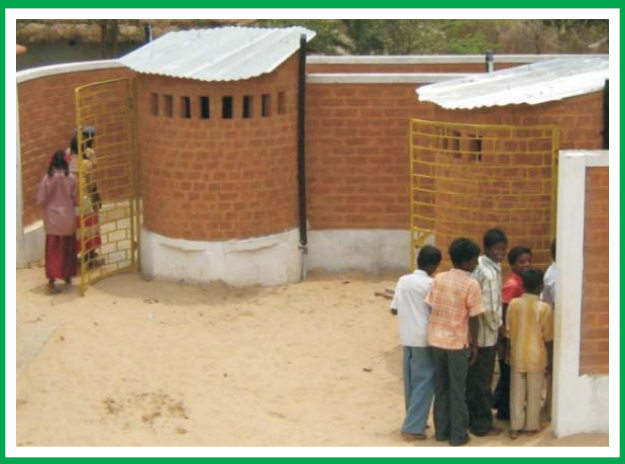

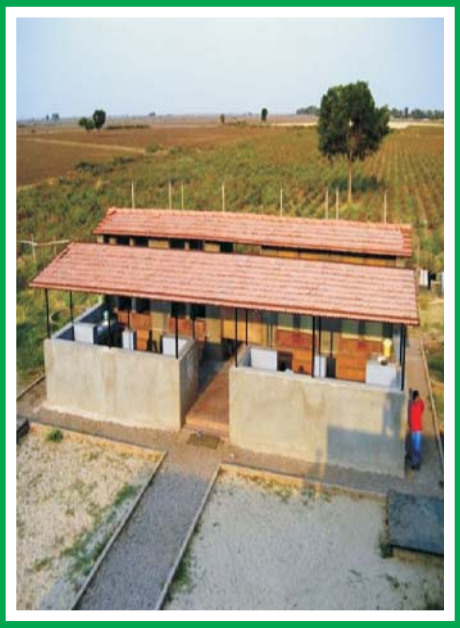

Ecological Sanitation
Practitioner's Handbook

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Contents Pages

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FOREWORD

India is experiencing a paradigm shift in rural sanitation. The Total Sanitation Campaign (TSC) has been able to accelerate and increase the rural sanitation coverage from a mere 21% as per 2001 Census to 73% in the current year with over 25,145 Panchayati Raj institutions (PRIs) becoming open defecation free "**Nirmal Grams**". TSC adopts an innovative '**community led**', '**demand driven**' approach in programme implementation and promotes flexible sanitation technology options.

While there is significant improvement in the sanitation situation in rural India, issues such as sustainability of sanitation through sustained usage of toilet facilities, non availability of water for sanitation, pollution of ground and surface water due to the conventional "Flush and Discharge", developing "Drop and Store systems" of sanitation for areas that normally are not able to support pit latrines or pour flush latrines specially relevant for hilly, water scarce regions, water logged, flood prone, nutrient scarce areas still need to be addressed. Since conventional sanitation systems fail to fulfill the fundamental principles of sustainable development, there is an urgent need to scale up alternative sustainable sanitation systems to address these issues.

Ecological Sanitation (ECOSAN) is one such sustainable sanitation system that saves water, prevents contamination and pollution of water and brings back the nutrients in human excreta back to the soil in the form of good manure. Economically, it helps improve food production and food security. Socially, it restores the dignity/ quality of human life against the practice of open defecation owing to lack of choice before communities.

The Ministry of Drinking Water and Sanitation has through policy changes in the TSC guidelines recognized ECOSAN as one of the technology options. To translate the policy changes into field level projects, a need was felt by all TSC programme managers and field level practitioners for receiving technical guidance on implementation of Eco sanitation.

This Practitioners Manual presents both the theoretical and practical aspects of implementation of Eco sanitation including detailed designs of different types of Ecosan Toilets and some case studies and successful Eco sanitation models set up in rural India. The manual has been developed in association with UNICEF based on a consultative workshop with all key stakeholders.

I am sure that all TSC programme managers and field level functionaries will find this practitioner's manual useful in integrating Eco sanitation concept with the ongoing TSC programme and develop several design options for different geographical regions particularly in schools. This would facilitate the integration of much desired sustainability issues in the ongoing national sanitation programme in rural areas and make TSC a Total Sustainable Sanitation Campaign.

(Navin Kumar)

Place: New Delhi
Dated: September 12, 2011

Chapter 1

Introduction to Ecological Sanitation

1. Introduction to Ecological Sanitation

Sanitation is a determinant of health and includes food, personal, domestic and environmental hygiene and access to adequate and safe water. It includes home sanitation and safe disposal of liquid, solid waste and human excreta. Sanitation is a fundamental requirement to ensure safe health, environment and the overall well being of the society. Unless proper, functional sanitation facilities are in use complemented with the right types of hygiene behaviours, communities will be vulnerable to recurrent incidences of water and sanitation related diseases.

The interlinkages of sanitation with many other development issues such as health, education, agriculture and poverty alleviation have been acknowledged widely in recent years. As a result, sanitation has been included as one of the priority areas in the Millennium Development Goals (MDGs) laid out by the United Nations.

While sanitation has been rated as one of the important medical advancements since 1804, several studies reflect that conventional sanitation technologies have been responsible for pollution of water bodies & propagation of water-borne diseases. Majority of the world's population having access to sanitation facilities still rely on either "Flush and Discharge" or "Drop and Store" systems.

Drop and store systems can be simple and relatively low cost but have many drawbacks. Often they cannot be used at all on rocky ground, where the groundwater level is high or in areas periodically flooded. They require access to open ground and the digging of new pits every few years.

Further, in the conventional sanitation approach, faecal matter and urine are dealt with as waste, not as a resource, and thus fail to recover useful products in it. Since conventional sanitation systems fail to fulfil the fundamental principles of sustainable development, there is an urgent need to explore alternative sanitation systems which are capable of fulfilling this important objective.

This publication explores the alternative sanitation approach called "Ecological Sanitation", which is gaining increased attention in sanitation discourse in recent years across the globe. Ecological sanitation is an approach based on the principle of "minimum resource utilization and maximum resource recovery". This approach can offer sound sanitation solutions in a framework of sustainable development.

Major part of this publication focuses on ecologically sound sanitation solutions that minimize resource consumption and attempt to eliminate pollution of natural ecosystems. In the context of rural India, where substantial numbers of sanitation facilities at household and school levels are being created in mission mode, promotion of sound sanitation practices founded on the principle of ecological sanitation will be of great benefit to rural communities in general and especially to communities living in ecologically fragile areas.

1.1 Sanitation Scenario in India

Sanitation scenario of rural India has improved quite significantly over the years due to the sustained efforts of the Government of India. Rural sanitation coverage in India was a mere 1% in 1980. Presently, over 73% of the rural population has been covered due to these efforts.

The Total Sanitation Campaign (TSC) launched by the Government of India in 1999 has been a key factor for this success. The TSC programme with a focus on awareness generation and demand creation brought out significant change in the sanitation approach. Introduction of the Nirmal Gram Puraskar (NGP) in 2003 under the TSC, an incentive scheme for open defecation free villages, brought out significant impetus to the programme by leveraging participation of the Panchayati Raj Institutions (PRIs) in sanitation promotion.

Water and sanitation facility in schools is also a major concern. India has the largest number of school going children in the world. Under TSC out of a target of 13,14,636 , 11,24,771 school toilet units have been constructed so far. Convergence between the TSC and the Sarva Shiksha Abhiyan (SSA), a flagship programme of Government of India for Universal Elementary Education, has strengthened the efforts towards achieving water and sanitation coverage in all schools.

Presently, of the 7.66 lakh primary and upper primary rural schools in India, 85% have water supply facilities, 58% have sanitation facilities and 43% have separate toilets for girls.

While there is significant improvement in the sanitation situation in rural India, issues such as poor usage of toilet facilities, low priority and awareness on sanitation among rural communities, lack of adequate water and infrastructure in schools are some key issues that still need to be addressed. Emerging issues such as contamination of surface and ground water due to flush & discharge or drop & store systems need to be addressed urgently. Promotion of sanitation technologies based on ecological sanitation has an important role in addressing these issues.

1.2 Importance of Sanitation

Studies conducted globally reveal that 80% of the common diseases can be prevented by providing water and sanitation facilities. Safe disposal of human excreta is an important component of sanitation as excreta contains organisms like bacteria, viruses and parasites

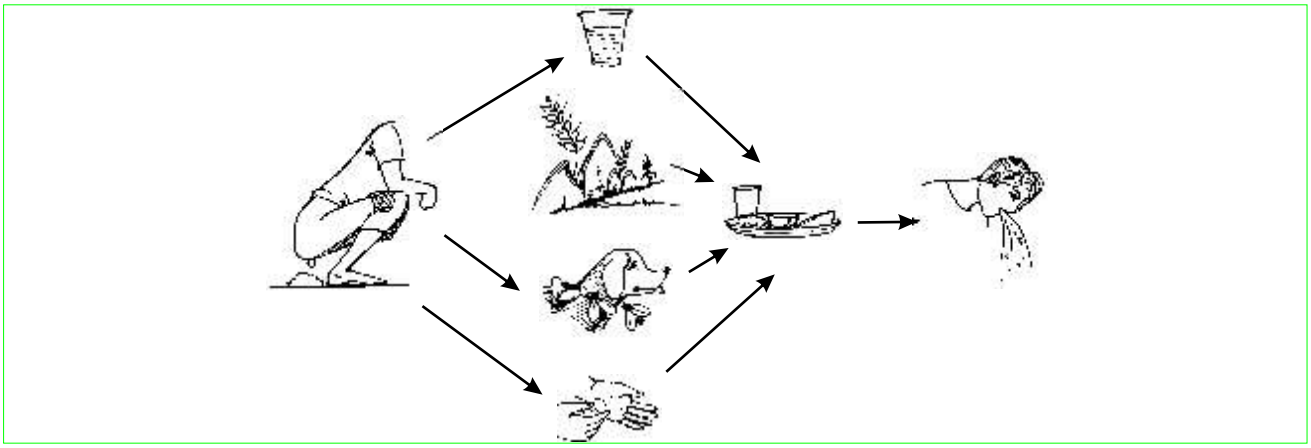


Figure 1.1 Faecal-oral disease transmission via fluids, fields, flies, fingers

responsible for diarrhoeal diseases. Most of the common diseases which lead to infant mortality such as diarrhoea, typhoid, cholera, worm infestations and respiratory diseases can be prevented by providing safe drinking water and sanitation facilities.

Disease causing pathogens in human excreta are passed on by an infected person to another person via various routes: flies, on fingers, in fluids and via surfaces such as fields (Figure 1.1). Improved sanitation and hygiene practices interrupts these routes of transmission and helps in preventing faecal-oral disease transmission. Therefore, sanitation is termed as the "Primary Barrier" against the faecal-oral disease transmission.

One gram of excreta contains

1 crore viruses
10 lakh bacteria
1,000 parasite cysts and eggs

Absence of appropriate sanitation facilities exposes women to dangerous and shameful conditions apart from causing severe health complications. In such conditions, women are compelled to relieve themselves only before sunrise or wait till sunset. Children without access to appropriate sanitation suffer from repeated diarrhoeal diseases and worm infestations which are a major cause of malnourishment, stunted growth and high mortality rates.

Impact of absence of sanitation facilities

- Contamination of water sources & environment
- Diarrhoeal diseases & worm infections
- Malnourishment and mortality among children
- Loss of dignity to women and girl children
- Accidents while defecating in unsafe locations
- High drop out rate among girls in schools
- Economic loss to families and the nation

Studies reveal that absence of separate toilet facilities for girls in school is a major cause for very high drop out rates among them. In India, only 4 out of 10 girls who enrol in schools complete schooling.

Apart from impact on health, lack of sanitation facilities has a direct linkage to the economic, literacy and social well being of a society. Diseases caused due to the absence of water and sanitation facilities impact economic well being of individuals as well as that of the nation. For example, diseases burden due to simple and preventable diseases leads to increased medical exchequer and infrastructure for treatment. An estimate by Central Health Bureau, Ministry of Health and Family Welfare, Government of India, shows that every year over 180 crore productive man days worth of Rs 1,200 crore is lost due to diarrhoeal diseases in the country.

1.3 Conventional Sanitation Systems : Drawback & Limitaions

Conventional sanitation systems adopted for disposal of human excreta are primarily based on either "flush and discharge" or "drop and store" principles. These methods, developed at early stages of evolution of sanitation concepts, aim to dispose human excreta rather than viewing it as a resource and treating at source. Conventional sanitation can be termed as following a "linear sanitation approach" also termed as "end of pipe" technology, leads to disposal of enormous quantities of nutrients present in human excreta unproductively into water bodies causing pollution, apart from wastage of precious fresh water.

Some of the limitations of conventional sanitation technologies are as follows:

- Massive infrastructure needed and high

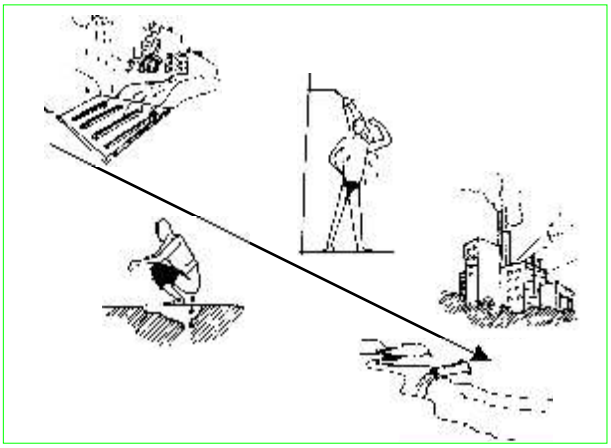


Figure 1.2 Flush and discharge method of disposal

maintenance costs of managing the flush and discharge systems are not affordable even by many developed nations of the world. Developing nations can ill afford the huge costs of environmental restoration such sanitation systems in the long run.

- Valuable nutrients present in human excreta are misplaced in the water bodies and environment as these conventional sanitation technologies fail to recover useful products. As a result, a linear flow of nutrients from rural areas to urban areas and nutrients accumulate in water bodies resulting in pollution.

- Pathogens present in faeces contaminate fresh water and the resulting sewage needs to go through a complex treatment processes.

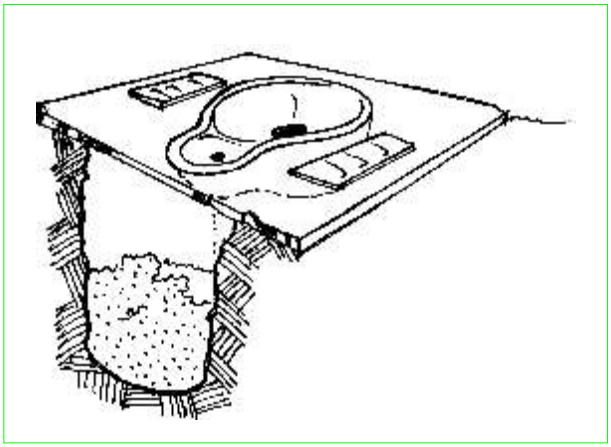


Figure 1.3 Drop and Store method of disposal

- Elimination of organic matter and nutrients at sewage treatment plants requires enormous amounts of energy and chemicals.

- Use of freshwater to transport human excreta in sewers results in high drinking water demand. In water-scarce regions, additional pressure is put on limited freshwater resources.

- Drop and store method of treating human excreta onsite has limitations too. Ground water especially in coastal areas and areas with shallow water table get contaminated by disease causing pathogens and nitrate present in human excreta.

1.4 Ecological Sanitation Systems : Advantages & Novel Features

Ecological sanitation systems render human excreta safe, preventing pollution rather than attempting to control it after pollution takes place and proposes to use the safe products of sanitized human excreta for agricultural purposes. Therefore it can be characterized as a “closed loop” sanitation system which treats human excreta as a resource. Human excreta are processed until they are completely free of disease organisms. Nutrients obtained in the form of compost and urine are recycled by using them in agriculture. As ecological sanitation systems adopt treatment processes that closely mimic the cycles of nature, it is sustainable and has no negative impact on the environment.

Some of the advantages in the use of ecological sanitation systems are:

- Ecological sanitation systems lead to saving enormous quantities of fresh water since urine diverting dry toilets and waterless urinals do not require water for flushing.

- Faeces and urine which require different treatment processes can be handled easily when separated at source. Studies show that the segregated treatment approach is both energy efficient and cost effective.

- Separation of faeces, which has high pathogen levels, from urine and absence of water used for flushing, significantly reduces the volume of waste fraction to be treated.
- By using ecological sanitation approach pollution of water sources and the risks posed by diarrhoeal diseases due to unsafe disposal of human excreta can be mitigated.

- Ecological systems facilitate decentralized and sustainable treatment options for safe disposal of human excreta.

- Compost obtained from ecological sanitation toilets is a good soil conditioner and increases soil fertility.

- Urine, which is usually sterile, is rich in nitrogen, phosphorous and potassium can be directly applied to crops or further processed as crystal fertilizer.

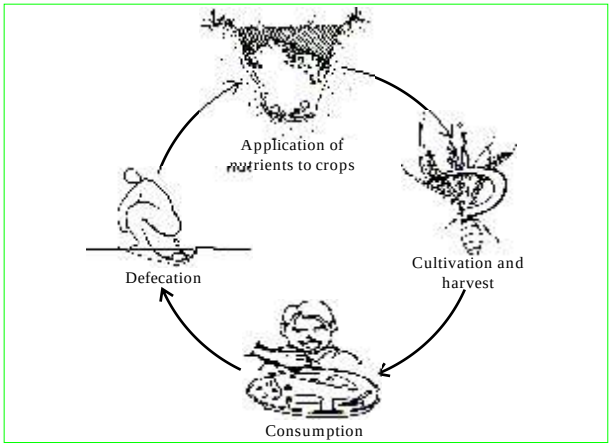


Figure 1.4 Closing the loop through ecological sanitation

- Recovery of nutrients from human excreta using ecological sanitation systems can effectively substitute mineral fertilizers which are non-renewable whose prices have increased multifold due to depletion of oil and phosphate rock reserves.

- Linking sanitation and agriculture using ecological sanitation approaches can play a major role in ensuring health security as well as food security of economically weaker sections of society.

1.5 Total Sanitation Campaign (TSC)

Rural sanitation came into focus in the Government of India in the World Water Decade of 1980s. The Central Rural Sanitation Programme was launched by the Government of India in 1986 to address rural sanitation in India. It was a supply driven, highly subsidy and infrastructure oriented programme. As a result of these deficiencies and low financial allocations, the CRSP had little impact on the gargantuan problem. The experience of community-driven, awareness-generating campaign based programmes in some states and the results of evaluation of CRSP, led to the formulation of the Total Sanitation Campaign (TSC) approach in 1999.

The Total Sanitation Campaign is a ‘community led’ programme with increased emphasis on awareness creation and demand generation for sanitary facilities in houses, schools and for cleaner environment. TSC adopts a comprehensive and integrated strategy for sanitation promotion which includes intensive IEC Campaign and behavior change communication involving Panchayati Raj

Institutions, Co-operatives, Women Groups, Self Help Groups, NGOs, technology improvisations to meet the customer preferences, hygiene practices, solid and liquid waste management.

Objectives

The main objectives of the TSC are as under:

- Bring about an improvement in the general quality of life in the rural areas.
- Accelerate sanitation coverage in rural areas and achieve cent percent sanitation coverage by 2017.
- Cover Schools and Anganwadis with sanitation facilities in rural areas by 2013 and promote hygiene education and sanitary habits among students.
- Motivate communities and Panchayati Raj Institutions in generating felt demand for sanitation facilities through awareness creation and health education.
- Encourage cost effective, appropriate and sustainable sanitation technologies in sanitation.
- Develop community managed environmental sanitation systems focusing on solid and liquid waste management.

Sanitation Components under TSC

Increased attention to software components such as Information, Education and Communication (IEC), human resource development, capacity building and generation of demand for sanitary facilities were included in the programme. Introduction of supply chain

Pattern of Allocation	Total Cost	Centre Share	State Share	Beneficiary Share
Incentives Per Unit Cost of Household Toilets (only for BPL families) [a]				
Plain areas		Rs 2,200	Rs 1,000	
Hilly areas		Rs 2,700	Rs 1,000	
School Toilets [b]				
Plain areas	Upto Rs 35,000	Upto 70% (Rs 24,500)	Upto 30% (Rs 10,500)	If necessary, mobilisation from PTA or from other funds such as MPLADS / MLALADS can be done.
Hilly areas	Upto Rs 38,500	Upto 70% (Rs 26,900)	Upto 30% (Rs 11,550)	
Anganwadi Toilets				
Plain areas	Upto Rs 8,000	Upto Rs 5,600	Upto Rs 2,400	If necessary, other funds like MPLADS / MLALADS can also be utilised.
Hilly areas	Upto Rs 10,000	Upto Rs 7,000	Upto Rs 3,000	
Community Sanitary Complexes [c]	Upto Rs 2,00,000	Upto Rs 1,20,000	Upto Rs 60,000	Upto Rs 20,000

Notes:

[a] Incentive for toilet construction is only provided to BPL families. The state government is free to provide additional incentive based on local needs.

[b] Co-educational schools are to be provided with separate toilet facilities for boys and girls.

[c] Community Sanitary Complexes are provided where people live in congested locations or they do not own land for toilet construction.

Table 1.1 Current financial allocation for hardware activities under the TSC programme

mechanisms such as rural sanitary marts, production Centers and provision for matching grants has helped in supporting the demand generated.

To address safe disposal of solid and liquid waste financial allocation has been earmarked in the TSC programme. Table 1.1 provides the details of the current allocation pattern for the hardware activities under the TSC programme.

Summary

In view of the problems associated with promotion of conventional sanitation systems especially in ecologically sensitive regions such as coastal, flood prone, shallow water table, hilly and dry areas, the TSC programme guidelines were amended to include promotion of ecological sanitation components. Ecological sanitation components include urine diverting dry toilets, waterless urinals and other related technologies can be promoted at households, community sanitary complexes, schools and anganwadis.

The TSC guidelines Para 9 (h) state that "Ecosanitation structures that allow storage of human excreta and urine, for composting or converting to usable and safe manure or fertilizer can be taken up under Total Sanitation Campaign. It should, however, be ensured that it does not involve the practice of manually cleaning and removing human excreta and is not in contravention of any existing provisions of law. Further, the structure should be so located that it does not lead to contamination of existing water bodies, water table below ground, rain water or other water streams. The concept of waterless urinals can also be promoted particularly for institutional toilet complexes to save precious fresh water. Such concepts should be promoted along with existing traditional approaches incorporating necessary modifications in consultation with community." Existing financial allocations earmarked under TSC for all the respective locations mentioned above can be utilized for promoting ecological sanitation technologies. Efforts may be made by States to integrate Ecosanitation with ongoing TSC projects.

Chapter 2

Ecological Sanitation

2. Ecological Sanitation

Ecological sanitation is based on three fundamental principles : pre-venting pollution rather than attempting to control it after we pollute; sanitizing the urine and the faeces; and using the safe products for agricultural purposes. This approach can be characterised as 'sanitize-and-recycle'.

This approach is a cycle – a sustainable, closed-loop system. It treats human excreta as a resource. Urine and faeces are stored and processed on site and then, if necessary, further processed off site until they are free of disease organisms. The nutrients contained in the excreta are then recycled by using them in agriculture.

Conserving water, energy and minimising environmental pollution are also the other important objectives of ecological sanitation systems.

Conventional treatment processes are often designed based on the principle that human excreta is a waste which has no useful purpose. In nature there is no waste - all the products of living systems are used as raw materials by other living systems. Recycling sanitized human urine and faeces by returning them to the soil serves to restore the natural cycling of life-building materials that has been disrupted by conventional sanitation practices. Further, the energy efficiency of this process is greater as recycling takes place more locally.

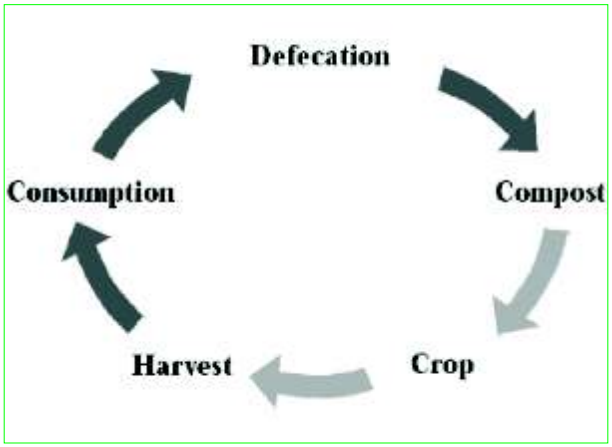


Figure 2.1 Closing the Loop: Ecological sanitation

Recycling of faeces and urine prevents direct pollution caused by sewage being discharged or seeping into water resources and ecosystems. A secondary benefit is that of recycling nutrients to soil and plants which reduces the need for chemical fertilizers. It restores good soil organisms to protect plants, and it is always available locally, wherever people live. Nutrients recovered from human excreta can be used to enhance the productivity of horticulture and agriculture in home gardens and farms, in urban as well as rural areas.

2.1 Nutrient Cycle

Nutrients such as nitrogen, phosphorous and potassium play an important role in the growth of plants. In general, nitrogen and potassium make up about 80 percent of the total mineral nutrients in plants; phosphorous, sulphur, calcium and magnesium together constitute 19 percent, while all the micronutrients together constitute less than 1 percent.

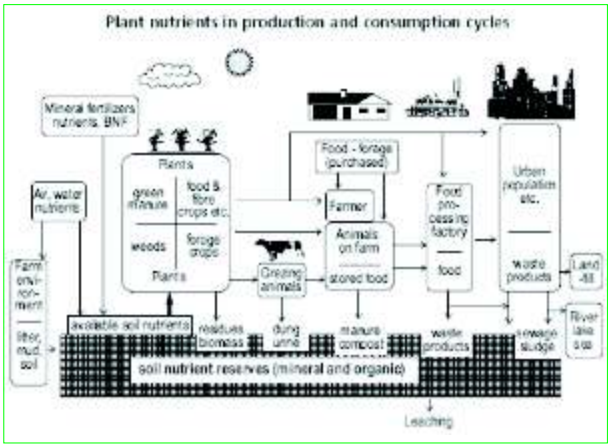


Figure 2.2 Nutrients in production and consumption cycles (Source: Finck, 1992)

Nitrogen is responsible for the dark green colour of stem and leaves, vigorous growth, branching / tillering, leaf production, size enlargement, and yield formation. Phosphorous is essential for growth, cell division, root lengthening, seed and fruit development, and early ripening. Potassium increases resistance of plants to disease, creates winter hardiness and drought resistance, and produces stiff stalks and stems to reduce water logging. It also increases grain plumpness as well as growth of fruit and root vegetables.

Nutrients present in soils are consumed by crops to produce food and other products for the benefit of human beings and animals. Crop products are often consumed far away from the production sites, some times thousands of kilometres away in another country. When crop products are moved, the nutrients contained in them are also transported. This implies movement of nutrients from the production area to the area where they are finally utilized.

If nutrients excreted as a waste after consumption are not recovered and simply discharged into water bodies, it causes a break in the natural nutrient cycle and leads to depletion of nutrients in the soil. As a result, these misplaced nutrients have to be substituted by chemical fertilisers produced from finite mineral and oil reserves. Providing nutrients to soil solely through fertilisers is often unaffordable by many poor and marginal farmers leading to food insecurity and poverty. Use of chemical fertilisers also leads to environmental pollution and degradation of soil health in the long run.

Human beings excrete most of the plant nutrients they consume through food after attaining adulthood as the body does not need all nutrients for body growth. Therefore, recovery of nutrients from human excreta offers a tremendous opportunity for closing the nutrient cycle and thereby ensuring sustainable growth of the society. By adopting ecological sanitation practices, plant nutrients that we consume can be recovered and recycled back to soils for ensuring food security.

Elements (g / ppd)	Urine	Faeces	Urine + Faeces
Nitrogen	11.0	1.5	12.5
Phosphorous	1.0	0.5	1.5
Potassium	2.5	1.0	3.5
Organic carbon	6.6	21.4	30
Wet weight	1,200	70 – 140	1,200 – 1,400
Dry weight	60	35	95

Table 2.1 Major elements present in human excreta (Source: Esrey et al. 2001)

Nutrients	Nutrients in 500 litres of Urine	Nutrients in 50 litres of Faeces	Total	Fertilizer needed to grow 250 kgs of cereal
Nitrogen	5.6 kg	0.09 kg	5.7 kg	5.6 kg
Phosphorus	0.4 kg	0.19 kg	0.6 kg	0.7 kg
Potassium	1.0 kg	0.17 kg	1.2 kg	1.2 kg

Table 2.2 Major nutrients present in human excreta and quantity of nutrients required to grow 250kg cereals (Source: WEDC)

2.2 Nutrients in Human Excreta

Urine and faeces excreted by human beings are a rich source of nutrients like nitrogen, phosphorous and potassium. On an average, every human being excretes 500 litres of urine and 50 litres of faeces in a year. These values vary according to age and dietary habits of an individual. Urine contains significant portion of nutrients excreted by the human beings. Studies suggest that around 80% of nitrogen, 66% phosphorous and 80% of potassium are present in urine. Feaces is rich in organic carbon with over 80%.

As illustrated in Table 2.1, the amount of nutrients present in human excreta of a person annually correspond to the amount of fertiliser needed to produce 250 kg of cereal, which is also the amount of cereal that a person needs as food every year. Therefore, food security of every human being can be ensured if nutrients are recovered back from excreta. Such an approach to human excreta management would ensure not only food security but also much desired sustainable environment.

Urine is usually sterile; unless it is cross contaminated with faeces, while it is important to inactivate pathogens present in human excreta before it is applied to agricultural lands. Treatment processes which can be adopted to render human excreta safe are discussed in the forthcoming sections.

The basic steps adopted to render safe handling and recycling of human excreta are listed below:

- Source Separation : Source separation of faeces, urine and wash water and ensuring that no water be used for flushing would reduce the volume of pathogenic material. Only the faecal fraction needs to be paid great attention.
- Isolation : The pathogenic material should be isolated until it is safe for recycling and this eliminates the risks of contamination.
- Volume Reduction : The volume and weight of pathogenic material is reduced by dehydration and / or decomposition to facilitate storage, transport and further treatment.
- Sanitization : Reducing pathogens to a harmless state, by sanitization: primary treatment on-site (dehydration / decomposition, retention), secondary treatment on / off site (further dehydration, high temperature composting, changes in pH by the addition of lime), and, if necessary, tertiary treatment (incineration).

2.3 Recycling Nutrients present in Excreta

Urine and faeces can be safely recycled back to

soil after treatment. Suitable treatment options can be introduced through ecological sanitation systems appropriate to the situation.

Urine can be subjected to various treatment processes like storage, volume reduction, hygienisation, struvite recovery and evaporation. Direct application of urine to crops after a short storage period is the most preferred option being adopted in rural areas presently. However, direct application of urine over a sustained period may lead to increase in soil salinity of agricultural lands requiring periodical monitoring and mitigation measures. Collection of urine from urban areas and institutions like schools and public places, transportation of large volume of urine increases the cost of application. Therefore, methods like struvite recovery, volume reduction and evaporation are being explored. Urine has proved to be a quick acting multi-component fertiliser which has very low heavy metal content. Better plant yield, taste and plant characteristics have been observed among plants fertilised with urine.

Dehydration or decomposition processes are applied to eliminate pathogens present in faeces. Aeration, increased temperature, high pH due to addition of ash and lime and microbial activities are some factors responsible for inactivation of pathogens in faeces. Compost obtained from the process is rich in carbon and a very good soil conditioner. Some benefits exhibited by compost are improved soil structure and water holding capacity, good microbial activities, prevention of pests and disease, moderation of temperature, slow release of nutrients and binding of heavy metals.

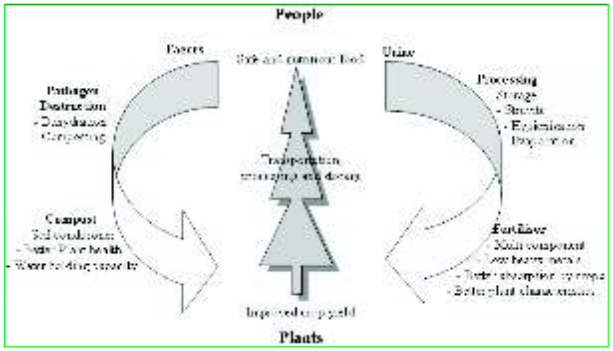


Figure 2.3 Recycling nutrients from excreta for food security

2.4 Ecological Sanitation Systems

Any sanitation system that sanitises waste materials and facilitates recovery of useful substances can be termed as an ecological sanitation system. However, it is quite difficult and a challenging task to classify the numerous methods which can be utilised to achieve this purpose. Single or a range of systems in combination can be employed to achieve this objective. The following schematic representation shows various ecological sanitation systems which can be employed to address major waste streams.

In this section, a few important cost effective and decentralised ecosanitation systems which can be employed in rural areas to treat human excreta are discussed. However, ecosan is not limited to these technologies alone, other

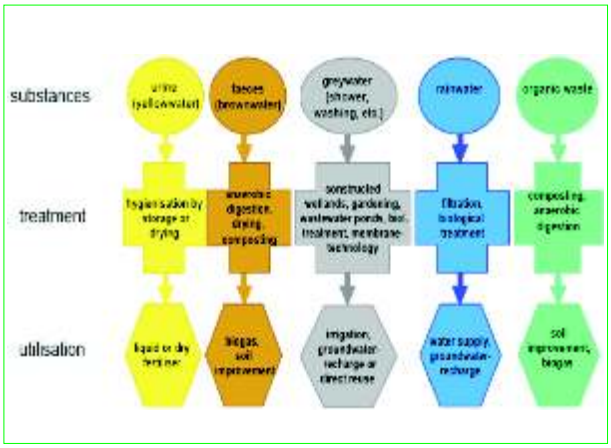


Figure 2.4 Overview of various ecological sanitation systems (Source : GTZ)

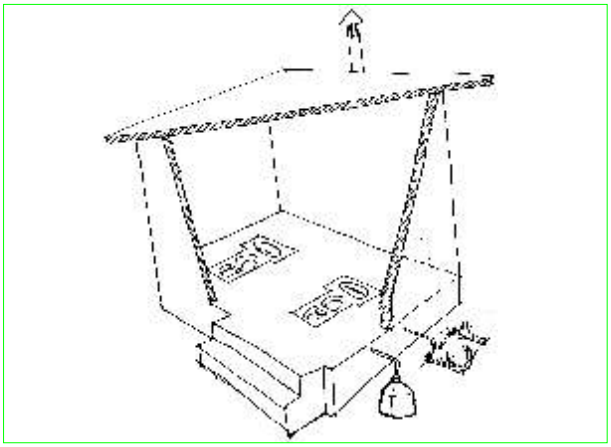


Figure 2.5 Ecosan toilet with twin chambers (UDDT)

technologies which are capable of meeting these objectives would also be considered as ecological sanitation systems.

Ecosan Toilets (UDDT)

Urine diverting dehydrating toilets which are commonly termed as “ecosan toilets” are widely being adopted across many parts of the world due to their versatile application and operational ease. Unlike other systems, ecosan toilets utilise dehydration process which is less complex and best suited to most places. Faeces, urine and wash water, especially in places like India, where people follow ablution after defecation, need to be separated using a specially designed toilet 3-hole seat (Figure 2.5).

The faeces and additive of soil, wood ash or dry leaves added after every use are collected in a chamber or removable bin placed directly below the toilet seat. By maintaining dry conditions inside the chamber and by enhancing air circulation through vent pipes provided to the chamber, dehydration of faecal matter is achieved. Due to factors such as increase in pH, higher temperature, aeration and dehydration, the mixture is sanitised and desiccated into a fine power-like substance after isolation period of 9-12 months. This dry residue or compost collected from the vault is a good soil conditioner which can be applied to agricultural lands.

Urine diverted to a storage tank can be applied to crops as a nitrogen rich fertiliser containing both phosphorous and potassium. Urine which is usually sterile does not require treatment unless cross contamination with faeces occurs. Wash water containing pathogens is diverted safely to a soak pit or a plant bed provided outside the toilet.

Ecosan toilets help in saving water, preventing contamination of ground water and recycling nutrients excreted by human beings to agriculture. It is suited for construction in all types of regions including dry, cold, hilly and plain areas.

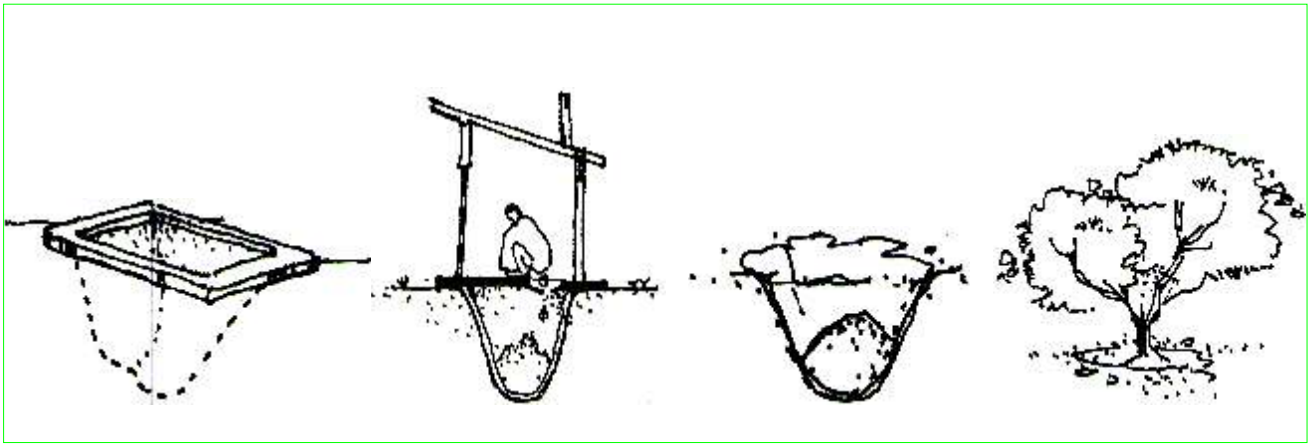


Figure 2.6 Process of construction of Arborloo composting toilet (Design: Peter Morgan, Zimbabwe)

Arborloo

Arborloo is a composting toilet which is widely used in various parts of Africa. Faeces and urine are collected together in an unlined pit. After every use, soil, dry leaves or ash are added to prevent odour and increase the carbon content of the mixture. A movable superstructure is placed over the pit to offer privacy to the users. The ring beam provided around the pit on top and the squatting plate placed over it is moved to a new location after the pit is filled-up.

A thick layer of soil cover is placed over the filled-up pit and is allowed to settle for some time. Later, vegetables or fruit plants are grown over it. It is observed that plants grow very well due to fertile composted material available below. Arborloo type composting toilets are more suited to areas where ground water table is very deep and as also for dry regions.

If Arborloo is implemented in Indian conditions, diverting the wash water to a separate soak pit should be considered in order to prevent smell inside the pit and any possible ground water contamination through leaching.

Fossa Alterna

Fossa Alterna is also a composting type toilet being widely promoted in Africa. It functions much like the Arborloo; however it has two pits constructed with ring beams placed over them permanently. Only the squatting slab and superstructure are moved between the two pits when one of them gets filled-up. Lining side walls of the pit with dry stones or bricks without mortar provides stability to the side wall of the pits.

Once one pit gets filled-up, it is covered with soil and the contents are allowed to compost for a period of 6-9 months before emptying. The compost emptied from the pit is applied as manure to crops and plants. The two pits constructed initially are used in rotation by moving the squatting slab and the superstructure.

Diverting the wash water to a separate soak pit should be considered in order to prevent odour and any possible ground water contamination through leaching. Fossa Alterna is suited for areas where ground water table is very deep and for dry regions.

The Ventilated Improved Double Pit toilets also function similar to Fossa Alterna.

Toilet Linked Biogas Plants

Biogas reactors such as fixed or floating dome

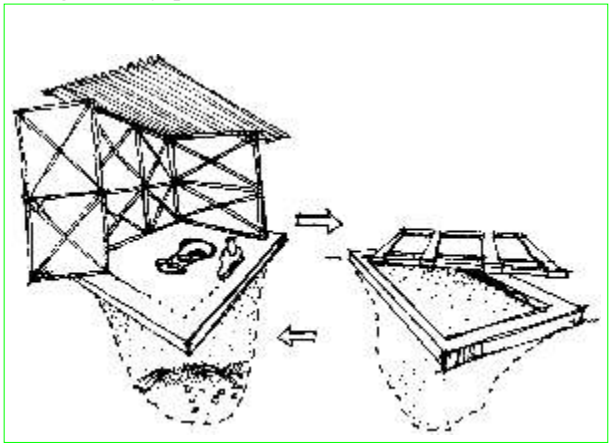


Figure 2.7 Use of Fossa Alterna composting toilet (Design: Peter Morgan, Zimbabwe)

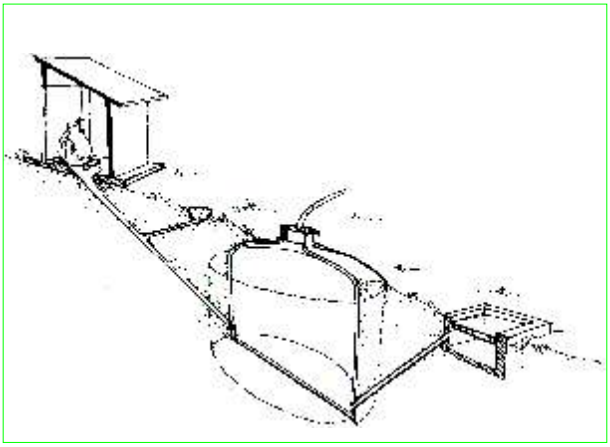


Figure 2.8 Toilet linked biogas system

type can be utilised to recover useful products from human and animal excreta and other organic waste from kitchen and agricultural farms. Useful products such as biogas (methane) for cooking purposes and enriched slurry for fertilising lands can be obtained from biogas plants.

When toilets are linked to biogas plants, low water-solid ratio must be ensured by using low-flush toilets or with suitable water-solid separation devices. Addition of solid materials like cow dung and organic wastes to the biogas plants apart from human excreta can help in reducing the water-solid ratio.

Slurry generated from biogas plants treating human excreta will contain pathogens. Therefore, secondary composting of the slurry is essential before it is applied to agricultural lands.

Biogas plants linked to toilets can be constructed for individual or a cluster of households and at institutions like residential schools. Biogas plants perform very well in locations with temperatures above 15 degrees. Cold climates severely limit their performance.

Dewats

Dewats systems of treating sewage provides useful by-products and the possibility of recycling water used for flushing and washing. Dewats system usually includes a settling tank, anaerobic digester and constructed wetland or polishing pond for complete disinfection of pathogens present in human excreta. In a Dewats system, biogas from anaerobic digester can also be obtained; however due to higher operation costs and maintenance requirements, it is normally not desired.

Dewats system is more suited for institutions or a cluster of households where large quantity of sewage is generated and sufficient land area is available for construction of its various components. While, smaller modules for individual households can also be adopted, proper system for treatment of waste water must be ensured.

Water conserved from the system after ensuring pathogen destruction can be used for irrigation and toilet flushing purposes. Sludge collected periodically from the system must be subjected to secondary composting before application to agricultural lands.

A case study on Dewats implemented by the Ecosan Services Foundation in Maharshtra is

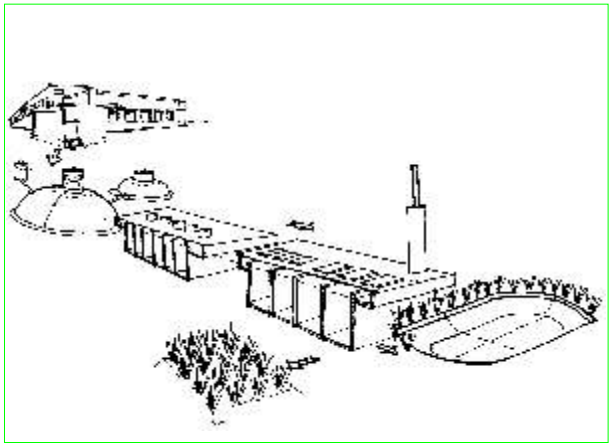


Figure 2.9 Dewats system for decentralised treatment of faecal sludge (Design: Ecosan Services Foundation, India)

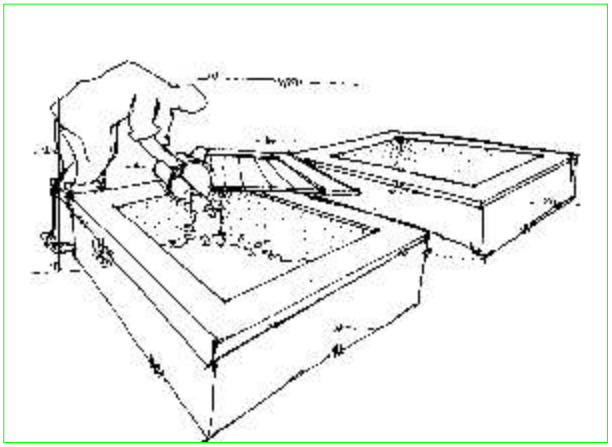


Figure 2.10 Secondary composting facility having two composting chambers for alternative use

included in the chapter on case studies in this publication.

Other systems (Secondary Composting)

Faeces collected prematurely from ecosan systems would contain pathogens. Contents emptied periodically from single vault ecosan toilet vaults or bins, removable or rotating vaults or the sludge removed from Biogas or Dewats systems must be treated before using them as compost. For such shorter retention systems, secondary composting facilities must be provided for ensuring completion of pathogen inactivation from the contents removed.

Also, it is advisable to have secondary composting systems with a minimum of two processing chambers / bins for alternating the composting process between them periodically. Special secondary composting facilities may have to be designed if large volumes of material are expected especially from a cluster of houses or community ecosan toilet complexes. Addition of carbonaceous materials along with the sludge improves composting efficiency and quality. Other factors involved in composting processes such as maintaining moisture content, aeration, temperature and pH apply as well.

Waterless Urinals

Waterless urinals were first introduced in Europe, North America, Japan and South Africa in the nineties to reduce consumption of water used for flushing in urinals. Waterless Urinals do not require water for flushing at all and thus save between 56,800 litres to 1,70,000 litres of water per urinal per year. Waterless urinals can be installed in urban as well as rural areas to conserve water and energy and to reduce volume of waste water generated.

Odour traps are installed in waterless urinals to ensure prevention of odour emission. Urine collected from homes, schools, institutions and public places can be stored in tanks and can be utilised for recovering nutrients present in human urine for productive industrial and agricultural purposes.

Waterless urinals can be adopted widely in all locations. Odour prevention using traps available in the market or developed using low-cost devices adopted from locally available materials can be utilised. However, regular maintenance of the systems is essential to ensure their effective performance.

2.5 Ecosan Systems Suitable for Different Locations

The following table provides an overview of some of the most common ecosan systems which can be adopted in India and their adoptability in different regions along with some key operational factors.

