

Assessment of the Appropriateness of Compost Toilets in Sri Lanka: 17 Key Questions

*(Report 2 of 3 from "Evaluation of the Appropriateness of Ecological
Sanitation in Relation to the Social, Cultural and Economic and
Financial Context of Sri Lanka")*

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TABLE OF CONTENTS

SUMMARY OF RESEARCH ON KEY QUESTIONS A - P	i
FINDINGS OF RESEARCH ON KEY QUESTIONS A - P	
Question a: Is the dry composting toilet appropriate for any age group?.....	1
Question b: Is the dry composting toilet appropriate for pregnant women?	2
Question c: Does dry composting toilet require special user’s instructions for menstruating women?.....	2
Question d: Does the content, texture and humidity of excreta influence the performance of composting toilet?	3
Question e: Does the nature, composition and pH of the additive (ash, sawdust, soil...) influence the performance of dry composting toilet?	3
Question f: Do air humidity and temperature in the composting chamber influence performance?	3
- Composting.....	4
- Climate in Sri Lanka.....	6
Question g: Is the compost obtained sanitized and totally free of harmful pathogens?	7
- Treatment.....	7
Question h: What is the capital cost of a 5 member’s family dry composting toilet, compared to a standard pour-flush toilet connected to a septic tank?	9
- Compost toilet	9
- Standard Pour-flush toilet connected to a septic tank.....	9
- Total Capital Cost.....	9
- Relative Capital Cost.....	14
Question i: What are the running costs (operation and maintenance) of a 5 members’ family dry composting toilet compared to potential cash benefits ...	11
- Operation and maintenance	11
- Cash benefits – Cost Benefit Analysis	12
- Net Present Value of Compost Toilet.....	16
Question j: What are the key marketing ingredients to generate demand for dry composting toilets from middle income and well off families in the Sri Lanka?	20
- Marketing	20
- Demand of middle income and well off families in Sri Lanka.....	21
Question k: What are the main institutional obstacles that would prevent ecological sanitation to go to scale?	22
- Legal situation regarding compost toilets in Sri Lanka	22
- Up-scaling ecological sanitation.....	22
Question l: Is it possible to design a mechanism to cover the solid excreta with ash or any other decomposing material?.....	23
Question m: Is it possible to have a flushing system for the urinal and washing area? Is it possible to design a bidet for urine and washing?.....	24

Question n: What are the different options for the disposal of water and urine?	26
- Storage and active reuse	26
- Drainage and passive reuse.....	29
- Constructed Wetland (no reuse)	31
Question o: What is the possibility for this toilet to be included into a bathroom? If it is possible what is the space requirements?.....	32
Question p: Can we use this toilet for multi-storied buildings?	33

ANNEXES

Annex 1: Estimation for the Construction of Dry Compost Toilet and Pour-Flush Toilet Underlying design of Dry Compost Toilet and Pour-Flush toilet	
Annex 2: Retail / Producer Margin for Selected Food Items, Second Quarter - 2006	

FIGURES

Figure 1: Technical drawing of seat riser	24
Figure 2: Urine Diverting Dry Toilet with individual storage.....	27
Figure 3: French drain and soil infiltration bed.....	30
Figure 4: Example of dry compost toilet with soil infiltration bed	31
Figure 5: Typical Arrangement of a seepage bed adapted from SLS 745.....	31

TABLES

Table 1: Temperature in Sri Lanka.....	6
Table 2: Recommendations for storage treatment of dry excreta and faecal sludge before use at the household and municipal levels.....	7
Table 3. Unit cost of implemented pour-flush and dry compost toilets in Sri Lanka	10
Table 4. Operation and maintenance cost for dry compost toilet over 10 years	12
Table 5. Estimated excretion of nutrients per capita in different countries.....	14
Table 6. Prices for compost in Colombo	14

BOXES

Box 1: Health protection measures.....	8
Box 2: Development of national guidelines.....	8
Box 3: Supply and Demand of Fertilizer in Sri Lanka.....	17
Box 4: Organizations active in ecological agriculture.....	17
Box 5: Market for organic fertilizer in Sri Lanka.....	18
Box 6: Large scale applications.....	18
Box 7: USAID project on Urban Waste management.....	18
Box 8: What is different about Social Marketing?.....	20
Box 9: Steps for marketing ecological sanitation in Sri Lanka	21
Box 10: Dong Cheng, Inner Mongolia, China.....	34
Box 11: Gerbers Stockholm, Sweden.....	34

Summary of Research on Key Questions a - p

Question a: Is the dry composting toilet with separation of urine and water from solid excreta appropriate for any age group: children, adolescent, adult and old people?

The dry compost toilet is appropriate for any age group.

Question b: Is the dry composting toilet appropriate for pregnant women?

Yes, the dry composting toilet is appropriate for pregnant women

Question c: Does dry composting toilet require special user's instructions for menstruating women?

ALL users of compost dry toilets should be informed that non-biodegradable materials, including tampons and sanitary pads, should not be left in the faecal chamber. A disposal bin should be provided.

Question d: Does the content, texture and humidity of excreta influence the performance of composting toilet? (For instance would frequent liquid stools hamper proper performance?)

No, the content, texture and humidity of excreta do not influence the performance of a dry composting toilet. If the faeces chamber should become too moist, additional absorbing material like wood, dust or ashes can be added.

Question e: Does the nature, composition and pH of the additive (ash, sawdust, soil...) influence the performance of dry composting toilet?

Different additives do not influence the good performance of the dry compost toilet.

Question f: Do air humidity and temperature in the composting chamber influence performance? What are the optimum ranges of humidity and temperature and are they compatible with local conditions?

Urine diverting dry toilets perform in cold, temperate and tropical climates. The ambient conditions in Sri Lanka, temperature 20 – 27 °C and relative humidity 70% - 90%, favor composting. The design and usage of the compost dry toilets in Sri Lanka favor and hinder composting. A combination of processes takes place.

Question g: Is the compost obtained sanitized and totally free of harmful pathogens?

The compost obtained from a properly operated compost toilet after the recommended storage time of one year is hygienically safe to handle. Reasonable minimum requirements of good practice to protect the health of the people using treated excreta should be established. The storage time could be decreased if the storage conditions comply with the respective recommendations of the WHO *Guidelines for the safe reuse of wastewater, excreta and greywater*.

Question h: What is the capital cost of a 5 member's family dry composting toilet, compared to a standard pour-flush toilet connected to a septic tank?

The range of capital cost for pour-flush toilets connected to a septic tank and soak pit is 48,000 LKR to 79,000 LKR. The range for dry compost toilets is 21,000 LKR to 37,000 LKR. The capital costs are determined by the design of the toilet, the chosen technology, geographical conditions and local market prices. Due to the higher tax and the unavailability of material the cost in Jaffna are up to 25% higher than in the South of Sri Lanka. The capital cost of a compost toilet is 83% (capital cost (compost and evaporation bed) / capital cost (pour-flush and soak pit) of the capital cost of a pour-flush toilet. 17 % of the capital cost can be economized by building a compost toilet instead of a pour flush toilet.

Question i: What are the running costs (operation and maintenance) of a 5 members' family dry composting toilet compared to potential cash benefits (taking into account current market value of produced compost and of bananas/pineapple grown with urine/water)

The cost of operation and maintenance (O&M) of a compost toilet in Sri Lanka are estimated for a worst case scenario to be 35,190 LKR over a period of ten years. Local prices for compost range between 6 and 35 LKR per kg compost. The theoretical cash benefit from compost over a period of ten years was estimated 9,380 LKR. The value of Nitrogen and Potassium in the produced urine was estimated 6,612 LKR over ten years. Phosphorus was not considered.

The net present value of the dry compost toilet is estimated 31,000 LKR, 55% of the NPV for a pour-flush toilet (56,700 LKR). This makes the compost toilet by far the better investment. This rough estimation does not substitute a comprehensive Cost-Benefit-Analysis, exploring different scenarios and collecting data for correct assumptions!

Question j: What are the key marketing ingredients to generate demand for dry composting toilets from middle income and well off families in the Sri Lanka socio economic and cultural contexts?

The compost dry toilet should not be a compromise but a desirable option. Reuse of material, is not the driving factor for demand in middle income and well off families. Environmental considerations could be marketed for environmentally conscious target groups. Up market dry compost toilets as solution for water scarce areas, areas with difficult soil conditions and high groundwater table can be marketed for middle income and well off families. Cost efficiency, design and user friendliness are the key marketing ingredients for creating demand in middle income and well off families.

Question k: What are the main institutional obstacles that would prevent ecological sanitation to go to scale?

Dry compost toilets are an approved technology by the Ministry of Health. However, the information did not reach the local level yet. Currently a handout for the local level is under preparation. For ecological sanitation to go to scale relevant legislation regarding the reuse of human excreta and greywater has to be adapted. So far the reuse of human excreta is not addressed. Relevant legislation has to be streamlined. Responsibilities have to be defined.

Question l: Is it possible to design a mechanism (similar to flushing the toilet) to cover the solid excreta with ash or any other decomposing material instead of the existing method of manually covering with ash after using of the toilet?

Yes, it is possible to design a mechanism (similar to flushing the toilet) to cover the solid excreta with ash or any other decomposing material. In China these mechanisms already exist. They have to be operated with the foot. One presses the foot pedal, which pulls a cable and opens a valve in the pipe. This releases an amount of ash down the pipe. The supply of ash is stored in the "cistern" at the top.

Question m: Is it possible to have a flushing system for the urinal and washing area? Is it possible to design a bidet for urine and washing, where this system would also become a similar system to use of water closet and bidet?

Yes, it is possible to have a flushing system for the urinal and washing area. However, ecosan toilets aim at reusing urine as fertilizer in agriculture. If the urine is not to be used at household level and has to be stored a minimum dilution is desired. To design a bidet for washing is possible. It should not be used for urinating.

Question n: What are the different options for the disposal of water and urine?

The different appropriate options for the disposal of water and urine, with **bold** options recommended, are:

- Storage and active reuse of urine
 - o **Individual storage and reuse**
 - o Semi-central storage
 - o Central storage
- Diversion and passive reuse of water and urine
 - High ground water table
 - o **Evaporation bed**
 - o French drainage
 - Low ground water table
 - o **Soil infiltration bed**
 - o Seepage bed
 - o Seepage trench
- Diversion of water and urine to constructed wetland without reuse

Question o: What is the possibility for this toilet to be included into a bathroom, together with the wash basin and the shower or any other modern facility? If it is possible what is the space requirements?

There is no problem to include UDDTs in a modern bathroom. No specific space is required.

