine diversion.

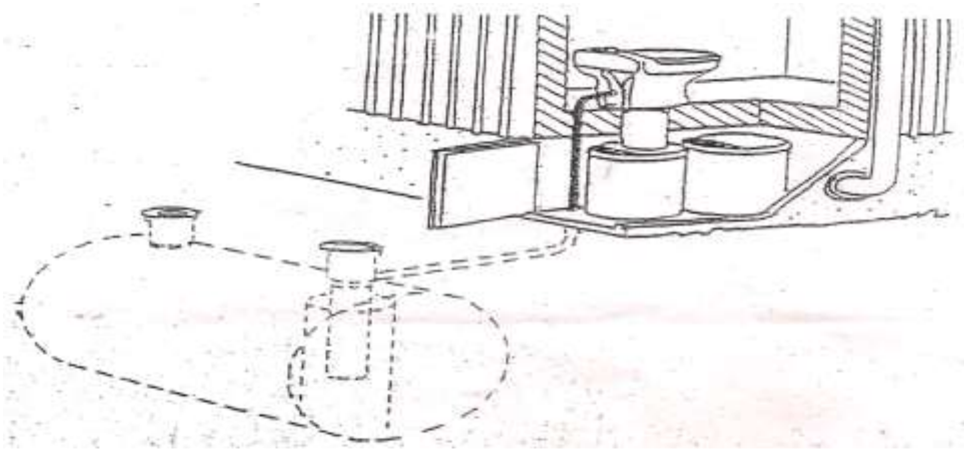

Fig.1: A Dehydrating Type of Toilet Ekologen, Faeces and Toilet Paper are Dropped into a Large Bucket. Urine is Piped into an Underground Storage Tank (Esrey, 2003)

Urine is flushed into an underground storage tank with 0.1 litre of flush water. The volume of the tank is 0.5 cubic metres per person. Faeces and toilet paper drop down into an insulated vault where it is collected by an 80 litre plastic containers. When the container is full (after 2 to3 months) it is put aside and an empty container is placed under the toilet. The full container is left in the vault for about 6 months. The dehydrated contents can then be further treated (secondary treatment) in a ventilated compost bin (for the toilet paper to decompose) or burnt.

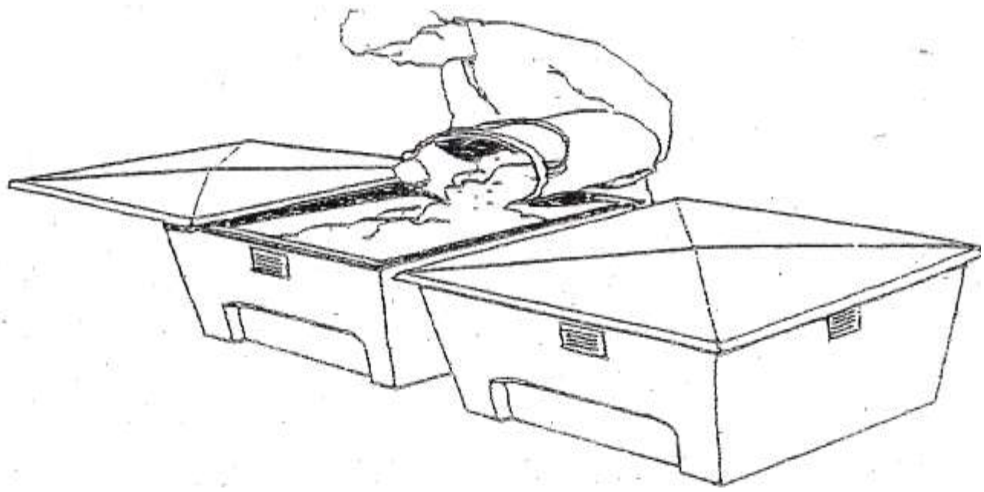

Fig.2: The Dehydrated Content of the Buckets are Transferred to Composting Bases for Secondary Treatment (Esrey, *et al*. 1998)

The WM Ekologen is a Well Tested, High standard system suitable for Indoor use in Modern Bathroom. It is used in Urban as well Rural Areas and in Institutions as well as Private Household.

3.2 The Teepan's Solar Heated Toilet

The greatest risk of failure with a sanitation system based on dehydration is wetness, as pointed out earlier. By adding a simple solar heater to the processing vault the risk of wetness can be reduced. After some early experiment with solar heated toilet in Tanzania the concept was further developed in Mexico and more recently in El Salvador and Vietnam. The purpose of the Teepan project in El Salvador 1994-97 was to rest and develop a sanitation system based on dehydration, urine diversion and solar heating in a single-vault device.

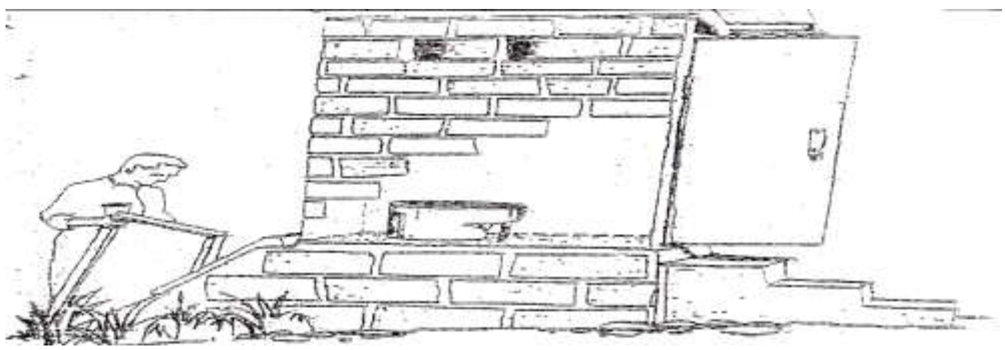

Fig.3: The Dehydrating Toilet that has a Solar- heat Collector to Increase Evaporation from the Processing Chamber (Esrey, *et al.* 1998)

The toilets are used in the same way as regular Lasf toilets. The input into the processing vault consist of human excreta and wood ash/or a soil/lime mixture in a proportions of 5:1. Urine is piped into a small soak pit near the toilet because human urine is usually not used as fertilizer in Central America, but for countries that use urine, it is collected and used for fertilizer. Toilet paper is placed in a box or bag kept next to the seat-riser and burn periodically.

Every 1 or 2 weeks the lid acting as solar-heat collector is removed and the pile of faces combined with ash/lime/soil accumulated below the toilet seat is shifted to the rear of the vault with a hoe or rake. Once every second or third month the dry odour free pile at the rear of the vault is shovelled into a sack and stored outside the toilet until recycled in the garden.

Some of the units have been equipped with a “pusher” to make it possible to shift the pile to the rear of the processing vault, see figure 10. The Teepan toilets are functioning very well. The solar heater accelerates the dehydration process. Most of the test units are completely dry and odour free and there is no fly breeding.

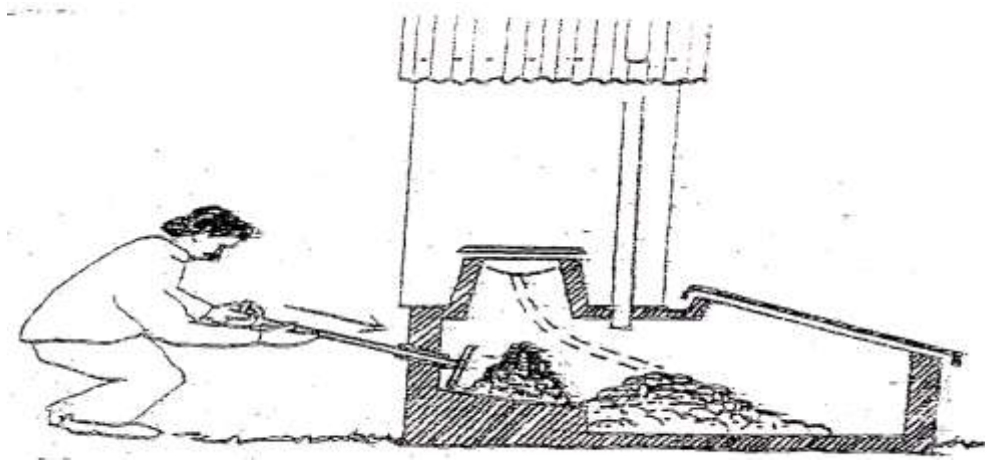

Fig.4: A Few Times a Month a Fixed Pusher is Used to Shift the Pile of Faeces and Ash from Below the Toilet Seat into the Solar Heated Processing Chamber (Esrey, *et al.*, 1998)

The building cost of a single vault device is less than that of a double-vault but makes it necessary to shift the pile every one or two weeks. This shifting of the pile probably facilitates the dehydration process.

3.3 The Double-Vault Solar Heated Toilet

This type of dehydrating toilet is common in Ecuador. Because of the dry atmosphere in this region there has been no need to develop techniques for urine diversion. After each use a handful of sawdust and/or ash is added. Each vault is used for 6 months before switching to the other vault. Each vault has a lid made of a wooden frame covered with thin galvanised iron painted black in order to absorb the sun's energy and assist the dehydration process. The chamber are ventilated by a vent-pipe and the vault lids each include a vent to let air in. the vent-pipe and the lid-vents are covered with metal fly-screen mesh.

The toilets are built from sun-dried mud bricks made on-site, combined with prefabricated wooden elements; seat-riser, lid for the toilet hole, vent-pipe and a door.

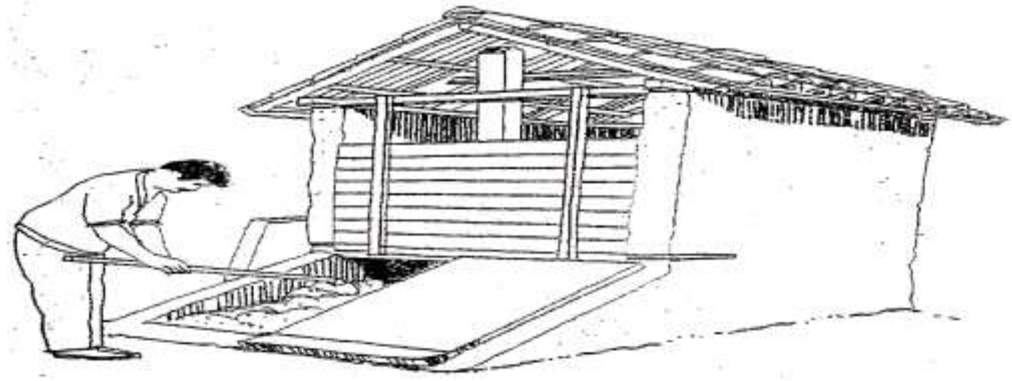

Fig.5: Double Vault Toilet with Solar Heater (Esrey, *et al.,* 1998)

Experience shows that extremely dry climate creates conditions which eliminate the need for urine diversions as well as solar heat collector (which originally were added in a humid climate in an attempt to speed up the evaporation from the processing vault).

4.0 CONCLUSION

In conclusion, the WM Ekologen dehydrating, Teepan solar heated and the Double-vault solar heated toilets are dehydrating toilets. They all work by provision of urine diversion process. Where the climate is extremely dry, urine diversion may not be necessary because the condition can facilitate evaporation. If properly managed they are highly effective, no smell, no fly breeding and their end products can be used as fertilizer for some crop production. They have been in use in Ecuador, Sweden and Teepan community outside San Salvador. It can also be practiced in our country Nigeria.

5.0 SUMMARY

In summary, this unit looked into three other ecological sanitation toilets based on dehydration. They are the WM Ekologen dehydrating toilet, Teepan solar heated toilet and the double-vault solar heated toilet. Their working mechanism and designs were described. We also noted some drying agents which can facilitate dehydration and their various retention periods in the vault and number of households that can use them during such period.

6.0 TUTOR-MARKED ASSIGNMENT

1. List 3 common characteristics of the three toilets discussed in this unit.

2. Briefly write on Teepan solar heated toilet.

7.0 REFERENCES/FURTHER READING

Esrey, S. A., Anderson & Ingvar. (2003). "Closing the Loop– Ecological Sanitation for Food Security."

Esrey, S. A, Gough, J., Paport, D., Sawyer, R., Hebert, M.S., & Vargas, J. (1998). *Ecological Sanitation*. Stockholm: Swedish International Development Agency.

Harmer, M.J. (1986). *Water and Waste Water Technology, SI Version*. (2nd ed.) New York: John Eily and Sons.