Ecosan Systems		Plain Areas with Deep Water Table	Dry Areas	Cold & High Altitude Areas	Coastal Areas with High Water Table	Flood Plains	Maintenance	Cost	Suitable Locations
UDDT	Double Vault	Suitable	Suitable	Suitable	Suitable	Suitable, if on raised level	Easy	Low	? Households ? Schools ? Community
	Double Vault with Solar Panels	Suitable	Suitable	Suitable	Suitable	Suitable, if on raised level	Easy	Medium (vault and panels increase the cost)	? Households ? Schools ? Community
	Single Vault with Removable Bins	Suitable	Suitable	Suitable	Suitable	Suitable, if on raised level	Complex (replacement of bins)	Very Low (depends on the type of bins used)	? Households ? Schools ? Community
	Revolving Vaults	Suitable	Suitable	Suitable	Suitable	Suitable, if on raised level	Easy	High	? Households ? Schools ? Community
Composting Toilets	Double Vault Composting Toilet	Suitable, but moisture content needs to be maintained	Suitable, but moisture content needs to be maintained	Not Suitable for very cold regions	Suitable	Suitable, if on raised level	Complex (maintaining C:N ratio & moisture content)	Low	? Households ? Schools ? Community
	Arborloo	Suitable	Suitable	Not Suitable	Not Suitable	Not Suitable	Easy	Very Low	? Households
	Fossa Alterna	Suitable	Suitable	Not Suitable	Not Suitable	Not Suitable	Easy	Low	? Households
Other Systems	Toilet linked Biogas	Suitable	Suitable	Not Suitable (Low Efficiency)	Suitable	Suitable, if on raised level	Complex	High	? Households ? Schools ? Community
	Dewats System	Suitable	Suitable	Not Suitable for very cold areas	Suitable	Suitable, if on raised level	Complex	High	? Schools ? Community
	Waterless Urinals	Suitable	Suitable	Suitable (freezing of pipe line & storage tank must be avoided)	Suitable	Suitable, if on raised level	Easy	Low	? Households ? Schools ? Community

Table 2.3 Features of different ecosan systems and their suitability for different locations

Chapter 3

Ecosan Toilets – Design Principles

3. Ecosan Toilets – Design Principles

Ecosan toilets or urine diverting dry toilets facilitate separation of urine, faeces and water used for anal cleansing (wash water) at the point of use. Ecosan toilets can have a single chamber or multiple chambers for collection and decomposition of faeces and ensuring pathogen inactivation. Urine and wash water are separated using specially designed toilet seats. While urine is diverted to a storage tank, the wash water is disposed off through a plant bed or soak pit. As Indians are basically "washers" (they practicing ablution with water after defecation), provision of wash water removal assumes importance in the ecosan toilet design.

Ecosan toilets are designed to desiccate faeces collected in the chambers through dehydration process. Increase in temperature, moisture removal, aeration and increase in pH by additives such as ash are the primary factors responsible for pathogen inactivation in ecosan toilets. After a chamber gets filled up, a storage period of 9-12 months is recommended for complete processing. Urine is usually sterile and can be directly used for fertilizing crops. However, if cross contamination of urine with faeces is suspected, a storage period of 1 month at temperatures over 20 degrees is recommended for pathogen inactivation, of urine.

In recent years, several ecosan toilets have been constructed in various parts of India and they are functioning effectively. Ecosan toilet are versatile, can be installed in most locations and are easy to maintain.

3.1 Design Features

Ecosan toilets can be constructed in various designs based on factors such as climate, temperature, availability of space, convenience and features desired by the users. Variation in design is achieved through modification of the faeces collection chamber and toilet seats installed.

Ecosan toilets are usually designed based on collection capacity of 500 litres of urine and 50 litres of faeces excreted by a person in a year. However, the usage pattern varies between households, schools and public places.

For designing ecosan toilet chambers, parameters such as ultimate volume of dessicated faeces and additives added, quantity of urine and wash water generated by a person per use must be taken into account. The ultimate volume of desiccated faeces and additives vary depending on the volume of faeces and additives added after every use. Table 3.1 provides average values which can be considered while designing ecosan toilets.

Components of an Ecosan Toilet

Chamber : Single, double, multiple chambers or removable bins are used for collection and processing of faeces.

Toilet Seat : Specially designed toilet seats are utilised for separation of faeces, urine and wash water. Toilet seats with two-hole or three-hole separation arrangements are utilised for this purpose.

Design Parameters	Average Values
Ultimate desiccated volume of faeces and additives added	0.25 to 0.4 litres / per person per use
Volume of urine	0.25 to 0.3 litres / per person per use
Wash water	1 to 2 litres / per person per use
Storage period of faeces for inactivation of pathogens	9–12 months (after a vault fills-up and is sealed for decomposition)
Storage of urine	Varies based on the collection frequency and size of the urine storage tank

Table 3.1 Design parameters and their average values for Ecosan Toilet design

Vent pipe : Vent pipes provided to the chambers facilitate aeration, moisture removal and increase in temperature.

Toilet Structure : Covered super structure provided to the toilets offer privacy to the users and also protects the chambers from rain, cold weather and from insects and animals.

Urine Storage : Collection of urine in a storage tank provided within or outside the toilet facilitates its application as liquid fertilizer for crops.

Wash Water Disposal : Planted beds or soak pits provided outside the toilets facilitate safe disposal of wash water containing faecal matter.

Additives : Wood ash, soil, saw dust and dry powdered leaves can be added as additives to the faeces to remove moisture, increase pH and achieve desired C:N ratio of the mixture.

3.2 Faeces, Urine and Wash Water Separation

In Ecosan toilets, separation of faeces, urine and wash water is achieved using specially designed pans with separation arrangements. Different types of ready to install ecosan toilet pans are being manufactured in India using fibre, plastic, concrete and ceramic materials. Cost of an ecosan pan ranges between Rs 500 – Rs 2000 depending on the material used and design. Many agencies also use low-cost on-site separation arrangements for pan fabrication to reduce cost.

Squatting Pans

- Squatting type ecosan pans with two-hole and three-hole separations are available in the market or can be fabricated onsite.
- In the two-hole separation pans, a drop hole for faeces and a collection area for urine are provided. Wash water is either removed from a separate anal washing area provided in the toilet or it is disposed in the urine collection area itself, if the user is not keen on separate collection of urine. Each chamber is provided with a separate pan.

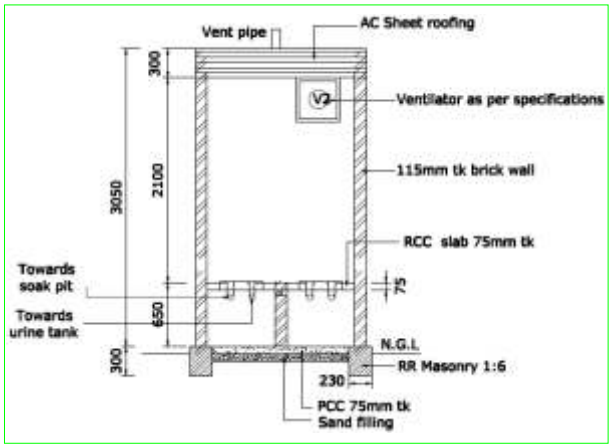


Figure 3.1 View of an ecosan toilet with twin faeces collection chambers

- In the three-hole separation pans, urine, faeces and wash water are removed using a single pan which has separate collection areas meant for each of these components. However, a separate pan is provided for every chamber in the ecosan toilet.

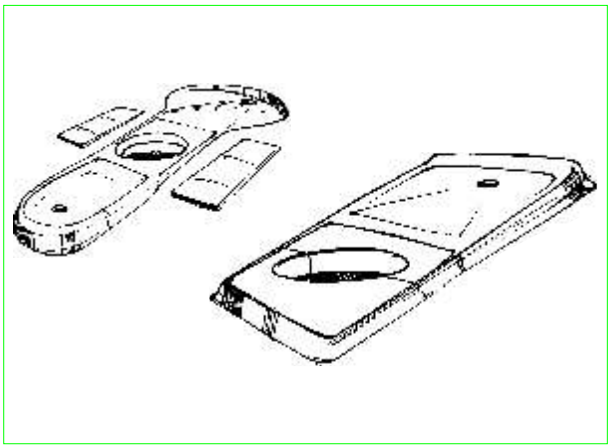


Figure 3.2 Three-hole ecosan toilet pan (left) and Two-hole ecosan toilet pan

- Some manufacturers offer pans which have a urine collection area and two drop holes for faeces collection. Therefore, a single pan installed in the ecosan toilet can provide access to both the faeces chambers while urine is collected in a common urine collection area located in the centre. Privacy is ensured by building a wall at the halfway mark of the 2 user pan. Such pans help in saving cost of installation. However, if urine collection is desired, a separate washing area must be provided.

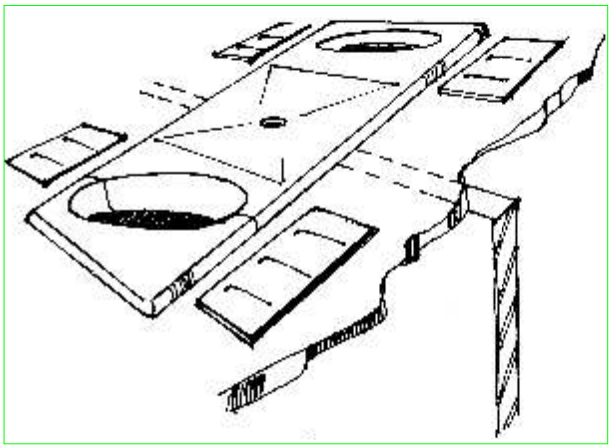


Figure 3.3 Single ecosan toilet pan provided over both the chambers

- Two or three-hole separation can also be created onsite while fabricating cover slabs for the chambers. For this purpose, holes required for faeces collection, urine and wash water collection areas are created in the slab while fabricating it. After installation of the slab, using cement mortar and pipes and plumbing accessories, the separations are created onsite. Onsite creation of separation reduces the high cost required for installation of pans available in the market.

- Dimension of the faeces drop hole is usually kept around 8 inches in either circular or square shape. In schools and anganwadis, some agencies provide a faeces drop hole of 4 to 6 inches depending on the age group of children.

Pedestal and Bench Type

- Pedestal and bench type ecosan toilet pans are being used in Europe and Africa where people practice wiping for anal cleansing. These pans have only urine and faeces separation arrangements. There is no

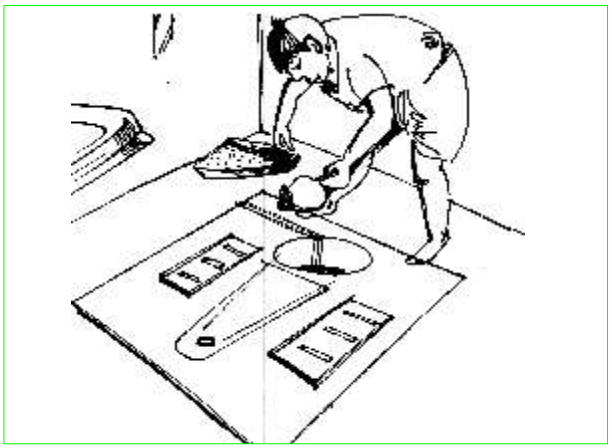


Figure 3.4 Providing on-site separation over concrete slabs using cement mortar

provision for wash water separation in these pans. In the Indian context provision for wash water separation is a must.

- Bench type ecosan toilet seat (Fig 3.5) can be constructed onsite using masonry and by fixing specially designed urine separation seats. Such seats are being produced in some of the European countries.

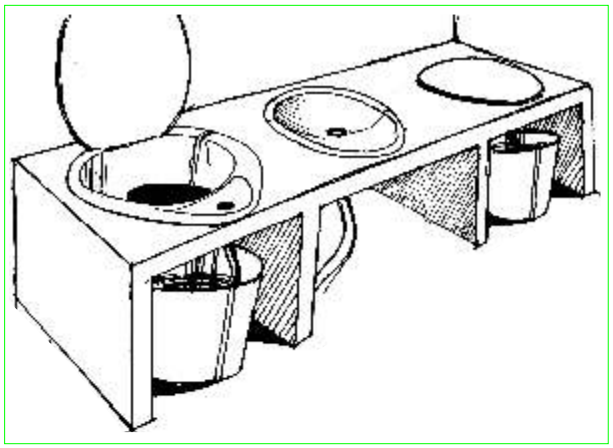


Figure 3.5 Bench type ecosan toilet pan with two toilet seats and a common washing area in the middle

- In bench type toilet seats, a bidet can be provided along side the ecosan pans for anal washing.

- Pedestal or bench type ecosan pans can facilitate comfortable use of toilets by old and physically challenged people. Therefore, further work is needed to provide a better wash water separation facility to address this issue.

- Ideas like using the idle ecosan pan for anal washing after necessary modifications or providing a separate bidet for anal washing can be explored. Bidets which function very much like wash basins are used for anal washing in many western countries.

- An attempt was made by EEDS, Bhopal under a UNICEF supported project to develop a pedestal type pan with wash water separation facility, but further research is required to develop a sound option.

3.3 Faeces Collection and Decomposition

Isolation of faeces for decomposition and pathogen inactivation can be achieved by providing faeces collection chambers below the ecosan toilet pans. Either removable or stationary chambers can be used for this purpose. The type of chamber is chosen based on factors such as site condition, space availability and decomposition process desired. Size of the chambers is decided based on the number of users, decomposition process selected, user space required for fixing ecosan pans and convenience.

Double Vault

- Twin chamber type ecosan toilets are built in many places, especially at households, as they can be managed very easily. (Fig 3.6)

- In twin chamber type ecosan toilets, after a

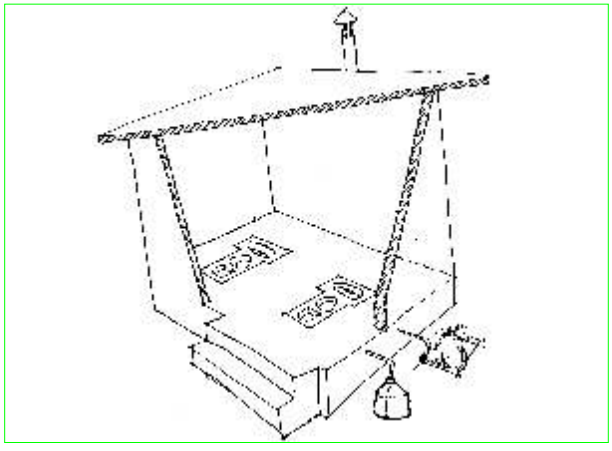


Figure 3.6 Double vault ecosan toilet with 3-hole separation pans over each vault

chamber gets filled-up, it is sealed and the contents are allowed to decompose over a period of 9 to 12 months approximately, while the other chamber is put into use.

- Upon dehydration, the contents are collected and applied as manure to agricultural fields or backyard gardens.

- A twin chamber ecosan toilet must have clear inner space of 1.65 m x 1.30 m between walls for ease of use and fixing two ecosan pans. Height of the chamber is kept as 0.6 m for a household with 5 members. However, height of the chambers can be increased to accommodate additional requirements needed in places like schools and community toilets.

- To provide safe access to elderly and physically challenged, floor area of the ecosan toilets can be increased as per the requirement.

- The chambers must have access openings to remove decomposed materials from the chambers after a period of 9-12 months. For this purpose, rear face of the chambers is kept open and sealed using a removable slab by applying lean cement mortar or mud puddle. Ready made stone slabs or concrete slabs fabricated onsite can be utilised for this purpose.

- Chambers must have an impermeable flooring to ensure dry condition and prevent leaching.

Single Vault with Bins

- Single vault ecosan toilets are constructed where a secondary composting facility is available for composting or space for building a twin chamber ecosan toilet is a constraint or reduction in cost is desired.

- Where a secondary composting facility is available, faeces collected in the chamber can be transported to a secondary composting facility periodically. However, this method requires careful handling and is not a recommended option due to risks of pathogen exposure.

- On the other hand, use of removable bins which can also be used as decomposition chambers finds wider application. As soon as a bin gets filled up, it is replaced with an empty bin to collect faeces. The bin which is full is moved either within the additional space available in the chamber or moved outside to a safer location to allow maturing of the contents.

- Bins made up of materials like tin or plastic can be used. In some locations, use of gunny bags for collecting faeces is found effective. It is better to keep the size of bin or bag small for ease of handling.

- Access door must be provided to the faeces collection chamber for removing the contents or the bins kept in it.

- Size of single chamber ecosan toilets are smaller in size as space for fixing an additional pan is not required like the twin

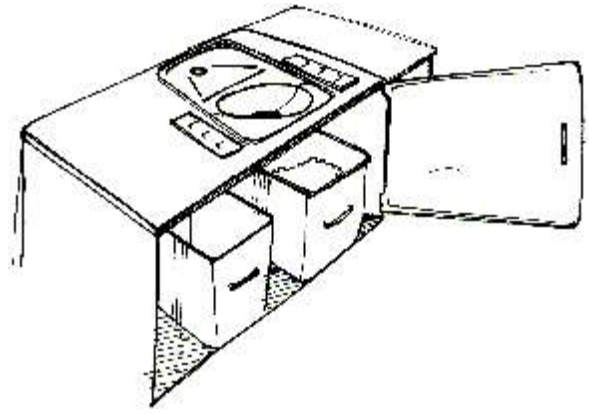


Figure 3.7 Single vault ecosan toilet with a 2-hole separation pan and removable bins

chamber toilets. A size of 0.9 m x 1.30 m clear inner space would be sufficient.

- Bins stored outside for maturing must be covered to prevent entry of rain water or contact with insects.

- Single chamber removable bin model of ecosan toilet is best suited for terraced buildings where an ecosan toilet is desired on first floor or on higher floor.

Solar Drying Vaults

- Solar drying vaults enhance dehydration rate of faeces and pathogen inactivation due to increased temperatures in the faeces chamber. Therefore, it is a desired feature in cold and high altitude locations. It can also be promoted in other areas if faster rate of dehydration is desired.

- Solar panels can be fixed either to a single or double vault ecosan toilet. Each chamber must be provided with a separate solar panel.

- The construction arrangements of solar vault ecosan toilets are very similar to single or double vault chamber ecosan toilets. However, the rear portions of the chambers are extended to accommodate solar panels

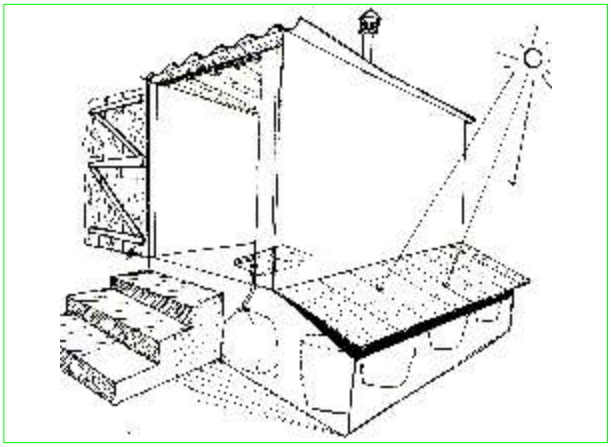


Figure 3.8 Solar bench type ecosan toilet with one seat and removable bins

at an inclined position.

- Solar panels made up of metal, aluminium or fibre sheets can be used, but these should be painted black for maximum absorption of solar radiation.

- Access openings to chambers are usually provided by installing solar panels which can be opened to remove desiccated materials or the bins placed inside the chamber.

- The solar panels installed should be water tight to prevent leakage of rain water into the chambers.

- As India lies in the northern hemisphere, maximum sunshine can be captured by a surface facing southern direction. Therefore, as far as possible solar panels should face the south direction.

- Maximum solar radiation is captured if sun-rays strike the solar panels at right angles. For this purpose, an inclination equal to latitude of the place is recommended. As the average latitude of India can be considered as 15 to 20 degrees, the panels should be installed at an angle between 15-20 degrees facing south.

Revolving Vaults

- Chambers of revolving type consist of several tanks fabricated either by dividing a large cylindrical tank into smaller tanks or by assembling smaller tanks into a unit which has several bins.

- A shaft and a rotating platform provided below the tank facilitate rotation of the unit.

- When a tank gets filled up, replacement of tank can be performed easily using revolving vaults.

- Dehydration of contents in the filled up bins occur within the toilet. The contents can be removed after it matures by emptying the bin through access doors provided.

- A commercial brand of revolving type ecosan toilet – "Carousel" is being manufactured in Norway.

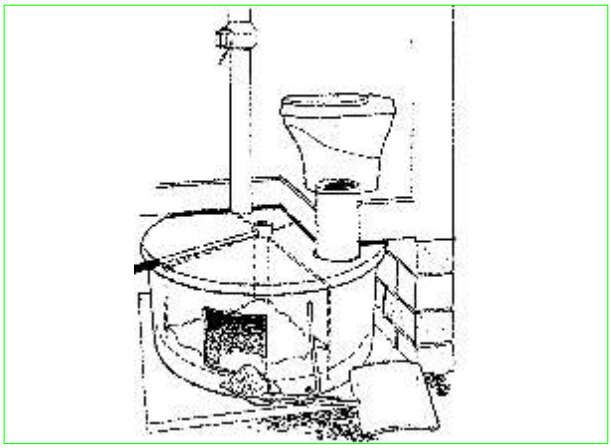


Figure 3.9 Revolving vault ecosan toilet "Carousel" (Source: EcoSanRes)

- As the vaults can be positioned under the ecosan toilet seat by rotation, installation of one toilet seat is sufficient.

- However, cost and maintenance of the system is higher than double vault type ecosan toilet. Industrial fabrication and presence of moving parts makes it expensive.

Terra Preta Sanitation

- Terra Preta Sanitation (TPS) is a recent innovation which mimics the Terra Preta do Indio, an anthropogenic black soil that was produced by ancient cultures in the Amazon region through the conversion of biowaste and faecal matter into long-term fertile soils.

- Toilet arrangement similar to a single vault ecosan toilet is used in this process.

- A fine charcoal mix prepared using powdered charcoal, finely cut wood (e.g. sawdust, sliced-cut wood, coconut husks etc.) and limestone or volcanic soil is added as additive to cover the faeces after every use.

- To induce "lacto-fermentation" process, a specially prepared liquid mix (consisting of effective micro-organisms including lacto-bacilli) is sprinkled over the charcoal mix added after every use.

- A single chamber with removable bins is used for this process. No vent pipe needs to be provided to the chamber as lacto-fermentation is an anaerobic process that does not produce odour.

- Faeces drop hole must always be kept covered to create anaerobic conditions. However, occasional opening of the lid for defecation won't affect the process.

- Bins which are full must be covered and stored for a period of 2-4 weeks.

- Later, the contents further processed for a 2-4 weeks period by vermi-composting results in fine Tera Petra Soil like compost. No addition of biowaste is essential for vermi-composting as the saw dust and sliced wood added as additives are available in the mixture.

- Also, addition of 500 ml liquid-mix with microbes prior to storage of urine in tanks prevents formation of ammonia. This helps in controlling odour generated by stored urine and ammonia released from urine.

3.4 Vent Pipe

- Vent pipe is important for the functioning of ecosan toilets as they facilitate aeration, conduct heat for better dehydration of faeces and prevent development of odour in the toilets.
- A single vent pipe can be provided to both the chambers using pipe fittings like elbow and couplers. It should be secured well to the wall of the toilet using clamps.
- Diameter of the vent pipes should be at least 100 mm and in humid areas it can be increased up to 250 mm to handle higher moisture levels.
- The vent pipes should be painted black for better absorption of solar radiation. PVC pipes are commonly used as vent pipes since they do not corrode.
- For effective functioning of the vent pipes, they should be fixed vertically and should not be having any bends to accommodate roof projections. Bends in vent pipe reduces its effectiveness.
- Vent pipes should be taken at least 50 cm above the roof level for safe release odour into the atmosphere and must be provided with a cowl wrapped with a screen to prevent entry of rain water and flies.

3.5 Urine Collection

- Urine should be collected undiluted as far as possible. Dilution with water increases the volume and storage capacity required.
- Pipes carrying urine from ecosan pans to urine storage tanks must be secured well to prevent leakage of urine into faeces chamber. Leakage of urine into faeces collection chambers hinders the dehydration process and causes unpleasant odour in the toilets.
- Most ecosan pans manufactured presently do not have an odour controlling measure to prevent odour generated from the pipes carrying urine and the urine storage tanks.
- To prevent this, measures such as placing a small spherical plastic float over the drainage hole of urine separation area of the pan, fixing a flexible flat tube at the end of the urine pipe inside the storage tank or extending the urine pipe up to the floor of storage tank so that urine collected in the tank itself acts as an odour seal can be adopted.
- Storage capacity of urine collection tank depends on the number of users and urine application cycle desired. At household level, jerry cans of 15-20 litres capacity are used as urine storage tanks which can be directly transported to agricultural fields. For schools and public places, large masonry or HDPE tanks can be installed for storing urine.
- Further details on urine storage and handling are provided in the waterless urinal section of this manual.

3.6 Wash Water Disposal

- Wash water contains pathogens due to the presence of faecal matter and therefore should be safely disposed to avoid health risks.
- A soak pit or a plant bed is used to

discharge the wash water generated from ecosan toilets.

- Location of the soak pit or wash water must be isolated and safe.
- Soak pit filled with gravel, brick bats and sand can be utilised for discharging the wash water into the ground safely.
- Plat bed of Canna Indica or any other plant used for phyto-remediation can be raised near ecosan toilets to safe dispose wash water.
- Size of the soak pit or plant bed required depends on the number of users and type of soil. Usually, a plant bed of 3 ft x 3 ft area or a soak pit of 3 ft x 3 ft x 3 ft volume is adequate for a household toilet.
- Size of the soak pit or plant bed must be increased accordingly for schools and public places where volume of wash water generated is high.

3.7 Additives

- Dry ash, soil, saw dust and crushed leaves are added as additives absorb excess moisture present in the faeces. These materials also helps to reduce odour, prevents contact of flies and unsightly view to the next user.
- Addition of these materials increases the carbon-nitrogen ratio which is good for the composting process and for application to fields.
- Materials like sanitary napkins, clothes and toilet paper or any other inorganic material like plastic, bottles should not be put in the faeces chambers as the dehydration process will not be effective to the decompose of these materials.
- As far as possible, the additives should be collected and stored in dry seasons after proper screening. Contact with insects like cockroaches should be prevented.
- A bucket and scoop can be used for storing additives in the toilet. After every use, the user must sprinkle handful of additives over the faeces collected in the chamber.
- To simplify the process of addition of additives, special additive dispensers like a hand held tipping container with holes on the cover or a mechanically operated dispenser can be designed to suit the requirement.

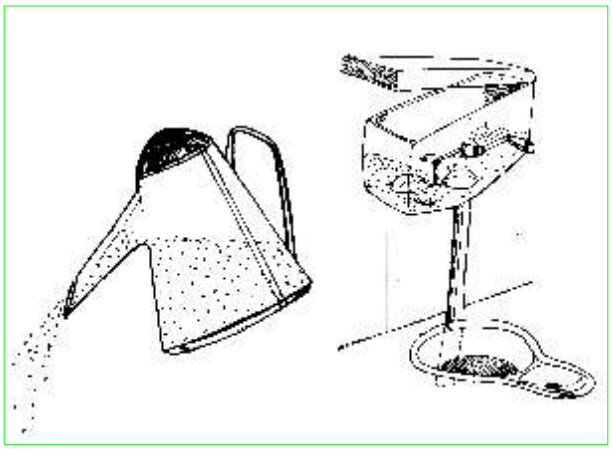


Figure 3.10 Container with handle and dispensing arrangement (left) and mechanically operated ash dispensing unit (right)

Chapter 4

Ecosan Toilets - Planning, Design Considerations and Technological Options

4. Ecosan Toilets - Planning, Design Considerations and Technological Options

This chapter is divided into two parts – Part A and Part B. In part A, aspects related to planning and design considerations to be considered in the promotion of ecosan toilets are discussed. In part B, the various technological options for implementing ecosan toilets are discussed.

The planning aspects provide details on the various steps involved in promoting ecosan toilets on ground. These are further classified into sections such as data collection, site selection, appropriate design, user involvement and implementation.

The section on design principles and design considerations describes the various aspects that are necessary for designing toilets optimally based on the requirement of users and local climatic conditions. The section on design considerations aspects are grouped into sections such as anthropometric data, climatic conditions for various zones and the suggested design parameters and wind and sunlight penetration for optimal disinfection and drying of toilet units.

Part B deals with technological aspects and includes standard designs developed for the promotion of ecosan toilets for households, anganwadis, schools and public complexes.

Chapter 4

PART A

Ecosan Toilets - Planning, Design Considerations and Technological Options

4.1 Planning

Before initiating construction of ecosan toilets, it is important to take up a range of planning exercises in order to ensure effective design, implementation and sustainability of the systems installed. These activities must be taken up for every toilet unit to be built in a project area. In addition to awareness and capacity building initiatives, undertaking site specific planning exercises help in making necessary adaptations based on the standard designs developed. Following aspects may be considered while promoting ecosan toilets:

- **Data Collection** : The number of users expected to use a system must be estimated before designing the facilities. Special care must be taken while designing toilets for schools and public places where the number of users is expected to grow in future. Facilities in schools and public places ought to be designed with a factor of minimum anticipated growth in the next 5-10 year period to prevent inadequacy of sanitation infrastructure.

- **Site Selection** : Appropriate location must be chosen based on the site conditions for construction of ecosan toilets. Factors including privacy, convenience, operational aspects like availability of space, drainage, emptying faeces and urine collection, availability of sun light and wind flow must be considered while selecting the site.

- **Appropriate Design** : The design of ecosan toilets must be based on the local environmental and operational factors. Environmental factors like temperature, humidity, soil, flood level, etc., play a very important role in the selection of design. In addition, operational factors like availability of materials, preference of users, local customs and beliefs, agricultural practices, etc., must be taken into account.

- **User Involvement** : Involving the users right from planning to the final implementation stage helps in understanding the requirements and to successfully complete the work to their satisfaction. Formation of user groups helps in leading the implementation and facilitating the post implementation support to the users. Systems for the proper operation and maintenance of ecosan toilets to be built in schools and public places must be discussed and instituted before hand.

- **Implementation** : The implementation phase would include mobilisation of work force, procurement of materials, contracting work and ensuring quality of work. Necessary steps needed to undertake these aspects must be planned well in advance. Approvals and consent of authorities for the implementation of facilities especially in schools, anganwadis and public places is equally important.

4.2 Design Principles

The ecosan toilets must be designed incorporating design principles which fulfil the requirements of the users as well as the site specific conditions. Designs developed keeping these principles help in ensuring that the facilities meet both the present and future needs efficiently. Adopting the following design principles especially for the ecosan toilet units designed for schools and public places are very important to develop efficient designs.

- **Site Specific** : The technological option should be chosen based on the site conditions. The adaptations in the design

will be often required especially for implementing ecosan toilets in schools and public places. Individual household ecosan toilets may also need such changes due to reasons such as space constraints and user convenience.

- **Future Demand**: Taking care of future demand is key aspect involved in design. Based on the data available, the future growth in the number of users must be worked out and incorporated in the design. Also, the facilities designed must allow expansion of the facilities to accommodate additional requirement without becoming redundant as far as possible.

- **User and Child Friendliness** : Ecosan toilets created in schools, public palaces and households with people with special needs must be designed according to their requirement. The ecosan toilets must be designed with facilities such as ramp, railing, toilet doors and circulation space with wheel chair access, special toilet chair designed for use in ecosan toilets, handles and door locks. Similarly, ecosan toilets built in schools and anganwadis should incorporate facilities based on the anthropometric requirement of children. In addition, anganwadi ecosan toilets must have good ventilation, adequate space, child friendly ecosan toilet pans and safety measures such as opening in doors so that latches can be opened from outside, etc.

- **Combining Facilities** : As far as possible, combining the facilities helps in reducing cost and saving space. Building shared water tanks, soak pits, urine collection tanks and common walls for toilets meant for both sexes in school and community ecosan toilets can be useful in this regard.

  Easy Maintenance : The facilities created should be designed in such a way that maintenance becomes easy. Measures like open plumbing and removable joints for water and sanitary fittings, proper floor slopes and wall tiling inside the toilet and circulation areas can be quite efficient in ensuring cleanliness.

- **Materials and Skills** : The systems designed must make full use of materials and skills available in a given area. As far as possible, dependence on external materials and skills should be avoided as it will have a bearing on the sustainability of the structures created.

- **Cost** : The structures designed should be based on the available financial resources and the benefits it offers to the community. Inappropriate design which does not take these factors into consideration eventually will fail to yield desired results.

4.3 Design Considerations

The standard design considerations based on the requirement of users and local climatic conditions are useful in optimising the design of toilet units. The design considerations can be grouped into various aspects such as anthropometric requirements, climatic conditions and wind and sunlight penetration. Some of these details are adopted from SSHE Manual published by UNICEF and DDWS prepared by VINYAS.

4.3.1 Anthropometric Data

It is important to adopt proper anthropometric data for the design of structures to achieve user friendliness in the facilities provided. The

considerations must address the need of people with special needs as well. It is very important with regard to the design of school ecosan toilets where children of different age group and varied capacities are expected to use the facilities. Households having people with special needs can also consider incorporation of facilities to cater to their needs for enabling use of the facilities created on their own.

S.No	Component	Recommended Standard
1	Ramp	• An ideal slope of 1:18 or a minimum of 1:12 with a minimum width of 1000 mm must be maintained for access by wheel chair users independently • The height of the railing should not exceed 780 mm and must have a lower level support at 600 mm level for younger children • The length of railing should be extended beyond 300 mm from the sloped ends of the ramp • Antiskid tiles must be used for flooring of ramp
2	Doors	• The entrance doors and toilets designed for the use of children / people with special needs must be minimum 1000 mm wide • All other doors should be at least 700 mm wide • Doors must have two door handles at 1025 mm and 693 mm height from finished floor level for use by children and adults • Doors shutters should be installed above 100 mm above finished floor level • Provide see through jalli above 900 mm level from finished floor level in the entrance doors to prevent collision among the users • Door edges must be painted with contrasting colours to assist children with low vision
3	Urinals	For Boys : • The boys urinal must be 500 mm wide and 600 mm in depth • Separators or walls between urinals must be installed • Walls must be impervious either with glazed tiles or plastering For Girls : • A enclosed urinal cubicle of minimum 700 mm width and inner length of 800 mm • Doors must be provided with handles and latches according to age • Hooks for hanging clothes must be provided
4	Ecosan Toilets	• Size of ecosan toilet for the use of children / people with special needs must be minimum 1750 mm x 2100 mm • Specially designed chairs with washing arrangements and strong handles for offering support to children / people with special needs must be provided in ecosan toilets designated for their use • Other ecosan toilets with two chambers must be at least 1200 mm x 1500 mm in size • At least one incinerator in one of the girls toilet is a must • Provisions like hooks, latches and handles for variable age groups must be provided. • One ventilator should be provided for each toilet
5	Hand washing	• The hand washing facility must be accessible to children of varying age group. • Sloping or stepped or independent wash basins can be installed for this purpose. • Taps must be installed at 600 mm to 770 mm height over the wash basins. • Top level of wash basins must be between 400 mm to 600 mm • Chubby holes must be provided for holding soaps at 500 mm to 600 mm height

Table 4.1 Anthropometric Data for Design of Ecosan Toilets

4.3.2 Design Parameters for Different Climate Zones

Climatic conditions across India are very diverse and the toilets designed based on the local climatic conditions help in optimising the design. The following table provides the design considerations of key elements in a toilet unit for various climatic zones across India.

SN		Zone I	Zone II	Zone III	Zone IV	Zone V	Zone VI
	Parameter	**West Coastal Tropical**	**East Coastal Tropical**	**Peninsular Plains**	**Gangetic Plains**	**Desert Areas**	**Eastern Hill Areas**
1	Site	Good rainwater drainage essential	Good rainwater drainage essential	Good rainwater drainage essential	Good rainwater drainage essential in view of the flat terrain and possibility of water stagnation	Nothing specially required	Good rainwater drainage essential
2	Layout	Building to be on the E-W to NE-SW axis to reduce solar heat gains and improve wind movements	Building to be on the E-W axis to reduce solar heat gains	Building to be on the E-W axis to reduce solar heat gains in summer and most part of winter	Building to be on the East-West axis to reduce solar heat gains in summer and receive the same in winter. Location of rooms to be judicially determined	Building to be on the East-West axis to reduce solar heat gains in summer and receive the same in winter. Compact planning to avoid exposure to sun	Building to be on the East-West axis to reduce solar heat gains in summer and receive the same in winter
3	Air Movement	Good arrangements for cross ventilation	Single banked modules with good arrangement for cross ventilation	Single banked modules for good cross ventilation	Open spacing desirable to take advantage of external air motion for cross ventilation just to fit. Excessive air changes in summer or winter brings in heat or cold respectively from outside	Not critical but desirable and hence compact planning needed	Opens spacing desirable to take advantage of external air motion for cross ventilation just to fit
4	Opening	25% of floor area and upto a maximum of 30% for ventilation, air movement and day lighting low sill heights, windows/ventilators horizontal	Upto 25% of floor area and up to a maximum of 30% for ventilation and day lighting	Upto 25% of floor area and up to a maximum of 30% for ventilation, air motion and day lighting. Winter sunshine may be desirable	maximum 25% and upto 30% of floor area for ventilation and day lighting	Maximum 12% of floor area	Upto 25% of floor area and up to a maximum of 30% for ventilation and day lighting
5	Roofs	May be light weight but should be insulative. Protection against heavy rainfall necessary.	Light weight with short time lags may be sufficient. Design for moderate rains	Light weight insulative or medium heavy with short time lags may be sufficient. Design for moderate rains. False ceiling and attic ventilation may be useful. Northern positions may need heavy foors also	Roofs should be designed for moderate rains. May be white washed for additional comfort, just before onset of summer, to reduce heat gains	roofs can be flat. May be white washed for additional comfort, just before onset of summer, to reduce heat gains	May be light weight but should be insulative. Protection against heavy rainfall necessary
6	External walls	Light weight, and thin, if possible, short time lag for heat transfer. Light external colours. Walls rain protected	Light weight, and thin, if possible, with short time lag for heat insulation. Light external colours, damp proofed	Light weight with short time lags will suffice. Local conditions may dictate heavy walls. Light colours on walls	careful consideration should be given to plan internal occupancy during hot summer months	May be thick with long heat transfer lag time	Light weight if possible with short time lags for heat insulation. Light external colours, damps proofed

Figure 4.2 Design considerations of key elements of toilet unit for various climatic zones

4.3.3 Wind and Sunlight Penetration

Good wind and sunlight penetration in the toilet units helps in disinfecting and drying toilets without the help of devices which run on electricity or mechanical energy. Adopting such design considerations in the design helps in saving energy and reduces the maintenance costs tremendously. Availability of natural ventilation and exposure to sunlight of a toilet unit can be designed based on the geographic location and local site conditions.

Wind Penetration

Wind penetration can be planned based on the prevailing wind path and the surrounding buildings in the vicinity of the proposed toilet unit. It is important to avoid placement of the toilet unit in the wind shadow zone caused due to the existence of a building nearby. For this purpose, a horizontal clearance of 5 times the height of the surrounding must be maintained between the toilet unit and the surrounding building. Provision of ventilators should be based on the prevailing wind directions in the locality.

Sunlight Penetration

The penetration of sunlight is governed by the geographical location and corresponding angle of the sun which varies for different latitudes of the locations. According to the geographical location, the sunlight penetration can be designed for a toilet complex. The following table provides clearances required for proper sunlight penetration in the eastern, western and southern directions for various locations in India. Clearance for sunlight in the northern direction of a building is not essential. The clearances worked out are based on the assumption that the surrounding buildings are only up to single storey which is usually the case in most of the rural India.

Zones		Coastal	Peninsular	East, Central & West	Gangetic Plains	Northern Hilly Zone
Latitude		12° North	20° North	24° North	28° North	36° North
Time	Direction*	Clearances (for surrounding buildings upto 1 storey)#				
7.30 AM	Western Side	8.7 m	11.76 m	14.23 m	17.91 m	
10.30 AM	Western Side	2.1 m	2.6 m	3.03 m	3.28 m	5.23 m
12'O clock	Southern Side	1.56 m	2.23 m	2.49 m	3.3 m	4.57 m
3.00 PM	Eastern Side	3.69 m	4.56 m	5.23 m	5.77 m	9.28 m
4.30 PM	Eastern Side	8.7 m	11.76 m	14.23 m	17.91 m	

* Clearance in Northern side does not matter for sun light penetration

The clearances are from outer toilet walls, not from the ramp or landing areas

Table 4.3 Placement of Toilet Blocks for Sunlight Penetration

Chapter 4

PART B

Ecosan Toilets - Planning, Design Considerations and Technological Options

4.4 Ecosan Toilets – Technological Options

In India, twin chamber ecosan toilets are being widely used. Although it is more expensive than a single chamber ecosan toilet, it is widely preferred due to its simple operation and maintenance requirements. It also helps in minimising the scope of exposure to faecal contamination, and enables complete pathogen disinfection prior to the removal of contents from ecosan toilet chambers. It is best suited for schools and communities where operation and maintenance is always very critical. Therefore, all the designs provided in this section are based on twin chamber ecosan toilet type. It is important to note that only when a proper system of operation and maintenance is assured, single chamber ecosan toilets should be considered.

This section contains various technological options for promoting ecosan toilets in the context of:

- households,
- anganwadis,
- schools and
- community level

Design details, drawings and estimates for each of these units mentioned are also provided. The design of structures is based on standard site conditions prevailing in most circumstances, however suitable modifications may be necessary to suit the local site conditions. Estimates of the civil works are based on the prevailing rates prescribed by CPWD for Delhi. Necessary changes in the estimates can be made based on the material and labour costs in other locations.

4.5 Household Ecosan Toilet

Ecosan toilets can be built in houses like conventional flush toilets. Building one ecosan toilet for a family of 5-7 members is ideal. However, the size of the faeces collection chamber should be altered for families with more members. Faeces, urine and wash water separation is most desired option commonly promoted.

4.5.1 Design Considerations

i) Capacity

- A household ecosan toilet is normally designed for use by 5 - 7 members.
- In special cases it is designed for use up to a maximum of 20 members in a residential scenario.
- In such situations, the faeces collection chamber(s) should be designed to accommodate higher number of users.

ii) Volume of Chamber

- For designing the storage volume of faeces collection chamber, an ultimate volume of desiccated faeces and additive mixture of 0.25 to 0.40 litres per person per day can be considered depending upon the local condition and usage pattern.

iii) Type of Chambers

- A twin chamber ecosan toilet is most ideal which requires very minimal maintenance compared to others.
- However, if there is no space for a double chamber ecosan toilet and the members of the household are confident of managing

the regular maintenance requirements, a single chamber ecosan toilet with removable bins can be chosen.

iv) Retention Period

- A minimum retention period of 10 months for pathogen inactivation of faeces and additive mixture in the faeces collection chamber must be considered in the design.
- If bins or any other removal method of collection is proposed for use, the bins or the secondary composting process where faeces is processed must take the appropriate retention period required for pathogen inactivation.
- Urine can be collected in jerry cans of 10-15 litres size. These can be stored or directly transported for agricultural applications.

v) Floor Space and Level

- The minimum floor dimension of ecosan toilets with single chamber must be 1.00 m in width and 1.20 m in length, while it should be at least 1.50 m in width and 1.20 m in length for twin chamber.
- The lower level of the faeces collection chambers of ecosan toilets should be above the high flood level expected in low lying and flood prone areas.

vi) Construction materials

- An ecosan toilet is designed with a leak proof faeces and urine collection chambers / tanks and super structure with pans / arrangements that help in source separation of faeces, urine and wash water.
- Ecosan toilets can be constructed using locally available materials like bricks, cement blocks, concrete, bamboo or other suitable materials can be used for construction of ecosan toilets.
- Cost of household ecosan toilets can be drastically reduced by using low cost materials like bamboo, thatch, gunny bags, etc., for the construction of superstructure. However, care should be taken to prevent entry of rainwater into the ecosan toilet.

vii) Customized designs

- The ecosan toilets can be constructed as per the convenience of users either within or outside the house.
- If the ecosan toilets are attached to bath rooms, care must be taken to prevent entry of shower water into faeces and urine collection tanks.
- Ecosan toilets can also be built in the upper floors of multi-storey buildings.
- This can be achieved either by building having faeces collection chambers right in the upper floors or through special chutes which transfer the faeces to collection chambers provided in ground floor.

4.5.2 Designs, Drawings and Estimates

Design details	Specification
No. of users	5 members
Average volume of desiccated material	0.25 litres / person / day
Retention period	300 days
No. of chambers	2 nos.
Size of faeces collection tanks • Volume of tanks needed • Size of one tank provided	 = 5 nos. x 300 days x 0.25 l/p/d = 375 litres = 1.20 m x 0.70 m x 0.50 m x 1000 litres = 420 litres
Size of chamber access hole	450 mm wide x 500 mm high
Size of urine collection tank	10-15 litres Jerry cans
Vent pipe	• 100 mm dia connecting both tanks • 500 mm above roof level • Cowl on top
Toilet size (floor area)	1.5 m width x 1.2 m length
Plant bed or Soak pit	0.45 m x 0.45 m size or 0.45 m x 0.45 m x 0.45 m size
Door	0.90 m x 2.1 m
Roof	1–2″ thick ferro-cement slab or AC/GI sheets
Super structure	Brick wall 115 mm thick

Table 4.4 Specifications of a typical Household Ecosan Toilet

4.5.3 Cost Estimate

The cost of a household ecosan toilet depends on factors like quality and type of material used, number of chambers opted (one or two), thickness of walls, finishing of the toilet unit, urine diverting pan opted and other amenities such as like doors and ventilators. The cost of a household ecosan toilets built based on these factors is expected to range between Rs 10,000 to Rs 20,000 given the current market price of the materials and labour across India.

Reduction in the cost of an household ecosan toilet can be achieved by constructing the superstructure with locally available materials such as thatch, bamboo, waste wood and gunny bags while the substructure of the toilet is constructed using proper masonry. Some of the options explored in a project funded jointly by UNICEF and SEI in Tamil Nadu implemented by REAL are given below.

The cost of a household ecosan toilet worked out based on the standard materials and current cost of materials and labour is about Rs 16,915. The drawings and the detailed estimate for a typical household ecosan toilet are provided on pages 53-55.

Brick Walls

Hollow Blocks

Mud Blocks

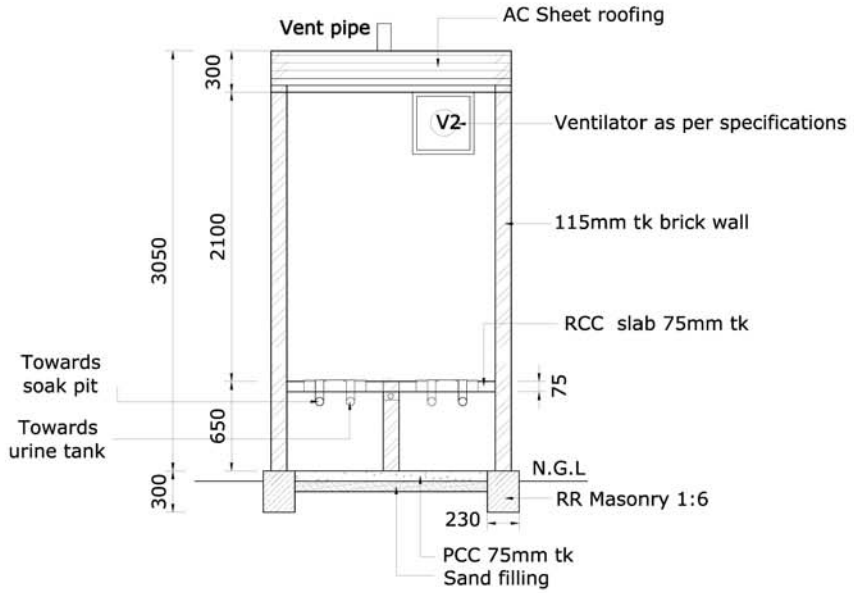
Figure 4.1 Normal options of superstructure

Coconut Thatch

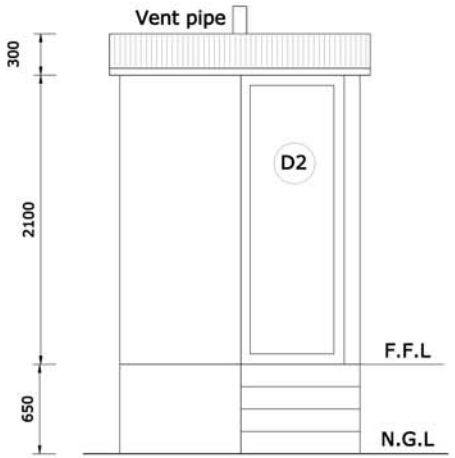
Palm Thatch

Waste Wood

Figure 4.2 Low cost options of superstructure



SECTION



FRONT ELEVATION

HOUSEHOLD ECOSAN TOILET

SPECIFICATIONS

CIVIL WORK

1.Foundation of wall footing in RR Masonry with 1:6 cement mortar
2.Super structure with brick masonry in cement mortar 1:6
3.Plastering in cement mortar 1:6
4.Flooring with 10mm thick cement mortar 1:2 inside the toilet 5.Floor bed for faeces chambers in cement concrete 1:4:8
6.Chamber slabs 75mm thick in RCC 1:2:4
7.Plastering in cement mortar 1:4 with water proof compound for inner sides and bottom of faeces collection chamber
8.Roof with 50mm thick ferro-cement slabs using 1:3 cement mortar, 6mm rods and chicken mesh or GI/AC sheets.