Question p: Can we use this toilet for multi-storied buildings? (flats & Apartment buildings)

Urine Diverting Dry Toilets (UDDTs) can be used for multi-storied buildings. There are several installations in different countries, e.g.

- o Sweden - 2 storey,
- o China 4-5 storeys,
- o India 2 storeys,
- o Uganda 2 storeys, and
- o Ethiopia 3 storeys.

Findings of Research on Key Questions a - p

Question a: Is the dry composting toilet with separation of urine and water from solid excreta appropriate for any age group: children, adolescent, adult and old people?

The dry compost toilet is appropriate for any age group. Often compost toilets are considered supposedly not suitable for old people and children. Therefore, users of compost toilets in Sri Lanka were asked particularly if these age groups would have any problems using the compost toilet. The problems stated in interviews were the high steps, the missing handrail, the squatting, and misuse by children and visitors. These problems are not confined to one age group and apply to disabled persons. All the stated problems are not easily addressed. The height of the steps can be decreased, a handrail can be attached. Photograph 1 shows a compost dry toilet in Matale. Because of the high steps the users attached a handrail for the elderly and the children. Like the other potential problems, the squatting is not a specific problem of the compost toilet and could be easily solved with a seat riser. Education is crucial to prevent misuse by users of any age group. Illustrations should be posted in the toilet to explain the use. None of the compost toilets visited in Sri Lanka was equipped with illustrations. Misuse problems are likely.

Children:

Users which converted their compost toilet to a pour flush toilet (Sites 1 & 12) sometimes stated children as a problem. Children would not be able to use it right. However, other households with small children are using their respective compost toilet without problems. It is obvious that education and instruction of the children is essential for the successful use of composting toilets. Problems which could arise for children are related to the size of the hole and the steps. The diameter of the holes could easily be reduced with a special device to put on the whole. The size of the steps can be minimized.

Old persons:

For old people usage problems mostly derive from joint pains or/and the incapability to squat. These problems can easily be addressed by changing the height of the steps or building a ramp and constructing a seat riser instead of a squatting slab. However, people who have problems squatting will also have a problem with a pour-flush toilet and not with a compost toilet only.

Adolescent, adult

Healthy adolescents and adults will not face particular problems. Men should squat for urinating. In Sri Lanka men squat and stand for urinating. If a behavior change is not possible a urinal should be provided.

Special attention should be given to the design of composting toilets for disabled people whatever age they are. Composting toilets can also be designed for handicapped people. They can have a ramp or be built on ground level.



Photograph 1: Dry Compost toilet in Matale with handrail attached by user (Photo: UNICEF, 2006)

Question b: Is the dry composting toilet appropriate for pregnant women?

Yes, the dry composting toilet is appropriate for pregnant women. Potential problems could be squatting and climbing of steps. None of these potential problems were stated by users which are currently using or used the toilet during pregnancy (Sites 2, 9 & 11). The problems with climbing or/and squatting can easily be addressed by lower steps and a seat riser.

Question c: Does dry composting toilet require special user's instructions for menstruating women?

ALL users of compost dry toilets should be informed that non-biodegradable materials, including tampons and sanitary pads, should not be left in the faecal chamber

Practice in Sri Lanka

In Sri Lanka the majority of women use cloth, referred to as "belt system", during their menstrual cycle. The used cloth will be washed and used again. Tampons and sanitary napkins are used mainly by women from middle and high income level. If tampons or sanitary napkins are used, they are wrapped up in paper and disposed off into the rubbish or/and burnt. Tampons are also flushed down the toilet, which is not recommended. In Sri Lanka it is not common to have a bin in the bathroom. Women use water for cleansing after defecating and urinating.

General Consideration

"Since sanitary napkins and tampons are mostly composed of non-biodegradable materials, they should not be disposed of in the faeces chamber. Instead, wrapping materials and a proper container for disposal should be provided. Depending on the solid waste management of the community, these materials can either be burnt or put with the residual solid waste." (WECF). Regarding the disposal of sanitary napkins and tampons there is no difference between the use of a pour-flush toilet and a compost toilet. Tampons and sanitary napkins should not be flushed down the toilet or disposed off into the compost chamber. A bin for the disposal of non-biodegradable material should be provided.

"During a woman's menstrual cycle, blood will inevitably enter the urine and faeces chambers when she is using the dry urine-diverting toilet. This organic material poses no threat to the sanitising or composting process in either the urine or faeces chamber nor to its future use as agricultural fertilizer or compost." (WECF) Traces of blood could be left after a woman uses a dry urine diverting toilet. This purely aesthetic problem is not relevant for Sri Lanka since water is used for cleaning after urinating and defecating. Blood is normally washed down.

Stakeholder Participation

Interviews with implementing stakeholders showed that this question was not considered in the planning process. However, it is important to include women in the planning and particularly the design process and also tackle sensitive issues such as menstruation. Before developing a new design the future users of the compost toilet have to be consulted. The experiences of users of the already existing pilot projects should be utilised. Interviews have to be conducted using a gender sensitive approach.

References:

- WECF (?), *Ecological Sanitation and Hygienic Considerations for Women*, Fact Sheet, Women in Europe for a Common Future (WECF), Utrecht
 Yolanda Foster (2006), personal communication
 Himali de Silva (2006), personal communication
 Olinka Randeniya (2006), personal communication

Question d: Does the content, texture and humidity of excreta influence the performance of composting toilet? (For instance would frequent liquid stools hamper proper performance?)

No, the content, texture and humidity of excreta do not influence the performance of a dry composting toilet. If the faeces chamber should become too moist, additional absorbing material like wood, dust or ashes can be added.

Question e: Does the nature, composition and pH of the additive (ash, sawdust, soil...) influence the performance of dry composting toilet?

Different additives do not influence the good performance of the dry compost toilet.

Possible additives are ash, lime, sawdust, dry soil, fruit husks, peat moss, etc. After each use the respective additive is sprinkled over the faeces to absorb moisture, prevent bad odors and insects and, in the case of alkaline additives, to increase the pH. The exact amount depends primarily on the users experience with their system. (GTZ 2005)

However, different additives do influence the sanitization process. Sanitization processes in a urine diverting dry toilet (UDDT), such as the dry compost toilet, are storage time, composting and desiccation. The design of the UDDT and the ambient conditions (see Question f) in the chambers determine the dominant sanitization process. The sanitization process in dry compost toilets in Sri Lanka is a combination of the mentioned processes, composting, desiccation and storage time.

The ambient conditions are mainly influenced by the choice of additive. Depending on the additive desiccation or composting will be the main process. The addition of alkaline material, e.g. ash and lime, increases the pH and facilitates desiccation. The addition of structural material rich in carbon, e.g., saw dust, fruit husk, dry leaves, straw, facilitates composting. The different additives could also be mixed. Each additive has a different absorbing capacity and therefore different amounts of the respective additive have to be added. If users are changing the type of additive, e.g. from ash to saw dust, problems could occur during the transitional period until the users know how much of the new additive they have to apply. However, as explained under Question c if the faeces chamber should become too moist, i.e. smells, additional absorbing material should be added.

References

- Del Porto D. and Steinfeld C. (1999) *The composting toilet system book. A practical guide to choosing, planning and maintaining composting toilet systems.* The center for ecological sanitation prevention (CEPP), Concord, Massachusetts. ISBN: 0-9666783-0-3.
- GTZ (2005) *Technical data sheets for ecosancomponent, 02 Dehydration toilets.* Gesellschaft für technische Zusammenarbeit, Germany
- Winblad U. and Mayling S-H. (ed.) (2004) *Ecological Sanitation.* SEI, Stockholm. ISBN 91 88714 98 5.

Question f: Do air humidity and temperature in the composting chamber influence performance? What are the optimum ranges of humidity and temperature and are they compatible with local conditions?

Urine diverting dry toilets perform in cold, temperate and tropical climates. The climatic conditions in Sri Lanka, temperature 20 – 27 °C and relative humidity 70% - 90%, favor composting. The design and usage of the compost dry toilets in Sri Lanka favor and hinder composting. A combination of processes takes place.

Different ambient conditions, like moisture content, temperature and pH, support different sanitizing processes (see Question e). High temperature, alkaline conditions (high pH) and low humidity are facilitating desiccation. Moderate to high temperature, pH 5-7, and high humidity do favor composting. Monitoring of desiccation is unproblematic. Whereas conventional composting is a complex process and requires a basic understanding of the process.

The following paragraph provides basic information about composting and influencing parameters. This overview should help to understand the complex composting process and the relevance for dry composting toilets in Sri Lanka. It has to be emphasized the sanitizing process in dry compost toilets is not solely composting. The so called “compost toilets” in Sri Lanka are not optimized for composting. The compost process in the chamber is not complete. The main characteristic of composting is the temperature rise occurring during decomposition (see below). This definition applies to batch-composting only. Systems that receive a continuous but small amount of organic matter, like the compost toilet, will usually not achieve the high temperatures except with solar heating (Otterpohl, 2006). Vermi composting* is an effective alternative. Further research on composting in dry toilets is needed and on-going in different regions of the world.

*Vermi composting: Worms are added to the faecal pile and eat the material. The released castings are safe to handle.

Composting

Composting is the controlled aerobic biological decomposition of organic matter to produce a soil conditioner. The compost dry toilet in Sri Lanka is not designed as a pure composting facility, the process is not completely controlled and a combination of processes takes place (see above).

The United States Department of Agriculture uses the following definition for compost: Compost must be produced through a process that combines plant and animal materials with an initial C:N [carbon to nitrogen] ratio of between 25:1 and 40:1. Producers using an in-vessel or static aerated pile system must maintain the composting materials at a temperature between 131F and 170F [55C and 77C] for 3 days. (<http://www.ams.usda.gov/nop/NOP/standards/DefineReg.html>)

Parameters which facilitate composting

pH: The optimum pH for microorganisms involved in composting is 6.5 - 7.5. The pH of the material in the composting chamber is determined by the additive used. Alkaline additives such as ash and lime increase the pH, whereas soil, sawdust, husks etc. maintain the pH at 6 – 7. In Sri Lanka ash or a mixture of soil and ash is used. The pH of the used ash and the material in the chamber is not analyzed yet and normally varies in every location. Because of the use of ash the pH is supposedly above 8.

Carbon to Nitrogen Ratio: Microorganisms require digestible carbon as an energy source for growth, and nitrogen and other nutrients, such as phosphorous and potassium, for protein synthesis to build cell walls and other structures. An optimum C:N ration for aerobic bacteria can be calculated. C:N ratio in the range 25:1 to 40:1 at which efficient composting occurs are reported. (Haug 1993, Del Porto & Steinfeld 1999)

The C:N ratio is influenced by the type of additive, the use of the toilet, and the operation and maintenance of the toilet. The dry compost toilet common in Sri Lanka diverts the urine and therefore increases the C:N ratio, which is favorable for composting. Sri Lankan users do not use toilet paper which is unfavorable regarding the C:N ratio. However, before using an empty chamber and before closing a full chamber, users are advised to cover the floor / pile with straw. (see Photograph 2). This practice facilitates composting.