UNIT 3 THE INDOOR LONG-DROP DEHYDRATING TOILET, THE INDOOR DEHYDRATING TOILET, THE CLIVUS MULTRUM SINGLE-VAULT COMPOSTING TOILET, THE 'CAROUSEL' MULTIPLE – VAULT COMPOSTING TOILET

CONTENTS

1.0 INTRODUCTION

In unit 2, we discussed three different designs of eco-san dehydrating toilets. In this unit, we are going further to discuss two dehydrating toilets and two composting toilets. Like any other eco-san toilets effective management is highly essential whether dehydrating or composting type.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- describe the indoor long drop dehydrating toilet
- describe the Clivus Multrum single-vault composting toilet
- point out some differences between the dehydrating and composting toilets.

3.0 MAIN CONTENT

3.1 The Indoor, Long-drop Dehydrating Toilet

In this type of eco-san toilet, the urine drains away from the squatting slab to a groove in the stone floor. From there it goes through an opening in the wall of the house, down a vertical drainage surface on the outer face of the building. Most of the urine evaporates on its way down the drainage surface and the rest, if any, is drained into a soakpit.

The faeces drop through the squatting hole, down the shaft, to a vault where the dried faeces are periodically collected, further dried on the roof of the neighbourhood public bath and finally used as fuel for heating water. Anal cleaning takes place on a pair of square stones next to the squatting slab. The water used for anal cleaning as well as bath water is drained in the same way as the urine. No liquids are thus led into the long drop shaft or the vault below. If this toilet is installed in a hot, dry climate, the faeces quickly dry out.

This is an example of the eco-san approach to sanitation applied to an urban situation with multi-storey housing and communal collections of dehydrated faeces by special staff. It also an example of a dry sanitation system used in a culture where people are washers. It is a traditional system and has been used in the towns like Yemeni for hundreds of years. There is no smell and no fly-breeding. Urine and cleansing water are evaporated and faeces are processed in three steps. First, they are dehydrated on site, second they are further dehydrated and subjected to direct solar radiation at the public bath and finally they are burnt.

3.2 The Indoor, Dehydrating Toilet

If this type of toilet is situated in a hot and dry climate it is possible to dehydrate the faeces without prior diversion of urine.

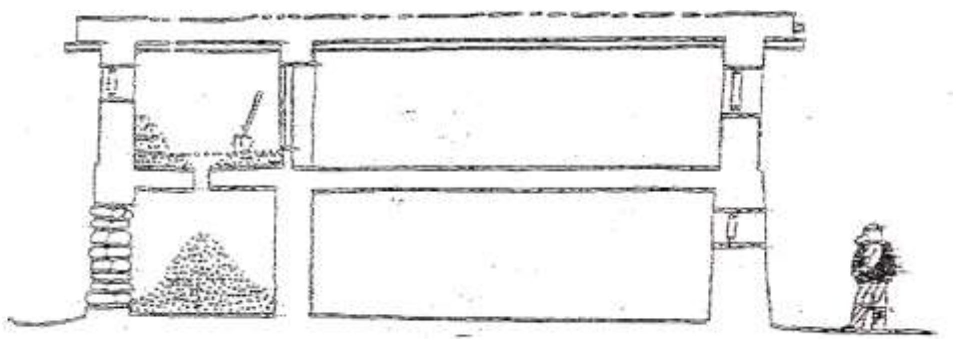

Fig.1: Indoor Dehydrating Toilet (Esrey, *et al.*, 1998)

Figure 1 shows that on the floor of a small room next to the kitchen/living room there is a thick layer of soil from the garden. In the floor a drop hole leads to a small ground-floor room. This room can only be reached from the outside. People excrete on the soil which is on the floor. Then they push soil and excreta together down the drop hole.

Urine goes the same way. Ashes from the kitchen are added from time to time. The household members bring loads of soil into the room when necessary. For the long winter a supply of soil is piled into one corner of the toilet room. A spade or shovel is also kept in the room. Normally there is no anal cleaning. Then later decomposed excreta are removed and spread on the fields.

As long as the toilet is well maintained and enough soil is pushed down the drop hole every day, there are no odours. In some, there is a faint smell of ammonia from urine splashed on the soil-covered floor of the toilet room. There is no fly breeding due to the dryness of the soil/excreta pile. The system has worked well in rural areas for hundreds of years but there may be some problems where households have no easy access to soil.

3.3 The Clivus Multrum Single-vault Composting Toilet

It is a single vault composting toilet with combined processing of urine, faeces and organic household residues. It consists of a composting vault with a slanting floor air conduits and it lower end a storage space. A tube connects the toilet seat-riser with the receptacle and there is often a special chute for kitchen refuse. There is a constant draught due to natural convection from an air intake in the composting vault, through the air conduits and out via a vent pipe.

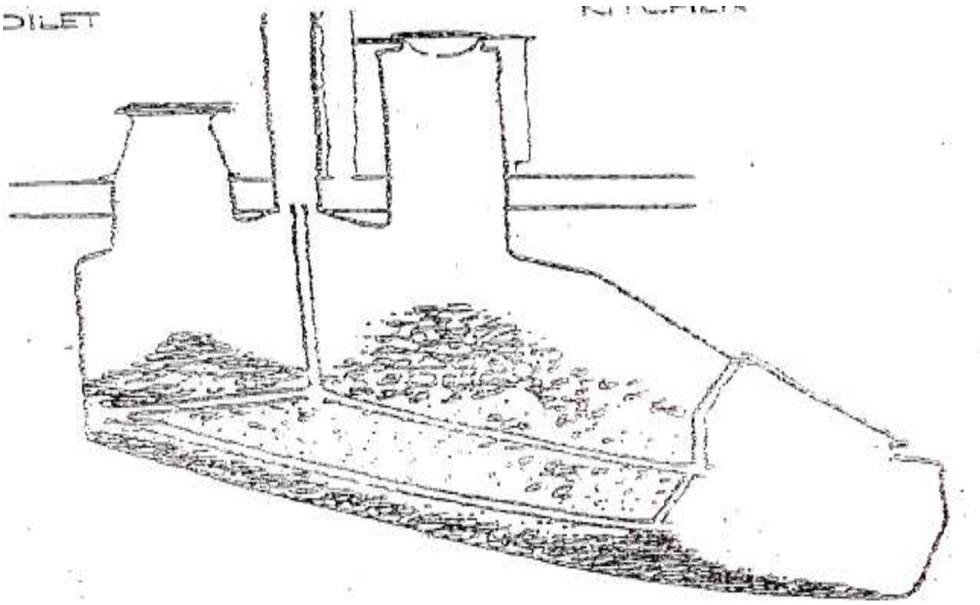

Fig.2: Clivus Multrum Composting Toilet Placed in the Basement of a House (Esrey, *et al.*, 1998)

This model has a separate chute from the kitchen for food left-over. Perforated pipes bring air into the centre of the compost pile. Into the multrum go not only faeces, toilet paper and urine but all kinds of organic kitchen and household residues: vegetable and meat scraps, peelings, bones, eggshells, floor sweeping, sanitary napkins and grass clippings (but not cans, glass, plastic or large amounts of liquids of any kinds).

In figure 1, because the floor of the multrum slopes, the contents are slowly sliding down from the fresh deposits at the upper end down to the storage part of the vault. The process of decomposition reduces the heap to less than 10% of the original volume. The owner must provide a starter bed covering the floor of the composting vault before using the multrum the first time. The bed consists of a 0.4-metre thick layer of peat moss and a 0.2-metre layer of garden soil rich in humus. You should first mix this soil with grass cuttings. The purpose of this bed is to absorb liquid for the oxidation of urine. The heap gradually becomes humus: a black, lumpy, substance similar to good garden compost. It may take 5 years until a household has to take out the humus for the first time. After that, they may have to take it out once a year (the large part of the receptacle is never emptied. Only material that has passed under the partition separating the storage vault from the rest of the receptacle is removed.) The amount of humus produced varies from 10 to 30 liters per person per year. The maximum number of users depends on factor such as temperature, humidity, amount and type of refuse, proportion of urine to faces, and volume of the receptacle. In most cases the maximum for one Clivus Multrum is regular, year – round use is 8 – 10 people.

The humus from the Clivus Multrum has a similar bacterial content to soil conditioner. Nowadays, Clivus Multrums are used not only in weekend houses but also in regular houses, in institutions and as public toilets. Multrum has a container for liquid storage below the composting vault. If the Multrum is properly built and looked after well, then it is reasonably nuisance free. Because there is no diversion of urine and because of the slanting floor there is a risk, except in very dry climate, that liquid accumulated at the lower end of the composing vault.

3.4 The 'Carousel' Multiple – vault Composting Toilet

The 'Carousel' has long been one of the most popular composing toilets, The design of the 'Carousel' features a below – the – floor processing vault consisting of a cylindrical outer tank in which a slightly smaller inner tank is able to rotate on a pivot. The inner tank is divided into four chambers and may be more on some models. The one in use is positioned directly below the drop chute from the toilet in the bathroom. When a chamber is filled, the inner tank is rotated so that the next chamber is positioned below the toilet. In this way each chamber is filled in sequence. The system is designed so that it will take at least a year for the entire unit. After this chambers to be filled when use is within the material in the oldest one is removed through an access door in order to make room for fresh material. Liquid drains through holes at the bottom of the inner tank into the outer one, where it may be evaporated or discharged into an evapo – transpiration bed.

The carousel is basically a multi – vault toilet. As such it effectively keeps fresh and sanitised faces separate. The same effect can be achieved as a much lower cost by using a series of collection buckets shifted manually instead of a rotating tank.

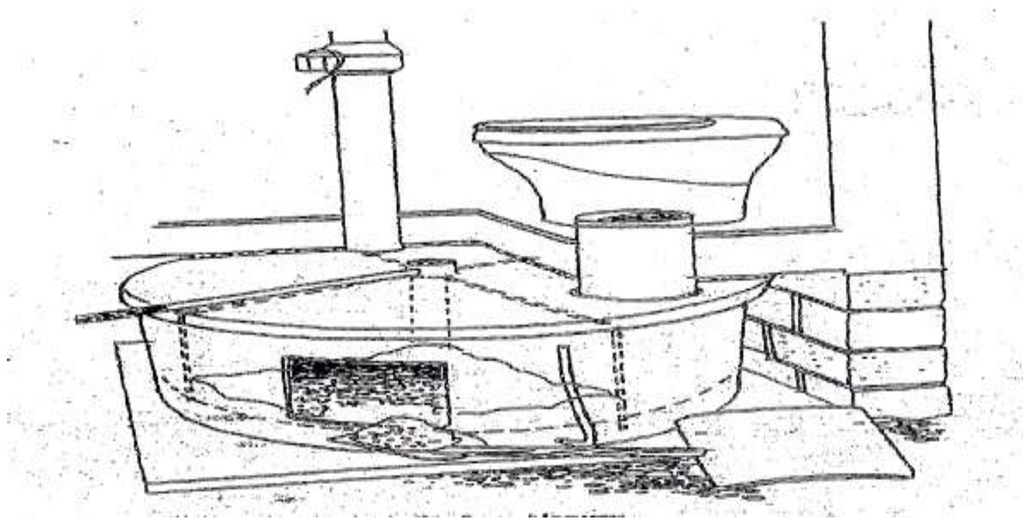

Fig.3: The Carousel Composting Toilet (Esrey, *et al.*, 1998)

4.0 CONCLUSION

In conclusion, both dehydrating and composting toilet can be very effective if properly managed. If the Multrum is properly built and looked after well, then it is reasonably nuisance free. Because there is no diversion of urine and because of the slanting floor there is a risk, except in very dry climate, that liquid accumulated at the lower end of the composting vault. Both composting and dehydrating toilets can be designed as multiple vault or single vault toilets. You can now describe any of the toilets discussed above. Can you? Answer the question below: Which of these eco-san toilets described in this unit would you recommend to your friend in a rural village? Give reasons.

5.0 SUMMARY

In summary, we discussed in this unit two types of dehydrating toilets: the indoor, long-drop dehydrating toilet and the indoor dehydrating toilet. Also discussed are two composting toilets: the Clivus Multrum single-vault composting toilet and the 'Carousel' Multiple-vault composting toilet.

6.0 TUTOR-MARKED ASSIGNMENT

1 State the functions of the following in the Clivus Multrum toilets:
2 Mixture of grass and soil.
3 Organic kitchen and household residues.
4 Perforated pipes.

7.0 REFERENCES/FURTHER READING

Esrey, S. A., Anderson & Ingvar (2003). "Closing the Loop – Ecological Sanitation for Food Security."

Esrey, S. A, Gough, J., Paport, D., Sawyer, R., Hebert, M.S., & Vargas, J. (1998). *Ecological Sanitation*. Stockholm: Swedish International Development Agency.

Morgan, P. (2004). *An Ecological Approach to Sanitation in Africa: A Compilation of Experiences*. Zimbabwe: Aquamore.

Jenssen, P. D. (2004). *Ecological Sanitation and Reuse of Wastewater: A Think Piece on Ecological Sanitation*. Norway: The Agricultural University of Norway, Norway.