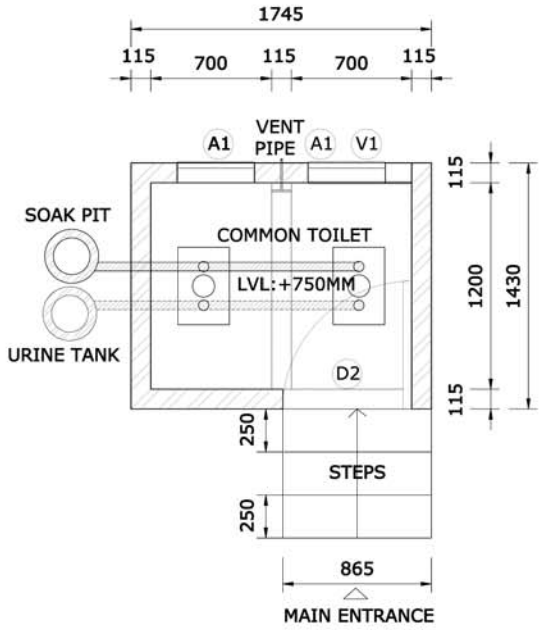
9.Ventilators made up of ready to install prefabricated cement concrete or as per availability
10.Doors of toilets made-up of GI/MS sheets fixed on country wood/angles
11.Access opening of faeces collection chambers covered with 5mm thick RCC slabs or stone slabs. Fixed in position with 1:12 lean cement mortar for opening it when these are to be emptied.

Plumbing and sanitary work :

12. Vent pipe and cowl of chambers and urine collection and waste pipes using PVC or HDPE 100mm dia.
13. Ecosan toilet pans with 3 holes made of fibre/ceramic/in-situ arrangement using cement mortar
14. Urine and wash water should be conveyed into urine collection tank through PVC/HDPE pipes min. 40mm dia.
15. Urine collection using 15 -20 litre capacity jerry can
16. Soak pit filled with boulders/brick ballast/sand for disposing anal cleaning water as per soil conditions.

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600



FLOOR PLAN

HOUSEHOLD ECOSAN TOILET

Notes :

1.Foundation design is indicative & may need changes as per site conditions
2.The minimum clear dimensions of the toilet units indicated must be maintained even if the walls are altered using other construction materials. However, an increase in the sizes are allowed for ensuring additional comfort
3.Location of urine tank and the soak pit are indicative.Actual location of these units may be decided as per the site conditions
4.Urinal and all the wastewater drainage pipes/drain must have 1:100 slope
5.Urine and anal cleaning wastewater pipes must be secured firmly to the Ecosan squatting pans to avoid leakage into the faeces collection chamber
6.Soak pit should be covered/enclosed to prevent entry of rainfall runoff water
7.Urine collection tank should be placed above ground and should be secured to the urine drainage pipe to prevent leakage of urine or ammonia
8.Provision of taps/waterlines to Ecosan toilets should be avoided as a precautionary measure for preventing leakages into faeces collection chambers. Only a bucket and mug must be kept inside the toilets for collecting water for ablution purposes

URINE PIPE LINE

WASTE WATER PIPE LINE

ECOSAN SQUATTING PAN

AREA :

AREA OF THE BUILDING : 2.50 SQ.M

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600

Bill of Quantities of Household Ecosan Toilet

#	Item	Unit	Qty	Rate	Amount
1	**Excavation**				
a	Foundation	cu.m	0.41	140.62	57.65
2	**PCC in 1:4:8**				
a	Flooring	cu.m	0.11	3,330.65	366.37
3	**Filling**				
a	Sand filling	cu.m	0.11	410.04	45.10
4	**Masonry work**				
a	RR masonry in CM 1:6 for foundation	cu.m	0.41	2,500.90	1,025.37
b	115mm tk brick work in CM 1:4	sq.m	16.09	367.67	5,915.81
c	Brick work in CM 1:6 for steps	cu.m	0.23	3,206.20	737.43
5	**Light roof**				
a	Roofing	sq.m	2.82	125.00	352.50
6	**Slab (Stone/Precast RCC)**				
a	75mm tk slab over chmabers	sq.m	1.85	620.00	1,147.00
b	Cover slab for chamber access	sq.m	1.13	620.00	700.60
7	**Plastering**				
a	Plastering of walls in 1:6	sq.m	15.30	92.00	1,407.60
b	Plastering in 1:4 with water proof compound for inner sides of the chambers	sq.m	7.99	105.47	842.71
8	**Cement floor**				
a	Flooring	sq.m	2.75	140.00	385.00
9	**Sanitary fixtures**				
a	Ecosan squatting pan	No	2.00	800.00	1,600.00
10	**Water and sanitary fittings (inclusive of all materials and labour costs)**				
a	Wastewater and urine pipes from toilets (1.5 inch dia PVC)	Rm	5.00	125.00	625.00
b	Urine tank (20 litres)	No	1.00	150.00	150.00
12	**Doors**				
a	D1	No	1.00	800.00	800.00
13	**Ventilator and windows**				
a	V1	No	1.00	300.00	300.00
14	**Painting work**				
a	White washing	Sq.m	15.30	20.00	306.00
b	Door and ventilator	Sq.m	2.16	70.00	151.20

Total Cost	**16,915.34**
Total Building Area in sq.m	**2.50**
Total Cost per sq.m	**6,766.14**

4.6 Anganwadi Ecosan Toilet with Urinals

The ecosan toilets at Anganwadis can be designed with a consideration of use by 40 children and a female worker. Care should be taken to design spacious units which provide a comfortable atmosphere to children and movement of caretaker to assist children using the toilets. Providing urinal units along with ecosan toilets offers comfort to children when they only want to urinate. Provision of washing facilities encourages hand washing practice among children. Ensuring availability of water in the anganwadi ecosan toilet is very important for the proper hygiene and maintenance.

4.6.1 Design Considerations

i) Capacity

- Anganwadi ecosan toilet can be designed for use by 40 children and a female caretaker. The unit can be used by both boys and girls.
- Provision of two squatting type urinals for 40 children can be considered.
- Handwashing facility with one tap for every 20 children is necessary.

ii) Volume of Chamber

- For designing the storage volume of faeces collection chamber, an ultimate volume of desiccated faeces and additive mixture of 0.20 to 0.30 litres per person per day can be considered depending upon the local condition and usage pattern.

iii) Type of Chambers

- A twin chamber ecosan toilet is most ideal which requires very minimal maintenance compared to others.
- Single chamber ecosan toilets will be difficult to maintain in an anganwadi situation.

iv) Retention Period

- A minimum retention period of 10 months for pathogen inactivation of faeces and additive mixture in the faeces collection chamber must be considered in the design.
- Urine can be collected in a tank of 500 litres capacity. It can be transported for agricultural applications.

v) Floor Space and Level

- The minimum floor dimension of ecosan toilets with double chamber must be 1.8 m length and 1.30 m in width for use by children with the assistance of a caretaker.
- The lower level of the faeces collection chambers of ecosan toilets should be above the high flood level expected in low lying and flood prone areas.

vi) Construction Materials

- An ecosan toilet is designed with a leak proof faeces and urine collection chamber and super structure with pans / arrangement that ensures source separation of faeces, urine and wash water.
- Bricks, hollow blocks or stone / mud blocks should be used for walls of anganwadi ecosan toilets to provide robust and safe construction which will last for several years.

vii) Customized Designs

- The anganwadi ecosan toilets can be constructed as per the space available.
- Urinals and washing area can be modified to suit the space available.

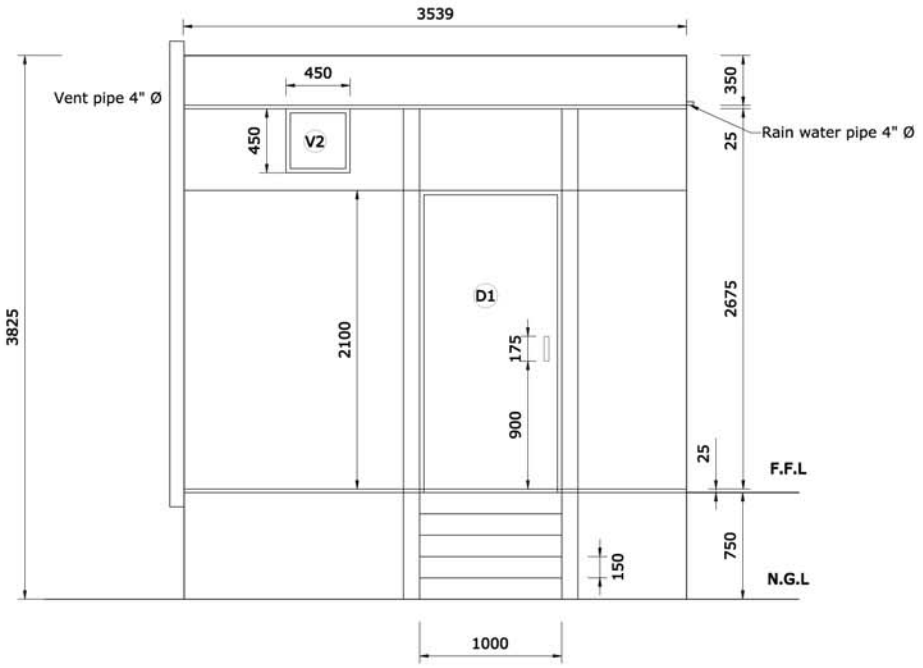
4.6.2 Designs, Drawings and Estimates

Design details	Specification
No. of users	40 children and a female caretaker
Average volume of desiccated material	0.20 litres / person / day
Retention period	300 days
No. of Ecosan Toilets provided	1 ecosan toilet with 2 chambers
Size of faeces collection chambers • Volume of chambers needed considering 15% usage of toilets • Size of each chamber provided	 = 41 x 0.15 x 300 days x 0.20 l/p/d = 369 litres = 1.30 m x 0.87 m x 0.50 m X 1000 litres = 565 litres
Size of chamber access hole	450 mm wide x 500 mm high
Size of urine collection tank	500 litre capacity tank
Vent pipe	• 100 mm dia connecting both tanks • 500 mm above roof level • Cowl on top
Toilet size	1.8 m length x 1.3 m width
Soak pit	1.10 m dia and 1.50 m deep
Urinals	2 nos. with squatting type urinal pans attached to a drain
Hand washing facility	Minimum 2 taps
Floor and wall tiles	Up to 0.90 m height on walls and over all the floor area
Door	0.9 m x 2.10 m
Roof	RCC roof over toilet and urinal areas
Super structure	Walls with bricks (230 mm thick for all outer walls and chambers, and 115 mm thick for interior walls)

4.6.3 Cost Estimate

In the design of anaganwadi ecosan toilet, features like one ecosan toilet, two urinals, hand washing facility, raised basement for free access, RCC roof cover and ceramic tiling on walls and floors for easy maintenance have been considered.

The cost of a standard design of an anganwadi ecosan toilet considered works out to Rs 80,630. The drawings and estimates of the anganwadi ecosan toilet are provided on pages 58 - 61.



FRONT ELEVATION

ANGANWADI ECOSAN TOILET

Plumbing and sanitary work :

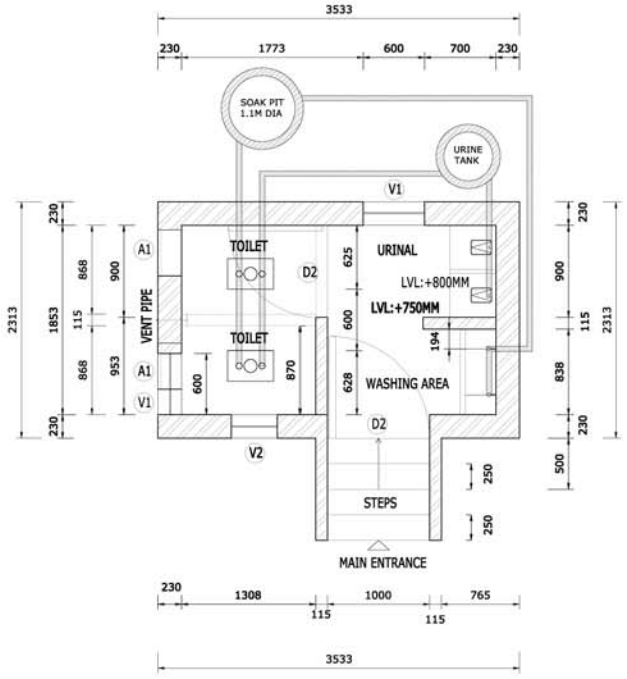
16. Water pipes and fittings in GI class B pipes/fittings or PVC
17. Vent pipe and cowl of chambers and urine collection and waste pipes using PVC or HDPE
18. Ecosan toilet pans with 3 holes made of fibre/ceramic/in-situ arrangement using cement mortar
19. Ceramic squatting type urinal pans for urinals 20. Urine drained out urinals through open drain may be conveyed into urine collection tank through PVC/HDPE pipes min. 50mm dia.
21. Urine collection tank in HDPE/Masonry tank as per local availability

22. Soak pit filled with boulders/brick ballast/sand for disposing anal cleaning and hand washing water as per soil conditions

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS

NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600



FLOOR PLAN

ANGANWADI ECOSAN TOILET

Notes :

1. Foundation design is indicative & may need changes as per site conditions
2. 115mm thick walls in 1:4 cement mortar. No reinforcement bars on alternative layers
3. All waterlines including plumbing arrangement for hand washing sink to be fixed open on walls using clips (not to be concealed in walls)
4. The minimum clear dimensions of the toilet units indicated must be maintained even if the walls are altered using other construction materials. However, an increase in the sizes are allowed for ensuring additional comfort
5. Location of urine tank and the soak pit are indicative. Actual location of these units may be decided as per the site conditions
6. Urinal and all the wastewater drainage pipes/drain must have 1:100 slope
7. Urine and anal cleaning wastewater pipes must be secured firmly to the Ecosan squatting pans to avoid leakage into the faeces collection chamber
8. Inspection chambers/elbows with door should be provided for periodic cleaning or snaking of urine and wastewater drainage lines
9. Urine collection tank must be placed below ground level to allow urine flow by gravity. However, the urine tank's top portion must be at least 150mm above the ground level to prevent entry of rain water
10. Soak pit should be covered/enclosed to prevent entry of rainfall runoff water
11. Provision of taps/waterlines to Ecosan toilets should be avoided as a precautionary measure for preventing leakages into faeces collection chambers. Only a bucket and mug must be kept inside the toilets for collecting water for ablution purposes
12. A floor slope of 1:50 for the circulation areas should facilitate draining of water from floors to specially provided outlets. Water spilled on floors should not be allowed to enter the toilet area

URINE PIPE LINE

WASTE WATER PIPE LINE

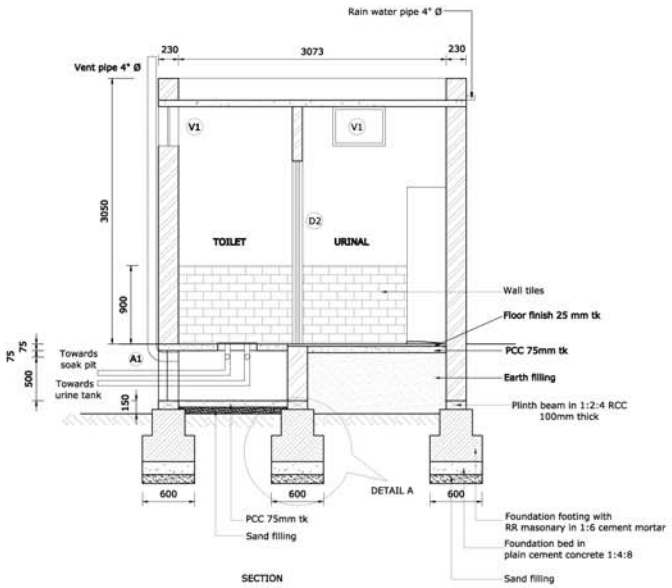
ECOSAN SQUATTING PAN

AREA :

AREA OF THE BUILDING : 8.17 SQ.M

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600

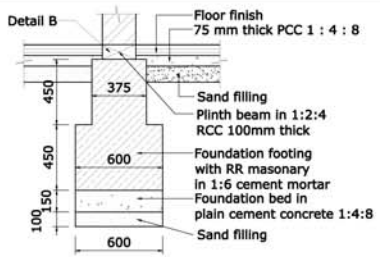


ANGANWADI ECOSAN TOILET

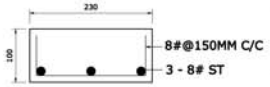
SPECIFICATIONS

CIVIL WORK

1. Foundation of footing bed in 1:4:8 plain cement concrete
2. Foundation of wall footings in RR Masonry with 1:6 cement mortar
3. Plinth band of 75mm thick in 1:2:4 reinforced cement concrete
4. Super structure with brick masonry in cement mortar 1:6 for 230 mm walls and 1:4 for 115 mm walls
5. Plastering in cement mortar 1:6 for walls
6. Plastering in cement mortar 1:4 with water proof compound for inner sides and bottom of faeces collection chamber
7. Glazed tiles up to 0.9m height on inner walls of toilets and urinals.
8. Flooring with anti-skid tiles/cement flooring in toilets, urinals and circulation areas and steps.
9. Lintels with reinforced cement concrete lintel of 150mm thick over ventilators and toilet & entrance doors
10. Roof with reinforced cement concrete in 1:2:4 of 100mm thick
11. Weathering course in lime and brick ballast (1:2) finished with 1:5 cement mortar
12. Water tanks made of masonry or HDPE to be placed on roof or as per suitability
13. Ventilators made up of ready to install prefabricated cement concrete or as per availability
14. Doors of toilets made-up of PVC panel or GI sheets fixed on country wood/angles
15. Access opening of faeces collection chambers covered with 5mm thick RCC slabs or stone slabs. Fixed in position with 1:12 lean cement mortar for opening it when these are to be emptied



GENERAL FOOTING SECTION DETAIL A



PLINTH BEAM - DETAIL B

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS

NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600

Bill of Quantities of Anganwadi Ecosan Toilet

#	Item	Unit	Quantity	Rate	Amount
1	**Excavation**				
a	Foundation	cu.m	8.48	140.62	1,192.60
b	Soak pit	cu.m	3.59	140.62	505.15
2	**PCC in 1:4:8**				
a	Foundation	cu.m	1.16	3,330.65	3,851.90
b	Flooring	cu.m	0.32	3,330.65	1,065.81
3	**Filling**				
a	Foundation	cu.m	1.55	62.15	96.39
b	Sand filling	cu.m	1.16	410.04	475.65
c	Infill in soak pit	cu.m	3.59	350.00	1,257.30
4	**Masonry work**				
a	RR masonry in CM 1:6 for foundation	cu.m	3.78	2,500.90	9,448.15
b	115mm tk brick work in CM 1:4	sq.m	4.40	367.67	1,618.67
c	230mm tk brick work in CM 1:6	cu.m	5.10	3,206.20	16,348.55
d	Brick work in CM 1:6 for ramp and steps	cu.m	0.30	3,206.20	961.86
5	**RCC Works**				
a	1:2:4 RCC Lintel (all type)	cu.m	0.02	4,569.06	105.09
b	1:2:4 RCC for (roof slab)	cu.m	0.82	4,569.06	3,733.76
6	**Slab (Stone/Precast RCC)**				
a	75mm tk slab over chambers	sq.m	2.41	620.00	1,491.10
b	75mm tk cover for leach pit	sq.m	1.73	620.00	1,071.71
c	Cover slab for chamber access	sq.m	1.13	620.00	697.50
7	**Plastering**				
a	Plastering of walls in 1:6	sq.m	55.49	105.47	5,852.37
b	Plastering in 1:4 with water proof compound for inner sides of the chambers	sq.m	5.22	105.47	550.55
8	**Ceramic tiles**				
a	Flooring	sq.m	5.68	814.16	4,624.02
b	Walls	sq.m	10.71	857.88	9,187.89
9	**Weathering course**				
a	Over roof area using brick ballast and lime	cu.m	0.61	1,200.00	735.46
10	**Sanitary fixtures**				
a	Ecosan squatting pan	No	2.00	800.00	1,600.00
b	Girls/Ladies urinal squatting pan	No	2.00	400.00	800.00
11	**Water and sanitary fittings (inclusive of all materials and labour costs)**				
a	Water pipes (1.25 inch dia GI)	Rm	5.00	250.00	1,250.00
b	Taps	No	2.00	175.00	350.00
c	Waste pipes (2 inch dia PVC)	Rm	12.00	125.00	1,500.00
d	Vent rainwater pipes (4 inch dia PVC)	Rm	4.00	260.00	1,040.00
e	Water tank (500 litres)	No	1.00	2,250.00	2,250.00
f	Urine tank (500 litres)	No	1.00	2,250.00	2,250.00
12	**Doors**				
a	D1	No	1.00	1,000.00	1,000.00
b	D2	No	1.00	800.00	800.00
13	**Ventilator and windows**				
a	V1	No	2.00	300.00	600.00
b	V2	No	1.00	250.00	250.00
14	**Painting work**				
a	Internal white washing	Sq.m	34.54	20.00	690.80
b	External cement painting	Sq.m	20.95	50.00	1,047.55
c	Door and ventilator	Sq.m	4.73	70.00	331.10
			Total Cost		**80,630.94**
			Total Area in sq.m		**8.17**
			Cost per sq.m		**9,869.15**

4.7 School Ecosan Toilets

Ecosan toilets with urinals can be built in schools to cater to the requirements of boys, girls and teachers. These units must be designed according to the number of students in schools. Use of a single ecosan toilet in a toilet complex by a maximum of 40 children and one urinal by a maximum of 20 children is an ideal design capacity to be considered while designing school ecosan toilet units for boys and girls.

It is also important to consider the use of ecosan toilets by children with special needs. Toilet units must have ramps, wide doors and larger sized toilet units to provide access to children with special needs. Provision of washing facilities encourages hand washing practice among children. Ensuring availability of water in the school ecosan toilet units is very important for the proper up-keep.

Provision of incinerators to safely dispose sanitary napkins should be considered in the toilets meant for girls. In addition, facilities like sanitary napkin vending machines can be installed in the toilets.

In this section, detailed design, drawings and estimates for school ecosan toilet units with student strength of 80, 160, 240 and 320 are provided. A ratio of 50:50 between boys and girls has been considered in the designs.

4.7.1 Design Considerations

i) Capacity

- A single school ecosan toilet can be designed for use by 40 children and two adult teachers.
- Similarly, provision of urinals for every 20 children can be considered.
- Handwashing facility with one tap for every 20 children is necessary.

ii) Volume of Chamber

- For designing the storage volume of faeces collection chamber, an ultimate volume of desiccated faeces and additive mixture of 0.20 to 0.30 litres per person per day can be considered depending upon the local condition and usage pattern.

iii) Type of Chambers

- A twin chamber ecosan toilet is most ideal which requires very minimal maintenance compared to others.
- Single chamber ecosan toilets will be difficult to maintain in a school situation.

iv) Retention Period

- A minimum retention period of 10 months for pathogen inactivation of faeces and additive mixture in the faeces collection chamber must be considered in the design.
- Urine can be collected in a tank of 500-1,000 litres capacity can be installed based on the strength of the schools. Provision for transporting urine for agricultural applications must be ensured.

v) Floor Space and Level

- At least one ecosan toilet for the use of children with special needs of a minimum size 1,750 mm x 2,100 mm should be provided in a toilet unit.
- Specially designed chairs with washing arrangements and strong handles for offering support to children with special

needs must be provided in ecosan toilets designated for their use.

- Other ecosan toilets with two chambers must be at least 1,200 mm x 1,500 mm in size.

- The lower level of the faeces collection chambers of ecosan toilets should be above the high flood level expected in low lying and flood prone areas.

vi) Ramp and Railing

- An ideal slope of 1:18 or a minimum of 1:12 with a minimum width of 1,000 mm must be maintained for access by wheel chair users independently.

- The height of the railing should not exceed 780 mm and must have a lower level support at 600 mm level for younger children.

- The length of railing should be extended beyond 300 mm from the sloped ends of the ramp.

- Antiskid tiles must be used for flooring of ramp.

vii) Incinerator

- At least one of the toilets must be connected to the incinerator through an access chute for disposal of sanitary napkins.

viii) Construction Materials

- An ecosan toilet is designed with a leak proof faeces and urine collection chamber and super structure with pans / arrangements that help in source separation of faeces, urine and wash water.

- Bricks, hollow blocks or stone / mud blocks should be used for walls of schools ecosan toilets to provide a robust and safe construction which will lasts for several years.

ix) Customized Designs

- The school ecosan toilets can be constructed as per the space available and the strength of children in a school.

- Urinals and washing area can be modified to suit the space available.

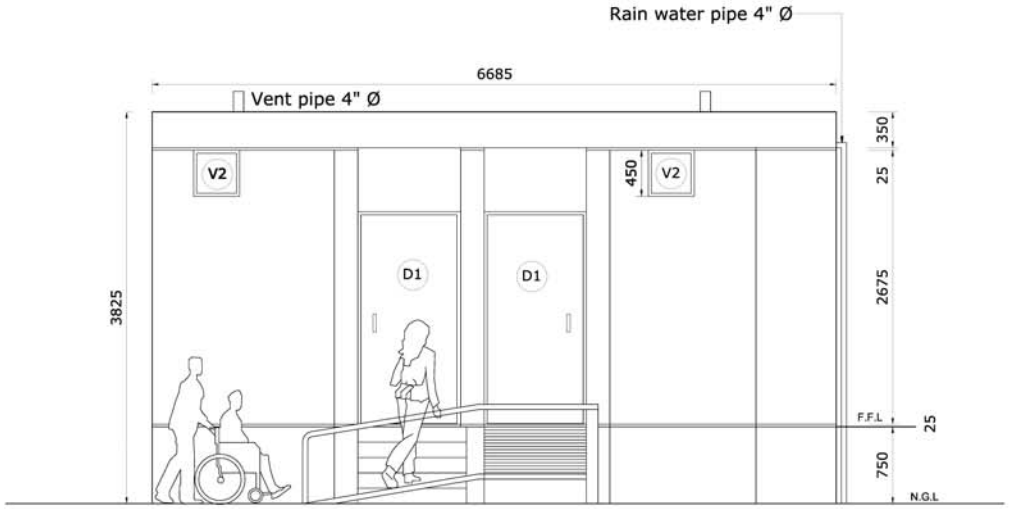
4.7.2 Design, Drawing and Estimates

Design details	Specification
No. of users	40 children and 2 teachers
Average volume of desiccated material	0.20 litres/person/day
Retention period	300 days
Type of ecosan toilet provided	Each ecosan toilet with 2 chambers
Size of faeces collection chambers • Volume of chambers needed considering 15% usage of toilets • Size of each chamber provided	 = 42 nos. x 0.15 x 300 days x 0.20 l/p/d = 378 litres = 1.30 m x 0.87 m x 0.50 m X 1000 litres = 565 litres
Size of chamber access hole	450 mm wide x 500 mm high
Size of urine collection tank	500 litre capacity tank
Vent pipe	• 100 mm dia connecting both tanks • 500 mm above roof level • Cowl on top
Toilet size (floor area)	CWSN: 2.1m length x 1.75 m width Normal: 1.5 m length x 1.2 m width
Soak pit for waste water disposal	1.10 m dia and 1.50 m deep
Urinals	1 for every 20 children (Boys – wall mounted waterless urinal pans. Girls – squatting urinal pans attached to drains)
Hand Washing Facility	Minimum 2 taps and 1 for every 20 child
Floor and wall tiles	Upto 0.90 m height on all walls and 1.2m height on walls in the urinal for boys. Floor tiles on entire floor area and ramp.
Door	Toilets for CWSN – 1.0 x 2.10 m, Others – 0.9 m x 2.10 m. Urinals - 0.75 m x 1.80 m
Roof	RCC roof over toilet and urinal areas
Super structure	Walls with bricks (230 mm thick for all outer and main load bearing walls and chambers, and 115 mm thick for interior walls)

4.7.3 Cost Estimate

In the design of school ecosan toilet units, features like ramp and one ecosan toilet for children with special needs exclusively in boy's and girl's toilet units, urinal facility for both boys and girls, hand washing facility, raised basement for free access, RCC roof cover and ceramic tiling on walls and floors for easy maintenance have been considered.

The estimated cost of school ecosan toilets for the student strengths of 80, 160, 240 and 320 are Rs 3,01,662, Rs 4,31,900, Rs 537,306 and Rs 6,47,012 respectively. The detailed design, drawings and estimates of the all school ecosan toilet units are provided from page 65 to page 80.



FRONT ELEVATION

SCHOOL ECOSAN TOILET

(80 CAPACITY - 40 BOYS + 40 GIRLS)

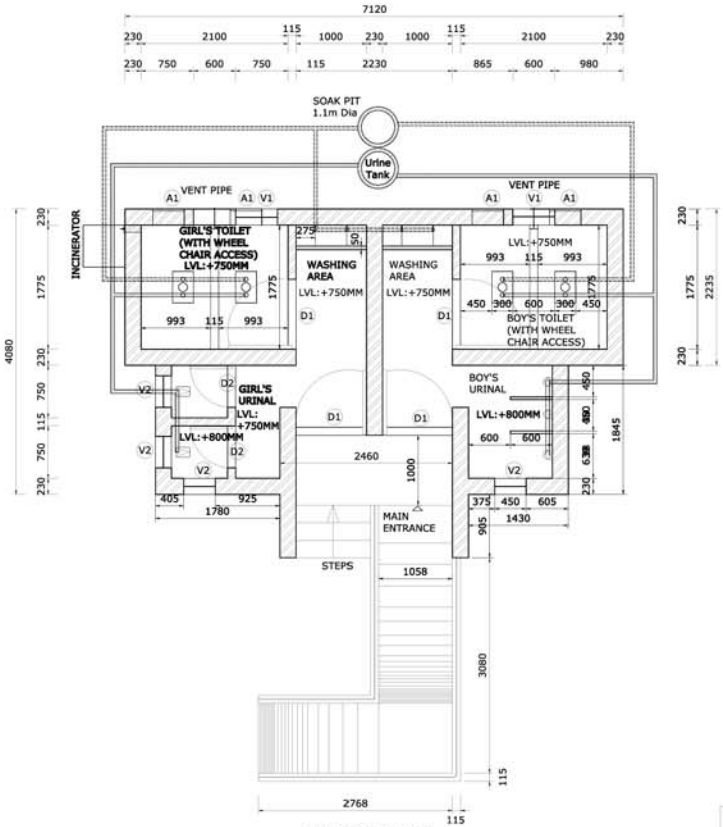
Plumbing and sanitary work :

17. Water pipes and fittings in GI class B pipes/fittings or PVC
18. Vent pipe and cowl of chambers and urine collection and waste pipes using PVC or HDPE
19. Ecosan toilet pans with 3 holes made of fibre/ceramic/in-situ arrangement using cement mortar
20. Ceramic squatting type urinal pans for girls urinals and wall fixing type urinal pans for boys urinals fitted with low-cost odour trap
21. Urine drained out from girls urinal through open drain may be conveyed into urine collection tank through PVC/HDPE pipes min. 50mm dia.
22. Urine collection tank in HDPE/Masonry tank as per local availability
23. Soak pit filled with boulders/brick ballast/sand for disposing anal cleaning water and hand washing water as per soil conditions

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS

NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600



FLOOR PLAN

SCHOOL ECOSAN TOILET

(80 CAPACITY - 40 BOYS + 40 GIRLS)

Notes :

1. Foundation design is indicative & may need changes as per site conditions
2. 115mm thick walls in 1:4 cement mortar. No reinforcement bars on alternative layers
3. All waterlines including plumbing arrangement for hand washing sink to be fixed open on walls using clips (not to be concealed in walls)
4. The minimum clear dimensions of the toilet units indicated must be maintained even if the walls are altered using other construction materials. However, an increase in the sizes are allowed for ensuring additional comfort
5. At least one incinerator either metallic or masonry type to be provided connecting two girls toilet units
6. Location of urine tank and the soak pit are indicative. Actual location of these units may be decided as per the site conditions
7. Urinal and all the wastewater drainage pipes/drain must have 1:100 slope
8. Urine and anal cleaning wastewater pipes must be secured firmly to the Ecosan squatting pans to avoid leakage into the faeces collection chamber
9. Inspection chambers/elbows with door should be provided for periodic cleaning or snaking of urine and wastewater drainage lines .
10. Urine collection tank must be placed below ground level to allow urine flow by gravity. However, the urine tank's top portion must be at least 150mm above the ground level to prevent entry of rain water.
11. Soak pit should be covered/enclosed to prevent entry of rainfall runoff water
12. Ecosan toilets for children/people with special needs should be provided with special toilet chairs to enable them to use the facility
13. Provision of taps/waterlines to Ecosan toilets should be avoided as a precautionary measure for preventing leakages into faeces collection chambers. Only a bucket and mug must be kept inside the toilets for collecting water for ablution purposes
14. A floor slope of 1:50 for the circulation areas should facilitate draining of water from floors to specially provided outlets. Water spilled on floors should not be allowed to enter the toilet area.

URINE PIPE LINE

WASTE WATER PIPE LINE

ECOSAN SQUATTING PAN

AREA :

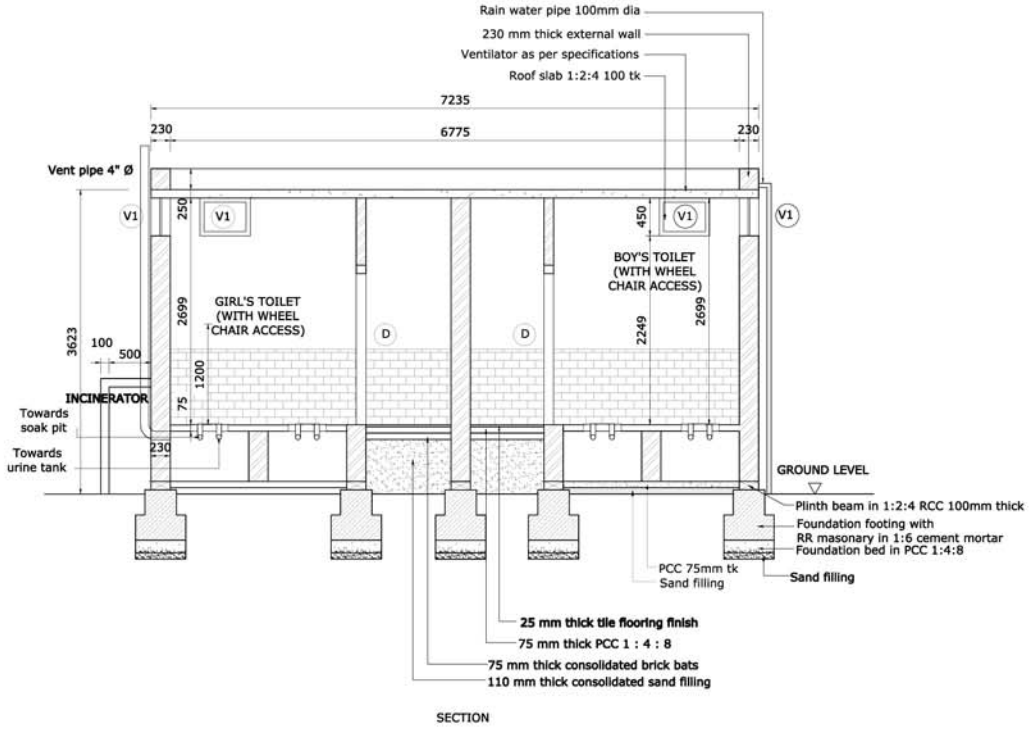
AREA OF THE BUILDING : 26.80 SQ.M

AREA OF THE RAMP : 8.50 SQ.M

TOTAL AREA : 35.30 SQ.M

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600



SECTION

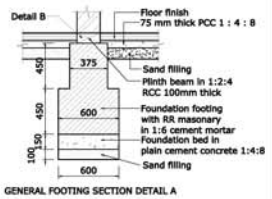
SCHOOL ECOSAN TOILET

(80 CAPACITY - 40 BOYS + 40 GIRLS)

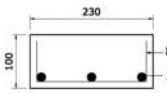
SPECIFICATIONS

CIVIL WORK

1. Foundation of footing bed in 1:4:8 plain cement concrete
2. Foundation of wall footings in RR Masonry with 1:6 cement
3. Plinth band of 75mm thick in 1:2:4 reinforced cement concrete
4. Super structure with brick masonry in cement mortar 1:6 for 230 mm walls and 1:4 for 115 mm walls
5. Plastering in cement mortar 1:6 for walls
6. Plastering in cement mortar 1:4 with water proof compound for inner sides and bottom of faeces collection chamber
7. Glazed tiles up to 0.9m height on inner walls of toilets and girls urinals. Glazed tiles up to 1.2m height on walls fixed with urinal pans in boys urinal.
8. Flooring with anti-skid tiles/cement flooring in toilets, urinals and circulation areas including ramp and steps.
9. Lintels with reinforced cement concrete lintel of 150mm thick over ventilators and toilet & entrance doors
10. Roof with reinforced cement concrete in 1:2:4 of 100mm thick or as per slab spanning
11. Weathering course in lime and brick ballast (1:2) finished with 1:5 cement mortar
12. Water tanks made of masonry or HDPE to be placed on roof or as per suitability
13. Ventilators made up of ready to install prefabricated cement concrete or as per availability
14. Doors of toilets and girls urinals made-up of PVC panel or GI sheets fixed on country wood/angles
15. Hand rail of ramp in GI B-Class 40mm pipes and fittings should be grouted firmly in concrete. Use of appropriate locally available material may be considered wherever necessary
16. Access opening of faeces collection chambers covered with 5mm thick RCC slabs or stone slabs. Fixed in position with 1:12 lean cement mortar for opening it when these are to be emptied



GENERAL FOOTING SECTION DETAIL A



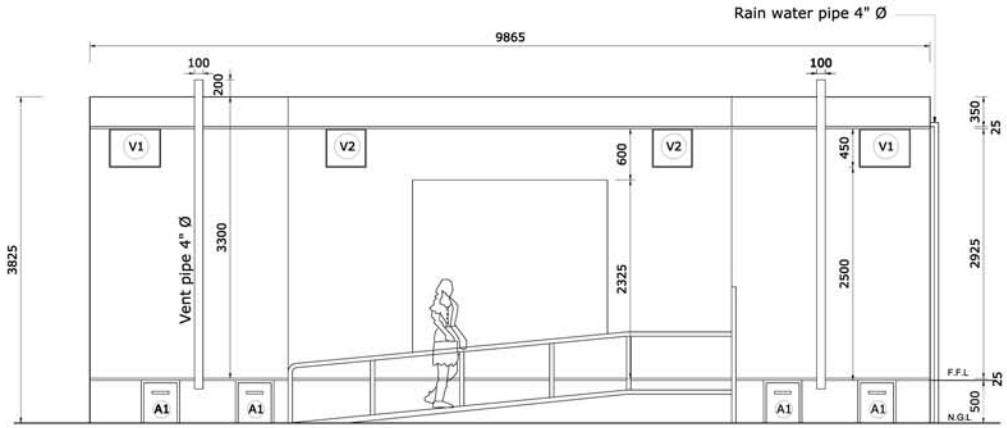
PLINTH BEAM - DETAIL B

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600

Bill of Quantities of School Ecosan Toilet - 80 Capacity

#	Item	Unit	Qty	Rate	Amount
1	**Excavation**				
a	Foundation	cu.m	22.14	140.62	3,112.82
b	Soak pit	cu.m	3.59	140.62	505.15
c	Ramp	cu.m	1.42	140.62	199.68
2	**PCC in 1:4:8**				
a	Foundation	cu.m	3.02	3,330.65	10,053.90
b	Flooring	cu.m	1.01	3,330.65	3,372.28
c	Ramp	cu.m	1.51	3,330.65	5,029.28
3	**Filling**				
a	Foundation	cu.m	9.13	62.15	567.43
b	Sand filling	cu.m	2.01	410.04	825.16
c	Consolidated brick bats	cu.m	7.76	700.00	5,433.75
d	Infill in soak pit	cu.m	3.59	350.00	1,257.30
4	**Masonry work**				
a	RR masonry in CM 1:6 for foundation	cu.m	9.86	2,500.90	24,660.77
b	115mm tk brick work in CM 1:4	sq.m	10.47	367.67	3,849.14
c	230mm tk brick work in CM 1:6	cu.m	24.80	3,206.20	79,513.76
d	Brick work in CM 1:6 for ramp and steps	cu.m	2.38	3,206.20	7,630.76
5	**RCC Works**				
a	1:2:4 RCC Plinth and Lintel	cu.m	0.10	4,569.06	472.90
b	1:2:4 RCC Roof	cu.m	2.92	4,569.06	13,355.36
6	**Slab (Stone/Precast RCC)**				
a	75mm tk slab chamber and hand wash areas	sq.m	8.10	620.00	5,022.00
b	75mm tk cover for leach pit	sq.m	2.75	620.00	1,705.00
c	Cover slab for chamber access	sq.m	2.25	620.00	1,395.00
7	**Plastering**				
a	Plastering of walls in 1:6	sq.m	143.00	105.47	15,082.32
b	Plastering in 1:4 with water proof compound for inner sides of the chambers	sq.m	14.67	105.47	1,547.46
8	**Ceramic tiles**				
a	Flooring	sq.m	26.80	814.16	21,819.49
b	Walls	sq.m	43.41	857.88	37,240.57
c	Ramp	sq.m	8.61	814.16	7,009.92
9	**Weathering course**				
a	Over roof area using brick ballast and lime	cu.m	2.01	1,200.00	2,412.00
10	**Sanitary fixtures**				
a	Ecosan squatting pan	No	4.00	800.00	3,200.00
b	Girls/Ladies urinal squatting pan	No	2.00	400.00	800.00
c	Boys/Mens urinal pans with odour trap	No	3.00	500.00	1,500.00
11	**Water and sanitary fittings (inclusive of all materials and labour costs)**				
a	Water pipes (1.25 inch dia GI)	Rm	6.00	250.00	1,500.00
b	Taps	No	4.00	175.00	700.00
c	Waste pipes (2 inch dia PVC)	Rm	3.00	125.00	375.00
d	Wastewater and urine pipes from toilets (3 inch dia PVC)	Rm	30.00	185.00	5,550.00
e	Vent and rainwater pipes (4 inch dia PVC)	Rm	12.00	260.00	3,120.00
f	Water tank (1000 litres)	No	1.00	4,500.00	4,500.00
g	Urine tank (1000 litres)	No	1.00	4,500.00	4,500.00
12	**Doors**				
a	D1	No	4.00	1,000.00	4,000.00
b	D2	No	4.00	800.00	3,200.00
13	**Ventilator and windows**				
a	V1	No	2.00	300.00	600.00
b	V2	No	4.00	250.00	1,000.00
14	**Incineator**				
a	Metal / Masonry incineator	No	1.00	1,500.00	1,500.00
15	**Painting work**				
a	Internal white washing	Sq.m	41.77	20.00	835.40
b	External cement painting	Sq.m	35.40	50.00	1,770.00
c	Door and ventilator	Sq.m	68.40	70.00	4,788.00
16	**Hand rails**				
a	MS rods and pipes for ramp	Rm	10.30	500.00	5,150.00
				Total Cost	**301,661.59**
				Total Building Area in sq.m	**26.80**
				Total Cost per sq.m	**11,256.03**



FRONT ELEVATION

SCHOOL ECOSAN TOILET

(160 CAPACITY - 80 BOYS + 80 GIRLS)

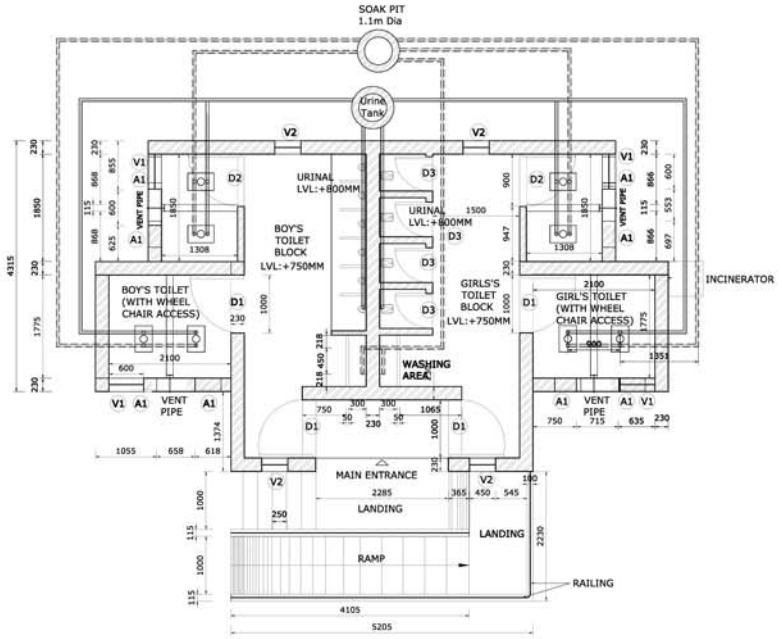
Plumbing and sanitary work :

17. Water pipes and fittings in GI class B pipes/fittings or PVC
18. Vent pipe and cowl of chambers and urine collection and waste pipes using PVC or HDPE
19. Ecosan toilet pans with 3 holes made of fibre/ceramic/in-situ arrangement using cement mortar
20. Ceramic squatting type urinal pans for girls urinals and wall fixing type urinal pans for boys urinals fitted with low-cost odour trap
21. Urine drained out from girls urinal through open drain may be conveyed into urine collection tank through PVC/HDPE pipes min. 50mm dia.

22. Urine collection tank in HDPE/Masonry tank as per local availability
23. Soak pit filled with boulders/brick ballast/sand for disposing anal cleaning water and hand washing water as per soil conditions

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600



FLOOR PLAN

SCHOOL ECOSAN TOILET

(160 CAPACITY - 80 BOYS + 80 GIRLS)

Notes :

1. Foundation design is indicative & may need changes as per site conditions
2. 115mm thick walls in 1:4 cement mortar. No reinforcement bars on alternative layers
3. All waterlines including plumbing arrangement for hand washing sink to be fixed open on walls using clips (not to be concealed in walls)
4. The minimum clear dimensions of the toilet units indicated must be maintained even if the walls are altered using other construction materials. However, an increase in the sizes are allowed for ensuring additional comfort
5. At least one incinerator either metallic or masonry type to be provided connecting two girls toilet units
6. Location of urine tank and the soak pit are indicative. Actual location of these units may be decided as per the site conditions
7. Urinal and all the wastewater drainage pipes/drain must have 1:100 slope
8. Urine and anal cleaning wastewater pipes must be secured firmly to the Ecosan squatting pans to avoid leakage into the faeces collection chamber
9. Inspection chambers/elbows with door should be provided for periodic cleaning or snaking of urine and wastewater drainage lines .
10. Urine collection tank must be placed below ground level to allow urine flow by gravity. However, the urine tank's top portion must be at least 150mm above the ground level to prevent entry of rain wateR
11. Soak pit should be covered/enclosed to prevent entry of rainfall runoff water
12. Ecosan toilets for children/people with special needs should be provided with special toilet chairs to enable them to use the facility
13. Provision of taps/waterlines to Ecosan toilets should be avoided as a precautionary measure for preventing leakages into faeces collection chambers. Only a bucket and mug must be kept inside the toilets for collecting water for ablution purposes
14. A floor slope of 1:50 for the circulation areas should facilitate draining of water from floors to specially provided outlets. Water spilled on floors should not be allowed to enter the toilet area.