Photograph 2: Pile of fecal material in chamber covered with straw (Photo: UNICEF 2006)

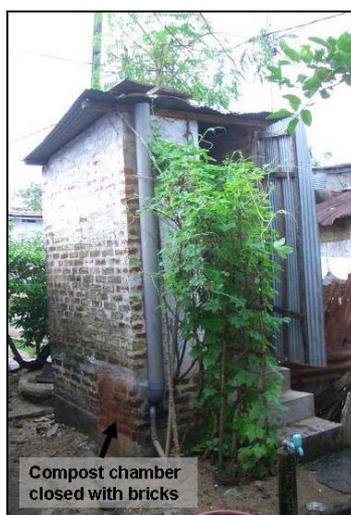
Moisture: The microbes responsible for composting need the right amount of moisture to grow. Too much water (saturated conditions) will drown them, and create conditions for the growth of odor-producing anaerobic bacteria (Del Porto & Steinfeld 1999). A moisture content of 40-70% (Haug, 1993, Del Porto & Steinfeld 1999) provides adequate moisture for microbial decomposition without limiting aeration.

The moisture content of the material depends on the relative humidity of the location, and on the usage and design of the toilet. The high air humidity in Sri Lanka (see climate) is favorable for the composting process. Furthermore people use water for cleansing after defecating. Instead of the material becoming too dry for composting the material in the chamber could become too moist. Anaerobic digestion will start. This process produces hydrogen sulfide, ammonia and amines and therefore unwanted odor.

Aeration: The microorganisms responsible for composting require free atmospheric or molecular oxygen. If there is an oxygen deficit (a state called "hypoxia"), the aerobes will die. They will be replaced with anaerobes (organisms that can exist only in the absence of molecular oxygen), which will slow the process and generate odors (Del Porto & Steinfeld 1999). It is therefore to allow airflow through the compost by ventilation and addition of structural material. The compost toilets in Sri Lanka are not designed to facilitate composting by aeration. During usage no structural material is added, which is unfavorable for composting.

Temperature: Mesophilic and thermophilic composting is possible. Mesophilic bacteria enjoy midrange temperatures, from about 20 to 40 °C. The ideal temperature for thermophilic (heat loving) bacteria is around 60 °C. As the bacteria, mesophilic and thermophilic, decompose the organic matter, they generate heat, and the inner part of a compost pile heats up the most. The measurement of the temperature can be used to judge how well the compost process is working and how far along the decomposition has progressed. The temperature at any point depends primarily on how much heat is being produced by microorganisms and how much is lost through aeration and surface cooling. Moisture content also affects temperature change; since water has a higher specific heat than most other materials drier compost mixtures tend to heat up and cool off more quickly than wetter mixtures. In any case adequate moisture levels (see above) for microbial growth must be maintained. (<http://compost.css.cornell.edu>)

The temperature inside the chamber of a compost toilet depends on the composting processes, the design of the toilet and the geographical location. The chambers of the visited compost toilets in Sri Lanka are closed by bricks and do not use any solar collectors for heating the inside of the chambers (see Photographs 3 & 4).



Photograph 3: Dry Compost toilet in Sri Lanka (Photo: UNICEF 2006)



Photograph 4: Solar heated UDDT in Uganda (Photo: C. Windberg 2006)

The ambient temperatures in Sri Lanka are favorable for composting. The following paragraph *Climate in Sri Lanka* provides detailed information. However, as said before, Systems that receive a continuous but small amount of organic matter, like the compost toilet, will usually not achieve the high temperatures necessary for composting.

Climate in Sri Lanka

The average mean temperature in Sri Lanka along the coast is 26.7 C and 19.7 C in the hill country. In Colombo the temperature varies from 26.4 C to 27.8 C. Relative Humidity varies from 70% during the day to 90% at night. In the lowlands the climate is typically tropical with an average temperature of 27°C in Colombo. In the higher elevations it can be quite cool with temperatures going down to 16°C at an altitude of nearly 2,000 meters. (<http://www.mysrilanka.com>) Table provides an overview of the temperatures throughout the year in different regions of the country.

Table 1: Temperature in Sri Lanka (Source: www.mysrilanka.com)

Area	Jan-April		May-August		Sept-Dec	
	Max.	Min.	Max.	Min.	Max.	Min.
Colombo	30°C	22°C	30°C	24°C	29°C	22°C
Kandy	31°C	17°C	29°C	21°C	28°C	18°C
Nuwara Eliya	21°C	14°C	18°C	16°C	18°C	15°C
Trincomalee	32°C	24°C	33°C	25°C	33°C	23°C

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- Del Porto, D. & Steinfeld, C. (1999) *The composting toilet system book*. Center for ecological sanitation prevention (CEPP), Concord, Massachusetts. ISBN: 0-9666783-0-3.
- Otterpohl, R. (2006) Personal communication
- Niwagaba, C., Magumba, B., Kigobe, M. and Kulabako R. (2005) *Sanitization of Faecal Matter by Co-Composting with Food Waste*, Department of Civil Engineering, Makerere University, Uganda

Internet resources

- <http://compost.css.cornell.edu>
- <http://www.mysrilanka.com>

Question g: Is the compost obtained sanitized and totally free of harmful pathogens?

The compost obtained from a properly operated compost toilet after the recommended storage time of one year is hygienically safe to handle. Reasonable minimum requirements of good practice to protect the health of the people using treated excreta should be established. The storage time could be decreased if the storage conditions comply with the respective recommendations of the WHO *Guidelines for the safe reuse of wastewater, excreta and greywater*.

The objective of the sanitization of faecal material in the dry compost toilet is to produce an end product, dried/composted faeces, which is hygienically safe to handle. A product totally free of harmful pathogens is not required. Hygienic safety needs to be accounted for when designing/planning a sanitation system, especially if the faeces are also intended for reuse as a fertilizer. To manage health risks an effective treatment to reduce the pathogen content and safe handling procedures are of importance. (Kvarnström et al 2006) The pathogen content in the faecal material is determined by the health status of the user. Before setting health based targets the health risk has to be assessed.

Treatment

According to Esrey et al. (1998) and Moe and Izurieta (2004) a high pH, a long storage time and high temperatures are the critical factors affecting microbial inactivation. The addition of an alkaline absorbent after usage, such as ash, lime or similar additives helps to destroy the pathogens and to decrease the risk of odours and flies (Jönsson et al. 2004). A moisture content of less than 12% will halt all biological activity (Austin 2001). Composting, incineration, urea treatment, warm storage and burial are options for secondary treatment of the faecal material.

For the reuse at household level the WHO *Guidelines for the safe reuse of wastewater, excreta and greywater* gives the following recommendations (Table 2):

Table 2: Recommendations for storage treatment of dry excreta and faecal sludge before use at the household and municipal levels^a (WHO 2006)

Treatment	Criteria	Comment
Storage; ambient temperature 2–20 °C	1.5–2 years	Will eliminate bacterial pathogens; regrowth of <i>E. coli</i> and <i>Salmonella</i> may need to be considered if rewetted; will reduce viruses and parasitic protozoa below risk levels. Some soil-borne ova may persist in low numbers.
Storage; ambient temperature >20–35 °C	>1 year	Substantial to total inactivation of viruses, bacteria and protozoa; inactivation of schistosome eggs (<1 month); inactivation of nematode (roundworm) eggs, e.g. hookworm (<i>Ancylostoma/Necator</i>) and whipworm (<i>Trichuris</i>); survival of a certain percentage (10–30%) of <i>Ascaris</i> eggs (≥4 months), whereas a more or less complete inactivation of <i>Ascaris</i> eggs will occur within 1 year.
Alkaline treatment	pH >9 during >6 months	If temperature >35 °C and moisture <25%, lower pH and/or wetter material will prolong the time for absolute elimination.

^a No addition of new material.

Since the pH in compost chambers in Sri Lanka is not known a storage time of 1 year is recommended. The reported storage time at visited sites is 1 to five years. However, the addition of ash is likely to increase the pH up to 9 and higher. Therefore even a shorter storage time could be possible.

Besides storage time additional health protection measures (see Box 1) such as safe handling procedures and for example a recommended withholding time of one month between the moment of application of the treated excreta as a fertilizer and the time of crop harvest (WHO 2006) have to be applied.

Box 1: Health protection measures

The risk for families and workers handling the dried/composted faecal material can be minimized by safe handling procedures. Kvarnström, E. et al 2006 identify the following points of risk and the respective measures:

- Emptying of the toilet/vault:
 - If available, use gloves etc for personal protection
 - When finished: wash hands, clean surfaces of the vault outside and equipment used or use special equipment used only for non-sanitized material
- Transportation and handling before sanitization:
 - If available, use gloves etc. for personal protection
 - When finished: wash hands, clean surfaces outside and equipment used
- Recontamination after sanitization:
 - Bacteria can regrow after sanitization, while protozoa, viruses etc. cannot
 - Well-cleaned tools and equipment should be used for the sanitized product

The risk for product consumers can be minimized by the following measures (WHO 2006):

- Excreta treatment;
- Crop restriction;
- Withholding periods between fertilization and harvest to allow die-off of remaining pathogens;
- Hygienic food handling and food preparation practices;
- Health and hygiene promotion;
- Produce washing, disinfection and cooking.

If the reuse of human excreta will be practiced on a large scale, the development of national guidelines is recommended (see Box 2).

Box 2: Development of national guidelines

For the development of national health based guidelines and standards in terms of water- and sanitation-related microbial hazards an integrated approach that combines risk assessment and risk management should be applied. This involves the assessment of health risks prior to the setting of health based targets and guidelines, taking into account the present health status of the population. Basic control and evaluation approaches have to be defined. All steps in the process from waste generation to treatment, use of excreta as fertilizers and product use or consumption should be encompassed.

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Question h: What is the capital cost of a 5 member's family dry composting toilet, compared to a standard pour-flush toilet connected to a septic tank?

The range of capital cost for pour-flush toilets connected to a septic tank and soak pit is 48,000 LKR to 79,000 LKR. The range for dry compost toilets is 21,000 LKR to 37,000 LKR. The capital costs are determined by the design of the toilet, the chosen technology, geographical conditions and local market prices. Due to the higher tax and the unavailability of material the cost in Jaffna are up to 25% higher than in the South of Sri Lanka. The capital cost of a compost toilet is 83% of the capital cost of a pour-flush toilet (capital cost compost and evaporation bed / capital cost pour-flush and soak pit). 17 % of the capital cost can be economized by building a compost toilet instead of a pour flush toilet.