UNIT 4 'SIRDO SECO' SOLAR HEATED COMPOSTING TOILET, THE MOVABLE BIN TOILET, THE CENTRE FOR CLEAN DEVELOPMENT (CCD) TOILET, ARBORLOO, FOSSA ALTERNA, AND SKYLOO

CONTENTS

1.0 INTRODUCTION

In the last unit, we discussed some eco-san toilets. In this unit, we are going to discuss another six ecological sanitation toilets that we need to know about in this course. As you go through the descriptions of each of them you can note their differences and similarities.

2.0OBJECTIVES

At the end of this unit, you should be able to:

- describe the movable bin toilet
- describe the fossa alterna
- explain how the Sirdo Seco solar heated composting toilet works
- indicate some differences between the CCD toilet and the skyloo toilet.

3.0 MAIN CONTENT

3.1 'Sirdo Seco' Solar Heated Composting Toilet

Like the Vietnamese toilet discussed earlier in unit 2 of module 1, it has a receptacle divided into two vaults. Above the dividing wall, there is a baffle which turns a handle and makes the baffle direct the excreta into the other vault.

A vent pipe, which goes from the receptacle to above the roof, takes away odors. As there is a screen on top of the vent pipe, it also acts as a fly trap. The two vaults have lids made of black painted aluminum sheets. The lids face the sun to collect a maximum of solar heat. This increases the evaporation from the vaults as well as the temperature of the surface of the compost pile.

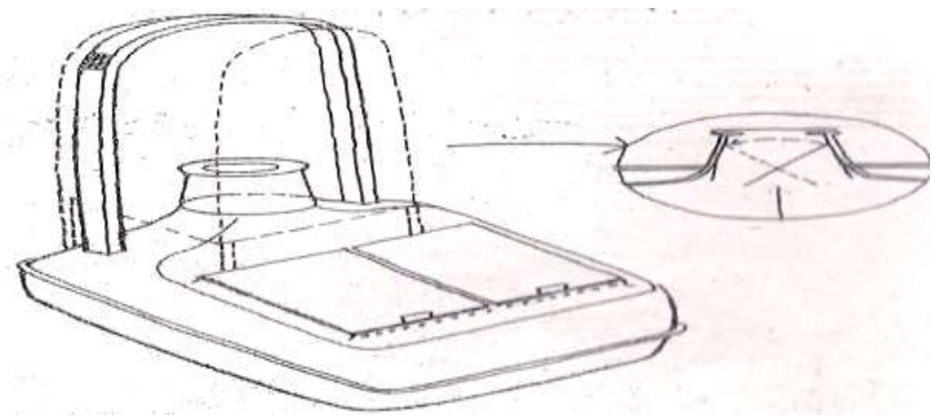

Fig.1: The Sirdo Seco Double Vault, Solar-Heated Composting Toilet. The Whole Toilet Including the Superstructure is made of Fiberglass (Esrey, *et al.*, 1998)

Each vault has a volume of 1.2 cubic meters. When the pile has reached the baffle the person looking after the toilet can shift the pile to the lower end of the receptacle. This means that people to empty the toilet only once a year at the most. (if 6-8 people use it regularly). When properly managed this toilet has a high capacity and works very well. It is easy to change from one vault to the other because of the baffle.

The 'Sirdo Seco' has been used with good result. One particular advantage with this lightweight, prefab model is that it is mobile. People living in squatter settlements can be ejected at short notice. If this happens they can arrange to have the toilet emptied and take it with them like a piece of furniture. This type of eco-san toilet is commonly used in Mexico.

3.2 The Movable Bin Toilet

This type of eco-san toilet uses two 240 liter standard wheeled plastic refuse bin as composing chambers. Near the base of each bin is a false floor mesh which allows liquid to drain through to the base and from there through a tube to a sealed evapo – transpiration bed. Air is drawn into the bin through a cut-out near the base and comes into contact with the bottom of the compost pile through the mesh – floor. In addition, perforated pipes running vertically along the inside walls of the bin help to aerate the pile.

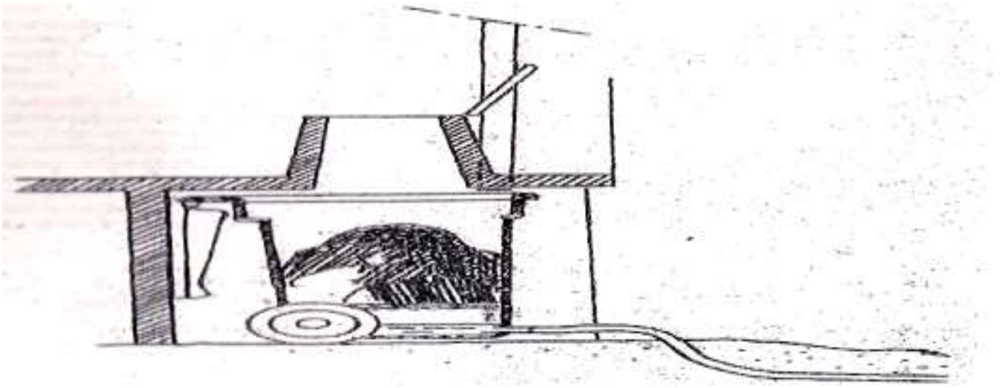

Fig. 2: A Composting Toilet with Liquid Separation (Esrey, *et al.*, 1998)

The processing chamber is a standard wheeled plastic refuse bin modified to drain away excess liquid. One bin is placed under the seat – riser to receive excreta, and is replaced with another one when full. This has been successful at producing innocuous humus-like residue.

3.3 The Centre for Clean Development (CCD) Toilet

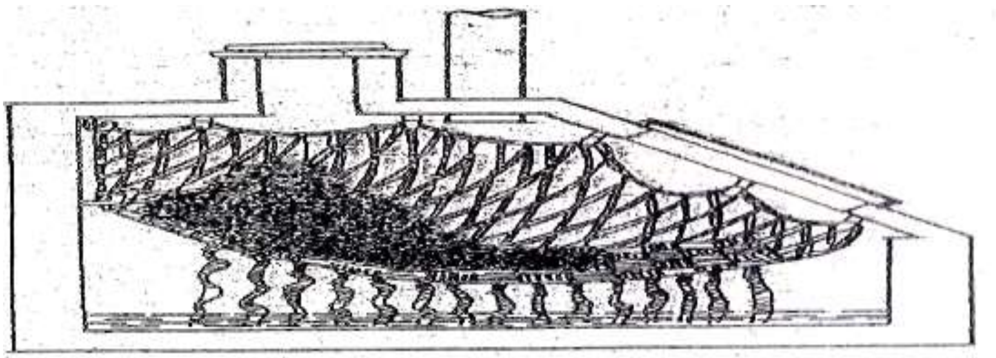

Fig. 3: The CCD Toilet (Esrey, *et al.,* 1998)

This type of toilet was developed by David Del Porto for Greenpeace and the Centre for Clean Development from where it derived its name "CCD Toilet". The design focuses on zero-discharge rather than diversion and recycling of urine. The CCD toilet consists of two water–

tight chambers built above ground. As with other double –vault toilets, excreta are deposited into one of the two chambers which are used alternately, to provide an extended period of composing time before the humus is removed for use as soil conditioner. Excreta fall on a mat woven from coconut palm fronds resting on top of nylon fishing net suspended inside the digestion vault, separating the solids from the liquids. This "false floor" allows air to penetrate the compost pile from all sides. Bulking agents such as coconut husks, small wood chips, leaves or vegetable food scraps are added via the seat – riser or drop hole periodically, both to provide a source of carbon (energy) and to increase the porosity of the pile so air can penetrate all the way through.

The CCD composting toilet is designed for the extremely humid climate. It has a "false floor made of fishing net to separate liquids and solids and wicks from old clothing to increase evaporation (Esrey, et al. 1998).

A large diameter vent pipe draws air up through the pipe from an intake opening located below the net along the rear wall of the vault. This airflow also helps to evaporate the liquids that accumulate to the floor of the digestion vault. Evaporation is further enhanced by wicks made from strips of polyester or rayon fiber (from old clothing), which are hung from the net to draw up the liquid from below, increasing the surface area exposed to the air stream. Another solution is to drain the liquid to an evapo-transpiration bed.

When the compost pile reaches higher just below the toilet seat – riser, the vault is closed off by moving the seat – riser to the pedestal on the other vault.

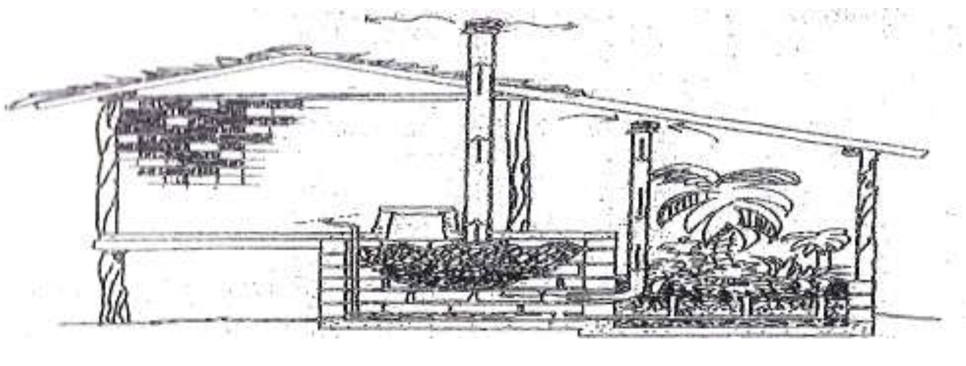

Fig. 4: The CCD Composting Toilet Attached to Greenhouse and Evapo-Transpiration (Esrey, *et al.*, 1998)

When the second vault is filled, the compost in the first vault is removed for use as soil conditioner by scooping it out through an access opening or removing the net entirely. This is the only real maintenance required beside regular addition of a bulking agent and periodic cleaning of the seat-riser with soap and a small amount of water. Experience thus far has been that it takes a family of up to 10 people over a year to fill one digestion vault.

The experience so far indicates that with a system of the CCD type it is possible to attain a degree of liquid evaporation and maintenance – free operation not previously reported for composting toilets in a humid environment. All of the demonstration units have achieved zero – discharge of pollutions for at least one – and – a half years of use. The CCD toilet is promising as an appropriate sanitation solution where environmental contamination is a major concern, and even in cultural settings in which a high level of maintenance is not likely to be expected, provided there is a supply of appropriate organic bulking agent available, such as leaves, vegetable scraps, and coconut husks on wood shavings. Because relatively little compost is generated and no urine is available for use as a fertiliser, it may not be the most appropriate technology in areas where recycling of nutrients is expected to be primary motivation for using an eco – san system.

3.4 The Arborloo

This is the simplest type of latrine and the one that involves the least amount of behaviour change from the conventional pit latrine. Anybody who had ever planted a tree in a full latrine pit can be said to be practicing eco-sanitation.

A shallow pit (1.2 m recommended) is dug and a slab and easily movable superstructure placed on top of it. The family uses the latrine, adding a mixture of soil and ash after each use, until it is three quarters full (usually between four and nine months). After this the slab and the superstructure are moved to another pit. A layer of soil is added to the full pit and a sapling placed into the soil. The tree grows and utilises the compost to produce large, succulent fruit. After a few years of latrine movement the result is an orchard that is producing fruit with a real economic value.

3.5 Fossa Alterna

This is similar to an Arborloo except that two shallow pits are dug and used like a twin pit latrine i.e. one is being filled while the other is maturing, and when the second is full; the first is emptied and used again. If a thin layer of soil is placed on the maturing pit, it becomes ideal for growing tomato or pepper plants. Watering of the plants helps the composting process. When the second pit is full, the contents of the first pit are placed on the garden or farm and the fertility of the land is increased.

3.6 Skyloo (single-vault)

A Skyloo latrine is constructed by building two brick and rendered vaults above ground level, placing latrine squatting slabs on top of the vaults and completed by building a superstructure on top of the slab.

The faeces drop through a squat hole not the vaults and are left to mature. The vaults are rotated in a similar manner to the Fossa Alterna. After a suitable retention time, the contents of the vaults are placed on to the garden or farm.

All the latrine designs use an 80cm diameter domed slab as the basic building unit. This design has been chosen because it means that the only raw material that needs to be bought and brought into the project areas is cement. The slabs do not contain any iron reinforcement bars which are expensive and only available in the major cities. The weight and size of the slab make it relatively easy to transport using low lost technology transport.

Fig. 5: Pictures of some Eco-san Outdoor Toilet Models

4.0 CONCLUSION

In conclusion, there are various types of ecological sanitation toilets which can be dehydrating or composting system, single or double vault. Bulking agents such as coconut husks, small wood chips, leaves or vegetable food scraps are needed in all the composting type. Arborlo is the simplest type of latrine and the one that involves the least amount of behaviour change from the conventional pit latrine. Anybody who had ever planted a tree in a full latrine pit can be said to be practicing eco-sanitation.