URINE PIPE LINE

WASTE WATER PIPE LINE

ECOSAN SQUATTING PAN

AREA :

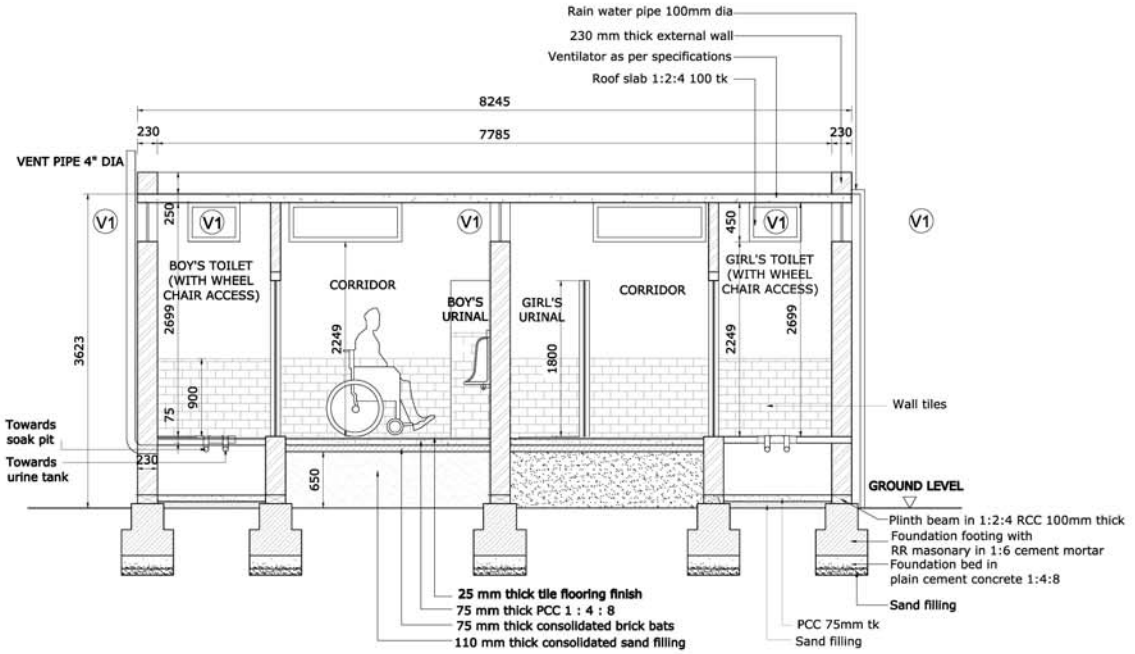
AREA OF THE BUILDING : 45.95 SQ.M

AREA OF THE RAMP : 11.60 SQ.M

TOTAL AREA : 57.55 SQ.M

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600



SECTION

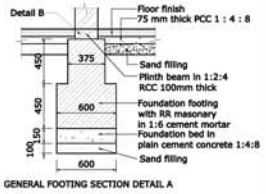
SCHOOL ECOSAN TOILET

(160 CAPACITY - 80 BOYS + 80 GIRLS)

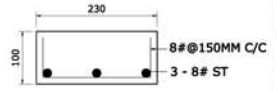
SPECIFICATIONS

CIVIL WORK

1. Foundation of footing bed in 1:4:8 plain cement concrete
2. Foundation of wall footings in RR Masonry with 1:6 cement
3. Plinth band of 75mm thick in 1:2:4 reinforced cement concrete
4. Super structure with brick masonry in cement mortar 1:6 for 230 mm walls and 1:4 for 115 mm walls
5. Plastering in cement mortar 1:6 for walls
6. Plastering in cement mortar 1:4 with water proof compound for inner sides and bottom of faeces collection chamber
7. Glazed tiles up to 0.9m height on inner walls of toilets and girls urinals. Glazed tiles up to 1.2m height on walls fixed with urinal pans in boys urinal.
8. Flooring with anti-skid tiles/cement flooring in toilets, urinals and circulation areas including ramp and steps.
9. Lintels with reinforced cement concrete lintel of 150mm thick over ventilators and toilet & entrance doors
10. Roof with reinforced cement concrete in 1:2:4 of 100mm thick or as per slab spanning
11. Weathering course in lime and brick ballast (1:2) finished with 1:5 cement mortar
12. Water tanks made of masonry or HDPE to be placed on roof or as per suitability
13. Ventilators made up of ready to install prefabricated cement concrete or as per availability
14. Doors of toilets and girls urinals made-up of PVC panel or GI sheets fixed on country wood/angles
15. Hand rail of ramp in GI B-Class 40mm pipes and fittings should be grouted firmly in concrete. Use of appropriate locally available material may be considered wherever necessary
16. Access opening of faeces collection chambers covered with 5mm thick RCC slabs or stone slabs. Fixed in position with 1:12 lean cement mortar for opening it when these are to be emptied



GENERAL FOOTING SECTION DETAIL A



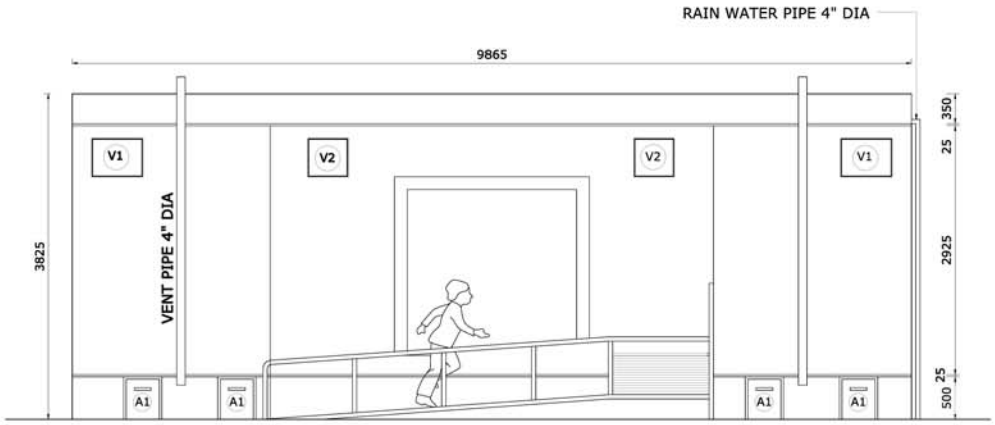
PLINTH BEAM - DETAIL B

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600

Bill of Quantities of School Ecosan Toilet - 160 Capacity

#	Item	Unit	Qty	Rate	Amount
1	**Excavation**				
a	Foundation	cu.m	30.36	140.62	4,269.22
b	Soak pit	cu.m	3.59	140.62	505.15
c	Ramp	cu.m	4.53	140.62	637.34
2	**PCC in 1:4:8**				
a	Foundation	cu.m	4.14	3,330.65	13,788.89
b	Flooring	cu.m	2.93	3,330.65	9,758.80
c	Ramp	cu.m	2.25	3,330.65	7,493.96
3	**Filling**				
a	Foundation	cu.m	16.81	62.15	1,044.54
b	Sand filling	cu.m	2.07	410.04	848.78
c	Consolidated brick bats	cu.m	2.70	700.00	1,890.00
d	Infill in soak pit	cu.m	3.59	350.00	1,257.30
4	**Masonry work**				
a	RR masonry in CM 1:6 for foundation	cu.m	13.52	2,500.90	33,812.17
b	115mm tk brick work in CM 1:4	sq.m	2.56	367.67	941.24
c	230mm tk brick work in CM 1:6	cu.m	36.27	3,206.20	116,288.87
d	Brick work in CM 1:6 for ramp and steps	cu.m	1.22	3,206.20	3,911.56
5	**RCC Works**				
a	1:2:4 RCC Plinth and Lintel	cu.m	0.14	4,996.44	699.50
b	1:2:4 RCC Roof	cu.m	4.60	4,996.44	22,983.62
6	**Slab (Stone/Precast RCC)**				
a	75mm tk slab chamber and hand wash areas	sq.m	1.60	620.00	992.00
b	75mm tk cover for leach pit	sq.m	2.75	620.00	1,705.00
c	Cover slab for chamber access	sq.m	1.80	620.00	1,116.00
7	**Plastering**				
a	Plastering of walls in 1:6	sq.m	264.83	105.47	27,931.62
b	Plastering in 1:4 with water proof compound for inner sides of the chambers	sq.m	20.00	105.47	2,109.40
8	**Ceramic tiles**				
a	Flooring	sq.m	36.00	814.16	29,309.76
b	Walls	sq.m	61.98	857.88	53,171.40
c	Ramp	sq.m	15.00	814.16	12,212.40
9	**Weathering course**				
a	Over roof area using brick ballast and lime	cu.m	3.45	1,200.00	4,140.00
10	**Sanitary fixtures**				
a	Ecosan squatting pan	No	8.00	800.00	6,400.00
b	Girls/Ladies urinal squatting pan	No	4.00	400.00	1,600.00
c	Boys/Mens urinal pans with odour trap	No	6.00	500.00	3,000.00
11	**Water and sanitary fittings (inclusive of all materials and labour costs)**				
a	Water pipes (1.25 inch dia GI)	Rm	8.00	250.00	2,000.00
b	Taps	No	4.00	175.00	700.00
c	Waste pipes (2 inch dia PVC)	Rm	6.00	125.00	750.00
d	Wastewater and urine pipes from toilets (3 inch dia PVC)	Rm	64.00	185.00	11,840.00
e	Vent and rainwater pipes (4 inch dia PVC)	Rm	24.00	260.00	6,240.00
f	Water tank (2000 litres)	No	1.00	9,000.00	9,000.00
g	Urine tank (2000 litres)	No	1.00	9,000.00	9,000.00
12	**Doors**				
a	D1	No	6.00	1,000.00	6,000.00
b	D2	No	4.00	800.00	3,200.00
13	**Ventilator and windows**				
a	V1	No	4.00	300.00	1,200.00
b	V2	No	4.00	250.00	1,000.00
14	**Incineator**				
	Metal / Masonry incineator	No	1.00	1,500.00	1,500.00
15	**Painting work**				
a	Internal white washing	Sq.m	151.68	20.00	3,033.60
b	External cement painting	Sq.m	113.15	50.00	5,657.60
c	Door and ventilator	Sq.m	17.85	70.00	1,249.50
16	**Hand rails**				
a	MS rods and pipes for ramp	Rm	11.42	500.00	5,710.00
				Total Cost	**431,899.25**
				Total Building Area in sq.m	**45.95**
				Total Cost per sq.m	**9,399.33**



FRONT ELEVATION

SCHOOL ECOSAN TOILET

(240 CAPACITY - 120 BOYS + 120 GIRLS)

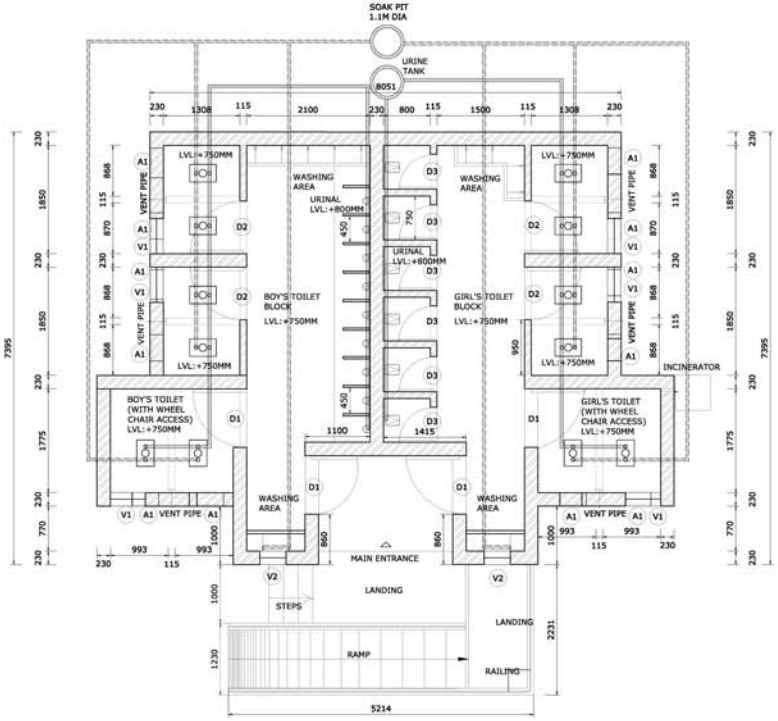
Plumbing and sanitary work :

17. Water pipes and fittings in GI class B pipes/fittings or PVC
18. Vent pipe and cowl of chambers and urine collection and waste pipes using PVC or HDPE
19. Ecosan toilet pans with 3 holes made of fibre/ceramic/in-situ arrangement using cement mortar
20. Ceramic squatting type urinal pans for girls urinals and wall fixing type urinal pans for boys urinals fitted with low-cost odour trap
21. Urine drained out from girls urinal through open drain may be conveyed into urine collection tank through PVC/HDPE pipes min. 50mm dia.

22. Urine collection tank in HDPE/Masonry tank as per local availability
23. Soak pit filled with boulders/brick ballast/sand for disposing anal cleaning water and hand washing water as per soil conditions

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600



FLOOR PLAN

SCHOOL ECOSAN TOILET

(240 CAPACITY - 120 BOYS + 120 GIRLS)

Notes :

1. Foundation design is indicative & may need changes as per site conditions
2. 115mm thick walls in 1:4 cement mortar. No reinforcement bars on alternative layers
3. All waterlines including plumbing arrangement for hand washing sink to be fixed open on walls using clips (not to be concealed in walls)
4. The minimum clear dimensions of the toilet units indicated must be maintained even if the walls are altered using other construction materials. However, an increase in the sizes are allowed for ensuring additional comfort
5. At least one incinerator either metallic or masonry type to be provided connecting two girls toilet units
6. Location of urine tank and the soak pit are indicative. Actual location of these units may be decided as per the site conditions
7. Urinal and all the wastewater drainage pipes/drain must have 1:100 slope
8. Urine and anal cleaning wastewater pipes must be secured firmly to the Ecosan squatting pans to avoid leakage into the faeces collection chamber
9. Inspection chambers/elbows with door should be provided for periodic cleaning or snaking of urine and wastewater drainage lines .
10. Urine collection tank must be placed below ground level to allow urine flow by gravity. However, the urine tank's top portion must be at least 150mm above the ground level to prevent entry of rain water.
11. Soak pit should be covered/enclosed to prevent entry of rainfall runoff water
12. Ecosan toilets for children/people with special needs should be provided with special toilet chairs to enable them to use the facility
13. Provision of taps/waterlines to Ecosan toilets should be avoided as a precautionary measure for preventing leakages into faeces collection chambers. Only a bucket and mug must be kept inside the toilets for collecting water for ablution purposes
14. A floor slope of 1:50 for the circulation areas should facilitate draining of water from floors to specially provided outlets. Water spilled on floors should not be allowed to enter the toilet area.

URINE PIPE LINE

WASTE WATER PIPE LINE

ECOSAN SQUATTING PAN

AREA :

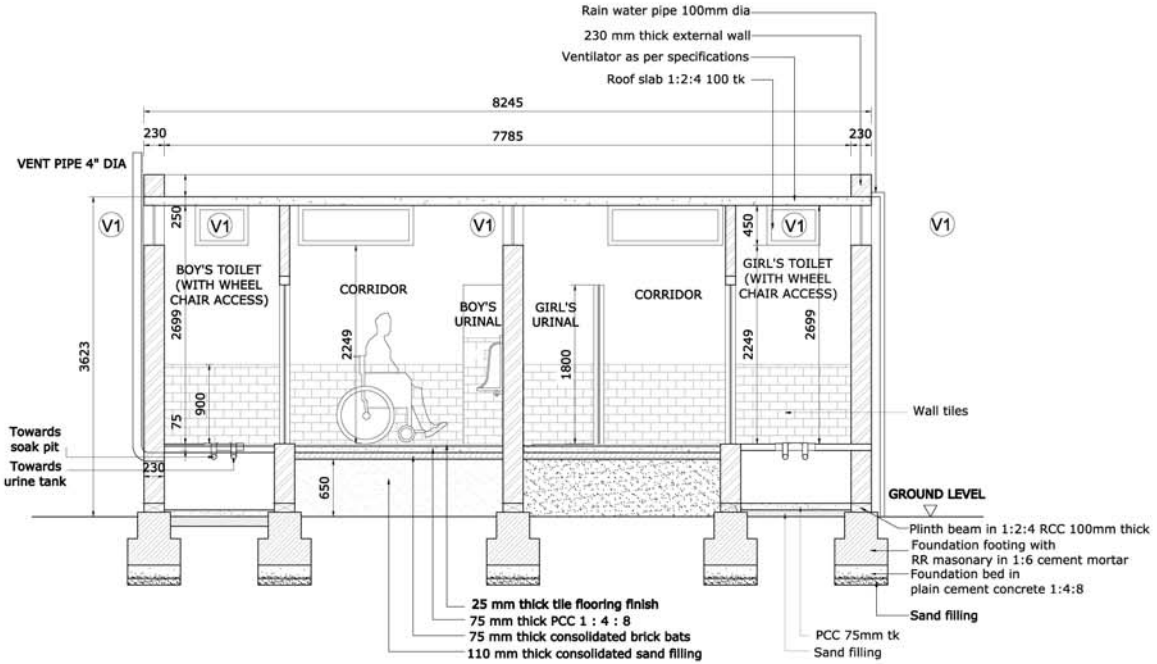
AREA OF THE BUILDING : 60.75 SQ.M

AREA OF THE RAMP : 10.93 SQ.M

TOTAL AREA : 71.68 SQ.M

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600



SECTION

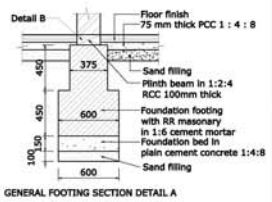
SCHOOL ECOSAN TOILET

(240 CAPACITY - 120 BOYS +120 GIRLS)

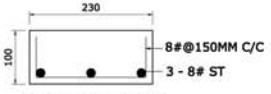
SPECIFICATIONS

CIVIL WORK

1. Foundation of footing bed in 1:4:8 plain cement concrete
2. Foundation of wall footings in RR Masonry with 1:6 cement
3. Plinth band of 75mm thick in 1:2:4 reinforced cement concrete
4. Super structure with brick masonry in cement mortar 1:6 for 230 mm walls and 1:4 for 115 mm walls
5. Plastering in cement mortar 1:6 for walls
6. Plastering in cement mortar 1:4 with water proof compound for inner sides and bottom of faeces collection chamber
7. Glazed tiles up to 0.9m height on inner walls of toilets and girls urinals. Glazed tiles up to 1.2m height on walls fixed with urinal pans in boys urinal.
8. Flooring with anti-skid tiles/cement flooring in toilets, urinals and circulation areas including ramp and steps.
9. Lintels with reinforced cement concrete lintel of 150mm thick over ventilators and toilet & entrance doors
10. Roof with reinforced cement concrete in 1:2:4 of 100mm thick or as per slab spanning
11. Weathering course in lime and brick ballast (1:2) finished with 1:5 cement mortar
12. Water tanks made of masonry or HDPE to be placed on roof or as per suitability
13. Ventilators made up of ready to install prefabricated cement concrete or as per availability
14. Doors of toilets and girls urinals made-up of PVC panel or GI sheets fixed on country wood/angles
15. Hand rail of ramp in GI B-Class 40mm pipes and fittings should be grouted firmly in concrete. Use of appropriate locally available material may be considered wherever necessary
16. Access opening of faeces collection chambers covered with 5mm thick RCC slabs or stone slabs. Fixed in position with 1:12 lean cement mortar for opening it when these are to be emptied



GENERAL FOOTING SECTION DETAIL A



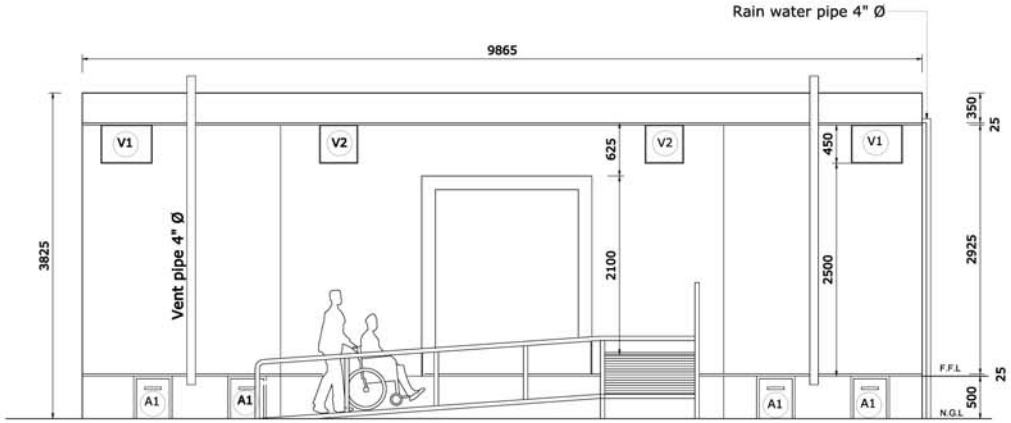
PLINTH BEAM - DETAIL B

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600

Bill of Quantities of School Ecosan Toilet - 240 Capacity

#	Item	Unit	Qty	Rate	Amount
1	**Excavation**				
a	Foundation	cu.m	38.28	140.62	5,382.93
b	Soak pit	cu.m	3.59	140.62	505.15
c	Ramp	cu.m	1.59	140.62	223.59
2	**PCC in 1:4:8**				
a	Foundation	cu.m	5.22	3,330.65	17,385.99
b	Flooring	cu.m	2.48	3,330.65	8,260.01
c	Ramp	cu.m	1.96	3,330.65	6,528.07
3	**Filling**				
a	Foundation	cu.m	20.01	62.15	1,243.62
b	Sand filling	cu.m	4.29	410.04	1,759.07
c	Consolidated brick bats	cu.m	2.93	700.00	2,047.50
d	Infill in soak pit	cu.m	3.59	350.00	1,257.30
4	**Masonry work**				
a	RR masonry in CM 1:6 for foundation	cu.m	17.052	2,500.90	42,645.35
b	115mm tk brick work in CM 1:4	sq.m	35.17	367.67	12,932.24
c	230mm tk brick work in CM 1:6	cu.m	41.59	3,206.20	133,355.75
d	Brick work in CM 1:6 for ramp and steps	cu.m	1.82	3,206.20	5,835.28
5	**RCC Works**				
a	1:2:4 RCC Plinth and Lintel	cu.m	0.20	4,996.44	1,022.77
b	1:2:4 RCC Roof	cu.m	6.08	4,996.44	30,353.37
6	**Slab (Stone/Precast RCC)**				
a	75mm tk slab chamber and hand wash areas	sq.m	3.41	620.00	2,114.20
b	75mm tk cover for leach pit	sq.m	2.75	620.00	1,705.00
c	Cover slab for chamber access	sq.m	6.75	620.00	4,185.00
7	**Plastering**				
a	Plastering of walls in 1:6	sq.m	312.54	92.00	28,753.82
b	Plastering in 1:4 with water proof compound for inner sides of the chambers	sq.m	19.50	105.47	2,056.67
8	**Ceramic tiles**				
a	Flooring	sq.m	64.00	814.16	52,106.24
b	Walls	sq.m	77.10	857.88	66,142.55
c	Ramp	sq.m	11.60	814.16	9,444.26
9	**Weathering course**				
a	Over roof area using brick ballast and lime	cu.m	4.56	1,200.00	5,472.00
10	**Sanitary fixtures**				
a	Ecosan squatting pan	No	12.00	800.00	9,600.00
b	Girls/Ladies urinal squatting pan	No	6.00	400.00	2,400.00
c	Boys/Mens urinal pans with odour trap	No	10.00	500.00	5,000.00
11	**Water and sanitary fittings (inclusive of all materials and labour costs)**				
a	Water pipes (1.25 inch dia GI)	Rm	15.00	250.00	3,750.00
b	Taps	No	13.00	175.00	2,275.00
c	Waste pipes (2 inch dia PVC)	Rm	16.00	125.00	2,000.00
d	Wastewater and urine pipes from toilets (3 inch dia PVC)	Rm	64.00	185.00	11,840.00
e	Vent and rainwater pipes (4 inch dia PVC)	Rm	26.00	260.00	6,760.00
g	Water tank (2000 litres)	No	1.00	9,000.00	9,000.00
h	Urine tank (2000 litres)	No	1.00	9,000.00	9,000.00
12	**Doors**				
a	D1	No	4.00	1,000.00	4,000.00
b	D2	No	6.00	800.00	4,800.00
C	D3	No	4.00	700.00	2,800.00
13	**Ventilator and windows**				
a	V1	No	8.00	300.00	2,400.00
b	V2	No	2.00	250.00	500.00
14	**Incineator**				
	Metal / Masonry incineator	No	1.00	1,500.00	1,500.00
15	**Painting work**				
a	Internal white washing	Sq.m	188.81	20.00	3,776.20
b	External cement painting	Sq.m	123.74	50.00	6,187.00
c	Door and ventilator	Sq.m	17.85	70.00	1,249.50
16	**Hand rails**				
a	MS rods and pipes for ramp	Rm	11.50	500.00	5,750.00
				Total Cost	**537,305.43**
				Total Building Area in sq.m	**60.75**
				Total Cost per sq.m	**8,844.53**



FRONT ELEVATION

SCHOOL ECOSAN TOILET

(320 CAPACITY - 160 BOYS + 160 GIRLS)

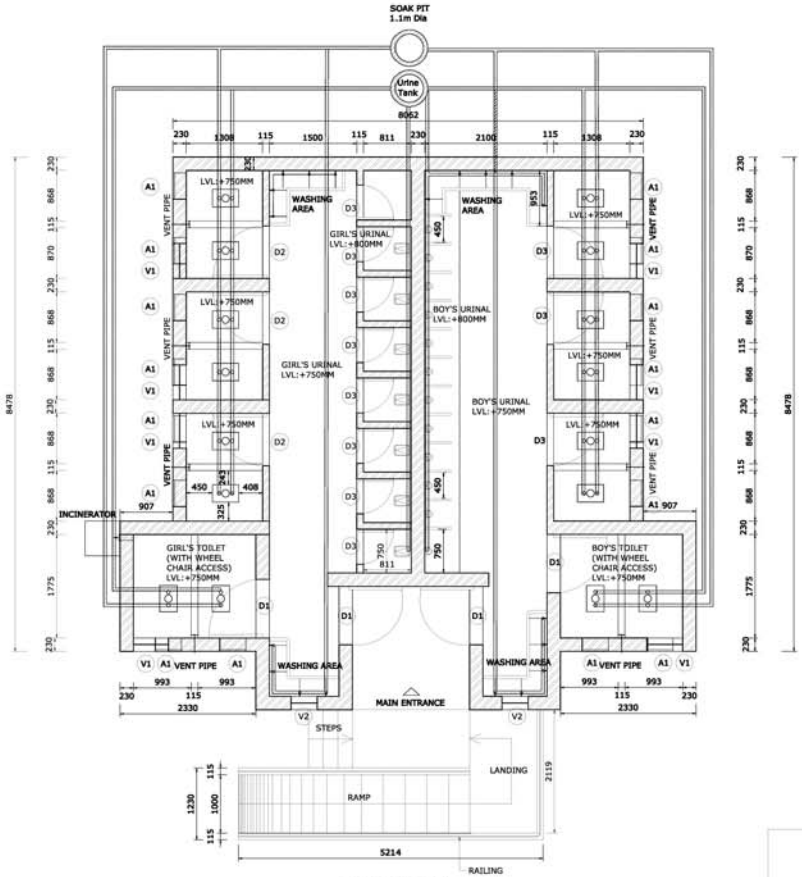
Plumbing and sanitary work :

17. Water pipes and fittings in GI class B pipes/fittings or PVC
18. Vent pipe and cowl of chambers and urine collection and waste pipes using PVC or HDPE
19. Ecosan toilet pans with 3 holes made of fibre/ceramic/in-situ arrangement using cement mortar
20. Ceramic squatting type urinal pans for girls urinals and wall fixing type urinal pans for boys urinals fitted with low-cost odour trap
21. Urine drained out from girls urinal through open drain may be conveyed into urine collection tank through PVC/HDPE pipes min. 50mm dia.

22. Urine collection tank in HDPE/Masonry tank as per local availability
23. Soak pit filled with boulders/brick ballast/sand for disposing anal cleaning water and hand washing water as per soil conditions

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600

ALL DIMENSIONS AND LEVELS ARE IN MM



FLOOR PLAN

SCHOOL ECOSAN TOILET

(320 CAPACITY - 160 BOYS + 160 GIRLS)

Notes :

1. Foundation design is indicative & may need changes as per site conditions
2. 115mm thick walls in 1:4 cement mortar. No reinforcement bars on alternative layers
3. All waterlines including plumbing arrangement for hand washing sink to be fixed open on walls using clips (not to be concealed in walls)
4. The minimum clear dimensions of the toilet units indicated must be maintained even if the walls are altered using other construction materials. However, an increase in the sizes are allowed for ensuring additional comfort
5. At least one incinerator either metallic or masonry type to be provided connecting two girls toilet units
6. Location of urine tank and the soak pit are indicative. Actual location of these units may be decided as per the site conditions
7. Urinal and all the wastewater drainage pipes/drain must have 1:100 slope
8. Urine and anal cleaning wastewater pipes must be secured firmly to the Ecosan squatting pans to avoid leakage into the faeces collection chamber
9. Inspection chambers/elbows with door should be provided for periodic cleaning or snaking of urine and wastewater drainage lines .
10. Urine collection tank must be placed below ground level to allow urine flow by gravity. However, the urine tank's top portion must be at least 150mm above the ground level to prevent entry of rain water.
11. Soak pit should be covered/enclosed to prevent entry of rainfall runoff water
12. Ecosan toilets for children/people with special needs should be provided with special toilet chairs to enable them to use the facility
13. Provision of taps/waterlines to Ecosan toilets should be avoided as a precautionary measure for preventing leakages into faeces collection chambers. Only a bucket and mug must be kept inside the toilets for collecting water for ablution purposes
14. A floor slope of 1:50 for the circulation areas should facilitate draining of water from floors to specially provided outlets. Water spilled on floors should not be allowed to enter the toilet area.

URINE PIPE LINE

WASTE WATER PIPE LINE

ECOSAN SQUATTING PAN

AREA :

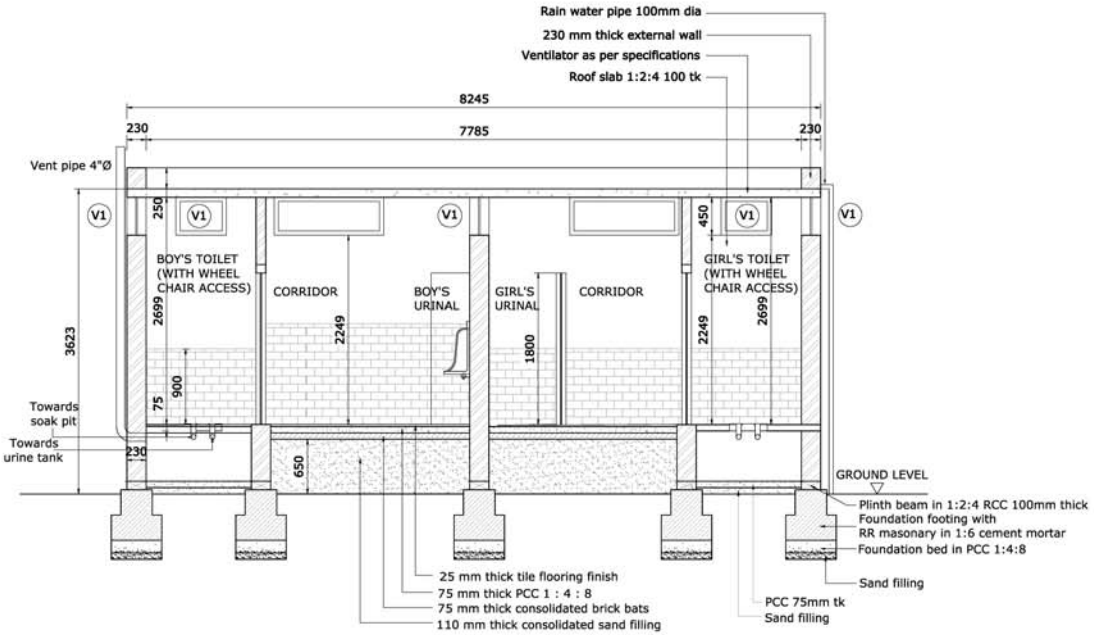
AREA OF THE BUILDING : 77.62 SQ.M

AREA OF THE RAMP : 10.42 SQ.M

TOTAL AREA : 88.04 SQ.M

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600



SECTION

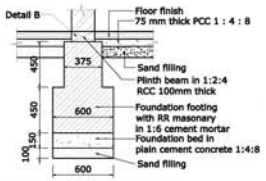
SCHOOL ECOSAN TOILET

(320 CAPACITY - 160 BOYS + 160 GIRLS)

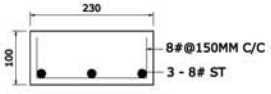
SPECIFICATIONS

CIVIL WORK

1. Foundation of footing bed in 1:4:8 plain cement concrete
2. Foundation of wall footings in RR Masonry with 1:6 cement
3. Plinth band of 75mm thick in 1:2:4 reinforced cement concrete
4. Super structure with brick masonry in cement mortar 1:6 for 230 mm walls and 1:4 for 115 mm walls
5. Plastering in cement mortar 1:6 for walls
6. Plastering in cement mortar 1:4 with water proof compound for inner sides and bottom of faeces collection chamber
7. Glazed tiles up to 0.9m height on inner walls of toilets and girls urinals. Glazed tiles up to 1.2m height on walls fixed with urinal pans in boys urinal.
8. Flooring with anti-skid tiles/cement flooring in toilets, urinals and circulation areas including ramp and steps.
9. Lintels with reinforced cement concrete lintel of 150mm thick over ventilators and toilet & entrance doors
10. Roof with reinforced cement concrete in 1:2:4 of 100mm thick or as per slab spanning
11. Weathering course in lime and brick ballast (1:2) finished with 1:5 cement mortar
12. Water tanks made of masonry or HDPE to be placed on roof or as per suitability
13. Ventilators made up of ready to install prefabricated cement concrete or as per availability
14. Doors of toilets and girls urinals made-up of PVC panel or GI sheets fixed on country wood/angles
15. Hand rail of ramp in GI B-Class 40mm pipes and fittings should be grouted firmly in concrete. Use of appropriate locally available material may be considered wherever necessary
16. Access opening of faeces collection chambers covered with 5mm thick RCC slabs or stone slabs. Fixed in position with 1:12 lean cement mortar for opening it when these are to be emptied



GENERAL FOOTING SECTION DETAIL A



PLINTH BEAM - DETAIL B

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600

Bill of Quantities of School Ecosan Toilet - 320 Capacity

#	Item	Unit	Qty	Rate	Amount
1	**Excavation**				
a	Foundation	cu.m	49.50	140.62	6,960.69
b	Soak pit	cu.m	3.59	140.62	505.15
c	Ramp	cu.m	1.59	140.62	223.59
2	**PCC in 1:4:8**				
a	Foundation	cu.m	6.75	3,330.65	22,481.89
b	Flooring	cu.m	5.82	3,330.65	19,384.38
c	Ramp	cu.m	0.53	3,330.65	1,765.24
3	**Filling**				
a	Foundation	cu.m	10.90	62.15	677.44
b	Sand filling	cu.m	6.14	410.04	2,517.65
c	Consolidated brick bats	cu.m	1.64	700.00	1,148.00
d	Infill in soak pit	cu.m	3.59	350.00	1,257.30
4	**Masonry work**				
a	RR masonry in CM 1:6 for foundation	cu.m	22.05	2,500.90	55,144.85
b	115mm tk brick work in CM 1:4	sq.m	45.47	367.67	16,717.95
c	230mm tk brick work in CM 1:6	cu.m	39.82	3,206.20	127,670.88
d	Brick work in CM 1:6 for ramp and steps	cu.m	2.61	3,206.20	8,368.18
5	**RCC Works**				
a	1:2:4 RCC Plinth and Lintel	cu.m	0.18	4,996.44	919.34
b	1:2:4 RCC Roof	cu.m	7.76	4,996.44	38,787.36
6	**Slab (Stone/Precast RCC)**				
a	75mm tk slab chamber and hand wash areas	sq.m	25.11	620.00	15,568.20
b	75mm tk cover for leach pit	sq.m	2.75	620.00	1,705.00
c	Cover slab for chamber access	sq.m	9.00	620.00	5,580.00
7	**Plastering**				
a	Plastering of walls in 1:6	sq.m	354.27	92.00	32,592.84
b	Plastering in 1:4 with water proof compound for inner sides of the chambers	sq.m	20.36	105.47	2,147.37
8	**Ceramic tiles**				
a	Flooring	sq.m	77.60	814.16	63,178.82
b	Walls	sq.m	98.37	857.88	84,389.66
c	Ramp	sq.m	11.40	814.16	9,281.42
9	**Weathering course**				
a	Over roof area using brick ballast and lime	cu.m	5.82	1,200.00	6,984.00
10	**Sanitary fixtures**				
a	Ecosan squatting pan	No	16.00	800.00	12,800.00
b	Girls/Ladies urinal squatting pan	No	8.00	400.00	3,200.00
c	Boys/Mens urinal pans with odour trap	No	12.00	500.00	6,000.00
11	**Water and sanitary fittings (inclusive of all materials and labour costs)**				
a	Water pipes (1.25 inch dia GI)	Rm	25.00	250.00	6,250.00
b	Taps	No	19.00	175.00	3,325.00
c	Waste pipes (2 inch dia PVC)	Rm	25.00	125.00	3,125.00
d	Wastewater and urine pipes from toilets (3 inch dia PVC)	Rm	90.00	185.00	16,650.00
e	Vent and rainwater pipes (4 inch dia PVC)	Rm	45.00	260.00	11,700.00
f	Water tank (2000 litres)	No	1.00	9,000.00	9,000.00
g	Urine tank (2000 litres)	No	1.00	9,000.00	9,000.00
12	**Doors**				
a	D1	No	4.00	1,000.00	4,000.00
b	D2	No	8.00	800.00	6,400.00
C	D3	No	6.00	700.00	4,200.00
13	**Ventilator and windows**				
a	V1	No	8.00	300.00	2,400.00
b	V2	No	2.00	250.00	500.00
14	**Incineator**				
	Metal / Masonry incineator	No	2.00	1,500.00	3,000.00
15	**Painting work**				
a	Internal white washing	Sq.m	214.89	20.00	4,297.80
b	External cement painting	Sq.m	139.38	50.00	6,969.00
c	Door and ventilator	Sq.m	35.54	70.00	2,487.80
16	**Hand rails**				
a	MS rods and pipes for ramp	Rm	11.50	500.00	5,750.00

Total Cost	**647,011.80**
Total Building Area in sq.m	**77.62**
Total Cost per sq.m	**8,335.63**

4.8 Community Ecosan Toilets

Ecosan toilets can also be constructed at community level in densely populated areas where space for promoting household ecosan toilets is a constraint. Either a large scale community ecosan toilet complex or a decentralised row type ecosan toilet unit can be promoted in such scenarios. Row type units have an advantage as these can be easily maintained by few families (3 – 4 numbers) who would use the toilet. A large community complex would require a very systematic maintenance routine.

Community ecosan toilet complex also must be made accessible to people with special needs. Therefore, provisions like ramp and toilets which can accommodate wheel chair must be provided. Other provisions like incinerator in women's toilet can be provided.

A community ecosan toilet complex for a village with a population of 500 has been considered in this section. A row ecosan toilet with four toilet units has been designed for the use by 12 families (i.e. one toilet for three families) with a total of 50 members.

4.8.1 Design Considerations

i) Capacity

- Community Complex - One ecosan toilet for 20 persons.
- Row Toilets - One ecosan toilet for 3 families

ii) Volume of Chamber

- For designing the storage volume of faeces collection chamber, an ultimate volume of desiccated faeces and additive mixture of 0.20 to 0.30 litres per person per day can be considered depending upon the local condition and usage pattern.

iii) Type of Chambers

- A twin chamber ecosan toilet is most ideal which requires very minimal maintenance compared to others.
- Single chamber ecosan toilets will be difficult to maintain in a community set-up.

iv) Retention Period

- A minimum retention period of 10 months for pathogen inactivation of faeces and additive mixture in the faeces collection chamber must be considered in the design.
- Urine can be collected in a tank of 500-2000 litres capacity can be installed based on the number of users. Provision should be made for transporting urine for agricultural applications.

v) Floor Space and Level

- In a large community ecosan complex, at least one ecosan toilet for people with special needs with a minimum size of 1750 mm x 2100 mm should be provided separately in toilet units meant for men and women.
- Specially designed chairs with washing arrangements and strong handles for offering support to children with special needs must be provided in ecosan toilets designated for their use.
- Other ecosan toilets with two chambers must be at least 1,200 mm x 1,500 mm in size.
- The lower level of the faeces collection

chambers of ecosan toilets should be above the high flood level expected in low lying and flood prone areas.

vi) Ramp and Railing

- An ideal slope of 1:18 or a minimum of 1:12 with a minimum width of 1000 mm must be maintained for access by wheel chair users independently.
- The length of railing should be extended beyond 300 mm from the sloped ends of the ramp.
- Antiskid tiles must be used for flooring of ramp.

vii) Incinerator

- In a community ecosan toilet complex, at least one of the toilets must be connected to the incinerator through an access chute for disposal of sanitary napkins.
- Provision of incinerator is also desirable in row toilets.

viii)Construction Materials

- An ecosan toilet is designed with a leak proof faeces and urine collection chambers / tanks and super structure with pans / arrangements that help in source separation of faeces, urine and wash water.
- Bricks, hollow blocks or stone / mud blocks should be used for walls of schools ecosan toilets to provide a robust and safe construction which will lasts for several years.

4.8.2 Design, Drawings and Estimates

Design details	Community Ecosan Toilet Complex	Row Ecosan Toilets
No. of users	500	50 users (12 families)
Average volume of desiccated material	0.25 litres/person/day	0.25 litres/person/day
Retention period	300 days	300 days
Type of ecosan toilet provided	Each ecosan toilet with 2 chambers	Each ecosan toilet with 2 chambers
Size of faeces collection chambers • Volume of chambers needed considering 15% usage of toilets • Total volume of chambers provided	= 500 x 300 days x 0.25 l/p/d = 37500 litres Providing 18 toilets with chambers of 1.8 m length x 0.87 m width x 1.50 m height = 18 x 1.80 m x 0.87 m x 1.50 m x 1,000 litres = 42,282 litres	= 50 x 300 days x 0.25 l/p/d = 3750 litres Providing 4 toilets with chambers of 1.31 m length x 0.87 m width x 0.90 m height = 4 x 1.31 m x 0.87 m x 0.90 m x 1,000 litres = 4,102 litres
Size of chamber access hole	500 mm wide x 750 mm high	450 mm wide x 500 mm high
Size of urine collection tank	2,000 litre capacity tank	500 litre capacity tank
Vent pipe	• 100 mm dia connecting both tanks • 500 mm above roof level • Cowl on top	• 100 mm dia connecting both tanks • 500 mm above roof level • Cowl on top
Toilet size (floor area)	CWSN: 2.1 m length x 1.75 m width Normal: 1.85 m length x 1.3 m width	1.85 m length x 1.3 m width
Soak pit for waste water disposal	1.10 m dia and 1.50 m deep	1.0 m dia and 1.00 m deep
Floor and wall tiles	Upto 0.90 m height on all walls. Floor tiles on entire floor area and ramp.	Only cement finish
Door	Toilets of PWSN: 1.00 m x 2.1 m Other Toilets: 0.90 x 2.1 m	0.90 m x 2.1 m
Roof	RCC roof over toilet and urinal areas	RCC roof over toilet and urinal areas
Super structure	Walls with bricks (230 mm thick for all outer and main load bearing walls and chambers, and 115 mm thick for interior walls)	Walls with bricks (230 mm thick for all outer and main load bearing walls and chambers, and 115 mm thick for interior walls)

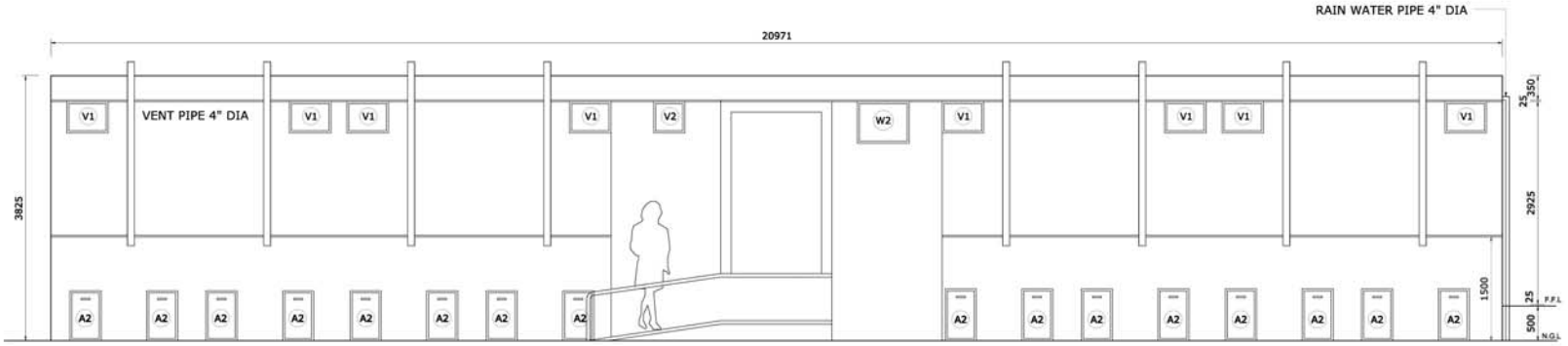
4.8.3 Cost Estimate

In the design of community ecosan toilet complex, features like ramp and one ecosan toilet for people with special needs exclusively in men's and women's toilet units, hand washing facility, raised basement for free access, RCC roof cover and ceramic tiling on walls and floors for easy maintenance have been considered.

In the row ecosan toilet, features like standard

finish with RCC roof, urine diverting pan, urine collection tank and wide steps for accessing the toilets are provided. Where necessary, these units also can be made friendly to people with special needs by incorporating a ramp and specially designed ecosan toilet chair.

The cost of community ecosan toilet unit (capacity 500 persons) and the row ecosan toilet unit (capacity 50 persons) works out to Rs 10,57,322 and Rs 1,43,464 respectively. The detailed design, drawings and estimates of community ecosan toilet & community row ecosan toilet are provided in page numbers 85 - 92.