Compost toilet

The first composting toilets in Sri Lanka were introduced in 2001/2002 by NWSDB and ecosolutions, UK. Implementing partners were SEVENATHA and SARVODAYA. Sevenatha and Sarvodaya did not build any other compost toilets after the pilot project. Currently the main implementing agencies involved in ecosan are Action Contre la Faim (ACF), Practical Action (PA) and Australian Red Cross. The basic design of the compost toilets built by the different agencies is the same - a double chamber system with an evaporation bed (mainly built by PA) or soil infiltration bed (mainly built by ACF, Australian Red Cross). Besides international literature the Sri Lankan documents *Manual on Latrine Construction* (Herath, 2005) and *Sanitation Guidelines* developed by World Toilet Organisation (Huba Panzerbieter, 2006) provide further design options. So far there is no urine collection in Sri Lanka. Storage facilities are therefore not considered in the cost estimate below. Urine collection on a small scale is possible with inexpensive plastic containers of different sizes. On a large scale, storage facilities are a major expenditure which is justified by the cost benefit of the gained fertilizer.

Standard Pour-flush toilet connected to a septic tank

The most common sanitation technology in Sri Lanka is the pour flush toilet connected to a septic tank. However, not every system which is labeled "septic tank" complies with the design requirements set by the *Code of Practice for the Design and Construction of Septic Tanks and Associated Effluent Disposal Systems*, Sri Lanka Standards Institution, 2003 (SLS 745). Often a simple collection pit (cesspit) is referred to as "septic tank".

Septic tanks are water tight multiple-chambered containers "in which wastewater is retained sufficiently long to permit separation of solid particles and partial digestion of accumulated solids." (SLS 2003) Septic tanks only provide primary treatment. Septic tank effluent must be treated before being discharged into the ground or surface water bodies. The SLS 745 recommend "soakage systems for the disposal of septic tank effluent below ground (soakage pits, seepage trenches, and seepage beds), and anaerobic bio-filters, constructed wetlands and percolation beds for the disposal of septic tank effluents above ground, or for on-site effluent reuse". The capital costs below are for pour-flush toilets connected to a septic tank and soak pit.

Total Capital Cost

The cost for compost toilets given in Table 3 are based on existing constructions done by Practical Action and ACF / Australian Red Cross. The Bills of Quantity (BoQs) of the compost toilets built in 2001/2002 are not considered since the prices changed considerably since then. The compost toilets built by ACF / Australian Red Cross are located in Jaffna, whereas Practical Action operates mainly in the southern region. The capital cost for the construction of pour-flush toilets connected to a septic tank and soak pit were only obtained from UNICEF. Including other implementing stakeholders than UNICEF the price range is anticipated even wider than given in Table 3.

Table 3. Unit cost of implemented pour-flush and dry compost toilets in Sri Lanka
(Source: Provided BoQs by respective Agency/NGO)

Total Cost in LKR	Location	Implementing Agency / NGO	Date
Pour-flush toilet connected to septic tank and soak pit			
55,000.00	Kilinochi	UNICEF	Apr-06
79,000.00	Jaffna	UNICEF	Jun-06
48,671.06	Galle	UNICEF	Jul-06
43,305.50	Ampara (no door)	UNICEF	Oct-06
44,098.00	Ampara	IOM	
33,398.26	Jaffna (no soak pit)	ACF	Nov-05
Double chamber dry compost toilet			
21,429.50		PA	Aug-06
36,919.40	Karainagar	ACF	
34,176.42	Neelankadu	ACF	Jun-05
36,435.06	Jaffna	ACF	Dec-05
36,910.97	Jaffna	Australien RC	Dec-05
36,710.97	Jaffna	Australien RC	Apr-06

The range of capital cost for pour-flush toilets connected to a septic tank and soak pit is 48,000 LKR to 79,000 LKR. The range for dry compost toilets is 21,000 LKR to 37,000 LKR.

Relative Capital Cost

To compare the capital cost of a pour-flush system and a dry compost toilet local conditions, material cost, rates for subcontractors and labor, and the basic design of the superstructure should be the same. Existing toilets and the respective BoQs do not provide the basis for an objective judgment of the capital cost involved. Therefore, BoQs were calculated for a compost toilet with an evaporation bed and a pour flush toilet connected to a septic tank and soak pit (see Annex I). The BoQ for the compost toilet are conservative. An evaporation bed is only needed in high groundwater areas, the height of the superstructure is normally less, additional features like a handrail, ash container, scoop and plants are included. The construction was assumed to take place in south of Sri Lanka. For the given scenario the capital costs are:

Pour-flush toilet connected to septic tank:	56,686.22 LKR
Compost dry toilet with evaporation bed:	46,943.59 LKR

Important is not the actual capital cost which might vary but the relation of the cost of a pour-flush system to the cost of a dry compost toilet system. The ratio is given below.

$$\text{Cost}_{\text{Compost toilet}} \times 100 / \text{Cost}_{\text{Pour-flush}} = 46,943 \times 100 / 56,686 = 82.8 \%$$

The capital cost of a dry compost toilet with evaporation bed is 83 % of the capital cost of a pour-flush toilet connected to a septic tank. 17 % of the capital cost can be economized by building a compost toilet instead of a pour flush toilet.

Capital costs are only one component of the system cost. Operation & maintenance and management of the respective system are major parameters contributing to the cost of the system and should be considered in the decision making process. Septic tanks accumulate sludge and should be emptied approximately after 5 years (WTO 2006). The sludge has to be treated separately. The main difference between any implemented UDDT system and a septic tank system is the potential of cash benefits from UDDT systems due to production of

fertilizer and soil conditioner. For operation and maintenance cost and potential cost benefits refer to Question i.

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- SLS (2003) *Code of Practice for the Design and Construction of Septic Tanks and Associated Effluent Disposal Systems*, Sri Lanka Standards Institution, 2003

Question i: What are the running costs (operation and maintenance) of a 5 members' family dry composting toilet compared to potential cash benefits (taking into account current market value of produced compost and of bananas/pineapple grown with urine/water)

The cost of operation and maintenance (O&M) of a compost toilet in Sri Lanka are estimated for a worst case scenario to be 35,190 LKR over a period of ten years. Local prices for compost range between 6 and 35 LKR per kg compost. The theoretical cash benefit from compost over a period of ten years was estimated 9,380 LKR. The value of Nitrogen and Potassium in the produced urine was estimated 6,612 LKR over ten years. Phosphorus was not considered.

The net present value of the dry compost toilet is estimated 31,000 LKR, 55% of the NPV for a pour-flush toilet (56,700 LKR). This makes the compost toilet by far the better investment. This rough estimation does not substitute a comprehensive Cost-Benefit-Analysis, exploring different scenarios and collecting data for correct assumptions!

Question i is addressed by the following paragraphs

- Operation and maintenance
- Cash benefits – Cost Benefit Analysis
 - o Compost and urine
 - o Market value of compost
 - o Market value of compost produced in dry toilets
 - o Market value of urine
 - o Market value of fruits and vegetable grown with urine/water
- Net present value of Dry Compost toilet

Operation and maintenance

Dry compost toilets in Sri Lanka infiltrate urine and wash water into a plant bed, preferably with plants with large nutrient consumption like banana and papaya. Faeces drop into a water-tight chamber and are covered with dry ash to absorb moisture, prevent insect breeding and to cover the faeces from the sight of the next user. A ventilation pipe ensures fresh air within the toilet room while drying the faeces. When the first faeces compartment fills, it is closed and the second one is used. When the second chamber is full the first chamber is emptied with a shovel. Depending on the implemented system compost toilets can either be emptied individually or could be emptied by a municipal service. Secondary treatment of partially composted material at a central composting plant is possible. For the scope of Question i, the existing system of individual emptying is regarded. Operation and maintenance therefore includes:

- Instruction of visitors on how to use the toilet. Illustrations should be posted on the walls.
- Closing of the faeces opening of the toilet when not in use.
- Cleaning of the toilet: Special care must be taken to keep the storage chamber dry.
- Monitoring and maintenance of the mosquito netting on top of the vent pipe.
- Emptying of the filled chamber
- Ash or other additive has to be always available.

Besides the repair of broken parts only the last four activities involve potential cost. The emptying can be done by the owner or subcontracted. If subcontracted the cost depend on the arrangement. For large scale applications an emptying service has to be provided. The respective arrangements determine the cost involved for the user. If ash is not available a different additive could be used or ash is bought on the local market.

Common problems with toilets inspected were broken urine pipes, doors and roofs, blocked evaporation or soil infiltration beds and the decay of bricks due to high air salinity. Two compost toilets of the pilot project were reported collapsed. The wall of one dry compost toilet was damaged due to heavy rain. Damage of doors and roofs, and collapsing walls can be prevented by proper design and construction. The quality of the plastering given in the capital cost estimation should not require any further plastering. The cost for operation and maintenance are based on a worst case scenario for an assumed 10-years life span of a compost toilet. The figures are shown in Table 4. The main expenditures, door, roof, plastering are not specific for compost toilets but also apply to pour-flush toilets. The replacement of the squatting pan should not be necessary if a ceramic version is provided. The total cost does not consider the interest rate used to discount future cash flows to their present values.

**Table 4. Operation and maintenance cost for dry compost toilet over 10 years
- Worst case scenario -**

Activity	Frequency	Material	Total amount for 10 years	Cost in LKR
Cleaning*	2 x 1 week	Water	-	-
Supply of additive**	1 x 1 week	Ash, Sawdust, Husks...	-	-
Emptying of full chamber***	1 x 1 year	Shovel, wheelbarrow	10 x 450 LKR	4,500
Repair of urine pipe****	1 x 1 year	2 ft. 4" PVC pipes + labor	10 x 700 LKR	7,000
Replacing of mosquito netting	1 x 1 year	Mesh cloth	10 x 25 LKR	250
Plastering	1 x 10year	Plaster + 1d skilled labor	1 x 4,046 LKR	4,046
Painting	1 x 10year	Paint + 0.5d skilled labor	1 x 2,316 LKR	2,316
Repair of evaporation bed*****	1 x 5 years	Rubble, Earth + labor	2 x 600 LKR	1,200
New door*****	1 x 5 years	Door + 0.5d skilled labor	2 x 2,900 LKR	5,800
New roof*****	1 x 5 years	Roof + 1d skilled labor	2 x 2,289 LKR	4,578
Squat pan*****	1 x 2 year	ecoPan	5 x 1,100 LKR	5,500
			TOTAL COST	35,190
<p>* Chemicals are rarely used for cleaning of compost toilets (Pasupathiraj 2006). ** Since it is possible to use a different additive if one is not available zero cost are assumed. *** Emptying takes maximum half a day. However, a full days salary for unskilled work (450 LKR) was assumed. **** The two feet piping (400 LKR) outside the superstructure are normally broken. Half day skilled work (300 LKR) was assumed. ***** The evaporation bed could get blocked. The rubble and earth should be replaced. One day skilled work was assumed. ***** Normally you would not have to replace the door/roof a repair could be enough. ***** ACF produces squatting pans for 1,100 LKR. If the market provides durable ceramic versions, which should be available for app. 2,000 LKR, a replacement is not necessary.</p>				
Skilled labor = 550 LKR / day, 300 LKR / 0.5 day				

Cash benefits – Cost Benefit Analysis

To estimate the cash benefit of a compost dry toilet system a comprehensive Cost Benefit Analysis (CBA) should be conducted. The initial results of a pilot project (costs and benefits experienced by beneficiaries) are used to estimate the net benefit values of different future scenarios theorized by the analyst. Benefits and cost of a project are determined and given a numerical value estimate. The net benefit is the difference between the total amount of cost

and the total amount of benefits (Gabucan 2006). Projects with a positive NPV should be undertaken.