5.0 SUMMARY

In summary, six different eco-san toilets were discussed in this unit. These are 'Sirdo Seco' solar heated composting toilet, the movable bin toilet**,** the Centre for Clean Development (CCD) Toilet, Arborloo, Fossa Alterna and Skyloo. They are all effective if well managed.

6.0 TUTOR-MARKED ASSIGNMENT

1. List six types of ecological sanitation toilets.
2. Describe any one of your choice.

7.0 REFFERECES/FURTHER READING

Esrey, S. A, Gough, J., Paport, D., Sawyer, R., Hebert, M.S., & Vargas, J. (1998). Ecological sanitation, Stockholm: Swedish International Development Agency.

http://www.eco-sanres.org/pdf_files/Fact_sheets/ESR2lowres.pdf.

http://www.ruaf.org/system/files?file=Ecological Sanitation - Closing the Loop.pdf.

http://www.uio.no/studier/emner/medisin/inthealth/INTHE4000/h07/undervisningsmat eriale/Water%20and%20Health%20article.pdf.

MODULE 3

UNIT 1 TREATMENT OF HUMAN FAECES AND URINE

CONTENTS

1.0 INTRODUCTION

One of the main goals of ecological sanitation is to capture the nutrients present in human excreta and urine and recycle them back to agriculture. Thus, a key part of an eco-san system is the destruction of most or all disease producing organisms before re-use of excreta products. Results from scientific studies of pathogen destruction in eco-san systems are now providing us with guidelines for the treatment of urine and faeces before re-use as fertiliser. In this unit, we are going to discuss how the urine and excreta can be made pathogen free or less dangerous before reuse.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- enumerate at list 5 reasons for not mixing urine and faeces
- state the reason for primary processing
- state the reason for secondary processing
- describe 2 treatment processes.

3.0 MAIN CONTENT

3.1 Urine

Urine contains few diseases–producing organisms, while faeces may contain many, storing undiluted urine for one month will render urine safe for use in agriculture. Undiluted urine provides a harsher environment for micro-organisms increases the die-off rate of pathogens and prevents the breeding of mosquitoes. At the homestead level, where crops are intended for the household's own consumption, urine can be used directly. It is recommended, however, that there should be 1 month between urine application and harvesting.

When urine is collected from many urban households and transported for re-use in agriculture, the recommended storage time at temperatures of 4-20^{0}c varies between 1 and 6 months depending on the types of crop to be fertilised.

3.1.1 Diverting Urine

There are a number of good reasons for not mixing urine and faeces:

a. It keeps the volume of potentially dangerous material small

b. The urine remains relatively free from pathogenic organisms

c. Urine and faeces require different treatment

d. It simplifies pathogen destruction in faeces

e. It reduces odour

f. It prevents excess humidity in the processing vault; and

g. The uncontaminated urine is an excellent fertiliser.

Urine diversion requires a specially designed seat-riser or squatting slab or pan that is functionally reliable and socially acceptable. The basic idea of how to avoid mixing urine and faeces is simple: the toilet user should sit or squat over some kind of dividing wall so that faeces drop behind the wall and urine passes in front of the wall.

3.2 Primaries and Secondary Processing

Eco-san systems are designed to use some of the physiochemical and biological factors to kill disease organisms in faeces. This occurs usually in two steps: primary processing and secondary processing.

3.2.1 Primary Processing

The purpose of primary processing is to reduce the volume and weight of faecal material to facilitate storage, transport and further (secondary) treatment. Primary processing takes place in chambers below the toilet where the faces are kept (contained) for a certain period. During this containment, the number of pathogens will be reduced as a result of storage time (6-12 months), decomposition, dehydration (ventilation and the addition of dry material), and increased pH (addition of ash, lime, urea) as well as the presences of other organisms add competition for nutrients.

3.2.2 Secondary Processing

The purpose of secondary processing is to make human faeces safe enough to return to the soil. Secondary processing takes places on site; in the garden, or off site; at a designated processing site. This step includes further treatment by high temperature composting or pH increase by the addition of urea or lime as well as longer storage time.

If a completely sterile end product is required the secondary processing could be carbonization or incineration. In areas where ambient temperatures reach up to 20^0c, a total storage time of 1½ to 2 years (including the time stored during primary treatment) will eliminate most bacterial pathogens (if kept dry) and will substantially reduce viruses, protozoa and parasites.

Some oil-borne parasite eggs may persist. In areas where the ambient temperatures reach up to 35^0c, a total storage period of 1 year will achieve the same result, as pathogen die-off faster at higher temperatures.

Where high temperature composting, 50-60 ^{o}C can be carried out, either in an open compost or in a mechanical composting bin and the storage period could be further reduced.

Treatment with alkaline materials also requires time for pathogens to die on to an acceptable level. A pH over 9 for at least 6 months to 1 year is sufficient in most climates to kill most pathogenic organisms. For additional safety the material can be bagged (in sacks) and stored for a further period. Where there is concern about the persistence of intestinal worm eggs, carbonization or incineration as the secondary treatment will ensure a sterile product.

3.3 Dehydration and composting

Before explaining these pathogen destruction systems in detail, we must step back and explain briefly at this point that there are three main eco-san systems that operate in slightly different ways to achieve more or less the same result. These are dehydrating systems, composting systems, and combined systems. These three systems and the different toilet designs that go with them work to produce the expected result.

3.3.1 Dehydration

In dehydrating system, we direct urine away from faeces to keep the processing chamber contents dry and the volume of material small. This also makes it possible for us to use the urine separately as a fertiliser. Faeces are dropped into a processing chamber where they are safely kelp out of the environment for a period of 6-12 months, and ash, lime or urea is added after each defecation to lower the moisture content and raise pH to 9 or higher. The system thus creates conditions of dryness, raised pH and time for pathogen die-off. The partly treated faecal material is then removed from the processing chamber and subjected to one of the four secondary treatments (high temperature composting, alkaline treatment, further storage, and carbonisation/incineration).

3.3.2 Composting

In composting toilet, human faeces, or in some cases faeces plus urine, are deposited in a processing chamber along with organic household and garden refuse and bulking agents (straw, peat moss, wood shavings, and twigs, etc).

A variety of organisms in the pile break down the solid into humus, just as eventually happens to all organic materials in the natural environment. Temperature, airflow, moisture, carbon materials and other factors are controlled to varying degrees to promote optimal conditions for decomposition. After a certain retention time (normal 6-8 months) the partly decomposed material can be moved to garden compost or an eco-station for secondary processing through high temperature composting.

3.3.3 Combined system

In a combined composting system, faeces and in some cases faeces and urine, are deposited in a processing chamber together with a liberal amount of soil. There are two main sub-types with slightly different processes: with a shallow pit or a raised processing chamber. Ordinary soil is added after each defecation, often with wood ash as well. Most pathogenic bacteria are destroyed within 3-4 months as a result of competition with soil-based organisms and favourable environmental conditions. The material is then removed and can be subjected to any one of the same four secondary treatments or within one family homestead, can be directly spread on fields and worked into the existing soil. A period of 12 months of composting in shallow pits it recommended before application to gardens. There further pathogen die-off occurs because of UV radiation, dryness and competition with other soil organisms. After 1 month, crops that are eaten raw can be sown with relative safety.

Generally, in households, urine can be used directly. In large-scale systems urine should be stored for about one month before use. Do not apply urine less than a month before harvest on vegetables, fruits and root crops that are to be consumed raw.

3.4 Treatment of Faeces

Faeces contain most of the pathogens in human excreta and are the main source for transmission of enteric infectious disease and parasites. This has earlier been highlighted in unit one of module one. Therefore we should treat faeces based on the principles as below;

Keep the volume of dangerous material small by diverting the urine and not adding water to the faeces.

Prevent the dispersal of material containing pathogens by storing it in some kind of secure device (processing chamber, tank) until safe for recycling.

Reduce the volume and weight of pathogenic material by dehydration and/or decomposition to facilitate storage, transport and further treatment.

Reduce pathogens to a harmless state by sanitisation through primary treatment on site (dehydration/decomposition, increase in pH, retention) followed by secondary treatment on/off site (high temperature compositing, increase in pH by the addition of lime or urea, and if necessary, carbonisation or incineration).

In properly maintained toilets, there will be no bad smell, wetness or fly breeding. The product is inoffensive and resembles soil, is light and easily handled without producing dust. However, these more pleasant aspects of the product should not be taken as proof of their safety and care should still be taken in handling the product. To further minimise risk, workers could wear gloves when emptying processing chambers or pits and bathe well afterwards-including careful hand washing. However, for a well-managed eco-toilet or processing chamber, pathogen counts should be considerably reduced after primary treatment.

The primary processing in an eco-san system is generally either through dehydration or decomposition, but a combination of both is also possible. The purpose of the primary processing is to destroy pathogenic organisms, to prevent nuisance and to facilitate subsequent transport, secondary processing and end use.

3.4.1 Dehydration

Dehydration means lowering the moisture content of the material in the processing vault to less than 20% addition of dry material (ash, sawdust, husks). No water, urine or moist plant material must be added to the processing chamber.

There is little reduction in volume because of the added dry material, and minimal decomposition of organic material because of low moisture content. The crumbly pile that remains when faeces dry out is not compost but rather a kid of mulch which is rich in nutrients, and fibrous material.

Dehydration is a way of destroying pathogenic organisms. It does this by depriving them of the moisture they need to survive. At this low moisture content there is little odour and no fly-breeding as there is so little breakdown of organic material, toilet paper or other things placed in the processing vault will not disintegrate regardless of storage time.

Toilet paper must therefore either be handled separately (commonly by burning it).or be composted in a secondary treatment process. Urine diversion is essential in eco-toilets based on dehydration. Where water is used for anal cleaning, this water should be diverted and can either be treated separately or mixed and treated with urine

3.4.2 Decomposition

Decomposition (composting') is a complex natural biological process in which organic substances are mineralised and turned into humus. The speed of decomposition is influenced by a number of environmental factors inside the pile such as the amount of oxygen (aeration), temperature, moisture, pH value, the ratio of carbon to nitrogen (C:N ratio), competition among micro organisms for nutrients, and the toxic by-products of decomposing organisms.

3.4.3 Aeration

Some of the micro-organisms in the pile need oxygen in order to play their role ion decomposition. Such organisms are called aerobic. Others that do not require oxygen are called anaerobic. Many organisms can survive conditions with or without oxygen. Air enters the processing chamber from the outside or is trapped inside the compost heap. Near the surface of the pile the process may be aerobic while in the interior it is often anaerobic. Under aerobic conditions, decomposition is rapid and odour-free. Under anaerobic conditions decomposition is slower and foul-smelling and the heat given off is only a fraction of that under aerobic conditions. Earthworms and insects play an important role in aeration by burrowing holes through the pile.

3.4.4 Temperature

High-temperature aerobic composting (with temperature-reaching>60^0c) will effectively destroy most pathogenic organisms, but such process temperature are in practice difficult to reach in a compositing toilet. The volume of material is too small, it tends to be too compact and it is difficult and unpleasant to turn the pile to aerate the central part. Occasionally higher temperatures can be found in a small die –off of pathogens, there should be a large input (four to five times the weight of faeces) of carbon rich material such as weeds, husks, word shavings and kitchen waste, combined with occasional turning to ensure a good supply of oxygen to the inside of the pile.

It is important to remember that temperature is not solely important for destroying pathogens. Pathogen destruction is a function of both temperature and time, so that lower temperature can achieve acceptable pathogen kill if the material is retained long enough. In many cases, this lower temperature/longer time strategy is preferable to more intensive management of the compost pile. Most composting toilets are designed for a retention time of 8-12 months.

3.4.5 Moisture

In a composting toilet, we get the best results in terms of pathogen destruction with a moisture content of 50-60%. At higher moisture content, conditions in the material become soggy and compact, and the organisms are deprived of oxygen. Low moisture content, on the other hand, slows down the activity of the micro-organisms, as they are starved for water.

An extremely wet compost toilet may result from a combination of some of the following factors; humid climate, water used for anal cleaning, too much urine has one in, too many users (too much time urine in relation to capacity to handle liquids), no addition of organic refuse, unventilated processing chamber, entry of rainwater, surface water or ground water. The most common reason for high moisture content in the pile is too much urine going into the processing chamber.

This can be corrected by installing a urine-diverting toilet seat or squatting plate which channels the urine away from the compost pile into a separate container. Another possibility is to have some type of false floor which allows the liquid to seep out, preferably into a place from where it can evaporate.