FRONT ELEVATION

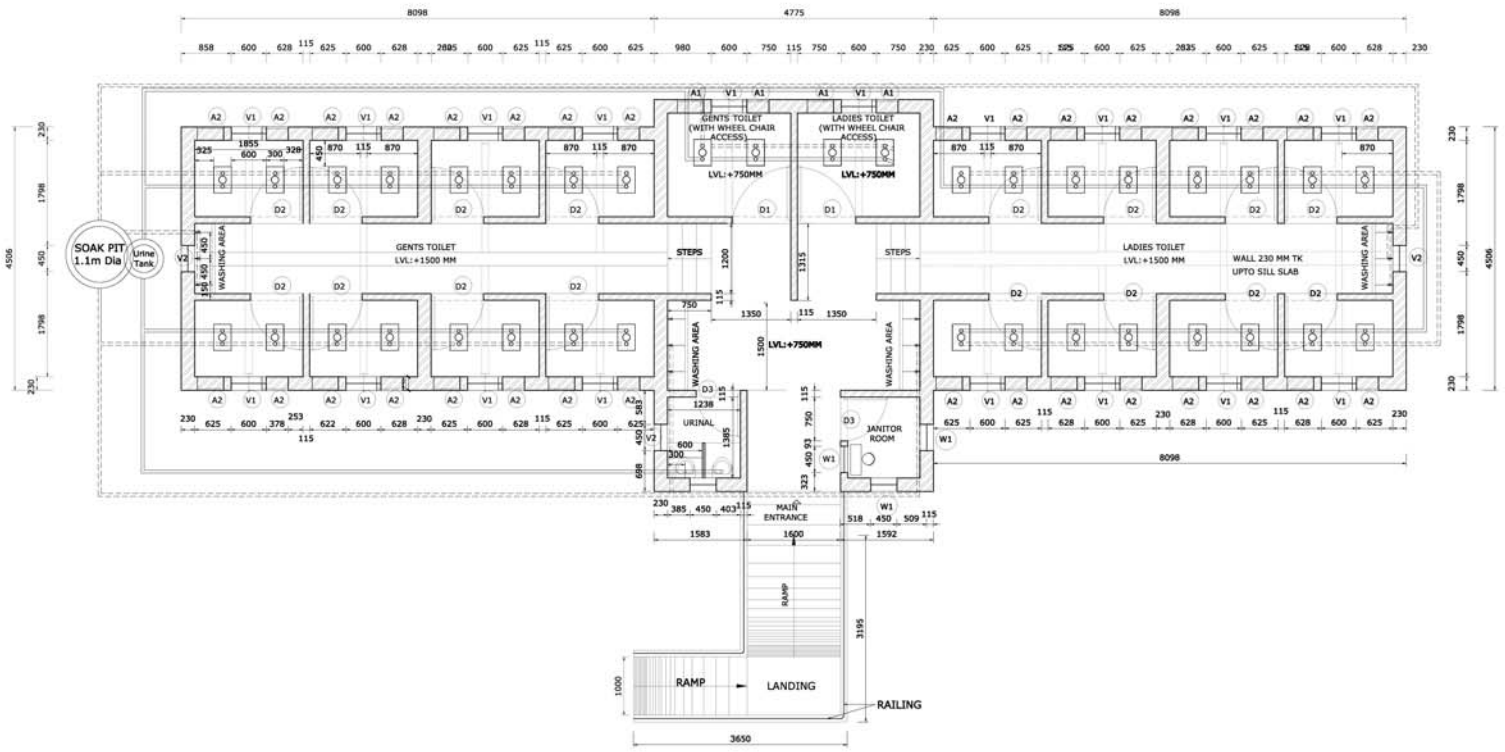
COMMUNITY ECOSAN TOILET COMPLEX

Plumbing and sanitary work :

17. Water pipes and fittings in GI class B pipes/fittings or PVC
18. Vent pipe and cowl of chambers and urine collection and waste pipes using PVC or HDPE
19. Ecosan toilet pans with 3 holes made of fibre/ceramic/in-situ arrangement using cement mortar
20. Wall fixing type urinal pans for men's urinal fitted with low-cost odour trap
21. Urine collection tank in HDPE/Masonry tank as per local availability
22. Soak pit filled with boulders/brick ballast/sand for disposing anal cleaning and hand washing water as per soil conditions

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A2-	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600



FLOOR PLAN

COMMUNITY ECOSAN TOILET COMPLEX

Notes :

1. Foundation design is indicative & may need changes as per site conditions
2. 115mm thick walls in 1:4 cement mortar. No reinforcement bars on alternative layers
3. All waterlines including plumbing arrangement for hand washing sink to be fixed open on walls using clips (not to be concealed in walls)
4. The minimum clear dimensions of the toilet units indicated must be maintained even if the walls are altered using other construction materials. However, an increase in the sizes are allowed for ensuring additional comfort
5. At least one incinerator either metallic or masonry type to be provided connecting two women's toilet units
6. Location of urine tank and the soak pit are indicative. Actual location of these units may be decided as per the site conditions
7. Urinal and all the wastewater drainage pipes/drain must have 1:100 slope
8. Urine and anal cleaning wastewater pipes must be secured firmly to the Ecosan squatting pans to avoid leakage into the faeces collection chamber
9. Inspection chambers/elbows with door should be provided for periodic cleaning or snaking of urine and wastewater drainage lines
10. Urine collection tank must be placed below ground level to allow urine flow by gravity. However, the urine tank's top portion must be at least 150mm above the ground level to prevent entry of rain water
11. Soak pit should be covered/enclosed to prevent entry of rainfall runoff water
12. Ecosan toilets for children/people with special needs should be provided with special toilet chairs to enable them to use the facility
13. Provision of taps/waterlines to Ecosan toilets should be avoided as a precautionary measure for preventing leakages into faeces collection chambers. Only a bucket and mug must be kept inside the toilets for collecting water for ablution purposes
14. A floor slope of 1:50 for the circulation areas should facilitate draining of water from floors to specially provided outlets. Water spilled on floors should not be allowed to enter the toilet area.

URINE PIPE LINE

WASTE WATER PIPE LINE

ECOSAN SQUATTING PAN

AREA :

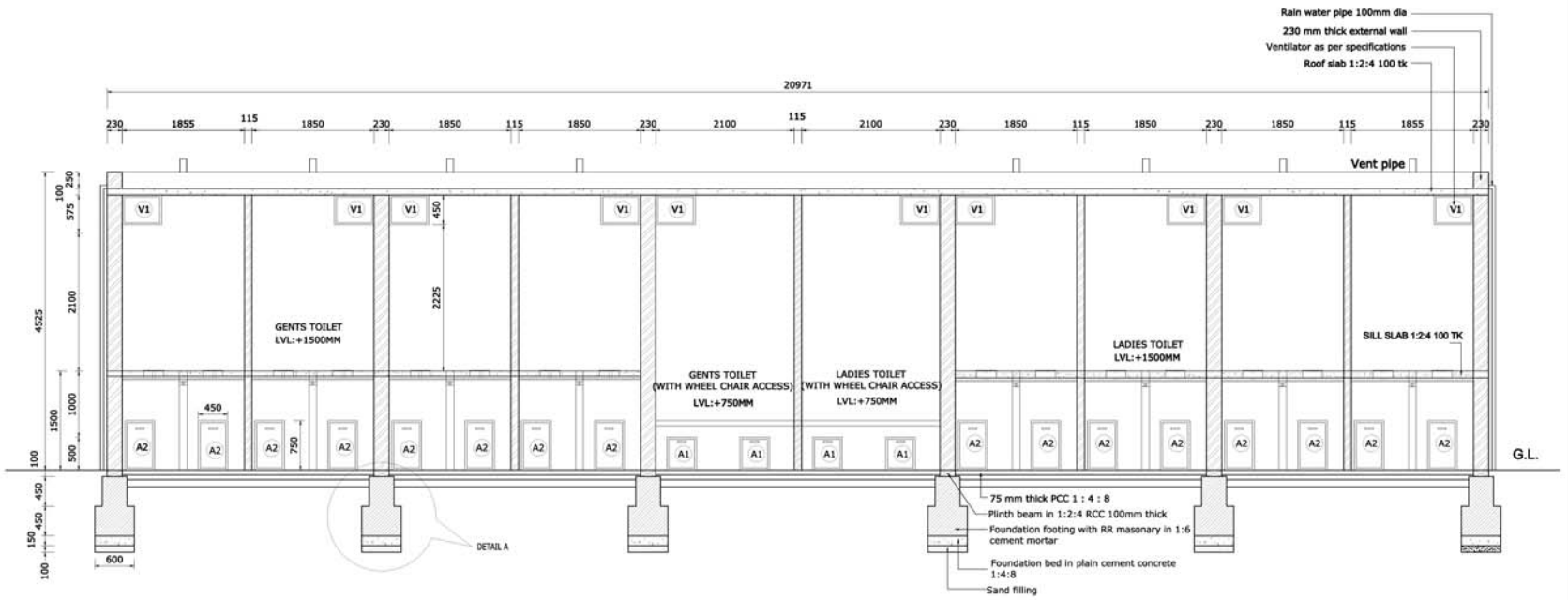
AREA OF THE BUILDING : 104.99 SQ.M

AREA OF THE RAMP : 9.47 SQ.M

TOTAL AREA : 114.46 SQ.M

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1-	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600



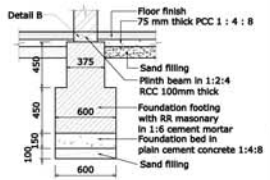
SECTION

COMMUNITY ECOSAN TOILET COMPLEX

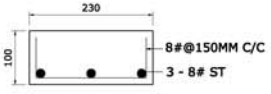
SPECIFICATIONS

CIVIL WORK

1. Foundation of footing bed in 1:4:8 plain cement concrete
2. Foundation of wall footings in rr masonry with 1:6 cement mortar
3. Plinth band of 75mm thick in 1:2:4 reinforced cement concrete
4. Super structure with brick masonry in cement mortar 1:6 for 230 mm walls and 1:4 for 115 mm walls
5. Plastering in cement mortar 1:6 for walls
6. Plastering in cement mortar 1:4 with water proof compound for inner sides and bottom of faeces collection chamber
7. Glazed tiles up to 0.9m height on inner walls of toilets.Glazed tiles up to 1.2m height on walls fixed with urinal pans men's urinal.
8. Flooring with anti-skid tiles/cement flooring in toilets,urinals and circulation areas including ramp and steps.
9. Lintels with reinforced cement concrete lintel of 150mm thick over ventilators and toilet & entrance doors
10. Roof with reinforced cement concrete in 1:2:4 of 100mm thick or as per slab spanning
11. Weathering course in lime and brick ballast (1:2) finished with 1:5 cement mortar
12. Water tanks made of masonry or hdpe to be placed on roof or as per uitability
13. Ventilators made up of ready to install prefabricated cement concrete or as per availability
14. Doors of toilets made-up of PVC panel or GI sheets fixed on countrywood/angles
15. Hand rail of ramp in GI b-class 40mm pipes and fittings should be grouted firmly in concrete.
    Use of appropriate locally available material may be considered wherever necessary
16. Access opening of faeces collection chambers covered with 5mm thick RCC slabs or stone slabs.
    Fixed in position with 1:12 lean cement mortar for opening it when these are to be emptied.



GENERAL FOOTING SECTION DETAIL A



PLINTH BEAM - DETAIL B

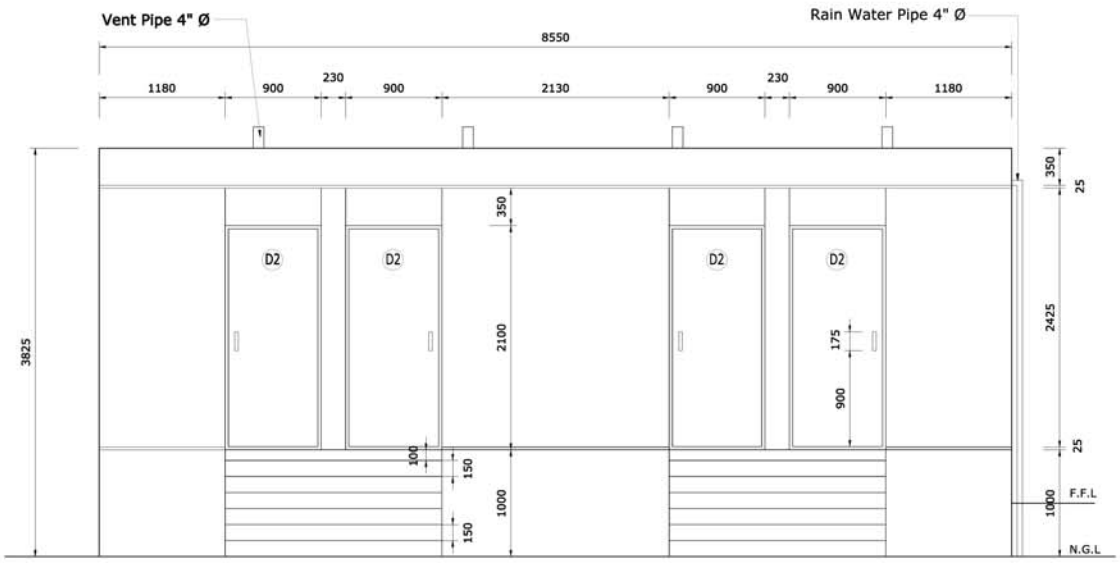
ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS

NAME	SIZES W x H
A1-	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600

Bill of Quantities of Community Ecosan Toilet Complex

#	Item	Unit	Qty	Rate	Amount
1	**Excavation**				
a	Foundation	cu.m	50.23	140.62	7,062.78
b	Soak pit	cu.m	3.59	140.62	505.15
c	Ramp	cu.m	2.21	140.62	310.49
2	**PCC in 1:4:8**				
a	Foundation	cu.m	6.85	3,330.65	22,811.62
b	Flooring	cu.m	6.42	3,330.65	21,382.77
c	Ramp	cu.m	1.54	3,330.65	5,129.20
3	**Filling**				
a	Foundation	cu.m	26.00	62.15	1,615.90
b	Sand filling	cu.m	8.51	410.04	3,489.44
c	Consolidated brick bats	cu.m	6.80	112.81	767.11
d	Infill in soak pit	cu.m	3.59	112.81	404.99
4	**Masonry work**				
a	RR masonry in CM 1:6 for foundation	cu.m	33.39	2,500.90	83,505.05
b	115mm tk brick work in CM 1:4	sq.m	204.42	367.67	75,159.10
c	230mm tk brick work in CM 1:6	cu.m	76.81	3,206.20	246,268.22
d	Brick work in CM 1:6 for ramp and steps	cu.m	0.88	3,206.20	2,821.46
5	**RCC Works**				
a	1:2:4 RCC Plinth band	cu.m	1.75	4,569.06	7,997.23
b	1:2:4 RCC Lintel band (all type)	cu.m	0.55	4,996.44	2,758.03
c	1:2:4 RCC for sill slab	cu.m	6.94	4,996.44	34,675.29
d	1:2:4 RCC for roof slab	cu.m	9.66	4,996.44	48,265.61
6	**Slab (Stone/Precast RCC)**				
a	75mm tk slab under hand wash areas (all)	sq.m	1.05	620.00	651.00
b	75mm tk cover for leach pit	sq.m	2.75	620.00	1,705.00
c	Cover slab for chamber access	sq.m	20.25	620.00	12,555.00
7	**Plastering**				
a	Plastering of walls in 1:6	sq.m	786.00	105.47	82,899.42
b	Plastering in 1:4 with water proof compound for inner sides of the chambers	sq.m	166.73	105.47	17,585.01
8	**Ceramic tiles**				
a	Flooring	sq.m	78.42	814.16	63,846.43
b	Walls	sq.m	142.41	857.88	122,170.69
c	Ramp	sq.m	8.00	814.16	6,513.28
9	**Weathering course**				
a	Over roof area using brick ballast and lime	cu.m	7.25	1,200.00	8,700.00
10	**Sanitary fixtures**				
a	Ecosan squatting pan	No	36.00	800.00	28,800.00
b	Girls/Ladies urinal squatting pan	No	8.00	400.00	3,200.00
c	Boys/Mens urinal pans with odour trap	No	8.00	500.00	4,000.00
11	**Water and sanitary fittings (inclusive of all materials and labour costs)**				
a	Water pipes (1.25 inch dia GI)	Rm	35.00	250.00	8,750.00
b	Taps	No	12.00	175.00	2,100.00
c	Waste pipes (2 inch dia PVC)	Rm	35.00	125.00	4,375.00
d	Wastewater and urine pipes from toilets (3 inch dia PVC)	Rm	120.00	185.00	22,200.00
e	Vent and rainwater pipes (4 inch dia PVC)	Rm	78.00	260.00	20,280.00
f	Water tank (2000 litres)	No	1.00	9,000.00	9,000.00
g	Urine tank (2000 litres)	No	1.00	9,000.00	9,000.00
12	**Doors**				
a	D1	No	2.00	1,000.00	2,000.00
b	D2	No	16.00	800.00	12,800.00
c	D3	No	2.00	700.00	1,400.00
13	**Ventilator and windows**				
a	V1	No	18.00	300.00	5,400.00
b	V2	No	3.00	250.00	750.00
c	W1	No	3.00	750.00	2,250.00
14	**Incineator**				
a	Metal / Masonry incineator	No	4.00	1,500.00	6,000.00
15	**Painting work**				
a	Internal white washing	Sq.m	597.00	20.00	11,940.00
b	External cement painting	Sq.m	219.00	50.00	10,950.00
c	Door and ventilator	Sq.m	64.39	70	4,507.13
16	**Hand rails**				
a	MS rods and pipes for ramp	Rm	12.13	500.00	6,065.00
				Total Cost	**10,57,322.40**
				Total Area in sq.m	**10,4.99.00**
				Total Cost per sq.m	**10,070.70**



FRONT ELEVATION

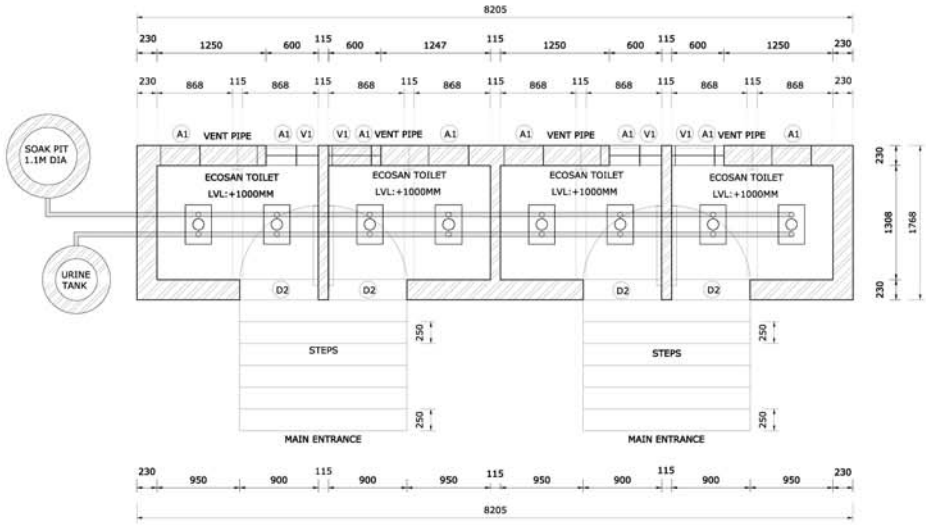
COMMUNITY ROW ECOSAN TOILET

Plumbing and sanitary work :

13. Vent pipe and cowl of chambers and urine collection and waste pipes using PVC or HDPE 100mm dia.
14. Ecosan toilet pans with 3 holes made of fibre/ceramic/in-situ arrangement using cement mortar
15. Urine and wash water should be conveyed into urine collection tank through PVC/HDPE pipes min. 40mm dia.
16. Urine collection using 15 -20 litre capacity jerry can.
17. Soak pit filled with boulders/brick ballast/sand for disposing anal cleaning water as per soil conditions

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600



FLOOR PLAN

COMMUNITY ROW ECOSAN TOILET

Notes :

1.Foundation design is indicative & may need changes as per site conditions
2.The minimum clear dimensions of the toilet units indicated must be maintained even if the walls are altered using other construction materials. However, an increase in the sizes are allowed for ensuring additional comfort
3.Location of urine tank and the soak pit are indicative.Actual location of these units may be decided as per the site conditions
4.Urinal and all the wastewater drainage pipes/drain must have 1:100 slope
5.Urine and anal cleaning wastewater pipes must be secured firmly to the Ecosan squatting pans to avoid leakage into the faeces collection chamber
6.Soak pit should be covered/enclosed to prevent entry of rainfall runoff water
7.Urine collection tank should be placed above ground and should be secured to the urine drainage pipe to prevent leakage of urine or ammonia
8.Provision of taps/waterlines to Ecosan toilets should be avoided as a precautionary measure for preventing leakages into faeces collection chambers. Only a bucket and mug must be kept inside the toilets for collecting water for ablution purposes

URINE PIPE LINE

WASTE WATER PIPE LINE

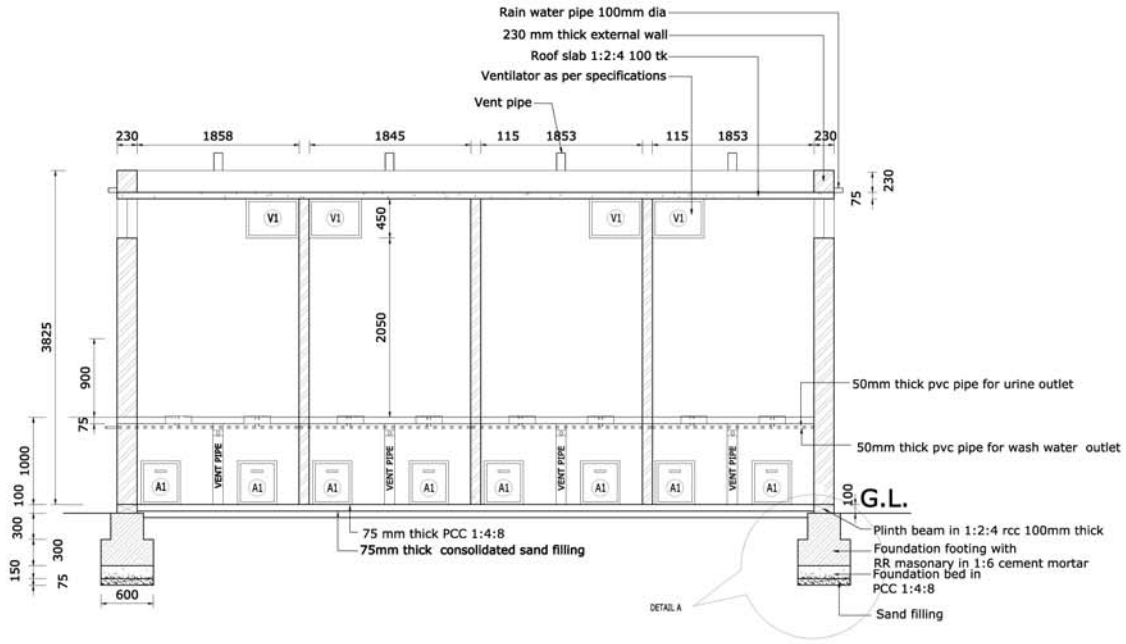
ECOSAN SQUATTING PAN

AREA :

AREA OF THE BUILDING : 14.50 SQ.M

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600



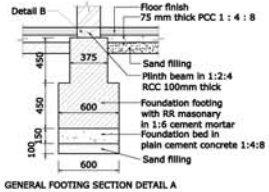
SECTION

COMMUNITY ROW ECOSAN TOILET

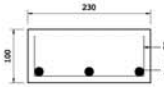
SPECIFICATIONS

CIVIL WORK

1. Foundation of footing bed in 1:4:8 plain cement concrete
2. Foundation of wall footing in rr masonry with 1:6 cement mortar
3. Super structure with brick masonry in cement mortar 1:6 for 230 mm walls and 1:4 for 115 mm walls
4. Plastering in cement mortar 1:6
5. Flooring with 10mm thick cement mortar 1:2 inside the toilet
6. Floor bed for faeces chambers in cement concrete 1:4:8
7. Chamber slabs 75mm thick in rcc 1:2:4
8. Plastering in cement mortar 1:4 with water proof compound for inner sides and bottom of faeces collection chamber
9. Roof of the toilet with 100mm thick rcc slab
10. Ventilators made up of ready to install prefabricated cement concrete or as per availability
11. Doors of toilets made-up of gi/ms sheets fixed on country wood/angles
12. Access opening of faeces collection chambers covered with 5mm thick rcc slabs or stone slabs. Fixed in position with 1:12 lean cement mortar for opening it when these are to be emptied



GENERAL FOOTING SECTION DETAIL A



PLINTH BEAM - DETAIL B

ALL DIMENSIONS AND LEVELS ARE IN MM

SCHEDULE OF OPENINGS	
NAME	SIZES W x H
A1 -	450X500
A2 -	450X750
D1 -	1000X2100
D2-	900X2100
D3 -	750X2100
V1 -	600X450
V2 -	450X450
W1-	600X600

Bill of Quantities of Community Row Ecosan Toilet

#	Item	Unit	Qty	Rate	Amount
1	**Excavation**				
a	Foundation	cu.m	13.20	140.62	1,856.18
b	Soak pit	cu.m	3.59	140.62	505.15
2	**PCC in 1:4:8**				
a	Foundation	cu.m	1.80	3,330.65	5,995.17
b	Flooring	cu.m	0.76	3,330.65	2,530.58
3	**Filling**				
a	Sand filling	cu.m	1.66	410.04	680.67
b	Infill in soak pit	cu.m	3.59	350.00	1,257.30
4	**Masonry work**				
a	RR masonry in CM 1:6 for foundation	cu.m	5.85	2,500.90	14,630.27
b	115mm tk brick work in CM 1:4	sq.m	18.98	367.67	6,978.38
c	230mm tk brick work in CM 1:6	cu.m	14.69	3,206.20	47,099.08
d	Brick work in CM 1:6 for ramp and steps	cu.m	1.31	3,206.20	4,200.12
5	**RCC Works**				
a	1:2:4 RCC Lintel (all type)	cu.m	0.09	4,569.06	411.22
b	1:2:4 RCC for (roof slab)	cu.m	1.45	4,569.06	6,625.14
6	**Slab (Stone/Precast RCC)**				
a	75mm tk slab over chmabers	sq.m	11.98	620.00	7,427.60
b	75mm tk cover for leach pit	sq.m	1.73	620.00	1,071.71
c	Cover slab for chamber access	sq.m	1.80	620.00	1,116.00
7	**Plastering**				
a	Plastering of walls in 1:6	sq.m	125.60	92.00	11,555.20
b	Plastering in 1:4 with water proof compound for inner sides of the chambers	sq.m	40.16	105.47	4,235.68
8	**Cement floor**				
a	Flooring	sq.m	17.97	140.00	2,515.80
9	**Weathering course**				
a	Over roof area using brick ballast and lime	cu.m	1.09	1,200.00	1,308.00
10	**Sanitary fixtures**				
a	Ecosan squatting pan	No	8.00	800.00	6,400.00
11	**Water and sanitary fittings (inclusive of all materials and labour costs)**				
a	Wastewater and urine pipes from toilets (2 inch dia PVC)	Rm	18.00	125.00	2,250.00
b	Urine tank (500 litres)	No	1.00	2,500.00	2,500.00
12	**Doors**				
a	D1	No	4.00	1,000.00	4,000.00
13	**Ventilator and windows**				
a	V1	No	4.00	300.00	1,200.00
14	**Painting work**				
a	Internal white washing	Sq.m	59.00	20.00	1,180.00
b	External cement painting	Sq.m	66.60	50.00	3,330.00
c	Door and ventilator	Sq.m	8.64	70.00	604.80
				Total Cost	**143,464.03**
				Total Building Area in sq.m	**14.50**
				Total Cost per sq.m	**9,894.07**

Chapter 5

Waterless Urinals

5. Waterless Urinals

Waterless urinals look very much like conventional urinals in design and these can be used in the same manner. However, waterless urinals do not consume water for flushing and thus result in saving anything between 56,800 litres to 1, 70,000 litres of water per urinal per year.

On an average, a person urinates about 1.5 litres a day. Urine, which is usually sterile and contains mostly water, does not require additional water for flushing to make it flow into drainage lines. Therefore, installing waterless urinals will reduce the quantity of fresh water used for flushing urine and also substantially reduce the volume of sewage generated.

Waterless urinals reduce cost as they do not require plumbing accessories required for water flush urinals. Importantly, the dry operation of waterless urinals and touch free operations reduces significantly the spread of communicable diseases. Odour trap mechanisms using sealant liquid, microbial control, membrane and curtain valve fitted to waterless urinals assist in preventing odour developed inside the drainage lines connected to urinals. Therefore, installing waterless urinals at homes, institutions and public places can offer several advantages.

However, waterless urinal models developed so far largely caters only to the need of men. Few attempts were made to develop female urinals in the past; however these have not been replicated very widely due to very low levels of

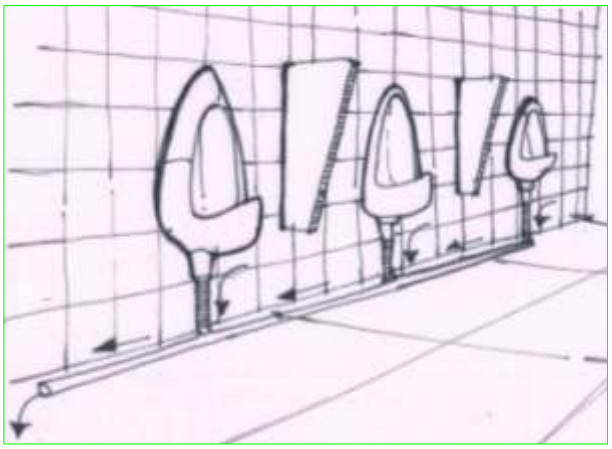


Figure 5.1 Schematic view of waterless urinals installation in a public place

success. Therefore, this section primarily deals with waterless urinal options developed for the use by men's or boys in schools. However, the proposed option for collecting urine from the present urinal design of girl's urinals has been discussed in detail as well.

5.1 Advantages of Waterless Urinals and Reuse of Urine

- Save enormous quantities of freshwater
- Enhance efficiencies of sewer lines and wastewater treatment plants
- Optimize cost of plumbing accessories at supply & consumption ends
- Conserve electricity used for pumping water & treating wastewater
- Replace chemical fertilizers with urine to

grow crops

- Recover fertiliser & other chemicals from urine
- Reduce emission of green house gases and pollution of water bodies

5.2 Disadvantages of Conventional Water Flush Urinals

- Conventional water flush urinals use approximately 4 litres of water for flushing. This figure goes up to 10-15 litres when a toilet pan with flush is used for urinating.
- Water used for flushing urine (liquid human waste is over 95% liquid) increases the volume of sewage generated in cities.
- Odour control in conventional urinals is only achieved by the use of water and deodorising agents.
- Use of hard water for flushing urine leads to scale formation causing blockages in drainage lines.
- Dampness in urinals offers favourable environment for growth of microbes and result in air borne infections.
- Hand operated valves used for flushing conventional urinals may lead to transmission of communicable diseases.
- Valves and plumbing lines used in conventional urinals require frequent maintenance which leads to higher maintenance expenditure.
- Naphthalene and strong acids used for cleaning conventional urinals contaminate waste water generated as some of these are carcinogenic in nature.

5.3 Functioning of Waterless Urinals

Odour associated with urine severely affects the performance of urinals. The enzyme urease present in sewer lines hydrolyses the urea present in urine into ammonia and carbonate. The latter decomposes spontaneously to carbonic acid and a second molecule of ammonia. The overall reaction can be written as follows:

$$NH_2(CO)NH_2 + 2H_2O \rightarrow NH_3 + NH_4^+ + HCO_3^-$$

Flushing with water is employed to control odour in the conventional urinals whereas waterless urinals are provided with odour control mechanisms installed to the urinal seats. Similar to conventional urinals, waterless urinals also require regular cleaning routines based on the number of users. However, waterless urinals can be cleaned using a moist sponge or brush without the use of water.

Precipitation of salts present in urine and other deposits such as hair, dead skin cells and cigarette butts can potentially block urinal drains. Use of hard water for flushing in conventional urinals also aggravates the

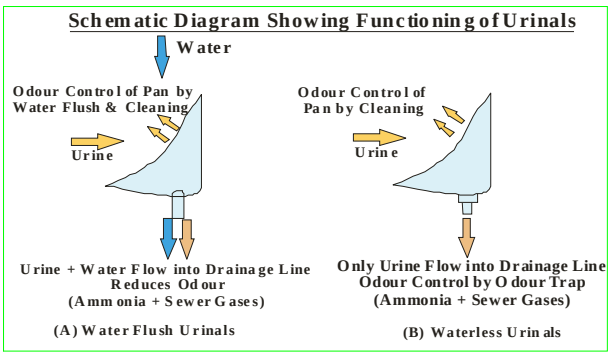


Figure 5.2 Schematic diagram showing functioning of urinals

problem. Both these problems are also eliminated in waterless urinals. Further, installation cost and maintenance cost of waterless urinals is less on account of absence of expensive flushing valves and fittings.

5.4 Odour Traps

Odour trap mechanisms fitted to waterless urinals assist in preventing odour developed inside the drainage lines connected to urinals from entering rest rooms. The first waterless urinal trap using sealant liquid method was patented by Mr Beetz of Austria in 1894, and was commercially exploited by the company F Ernst Engineer in Zurich, Switzerland, who was the sole supplier of waterless urinals worldwide for approximately 100 years. Since then, apart from sealant liquid traps, odour prevention methods using microbial control and membrane / curtain valves have been developed across the globe. The following section describes some of the popular odour prevention traps available in the market in detail.

5.4.1 Sealant Liquid Type Odour Traps

Odour traps using sealant liquids made of vegetable oils or aliphatic alcohols are fitted to urinal bowls to prevent odours from reaching the washroom. As sealant liquids have lower specific gravity than urine, these allow passage of urine but prevent odour emitted by drainage lines. The sealant liquid is contained either within a replaceable or built in cartridges provided to the urinal pans.

Maintenance

- Cartridges need to be replaced or cleaned when precipitates of urine and foreign objects such as cigarette butt get deposited in the trap.
- The sealant liquid also needs refilling as they evaporate and also get washed away owing to the urine flow.

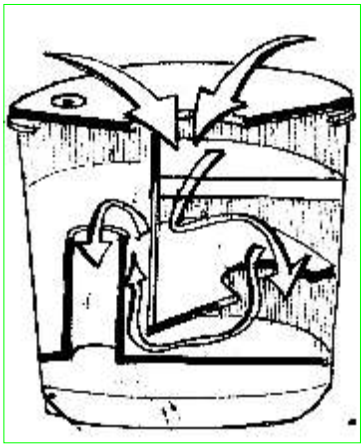


Figure 5.3 Sealant liquid type waterless urinal odour trap (source: waterwisetech.net)

Merits

- Performance of sealant liquid based odour traps has been found to be very good. In countries such as USA, presently, legalisation permits only use of liquid filled traps.

Demerits

- To retrofit an existing conventional urinal into sealant liquid type waterless urinal, the old urinal pans have to be replaced.
- Models of waterless urinals working based on the sealant liquid are expensive than other models.
- Regular replacement of cartridges and refilling of sealant liquid increases the maintenance cost.

Availability

- In India, sealant liquid based waterless urinals are being marketed by companies such as Parryware, Hindware, Falcon and Waterless.

- The cost of a waterless urinal pan with sealant liquid trap ranges from Rs 6,000 to Rs 15,000.

5.4.2 Membrane Type Odour Traps

Membrane based traps use rubber, silicone or LDPE in the shape of tubes is used for controlling odour. The membrane acts as one way valve allowing urine to flow while blocking odour released from drainage lines. The top portion of the tube is fixed to a holder to keep its mouth open. Rest of the portion deforms into a flat tube due to its flexibility and prevents odour when urinal is not in use.

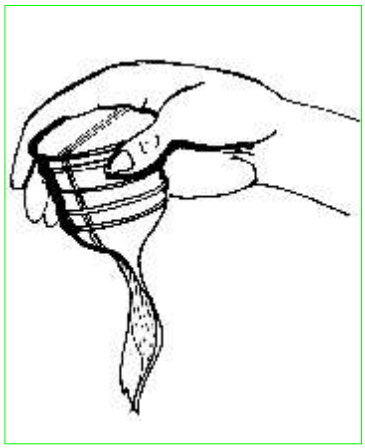


Figure 5.4 Membrane type waterless urinal odour trap (Design: Keramag)

A design variation of membrane-based trap is one in which, silicone tubes having their bottom portion split into two curtains have been introduced to reduce the requirement of frequent maintenance and to enable ease of cleaning. Urine with grit up to 2 mm is allowed to pass through.

Maintenance

- Precipitates of urine and foreign materials deposited in inner surface of the membranes need to be cleaned regularly.
- The cleaning frequency depends directly on the number of uses per day.
- Membranes need to be replaced between three months to six months depending on quantum of usage.

Merits

- Performance of membrane based odour traps has been found to be very good. Membranes made of rubber manufactured by Keramag and silicone curtain valves manufactured by Addicom are being widely used in Europe and other foreign countries.

Demerits

- To retrofit an existing conventional urinal into rubber membrane type waterless urinal, the old urinal pans have to be replaced. However, silicone curtain valves can be fitted to existing urinal pans.
- Models of waterless urinals working based on the membrane traps are expensive than other models.
- Regular replacement of membrane traps increases the maintenance cost.

Availability

- Membranes traps manufactured by Keramag and Addicom have to be imported.
- In India, a low-cost variant is being manufactured by Shital Ceramics, Gujarat. The trap costing Rs 100 is suitable for low-end urinal pans which costs around Rs 300-500. The trap fits below the low-cost urinal basins from the bottom and the drain pipes can be fixed to the trap for drainage.

5.4.3 Biological Blocks for Odour Control

Biological blocks used for making urinals into waterless contain a number of active ingredients, including microbial spores and surfactants. These blocks are placed either in the urinal pans or housed within a dome inserted into the urinal waste outlet to gain contact with the urine flow.

Figure 5.5 Biological blocks placed in urinals for odour control

Upon interaction of urine with the block, the spores become active 'good' bacteria that 'feed' upon the urine and then multiply. By breaking down the urine into components, the build-up of sludge and crystals which cause blockages are prevented. They also generate an environment hostile to odour causing bacteria. A busy urinal seat requires replacement of blocks which cost Rs 20 each at an interval of 2-3 days.

Maintenance

- Apart from regular cleaning of urinal pans, there is no maintenance required for water urinals functioning using biological blocks.
- Biological blocks need to be replaced approximately 2-3 days based on the usage.

Merits

- Biological blocks are found to be effective in making urinals water free. In India, few corporate offices and malls have started using Biological blocks.
- Any existing conventional urinal can be converted into a waterless urinal by providing biological blocks to urinal pans.

Demerits

- Regular use of biological blocks increases the maintenance cost.

Availability

- Biological blocks are being marketed by several suppliers in India.
- At present, the biological blocks are priced around Rs 20 per block.

5.4.4 Comparison of Popular Odour Traps in the Market

Description	Membrane Traps	Sealant Liquid	Biological Blocks
Odour Control	Good	Good	Good
Cost of the system	Trap can be fitted to existing urinal pans costing around Rs 500 - 1750. Cost of a trap is Rs 1200 (Silicone Curtain Valve of Addicom).	New Urinal Pan with cartridge has to be procured. A single urinal costs Rs 6,500 - 14,000	Any urinal can be made waterless using bio-blocks. A bio-block costs Rs 20 (Lasts for 2-3 days depending on no. of users)
Retrofitting of Existing Urinals	Traps can be fitted to existing urinals	New sealant liquid based urinal pans to be installed	Bio-blocks can be placed in existing urinal pans
Replacement of Parts	Membrane needs to be replaced once in a year.	Sealant Liquid (approx. 1000 uses) & cartridge replacement (approx. once in a year).	Bio-blocks need to be replaced once 2-3 days based on usage.
Clogging Frequency	High (Silcone curtain valves require low maintenance)	Medium	Low
Maintenance of Pan & Trap	High	Medium	Low (only pan)
Flow of Particles through Trap	< 2 mm size particles	Particles accumulate in trap cartridge	Same as in normal urinals
Dependence on Suppliers	Supply of membranes	Supply of cartridge and sealant liquid	Supply of bio-blocks

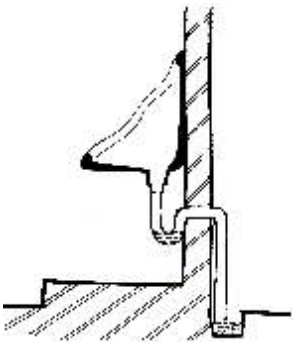
5.4.5 Other Type of Odour Traps

Air enclosing trap using an adsorbing membrane sheath and a spring controlled tray to facilitate passage of urine by gravity has been introduced by Sunming in India recently. The model does not require replacement of cartridge.

An odour trap Zerodor which does not require replaceable parts or consumables resulting in low maintenance costs has been developed at IIT Delhi. This model is in final test stage yet to be made commercially available.

Other than the commercially available odour traps, few simple and low-cost techniques are being utilised to create waterless urinals.

- A U-bend can be fitted to the urinal drainage pipe below the urinal seats to retain some quantity of urine to prevent entry of odour from the plumbing lines or storage tank. However regular cleaning of the U-bend may be necessary to remove scales formed due to precipitates.
- The drainage pipes transferring urine to collection tanks from urinals can be extended up to the bottom of collection tanks so that the stored urine in the tank itself acts as liquid seal.
- Pouring some quantity of oil in the collection tank also helps to create a seal over the collected urine to prevent odour. This method is suitable only for small collection tanks like jerry can.



Installation of U bends in the pipe line

Use of surgical gloves or rubber tubes below the urinal pans

Extending the urine collection pipes into the floor of the urine collection tank or by pouring oil in it

Figure 5.6 Simple low-cost methods for making waterless urinals

- Flexible rubber tubes, surgical gloves or condoms with a small hole at their closed end can also be fixed to urinal pans with suitable plumbing arrangement to act as odour traps.

5.5 Design Considerations and Installation Procedures

5.5.1 Design Considerations

- The standard design considerations used for conventional urinals apply to waterless urinal installations in public urinals for men and school toilets for boys.

- Platform below the urinal cubicle of 600 mm wide must be raised by at least 100 mm with a slope of 1:100 towards the wall to avoid flow of urine spilling due to carelessness of the users.

- Provision for separate scour / drain vents for

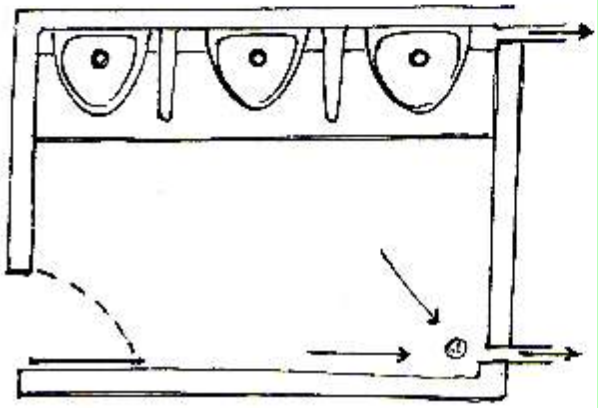


Figure 5.7 Layout of a urinal having separate urine and floor drainage provisions

Description	Boys urinals	Men's urinals
No. of urinals	1 for every 20 users	1 for every 20 users
Width of urinal cubicle	450 - 600 mm (adult's require a space of 600 mm Hence one urinal width may be kept as 600 mm for use by teachers)	600 mm
Depth of urinal cubicle	600 mm	600 mm
Height of urinal lip from the floor level	450 - 500 mm	600 mm
Height of separators between urinal cubicles (side walls or panels / slabs)	1,200 mm	1,200 mm

draining the wash water used for cleaning the floor of the platform and passage areas of the urinals must be provided. This should not be clubbed with main urinal pipes carrying urine. This should be drained into to a soak pit or a plant bed.

- Walls of the urinals should not be porous as porous walls might absorb urine spilling outside the urinal pan. Glazed tiles or enamel painting up to the top level of urinal seats must be provided from the floor level.

5.5.2 Odour Traps

- An appropriate type of waterless urinal odour trap can be chosen based on the location, investment, maintenance costs and the availability of spares.

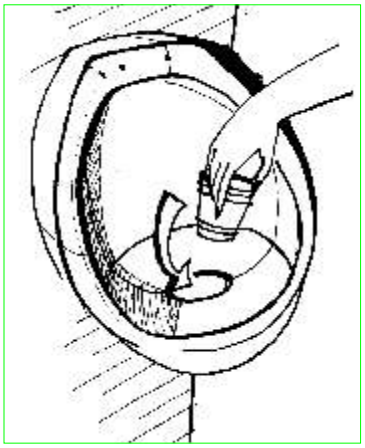


Figure 5.8 Follow regular maintenance routines of waterless urinal odour traps as instructed by the manufacturers

- Maintenance instructions of the manufacturer should be properly followed for proper functioning of the odour traps.

- Cleaning staff must wear gloves and face masks while attending maintenance works.

- Users of urinal must be educated to avoid spitting, throwing of cigarette butts and chewing gum in the urinal pans.

5.5.3 Drainage Pipes and Fittings

- There should not be any sharp 90° bends in the urine drainage pipes to prevent accumulation of deposits.

- Pipes carrying urine should be at least 2 inch in diameter (except the connector lines below the urinal pans) and they must be laid with a slope of at least 1:100.

- Connector pipes from urinals seats must be secured well to the main urine drainage pipes to prevent odour emission.

- Non-corrosive pipes like polyethylene (PE) or polyvinyl chloride (PVC) Pipes can be used for carrying urine.

- Length of urine drainage pipes should be kept short to prevent clogging. This can be achieved by providing inspection chambers at regular intervals.

- As far as possible, the urine drainage pipes should not be concealed within the walls or below the floors as they may have to be replaced after some years.

- Vent pipes should not be provided to urine drainage pipes to prevent loss of nitrogen in the form of ammonia gas. If necessary, a one

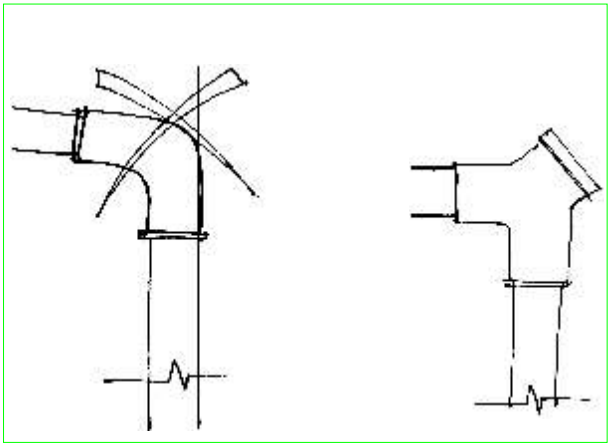


Figure 5.9 Providing bends in the urine collection pipes

Capacity of Tank (litres) = No. of Users x Volume of Urine (litres / day) x Storage Period (days)

Where,
No. of Users = No. of users expected to use the facility per day
Volume of Urine = Usually 1.5 litres per person per day must be taken. For day schools about 0.5 litre per student can be adopted.
Storage Period = It depends on the emptying frequency desired. A minimum of 15 days can be taken for ease of operations.

Note: It is advisable to install more than one tank totaling the total capacity of tank calculated in view of maintenance requirements that may arise periodically

way air admittance valve can be provided to equalize gas pressure in the pipeline.

5.5.4 Storage of Urine and Pumping

- Storage tanks made of plastic materials, inflatable rubber and high quality masonry can be used when reuse of urine is intended. These can be over ground or below ground, but adequate precautions for structural safety must be followed. The following relation can be used to calculate the capacity of storage tank required.
- The inlet pipe to the urine storage tank should be extended up to floor level to prevent turbulence in the tank.
- A one way air admittance valve to equalise gas pressure can be provided in large tanks. Instead cover of the urine tank can also be kept slightly loose or a very thin vent pipe can be fixed to the storage tanks on top for this purpose.
- Use of gloves and face mask is a must for inspection and urine emptying routines.
- Storage tanks should be located in safe locations to prevent any untoward incidents.
- Urine can be emptied either manually or pumped out using pumps from collection tanks.
- For large storage tanks where electric pumps are installed, it is advisable to use non-corrosive pumps which can handle some amount of sludge load.
- For small storage tanks, very small submersible pumps with plastic impellers

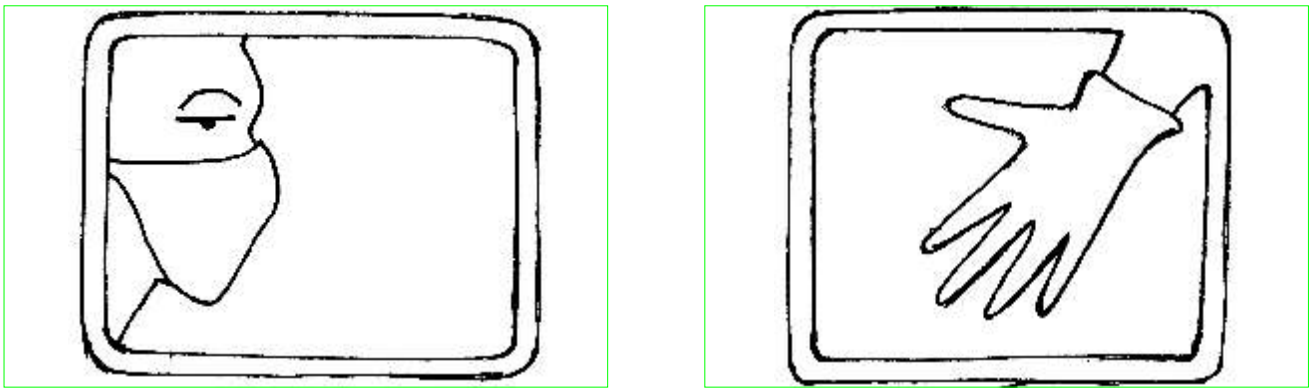


Figure 5.10 Use of protective gears during maintenance of waterless urinals is very important

which are normally used in household air coolers can be used.