The net benefit should account for all the benefits and costs from the project that affect society, including those that do not have a direct impact on individual beneficiaries, such as environmental impacts (Gabucan 2006). Not every benefit could be quantified. If quantification proves impossible, the remaining benefits and costs must be considered qualitatively. A Cost Benefit Analysis should be based on a data collection indented for the application in a CBA model.

The necessary data for Sri Lanka is not available. The pilot project in Sri Lanka did not focus on the creation or monitoring of demand. A comprehensive evaluation of the pilot project is still outstanding. The questionnaire for an evaluation done in 2003 (Wickremasinghe 2003) does not include a single question regarding potential reuse. The material of two toilets, out of the 26 compost toilets visited by the consultant, was reused (Site 18 & 19), the material of site 18 is collected by a small ornamental business. Part of the material of site 19 is reused for home gardening on the compound and part of it is used 10 km away. It was reported that of the five toilets emptied in Jaffna, three users applied the material to their plants. One family is eating the tomatoes planted on top of the soil infiltration bed. No cash benefit is reported. (Pasupathiraj 2006) Taking the existing data into account it could be said there is no market and therefore no cash benefit for the obtained compost. The same applies to produce grown with urine/water since there is no data available on actual reuse of urine.

However, the following paragraphs estimate the theoretical value of compost and urine assuming a market. Only quantitative benefits regarding compost and urine use are discussed. Considered aspects are only the potential income from the sale of compost and the value of savings from a reduction in fertilizer use due to the potential use of urine. Not considered are the potential income from a sale of urine, the value of the saving from a reduction in fertilizer due to use of compost, the value of fertilizer cost savings plus the value of resulting crop increase and the value of the saved water. Of the quantitative costs incurred by the implementers and users only the construction and O & M cost are considered. Training and appraisal cost are disregarded.

Compost and Urine

Question i focuses on the market value of produced compost. Compost is a soil conditioner which enhances soil properties such as water holding capacity and ion buffering capacity. It helps to moderate soil temperature, adds microorganisms and additional elements beneficial to plants such as boron, manganese, iron, copper and zinc (Esrey et al. 2001). Faecal matter is especially rich in phosphorous, potassium and organic matter. Ash which is added to the faeces also increases the buffering capacity and the pH of the soil. If faeces are used as an fertilizer, the application rate can be based on the current recommendation for the use of phosphorous-based fertilizers. However, faeces are often applied at much higher rates, at which the structure and water-holding capacity of the soil are also noticeably improved. (Jönsson et al. 2004)

The amount of nutrients in urine is much higher compared to faecal material. Urine is a quick-acting nitrogen-rich complete fertilizer (Jönsson et al. 2004), which should be utilized in agriculture. Table 5 gives an estimate of the average excretion of N and P in different countries according to the respective diets. As input for the estimation Jönsson et al. 2004 used the FAO statistics on the food supplied, found on the FAO web page called "Nutrition Data – Food Supply – Crops Primary Equivalent". Data on yearly excretion of nutrients vary. Esrey et al. 1998 gives the following estimate for yearly excretion – not adjusted to specific diet – Nitrogen: app. 4.55 kg, Phosphorus: app. 0.58 kg, Potassium: app. 1.27 kg.

Table 5. Estimated excretion of nutrients per capita in different countries (Jönsson & Vinnerås, 2004)

Country		Nitrogen kg/cap, yr	Phosphorus kg/cap, yr	Potassium kg/cap, yr
China, total		4.0	0.6	1.8
	Urine	3.5	0.4	1.3
	Faeces	0.5	0.2	0.5
Haiti, total		2.1	0.3	1.2
	Urine	1.9	0.2	0.9
	Faeces	0.3	0.1	0.3
India, total		2.7	0.4	1.5
	Urine	2.3	0.3	1.1
	Faeces	0.3	0.1	0.4
South Africa, total		3.4	0.5	1.6
	Urine	3.0	0.3	1.2
	Faeces	0.4	0.2	0.4
Uganda, total		2.5	0.4	1.4
	Urine	2.2	0.3	1.0
	Faeces	0.3	0.1	0.4

Given the high nutrient content of urine, urine is included in the estimation of the potential cost benefits.

Market value of compost

The market value of compost depends on market location. In an agricultural region the value will be higher than in an urban setting without home gardening. Table 6 shows the results of a rapid market research. The price for compost ranges from 6.60 LKR / kg (wholesale) to 35 LKR (retail).

Table 6. Prices for compost in Colombo

Price in LKR	Quantity in kg	Price per kg in LKR	Source	Comments
35	3	11.67	Crystal Green Ltd.	own compost plant - use cow dung and chicken litter
85	10	8.50		
150	20	7.50		
40	2	20.00	CIC- Agrochemicals	own compost plant
80	5	16.00		
270	25	10.80		
140	20	7.00	Burns Environmental Technologies	own compost plant - solid waste of Colombo
328	50	6.56		
35	1	35.00	A. Baur & Co Ltd	
260	20	13.00		
500	40	12.50		
15	1	15.00	Pettah Forage Centre	buy and sell compost
900	50	18.00	New Lanka Forage Stores	buy and sell compost
25	2	12.50	Gami Seva Sevana	produce and sell
30	1.5	20.00	Private, neighbour to Site 18	product of compost bin

Market value of compost produced in dry compost toilets

The market value of compost produced in dry compost toilets can only be estimated. Compost obtained from compost toilet is not sold yet and users of existing compost toilets do not intend to do so. The storage time of faecal material in the compost toilets of the pilot phase is between one and five years in the pilot project of. Therefore the amount of produced compost is limited. Of 13 toilets used since 2001/02 ten toilets were emptied once, two toilets twice and at one toilet nobody was present to provide information. At two sites the compost was used (Sites 18 & 19). Site 18 was also equipped with a compost bin. The compost produced by the composed bin was packed and sold by the neighbor (see Photograph 5). This approach is also viable for improving livelihoods through dry compost toilets. Photograph 6 shows the material of an emptied compost chamber in Jaffna. According to information from ACF the owners used the material in home gardening and/or put on the plants, bananas and tomatoes, which receive the diverted urine (Pasupathiraj 2006).



Photograph 5. Small scale business with compost produced in compost bin, Colombo (Photo: UNICEF 2006)



Photograph 6. Solid material obtained from Dry Compost Toilet in Jaffna (Photo: K. Pasupathiraj 2006)

The generated volume of compost is small compared to urine. An adult person generates approximately 50 kg faeces and 500 litre urine in one year. Composting reduces the volume between 40 to 70%. An evaluation of ecosan toilets in Bolivia did not report any significant changes in household economy due to the production of compost (UNICEF 2006). However, there are also success stories. In 2001 the VinaSanRes ecosan project, implemented in 1997 targeting 62 rural household in Vietnam, was appraised. 33 households were interviewed. Roughly half of them reported a monetary benefit from their compost, in form of savings in fewer fertilizer purchase, sale from compost or in increase of crop yield due to the use of compost. (Nghien, 2000)

Estimation of cost benefit of obtained compost over a period of ten years

If the compost produced in dry toilets complies with national standards it will have the same market value than conventional compost (see Table 6). The following calculation of the market value for compost obtained from compost toilets is based on a moderate scenario with medium generation of faeces, medium volume reduction (60%) through composting and medium market price. Assuming a household of five, including two children, produces 200 kg of faecal material in one year, 80kg of compost could be obtained after one year of storage. If the compost is sold for 20 LKR/kg a yearly income of 1600 LKR could be generated from compost. Using a discount rate of 10 percent, the present value of 1,600 LKR for each of the years 2-10 can be calculated. The sum - 9,380 LKR - gives the present value of the compost.

Since faecal material is rich in phosphorous and potassium the value could also be estimated as the cost savings in the reduction of use of phosphorus-based fertilizer.

Market value of fruits and vegetable grown with urine/water

The specific market value of fruits and vegetable fertilized with urine can not be established, since there is no reuse of ecosan products at the moment. However, if the users are encouraged to engage in home gardening and use the ecosan products and/or use the ecosan products for already ongoing agricultural activities the difference in crop production has to be established. The market value of the produced produce is assumed to be the same than for “normal” fruits and vegetables. If the fruits and vegetables fertilized with urine are branded with a certain bio-label they might reach a higher market value since organic products are normally more expensive than non-organic products. According to interviews in rural Sri Lanka, Puttalam, Galle and Hambantote district, people buy the better looking fruits. The type of used fertilizer is not part of the decision making process for a certain fruit. Therefore a higher price is paid for the better fruit / vegetable. For prices on selected food items also see the *Retail/Producer Margin* published by the Department of Census and Statistics. The figures for the second quarter of 2006 are attached in Annex 2.

Market value of urine

The monetary value of nutrients in urine is much higher than the monetary value of compost and could be marketed as an incentive for dry compost toilets at household level as well as for the development of micro-enterprises around urine-diverting sanitation systems and services. The value of urine as fertilizer is most often not known by farmers in developing countries. A behavior change towards using urine requires more education and information sharing than the efforts for using the compost. This pattern was observed in Uganda (Windberg 2005), Vietnam (Nghien 2000), Bolivia (UNICEF 2006) and Mexico and could be explained by the already established use of cow dung and green manure as fertilizer. Farmers are therefore familiar with the use of solid material for fertilizing. The use of liquid fertilizer like urine has to be introduced. Demonstration gardens are the best tool since the benefits can be seen (and eaten).