3.4.6 Carbon-nitrogen Ratio

Micro-organisms feed on organic matter containing, among other nutrients, carbon and nitrogen, carbon is used for energy and nitrogen is for body building. The optimum carbon to nitrogen (C: N) ratio is within the range of 15:1 to 30:1 in the initial mixture.

Since faeces, and especially urine, are rich in nitrogen, it is best to start a processing chamber with material rich in carbon such as green grass clippings, vegetable scraps, straw, husks, wood shavings or a combination of these. Addition of these material tot eh compost increase the C: N ratio. Excluding urine from the compost has a similar effect, as lowers the amount of nitrogen in relation to carbon.

The addition of layers of finely chopped carbon-rich material also helps to provide oxygen to the pile and to achieve rapid and complete decomposition.

3.4.7 Microbial Activities in the Compost Toilet

A variety of organisms lives in the compost heap and contributes to the biodegradation of the excreta. They range in size from viruses, bacteria, fungi and algae to ants, mites, spiders, and earthworms. Their activities are responsible for rapid decomposition.

Earthworms and insects mix and aerate the pile, tearing apart the contents. If the environment is favourable to them, they will multiply, burrow holes in the pile, eat odorous organic material and convert it all into humus.

4.0 CONCLUSION

Nutrients present in human faeces and urine can be captured and recycled back for agriculture. Various treatment approaches can be applied to make them free from pathogens. These approaches are classified into primary processing and secondary processing.

5.0 SUMMARRY

In summary, this unit discussed treatment of human faeces and urine. Reasons for urine diversion were highlighted. We also described the primary processing and the secondary processing and at the same time stated their importance.

6.0 TUTOR-MARKED ASSIGNMENT

State how the following contribute to treatment of faeces:

1. Temperature
2. Microbial activities.

7.0 REFERENCES/FURTHER READING

Jenssen, P. D. (2004). *Ecological Sanitation and Reuse of Wastewater: A Think Piece on Ecological Sanitation.* Norway: The Agricultural University of Norway.

Okoroda, M.O. (1990). ‘Training the Trainers on Ecological Alternatives in Sanitation. http://www.eco-san.co.za/product_info.html www2.gtz.de/eco-san/English/16.

UNIT 2 GREY WATER

CONTENTS

1.0 INTRODUCTION

In our daily activities at our various homes we use water in various ways. We use water in cooking, washing, bathing, scrubbing and so on. Most often, the water used become dirty and is thrown out. It is this left over but dirty water from our homes that are called grey water.

Grey water is wastewater generated from domestic activities such as laundry, dishwashing, and bathing, which can be recycled on-site for uses such as in landscape irrigation. Grey water differs from water from the toilets which is designated sewage or black water to indicate it contains human waste.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- define grey water
- state the applications of recycled water
- state the benefits of grey water recycling.

3.0 MAIN CONTENT

3.1 Definition of Grey water

Grey water is domestic waste water other than that which comes from the toilet. It results from food preparation, personal washing and washing of cooking/eating utensils (Amadi, 2009).

Grey water gets its name from its cloudy appearance and from its status as being between fresh, potable water (known as "white water") and sewage water ("black water"). In a household context, grey water is the leftover water from baths, showers, hand basins and washing machines only. Some definitions of grey water include water from the kitchen sink. Any water containing human waste is considered black water.

SELF-ASSESSMENT EXERCISE

List four activities in your home where you generate grey water.

3.2 Elimination of Grey water

Domestic wastewater is usually combined at the sewer, so that grey and black water are removed together using a shared sewerage system in a process called elimination.

Sewage water can then be treated to limit pollution and health risks, before being returned to the environment at large. Most grey water ends up as effluent in rivers and oceans in this way. There are other alternatives to eliminating grey water that allow for efficient use; using it to irrigate plants is a common practice. The plants use contaminants of grey water, such as food particles, as nutrients in their growth. However, salt and soap residues can be toxic to microbial and plant life alike, but can be absorbed and degraded through constructed wetlands and aquatic plants such as sedges, rushes, and grasses.

SELF-ASSESSMENT EXERCISE

In what ways do you eliminate gray water in your home?

3.3 Recycling

Most grey water is easier to treat and recycle than black water, because of lower levels of contaminants. While all grey water contains micro-organisms, the health hazards associated with grey water from a multiple-dwelling source should be considered differently from that of a single dwelling grey water source.

If collected using a separate plumbing system from black water, domestic grey water can be recycled directly within the home, garden or company and used either immediately or processed and stored. If stored, it must be used within a very short time or it will begin to putrefy due to the organic solids in the water. This may result to odour nuisance.

Recycled grey water of this kind is never safe to drink, but a number of stages of filtration and microbial digestion can be used to provide water for washing or flushing toilets. Some grey water may be applied directly from the sink to the garden or container field, receiving further treatment from soil life and plant roots. Given that grey water may contain nutrients, pathogens, and is often discharged warm, it is very important to store it before use in irrigation purposes, unless it is properly treated first.

3.3.1 Systems

At present, several water recycling systems exist which can be used to: recycle the water without purifying it and recycle the water while purifying or decontaminating it.

3.3.2 Water Recycling Systems without Purification

Water recycling without purification is used in certain agricultural companies (e.g., tree nurseries) and dwellings for applications where potable water is not required (e.g., garden and land irrigation, toilet flushing). It may also be used in dwellings when the grey water (e.g., from rainwater) is already fairly clean to begin with and/or has not been polluted with non-degradable chemicals such as non-natural soaps (thus using natural cleaning products instead). This water system also needs a supply of water to recycle and reuses water as well. It is also not recommended to use water that has been in the grey water filtration system for more than 24 hours or bacteria builds up affecting the water that is being reused. Water purification/decontamination systems then again are used for applications where potable water *is* required (e.g., to allow drinking, and/or for other domestic tasks as washing, showering).

3.3.3 Water Recycling with Purification

For filtering the water to become potable (or near-potable), there are numerous systems based on *soft* processes. These include natural biological principles such as mechanical systems (sand filtration, lava filter systems and systems based on UV radiation) biological systems (plant systems as treatment ponds, constructed wetlands, living walls) and Bio reactors or compact systems as activated sludge systems, biorotors, aerobic and anaerobic biofilters, submerged aerated filters.

Finally, "hard", direct processes, such as distillation (evaporation) or mechanical processes such as membrane filtration, (typically ultra filtration and reverse osmosis, which are capable of treating high volumes of grey water) can create potable, or near-potable water. There seem to be no commercially available "hard" grey water recovery devices suitable for on-site use in the individual household, even though a number of such technologies exist.

In order to purify the potable water adequately, several of these systems are usually combined to work as a whole. Combination of the systems is done in two to three stages, using a primary and a secondary purification. Sometimes a tertiary purification is also added.

Some municipal sewage systems recycle a certain amount of grey and black water using a high standard of treatment, providing reclaimed water for irrigation and other uses.

3.4 Application of Recycled Grey Water

There are various ways of application of recycled grey water. These are discussed below.

3.4.1 Irrigation

Grey water typically breaks down faster than black water and has lower levels of nitrogen and phosphorus. However, all grey water must be assumed to have some black water –type components, including pathogens of various sorts. Grey water should be applied below the surface where possible (e.g., via drip line on top of the soil, under mulch, or in mulch field trenches) and not sprayed as there is danger of inhaling the water as an aerosol.

Long-term research on grey water use on soil has not yet been done and it is possible that there may be negative impacts on soil productivity. In any grey water system, it is essential to put nothing toxic down the drain—no bleaches, bath salts, artificial dyes, cleansers, and no products containing boron (which is toxic to plants at high levels).

It is crucial to use all-natural; biodegradable soaps whose ingredients do not harm plants. Most powdered detergents, and some liquid detergents, are sodium-based, which can inhibit seed-germination and destroy the structure of soils by dispersing clay.

3.4.2 Indoor Reuse

Recycled grey water from showers and bathtubs can be used for flushing toilets in most European and Australian jurisdictions and in United States jurisdictions that have adopted the International Plumbing Code. Such a system could provide an estimated 30% reduction in water use for the average household. The danger of biological contamination is avoided by using:

A cleaning tank, to eliminate floating and sinking items an intelligent control process that flushes the collected water if it has been stored long enough to be hazardous; this completely avoids the problems of filtration and chemical treatment.

3.4.3 Extreme Living Conditions

Grey water use promotes the ability to build in areas unsuitable for conventional treatment, or where conventional treatment is costly. The grey water recycling, might be used to reduce water consumption and increase oxygen generate

3.4.4 Heat Reclamation

Devices are currently available that capture heat from residential and industrial grey water, through a process called drain water heat recovery, grey water heat recovery, or hot water heat recycling.

Rather than flowing directly into a water heating device, incoming cold water flows first through a heat exchanger where it is pre-warmed by heat from grey water flowing out from such activities as dishwashing, or showering. Typical household devices receiving grey water from a shower can recover up to 60% of the heat that would otherwise go to waste.

3.5 Ecology

Because grey water's use, especially domestically, reduces demand on conventional water supplies and pressure on sewage treatment systems, its use is very beneficial to local waterways. In times of drought, especially in urban areas, grey water use in gardens or toilet systems helps to achieve some of the goals of ecologically sustainable development.

The potential ecological benefits of grey water recycling include: lower fresh water extraction from rivers and aquifers; less impact from septic tank and treatment plants infrastructure.

- Topsoil nitrification
- Reduced energy use and chemical pollution from treatment
- Groundwater recharge
- Increased plant growth
- Reclamation of nutrients
- Greater quality of surface and ground water when preserved by the natural purification in the top layers of soil than generated water treatment processes

4.0 CONCLUSION

In conclusion, grey water is domestic waste water other than that from the toilet. It results from food preparation, personal washing and washing of cooking utensils. The grey water can be eliminated together with black water using a shared sewerage system. The grey water can also be recycled without purification or with purification. It can be recycling directly within the home, garden or company and used either directly or processed and stored. To provide water for washing and flushing of toilets grey water can undergo a number of stages of filtration or microbial digestion. The recycled grey water therefore can be used in irrigation, indoor reuse and also in heat reclamation.

5.0 SUMMARY

In this unit, we discussed grey water which is the waste water from domestic uses other than that from the toilet. The unit highlighted the process of eliminating grey water from homes and also its ways of recycling. The recycled grey water can be applied or utilized in irrigation, indoor reuse and heat reclamation. Finally we listed the potential ecological benefits of grey water recycling.

6.0 TUTOR-MARKED ASSIGNMENT

1. What are the various applications of grey water that have been recycled?
2. List eight potential ecological benefits of recycling grey water.

7.0 REFERENCES/ FURTHER READING

Amadi, A.N. (2009). *Modern Environmental Sanitation*. Owerri: Nationwide Printers and Publications Co. Ltd.

GTZ.technicaldatasheets.http://www.gtz.de/en/themen/umweltinfrastruktur/wasser/9397.htm.

GTZprojectdatasheets.http://www.gtz.de/en/themen/umweltinfrastruktur/wasser/9399.hm

Eco-sanRes Global Map of eco-san activities. http://www.eco-sanres.org/.

GTZ (2005). Urine Diversion Dry Toilets Dissemination Programme Guangxi Province, China'. Eco-san Project Data Sheet #005. Available at: http://www.gtz.de/en/themen/umwelt-infrastruktur/wasser/9399.htm.

UNIT 3 BIOGAS

CONTENTS

1.0 INTRODUCTION

Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Organic waste such as dead plant and animal material, animal faeces, and kitchen waste can be converted into a gaseous fuel called biogas. Biogas originates from biogenic material and is a type of bio fuel.

Biogas is produced by the anaerobic digestion or fermentation of biodegradable materials such as biomass, manure, sewage, municipal waste, green waste, plant material, and crops. Biogas comprises primarily methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulphide (H_2S), moisture and siloxanes. (*Wikipedia, the free encyclopedia*).

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- define biogas
- state the composition of biogas
- list sources of biogas production
- explain biogas utilisation.

3.0 MAIN CONTENT

3.1 Biogas and Bio-fuel

Biogas is only one of many types of bio-fuels, which include solid, liquid or gaseous fuels from biomass. Any combustible fuel derived from recent (non-fossil) living matter (biomass) may be considered a bio-fuel, including ethanol derived from plant products, biodiesel from plant or animal oils, as well as, biogas from biomass. All bio-fuels are produced from sources which are renewable and are included as a subset of renewable energy sources that also include energy produced from solar, hydro, tidal, wind, and geothermal sources. Biogas, like natural gas, has a low volumetric energy density compared to the liquid bio-fuels, ethanol and biodiesel. However, biogas may be purified to a natural gas equivalent fuel for pipeline injection and further compressed for use as a transportation fuel. Methane, the principal component in biogas, has four times the volumetric energy density of hydrogen (H_2) and is suitable for use in many types of fuel cell generators.