5.6 Urine Collection from Girl's Urinals in Schools

Suitable urinal pans and odour traps which can function effectively in urinals designed for females are yet to be available in the market. Therefore, providing waterless urinal facilities with such options is not feasible. However, urine being collected from girl's urinals in schools can be diverted to urine storage tanks with few precautions. Adopting the following steps will facilitate collection of urine from girl's urinals.

- Open drains normally provided for collecting urine from squatting tiles laid in girl's urinals can be diverted to urine storage tanks. Urine storage tank being provided for boy's urinal can be utilised for collecting urine from the girl's urinals as well.

- Ensuring a gradient of 1:100 and providing glazed tiles for the drains can help in smooth flow of urine from the urinals and to reduce odour in the urinals.

- It is preferable to filter urine using sand and charcoal filter bed before it is collected in a storage tank. This is especially recommended for secondary or high schools where older girls use the urinals during menstrual periods. By providing this arrangement, collection of unwanted materials other than urine can be prevented.

- The sand and charcoal filters must be periodically cleaned and the waste collected must be disposed either in the ecosan toilet chamber or composted outside in a separate composting facility.

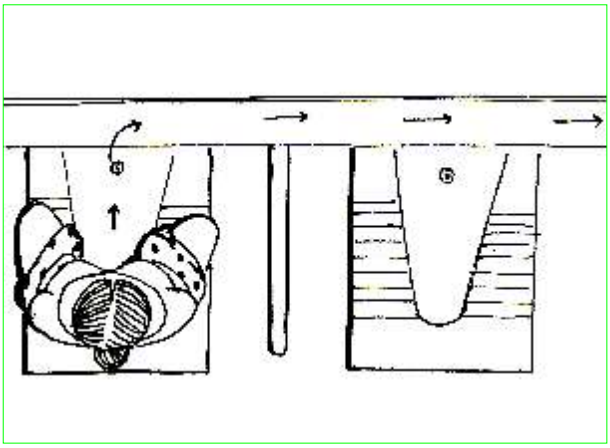


Figure 5.11 Layout of a girl's urinal attached to urine collection drain

- Use of acids or detergents for cleaning urinals should be strictly avoided as this will affect the quality of urine being collected.

- Urinals must be only washed with moist cloth / brush.

- Urinals should not be flushed with water as it will dilute and increase the volume of urine being collected.

5.7 Innovative Urinal Designs

Public toilets that are badly designed, badly maintained, and poorly located generate a sense of neglect, attracting vandalism, anti-social behaviour and social disorder. Poor quality of construction and inappropriate designs of urinals lead to improper use of facilities in most cases. As a result, most urinals suffer from the vicious cycle of bad use and improper construction or maintenance.

Waterless urinals are a good option to be considered while promoting public urinals because they overcome the need for water as

well as infrastructure required for conventional urinals. Unmanned public urinals usually constructed on streets and less density areas can be improved to provide better aesthetic and environment to the user. Quality of construction is an issue in most of such stand alone urinals constructed in less crowded areas.

Innovative waterless urinal models, which are inexpensive and offer aesthetic surroundings, can provide sound solution to the problem being faced in the public urinal front. The following innovative urinal designs can be promoted as per the feasibility and budget available:

- Waterless Public Urinal Kiosks
- Green Waterless Urinals
- Homemade Urinals (Eco Lilly)

5.7.1 Waterless Public Urinal Kiosks

Waterless Public Urinal Kiosk is a stand-alone concrete reinforced pre-fabricated urinal kiosk which can be installed in public places and institutions. Although pre-fabricated urinal kiosks made of steel and FRP have existed in the past, the kiosks made of concrete can be cheaper and robust.

Urine collected can be diverted to a storage tank for recovery of nutrients from urine or to normal sewer lines / soak pit. The surrounding area of the urinal kiosk covered with a planted hedge to offer privacy to the users. In place of the planted hedge, billboards can also be erected at public places to generate revenue for maintenance of the urinals.

This approach of using pre-fabricated concrete structures will ensure higher standards of urinals unlike the current onsite construction of urinals which results in poor quality.

Figure 5.12 Formwork used for fabrication of public urinal kiosk (Photo: R Sakthivel)

Figure 5.13 Reinforced concrete public urinal kiosk (Photo: R Sakthivel)

Prefabricated FRP urinal kiosks are being used very recently in some parts of the country; however these are expensive and prone to vandalism.

The prefabricated concrete structure can fabricated in an industry or onsite, and transported to a desired site of a city and institution for creating urinals for men. A public urinal kiosk can offer a pleasant atmosphere to the users due to its open and attractive surrounding. Cost of the pre-fabricated urinal is very low compared to FRP or other materials. The public urinal kiosk can be constructed between Rs 10,000 to Rs 30,000 as per the design adopted.

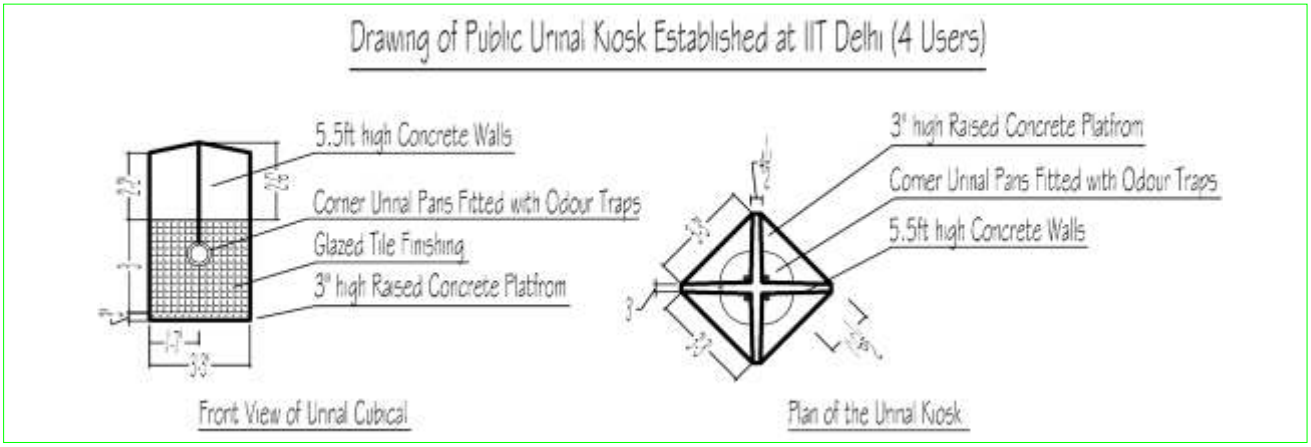


Figure 5.14 Drawing of public urinal kiosk established at IIT Delhi

Advantages of Waterless Public Urinal Kiosks

- Open and green surrounding provides good aesthetic environment.
- Low cost of construction and easy to maintain.
- Quality of construction is assured due to centralised production.
- Any concrete fabrication industry can produce it.
- Strong RCC structure can withstand any act of vandalism.
- Low odour due to open surroundings and requires lesser space.
- Suitable for parks, road side sites, schools and institutions.

5.7.2 Green Waterless Urinal

A Green Waterless Urinal (GWU) is low-cost onsite urine application model suitable for sites where adequate space is available and the numbers of users are limited. Urine collected is diverted to a plant bed of Canna Indica and Ficus planted around the urinal. For enabling uniform distribution of urine to the plant bed, a perforated pipe connected to the urinal is laid along the plant bed. As urine contains essential plant nutrients such as nitrogen, phosphate and potassium, these are utilized by the plants for their growth. The plantation also doubles as a hedge around the urinal offering privacy to the users.

The bed must be surrounded by earthen bunds to prevent flow of urine to nearby areas during rainy seasons. At periodic intervals, watering and emptying of the phosphate deposits is carried out to maintain the system. Treatment for reducing salinity of the soil must be taken up at regular intervals.

Figure 5.15 Green urinal established at IIT Delhi (Photo: R Sakthivel)

Figure 5.16 Plant bed of green urinal with perforated pipe (Photo: R Sakthivel)

This model of onsite utilization of the urine through GWUs can be adopted in public places, gardens and institutions where there is open space. The initial and maintenance cost of GWUs is also very low compared to the normal urinals. GWUs can be established at a cost of Rs 500 to Rs 10,000 based on the design adopted.

Advantages of Green Waterless Urinal

- Open and green surroundings provide very good aesthetic environment to users.
- No waste is generated as urine is led to plant bed.
- Low cost of construction (existing compound walls can be used).
- Suitable for parks, road side sites, schools, institutions and individual houses.
- Requires lesser space and easy to install anywhere.
- Lower level of ammonia smell due to open environment.

5.7.3 Self Constructed Urinals

Self Constructed urinals are simple options for creating waterless urinals in rural areas. “Eco-lily” is one such model promoted in some parts of Africa. A plastic funnel can be inserted to the opening of a plastic jerry can and an old light bulb or a table tennis ball is placed into the funnel. The bulb or ball act as an odour seal while it floats when urine enters the funnel and releases urine into the jerry can. Connecting a short hose in the bottom of the funnel for directing urine to bottom of the jerry can prevent emission of gas due to turbulence.

Special designs of funnels which offer convenience to both men and women can be fabricated at low cost using locally available materials such as tin sheets. Regular cleaning of the bulb or float and the funnel is necessary for removal of the deposits. However, use of bulb

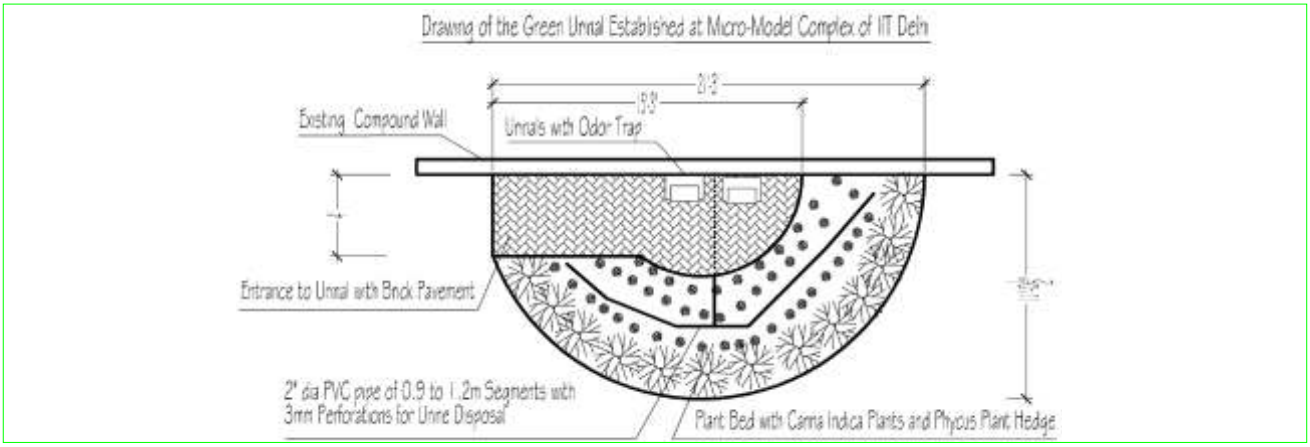


Figure 5.17 Schematic of green urinal established at IIT Delhi (Photo: R Sakthivel)

may contaminate urine as solder and metal cap of the bulb contains heavy metals.

Figure 5.18 Self constructed urinal "Eco-lily"

Advantages

- Self constructed urinals can be created at any desired location such as farms, out houses and temporary camping sites.
- Construction of these urinals is very low cost.

In rural areas, when cans are full, they can be transported to agricultural plots for fertilisation of crops when they are full.

5.8 Cost Estimate

A standard waterless urinal seat can be created in the cost range of Rs 500 to Rs 8,000. The cost of installation depends on the type of odour trap chosen.

In a large toilet unit where a number of urinal seats are created, the cost of pipeline and storage facilities have to be included apart from the cost of urinal seats and odour traps. The cost of installation of waterless urinals are included in the standard designs provided in Chapter 4.

5.9 The Way Forward

Institutions and Public Places: Installation of waterless urinals should be made mandatory for institutions and public places. Enforcing proper maintenance routines for the upkeep of waterless urinals in such locations will result in conservation of fresh water and reduce environmental pollution.

Building Code for Houses: Installation of waterless urinals as an integral component of toilets in individual houses should be made mandatory for large houses with several toilets. Provision of a urinal in at least one of the toilets which is often used in the house can minimise the use of conventional toilets for urination. Such a change in the building code can help in preventing wastage of enormous quantities of fresh water and generation of large volumes of sewage in the cities.

Female Urinals: Innovative designs of waterless urinal designs are yet to be developed for meeting the requirements of female population. Currently, toilets double as urinals for the use of female population. In schools, squatting slabs connected to open drains are being used as urinals for girls. As a result, issues like increased cost of construction, excessive odour problems, poor maintenance and inconvenience to the users are being faced. Therefore, further work to address the above issues needs to be taken up.

Industrial Application of Urine: Apart from the use of urine in agriculture, industrial applications using human urine need to be developed to utilise the urine harvested by installing waterless urinals. Diverting and collecting urine separately from sewage can reduce nitrate levels in the effluents discharged to water bodies and ground water. The problem of eutrophication of the water bodies can also be prevented due to lower of levels of nutrients,

especially phosphate.

Awareness: Awareness among builders, engineers, architects, town planners and policy makers is essential to promote waterless urinals on a large scale. Efforts to popularise the concept can result in large scale replication of waterless urinals across the country.

Maintenance: Undertaking proper maintenance routines of waterless urinals installed is essential for ensuring their effective functioning. Improper maintenance of the waterless urinals may result in failure of this novel concept. Therefore, sensitising the users, training of maintenance staff and allocation of adequate budget for meeting the maintenance requirements must be ensured after installation of waterless urinals.

Chapter 6

Hygienic Operation and Maintenance

6. Hygienic Operation and Maintenance

Hygienic operation and maintenance of ecosan toilets and waterless urinals is very important. As these are quite new concepts, users of these facilities have to be educated on how to use and maintain them properly. Although these are robust technologies compared to other sanitation systems, following proper maintenance procedures is very important for their effective functioning. Improper use and maintenance would lead to failure of the systems and create a negative impression among the users on the effectiveness of these technologies. Apart from conducting training on how to use and maintain these facilities, regular follow-up and maintenance support should also be planned.

6.1 Safe Use of Ecosan Toilets & Waterless Urinals

6.1.1 Ecosan Toilets

How to Use Ecosan Toilets

Users must be clearly explained about the steps involved in using the ecosan toilets. The concept and advantage of separation of faeces, urine and wash water must be explained in detail. In addition, functioning of every component of the ecosan toilet must be explained to the user in detail.

Adding Additives

- Small quantity of additives such as ash, soil or dry powdered leaves must be added to faeces chamber after every use of the toilet.
- Additives and a scoop for administering it should placed in a container with inside the toilet.
- Additive must not be allowed to fall into urine or wash water separation areas to prevent clogging.

Ablution Water

- A mug or container must be used for

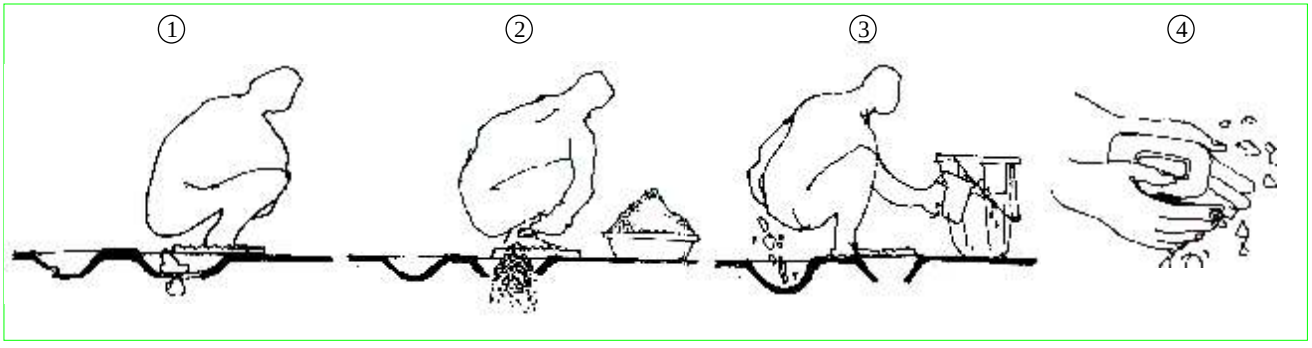


Figure 6.1 How to use an ecosan toilet

Steps:
1. Defecate in the faeces hole and urinate in the urine collection area provided
2. Sprinkle a small quantity of additive over the faeces collected in the chamber after defecation
3. Move backwards to perform ablution in the wash-water collection area after covering the faeces hole in the pan with a lid
4. Wash hands with soap after defecation

bringing water into the ecosan toilet for the purpose of ablution.

- Water used for ablution must be handled with care to avoid spilling of it into faeces chambers.

Hygiene

- Hand washing using soap / mud / ash after defecation should be practiced for ensuring hygiene.
- It is always better to wear footwear while using the toilets.

Other Precautions

- Lid of faeces drop hole must always be covered when not in use.
- Doors of the toilets must be kept closed to prevent entry of rain water or any pet animals and insects.
- Toilet seats must only be wiped with moist cloth or brush.

6.1.2 Waterless Urinals

How to Use Waterless Urinals

- Waterless urinals are used in the same way as normal urinals.
- However, spitting, throwing cigarette buds, beedis or chewing gum is strictly prohibited.

Maintenance

- Only moist cloth or brush should be used for cleaning the urinals, water should not be used.
- Use of chemicals or acids for cleaning is strictly prohibited.

6.2 Maintenance of Ecosan Toilets and Waterless Urinals

6.2.1 Ecosan Toilets

- Careful and judicial use of water in the ecosan toilet is recommended.
- It is advisable not to have provision of running water in the ecosan toilets.
- Vent pipe should be periodically checked for blockage and cleared.
- Access vents of faeces chambers must be sealed properly and no leakage from it or into it should be allowed.
- Water should never be allowed to enter faeces collection chamber.
- If accidentally or by mistake water is added to faeces chamber, sufficient quantity of additive must be added to soak the excess water.
- Rainwater should not be allowed to enter the toilet or faeces chambers. Check whether doors or ventilators are installed properly to prevent entry of rainwater into the toilet.
- Wash water beds / soak pit must be maintained properly to dispose off the wash water generated.
- Urine storage tanks should be monitored and emptied periodically.
- In case insects like cockroaches are found in faeces chamber, dry powdered neem leaves and turmeric powder may be used to control the same. No chemicals should be used for such operations.

6.2.2 Waterless Urinals

- Waterless urinals installed especially in schools and public places require regular cleaning.
- Only wet cloth or brush must be used for cleaning the urinals without pouring water into them.
- No chemicals or acids should be used for cleaning urinals as this affects the performance of odour traps and also the quality of urine being collected.
- Odour traps fixed to urinals must be checked periodically. Replacement of these must be taken up based on requirements specified by manufacturers.
- Occasional flushing with water helps in removing sediments settling in the pipes. However, this should not be taken up as a regular activity as it will dilute the urine collected in the storage tanks.
- Pipes carrying urine should be cleaned using thin wires to remove settled particles especially in long urine collection pipe lines laid in schools or public places.
- There should not be any loose joints in the fixtures as this would result in leading to leakage of urine and emissions of odour.
- Storage tanks must be monitored and emptied at periodic intervals to avoid overflow of urine.

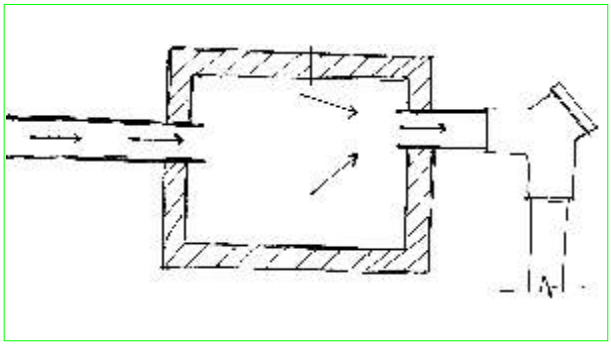


Figure 6.2 Provide collection chambers at periodic intervals to break length of pipe lines and install bends with openable doors for maintenance

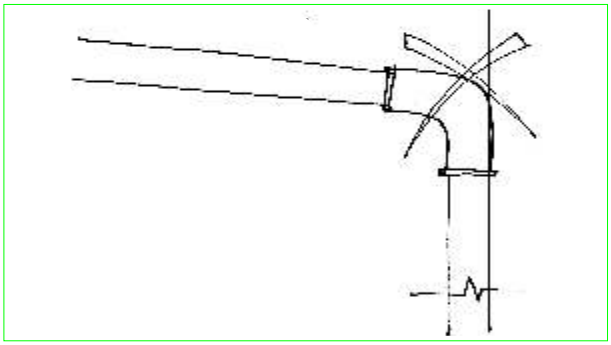
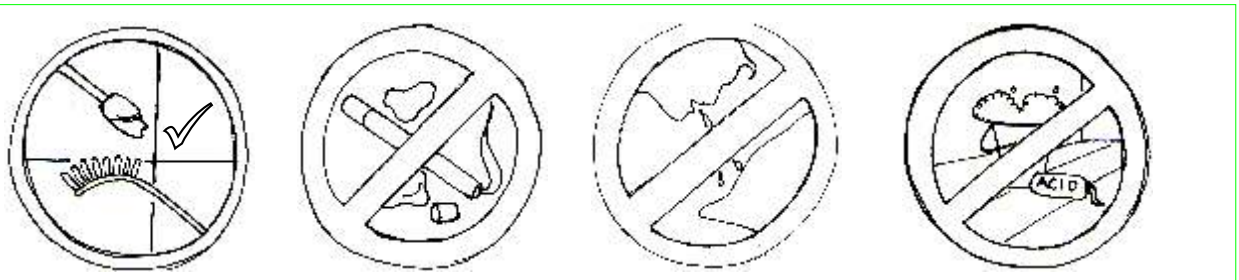


Figure 6.3 Avoid sharp bends and provide proper slope for the urine collection pipes



Use only moist cloth and brush for cleaning | No cigarette butts and chewing gum | No spitting in the urinal pan | No use of acids and chemicals for cleaning

Figure 6.4 Do's and Dont's to be followed for maintenance of waterless urinals

6.3 Safe Handling of Faeces and Urine

- Young children should not be allowed to play inside ecosan toilets or handle urine storage tanks.
- Persons inspecting or handling large urine collection tanks must wear face masks to avoid any untoward incident due to strong ammonia gas presence.
- Use of protective hand gloves while servicing / repairing the systems is recommended to avoid contact with faecal matter.
- Use of footwear like shoes / gumboots while handling urine and faeces helps in avoiding contact with pathogenic matter.
- Tools for repairing and containers used for removing contents from the systems must be cleaned properly and stored after every use.

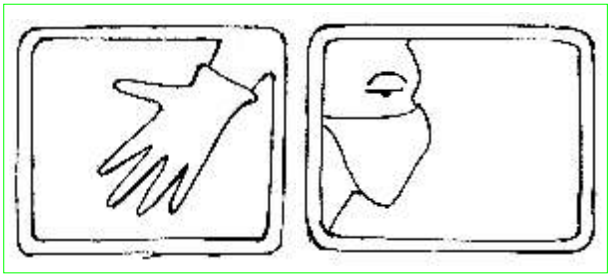


Figure 6.5 Always wear protective gear like gloves, mask and footwear while handling faeces and urine

6.4 Post Implementation Support

- Regular inspection of the systems installed is a must for identifying the problems before they get worse.
- Periodic maintenance of ecosan pans, waterless urinal odour traps and urine collection and wash water disposal pipes is required to prevent clogging of the systems.
- Schools and families who do not have their own land need support for disposal of contents from chambers and stored urine at periodic intervals. Therefore, for sustainability of the systems created introducing a system to link farmers who require these for application to agricultural lands with owners of ecosan facilities is very important.
- Repairs can occur to the systems installed due to wear and tear over a period of use. Therefore, assistance of technicians who are trained to repair these must be made available.
- Timely availability of spares like ecosan toilet pans, waterless urinal pans and odour traps, pipes and fittings is a must for replacing the broken parts. Users must know where these are available and the technicians who can fix these.

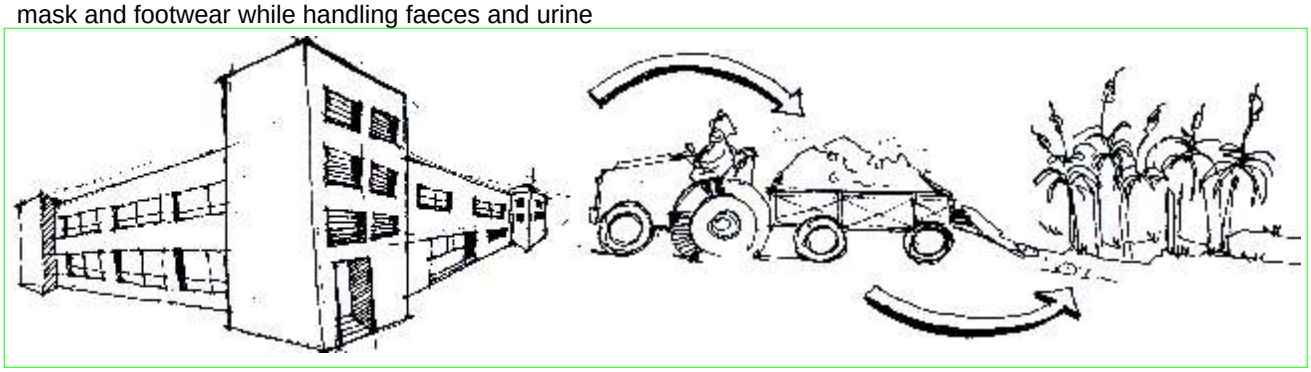


Figure 6.6 Link farmers with schools and landless families having ecosan toilets for disposal and utilisation of compost and urine at regular intervals

Chapter 7

Ecosan in Disaster and Special Situations

7. Ecosan in Disaster and Special Situations

Natural disasters such as cyclone, floods and earthquakes apart from playing havoc with people's lives and properties can cause severe damage to water and sanitation infrastructure.

Apart from provision of immediate priorities like food, health, shelter and water in disaster affected areas, ensuring proper sanitation amenities is very important for preventing disease outbreak. Sanitation systems need to be designed to withstand the impact of disaster situations. In the absence of this, unsanitary conditions can lead to disease outbreak.

7.1 Current Sanitation Practices

Sanitation systems implemented in disaster prone areas are often not designed to meet eventuality of disasters. Most agencies fail to consider this aspect in the design of sanitation options. Often it has been seen that when aid agencies implement sanitation facilities for disaster affected regions, aid agencies tend to implement systems that are easy to implement without much regard to impact on environment or long term sustainability.

The goal often is to minimise implementation time and spend the available financial allocation. Although some of the available options are exhibit based on sound principles of managing human excreta, these often fail in coastal, high water table or flood prone areas. Conventional sanitation solution require water for flushing excreta and this some times can be challenging in disaster situations if conventional flush toilets are promoted.

Some of the most common measures adopted for safe disposal of excreta in the disaster situations are as follows:

Controlled open defecation field : In disaster relief shelters controlled open defecation field is an option for immediate excreta disposal. A secluded open field which is away from water sources could be demarcated for controlled open defecation. The area is further divided into strips for the use of one strip at a time. Usually separate enclosures are demarcated for men and women with protective fence offering privacy.

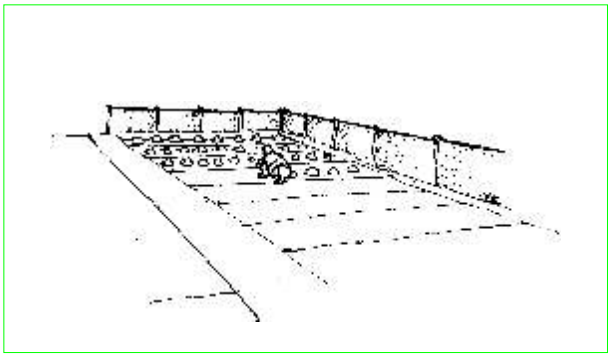


Figure 7.1 Use of open fields for controlled defecation in relief shelters

Trenches : In disaster relief, trenches for purpose of defecation are created in the same way as controlled defecation fields. However, instead of the large defecation strips, shallow (20 - 30 cm wide and 15 cm deep) or deep (0.8 m wide and 2 m deep) trenches are created in long strips for disposal of excreta. A wooden

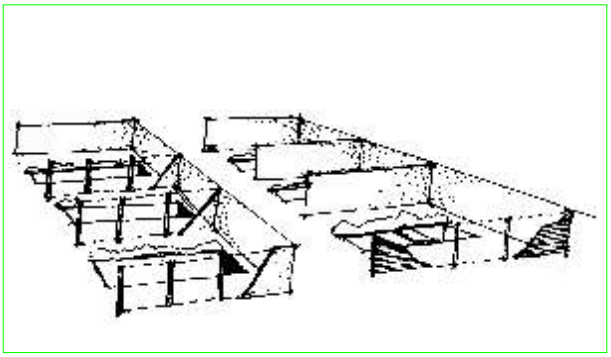


Figure 7.2 Trenches used for controlled defecation in relief shelters

platform is provided as squatting slab in the case of deep trenches for safety. Excavated earth kept adjacent to the trench is used for covering excreta after every use with the help of a shovel. Portable enclosures with several partitions can be erected over the trenches to offer privacy and simultaneous use of the trench by more than one person.

Dry toilets : Dry toilets having a pit or a bore hole for disposal of excreta is created as an emergency option near relief camps for providing sanitation facility. These are usually constructed away from water sources to prevent contamination. Squatting slab with either temporary or permanent superstructure are provided to the toilet. The unit is shifted to a new location after the pit or borehole is filled-up. Several units can be created adjacent to each other for serving large number of people.

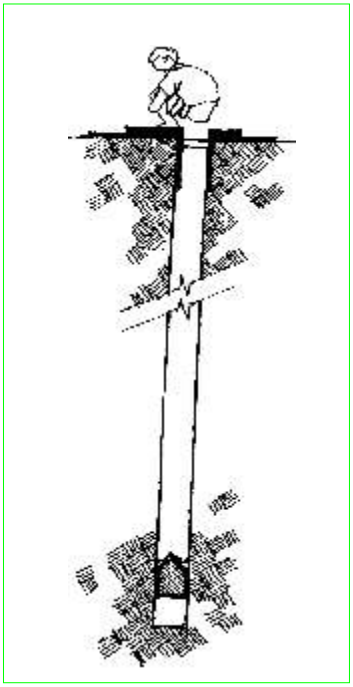


Figure 7.3 Use of boreholes for disposal of human excreta

Pour flush toilets : Pour flush toilets with twin or single pit are the most common excreta disposal solution provided by many relief agencies during emergency situations. Faeces is collected in pits created either below or outside the toilet area. The squatting slab, toilet pan and superstructures are also provided to the toilet. Care should be taken when implementing these types of toilets in coastal and high water table areas to prevent contamination of ground water.

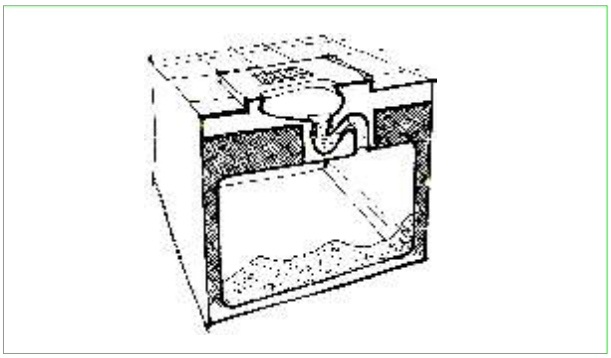


Figure 7.4 Pour-flush toilets for disposal of human excreta

7.2 Ecosan Toilets in Disaster Situations

When normal flush toilets are constructed in flood prone areas, they get affected during floods and create unsanitary conditions. This has been a major problem with conventional sanitation solutions in coastal areas and areas close to major rivers of India. Normal flush toilets become unusable when the leach pits or septic tanks get filled-up with flood water. Dewatering and cleaning these facilities to prevent contamination and to bring them back in use becomes an extremely tedious task.

Promotion of ecosan toilets in disaster prone areas has several advantages both as a short or long term sanitation solution. Already many

agencies have successfully adopted ecosan toilets considering this aspect. However, if ecosan toilets are newly introduced to an area under a disaster relief programme, the real challenge is to educate people on the benefit of ecosan toilets very quickly.

Benefits of Ecosan toilet in a disaster situation

- Ecosan toilets do not cause pollution of ground water sources in the area.
- Ecosan toilets require very little water only for anal washing.
- Dry faeces collection and urine diversion decreases the volume of material to be treated and improves efficiency of the pathogen inactivation process.
- As ecosan toilets are constructed above the ground level, these are less prone to damage in case of flooding and cyclones.
- Nutrients from faeces and urine collected through ecosan toilets can be utilised for growing agricultural crops and in the kitchen garden.

Challenges in promoting Ecosan toilets

- Users need to be educated about proper use of ecosan toilet if they are not familiar with it already.
- Ecosan toilets are slightly more expensive than normal toilets.
- Requirement of physical infrastructure to be created might take some time before facilities.
- Recycling of urine and composted faeces may not be a priority immediately after the disaster situation.
- Consistent follow up and support is needed to ensure proper use of ecosan toilets.

7.3 Design Principles and Considerations

The design considerations for any sanitation system provided in a disaster relief and rehabilitation situation must include the following sustainability criteria (Kvarnström and Petersens, 2004).

- The sanitation systems promoted should not pollute groundwater, especially if shallow wells are being used as a drinking water source, and surface water.
- The system should not require water for transporting waste since water is usually precious in emergency situations.
- The system should be able to sanitise the waste to destroy pathogens and prevent contact of users with excreta to protect public health.
- The system must have low capital, (cost as well as operation and maintenance) costs to be financially sustainable.

As ecosan toilets meet these criteria, these can be promoted as a sound option for safe disposal of human excreta in disaster and emergency situations. The following aspects in the design considerations should be adhered to while promoting ecosan toilets in disaster prone areas:

- Basement and the faeces collection chambers of ecosan toilets must be raised above the high flood level anticipated in an area.
- Faeces collection chambers must be water tight to prevent entry of water during

floods.

- Doors and ventilators of the toilet must be able to prevent entry of rain water during heavy rains.

- The material chosen for construction of ecosan toilet, especially the superstructure should be able to withstand wind and heavy rains.

- If the area is situated in seismic zones, the structure should be designed considering the stability required for earthquakes.

7.4 Promotion of Ecosan Toilets in Disaster Prone Areas

Ecosan toilets can be promoted in disaster prone areas in two ways. First, permanent ecosan systems can be installed in areas which are identified as disaster prone. Second, temporary measures can be used for providing sanitation facilities in post disaster situations. These are discussed in the following sections in detail.

7.4.1 Permanent Measures

Ecosan Toilets in Households : Although ecosan toilets can be constructed in almost all areas, according priority to its promotion in flood prone areas located in coastal and flood plains major rivers has a definite advantage. By installing ecosan toilets in these areas, one can ensure that people have safe sanitation facilities even during floods, apart from preventing ground and surface water contamination.

Since ecosan toilets have an elevated basement and isolated water tight faeces collection chambers, they will function better in flood situations than normal flush toilets. Therefore, building ecosan toilets in the areas which are prone to regular floods and cyclones is recommended. The designs discussed in previous section of this publication can be adopted.

An innovative design of a portable ecosan toilet constructed using bamboo with removable containers has been developed for installation in flood prone areas by Megh Pyne Abhiyan, a NGO working in Bihar. The portable unit can be utilised as normal ecosan toilets by the communities in their houses and the same units can be shifted to elevated locations during floods where people stay in make shift dwellings for some period.

Ecosan Toilets in Rehabilitation Shelters : Building ecosan toilets in rehabilitation shelters which accommodate disaster affected people during disaster has several advantages. The ecosan toilets built in such shelters can serve the need of urgent people when they are temporarily accommodated in relief shelters during disasters.

Ecosan Toilets in Schools : Apart from providing ecosan toilets in relief shelters, it can be promoted in the schools located in disaster prone areas. Schools which are usually built as permanent structures act as relief shelters in

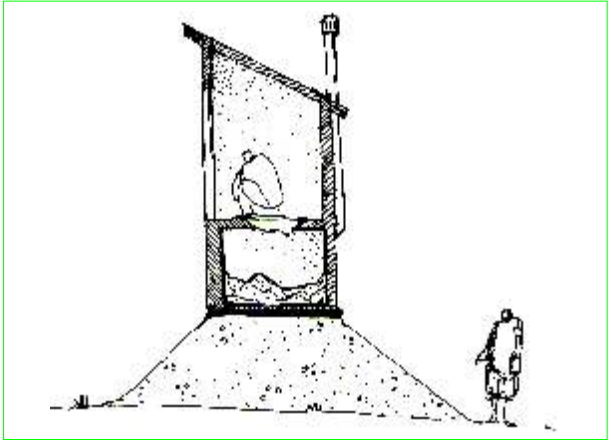


Figure 7.5 Construction of ecosan toilets above high flood level

many areas. Therefore, building ecosan toilets in schools would be ideal as children and people in the area will become familiar with the use of ecosan toilets.

7.4.2 Temporary Measures in Relief Operations

Relief camps with high concentration of people can become a potential place for disease outbreak if safe disposal of excreta is not provided. Therefore, systems for safe excreta disposal must be provided on an immediate basis. As construction activities to build ecosan toilets would take longer time, ready-made solutions given below can be deployed immediately.

Peepoo Bags : The Peepoo is a single use bio-degradable bag used for defecating and safe disposal of excreta. The chemically treated bag sanitizes human excreta from contaminating the immediate and larger environment. The peepoo bag was developed by the Swedish company "Peepoople" to provide solutions where provision of sanitation infrastructure is not feasible or where they have to be provided immediately. Therefore, use of peepoo bags for safe disposal of human excreta is quite suitable for urban slums and temporary settlements like disaster relief camps.

The Peepoo bag is a slim, elongated bag (14 x 38 cm) with a thin inner liner (25 x 24 cm) designed to be used once for defecation and urination. Wash water should not be allowed to enter the bag, and it should be disposed safely to a soak pit or plant bed as discussed in earlier sections.

The bag is made from degradable bio-plastic (EU standard EN13432) and comprises a mixture of aromatic copolyesters and polylactone acid, with small additives of wax and lime (the base ingredient of the mixture is "Ecoflex" manufactured by BASF in Germany). The plastic is produced using 45% renewable materials (Peepoople intends to find a solution to make the plastic 100% renewable in the

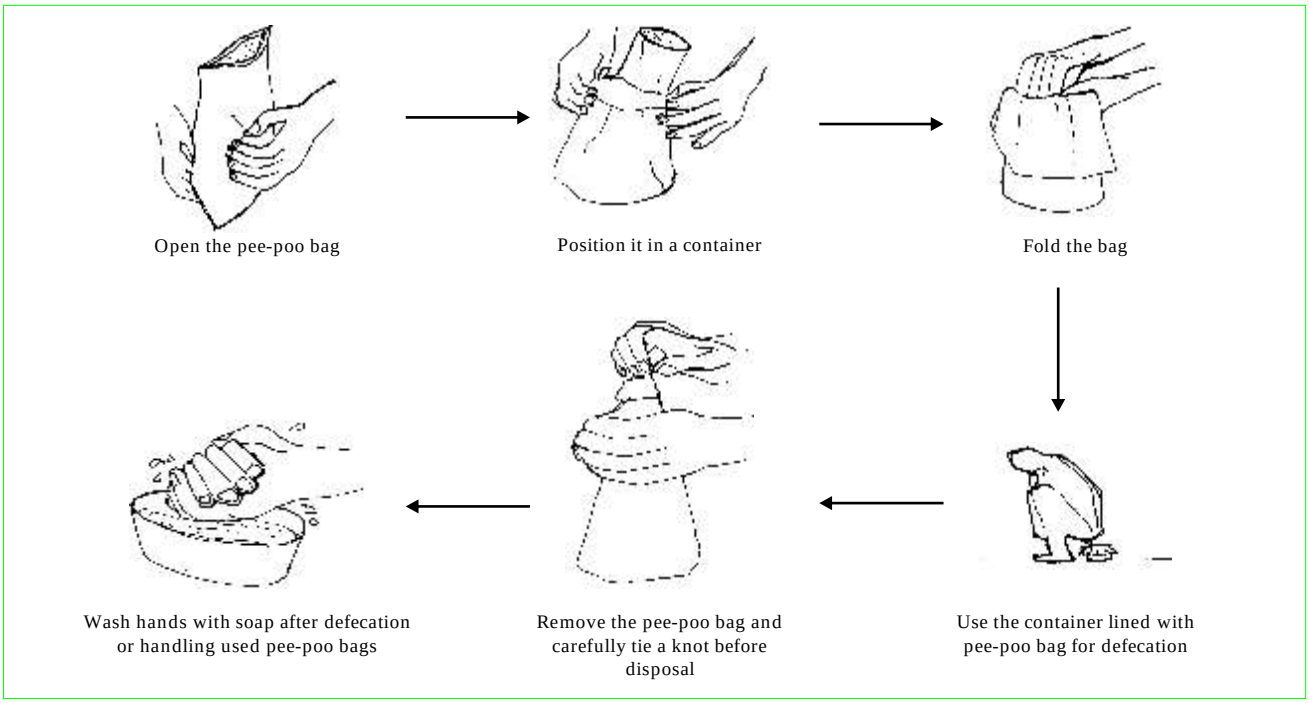


Figure 7.6 Steps depicting the use of pee-poo bags for safe disposal of human excreta

future).

Its two-layer design ensures that the bacteria in human excreta do not come into contact with skin because the inner, wider tube helps to keep the hands clean when holding or closing the bag. Each bag contains 4 g of urea, which rapidly destroys pathogens in human excreta (including the hard to destroy helminth eggs). Ammonia produced by urea helps in sanitising excreta and makes it safe to use as fertilizer within a relatively short period of time (2-4 weeks at average temperatures of at least 20ºC).

The Peepoo eliminates the need for fixed and hard infrastructure for a soft approach to sanitation and excreta management. After use, the Peepoo bags should be collected and stored for use as fertiliser in agriculture. The design of the bag offers a clean and hygienic way of excreta management.

Ready to Install Ecosan Toilets : Ready to install ecosan toilets can be installed during emergency situations at relatively high speed. Such ready to install models of conventional flush toilets are already available in the market. They are being manufactured using PVC or fibre materials.

The ready to install ecosan toilet models can be fabricated with provisions like ecosan squatting pan, removable faeces collection chamber and vent pipe. These ready to install toilets can be designed as single or modular type units. Modular type units created adjacent to each other have an advantage as they help in reducing the installation cost drastically.

Alternatively, various pre-fabricated ecosan toilet components made up of concrete can be kept ready in disaster prone areas for rapid deployment. Ecosan toilet components like squatting slab, chamber cover slabs, roof panels and other accessories can be fabricated and kept ready well in advance. Some agencies have also used prefabricated circular RCC rings as faeces collection chambers by dividing it into twin chambers using brick walls. Using such prefabricated components the ecosan toilets can be installed wherever necessary. Cost of such installations will be quite cheaper than commercially produced ready to install toilets.

Further, research is required on the type of portable ecosan facilities that are appropriate for emergency situations and their cost. If ecosan compatible toilets are to be used during emergencies, then easy to assemble units should be available for installing as soon as an emergency strikes.

Mobile Ecosan Toilets : Mobile ecosan toilets are another very important system which can be put into service during emergencies and other events where emergency sanitation facilities are needed. Similar to the mobile conventional toilets already in service, the mobile ecosan toilets can be pressed into service rapidly.

The mobile ecosan toilets have an advantage over conventional toilets as they require very little water. Also, the faeces collection chambers can be put into service for a longer duration as they do not get filled-up with large quantities of water used for flushing.

Wherever the Need, a UK based charity working in India, has developed a mobile ecosan toilet model keeping these factors into consideration. However, the heavy unit needs to be pulled by motorised vehicles like a tractor or van. This could be a deterrent for deployment in disaster affected areas where roads are damaged very severely. The agency is now considering a design which is light weight to facilitate portability.

Keeping this in mind, Megh Pyne Abhiyan has developed a simple push cart type ecosan toilet

using bamboo for use in flood prone areas of Bihar. This push cart based ecosan toilet can be moved easily to relief camps or temporary shelters during floods. Being very light in weight, it can be pushed to the desired location with ease.

7.5 Important Precautions to be Adopted

- Effective communication campaign with respect to the operation and maintenance of ecosan toilets and handholding with users must be taken up as part of the programme to familiarise the communities with the concept.
- Staff involved in the programme must be trained and should have all the details about the systems to trouble shoot and assist the communities.
- Safety precautions such as wearing gloves, footwear and face mask while handling repairs of pipelines and storage tanks installed in the ecosan toilets must be ensured to prevent any health risks.
- In large community ecosan toilet systems installed during disaster situations, steps to ensure availability of adequate quantities of additives like soil, ash, dry leaves or saw dust must be ensured for the proper maintenance of the ecosan toilets.
- Steps to maintain the high quality of construction required by ecosan toilets must be taken up to ensure effective functioning of the systems in disaster situations.
- As immediate utilisation of composted faeces and urine collected from ecosan toilets for agricultural purposes in the disaster affected areas may not be immediately possible, provisions for collection and storage of these materials have to be established in consultation with the farmers in the area.

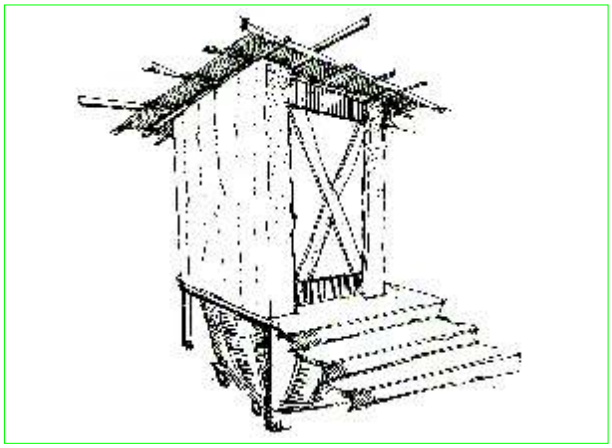


Figure 7.7 Mobile ecosan toilets for temporary relief operations

Chapter 8

Safe Application of Human Excreta in Agriculture

8. Safe Application of Human Excreta in Agriculture

Many societies in the world have been utilising human excreta as a source of nutrients in agriculture. Use of wastewater for agriculture is a very common practice in peri-urban areas. Scarcity of water and fertilizing quality of wastewater are two factors that have led to the use of wastewater for agriculture. However, the risk posed by pathogenic micro-organisms present in untreated wastewater is often neglected. Therefore, it is necessary to reduce the pathogenic elements in the human excreta to safer levels before the use of human excreta in agriculture. In this regard, guidelines for the use of wastewater and excreta has been developed by the WHO to prevent disease outbreak through faecal contamination.

On the other hand, source separation of urine and faeces proposed through ecological sanitation concept aids in applying the different set of treatments required by urine and faeces to make them safe for reuse as in agriculture. In countries like China, Japan and Sweden, the practice of source separation of faeces and urine has been adopted in ecosan pilots due to the nutrient value of urine as also to reduce the volume of faeces collected in the toilets. The benefits of source separation (as listed by the EcoSanRes programme) are as follows:

Volume reduction - the collection system will fill up much slower if the urine is diverted and the volume of faecal material will be kept small. Further reduction of the volume and weight of faeces through dehydration / decomposition is possible.