Estimation of cost benefit of obtained urine:

Data from National Fertilizer Secretariat (NFS) shows that Urea and Muriate of Potash (MoP) are by far the most common used fertilizer in Sri Lanka. According to NFS statistics 370,800 Metric tones (MT) Urea, 102,900 MT MoP and only 1,200 MT NPK fertilizer were used in 2005. This calculation will therefore focus on the nitrogen and potassium content of urine and the value compared to Urea and MoP.

Jönsson & Vinnerås, 2004 (Table 5) estimate the yearly excretion of nitrogen (N) in urine per capita in India 2.3 kg and potassium (K) in urine is 1.5 kg. - Notice this is only the nutrient value of urine! - Since the diet in Sri Lanka is similar to the one in India the same amount is assumed. Assuming a family of five excretes the amount of N and K equivalent to four adult persons, the given family produces 9.2 kg N and 6 kg K per year. Urea contains 46 percent nitrogen. So the family produces the equivalent of 20 kg Urea per year. Urea is heavily subsidized. 1kg Urea cost about 36 LKR (Quotes: A.Baur & Comp., CIC). So the excreted N is worth 720 LKR. MoP contains 60 percent Potash (K_2O) or 49.812 percent K ($K_2O \times 0.8302 = K$). The family produces therefore the equivalent of 12 kg MoP per year. 1kg MoP cost about 34 LKR (Quotes: A.Baur & Comp., CIC). So the excreted K is worth 408 LKR. Using a discount rate of 10 percent, the present value of 1,128 LKR (408 LKR + 720 LKR) for each of the years 2-10 can be calculated. The sum – 6,612 LKR - gives the present value of N and K.

Net Present Value of Compost Toilet

The cost of the toilet was calculated 46,900 LKR by subtracting the net present value of the products urine and compost 16,000 LKR (6,612 LKR + 9,380 LKR) the net present value of the compost toilet is app. 31,000 LKR. Since a pour flush toilet does not produce any cash

benefit the net present value (NPV) is equivalent the capital cost. The net present value of the capital cost for a dry compost toilet is therefore only 55% of the one for a pour flush toilet, which makes the compost toilet by far the better investment.

$$\text{NPV}_{\text{Compost toilet}} \times 100 / \text{NPV}_{\text{Pour-flush}} = 31,000 \times 100 / 56,700 = 55 \%$$

It has to be emphasized that this calculation only gives a rough idea and only conservative values were used. Other estimations use 4.55 kg N yearly excretion for India (Mara 2005). For the purpose of this report 2.55 kg N / year were assumed. The value of Phosphorus was not taken into account. This rough estimation does not substitute a comprehensive Cost-Benefit-Analysis, exploring different scenarios and collecting data for correct assumptions. Regarding the reuse component it has to include potential cost for storage, transport and application. On the other hand it should be noted that for the poor the produced excreta fertilizers are of even higher value than just the monetary value of the NPK content since they normally can not afford to buy fertilizer. Dry compost toilets therefore contribute substantially towards poverty alleviation.

Box 3 illustrates the overall situation regarding supply and demand of fertilizer in Sri Lanka. The data show there is a huge demand of fertilizer which is not met by the local market. Large scale ecosan implementations could play an significant part in supplying fertilizer.

Box 3: Supply and Demand of Fertilizer in Sri Lanka

According to the FAO Country Profile (FAO 2006) for Sri Lanka the fertilizer* production in 2002 was 10,546 MT, fertilizer* consumption in 2002 was 284,218 MT.

According to NFS (NFS 2006) of 370,800 MT Urea consumed in 2005 318,760 MT were imported!

* N, P₂O₅, K₂O

To estimate the accurate value of the obtained fertilizer the situation of the local market is crucial. Box 4 cites the MONLAR (Movement for National Land and Agriculture Reform) Health Policy. MONLAR carried out a research to identify organizations which are active in ecological agriculture. Box 5 provides information on market opportunities for organic fertilizer in Sri Lanka.

Box 4: Organizations active in ecological agriculture

In a research that we, MONLAR, conducted in 2003 and 2004, we were able to list over 500 organizations in Sri Lanka from all geographical areas, that were engaged in this type of ecological agriculture. Some call it organic home gardening, some others use other names such as agro forestry, sustainable agriculture etc. We have briefly documented these and have initiated a programme of training in ecological agriculture. Over 180 such organizations sent their activists and staff for these training programmes that were conducted by some of the best experts in this subject. (Fernando, 2006)

Box 5: Market for organic fertilizer in Sri Lanka

Organic fertilizer/soil conditioner: In Sri Lanka there is a vast but not developed market for organic fertilizer. The government heavily subsidizes artificial fertilizer. To minimize this burden and to decrease the high amount of imported fertilizer the use of organic fertilizer is encouraged. Normally green manure, cow dung mixed with grass and straw, is used as organic fertilizer. The non availability of cow dung and the high labor involved in the preparation of green manure often prevent local farmers / home gardeners to use green manure. Nuwara Elya, one of the main agricultural production areas, imports truck loads of cow dung into the region to produce organic fertilizer.

Organic Agriculture: There is a growing market for organic food world wide. The export orientated organic farmers in Sri Lanka mainly produce for the European Market. The organic agriculture within European Union-countries is governed by EU regulation EEG 2092/91, which also sets criteria for importing organic products from "third countries". The EU regulation regulates all inputs allowed in certified organic agriculture. Human derived nutrients are at present not included in the EU regulation which makes it difficult for organic farmers to use human urine or human compost, even though some national organic farmers union or organic agriculture certifying organizations would not prohibit the use per se. "The IFOAM* norms state that in organic farming the use of human excreta is prohibited on crops for human consumption. However, exceptions may be made according to the same norms and an annex to the norms states that source-diverted human excreta may be used if it is monitored to avoid contamination, and not directly applied on edible parts of crops." (Ecosanres 2006) Even though export orientated companies producing for the European market can not be targeted at the moment organic agriculture has a considerable potential to provide a market for ecosan products. The possibilities of a national certificate for produce and fruits produced with (human derived) organic fertilizer have to be explored.

*IFOAM: international organization for organic farming movements

Operation cost and ash benefits are largely dependent on the management of the system. The situation for large scale applications is very different from the described small scale applications (see Box 6).

Box 6: Large scale applications

Large scale applications involve potential operation and maintenance costs. These are set by the chosen management system and the fees involved for the users. The management system would involve emptying of the compost collection devices and the potential storage tank. The cash benefit of large scale application is mainly dependent on transport cost involved and local market opportunities for the sale of fertilizer and soil conditioner. Large scale applications of dry compost toilets should be supported by campaigns to create a market for organic fertilizer. Contacts to local farmers and fertilizer companies, also in regard to collection and marketing, have to be established.

Alliances should be formed for the implementation of large scale projects one such alliance could utilize already established networks (see Box 7).

Box 7: USAID project on Urban Waste management

The already existing networks and baseline studies of the solid waste management project of USAID implemented in 2002 could serve a large scale reuse orientated ecosan application. USAID trained local staff members to test the compost obtained from urban solid waste and coordinated a meeting among representatives of Sri Lanka's Department of Agriculture and research institutions of the tea, rubber, coconut and other export crop industries to ensure the compost would be accepted by local markets. Using this input the government finalized national standards for compost. (<http://usinfo.state.gov>)

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Question j: What are the key marketing ingredients to generate demand for dry composting toilets from middle income and well off families in the Sri Lanka socio economic and cultural contexts?

The compost dry toilet should not be a compromise but a desirable option. Reuse of material, is not the driving factor for demand in middle income and well off families. Environmental considerations could be marketed for environmentally conscious target groups. Up market dry compost toilets as solution for water scarce areas, areas with difficult soil conditions and high groundwater table can be marketed for middle income and well off families in respective areas. Design, cost efficiency, and user friendliness are the key marketing ingredients for creating demand in middle income and well off families.

Marketing

“Marketing consists of activities by which you reach customers and persuade them to buy and use a product or service. Marketing works on the principle of a voluntary ‘exchange’ between consumer and producer where both gain. Consumers get benefits they want and producers gain profits.” (WSP2004) Marketing is not mere advertising. The Four-P-Strategy – Product, Price, Place, Promotion - is widely used. The challenge for marketing sanitation, in particular a dry compost toilet, is that it involves not only marketing a product but also marketing a behavior change. Social Marketing strategies, using marketing techniques to serve social objectives, have to be applied for all target groups (see Box 8).

Box 8: What is different about Social Marketing?

Product: This may be a tangible item (condom, oral rehydration sachet, home toilet), a service (AIDS testing, pit emptying) or a practice (vaccinate children, wash hands with soap). Commercial marketers only want to sell the product; social marketers also want customers to use it correctly or behave differently.

Price: Commercial prices must cover all costs whereas social marketers might choose to subsidize certain items in order to reach the poor, who may also have social and other ‘costs’ to overcome.

Place: The product needs to be available to the target group, and public channels such as government outreach workers or volunteers, as well as private shops and artisans, can bring the market close to customers.

Promotion: Creating demand for a totally new product or service is more challenging than the commercial practice of winning market share from competitors.

Source: WSP 2004

The different steps for marketing ecological sanitation are explained in Box 9. In general these steps are applicable for any sanitation strategy. However the steps below are adapted to promoting the dry compost toilet in Sri Lanka.

Box 9: Steps for marketing ecological sanitation in Sri Lanka

(adapted from WSP 2004)

Win consensus

A policy consensus on the approach has to be established. In the initial stage this could focus on a defined region only - In Sri Lanka these were the pilot project areas, Colombo, Matale, Kaluthera. You need at least one influential and committed person to bring the program forward.

Learn about the market

Demand and supply have to be understood. Site visits should be undertaken to understand how people meet their sanitation needs, who provides the service and what is perceived as a modern sanitation facility.

Overcome barriers and promote demand

Partnerships between government, especially local government, and the private sector providers of sanitation services have to be formed. The existing regulation should become more supportive. This process is ongoing in Sri Lanka. Guidelines and manuals are just under preparation. Mass media should be used for nation wide advertising campaigns, production and sales should be organized locally. Awareness raising campaigns, introducing the system as a desirable option and not a compromise should be launched. Pilot projects – in particular in upper class settings – are needed for site visits to convince users and decision makers about the practicability and user friendliness of the system.

Develop the right products

“Developing suitable products requires a different approach from that adopted by most sanitation engineers. Instead of designing to a minimum specification, toilet products should be designed to a target price, for a market niche. If the design is too expensive, the technical specification needs revising so as to reduce the cost.” (WSP 2004) This approach varies for each target group.

Develop a thriving industry

The development of an industry around ecological sanitation options includes capacity building through training, credit and other services for small businesses. The evolving market has to be monitored.