3.2 Typical Composition of Biogas

Compound	Chemical	%
Methane	CH_4	50–75
Carbon dioxide	CO_2	25–50
Nitrogen	N_2	0–10
Hydrogen	H_2	0–1
Hydrogen sulphide	H_2S	0–3
Oxygen	O_2	0–0

The composition of biogas varies depending upon the origin of the anaerobic digestion process. Landfill gas typically has methane concentrations around 50%. Advanced waste treatment technologies can produce biogas with 55–75% methane which for reactors with free liquids can be increased to 80-90% methane using in-situ gas purification techniques. As-produced, biogas also contains water vapour.

The fractional volume of water vapour is a function of biogas temperature; correction of measured gas volume for both water vapour content and thermal expansion is easily done via a simple mathematic algorithm which yields the standardised volume of dry biogas.

In some cases, biogas contains siloxanes. These siloxanes are formed from the anaerobic decomposition of materials commonly found in soaps and detergents. During combustion of biogas containing siloxanes, silicon is released and can combine with free oxygen or various other elements in the combustion gas. Deposits are formed containing mostly silica (SiO_2) or silicates (Si_xO_y) and can also contain calcium, sulphur, zinc, phosphorus. Such white mineral deposits accumulate to a surface thickness of several millimeters and must be removed by chemical or mechanical means.

Practical and cost-effective technologies to remove siloxanes and other biogas contaminants are currently available.

3.3 Biogas Production

3.3.1 Biogas from Feedstock

Biogas can be produced from a broad range of feedstock that is suitable for anaerobic digestion. Current ethanol technology requires feedstock with high fermentable carbohydrate levels (e.g. corn and sugarcane), while biodiesel production requires feedstock with high oil content (e.g. waste vegetable oils or virgin vegetable oil from oil seed crops). Both technologies require extensive pre-processes of feedstock and only yield fuel from a portion of the native biomass material. In contrast, biogas can be made from most biomass and waste materials regardless of the composition and over a large range of moisture contents, with limited feedstock preparation. Feedstock for biogas production may be solid, slurries, and both concentrated and dilute liquids. In fact, biogas can even be made from the left over organic material from both ethanol and biodiesel production.

Most of the existing installations are processing residual sludge from wastewater treatment plants. Other facilities are processing wastes from chicken processing, juice processing, brewing, and dairy production. However, the range of potential waste feedstock is much broader including: municipal wastewater, residual sludge, and food waste, food processing wastewater, dairy manure, and poultry manure, and aquaculture wastewater, seafood processing wastewater, yard wastes, and municipal solid wastes. Food processing wastewaters may come from citrus processing, dairy processing, vegetable canning, potato processing, breweries, and sugar production.

There are many potential energy crops, which may be suitable for biogas production including: sugarcane, sorghum, napier grass, as well as woody crops (tree crops). The best crops should have low fertility requirements, and low energy costs for planting and harvesting. Further, ethanol production from an energy crop will produce large volumes of stillage wastewater, which can be converted to biogas. Also, the production of biodiesel from oil crops produces a glycerol wastewater that also may be converted to biogas.

3.3.2 Biogas from Sludge and Manure

The anaerobic digestion of sludge is perhaps the oldest anaerobic digestion technology. In spite of the many advances made in reactor designs for wastewater treatment, few can be applied in treatment of sludge and manure, as the high suspended solids content of this waste impedes biomass immobilisation. However, a better understanding of the anaerobic digestion process has resulted in increases in organic loading rate (OLR) and process performance for sludge and manure treatment. In addition, the tendency of sludge and manure to cause odours and to host pathogens benefits the application of anaerobic digestion for treatment of these wastes for odour and pathogen reduction, as well as energy production.

3.3.3 Characteristics of Sludge and Manure

In contrast to wastewater, the principle component contributing to the organic strength of sludge and manure is organic suspended solids (SS). The most important parameters for characterizing these slurries are total solids content (TS) and volatile solids content (VS). While chemical oxygen demand (COD) could also give a measure of the organic strength of slurries, sampling difficulties and limits of the COD procedure make COD measurements of slurries impractical. There is an upper limit for TS content above which the material is no longer slurry, and mixing and pumping becomes problematic. This upper limit for TS is dependent on the rheological properties of the SS making up the slurry. For most manure and sludge this occurs at TS of 10-15%. Waste with a higher TS content may be a candidate for high solids treatment or it will require dilution (preferably with effluent) if it is to be treated as a slurry.

Water is a principal component of manure and sludge, and facilitates the ability to transport the SS as a fluid. However, not only does the water content dilute the potential bio-energy content of the slurry, it also may impact anaerobic digester design and operation, by increasing the digester volume due to hydraulic retention time (HRT) limitations. Also, for mesophilic and thermophilic processes, the water content increases the consumption of heating energy. For slurries at 1% TS or less with an ambient temperature of 20 ^{o}C, digestion at mesophilic temperatures may consume the majority of biogas produced. Thus, in treatment of slurries with less than about 2% TS, pre-treatment methods for concentrating the solids should be considered. If treatment of the separated liquids is desired, then anaerobic wastewater treatment processes should be considered for the liquid fraction.

When considering biogas production from slurry, the VS content of the material is as important as the TS content, since it represents the fraction of the solid material that may be transformed into biogas. Most manure and sludge from municipal wastes have a VS content of 70-90% of the TS content. The fixed solids (FS, also termed the ash content) is comprised of inorganic material (grit, minerals and salts), which dilute energy content and can impact the treatment process. For some sludge from industrial sources, high FS may come from the use of process chemicals (e.g. lime precipitation).

Although the VS content is an indicator of potential methane production, the specific methane yield on a VS basis is not a constant, in contrast to the specific methane yield on a COD basis which is precisely 0.35 m^3/kg COD destroyed. This is due to the composition of the VS of the waste which includes both readily degradable organic compounds including lipids, proteins, and carbohydrates, as well as more refractory organics which may include lignocellulosic materials, complex lipopolysacharides, structural proteins (keratin) and other refractory organics. For pure carbohydrates the specific methane yield on VS basis is 0.38 m^3/kg VS destroyed, for proteins the yield varies depending on amino acid profile and averages 0.6 m^3/kg VS destroyed and for pure lipids (vegetable oil) the specific methane yield is 1.0 m^3/kg VS destroyed. This difference can be attributed to the high H:C ratio of lipids compared to carbohydrates. The complex nature of the composition of an organic waste means that the methane yield is best determined from anaerobic treatability assays on a suitable sample.

Finally, other components of sludge and manure can affect anaerobic treatment. For some manures (poultry and swine), the high protein levels in the manure contain significant amounts of nitrogen and sulphur which, upon mineralisation to ammonia and sulphide, can limit the OLR due to their inhibitory effects. The sulphide also impacts biogas utilisation and clean-up requirements. In municipal and industrial sludge, there is a potential for high concentrations of heavy metals, which can cause inhibition or competitive micronutrient deficiencies when anaerobic treatment is applied to these wastes. Also, inhibitory chemicals present in the sludge from industrial sources or in municipal sludge receiving industrial wastewaters can cause operational problems in anaerobic sludge digestion.

3.3.4 Biogas from Municipal Solid Waste (MSW)

Currently, treatment processes such as anaerobic digestion and composting offer the only biological route for recycling matter and nutrients from the organic fraction of municipal solid waste (MSW). Anaerobic digestion has been demonstrated to be a viable option for the management and stabilisation of the biodegradable fraction of those wastes. Anaerobic digestion typically results in a 50% reduction of organic matter (volatile solids). The extent of conversion is dependent upon the feedstock and is similar to that obtained by aerobic composting operated at comparable residence times. Approximately 90% of the energy from the degraded organic matter is retained in the form of methane. The widespread natural occurrence of methane bacteria demonstrates that anaerobic digestion can take place over a variety of moisture contents from 60 to more than 99 percent. Thanks to this tolerance, anaerobic processes can be applied for decomposition of dry solids such as MSW.

For MSW, the quantity of methane is not trivial and typically amounts to around 100 to 200 cubic meters of biogas per ton of organic MSW digested. If we assume MSW contains about 30% water and 15% ash, one ton of MSW is equivalent to about 0.32 tons of dry organic matter. Treating one ton of this feedstock would generate about 0.21 tons of compost (dry weight including ash). The methane can be used in part for process energy requirements (coarse shredding of the input and leachate recycle) and the balance sold as a renewable energy. (Map and Directions acwilkie@ufl.edu)

3.4 Treatment of Biogas

The hydrogen sulphide contained in biogas caused odours, corrosiveness, and sulphur emissions when the gas is burned. High levels of sulphide in biogas may require removal to protect equipment if the gas is to be used in internal combustion engines, turbines, or fuel cells. The concentration of hydrogen sulphide in the gas is a function of the digester feed substrate and inorganic sulphate content. Wastes which are high in proteins containing sulphur based amino acids (methionine and cysteine) can significantly influence biogas hydrogen sulphide levels. For instance, layer poultry waste containing feathers made of keratin may produce biogas sulphide levels up to 20,000 ppm.

Also, sulphate present in the waste, either from an industrial source (eg. pulping of wood) or from seawater (marine aquiculture) will be reduced by sulphate reducing bacteria in the digester and end up contributing to sulphide levels in the gas.

The treatment of biogas may include removal of components including hydrogen sulphide, water, mercaptans, carbon dioxide, trace organics, and particulates. Due to the corrosive nature of hydrogen sulphide, removal processes for this component are well developed and include both dry and wet removal processes. In a wet process the biogas is passed up-flow through a stripping tower where the aqueous solutions are sprayed counter-currently. The tower is generally separated by distribution trays which maximize contact between the biogas and the solution.

For small-scale biogas producers, an alternative to the wet absorption systems described above is dry adsorption or chemisorptions. Several dry processes are available, using particles of either activated carbon, molecular sieve, iron sponge or other iron-based, granular compounds to remove sulphide from the gas phase to the solid phase. These are sometimes referred to as dry oxidation processes because elemental sulphur or oxides of sulphur are produced (and can be recovered) during oxidative regeneration of the catalyst.

In addition to those aqueous absorbents described for H2S removal, there are many chemical solutions commercially available which can be used to remove CO2 and H2S concurrently. In general, these processes employ either solvation solutions where the objective is to dissolve CO2 and H2S in the liquid, or solutions which react chemically to alter the ionic character of these gases and therefore drive them into solution. Solutions of the former category include the solvents and the latter include the alkanolamines and alkaline salts.

There are membrane materials which are specially formulated to selectively separate CO2 from CH4. The permeability of the membrane is a direct function of the chemical solubility of the target compound in the membrane. To separate two compounds such as CO2 and CH4, one gas must have a high solubility in the membrane while the other is insoluble. Accordingly, rejection (separation) efficiencies are typically quite high when the systems are operated as designed.

3.5 Storage of Biogas

Biogas is not typically produced at the time or in the quantity needed to satisfy the conversion system load that it serves. When this occurs, storage systems are employed to smooth out variations in gas production, gas quality and gas consumption. The storage component also acts as a reservoir, allowing downstream equipment to operate at a constant pressure.

A wide variety of materials have been used in making biogas storage vessels. Medium-and high-pressure storage vessels are usually constructed of mild steel while low-pressure storage vessels can be made of steel, concrete and plastics. Each material possesses advantages and disadvantages that the system designer must consider. The newest reinforced plastics feature polyester fabric which appears to be suitable for flexible digester covers. The delivery pressure required for the final biogas conversion system affects the choice for biogas storage.

3.6 Biogas Utilisation

Biogas can be used readily in all applications designed for natural gas such as direct combustion including absorption heating and cooling, cooking, space and water heating, drying, and gas turbines. It may also be used in fuelling internal combustion engines and fuel cells for production of mechanical work and/or electricity. If cleaned up to adequate standards is may be injected into gas pipelines and provide illumination and steam production. Finally, through a catalytic chemical oxidation methane can be used in the production of □□methanol production.

3.6.1 Direct Combustion

Biogas conversion in direct combustion provides the simplest method of direct utilisation on-site. Most combustion systems designed for either propane or natural gas may be easily modified for biogas. Care must be taken to consider the heat input rate, the fluid handling capability, the flame stability and the furnace atmosphere when such modifications are made. Due to the lower heating value of biogas equipment may operate at a lower rating and the size of gas inlet piping may need to be increased.

If cogeneration is employed in the biogas conversion system heat normally wasted may be recovered and used for hot water production. In the gas of gas turbines, the waste heat may be used to make steam and drive an additional steam turbine with the final waste heat going to hot water production and this is termed a combined cycle cogeneration system. Combining hot water recovery with electricity generation, biogas can provide an overall conversion efficiency of 65-85%. Modern gas turbine plants are small, extremely efficient, and visually unobtrusive.