Less smell - the smell will be less when keeping the urine and faeces apart and will result in both more convenient and acceptable use of the toilet and handling of the excreta.

Prevention of dispersal of pathogen containing material - a drier faecal fraction will cause less risk for leaching and transport of pathogens through fluids to the groundwater and to the surrounding environment.

Safer and easier handling and use of excreta - the faeces will be drier, which would be beneficial for pathogen reduction. In addition, drying will facilitate further reduction of pathogens by various other treatment means and will also make it easier to handle and to the separated urine and faecal fractions.

8.1 Pathogens in Faeces and Urine

8.1.1 Pathogens in Faeces

From a risk perspective, the exposure to untreated faeces is always considered unsafe, due to the potential presence of pathogens. Enteric infections are transmitted by pathogenic species of bacteria, viruses, parasitic protozoa and helminths. The pathogens in faeces mainly cause gastrointestinal symptoms such as diarrhoea, vomiting and stomach cramps. Several may also cause symptoms involving other organs and severe sequels.

Group	Pathogen	Disease- Symptoms
Bacteria	Aeromonas spp.	Enteritis
	Campylobacter jejuni / coli	Campylobacteriosis - diarrhoea, cramping, abdominal pain, fever, nausea; arthritis; Guillain - Barré syndrome
	Escherichia coli (EIEC, EPEC, ETEC, EHEC)	Enteritis
	Pleisiomonas shigelloides	Enteritis
	Pseudomonas aeruginosa	Various; bacteraemia, skin infections, ear, infections, meningitis, pneumonia
	Salmonella typhi / paratyphi	Typhoid / paratyphoid fever - headache, fever, malaise, anorexia, bradycardia, splenomegaly, cough
	Salmonella spp.	Salmonellosis - diarrhoea, fever, abdominal cramps
	Shigella spp.	Shigellosis - dysentery (bloody diarrhoea), vomiting, cramps, fever; Reiter's syndrome
	Vibrio cholerae	Cholera - watery diarrhoea, lethal if severe and untreated
	Yersinia spp.	Yersinioses - fever, abdominal pain, diarrhoea, joint pains, rash
Virus	Adenovirus	Various; respiratory illness. Here added due to the enteric types (see below)
	Enteric adenovirus 40 and 41	Enteritis
	Astrovirus	Enteritis
	Calicivirus (incl. Noroviruses)	Enteritis
	Coxsackievirus	Various; respiratory illness; enteritis; viral meningitis
	Echovirus	Aseptic meningitis; encephalitis; often asymptomatic
	Enterovirus types 68-71	Meningitis; encephalitis; paralysis
	Hepatitis A	Hepatitis - fever, malaise, anorexia, nausea, abdominal discomfort, jaundice
	Hepatitis E	Hepatitis
	Poliovirus	Poliomyelitis - often asymptomatic, fever, nausea, vomiting, headache, paralysis
	Rotavirus	Enteritis
Parasitic protozoa	Cryptosporidium parvum	Cryptosporidiosis - watery diarrhoea, abdominal cramps and pain
	Cyclospora cayetanensis	Often asymptomatic; diarrhoea; abdominal pain
	Entamoeba histolytica	Amoebiasis - Often asymptomatic, dysentery, abdominal discomfort, fever, chills
	Giardia intestinalis	Giardiasis - diarrhoea, abdominal, cramps, malaise, weight loss
Helminths	Ascaris lumbricoides	Generally no or few symptoms; wheezing; coughing; fever; enteritis; pulmonary eosinophilia
	Taenia solium / saginata	
	Trichuris trichiura	Unapparent through vague digestive tract distress to emaciation with dry skin and diarrhoea
	Hookworm	Itch; rash; cough; anaemia; protein deficiency
	Shistosomiasis spp.	

Table 8.1 Example of pathogens that may be excreted in faeces (can be transmitted through water and improper sanitation) and related diseases, including examples of symptoms they may cause (adapted from e.g. CDC, 2003c; Ottosson, 2003; SMI, 2003) (Source : EcoSanRes)

In fresh faeces, there are four main groups of organisms of concern to humans: bacteria, viruses, protozoa and helminths. These organisms once excreted:

- may be immediately infectious;
- may require a period of time outside of the body to become infectious; or
- may require an intermediate host before becoming infectious.

Bacteria and viruses are immediately infectious once excreted. Protozoa are excreted primarily as cysts, and can be immediately infective or require a period of time outside the body. The eggs of helminths, many of which are resistant to environmental conditions, require a period of time outside of the body. Some parasites, such as bilharzia, also require an intermediate host before becoming infectious.

8.1.2 Pathogens in Urine

Urine is normally sterile in the urine bladder, but gets contaminated while discharged from the lower parts of urinary tract. Several types of bacteria may cause urinary tract infections. The environmental transmissions of these are normally of low importance. E. coli is the most common cause of urinary tract infections, where certain clones may also be associated with gastrointestinal infections.

The pathogens traditionally known to be excreted in urine are Leptospira interrogans, Salmonella typhi, Salmonella paratyphi and Schistosoma haematobium. There is a range of other pathogens that have been detected in urine but their presence may not be considered significant for the risk of environmental transmission of disease.

However, the significant risk of contamination of urine occurs due to faecal cross-contamination. Faecal contamination usually

Pathogen	Urine as a transmission route	Importance
Leptospira interrogans	Usually through animal urine	Probably low
Salmonella typhi and Salmonella paratyphi	Probably unusual, excreted in urine in systemic infection	Low compared to other transmission routes
Schistosoma haematobium (eggs excreted)	Not directly but indirectly, larvae infect humans via freshwater	Need to be considered in endemic areas where freshwater is available
Mycobacteria	Unusual, usually airborne	Low
Viruses: CMV, JCV, BKV,	Not normally recognized other than adeno, hepatitis and others single cases of hepatitis A and suggested for hepatitis B. More information needed	Probably low
Microsporidia	Suggested, but not recognized	Low
Venereal disease causing	No, do not survive for significant periods outside the body	-
Urinary tract infections	No, no direct environmental transmission	Low

Table 8.2 Pathogens that may be excreted in urine and the importance of urine as a transmission route (Source : EcoSanRes)

occurs at the urine diverting toilets when urine comes into contact with faeces.

8.2 Processing and Application of Faeces

As mentioned in the previous section, faeces contains most of the pathogens. Therefore, disease transmission through faeces can be effectively prevented by containing it and effecting appropriate treatment methods by building ecological sanitation systems.

Following proper hygienic practices like hand washing after defecation and handling of waste as also food hygiene are necessary to prevent secondary channels of disease transmission. The following table provides various factors responsible for disinfection of pathogens in faeces and rendering it safe for agricultural applications.

Ecosan toilets are designed to process human faeces to a harmless state. The treatment to destroy pathogenic organisms present in human faeces is effected either within or outside the system. Broadly, the process of pathogen

Temperature	Most micro-organisms survive well at low temperatures (<5°C) and rapidly die-off at high temperatures (>40-50°C). This is the case in water, soil, sewage and on crops. To ensure inactivation in e.g. composting processes, temperatures around 55-65°C are needed to kill all types of pathogens (except bacterial spores) within hours (Haug, 1993).
pH	Many micro-organisms are adapted to a neutral pH (7). Highly acidic oralkaline conditions will have an inactivating effect. Addition of lime to excreta in dry latrines and to sewage sludge can increase pH and will inactivate micro-organisms. The speed of inactivation depends on the pH value, e.g. it is much more rapid at pH12 than at pH 9.
Ammonia	In natural environments, ammonia (NH3) chemically hydrolysed or produced by bacteria can be deleterious to other organisms. Added ammonia-generating chemical will also facilitate the inactivation of pathogens in e.g. excreta or sewage sludge (Ghigletti *et al.*, 1997; Vinnerås *et al.*, 2003*a*).
Moisture	Moisture is related to the organism survival in soil and in faeces. A moist soil favours the survival of micro-organisms and a drying process will decrease the number of pathogens, e.g. in latrines.
Solar radiation / UV-light	UV-irradiation will reduce the number of pathogens. It is used as a process for the treatment of both drinking water and wastewater. In the field, the survival time will be shorter on the soil and crop surface where sunlight can affect the organisms.
Presence of other micro-organisms	The survival of micro-organisms is generally longer in material that has been sterilized than in an environmental sample containing other organisms. Organisms may affect each other by predation, release of antagonistic substances or competition (see Nutrients below).
Nutrients	If nutrients are available and other conditions are favourable, bacteria may grow in the environment. Enteric bacteria adapted to the gastrointestinal tract arenot always capable of competing with indigenous organisms for the scarce nutrients, limiting their ability to reproduce and survive in the environment.
Other factors	Microbial activity is dependent on oxygen availability. In soil, the particle size and permeability will impact the microbial survival. In soil as well as in sewage and water environments, various organic and inorganic chemical compounds may affect the survival of micro-organisms.

Table 8.3 Physicochemical and biological factors that affect the survival of microorganisms in the environment (Source : EcoSanRes)

inactivation in ecological sanitation systems can be grouped into two categories (i) dehydration and (ii) composting.

8.2.1 Dehydration

The process of dehydration involves removal of moisture from faeces through evaporation and addition of dry materials (ash, sawdust, husks) used as additives. Therefore, addition of water or moist materials in the faeces collection chambers are avoided in the ecosan toilets. The dehydrated material obtained finally is rich in nutrients, carbon and fibrous material. Dehydration helps in destroying pathogenic organisms including helminth eggs by depriving moisture required for their survival. Addition of organic matter like toilet papers or kitchen waste should be avoided as the dehydration does not disintegrate organic matter. The process of dehydration functions very well in dry hot climates.

8.2.2 Composting

In the composting process, organic substances are mineralized and turned into humus. To enable biological decomposition process a humidity of around 60% is essential. Effective aeration, moisture content and carbon to nitrogen ratio of (about 30:1) must be maintained for the system to be efficient. The carbon to nitrogen ratio can be maintained by adding carbonaceous materials like sawdust, kitchen refuse, toilet paper, weeds, grass clippings. Factors like storage time, unfavourable pH value, competition for food, antibiotic action and the toxic by-products of decomposing organisms favour composting process. Composting process is particularly effective in humid climates.

8.2.3 Handling

The ecosan toilets should be designed to retain the mixture of faeces and additives for a period of 9-12 months to effect dehydration and / or composting process. The maturation period should be counted after faeces collection process has been stopped in a faeces collection chamber or removable bin. Therefore, after an ecosan toilet chamber / bin is full, it should not be used further and no water or urine should be allowed to enter it. The maturation process should be carried out preferably within the ecosan toilets, and if necessary it can be carried out outside the system.

When the secondary process of composting is carried outside the system, the materials must be handled with extreme care. The materials subjected to secondary processing must be isolated and stored safely to prevent contact with insects, animals and the outside environment. Persons handling these materials must wear shoes and gloves for safety. Also, the tools used must be cleaned and disinfected after every use.

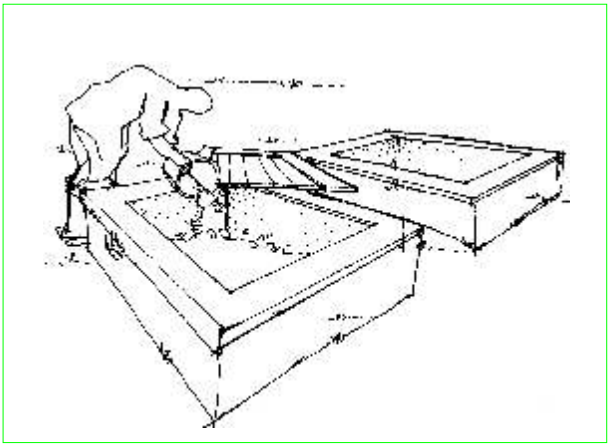


Figure 8.1 Secondary composting of faeces using two composting tanks alternatively

8.2.4 Application Procedure

Compost is rich in macro and micro nutrients as well as organic matter, which increases the water-holding and ion-buffering capacity of the soil, serves as food for the micro-organisms and is important for improving soil structure. The compost harvested can be applied to crops as a fertiliser and to improve soil properties. Faecal matter is especially rich in phosphorous, potassium and organic matter. Both organic matter and ash, which are often added to the faeces, increase the buffering capacity and the pH of the soil, especially important on soils with low pH. Organic matter also improves the structure and the water-holding capacity of the soil.

Compost can be applied to crops as given below:

- Compost should be applied and mixed into the soil preferably before cultivation or showing to ensure availability of phosphate for proper plant growth.
- Local application in holes or furrows close to the plants can make the nutrients available to the plants.
- The application rate of compost can be based on the current recommendation for the use of phosphorous-based fertilizers.
- It is better to apply compost supplemented with a source of nitrogen. Urine or urea fertiliser can be applied as a source of nitrogen.

8.3 Processing and Application of Urine

Urine harvested by installing ecosan toilets and waterless urinals can be utilised as a resource in agriculture. As urine contains macro nutrients such as nitrogen, phosphorus, potassium and sulphur, among others, it can be termed as quick acting multi-component fertiliser. Also, urine has very low concentration of heavy metals than conventional chemical fertilisers.

Presence of pharmaceutical residues in urine and its effects on crops is an issue being debated. However, other factors like the risks posed by pesticide residues in agriculture, use of sewage and animal manure which also contain high level of pharmaceutical residues for agriculture and the release of these in water bodies are of much higher concerns to be noted.

Higher nutrient (NPK) uptake by plants from liquid urine than from solid mineral fertilisers was observed. Crop trials conducted in India and various parts of the world have shown that crops fertilised with urine produce higher yield and show better plant characteristics. Therefore, by using urine as a fertiliser, small and marginal farmers from rural areas can benefit by replacing it with the expensive chemical fertilisers.

Urine which is usually sterile may get cross contaminated with faeces in the ecosan toilets. However, pathogens present in urine can be disinfected by storing urine for longer period. Hydrolysis of urea in urine into ammonia helps in disinfecting the pathogens. The table provided below contains the Swedish guideline for storage of urine for pathogen elimination from urine. Direct use with short time storage is adequate for urine collected from small domestic systems. Higher ambient temperatures in countries like India results in disinfection within a short storage period of 3-7 days.

Storage temperature	Storage time	Possible pathogens in the urine mixture after storage	Recommended crops
4°C	≥1 month	Viruses, protozoa	Food and fodder crops that are to be processed
4°C	≥6 months	Viruses	Food crops that are to be processed, fodder crops[d]
20°C	≥1 month	Viruses	Food crops that are to be processed, fodder crops[d]
20°C	≥6 months	Probably none	All crops[e]

[a] Urine or urine and water. When diluted it is assumed that the urine mixture has at least pH 8.8 and a nitrogen concentration of at least 1 g/l.

[b] Gram-positive bacteria and spore-forming bacteria are not included in the underlying risk assessments, but are not normally recognized for causing any of the infections of concern.

[c] A larger system in this case is a system where the urine mixture is used to fertilizecrops that will be consumed by individuals other than members of the household from which the urine was collected.

[d] Not grasslands for production of fodder.

[e] For food crops that are consumed raw it is recommended that the urine be applied at least onemonth before harvesting and that it be incorporated into the ground if the edible parts grow above the soil surface.

Table 8.4 Table Recommended Swedish guideline storage times for urine mixture[a] based on estimated pathogen content[b] and recommended crop for larger systems[c]. (Adapted from Jönsson et al., 2000 and Höglund, 2001) (Source : EcoSanRes)

8.3.1 Storage and Handling

Loss of ammonia must be controlled during storage and application processes. By keeping the storage containers of urine covered and use of very thin aeration pipes or use of one way air admittance valves, loss of ammonia can be reduced. Persons involved in application of urine must take precautions like wearing of gloves, boots and face mask. Sufficient care must be taken when inspecting large urine collection tanks due to high ammonia levels present in it. Hand washing with soap after urine application is also important. Phosphate precipitates settling down in urine tanks due to spontaneous precipitation can be recycled as fertiliser to crops.

8.3.2 Methods of Urine Application and Processing

Urine can be used in various ways to fertilise agricultural crops. Most preferred use is the direct application of urine after a short storage period. Direct application of urine is preferred if the urine collection sites are closer to agricultural fields and if the farmers have no reservation in using urine as a fertiliser. In the Indian context, other processing methods like struvite precipitation and co-composting of urine with organic matter can also be utilised. These two methods are ideal for farmers having reservations in handling liquid urine. Struvite precipitation reduces the cost of transportation of urine collected from urban areas to farms located at a distance.

8.3.2.1 Direct Application of Urine to Crops

Direct application of urine to crops can be carried out using various methods. Surface irrigation is one of the easiest and the most common method adopted widely. Other

methods like deep injection and drip irrigation are also practiced wherever possible.

Surface Application

- Urine can be directly applied on the surface of agricultural lands during land preparation and after planting crops.
- Urine must be applied to soil around the plants by creating furrows. The furrows should be covered with soil after application of urine to prevent loss of nitrogen through ammonia gas.
- Use of watering cans which are commonly used in home gardens can be ideal for application of urine.
- Watering the plants after application of urine is necessary if urine is applied undiluted.

Deep Injection

- Deep injection of urine up to 6 inches below the ground surface considerably reduces the loss of ammonia. This method is more suited for horticultural plantations where plant density is usually lower.
- Using subsoil injectors and pot irrigation method (use of PET bottles having small holes at bottom can be handy) deep injection of urine can be achieved at low cost.
- For large scale application to traditional crops, custom made mechanised agricultural tools can be designed for deep injection of urine.

Drip Irrigation

- Urine applied along with irrigation water and applied through drip irrigation.
- Fertilisation tank filled with urine to be applied to crops is connected to water mains carrying water for drip irrigation.
- Regular maintenance of emitters and tubes are necessary to prevent clogging.

Dosage

Urine should be applied to crops based on the nitrogen content in urine and the nitrogen requirement of the crops. The frequency of application of urine can be determined based on the nutrient requirement of the crop at various stages. The urine dose calculated for various stages of the crops can also be also split into several rounds of application. The decision to supplement the requirement of phosphate and

Deep injection with pot irrigation method

Deep injection through soil injector

Drip irrigation

Figure 8.2 Various methods of application of urine to agricultural crops apart from direct application

Crop	Recommended dose of fertilizer	Human urine litre / ha	Urine required per plant (litre)	SSP required kg / ha*	MOP required kg / ha*
Maize	150:75:40	50,000	0.9	-63	-67
Finger millet	100:50:50	33,333	0.6	-42	-47
Jowar	100:75:40	33,333	0.13	115	-22
Pearl millet	100:65:25	33,333	0.15	52	-47
Wheat	100:75:50	33,333	0.06	115	-6
Paddy	100:50:50	33,333	0.29	-42	-6
Chilli	150:75:75	50,000	1.69	-63	-8
Tomato	250:250:250	38,333	3.38	218	-2
Brinjal	125:100:50	41,667	1.13	182	-28
Radish	75:38:38	25,000	0.11	-28	-3
Banana	405:245:507	135,000	53.33	115	36
Sugarcane	250:100:125	83,333	2.25	97	478
* - sign denotes nutrients applied in excess quantity through urine, and these are not to be supplemented.					

Table 8.5 Recommended dose of urine for various crops in the Indian conditions - based on an average values of 0.45%N, 0.17%P and 0.16%K in urine. (Source : Dr C A Srinivasamurthy, GKVK, Bengaluru)

potassium is worked out based on the quantity of urine applied to crops using nitrogen as an indicator. The Table 8.5 provides the amount of urine required for some of the common crops grown in India.

Precautions

- While urine collected from a domestic system can be applied directly, the urine is collected from a public system, which has higher possibilities of cross contamination with faeces, must be stored for sufficient duration before it is applied to food and fodder crops.

- Application of urine to edible crops must be stopped one month before the harvest of crops.
- Urine can be applied to crops either diluted or undiluted. Urine can be diluted with water in the ratio from 1:3 to 1:15. Dilution with water reduces fertiliser burn, clogging of drip nozzles and odour problem. Applying undiluted urine has few advantages like handling of low volume of liquid and it can also be easily covered with soil after urine application in furrows. However, irrigation with water should be carried out after urine application.

- Urine should be applied to the soil around the plants and not onto the plant as it can cause “burning” of leaves.

- As urine contains chlorides, care must be taken when it is applied to chloride sensitive crops such as potatoes and tomatoes.

- As urine is rich in nitrogen, the other nutrients required by the crops must be supplemented with compost or chemical fertilisers.

- Caution should be exercised while applying urine in sandy areas having shallow aquifers to prevent leaching.

- Increase in the salinity of agricultural lands over a period of urine application must be taken into account. Measures like treatment with gypsum, crop rotation with salt tolerant crops and use of smaller pots where soil can be exchanged are some measures which can be adopted.

8.3.2.2 Recovery of Struvite

Struvite (Magnesium Ammonium Phosphate - $MgNH_4PO_4.6H_2O$) is a solid white crystal which can be obtained by the addition of magnesium to urine. White deposits often observed in choked urinal or sewage pipes are struvite formed due to naturally occurring precipitation reaction between phosphate and magnesium under favourable conditions like high pH and temperature. Recovery of struvite from urine makes it a favourable product for easy transportation and application to agricultural crops. This process also overcomes the problems associated with the direct application of urine. Application of struvite to agricultural crops is also beneficial due to its capability of slow release of phosphate and low heavy metal concentration.

Struvite from urine can be recovered as given below:

- Ammonium and phosphate in urine can be precipitated by the simple process of addition of magnesium.
- This process is carried out when urine kept in a closed container reaches a pH of over 8.
- Based on the phosphate concentration of stored urine, a magnesium dose in the molar ratio of 1.1 Mg to 1 P is dosed for struvite precipitation from urine.
- Magnesium sources like $MgCl_2$, $MgSO_4$, MgO and bittern (brine from salt pans) can be used for struvite precipitation from urine.
- Urine is dosed with magnesium in a specially designed reactor and stirred for 10 minutes to obtain struvite precipitates.
- After struvite precipitates settle in the reactor, these are separated from urine using filtration technique.
- The struvite precipitates so obtained are dried and used as a fertilizer to crops.

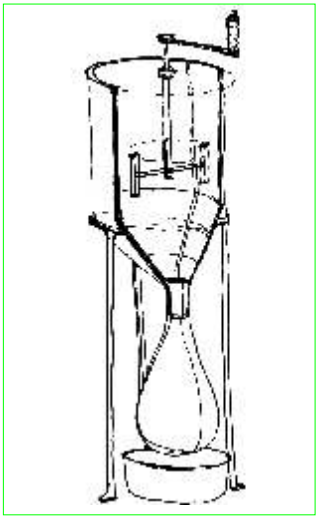


Figure 8.3 Struvite Precipitation Reactor

8.3.2.3 Co-composting

Urine can be applied to organic waste during composting to enrich its nutrient value. Although this is an emerging practice, there are few studies which successfully used urine for co-composting process. Use of urine also accelerates the composting process. This method is more suitable if farmers have reservation in directly handling liquid urine to crops.

The following aspects may be considered while co-composting with urine.

- Urine can be applied while composting organic waste.
- Studies have shown that maintaining 0.8%

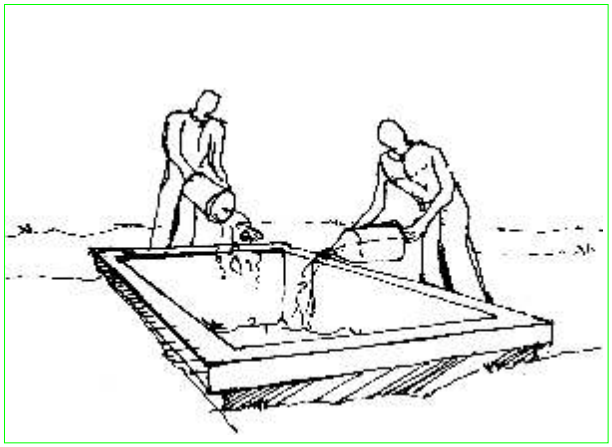


Figure 8.4 Co-composting of organic matter with urine

of nitrogen with the use of 10 to 20% of urine by volume in 3 split doses produces optimum results.

- Presence of nitrogen and phosphorous in urine enhances the nutrient value of compost.
- Higher composting temperature is observed in urine dosed compost heaps.
- Loss of nitrogen should be avoided while dosing urine in co-composting process.

Chapter 9

Implementation Framework

9. Implementation Framework

The TSC programme was amended to include promotion of Ecological Sanitation approach acknowledging its relevance for sustainable sanitation in general and relevance for ecologically sensitive regions such as coastal, flood prone, shallow water table, hilly and dry areas.

The revised TSC framework (para 9h of TSC guidelines) encourages promotion of ecological sanitation components that allow storage of human excreta and urine, for composting or converting to usable and safe manure or fertiliser. A note of caution states that ecosan should not lead to manual handling of night soil, and should not contravene any existing provisions of the law. These structures should be so located that they do not lead to contamination of existing water bodies, water table below ground, rain water or other water streams.

Under the revised TSC frame work, ecological sanitation components like urine diverting dry toilets, waterless urinals and other related technologies can be introduced at households, community sanitary complexes, schools and anganwadis. The revised frame work does not provide any special financial provisions for the promotion of ecological sanitation facilities which usually cost little higher than conventional leach pit toilets. However, within the existing financial allocations earmarked for household toilets, community sanitary complexes, schools and anganwadis toilets (refer table in chapter-1), ecological sanitation technologies can be promoted.

9.1 Strategies for Promotion of Ecological Sanitation

Ecological sanitation has been identified as an alternative and sound approach to conventional sanitation by many experts and organisations worldwide. It has the potential of bringing sustainability in the field of wastewater management and sanitation. The “Bellagio Principles”, a unanimous recommendation by a group of experts from a wide range of international organisations involved in environmental sanitation that met in February 2000 in Bellagio, Italy, calls for a new paradigm and approach in environmental sanitation. The revised TSC framework acknowledges this need and seeks to promote ecological sanitation in the rural areas of India.

As ecological sanitation is an inter-disciplinary field, there is an urgent need for an integrated approach towards its promotion with the involvement of practitioners from diverse sectors. Involving communities right through planning and implementation using participatory approaches are very important for the success and sustainability of ecosanitation initiatives. Capacity building is another important aspect that needs to be given adequate focus for the promotion of ecological sanitation. Capacities to appreciate and promote ecological sanitation systems especially through formal sanitation and agriculture education should also be considered. Ecological sanitation, which is a relatively new paradigm in the field of sanitation, requires further research,

Bellagio Principles - 2000

(1) Human dignity, quality of life and environmental security at household level should be at the centre of the new approach, which should be responsive and accountable to needs and demands in the local and national setting.

- solutions should be tailored to the full spectrum of social, economic, health and environmental concerns
- the household and community environment should be protected
- the economic opportunities of waste recovery and use should be harnessed

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

- decision making at all levels should be based on informed choices
- incentives for provision and consumption of services and facilities should be consistent with the overall goal and objective
- rights of consumer and providers should be balanced by responsibilities to the wider human community and environment

(3) Waste should be considered a resource, and its management should be holistic and form part of integrated water resources, nutrient flow and sanitation.

- inputs should be reduced so as to promote efficiency and water and environmental security
- exports of waste should be minimised to promote efficiency and reduce the spread of pollution
- wastewater should be recycled and added to the water budget

(4) The domain in which environmental sanitation problems are resolved should be kept to the minimum practical size (household, community, town, district, catchment, city) and wastes diluted as little as possible.

- waste should be managed as close as possible to the source
- water should be minimally used to transport waste
- additional technologies for waste sanitisation (sic) and reuse should be developed

(Source : WSSCC – SANDEC)

Table 9.1 Bellagio Principles

documentation and advocacy initiatives for effective application and scaling-up. Creating enabling environments through proper financial, institutional arrangements and implementation frameworks are essential to support communities and institutions to implement and benefit from concepts of ecological sanitation. Also, bringing synergies

Figure 9.1 Inter-disciplinary fields associated with ecological sanitation (GTZ)

between sustainable agriculture and ecological sanitation can bring about greater appreciation and knowledge on the potential of resource recovery from human and other wastes with the help of ecological sanitation concepts.

9.1.1 Project Planning and Implementation

Use of participatory methods is critical to ensure the success of hygiene and sanitation programmes and this would be true for ecosan also. Participatory methods support achievement of effective project planning and implementation, finding practical solutions and monitoring health and environmental impacts. Participatory methods can also improve communication both within and between the community and support agencies. Effective implementation requires a balance between local, traditional knowledge and outside expertise which becomes possible with a participatory approach. Another advantage of participatory approaches is their potential to stimulate self-confidence and creativity of the community members.

A variety of participatory tools used for implementing water and sanitation programmes have shown great deal of success. These participatory planning and implementation approaches developed so for mainly deal with conventional systems of water supply and sanitation. Therefore, these tools should be adapted wherever possible to the specific needs of ecosan programmes enabling them to address the philosophy of a closed loop approach to sanitation. Some of the participatory planning tools used successfully in water and sanitation programmes are given below:

Participatory Hygiene and Sanitation Transformation (PHAST) : Participatory hygiene and sanitation transformation (PHAST) is an adaptation of the SARAR (Self-esteem, Associative strengths, resourcefulness, Action-planning, and Responsibility) methodology of participatory learning to the specific context of sanitation issues. It uses a participatory approach to community learning and planning that follows a seven step framework: (i) problem identification, (ii) problem analysis, (iii) planning for solutions, (iv) selecting options, (v) planning for new facilities and behaviour change, (vi) planning for monitoring and evaluation, and (vii) participatory evaluation.

Open Planning of Sanitation Systems : The framework recommended by the EcoSanRes Programme is based on the Open Comparative Consequence Analysis (OCCA) methodology. This planning process is performed in five steps: (i) problem identification, (ii) identification of boundary conditions, (iii) terms of requirement, (iv) analysis of possible solutions, and (v) choice of the most appropriate solution. At least three options should be selected and presented to the stakeholders for evaluation and selection of the most appropriate solution based on the terms of requirement developed after the first two steps using participatory approaches.

Multi-Criteria Decision Support Systems (MCDSS) : Decision Support Systems (DSS) are derived from the theory of decision analysis and designed to help decision makers resolve issues of trade-offs through the synthesis of a variety of information. Multi-Criteria Decision Support Systems (MCDSS) are used when there is a need to identify trade-offs between of a variety of information, often including both quantitative and qualitative data, as is the case with sanitation. The advantages of using MCDSS in decision-making are that it can increase transparency, stakeholder participation, and optimisation by application of several criteria in

the decision process. The process of a MCDSS planning approach can be highlighted in six steps; (i) definition of the problem, goals and objectives, (ii) definition of Criteria, (iii) definition of Alternatives, (iv) definition of Preferences, and (v) decision Making.

Household Centred Environmental Sanitation Approach (HCES) : A relatively new tool for environmental sanitation is seen as being almost ideal for ecosan projects. This is the Household Centred Environmental Sanitation Approach (HCES), a new approach for planning environmental sanitation services, with the promise of correcting current unsustainable practices in planning and resource management by concentrating on two main components; (i) The focal point of environmental sanitation planning should be the household, reversing the customary order of centralised top-down planning. The user of the services should have a deciding voice in their design, and sanitation issues should be dealt with as close as possible to the site where they occur. With the household as the key stakeholder women are provided with a strong voice in the planning process, and the government's role changes from that of provider to that of enabler, and (ii) a circular system of resource management should be used emphasising the conservation, recycling and reuse of resources, in contrast to the current linear sanitation service system.

Community Led Total Sanitation (CLTS) : CLTS is an innovative methodology for mobilising communities to completely eliminate open defecation (OD). Communities are facilitated to conduct their own appraisal and analysis of open defecation (OD) and take their own action to become ODF (open defecation free). At the heart of CLTS lies the recognition that merely providing toilets does not guarantee their use, nor result in improved sanitation and hygiene. By raising awareness that as long as even a minority continues to defecate in the open everyone is at risk of disease, CLTS triggers the community's desire for change, propels them into action and encourages innovation, mutual support and appropriate local solutions, thus leading to greater ownership and sustainability.

9.1.2 Selection of Technology

Selection of suitable technology plays an important role in the success of an ecological sanitation programme. Ecological sanitation system to be implemented in an area should be selected based on various factors such as climate, availability of materials, geography of the area, agricultural practices, social factors, economic conditions of the population and technical skills available. Some of these factors are explained as below:

Climate : The factors like temperature, humidity and precipitation should be considered while selecting appropriate type of ecological sanitation system.

Materials : The availability of materials determines the suitability an ecosan system in an area. Civil works can be designed according to the availability of materials.

Geography : Type of land, soil and water table should be considered while designing ecosan systems as well as reuse of urine and compost for agriculture. These factors are critical for areas which area prone to floods.

Agriculture : The characteristics of local agriculture and home gardening should be taken into account while planning recovery and application of nutrients.

Social Factors : The customs, beliefs, values and

practices should be taken into account while planning the ecological sanitation systems. Especially promotion of source separation of urine and faeces, waterless urinals and recycling of nutrients in some communities require considerable amount of awareness and education.

Economic Condition : The systems designed must commensurate with the financial ability of communities to build. Identifying suitable options through participatory process help in overcoming this aspect.

Technical skills : The level of technology adopted should be based on the technical skills locally available or what can be created in an area.

9.1.3 Capacity Building

The following capacity building initiatives can be taken to effectively promote ecological sanitation systems :

Awareness Camps : Awareness camps conducted on ecological sanitation concepts targeted towards individual families, women's self-help groups and school children can play a very important role in taking forward the message to the communities. Identifying key leaders like political, religious and community leaders and involving them in the awareness creation activities can be very effective. Apart from these, awareness creation among sanitation workers, key NGOs in the area and officials and policy makers are also very important to provide impetus to the programme.

Mass awareness and door to door campaigns, cultural programmes, wall paintings, audio-visuals, pamphlets and brochures prepared on ecological sanitation can be utilized to raise awareness among the target group. Key messages related to ecological sanitation like advantages of ecosan over conventional sanitation systems, how to use and maintain ecosan toilets, benefits of nutrient recovery from waste, safe application of urine and compost in agriculture and success stories can be disseminated.

Training Programmes : Training programmes to impart skills related to promotion and management of ecological sanitation components including safe application of nutrients recovered from human waste for agriculture are very important. These training programmes can be imparted to community members, village level workers and officials involved in sanitation promotion. Also, targeted training programmes on the use of urine and compost derived from ecological sanitation systems can be conducted for officials from agricultural departments to actively engage them in the promotion of ecological sanitation.

Special training programmes for masons, engineers and sanitation workers who will be involved in the construction activities should be conducted exclusively. These programmes should involve practical teaching sessions on various construction aspects. Showing functional ecosan toilets during training programmes can bring about greater understanding among the participants. Therefore, a training programme should be organized either at a location where an ecosan toilet is functional or at least a model ecosan toilet is built prior to or during a training programme.

Exposure Visits : Taking people on exposure visit to locations where ecological sanitation systems are functional can be quite handy in transferring knowledge. Discussions exchanged

with communities already using these facilities will be a real eye-opener to the visiting members. Members from the target community, SHG members, innovative farmers, influential leaders, sanitation workers, school teachers, agriculture officers and other officials involved in sanitation promotion can be taken on such exposure visits. Works carried out by agencies like Scope (Trichy), GKVK (Bangalore), Ecosan Services Foundation (Pune) and many other locations (detailed list attached in annexure - X) can be chosen for taking people on exposure visits based on the available financial resources.

9.1.4 Pilot Demonstrations

Pilot demonstrations play a very important role in inspiring people to adopt ecological sanitation systems. However, it is very important to choose right locations and the beneficiaries for success of the initiative. A failed demonstration can create negative impression of the proposed initiative. Choosing locations of the pilot demonstrations where the users are keen to change their sanitation practice can be very supportive for creating awareness. The following types of pilot demonstrations can be undertaken to promote ecological sanitation.

Schools : Children in schools have successfully played the role of change agents in many water and sanitation programmes implemented worldwide. Providing ecological sanitation systems in schools can play a very vital role in creating awareness among the school going children, and through them to their families and the entire community. Ecosan toilets implemented in few schools across India have been well received by children. Therefore, providing ecosan toilets in schools prior to the initiation of community level interventions will result in positive impact through the child to child, child to family and child to community channels of awareness and motivation initiatives established. It also important to identify and train teachers who can take charge of the programme and impart hygiene and sanitation related skills to the children.

Public Places : Establishing pilot demonstration units in public places like local government offices, markets and other local places of importance where large numbers of people gather can help in taking the message forward. The type of pilot units chosen must be identified based on the long term interventions planned at the community level. Also, establishing proper systems of maintenance and safe up-keep of the facilities created are very crucial. Involving officials and staff who are keen on the systems is essential for success of the initiative.

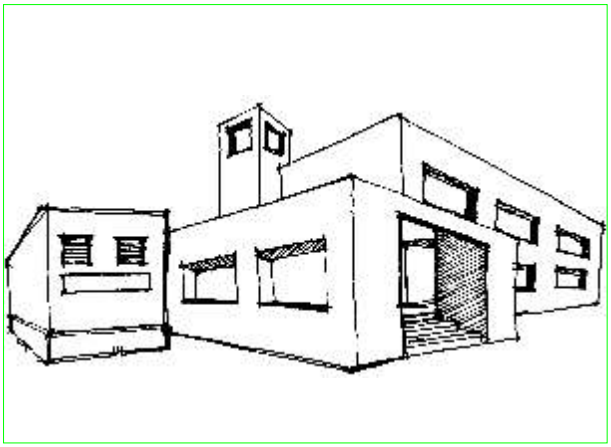


Figure 9.2 Promotion of ecosan toilets and waterless urinals in public places and schools

Model Families : Identifying enthusiastic families who can be role models to the entire community paves a very strong foundation for success of the initiatives. Such individuals can be identified through discussions with the community and observations by field level workers. After necessary training, ecological sanitation systems can be implemented in their houses. Periodical monitoring and support to the chosen model families are essential to

trouble shoot minor problems that emerge in the course of time.

Sanitation Parks : Sanitation parks which houses various demonstration units can be constructed to show case the various ecological sanitation options available to the communities. Such parks can be established at the Block / District level. These parks can be managed by NGOs or Production / Building centres. Other useful sanitation components like solid and liquid waste management options, rainwater harvesting techniques and water treatment techniques can also be included.

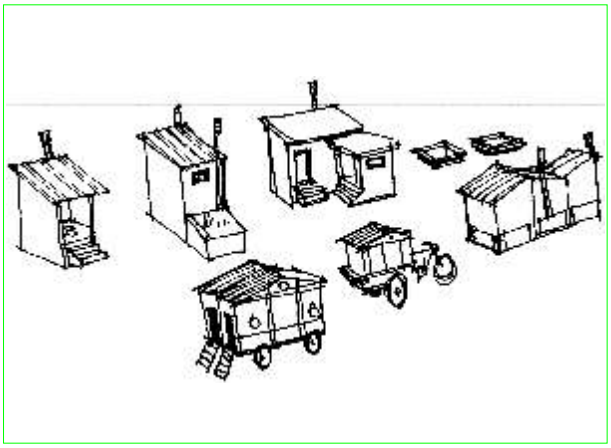


Figure 9.3 Demonstration of various technological options through sanitation parks

Agricultural Experimental Plots : It is very important to showcase the benefits of nutrient recovery for agriculture from human waste. By establishing agricultural experimental plots, the effectiveness of crops grown using human waste like urine and compost can be demonstrated. Such experiments can be conducted with the help of proactive farmers. Crop studies should be properly conducted with the involvement of agriculture experts so that the improved yield is recorded and displayed to the communities. Based on such experiments, appropriate dosage of urine / compost for various crops can be identified for the local area as well.

9.1.5 Supply Chain Mechanism

Instituting effective supply chain mechanisms can play a very vital role in supporting the demand created for ecological sanitation through awareness and education programmes. Aspects related to both hardware and software is essential for assisting people who are willing to construct ecosan toilets. Ensuring hardware support towards making the construction materials such as pans, slabs, pipes and plumbing materials available locally is very important. Similarly, the software aspects such as ensuring the availability of skills and knowledge to construct ecosan toilets are equally essential.

Production Centres / Sanitary Marts : Production centres / sanitary marts can be established to make hardware components that are essential for the construction of ecosan toilets. Existing units which are already involved in the production of sanitary items can also start producing ecosan related components. These units can stock essential components such as ecosan toilet seats, pipes, plumbing items, jerry cans, prefabricated ventilators and doors and concrete slabs. Based on the local availability of bricks, sand and cement, a decision whether to stock these items can be taken up. Setting-up of local production centres / sanitary marts managed by SHGs or NGOs can drastically reduce the cost of sanitary items as they can produce and sell these products at a reasonable price than private operators.

Local Entrepreneurs & Youth : Involving local entrepreneurs who are into construction activities can be beneficial. Also, local youth who are looking for employment can be trained in construction activities. Necessary training and incentives to take part in the programme should be devised considering the marketing sanitation approach. Creating a local workforce

can enable availability of skills within the communities for scaling-up and sustainability of the initiatives. As members of the local community, these trained individuals will be in a better position to motivate people to adopt ecological sanitation components.

NGOs : Local NGOs having rapport with the communities should be involved in promoting ecological sanitation activities. Their close interactions with the communities place them in an advantageous position to promote a difficult development component like sanitation. These NGOs should be trained along with necessary programme support to carry out work related to ecological sanitation. The potential of establishing sanitation parks, production centres and experimental plots with the NGOs should be explored for long-term sustainability of the initiatives.

9.1.6 Financial Instruments

SHGs / Banks : Making credit facilities available to economically weaker communities for construction of toilets provides greater impetus towards the achievement of sanitation coverage. Financing sanitation aspect is a well recognised need that has been identified by many successful sanitation programmes across India and abroad. Therefore, enabling credit facilities for constructing ecosan toilets, which also cost slightly more than conventional leach pit toilets, is essential. Women's self help groups and local banks can provide necessary credit to the needy families for construction of ecosan toilets. Therefore, involving SHGs in the promotion of ecological sanitation has an advantage. Linkages with banks for ensuring credit facilities must also be given importance to substantiate the credit requirement of SHGs. Therefore, the SHGs can effectively act as a channel of motivation and also fulfil the credit requirements for improving sanitation coverage.

Subsidy : Subsidy for sanitation has always been a contentious issue in the sector. However, an innovative resource oriented sanitation approach like promotion of ecological sanitation calls for additional financial allocations and sustained efforts at all levels. Especially schools and institutions which are willing to adopt these facilities require additional funds as they cost higher than conventional sanitation systems. The positive aspects offered by ecological sanitation systems such as conservation of water, prevention of environmental pollution, potential of nutrient recovery and long-term sustainability should be considered while designing financial instruments.

9.1.7 Maintenance and Follow-up

Ecological sanitation systems require proper care and maintenance compared to conventional sanitation systems. The families, school children and local communities involved in the programme must be trained to use and maintain these facilities properly. The users must know that improper use of any toilet may turn it into a nuisance, threaten public health, and pollute the environment. In addition, the users must be trained to take advantage of the significant resource potential of recycling plant nutrients using ecological sanitation systems. These relate to the safe handling, transportation and recycling of the outputs from ecological sanitation systems. For large-scale ecological sanitation programmes, it is also essential that a significant part of the local community shares this understanding and commitment.

Monitoring the functioning of ecological sanitation systems installed over a period of

time is essential after the implementation phase. Communities need handholding support to trouble shoot minor problems which may arise in the initial periods. Necessary supply of spares and skills required to sort out these problems must be made available locally. NGOs or production centres can stock such items. Implementing agencies must take these factors into consideration in the programme design.

9.1.8 Research and Documentation

Research and documentation on ecological sanitation systems is essential to show case its effectiveness and applicability in various conditions. Most studies that are currently available are from countries like Sweden, Germany and China where extensive research has been carried out. Therefore, there is a tremendous need for conducting research with respect to a vast country like India which has different agro-climatic zones.

The potential topics for research are developing norms for safe processing of urine and compost through various ecological sanitation systems, design aspects with respect to various geographical locations, urban and rural settings and cost efficient models, protocols for application of urine and compost to different agriculture crops and soils. Also, there is an urgent need to develop ecosan toilets designs that can suit people who want modern systems like in the pour flush toilets, and offer convenience to Indian users who are mostly washers.

Documentation and dissemination helps in scaling-up and wider replication of a successful programme. Ecological sanitation initiatives carried out by various individuals and agencies need to be documented and highlighted. It is important to document both the successes and failures of programmes. Various forms of print, electronic and audio-visual systems available can be made use of to highlight success stories to a wider audience. The lessons learnt from such studies can be incorporated into the awareness generation and capacity building initiatives taken up to promote ecological sanitation.

Chapter 10

Case Studies

10. Indian Case Studies

Case Study 1

Ecosan Community Composting Toilet

Considering the benefits of ecosan approach, the Musiri Town Panchayat of Trichy District in Tamilnadu approached Society for Community Organisation and Peoples Education (SCOPE) to renovate a dilapidated public toilet into a community ecosan toilet complex. SCOPE took up the challenge and constructed a community ecosan toilet complex which is being successfully used since 11th April 2006.

ECCT initiative

The Ecosan Community Composting Toilet (ECCT) complex functions just like a conventional toilet complex. Faeces, urine and wash water are separated at source using 3-hole ecosan pans (Fig 10.1). While composting of faeces collected in the faeces collection chambers provided below the toilet units, urine is collected in large tanks. Wash water generated is sent to a plant bed for disposal. Compost and urine collected from the ECCT is used as fertilizer for agricultural crops. For the purpose of community use, the ECCT has been designed with large volume of faeces collection chambers and urine collection tanks.

Figure 10.1 External View of the community ecosan complex (Source : R Sakthivel)

Although use of ecosan toilets differs from the conventional flush toilets, awareness and demonstration drives on the benefits and use of ecosan toilets helped in sensitizing the user group. For regular maintenance of the system, a caretaker has been appointed by the Panchayat. SCOPE provides regular support for the upkeep of the facility and managing the compost and urine generated. For the first time, "Use and Get Paid" scheme was piloted in 2008 to promote the concept of nutrient recovery to a wider audience. Under this scheme, the user is entitled to receive Ten Paise for each use, which is recorded and paid monthly. On an average, each family is being paid between Rs 25 to Rs 40 per month for using the toilet.

Other Special Features

- Pedestal type ecosan pans for elderly and physically challenged.
- Rain water harvesting facility in the campus.
- Incinerator in women's block for safe disposal of sanitary napkins.
- Adequate water facility ensured.

Design Features of ECCT	
? Site area – 2600 square feets	? Buckets and mug for carrying water
? Two blocks – 7 toilets in each (separate for men and women)	? Ash storage in buckets in toilets
? Size of the toilet – 7 ft x 5 ft x 7 ft (level from super structure)	? Message board inside each toilet
? Size of fa eces chamber – 6 ft x 3 ft x 5 ft (two per toilet)	? Ceramic tiling on walls and floors
? 3-Hole FRP Ecosan pans (two per toilet)	? Only mopping of pans and floors for cleaning
? No water taps inside the toilet	? Use of EM solution for cleaning
? Common water taps for water collection and hand washing	? Pipes are painted yellow (urine) and blue (wash water) for easy identification
? Mirror over wash basin	? Urine collected in a sump and wash water led to Canna Indica plant bed

Table 10.1 Design features of ECCT

Figure 10.2 View of a toilet in the community ecosan complex (Source : R Sakthivel)

Figure 10.3 Composted material being collected from a toilet chamber (Source : R Sakthivel)

- Room for storing ash and other tools.

Conclusion

SCOPE has constructed 5 ECCTs and 25 ecosan toilet complexes in schools in various parts of the State. The initiative shows that ECCTs can be successfully built and managed in locations where space for building individual household ecosan toilets is a constraint. Collection of faeces and urine in a central location offers tremendous potential for recovery of nutrient from human excreta.

The initiative, apart from reducing the environmental pollution, results in conservation of water and drastic reduction in the operation and maintenance costs. Low electricity consumption due to minimal water requirement and absence of periodic cleaning charges incurred for empting the septic tanks, which is necessary for the conventional toilet complexes built in rural areas, amounts to greater savings in the O&M costs.