Regulate final disposal

The final disposal has to be regulated to prevent environmental pollution and hygienic risk. In the case of dry composting toilets the users should either be trained how to empty the toilets and use the material or a public emptying system can be established.

Demand of middle income and well off families in Sri Lanka

The compost dry toilet should not be a compromise but a desirable option. Reuse of material, is not the driving factor for demand in middle income and well off families. Environmental considerations could be marketed for environmentally conscious target groups. Up market dry compost toilets as solution for water scarce areas, areas with difficult soil conditions and high groundwater table can be marketed for middle income and well off families. Cost efficiency, design and user friendliness are the key marketing ingredients for creating demand in middle income and well off families. Special attention should be given to the following components:

- *Service:* Middle income and well off families as well as other target groups will only chose to use a compost system if the maintenance does not require extra efforts compared to conventional systems. A public service for emptying should be established if the product is not used.
- *Presentation:* The dry compost toilet should not be presented as a compromise for difficult locations. The focus is also not on the reuse of products. It should be presented as a fancy, desirable option – “The new arrival from Sweden” – which is cost efficient and easy to operate. Convincing upper class hotels to install ecological sanitation systems would help considerably to create demand.
- *Design:* A dry compost toilet, could look like a conventional flush toilet. You should design a seat riser which looks like conventional ones but also put enough effort into designing a modern distinct seat riser. Ceramic versions are a must. If your toilet

looks nicer than conventional ones the different technology is bought in the package. Consult with professionals for marketing conventional sanitary ware.

- *Comfort:* In Sri Lanka the toilet should have a lid, which closes the drop hole to prevent the user from seeing the faecal material. An ash dispenser version (see Question l) and a bidet version (see Question m) should be available. Different technologies for increasing the user comfort regarding the use of water for cleansing should be developed (see Question n).
- *Choice:* As mentioned before, there has to be a choice of different options and designs. It also has to be noted that urine diverting is possible where a flush system is already installed.

References:

WSP (2004) *The Case for Marketing Sanitation*, Field Note, Water and Sanitation Program, Nairobi

Question k: What are the main institutional obstacles that would prevent ecological sanitation to go to scale?

Dry compost toilets are an approved technology by the Ministry of Health. However, the information did not reach the local level yet. Currently a handout for the local level is under preparation. For ecological sanitation to go to scale relevant legislation regarding the reuse of human excreta and greywater has to be adapted. So far the reuse of human excreta is not addressed. Relevant legislation has to be streamlined. Responsibilities have to be defined.

Legal situation regarding compost toilets in Sri Lanka

Dry Compost toilets are an approved technology by the Ministry of Health and recognized by the Ministry of Urban Development and Water Supply as a safe sanitation option in the revised National Policy for Rural Sanitation. Every Ministry has to be informed, particularly the Ministry of Local Government and Provincial Councils, the Ministry of Environment, the Ministry of Education, and the Ministry of Agriculture. The relevant regulations and guidelines also have to include ecosan toilets as an option and the information has to be passed down to the staff in the field. The Public Health Inspector (PHI) attached to the Ministry of Health and to the Ministry of Local Government and Provincial Councils approves toilet construction. Without the PHIs approval no compost toilets can be built legally. At this stage it is crucial to distribute a handout containing the basic information about dry compost toilets. This process is currently undergoing. Standards for the construction of dry compost toilets to be included in the Sri Lanka Standards are under preparation. The Pradeshiya Sabha Act, the Municipal Council Ordinance, and the Urban Council Ordinance should be reviewed in regard of conformity with the approval of dry compost toilet systems.

Up-scaling ecological sanitation

For ecological sanitation to go to scale the reuse of ecosan products has to be addressed. A legal framework to govern the reuse is needed. Relevant legislation regarding the reuse of human excreta and greywater has to be adapted. Legislation on Environment in Sri Lanka includes several acts which could have an impact on the reuse of human excreta in agriculture. Some of them are listed below:

Legal responsibility on sanitation and solid waste management of Sri Lankan Local Authorities can be considered under following areas.

- (i) Constitutional provisions
- (ii) Provision in governing legislations of Local Authorities.
- (iii) Provisions under other legislations.
- (iv) Provisions under provincial statutes.
- (v) Provisions under Subsidiary Laws.

ii:

- Provincial Councils Act No. 42 of 1988
- Municipal Councils Ordinance No. 16 of 1947
- Urban Councils Ordinance No. 61 of 1939
- Pradeshiya Sabha Act No 15 of 1987 (done by MoLocal Gov.)

iii:

- National Environmental Act No 47 of 1980
- Urban Development Authority Law no 41 of 1978
- Nuisance Ordinance No. 15 of 1862
- Fertilizer Act No 21 of 1961
- Irrigation Ordinance (Cap. 453)
- National Water Supply and Drainage Board Act No 2 of 1974
- CEA Regulations -1990
- Standards

Currently none of these regulations refers to the use of human excreta for agriculture. Regulation on organic agriculture and organic fertilizer is under preparation. At this stage it is important to lobby for the incorporation of ecosan products into respective regulations.

The legal framework should not prescribe specific technologies but should be based on the principles of maximizing public health and environmental protection. To identify necessary changes within the existing institutional framework a comprehensive analysis of the existing policy framework should be conducted. A completed policy analysis will also be helpful for developing an action plan.

Question 1: Is it possible to design a mechanism (similar to flushing the toilet) to cover the solid excreta with ash or any other decomposing material instead of the existing method of manually covering with ash after using of the toilet?

Yes, it is possible to design a mechanism (similar to flushing the toilet) to cover the solid excreta with ash or any other decomposing material instead of the existing method of manually covering with ash after using of the toilet. In China these mechanisms already exist. Photographs 7 & 8 show different of an ash dispenser which has to be operated with the foot. One presses the foot pedal, which pulls a cable and opens a valve in the pipe. This releases an amount of ash down the pipe. The supply of ash is stored in the "cistern" at the top.



Photograph 7: Ash dispenser, China
(Photo: R. Holden 2001)



Photograph 8: Ash dispenser, China
(Photo: A. Austin 2001)

Photograph 9 and Figure 1 show a more recent version of an ash dispenser in China. The ash is directed towards the lid covering the drop hole. The lid rotates releasing the ash over the fresh fecal material.



Photograph 9: Seat riser for UDDT with black lid covering the drop hole (Photo: F.Klingel)

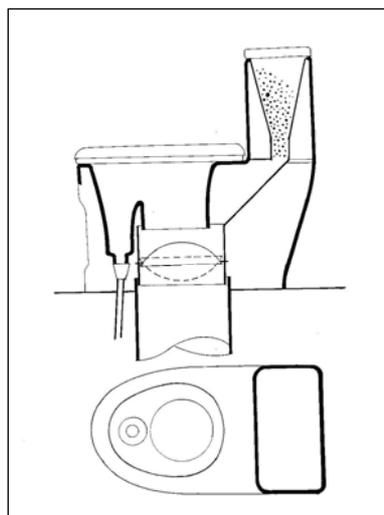


Figure 1: Technical drawing of seat riser to the left with ash dispenser (Source: F.Klingel)

When choosing an ash dispenser the following potential problems may occur (Calvert P., 2006; Holden R., 2006):

- If the ash or the respective additive is not dry it easily clogs and blocks the pipes. This could be relevant for Sri Lanka, due to the high humidity.
- Depending on the design, the additive has to be well sieved to prevent blocking.
- If the dispenser is broken people might stop applying the additive.
- Make sure to design a mechanism which assures the faeces are covered.
- The potential of an “ash and forget” mentality increases. As users might just push the pedal and not realize if the system does not work properly.
- Refilling of exchanging the material in an ash dispenser might be more complicated than using a bucket.

Nevertheless, a properly designed ash dispenser could be a very good solution for middle income communities, even though these might adapt well to a scoop system. For poor communities an ash dispenser is not recommended since a scoop is far cheaper, more effective and hardly gets broken. Always remember: “The more moving parts, the more could go wrong!”

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Question m: Is it possible to have a flushing system for the urinal and washing area? Is it possible to design a bidet for urine and washing, where this system would also become a similar system to use of water closet and bidet?

Yes, it is possible to have a flushing system for the urinal and washing area. However, ecosan toilets aim at reusing urine as fertilizer in agriculture. If the urine is not to be used at household level and has to be stored a minimum dilution is desired. To design a bidet for washing is possible. It should not be used for urinating.

For large and medium scale ecosan systems storage and transport of the ecosan products, fertilizer and soil conditioner, are important parameters. To minimize the cost of the system regarding storage and transport urine should be as less diluted as possible.

Flushing of combined urine and washing area

A flushing of the urine or urine-washing section with minimal water use is possible. The question is, if one uses this section for washing would it still be necessary to flush after finishing washing? A possible option to optimize the storage and reuse of urine would be to develop a mechanism which diverts the undiluted urine to the storage tank and the washing water to the grey water system. A possible mechanism could be: Moving forward on the slab to the washing area, releases a valve which opens the greywater pipe and closes the urine pipe or the same when removing the hand shower from the hook.

Bidet

A bidet for urine and washing is not recommended. The system should be the same as the use of a water closet (WC) and a bidet. The WC / UDDT is used for urinating and defaecating while the bidet is used for washing only. An UDDT is easily combined with a bidet. This option is preferable to a combined urine and washing area since the urine can be stored undiluted. Photograph 10 shows an UDDT and bidet developed in the Philippines.



Photograph 10: UDDT and Bidet, Philippines (Photo: D.Lapid)

Waterless Urinal

Since men are often standing while urinating the installation of a urinal is sometimes easier than a behavior change. For the collection of undiluted urine the use of a waterless urinal is necessary. There are various low and high cost waterless urinals available (see GTZ 2005). Slab urinals are known in Sri Lanka. They are a small channel in the slab where urine is collected and drained away. More high tech solutions use mineral oil or aliphatic alcohols as sealing liquids. The urine, which is heavier than the liquid, sinks down through the liquid and further down to the drain. A simple but very effective technology is the use of a rubber membrane, or even a condom would do (Otterpohl, 2006). Urine passes through the membrane by gravity and the membrane closes instantly afterwards, preventing smell. Photograph 11 shows the membrane and Photograph 12 the nicely designed up-market version obtainable from Keramag.



Photograph 11: Rubber membrane
(Photo: Keramag)



Photograph 12: Waterless Urinal
(Photo: Keramag)

References

- GTZ (2005) *Technical data sheets for ecosan components, 01 Urine Diversions*. Gesellschaft für technische Zusammenarbeit, Germany
 Otterpohl R. (2006) Personal communication

Internet resources

www.swamp-eu.org

Question n: What are the different options for the disposal of water and urine?