An additional direct combustion conversion process which should be considered is the use of steam to run adsorption refrigeration systems. Such systems can be employed to provide heating and cooling and can utilise waste heat from a topping cycle. In typical adsorption systems, a fluid is contacted with salt brine and the heat of solution is rejected.

Input heat then boils the fluid from the brine; it is condensed and then used as a refrigerant fluid in a standard expansions valve arrangement. Multi-staged adsorption systems can be combined to improve the coefficient of performance of the overall system.

3.6.2 Internal Combustion Systems

For smaller biogas installations shaft horsepower and electrical generation is most effectively met by the use of a stationary internal combustion engine. Adequate removal of hydrogen sulphide to below 10 ppm is important to reduce engine maintain requirement. Often more frequent changing of engine oil and testing for oil sulphur content can increase engine component life. Some applications have used a dual-fuel carburetor so that propane or natural gas can be employed to start-up and shut down the engine system effectively removing trace sulphide from the internal parts.

When waste heat from engine cooling and exhaust gases is recovered and used the efficiency of the engine cogeneration system improves. Waste heat may be used for digester heating, space heating, hot water and or refrigeration.

3.6.3 Vehicular Use

Biogas, if compressed for use as an alternative transportation fuel in light and heavy duty vehicles, can use the same existing technique for fuelling already being used for compressed natural gas vehicles. In many countries, biogas is viewed as an environmentally attractive alternative to diesel and gasoline for operating buses and other local transit vehicles. The sound level generated by methane-powered engines is generally lower than that generated by diesel engines and the exhaust fume emissions are considered lower than the emission from diesel engines, and the emission of nitrogen oxides is very low. Application of biogas in mobile engines requires compression to high pressure gas (>3000 psig) and may be best applied in fleet vehicles. A refueling station may be required to lower fuelling time and provide adequate fuel storage.

4.0 CONCLUSION

In conclusion, biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Organic waste such as dead plant and animal material, animal faeces, and kitchen waste can be converted into a gaseous fuel called biogas. Biogas originates from biogenic material and is a type of bio fuel. The composition of biogas varies depending upon the origin of the anaerobic digestion process. Biogas can be produced from a broad range of feedstock that is suitable for anaerobic digestion and can be used readily in all applications designed for natural gas such as direct combustion including absorption, heating and cooling, cooking, space and water heating, drying, and gas turbines.

5.0 SUMARRY

In this unit, we explained the meaning of biogas, the composition of biogas, various sources of biogas production and biogas treatment. Furthermore, the storage and utilisation of biogas were discussed. We also explained the utilisation such as direct combustion including absorption, heating and cooling, cooking, space and water heating, drying, and gas turbines.

6.0 TUTOR-MARKED ASSIGNMENT

In a tabular form present the chemical composition of biogas.

7.0 REFERENCES/FURTHER READING

Map and Directions acwilkie@ufl.edu.

Wikipedia, the free encyclopaedia.

UNIT 4 FINANCIAL CONSIDERATIONS, ADVANTAGES AND ARGUMENTS FOR THE USE OF ECOLOGICAL SANITATION, AND MAKING ECOLOGICAL SANITATION WORK

CONTENTS

1.0 INTRODUCTION

This unit is the concluding unit of this course. Having discussed much on ecological sanitation, we need to know the financial considerations of these ecological systems and also need to address the unfamiliar aspects and sensitivity of these systems so that you can better appreciate the need to consider carefully both the design and management options that you can recommend to your client.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- describe the financial consideration of ecological sanitation systems
- state the advantages of eco-san

- list 5 sensitive areas that can make eco-san systems not to work if the areas are not taken care of.

3.1 Financial Consideration

The introduction of eco-san systems is bound to lower the total cost of urban sanitation. Sewers, treatment plants and sludge disposal arrangements will cost several times as much as an eco-san system. This is particularly important for Third World countries, where public institutions face stringent financial limits. Eco-san system require much less investment as they need neither water for flushing nor pipelines for the transport of sewage, nor treatment plants and arrangements for the disposal of toxic sludge.

However eco-san system will involve cost for information, training, monitoring and follow-up that are greater than corresponding costs for conventional sanitation systems. Furthermore, an urban eco-san system will generate additional costs that are not usually present in small rural eco-san projects, such as the safe handing, transportation, storage of urine and dehydrated or composted material from many devices. On the other hand, the economic (and ecological) value of the fertilisers produced could be significant.

Successful sanitation relies on sound finances. In principle, households should fully repay investment and operational and maintenance costs to ensure the sustainability of a local eco-san system. In practice, pilot peri-urban sanitation programmes involving free or highly subsidized demonstration models are likely to fail in the long run when false expectations has been raised regarding the cost of the system.

Initial subsidies should not vary significantly from the long-term pricing structures. Many families may accept a free toilet only to abandon it. Users' willingness to contribute their own resources, rather than relying on external financing is a strong indicator of acceptance and enduring success.

In urban programmes that require large scale support services, payment collection becomes a crucial issue. In order to improve collection, payments can be collected by financial institutions (bank, or co-operatives) or a local non-governmental Organisation might inspire more confidence from the users.

Some of the funds should be held by community organisations, for promotion, training and monitoring activities. Another portion could be transferred, for example, to a trust fund, aimed at financing new eco-san projects or improving existing ones. If possible some funds should be reserved for further research and development, as there has been little independent funding for quality scientific research.

3.2 Advantages of Ecological Sanitation

If this vision of ecological sanitation could be realized, then it would confer a great many advantages to the environment, households and families and to municipalities. To conclude this unit, here is the summary of these advantages below.

3.2.1 Advantages to the Environment

If ecological sanitation could be adopted on a large scale, it would protect our groundwater, streams, lakes and sea from faecal contamination. Less water would be consumed. Farmers would require fewer amounts of expensive commercial fertilisers, much of which today washes out of the soil into water, thereby contributing to environmental degradation.

Eco-san allows us to make use of the high fertiliser value of urine. The 400-500 liters of urine produced by each person during a year contains enough plant nutrients to grow 250 kilograms of grain, enough to feed one person for one year. Urine is rich in nitrogen, phosphorus and potassium. As much as 90% of the fertiliser value of human excreta is in the urine. This important resource is much easier and safer to handle in the form of pure urine than it is in a mix of urine and faeces. Urine can be diluted with water and put directly on vegetable gardens and agricultural fields or saved in underground tanks for later use.

Eco-san also allows us to recover the resource value of faeces. Human faeces can be turned into a valuable soil conditioner. But faeces may also contain dangerous micro-organisms. Before we can recycle faeces back to the soil, these pathogens must be destroyed. Pathogen destruction as well as handling is safer, easier and less costly if the faeces are not mixed with urine and water.

Large scale recycling would rejuvenate rural and urban agriculture. Returning human urine and sanitised faeces to rural areas on a regular basis has the potential to replenish soil nutrients to levels at which productivity will rise dramatically. A Swedish study found that the nutrient content of compost removed from composting toilets compared well with that of farmyard manure, and in some ways was superior.

Large scale recycling would reduce the greenhouse effect. The recycling of human excreta could help to reduce the greenhouse effect if practiced on a large scale as part of a comprehensive programme to increase the carbon content of soils. Most efforts to address the atmospheric build-up of carbon dioxide (CO_2), which is believed to be causing climate change, have focused on reducing the CO_2 emissions from fossil fuel burning and the clearing of rain forests. However, scientists have recently begun to focus on the ability of soil to serve as a sink for excess atmospheric carbon. (In soils carbon is stored in the form of humans and decaying organic matter.) A number of factors influence the accumulation of carbon in soils. Returning sanitised human excreta to degraded lands would play a significant role in the process by enhancing soil fertility, increasing plant growth and hence the amount of CO_2 pulled from the atmosphere through photosynthesis. A modest doubling of the 1% (as a result of erosion) to 2% over the course of 100 years would balance the net annual increase of atmospheric carbon over that time.

3.2.2 Advantages to Households and Neighborhoods

Eco-san systems, if properly managed and maintained do not smell or produce files and other insects. This is a great advantage over ordinary pit toilets. Urine and faeces do not come into contact to pro0duce smell. Moisture levels are too low for fly breeding.

A frequently heard objection to ordinary pit toilets is that small children may fall into them and die. Eco-san systems pose no such risk because they are neither deep nor wet and usually built entirely above ground.

No matter how unpleasant the immediate environment may be, individual households can improve their conditions considerably by adopting an eco-san system. There is no need to wait for the authorities to come and install piped water and a sewerage system. The device itself can be immediately have the privacy, convenience and aesthetic advantages of an odourless and flyless toilet, attached to or even built right into their homes, however small. This is of course particularly important for women. Where groups of households do not have toilets and open defecation is practised, these householders can improve their part of a neighbourhood dramatically.

The health benefits of toilets are usually not an important selling point for consumer acceptance. However, some consumers may find it attractive to know that if a large area of their community can be made more sanitary, the likelihood of diarrhoea and worm infections will decrease, leading to overall better health and better study results for school children[4].

The nutrition of families would also improve if urine and faeces were recycled to grow additional vegetables in garden plots, and balconies.

The fertiliser value of recycled urine and the soil-improving properties of decomposed faeces should produce excellent crops even from poor soil or soil-horticulture.

This again is particular important for women as they normally are the ones responsible for the household's food production.

Some designs of eco-san toilets are lightweight and movable. The urban poor usually do not own the land on which they live and do not wish to invest money in structures they cannot take with them. With the eco-san approach it is possible for them to have a prefabricated toilet unit that can be moved. This has proved to be an important selling point for the prefabricated toilets.

The emptying of ordinary pit toilets and the sludge removal from septic tanks is messy, expensive and technically difficult. In many informal settlements, the vacuum trucks needed for the process cannot negotiate the narrow streets and the steep slopes. If contents are removed by hand, the sludge is smelly, wet and dangerous to the workers. Eco-san system based on dehydration or decomposition reduce the volume of material to be handled and transported and result in a dry, soil-like, completely inoffensive and easy-to handle product. As the toilet is built completely above ground there is easy access to the sanitised faeces for recycling and easier management of contents for pathogen destruction.

A great problem of building toilet in some area is the subsoil and ground water conditions. In some area, the ground is too hard for digging. In other areas the water-table is close to the surface. Both conditions prevent or make difficult the construction of pit toilets, VIP toilets or pour-flush toilets.

As eco-san system can be built entirely above ground, they allow construction anywhere a house can be built, they do not collapse, they do not destabilise the foundations of nearby buildings and they do not pollute the groundwater.

It is often said that one cannot have good toilets without water: This is because some sanitation systems depend on water for transport of faeces and urine to an off-site location. Most eco-san toilets do not need water, in fact, for many designs; water is harmful to their proper. Over half the population of the developing world has no sanitary system of excreta disposal. The market for appropriate sanitation devices is enormous and the demand is there. Also over half of poor people are unemployed. The majority of eco-san toilets do not require expensive or high-tech equipment. Jobs can be created for builders and for collectors of urine and sanitised faeces. These products can be sold to farmers or households could use them to grow food. An entire mini-economy could potentially develop around ecological sanitation systems, especially in urban areas.

3.2.3 Advantages to Municipalities

Municipalities all over the world are experiencing greater and greater difficulties in supplying water to households and neighborhoods. In many cities water is rationed and supplied only a few hours a week. Wealthier households collect this water in large tanks while the poor queue up at public taps to receive their daily ration. Eco-san systems do not use these scarce water resources and may result therefore in a more equitable allocation of water to rich and poor households.

A major advantage of eco-san systems is that they have the potential to increase sanitation coverage more quickly than any other method. Municipal governments are under increasing pressure to provide sanitation on coverage for the entire urban population. Even if there is political will, the options available are severely limited owing to lack of water and/or money (for flush-and discharge systems) and lack of space and/or difficult ground or groundwater conditions (for drop-and-store system). The eco-san options, discussed in units 6-9 are in general affordable to the poor and have almost no recurrent costs for operation and maintenance. In most cases, they require no excavation, do not depend on water and pipe networks and, as the units have no odour and can be placed anywhere (even inside a house and on upper floors), they can be used even in congested areas. Eco-san could be an inexpensive and attractive alternative to expansion of sewerage systems.

Finally, eco-san systems allow, decentralised urban waste-to resource management. The burden for guaranteeing a well functioning urban sanitation system is taken from the municipal government and transferred to neighbourhood level where citizens can monitor conditions and take direct action when necessary. The role of municipal government then becomes regulatory with the goal of safeguarding public health.

3.3 Arguments for the Use of Ecological Sanitation

Often, water used in flush toilets is of drinking quality. Only 1% of global water is drinkable, therefore, it is a precious resource. Water fit to drink is being used for other purposes that can use lesser quality water, such as toilets.