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Case Study 2

Application of Urine as Liquid Fertilizer to Crops on Farmers Fields

Introduction

In recent years, Indian agriculture is more dependent on the use of fertilizers of fossil fuel origin. The consumption of fertilizers has increased, and it is expected that over the years, there would be acute shortage of raw materials required for the production of fertilizers. In this context, use of human urine as a liquid fertilizer which has appreciable quantities of nutrient elements required by the plants is one of the options to be explored. The Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Bangalore has been involved in conducting research studies on the possibilities of using human urine as a liquid fertilizer, and to study its impact on soil properties and yield crop.

Objectives

- To characterize human urine for its nutrient composition and pollution potential, if any.
- To study the short and long term impact of human urine on physical, chemical and biological properties of soil, yield and quality of crops.
- Agronomy evaluation of urine for crop production.
- To work out the cost economics of use of human urine for crop production.

Methodologies

The following methodologies were adopted in the research works carried out since 2006:

- Collection and analysis of urine for its physical and chemical properties.
- Green house experiments with radish as test crop.
- Field experiments of different crops both in the research farm and in farmer's fields.

Results

The research work has paved way for safe utilization of human urine as a liquid fertilizer. The findings of the research work carried out are as given below:

1) Urine is slightly alkaline in reaction, has appreciable amount of soluble salts and a low BOD and COD load. It contains appreciable amount of plant nutrient elements especially N, P and K in addition to secondary and trace elements required by crops. There is slight variation in the quality of urine depending on the age of the persons and the diet.

2) Human urine can be used as a supplement / alternative to chemical fertilizers as the crop yields are on par or slightly higher than that obtained from chemical fertilizers.

3) The crop quality was found to be on par or better in crops using urine as a liquid fertilizer.

4) The physical, chemical and biological properties of soil were not affected due to human urine application, but better properties were observed than found in chemical fertilizer application.

Quantity of urine required for meeting the Nitrogen requirement of crops and the cost economics for different crops is given below:

Figure 10.4 French bean crop grown using human urine in two splits doses (Source : GKVK, Bangalore)

Figure 10.5 Pole bean crop grown using human urine and cattle urine (Source : GKVK, Bangalore)

Crops	Recommended dose of fertilizers (kg / ha)			Quantity of Human Urine Required (lts)	Cost of Equivalent Chemical Fertilizer Required / ha (Rs.)	Total cost towards Human Urine + Fertilizers / ha (Rs.)	Savings (Rs.) / ha
	N	P	K				
Maize	150	75	40	50,000	3,599	719	2,881
Banana	400	240	500	1,33,333	13,473	5,792	7,681
Tomato (Hybrid)	250	250	250	83,333	10,265	5,464	4,801
Tomato (Local)	115	100	60	38,333	3,962	1,764	2,198
Brinjal	125	100	50	41,667	3,992	1,716	2,275
Chilli	150	75	75	50,000	3,862	1,250	2,612
Capsicum	150	75	50	50,000	3,674	1,250	2,424
French bean	63	100	75	21,000	3,533	2,323	1,210
Cabbage	150	100	125	50,000	4,815	1,934	2,881
Cauliflower	150	100	125	50,000	4,815	1,934	2,881
Amaranthus	100	50	50	33,333	2,575	833	1,741
Palak	150	100	100	50,000	4,628	1,747	2,881
Hebbal avarae	25	50	25	8,333	1,605	1,125	480

Table 10.2 Nitrogen requirement of crops and the cost economics for different crops

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Summary of yield in t/ha for different type of treatments studied							
Year of Experiments	Yield of Crops Studied in t/ha	Control	Regular Dose of Fertilizer (RDF)	Human Urine	Farm Yard Manure (FYM) + Human Urine	Cow Urine	Treatments Conducted
2007-08	Maize	40.37	79.37	80.95	n.d.	n.d.	Replications. 3. 10 treatment combinations - control & RDF as checks, RDN through human urine with & without gypsum applied to soils as in single dose and in 6 split doses
	Banana	19.38	28.41	30	n.d.	n.d.	Replications. 3. 10 treatment combinations - control, RDF as cecks, RDN through urine with & without gypsum applied to soils as in single dose and in 8 split doses
2009-10	Finger millet	2.11	n.d.	3.78	4	3.22	Treatment - I (for French bean, Ash gourd, pole bean & squash) Replications. 3. 14 treatment combinations - RDF&FYM alone, as checks, RDN through human urine & cattle urine (with & without gypsum applied to soils) in single application two & three split doses Treatment - II (for French Bean, Finger millet, Field bean, Tomato Brinjal, Bhendi & potato) Replications.3, Treatments: 9. Absolute control, 40% of N through human urine and cattle urine as basal and 60% N in 3 splits with and without gypsum applied to soil and 40% N through farm yard manure as basal and 60% N through human urine and cattle urine in 3 splits doses.
	French bean	1.19	n.d.	3.99	4.87	2.41	
	Hebbal Avare	1	n.d.	4.61	4.61	4.04	
	Tomato	16.6	n.d.	28.3	29.6	27.6	
	Brinjal	9.2	n.d.	32.5	33.6	29.6	
	Bhendi	7	n.d.	13.2	13.7	12.3	
	Potato	2.89	n.d.	5.59	6.68	4.82	
2010-11	Cowpea	2.32	3.2	3.05	4.37	3.14	Replications. 3. Treatments: 9. Absolute control, 40% of N through human urine / cattle urine as basal and 60% N in 3 splits with and without gypsum applied to soil and 40% N through farm yard manure as basal and 60% N through human urine and cattle urine in 3 split doses.
	Aerobic rice	2.99	5.02	5.36	5.54	5.2	
	Soybean	2.04	2.81	2.62	3.84	2.75	
	Finger millet	1.15	2.28	2.75	2.84	2.29	
	Maize	3.84	6.69	6.89	7.1	6.55	

Note: n.d. denotes study was not done

Table 10.3 Summary of yield in t / ha for different type of treatments studied

Case Study 3

Decentralized Wastewater Management

Introduction

A pilot project for demonstrating alternative decentralized wastewater management was implemented with the cooperation of Badlapur Municipality Council at “Adarsh Vidya Mandir School” located in Badlapur town, in Thane district, Maharashtra. The number of students attending Senior and Junior College is about 1,400 and 1,200 per day respectively. The project was initiated in the month of April 2006 was successfully commissioned in September 2008.

Project Objectives

The prime objective of the project is to meet the sanitation needs of the students and the people attending special programmes such as wedding ceremonies at the school premises, but also protects the environment and raises awareness amongst the students, about the importance of water and sanitation in promoting health and hygiene.

Technologies applied

A single-storied sanitation block having two independent enclosures for ladies and gents has been constructed next to the school building. Each enclosure is equipped with 4 bucket-flush squatting-type toilets and 1 western-style cistern-flush pedestal (for the physically challenged). Waterless urinals are provided in the gents' toilet block; while the ladies' toilet block has an increased number of toilets. Sufficient numbers of washbasins (3 numbers) are provided in each toilet block. A flow chart of the wastewater management scheme implemented is depicted in the figure 10.6.

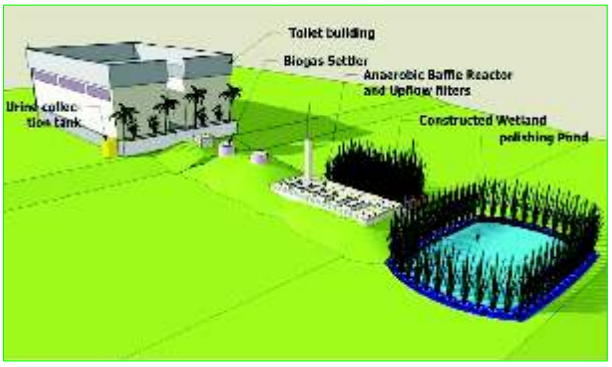

Figure 10.6

Blackwater along with greywater from the washbasins is discharged to a “biogas settler”, where solids are retained and subjected to anaerobic decomposition. The biogas settler effluent is drained by gravity flow to an Anaerobic Baffled Reactor (ABR) and Up-flow Filter (UF) for further anaerobic treatment. Post treatment of the UF effluent happens in a small-scale horizontal flow constructed wetland (HFCW). The final stage of treatment is a pond that doubles-up as storage tank.

Waterless urinals with membrane stench traps that are specially adopted to fit Indian urinals are provided in the gents compartment for the source-separate collection of urine, which is drained into a collection tank outside the toilet block. The tank is provided with a fail-safe overflow emptying to the anaerobic treatment plant. Treated water and urine will be used in a yet to be established kitchen garden. Sludge drying beds will be constructed for dewatering the sludge from the biogas settler, baffled reactor and up-flow filter.

Design information

In order to keep water consumption low, specially designed squatting pans (rural pour-flush pans) made of ceramic that require a little amount of water for flushing the excreta have been installed and no water taps are provided

inside the cubicles. The toilet users have to fetch water for cleansing and flushing with a bucket (approx. 5 litres) from a central tank that is located inside the enclosure. Daily total wastewater production (black water plus grey water) is estimated to be about 8.0 m^3 (i.e. 8,000 litres).

The hemispherical shaped biogas settler provides a volume of approx. 21 m^3 at an inner diameter of 1.25 m. The anaerobic baffled reactor volume is approx. 12.0 m^3. The reactor comprises 6 compartments of 2.0 m3 each and provides for 1.5 days hydraulic retention time at a wastewater production of 8 m^3/ d). The anaerobic up-flow filter volume is approx. 14.6 m^3. The up-flow filter comprises of 4 compartments of approx. 3.6 m^3 each. The height of the filter media (gravel of 40 mm diameter) is 0.75 m. Length and width of the horizontal flow constructed wetland is 6.00 m by 3.00 m. Main filter media is fine gravel with a grain size of 4 – 8 mm. Height of filter media (at inlet) is approx. 0.70 m. Saturated water depth is approx. 0.60 m. The pond has an effective volume of 12 m^3 at a maximum depth of about 1.20 m.

Benefits of Decentralised Wastewater Management

- The final effluent collected in the polishing pond is reused for irrigation purposes.
- The biogas produced (from biogas settler and the anaerobic baffled reactor) is used either for cooking / lighting purpose.
- The urine collected is used for agriculture / gardening within the school campus.
- The dried sludge from the biogas settler, baffled reactor and up-flow filter is applied as soil amendment within the school premises for agricultural / gardening purposes.

Operation and maintenance

For O&M of the toilet block and reuse of the recyclates, caretakers cum resource managers (1 female and 1 male person) are hired. Students will support the resource managers in their daily work (e.g. application of nutrients, gardening activities, etc.

Cost of Treatment System

Component	Cost (Rs)
Biogas settler	1,20,000
Baffled Reactor	1,20,000
Up-flow filter	1,20,000
Constructed wetland	50,000
Pond	40,000
Total	4,50,000

Conclusion

The project demonstrates that along with improved sanitation, recovery of useful products from decentralized wastewater management is possible. The campus has successfully substituted LPG by biogas and uses treated water and urine for agricultural purposes. The Badlapur Municipality Council is planning to replicate the concept in other areas of the municipality.

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Case Study 4

Improved Traditional Composting Toilets with Urine Diversion in Leh

Leh is situated in a mountainous desert 3,500 m above sea level in the Himalayas with long cold winters and severe water scarcity with rainfall below 100 mm per year. With modernisation happening around, the traditional sanitation system being practised in the Ladakh region has been gradually replaced by the waterborne toilet systems. This development gradually led to the increase in water supply problems and also pollution of surface and groundwater sources due to leakages and disposal of untreated wastewater. An additional problem of waterborne systems in this region is freezing of pipes during winters with temperatures reaching minus 30°C.

The Initiative

Ladakhi Ecological Development Group (LEDeG), an NGO working in the Ladakh region, has taken various steps to preserve and develop ways of living adapted to the local conditions and values. In order to revitalise the traditional sanitation system of Ladakh, LEDeG created a demonstration facility in its Ecology Center for visitors in Leh, apart from promoting few more household toilets. The toilet at LEDeG is used by the workers and visitors of the LEDeG Ecology Centre in Leh. It is based on the traditional local toilet system, improved by a black-painted vent-pipe (like in VIP latrines) to ventilate the collection chamber and reduce annoyance by flies.

Traditional Sanitation System

Due to an extremely dry climate it is possible to process human excreta indoors without prior diversion of urine, by using a combination of soil composting and dehydration. On the floor of a small room upstairs, typically in some distance 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 (September–May), a supply of soil is piled into one corner of the toilet room upstairs. A spade or shovel is also kept in the room. Normally there is no anal cleaning. The decomposed excreta are removed in spring and again at the end of summer 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 cases there might be 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 in recent years there have been some problems in the central part of the town of Leh where households have no easy access to soil."

Cost

The construction of the toilet was included in the ordinary construction of the Ecological Center. Total investment for the demonstration toilet was Rs 40,000 Indian Rupees. The costs for each ecosan toilet in a household was Rs 15,000 – Rs 20,000 INR. Direct economic benefits of the project are not described, but the complete dependence on natural fertilisers will prevent the farmers to buy artificial fertilisers for food production recovering all the nutrient contents

Figure 10.7

Figure 10.8

in human excreta.

Maintenance and Reuse

The issue of handling faeces is not a problem as in the upper Himalayas the composted excreta is seen as important resource for nutrients traditionally since centuries. The excreta material (plus soil) is traditionally collected for reuse as fertiliser and soil conditioner once a year by the families to grow barley or vegetables. Due to the very low temperatures, the material has not always finished the composting process before collection. It is therefore taken out, brought to a nearby field (200 meters) and covered with soil to finalise the composting process. After a period of 20-30 days, it is applied to the fields.

Conclusion

The improved sanitation system would be accepted if it is properly used and maintained. Improving the traditional system with ventilation increases the comfort of the system. Addition of ashes from the kitchen is added from time to time to reduces moisture and also improves the quality of compost. Creating awareness on the proper use of the toilet would help in misuse of the facility. The other problems like freezing urine in the diversion pipe during cold winters and extending the time of the storage time to minimise the pathogenic contamination have to be properly addressed.

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Case Study 5

Promotion of Ecosan Toilets using Bamboo in Manipur Region

Developmental issues, especially those related to health, water supply and sanitation have been largely ignored due to the constant conflicts between different ethnic groups in the Manipur region. Arghyam's intervention in Manipur had the twin purpose of beginning an attempt to address the water quantity, quality and sustainable sanitation issues and to glean an understanding of ground realities which would help in engaging deeper in the region. Arghyam partnered with two organisations: Wangjing Women and Girls Society (WWAGS) and Youth Volunteers Union (YVU) to field test ecological sanitation (ecosan) in 4 villages in Thoubal and Senapati districts.

Sanitation Situation

Statistics on sanitation from the physical progress report of the Total Sanitation Campaign (TSC) on construction of Individual Household Level Latrine (IHHL) shows that up to December 2009 only 7.18% construction had been achieved. The sanitation facilities built by people did not go beyond a basic superstructure. The sustainability of these facilities are suspect and they are also associated with public health issues as they emit foul odour, attract flies and maggots etc. As a user mentioned, often ducks and chicken fall into these pits and then move around the house, creating a health risk for the households. However, the community's need for privacy provided an entry point for construction of sustainable sanitation structures.

The project

Ecosan toilets were identified as a sustainable

Figure 10.9 An open pit toilet having only a superstructure for privacy used by families in the region (Source : Arghyam)

sanitation technology for the project sites as it was seen to have two distinct advantages over the earlier open pit model – convenience of use and reduction of health risks due to containment of faecal matter. The construction of 35 ecosan toilets (10 by YVU and 25 by WWAGS) was planned on a pilot scale. Since training was recognised as a perquisite for proper ecosan construction training sessions were also factored in for masons and NGO staff. The processes of community consultation and social mobilization were also embedded into the projects which were planned as coterminous with each other to ensure that the learnings would feed into an improved and scaled up implementation phase.

Challenges

The projects were posed with several challenges in the initial and mid-term because of steep rise in costs and challenges faced by users. The cost of construction of ecosan toilets was initially pitched at Rs 10,000. However, due to increase in price of the raw materials, the cost changed rapidly and almost doubled within a period of 3 months after the projects were commissioned. This steep rise in cost meant that the number of toilets proposed had to be rationalised. The unexpected inflation also led to serious concerns

about scalability and affordability.

Innovations

Use of bamboo: In order to address the issue of high cost, WWAGS and YVU used innovative construction techniques to bring down the costs. The North Eastern region has large reserves of bamboo, which were used for construction of superstructure of the ecosan.

Ecosan pans: Other innovations such as using a plastic bucket, sawed into half instead of a ceramic pan brought down costs by Rs 2000 per unit. Both the organisations also consulted with neighbouring NGOs with experience in constructing ecosan using novel techniques to keep their costs low.

Revolving fund: YVU also eased the burden of construction by setting up a revolving fund. Households were given a loan which added to their contribution to the SHG fund. As a critical mass of households started taking loans, the money pool for lending to other household increased. Thus, the external money acts as a seed fund and the balance is generated within the community.

Figure 10.10 Household ecosan toilet with bamboo super-structure (Source : Arghyam)

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Case Study 6

Promotion of Household Toilet Linked Biogas in Kerala

BIOTECH, an NGO established in 1994 in Kerala, specialized in the development of biogas digesters for the treatment of the organic fraction of MSW (OFMSW) and toilet waste. Different sizes of plants have been developed for use in domestic, institutional and municipal levels. Up to date, BIOTECH has installed over 16,300 domestic plants. Most of them have a volume of $1m^3$, but models with a volume up to 6m3 are also available, with a possibility to connect toilets. Apart from this, about 230 institutional and 46 municipal level plants with capacities upto $25m^3$ have been installed across Kerala by BIOTECH. Considering the advantages of prefabricated portable plants, BIOTECH is promoting domestic plants entirely with fibreglass reinforced plastic (FRP) in the recent years.

Domestic Biogas Plants

Domestic plants with a volume of $1m^3$ to $6m^3$ are available. The smaller ones ($1m^3$ and $2m^3$) exist with or without water jacket, whereas the bigger ones are all designed with water jacket. This technology, where the gasholder does not float directly on the effluent but in a filled water compartment, enables to minimise the gas loss and improves the cleanliness of the plant. For the models having a volume of $2m^3$ or more, BIOTECH offers the possibility to connect toilets in addition to the food waste input.

Advantages of FRP Biogas

- Less time is spent on transportation as the plants can be easily carried.
- Less time is spent to install the plant (Takes 2 days for RCC plant and only 2 hours are needed for FRP plants).
- No special manual skills are needed to install the plant.
- The excavation of a pit is not absolutely necessary. Reduction in labour charge and offers the possibility to installation of plants on the roof-tops.
- The FRP plants can resist salt water in the places close to sea.
- The attractiveness is better and the customers can even chose their preferred colour. In addition, as it is movable, they can take it with them if they move.
- The advertisement is easier and a road show can be used to promote them.

Figure 10.11 FRP biogas plant installed by BIOTECH in Kerala (Source: BIOTECH)

However, despite all these advantages, the price is a big drawback. Indeed, a $1m^3$ RCC plant costs about Rs 10,000 whereas a $1m^3$ FRP is about Rs 15,000. For a $2m^3$ toilet linked plant the price increased from about Rs 23,000 to Rs 33,000.

Anaerobic Co-digestion

The process anaerobic co-digestion to simultaneously treat faces and kitchen waste in

the same digester was adopted in toilet linked biogases. In the case of the co-digestion of food waste and toilet waste, the low C:N ratio and biodegradability content of the toilet waste are compensated by the high values characterizing those two parameters for the food waste. Thus, the major problem of ammonia toxicity due to low C:N ratio is avoided and the low biogas yield due to the small content of biodegradable matter is increased. At the opposite, the high content of macro and micronutrients of toilet waste compensate the relatively low content of those ones in the food waste. The so obtained effluent is a rich source of inorganic plants nutrients. If pathogens are not sufficiently inactivated during the AD process, an improper use of the fertilizer can lead to infection of the families.

Key Features

Technical performance: The monitoring of the ordinary biogas plant and the toilet linked biogas plant showed that both plants are working satisfactorily regarding their technical performance. The daily gas production of 680L is sufficient to cook the main dishes of a family.

Quality of the effluent: The toilet linked plant shows a very high reduction in pathogen content, but still, the concentration of E. Coli and total Coliforms only allows for restricted irrigation according to the WHO-guidelines for “safe use of waste water, excreta and greywater”. Therefore, the effluent is only fit for direct application to the roots of the crops or banana and coconut trees.

Economical Feasibility: The increased investment cost is a deterrent. Mass production of biogas plants to reduce cost and subsidy from Government is necessary for making it affordable. A positive aspect is the maintenance free operation of the systems, which turned out to be very robust and broken pieces are rare.

Social aspects: In general, acceptance of the toilet linked biogas systems among the people is very good and most families would recommend it to others. The improved waste management and the production of biogas were mentioned as the main advantages.

Conclusion

The promotion of toilet linked domestic biogas plants helps in increasing the benefits derived from improved sanitation. BIOTECH intends minimize the price by producing the plants at large scale. Continued assistance in the form of subsidies can help the aspiring families to install these plants while improving their sanitation status. Adopting precaution in the handling and disposal of effluent from the toilet linked biogas is highly essential.

Reference

For further details, contact
A Saji Das
Bio-Tech PB No. 520
MP Appan Road
Vazhuthacaud 695014
Kerala
www.boitechindia.org

Case Study 7

Promotion of Ecosan Toilets in Schools

School is important for cognitive, creative and social development of children. The School Sanitation and Hygiene Education programme plays an important role in ensuring safe, secure and healthy environment for children to learn better and face the challenges of future. The TSC and SSA programmes of the Government of India aims to ensure that all the schools have basic sanitation and drinking water facilities and good hygiene practices are taught to the children.

Ecosan Toilets in Schools

With this background, Wherever the Need India Services (WTN) gives special focus to school sanitation and hygiene promotion in the schools. The programme ensures that the hardware and software aspects are adequately addressed to bring about sustainable changes in the school as well as in the surrounding areas.

The need for ensuring adequate toilet facilities to commensurate with the student strength was indentified from the failure of many existing schools implement under TSC programme. To address this issue, WTN ensured that the adequate number of ecosan toilets and urinals were constructed for boys and girls separately. So far, WTN has constructed over 57 sanitary blocks in the states of Tamil Nadu, Andhra Pradesh and Bihar. The school ecosan toilets built by WTN ranges from 100 to 1500 student strength for primary to high school level.

Figure 10.12 School ecosan toilet in a primary school (Source : S Paramasivan)

Figure 10.13 Napkin vending machine installed in a girl's toilet (Source : S Paramasivan)

Strategies Adopted by WTN

- Involvement of child as a change agent to promote sanitation in the proven route of Teacher - Children - Family - Community
- Greater emphasis on attitude and behavioral change through hygiene education
- Child and disabled friendly water and sanitation design options
- School as knowledge center and teacher as facilitator / motivator
- School environmental cleanliness by plantation, solid and liquid waste management
- Participation of students, teachers and parents in O&M facilities created

Cost of the Toilets

The cost of school ecosan toilet unit varies from Rs 80,000 to Rs 7,35,000 based on the strength of the students in a school. Based on the local site condition, the cost of school ecosan toilet complex is substantially reduced by constructing roof cover over only the ecosan toilets and leaving the urinal area open. Use of eco-friendly local materials like mud blocks is also promoted as far as possible. Napkin vending machines and incinerators for safe disposal of sanitary pads are also installed in girl's toilet blocks.

Conclusion

The school sanitation programme by WTN shows that it can bring about significant changes in the sanitation situation in an area as the children can be a real change agents. Such changes evident based on the improvement in hygiene practices among the population and increased demand for household ecosan toilets in the programme areas. However, intensive health and hygiene education programme at least for a period of one year after the construction of the facility and regular follow-up visits later on ensures sustainability of the initiatives. Formation of Children maintenance committee is part of the initial work and motivating few teachers for follow up is very important. Menstrual hygiene is a topic which needs special attention.

For further details, contact :

S Paramasivan
Country Director
Wherever the Need India Services
Pondicherry
www.whereverthenеed.org.in

Case Study 8

Experience of Promotion of Household Ecosan Toilets and Reuse of Compost in Gujarat

Vankwad is a village located thirty-five kilometres in the north-east of Rajkot in Gujarat state. The village is typical of those found in this part of Gujarat, mainly given over to agriculture, especially dairy and subsistence farming. It is made up of 113 families with an approximate population of 1,400.

WATSAN Scenario

Water supply through the Government supply network is periodic with an indeterminate flow. There are four standpipes scattered around the village from which people collected water. An external water pump which was commissioned to complement the Government water supply got silted-up and became unusable. The two water storage units also got damaged and were unused. When the supply is not adequate, villagers collect water from the farm wells and / or the dam, a walk of three kilometres. A communal flush toilet with septic tank had also fallen into disuse (and disrepair) because of the lack of water and because people felt it was too far away to use frequently, even when there was enough water. With no other toilets in the village and most people defecated in the open.

Figure 10.14 A bath attached household ecosan toilet built in Vankwad (Source : S Paramasivan)

Figure 10.15 Ceramic ecosan pan with a common urine and washwater collection trough installed over a twin chamber ecosan toilet (Source : S Paramasivan)

The Project

At the beginning of the project implemented by the SSP with the support of WTN, a number of village meetings were conducted to educate and create awareness among people. Local people were formed as volunteers and some of the senior villagers were taken on exposure visit to ecosan projects in Tamil Nadu. The first part of the project was very straight forward as the water pump was repaired to provide a more constant supply of water to the village and school. The pump, linked to one of the repaired storage units to store water, is now being maintained by a local committee.

The preference of ecosan toilet units emerged in the village meetings particularly after their experiences with the existing communal unit. Many women also requested some form of bathing room to be attached to provide privacy for them and their children, especially daughters. However, despite the best efforts of local educators, it took far longer than normal to engage the village in the use and benefits of ecosan. There is no logical reason for this, but

may be due to some underlying resistance relating to the subject matter in general. The construction was very simple. Using locally quarried stones and porcelain ecosan pans produced in Gujarat, ninety-nine ecosan toilet units were constructed within one year in Vankwad.

Impact

A comprehensive visit one year later in November 2009 revealed outstanding results. The positive response was overwhelming. Ninety-one of the ninety-nine units were fully in use, five chambers had been opened and another seventeen were awaiting opening. The compost itself was very fine and dry. The first chamber opened in the village had 178 kgs of compost removed from it.

People constantly related positive stories of their experience after construction of the units. Everyone was positive. Mothers felt happier that the units provided their daughters with safety and privacy. One young boy explained how previously he used to help his grandfather walk to the fields so he could defecate, causing a great deal of awkwardness – now his grandfather used the family ecosan. Many times the words safer, privacy and dignity were used by the people.

Reuse of Toilet Compost

One farmer who was the first to use toilet compost on his farm had seen big differences in cauliflower crop and his observations were :

- Cauliflowers needed less water where compost was used
- Where pest attacks did occur only the infected plant needed to be uprooted rather than the whole crop, as before
- No family illness from pesticide covered residue in food, as suffered before
- Cauliflowers were larger & had more florets which led to a three fold increase in income
- Savings due to no pesticides purchased

Conclusion

The Self Help Groups (SHGs) that were formed during the early part of the project are all thriving and are now linked to other SHG Associations. There is a general increase in people's self confidence. Significant achievements like water connections for all houses, new houses for twenty eight families, new road and flooring for temple area have been possible with the increased unity and enthusiasm among the communities as a result of the project. Whereas previously teachers would refuse to stay in the village, there is now one female teacher who lives there, because the facilities have improved. One item that was highlighted was that people are healthier and visits to the fortnightly mobile medical clinic have reduced drastically.

Reference

Field Note on Ecosan Project Implemented by SSP and WTN in Gujarat

Figure 10.16 Cauliflower crop to which toilet compost was applied by a farmer in vankwad (Source : S Paramasivan)

International Case Studies

Case Study 1

Promotion of Eco-toilets in Gunagxi Province of China

In 1997-1990, the modified versions of the Vietnamese double-vault dehydrating toilets were installed in several provinces of China by the SIDA funded SanRes programme in cooperation with UNICEF and Chinese Ministry of Health. Many successful replications were carried out based on the work carried out in Dalu village of the Guangxi province. Following the success of the Dalu village pilot project the Yongning country party committee and Government of the Guangxi province decided to introduce eco-toilets in a comprehensive village improvement programme. By the end of 2000, 45 villages with a total population of nearly 10,000 had introduced the 'ecovillage' package, including double-vault eco-toilets with urine diverting fibreglass squatting pan.

Technical Details

- The toilets are placed indoors, usually on the second or third floor.
- Faeces drop through a 20 cm wide PVC chute down to a ground level double vault processing chamber.
- A baffle, similar to the one shown in Figure 2.5, directs the faeces to one of the vaults.
- A specially designed squatting pan diverts the urine to a ground level collection point from where it is either fed to the household pigs or used as fertilizer in the household's own vegetable garden.
- A vent pipe extending above the roof of the building ventilates the toilet room via the processing chamber.
- School toilets have pedal-operated ash dispensers developed specifically for the programme.

Factors Responsible for the Success of the Yongning Eco-village Programme

- Political leadership and sound administration
- Collaboration between government departments
- Strong technical guidance and effective use of demonstration models
- Effective mobilization of finance from central government, local government and villagers
- Building on tradition and actual living conditions, solving perceived problems
- Comprehensive approach linking sanitation, health, agricultural production and domestic and economic improvement.

Cost

At the household level, the actual construction costs for ecological sanitation are easy to calculate and can be remarkably low. In 2001, the total cost of materials for a typical eco-san toilet in Guangxi province was CNY 284 (= USD 35). This is only a third of the cost of a three chamber septic tank or a biogas toilet. Private entrepreneurs in different parts of China now produce several models of urine-diverting squatting pans. The pans are made of plastic,

fibreglass or porcelain and range in price from USD 5 to 10.

Conclusion

The development in Guangxi province in China is an example of the Vietnamese concept brought up to date. As the eco-toilets have a standard of finish equivalent to that of a modern urban bathroom and a vent pipe to reduce odours, most households in Guangxi prefer to place the eco-toilet inside the house. Following the success of the original pilot project more than 100,000 families in other parts of Guangxi province installed urine-diverting, ventilated, double-vault toilets inside their houses between 1998 and 2003. The total number of eco-toilets in China is estimated at 685,000 in 17 provinces (2003).

Based on the publication “Ecological Sanitation” by SEI, Stockholm, Sweden, 2004

Case Study 2

Use of Compost in Agriculture in Zimbabwe

The demonstration that human excreta can change into these soils and humus can be an important step in convincing people that something good can come out of practicing ecosan. When fully composted, toilet compost is pleasant to handle and safe to use. It can greatly enhance the fertility of very poor soils and can also be used as a potting soil or added to vegetable and flower beds.

Toilet compost varies a great deal in texture and colour depending on the amount and type of soil added. Where sandy soil has been added, the toilet compost is sandy and almost humus-free. Presence of dried out fly cocoons shows that the material was once excreta. Where fertile soil and leaves have been added, the toilet compost is much more humus-like. The humus-like sieved soil makes it an excellent potting soil for planting seedlings.

Compost from toilet pit

Toilet compost is obtained from Fossa Alterna or Arborloo. A test crop of spinach grown on poor soil was compared to spinach grown in the same poor soil mixed with an equal volume of pit compost. After 30 days of growth, the harvest was increased 7 times for the enhanced soil. The same growth test was done with covo grown on poor soil compared to covo grown on the same poor soil mixed with an equal volume of pit compost. After 30 days of growth, the harvest was increased 4 times.

For the lettuce growth test in poor and enhanced soil, after 30 days of growth the harvest was increased 7 times. The onion growth test in poor and enhanced soil produced similar results, with a harvest increase of nearly 3 times after four months of growth. In all of these examples, the use of urine would have enhanced the production further.

Compost from urine-diverting toilet

When the urine-diverting toilet is used, urine builds up in the urine chamber. A mix of faeces, soil, ash and leaves, builds up in the secondary composting unit. This final compost is rich in nutrients and also contains seeds which have passed through the alimentary canal. If the local diet includes tomatoes, then if this compost is placed in a container and watered young tomato plants will spontaneously grow.

Figure 10.17 Compost being removed from a Fossa Alterna

Figure 10.18 Comparison of lettuce grown in normal soil (left) and soil enhanced with compost (right)

Figure 10.19 Comparison of onion grown in normal soil (left) and soil enhanced with compost (right)

These may germinate in considerable numbers, but if most of the young plants are removed leaving the strongest two, the tomatoes will grow strongly using the nutrients contained in the bucket. Extra nutrients like diluted urine can be applied if necessary. The result of growing tomato plants in the urine-diverting toilet compost will be a healthy crop of tomatoes.

Growing trees using toilet compost

When an Arborloo is used the tree is planted directly in the toilet pit. But it is also possible to plant trees in toilet compost which has been excavated from a compost toilet pit and transferred to a hole dug specifically for a tree. The tree pit dug was 60 cm X 60 cm and 60 cm deep.

Toilet compost was dug out and the tree pit was filled with the toilet compost to ground level. In this example, the toilet pit compost was excavated from a Fossa Alterna pit after only 6 months of processing when it was not fully composted, instead of the recommended 12 months. However, the material was sufficiently composted to be easily transferred from the toilet pit to the tree pit. Bricks were laid around the tree pit and the pit filled again with good topsoil. A hole was dug in the middle and topsoil added to the base of the hole. A young mulberry tree was planted in the hole and the soil levelled. Leaf mulch was then added and the tree watered. After four months, the mulberry tree showed excellent growth and was in good health. As the tree grew extra mulch and compost was added. Manure and other fertilisers can also be dug into the soil as the tree grows and requires extra feeding.

Based on the SEI publication “Toilets that Compost” by Peter Morgan, Aquamor, Zimbabwe, 2007

Case Study 3

Promotion of Clivus Multrum Composting Toilets in Sweden

The “Clivus Multrum”, a single-vault composting toilet, was introduced for use in the weekend houses in Sweden more than 50 years ago. Since then a wide variety of models have come on the market and they are now used in different parts of the world, including North America and Australia. Commercially available composting toilets range from small units about the size of a standard flush toilet fixture to larger ones which utilize a simple toilet pedestal in the bathroom connected by a drop chute to a composting vault below the floor.

Design Features

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 at the 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. Into the Multrum, apart from faeces, toilet paper and urine but all kinds of organic kitchen and household residues: vegetable and meat scraps, peelings, bones, eggshells, floor sweepings, sanitary napkins and grass clippings (but not cans, glass, plastic or large amounts of liquids of any kind) are added.

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.

Operation and Maintenance

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 liquids and to provide the microbes required 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 litres per person per year. The maximum number of users depends on factors such as temperature, humidity, amount and type of refuse, proportion of urine to faeces, and volume of the receptacle. In most cases the maximum for one Clivus Multrum in regular, year-round use is 8 to 10 people.

Earthworms

Composting human excreta with earthworms is an important part of the ecology. Introduction of earthworms by daily misting with water for creating moist conditions inside Clivus showed remarkable effect on the composting process. Except for two mounds under the toilet and kitchen chutes, the rest of the composting material is flat. The materials inside were flattened by the worms with their castings covering the entire surface. Worms prefer food

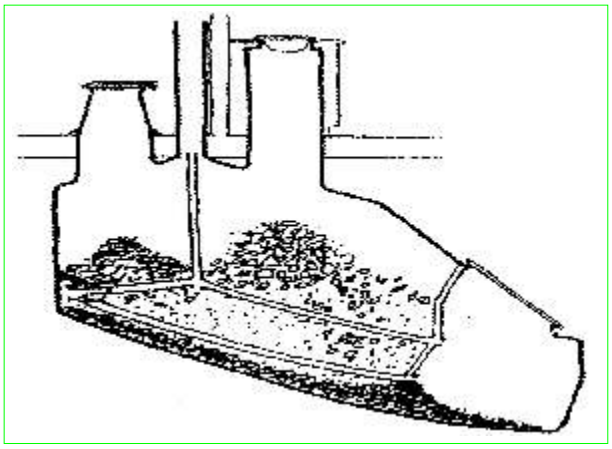

Figure 10.20 Clivus Multrum installed in the basement of a house has separate chutes connecting the toilet and kitchen along with a network of perforated pipes for aeration of the pile (Design: Richard Lindstorm, Sweden)

scraps to excrement but they like excrement just fine.

Conclusion

The humus from the Clivus Multrum has a similar bacterial content to soil. Presently, Clivus Multrums are used not only in weekend houses but also in the regular houses, in institutions and as public toilets. About 10,000 Clivus Multrum toilets are in use worldwide. In order to eliminate the problem of liquid accumulation at the lower end of the composting vault, the second generation models have been provided with a liquid storage below the composting vault

Based on the publication “Ecological Sanitation” by SEI, Stockholm, Sweden, 2004

Case Study 4

Promotion of Multiple-vault Composting Toilet "Carousel" in Norway

The "Carousel" is a multiple-vault composting toilet widely used in Norway. The "Carousel" is manufactured by Vera Miljö A/S of Norway, has long been one of that country's most popular composting toilets, and reportedly over 30,000 units have been manufactured there and in the US since 1972. A similar type is also manufactured in Sweden. Outside Scandinavia the carousel-type toilet is manufactured in Australia under the name of Rota-Loo. In addition to sales in Australia and New Zealand, Rota-Loos are in now in use on some of the islands in the South Pacific.

Design

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 (six 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.

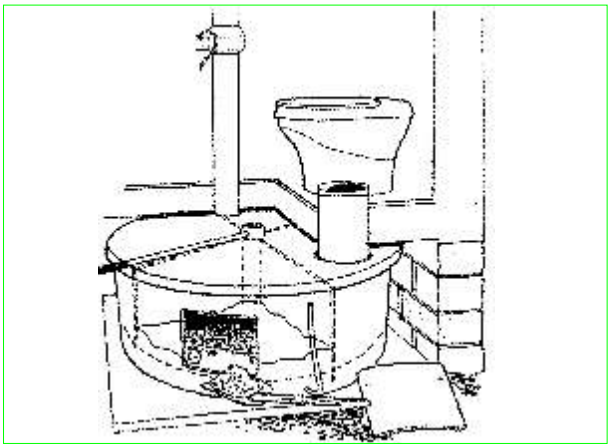

Figure 10.21 The 'Carousel' composting toilet installation below a toilet in Norway

The system is designed so that it will take at least a year for all of the chambers to be filled when use is within the design capacity of the unit. After this point, when a chamber is filled, 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. Several different size units of varying capacity are available at prices between USD 1,700 and 2,300 (SEK 14,000 to 19,000).

Conclusion

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

Based on the publication "Ecological Sanitation" by SEI, Stockholm, Sweden, 2004

Annexures

Indian Agencies Supplying Ecosan Toilet and Waterless Urinal Components

Agency	Contact Details	Product Details
i) Ecosan Toilets		
Eco-Solutions	Mr. Paul Culvert 'Pulari', 49 Asan Nagar, Vallakadavu Trivandrum 695008, Kerala Tel : +91 471 2502622 Email: paulc@vsnl.com paul@eco-solutions.org Web: www.eco-solutions.org	Fibre / Plastic Ecosan Pans
Prakash Ceramics	Mr. Prakash Vagadia Road, Thangadh - 363530, Gujarat Tel:: +91-02751-220856 Fax No.:+91-02751-220859 Email : prakasceramic@yahoo.in	Ceramic Ecosan Pans
Shital Ceramics	Mr. Jayesh Sompura 15, Milan Park Society, Nr. Swastik Cross Road, Navrangpura, Ahmedabad - 380 009, Gujarat Phone: +91-79-26402123 Fax: +91-79-26423061 Email: shitalcera@yahoo.com Web: http://ruralsanitation.net/	Ceramic Ecosan Pans
Energy, Environment and Development Society (EEDS)	Ajit Kumar Saxena R-12 GTB Complex New Market Bhopal, Madhya Pradesh Phone: 0755-2768369 Email: saxena.ajitkumar@gmail.com eeds@rediffmail.com, eedsngo@gmail.com	Micro Concrete Ecosan Pans
Fibro Reinforced Plastic (P) Limited	Mr. S.R.G. Nathan – Director #48 / B, 4TH “N” Block, Stage, Rajajinagar, Bangalore- 560010, Karnataka Phone: 091- 080 – 23121242, 23123071, 23123085 Fax: 091- 080- 23121242 Mobile: 9844010185 Email: fibro_reinforced@vsnl.net fibroeinforced@yahoo.com Web: http://www.frppl.com	Fibre Ecosan Pans
ARIES	# 169, New H Sector, Govindpura Bhopla, Madhya Pradesh, India Phone: +91-(0)755-2587777 Mobile: +91-(0)98-26065345 Fax: +91-(0)755-5221719 Email: ariesngo@rediffmail.com	Ecosan Pans

ii) Waterless Urinals		
Shital Ceramics	Mr. Jayesh Sompura 15, Milan Park Society, Nr. Swastik Cross Road, Navrangpura, Ahmedabad - 380 009, Gujarat Phone: +91-79-26402123 Fax: +91-79-26423061 Email: shitalcera@yahoo.com Web: http://ruralsanitation.net/	Low-cost membrane based waterless urinal odour trap with ceramic pan
Parryware	Available in all showrooms Web: http://www.eparryware.com	Sealant Liquid based waterless urinal odour trap with fibre/ceramic pan
Hindware	Available in all showrooms Web: http://www.hindwarehomes.com	Sealant Liquid based waterless urinal odour trap with fibre/ceramic pan
Falcon Waterless	West Coast Enterprises Pvt. Ltd. Sneh Centre, 4th Floor F.C. Road (Lalit Mahal Crossing) Shivaji Nagar, Pune 411005 Tel: +91 (93) 7161 7026 Email: info@westcoastwaterfree.com Web: www.westcoastwaterfree.com	Sealent Liquid based waterless urinal odour trap with fibre/ceramic pan
Eagle Build-Tech	Mr. Sanjay Sharma Plaza Cinema Connaught Place New Delhi Phone: 91-11-65661864 9818326052 Email: ip@eagle-grp.com	Bio-Blocks for waterless urinals
AG Aqua Solutions	17, Pusa Road, 2nd Floor Karol Bagh, New Delhi – 110005 Phone: 011 – 47999850/1/2/3/4/6/7 Mobile: +91 9899999339, +91 9711436534 Fax: 011 – 47999855 Email: sales@savewater.co.in Web: http://www.savewater.co.in	Mechanical air enclosing odour traps with fibre/ceramic pan

List of Resource Agencies

S. No.	Organization	Contact Person	Contact Details
1	BIOME , Bangalore	Mr S Vishwanath Director	1022, 6th Block, 1st Floor, HMT Layout Vidyaranyapura Main Road Vidyaranyapura, Bangalore – 560 097 Karnataka Phone: 91-80-41672790 Email: contact@biome-solutions.com Web: www.biome-solutions.com
2	Bio-Tech	Mr A Saji Das	Bio-Tech, PB No. 520, MP Appan Road, Vazhuthacaud, Thycad P.O, Thiruvananthapuram (Dist). PIN - 695014, Kerala, India. Phone: 91-471-2331909, 2321909 Email: biotechindia@eth.net Web: www.boitechindia.org
3	BLESS, Cuddalore	Mr Antony Samy Secretary	BLESS Learning Centre East coast Road Reddichavady Cuddalore:607402 Tamilnadu Phone : 91-0413-2615782, 2611047 Email: anthony@blessngo.org.in Web: www.bless.org.in
4	Centre for Science and Environment	Training coordinator	41, Tughlakabad Institutional New Delhi - 110062 Phone: 91-11-29955124 Email: cse@cseindia.org Web:www.cseindia.org
5	Consortium for DEWATS Dissemination (CDD) Society	Mr Joe D'Souza Advisor	621, 5th Main Road OMBR Layout Banaswadi Post Bangalore 560 043, INDIA Phone: 91- 80 - 25452804 Email: bangalore@cddindia.org Web:www.cddindia.org
6	Eco Pro - Auroville Environmental Initiatives	Mr Lucas Dengel Chief Functionary	Saracon Building, Kottakarai Auroville Tamil Nadu - 605 101 Email: lucasdl@auroville.org.in
7	Eco solutions	Mr Paul Calvert Chief Functionary	'Pulari', 49 Asan Nagar Vallakadavu Trivandrum - 695008 Kerala Phone: 91- 471- 2502622 Email: paulc@vsnl.com Web: www.eco-solutions.org

8	Ecosan Service Foundation	Mr Dayanand Panse Chief Functionary	Vishwa Chandra, 1002/42 Rajendra Nagar Pune – 411030 Maharashtra Phone: 91- 20- 64000736 Email: ecosan@ecosanservices.org Web: www.ecosanservices.org
9	Energy Environment & Development Society	Mr Ajit Kumar Saxena Director	R-12 GTB Complex, New Market Bhopal Madhya Pradesh Phone: 0755-2768369 Email : eedsngo@gmail.com
10	Environmental Sanitation Institute	Director	Gandhi Ashram, Ashram Road Ahmedabad - 390027 Gujarat Phone:91-79-7558052 Email: safai@icenet.net Web: www.esi.org.in
11	FODRA	Mr Madhav Naik Director	130, Neelgiri Appartments Sector-9, Rohini India, 110 085 Phone:+91-11-40686625 E-mail: fodra.delhi@yahoo.co.in Web: www.fodra.org.in
12	Indian Green Service	Mr C Srinivasan Director	Indian Green Service (IGS) Vellore Tamilnadu Phone: 09443318523 Email: velloresrini@hotmail.com
13	Indian Institute of Technology Delhi (IIT Delhi)	Dr V M Chariar Professor	Centre for Rural Dev & Technology IIT Delhi, Hauz Khas New Delhi 110016 INDIA Phone: 91 -11-2659 6358 Email: vijayaraghavan.chariar@gmail.com Web: web.iitd.ac.in/~chariarv
14	Indian Institute of Technology Kanpur (IIT Kanpur)	Dr Vinod Tare Professor	Dept. of Civil Engineering IIT Kanpur Room: 116 Western Laboratory Kanpur, Uttar Pradesh Phone: 91-512- 259 7792 Email: vinod@iitk.ac.in
15	Key Resource Centre Uttaranchal Academy of Administration	Dr Vinod K Mishra Programme Director	Uttaranchal Academy of Administration, Ardwell Camp, Mallital Nainital -263 001 Uttaranchal Phone : 91-5942- 236141 Email: krcntl@gmail.com Web: www.uaoa.in

16	Ladakh Ecological Development Group	Director	Karzoo, Leh Ladakh – 194101 Jammu & Kashmir Phone: 91-1982- 253221 Email: mail@ledeg.org Web: www.ledeg.org
17	Megh Pyne Abhiyan	Mr Eklavya Prasad Chief Functionary	C/o Dr.A.Sinha, Dr.R.V.P.Sinha Clinic Rajvibhuti, Salimpur Ahara Patna – 800 003 Bihar Phone:09810307445 Email: graminunatti@gmail.com
18	MYRADA KVK	Mr P Alagesan Director	272 – Perumal Nagar, Puduvalliampalayam, Kalingiyam – 638 453 Gobichettipalayam – Taluk Erode District Tamil Nadu Phone : 91- 04285- 241626, 241727 E-mail : myradakvk@gmail.com Web : www.myradakvk.org
19	National Research Centre for Banana	Dr K J Jeyabhaskaran Senior Scientist	Thogamalai Road,Thayanur Post, Tiruchirapalli - 620 102 Tamil Nadu Phone : 91-431-2618104 Email: jeyabaskaran_kj@yahoo.com Web: www.nrcb.tn.nic.in
20	Nirmal Gram Nirman Kendra	Mr Srikant Navrekar Director	At Govardhan, PO Gangapur, Nashik - 422222 Maharashtra Phone: 91-253-2231598 Email: nirmalgram@rediffmail.com
21	People's Learning Centre for Water and Sanitation	Mr Praveen Bhikadiya Programme Coordinator	C-1157, 1st Floor, Manu Raja Chamardiwala Opp. SBS, Kaliyabhid Bhavnagar 364002 Gujarat, India Phone: 91-278-2573061 Email: plcwatsan@dataone.in Web: www.plcwatsanutthan.org
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23	Ramakrishna Mission Lokasiksha Parishad	Mr Chandi Charan De Co-ordinator	Po Narendrapur Kolkata - 700103 West Bengal Phone: 91-33-24772201, 33-24772070 Email: rkmwatsan@gmail.com

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Comments and suggestions on this manual are welcome.

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