Mixing feces and urine makes treatment difficult. All waste water treatment plants use some natural/biological processes, but nature does

not normally have this waste water, so there are no microbes that can deal with this mix. In order to treat waste, treatment plants have to do this in stages. Each stage treats a different component of the mix by creating the right environment for microbes to do their work (aerobic, anaerobic, anoxic and the right pH). This is costly and requires energy.
A mix of domestic and industrial effluent in water cannot be treated properly, for heavy metals and other pollutants make this water unsuitable for reuse. This is normally discharged into the ground or water bodies.

Because of the complexity of the treatment process, treatment plants tend to be large. This requires costly infrastructure to build and maintain it, often out of the reach of poorer communities. John Jevons states that responsible, safe and legal composting of human waste could be key to maintaining nutrient levels in the world soils. Urea is the major component of urine, yet we produce vast quantities of urea by using fossil fuels. By properly managing urine, treatment costs as well as fertiliser costs can be reduced. Faeces also contain recognised nutrients, and could be used for modern agriculture, as micronutrient deficiency is a significant problem.

3.4 Making Ecological Sanitation Work

The ecological sanitation systems described in the earlier units are neither widely known nor well understood. They cannot be replicated without a clear understanding of how they function and how they can malfunction. They have several unfamiliar features, such as urine diversion toilet seats and squatting slabs, which raise questions about their cultural acceptability. In addition they require more promotion, support, education and training than ordinary pit, VIP pour-flush toilets.

Much has been learned about ecological sanitation systems from the many units in use in the world today. In a place like northern Vietnamense hundreds of thousands of rural households have double-vault toilets and recycle their products in agriculture. In Mexico and Central America there are tens of thousands of units of a similar type and in USA and Sweden there are many thousands of Clivus Multrums and similar devices. In Ladakh and Yemen there are hundreds of their traditional versions. Among these, there are successes and there are failures and our country Nigeria can learn from both, this is why in the early part of this course we describe the design and management features of ecological sanitation systems, so that mistakes can be avoided, and suggested promotion and support strategies that have proved to be essential for proper functioning of these systems.

Here, the unfamiliar aspects and sensitivity of these systems is discussed so that the reader can better appreciate the need to consider carefully both the design and management options and the promotion and support aspects.

3.4.1 The Unfamiliar Aspects

Probably the most unfamiliar aspect of ecological sanitation options is that it requires some handling, at the household level, of the products. Some concerns have been voiced about the cultural acceptability and health aspects of this handling in different parts of the world. While some cultures do not mind handling human excreta (faecophilic cultures), others find it ritually polluting or abhorrent (faecophilic cultures). Most cultures are probably somewhere in between these two extremes and experience is that when people see for themselves how a well-managed eco-san system works most of their reservations disappear. We should not therefore presuppose how a culture will react but rather carry out a trial and gauge the reaction.

A more important point about handling is that once ecological sanitation has gone to scale and hundreds or thousands of units are in use in towns and cities, individual households no longer need handle the products at all. At that scale the output from eco-san toilets can be collected, further processed and sold or centralised collection centres with trained personnel.

A second cultural issue, which causes debate, is whether eco-san toilets will be used properly in cultures where washing after defecation is mandated by tradition and religion. It is assumed that such cultures would always require users to wash over the vault and this additional water would soon spoil the delicate process going on inside. This concern is again overcome with greater familiarity of where these systems are used. Muslim cultures, where kinds of eco-san system have been traditional, wash away from the toilet opening. This is done by tradition, for the principles behind their dry systems require that is be done this way. As this has posed no problem in these traditional systems it is difficult to believe it should pose insurmountable problems in other washer cultures. Experience has shown that such a modification of toilet behavior is indeed possible.

Urine diversion toilet, seat-risers and squatting slabs are a unique innovation intended to keep vault contents dry and in some cases to allow the urine to be used as a fertiliser. These are so unfamiliar in most areas of the world that newcomers to the systems often find it hard to believe that they work properly. Sometimes newcomers to the systems remark that they do not believe they can be used by males. Others question whether they can be used by females. Experience shows that these designs work equally well for both sexes, as long as they squat or sit. Some communities have designed their toilet units with separate urinals for men so that the main seat-riser or slab does not have to be used by those who prefer to urinate standing.

Skeptics often claim that eco-san is an inferior alternative: it will be smelly, fly-producing and incompatible with modern living. In many cultures the toilet is placed far away from the house. It has a rough finish, is dark and not kept very clean. This low-standard toilet has given eco-san systems a poor image. This is a valid concern, for as mentioned many times elsewhere in this course eco-san systems are more sensitive to bad design and management than other on-site options such as pit toilets. If they are not designed and managed properly, taking into account nature, culture and process, they can be unpleasant and not achieve the health and environmental protection features for which they were intended. However, once newcomers gain familiarity with the options and see them in practice when designed, built and managed properly, they realise that eco-san can be a high-standard, modern option. Upscale versions for non-poor households have been developed in Europe and North America. These are very attractive and situated inside a modern bathroom, so the image changes completely. Such systems, rather than being inferior, should be viewed as superior: they protect the environment as no other existing toilet option can.

A concern is often expressed that some of these systems are simply too expensive for low income households in developing countries like Nigeria. Eco-san systems need not cost more than conventional systems. In most cases it is possible to find or develop an eco-san option to fit the budget. Some eco-san systems are sophisticated and expensive, while others are relatively simple and low-cost. There is often a trade-off between cost and operation: lower cost solutions mean more manipulation and care of the sanitation system but with higher cost solutions, manipulation and care can be reduced.

Eco-san systems need not be expensive to build because:

- The entire device is built above ground-there is thus no need for expensive digging and lining of pits;

- Urine is diverted, no water is used for flushing and the volume of the processing vault(s) is fairly small (as they are emptied periodically);

- The contents of the processing vault(s) are dry which means that there is no need for expensive water-tight constructions.

Finally, people unfamiliar with these options cannot imagine how they can be used in multistory buildings. However, this has been successfully achieved in Sweden and some other countries.

3.4.2 Sensitivity of these Systems

Eco-san options are more complex than drop-and-store systems but infinitely less complex than flush-and-discharge. The potential advantages of ecological sanitation can only be realised as long as the system functions properly. There is particularly with a new concept, the risk that those who plan, design and build do not fully understand the basic principles involved and how they relate to local conditions. This may lead to the selection of a system or options within the system that fit neither climate nor socio-economic conditions. With the right system in place the most common reasons for failure are lack of participation from the user, lack of understanding of how the system works, defective materials and workmanship and improper maintenance.

3.4.3 Lack of Participation

A sure recipe for failure of an ecological sanitation programme is to put it in place without the participation of the intended users and without proper instruction. This is clearly illustrated by the following example.

In 1992-94, in a project financed by Inter American Development Bank (IDB) through the Social Investment Fund, the government of El Salvador built 50,263 so-called eco- toilets. The total investment was 12.5 million dollars. The toilets were built by contractors without community participation and little or no community training.

A sample survey of 6,380 families carried out in 1994 showed that 39% of the toilets were used adequately, 25% were used inadequately and 36% were not used at all.

These findings led to the development of a hygiene education strategy that focused on personalised education for all family members through home visits, participation of organised women in the implementation of the whole educational process, education materials and user-friendly monitoring and evaluation. The impact of this hygiene education model was significant. After the completion of the first education module, the percentage of proper use increased to 72%, and the toilets that were being used improperly or were not being used at all decreased to 18% and 10%, respectively.

The lesson learnt from this whole process was that the problems of nonuse or improper management are not because of the technology itself but because of the interaction between technology and user. Therefore, the promotion of this type of technology should be on a personal and family basis, in order to provide advice on the spot. The need for behavioural changes, proper use and maintenance should be stressed.

3.4.4 Lack of Understanding

Sanitation is a complex matter. The raw material we are dealing with is potentially lethal and will, if not managed properly, cause considerable nuisance. Sanitation is also a topic that in many cultures is surrounded by taboos. Cases where eco-san systems have failed is due to ignorance and lack of experience.

When a properly selected and well built eco-system fails, the most common fault is that the process has turned wet. In a system based on dehydration the humidity of the contents of the processing vault should quickly be reduced to less than 20%. If this is achieved there is no smell, no fly breeding and very rapid pathogen destruction. If the contents, for various reasons, remain damp, they will smell, flies and other insects will breed in the pile and pathogenic organisms will survive longer.

In a system based on decomposition the corresponding humidity should ideally be between 50% and 60%. If the content of the processing vault become too wet the decomposition process will slow down the compost pile will smell, there will be flies, and pathogenic organisms will survive longer.

Fly breeding in toilets is basically related to wetness of the contents of the processing vaults. In a properly functioning dehydration system there would be no fly breeding, but if something goes wrong and the contents turn wet, fly breeding is likely to occur. The risk of fly breeding is greater in a composting system for two reasons: it operates with a much higher process humidity and fly eggs may be introduced into the processing vault together with kitchen scraps.

Pathogen destruction is a key issue in eco-san. In a malfunctioning or wrongly used eco-san system pathogenic organisms may survive and, through recycling of inadequately processed faeces, be released into the environment

3.4.5 Defective Materials and Workmanship

Eco-san systems are no more sensitive to poor workmanship and defective materials than any other sanitation system. In some ways, they are less sensitive because the processes involved are dry and the volumes handled comparatively small. Common faults include seepage of water into the processing vault, and leaking urine conduits.

3.4.6 Improper Maintenance

Many eco-san systems have failed because they received improper maintenance. Usually this has been because they were viewed simply as new types of devices rather than as whole systems that also include the interacting elements of nature, society, process and device. Often, new devices have been installed without adequate attention to the education and ongoing technical assistance that may be necessary to ensure that users understand and accept to do what is required to make them work.

All sanitation technologies require maintenance to function properly. Large water-borne sewerage systems with centralized treatment plants, for example, must receive constant maintenance from a professional staff. However, since in eco-san systems more of the processing occurs on site and because sanitising and recycling human excreta is inevitably more complex than simply disposing of them as wastes, eco-san devices generally require a higher level of maintenance by users than conventional flush toilets or pit toilets.

The amount of maintenance required by users of eco-san systems varies a great deal, depending upon the design strategy, climate and other local conditions. Good system design can minimise the need for intensive maintenance, and the tasks required need not be difficult. For example, systems that rely on composting often require the regular addition of bulking agents and periodic checking to ensure that ventilation pipes are not blocked. Some systems may require the transfer of partially processed solids to a secondary processing area. Many systems require that the toilet seat-riser or squatting hole be in some way closed-off when not in use. All systems require periodic inspection and removal of the end products. The major common element in the maintenance of eco-san systems is that the user must ensure that the system is working properly. However, it is important to note that many operations and maintenance functions, such as emptying of toilet vaults, transport and secondary treatment can be carried out by special service providers, either as a public service or through private enterprise. Service contracts will minimise the burden on households and also enable municipal administrations to guarantee a satisfactory standard of operation and maintenance.

3.4.7 Non-use

The alternative to the use of a sanitary device is often open defecation. Non-use is therefore a potential public health risk. There could be a number of reasons for non-use: the eco-san concept may not be accepted by the users, it may be poorly understood or it is rejected because the system does not function properly or is difficult to use. Important factors in acceptance are traditional attitudes, habits and taboos related to defecation and human excreta.

4.0 CONCLUSION

In conclusion, this unit taught us that introduction of eco-san systems is bound to lower the total cost of urban sanitation. Sewers, treatment plants and sludge disposal arrangements will cost several times as much as an eco-san system. Also we learnt that the most unfamiliar aspect of ecological sanitation options is that it requires some handling of the products at the household level. Some concerns have been voiced about the cultural acceptability and health aspects of this handling in different parts of the world and for this reason this unit also discussed what makes ecological sanitation work.

5.0 SUMMARY

In summary, this unit looked at financial considerations as eco-san systems is bound to lower the total cost of urban sanitation. Sewers, treatment plants and sludge disposal arrangements will cost several times as much as an eco-san system. Eco-san system has advantages to the households, environment and municipalities. The systems do not use the scarce water resources and may result therefore in a more equitable allocation of water to rich and poor households, though there are some arguments for the use of ecological sanitation, in this unit despite these arguments approaches were described that can make ecological sanitation work.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain briefly how you could make ecological sanitation work in a country like Nigeria where it is not familiar.
2. Write briefly on ‘non-use’.

7.0 REFERENCES/ FURTHER READING

Esrey, Steven A & Anderson Ingvar (2001). *Ecological Sanitation: Closing the Loop.*

http://www.historyonthenet.com/Romans/clothing.htm Web article, The Romans - Clothing Bracken (2006). “The Road Not Taken: How Traditional Excreta and Grey water Management may Point the way to a Sustainable Future.

UNESCO/IHP and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH (2006). “Capacity Building for Ecological Sanitation – Concepts for ecologically sustainable sanitation in Formal and Continuing Education.