The different appropriate options for the disposal of water and urine are:

- Storage and active reuse of urine
 - o **Individual storage and reuse**
 - o Semi-central storage
 - o Central storage
- Diversion and passive reuse of water and urine
 - High ground water table
 - o **Evaporation bed**
 - o French drainage
 - Low ground water table
 - o **Soil infiltration bed**
 - o Seepage bed
 - o Seepage trench
- Diversion of water and urine to constructed wetland without reuse

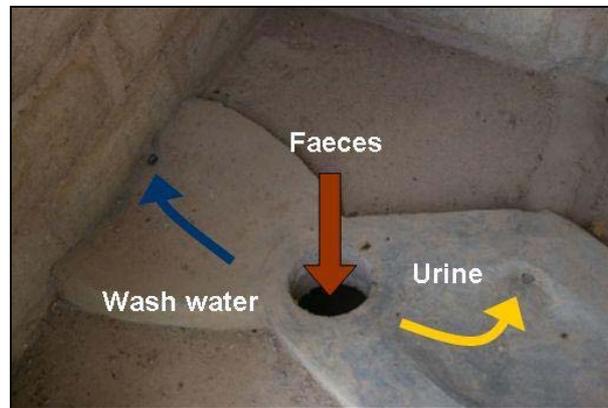
The **bold** options are the recommended options. However, storage and active reuse of urine should be the preferred option. Drainage and passive reuse is a viable option if an active reuse is not possible or wanted.

The used systems in Sri Lanka are evaporation beds and soil infiltration.

Storage and active reuse

Of the three fractions produced in dry compost toilets in Sri Lanka - wash water, urine, faecal material - urine is the most valuable. Urine is rich in nitrogen and phosphorus. It can be stored individually, semi-central or central and used as hygienic fertilizer.

The volume to be stored and transported is crucial for the arising cost in particular for large scale applications. Therefore, in Sri Lanka the use of wash water has to be addressed. Wash water should be diverted and treated separately, e.g. together with grey water in a constructed wetland or in soil infiltration beds. Respective squatting slabs (see Photograph 13) and seats are available and can be further developed (see also Question m). In small scale applications the urine could either be stored undiluted or diluted. If urine and wash water are stored together the storage container fills faster. More or bigger jerry cans/containers are needed.



Photograph 13: Squatting slab diverting wash water and urine separate, Burkina Faso (Photo: CREPA)

Individual Storage

The urine can be collected at individual toilets in jerry cans or other containers. The schematic drawing in Figure 2 shows a possible solution for individual urine storage. Photograph 14 shows the storage of urine using a jerry can. In Photograph 15 a urine storage container with a tap can be seen. Photograph 16 shows the urine collection tank of an UDDT installed in a school.

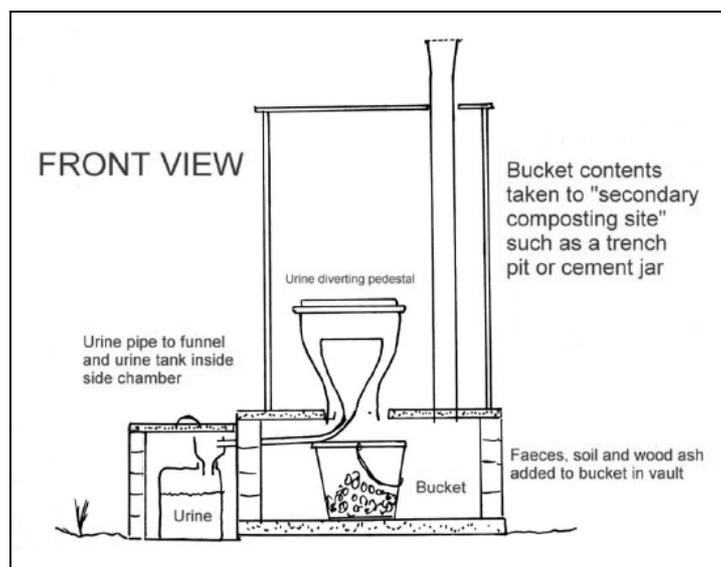


Figure 2: Urine Diverting Dry Toilet with individual storage (Source: Morgan 2004)



Photograph 14: Use of jerry can for storage of urine, Uganda (Photo: C.Windberg 2006)



Photograph 15: Urine container with tap, Uganda (Photo: C.Windberg 2006)



Photograph 16: Urine collection tank installed in school, Uganda (Photo: C.Windberg 2006)

Semi-central storage

The urine generated by a number of households can be drained to a semi-central tank located in or adjacent to a cluster of houses. The storage tanks in Photograph 17 are located in Kullön, Sweden. 775 people in 250 households are using a urine-diverting toilet system. The urine is collected at neighborhood level in 13 tanks (Kvarnström et al. 2006).



Photograph 17: Two urine tanks at Kullön during construction (Photo: M. Johansson)

Central Storage

The urine collected from a cluster of households can be transported to a central storage facility for large scale agricultural reuse.

In 1997 a large scale urine collection system was established in Stockholm. Urine from three residential areas and one conference centre is transported to the Lake Bornsjön area where it is stored and replaces chemical fertilizer in agriculture. The condominium organizations at household level are responsible for the collection tanks in the residential areas. They contract an entrepreneur to transport the urine to the centralized storage. Tanker lorries are used for transportation and the distance is approximately 30 km. The Stockholm Water Company is responsible for storage (in “balloon tanks”) and the spreading on farmland. Photograph 18 shows one of three PVC balloon tanks of 150 m³ each. The urine is used on fields in the background owned by the Stockholm Water Company. (Kvarnström et al. 2006)



Photograph 18: Balloon tank at Bornsjön (Photo: VERNA)

Drainage and passive reuse

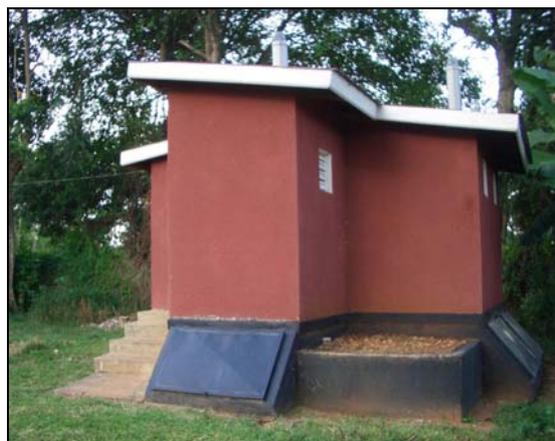
If the collection and active reuse of the urine is not wanted or possible, urine and wash water can be diverted together. Contamination of the groundwater has to be prevented.

In areas with high groundwater table an evaporation bed is recommended. Where an evaporation bed is not possible a French drain system could be used.

In areas with low ground water table soil infiltration beds are recommended. Seepage pits and seepage trenches are further options. For the design and applicability of any of these options the percolation rate of the ground has to be established before construction. Plants with a high demand of nutrients should be planted on top or around these infiltration systems to ensure nutrient uptake (passive reuse).

Evaporation bed

In areas with high ground water table an evaporation bed is recommended. Photograph 19 shows a solar heated urine diverting dry toilet with an evaporation bed. However, no plants are grown at the time of taking the photograph. To assure optimum nutrient uptake plants with high nutrient consumption like banana, papaya or maize should be planted.



Photograph 19: Solar heated UDDT with evaporation bed, Uganda
(Photo: C.Windberg 2006)

French drain

If the space requirements for an evaporation bed can not be met or for any other reason which do not allow for the construction of evaporation beds French drain filters can be used alternatively. French drain filters are simplified horizontal gravel filters for sites with high groundwater table. At the end of the French drain filter, water is infiltrated to the soil through

a plant bed. If possible plants can be grown beside the French drain to provide additional groundwater protection. An example of a French drain constructed 2005 by WTO and Habitat for Humanity in Galle is shown in Figure 3. This French drain is connected to a septic tank.

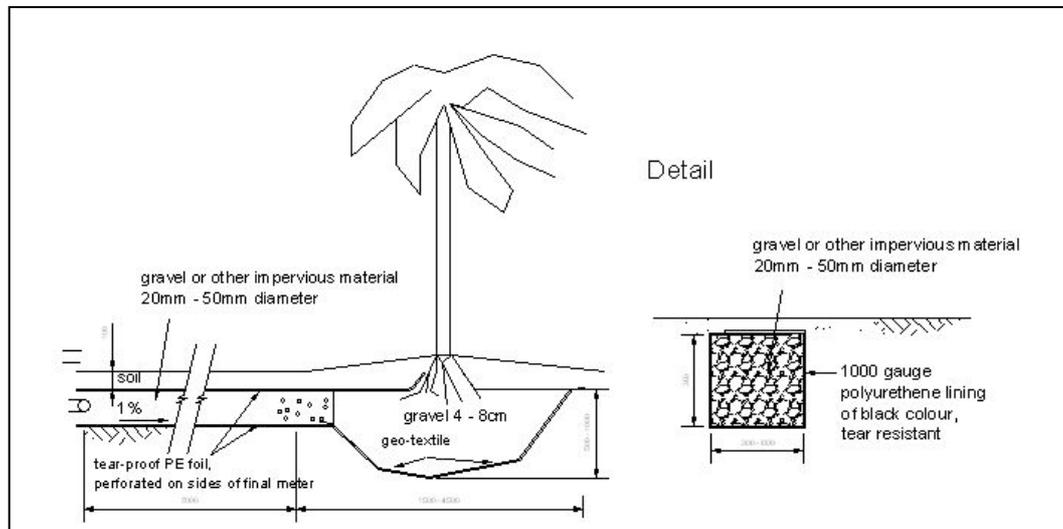


Figure 3: French drain and soil infiltration bed (Source WTO, 2006)

Soil infiltration bed - seepage bed – seepage trench

In areas with low ground water table urine and wash water can be diverted directly into the ground. This can be done by

- Soil infiltration beds: single pipe leading underground to a plant (Figure 4)
- Seepage beds: bed of prepared aggregate (Figure 5) or a
- Seepage trenches: trench filled with prepared aggregate.

Seepage trenches are similar to seepage beds except that they are suitable for sloping ground where the ground slope is less than 25 per cent. (SLS 745)

Plants with a large nutrient consumption, e.g. banana or papaya should be planted on top of a soil infiltration bed. Seepage beds and seepage trenches should be located around existing productive plants, such as banana or papaya to provide additional groundwater protection and additional benefits through improved yields. If there is no vegetation existing it should be planted. Dry compost toilets with soil infiltration and seepage beds are built by ACF and Australian Red Cross.

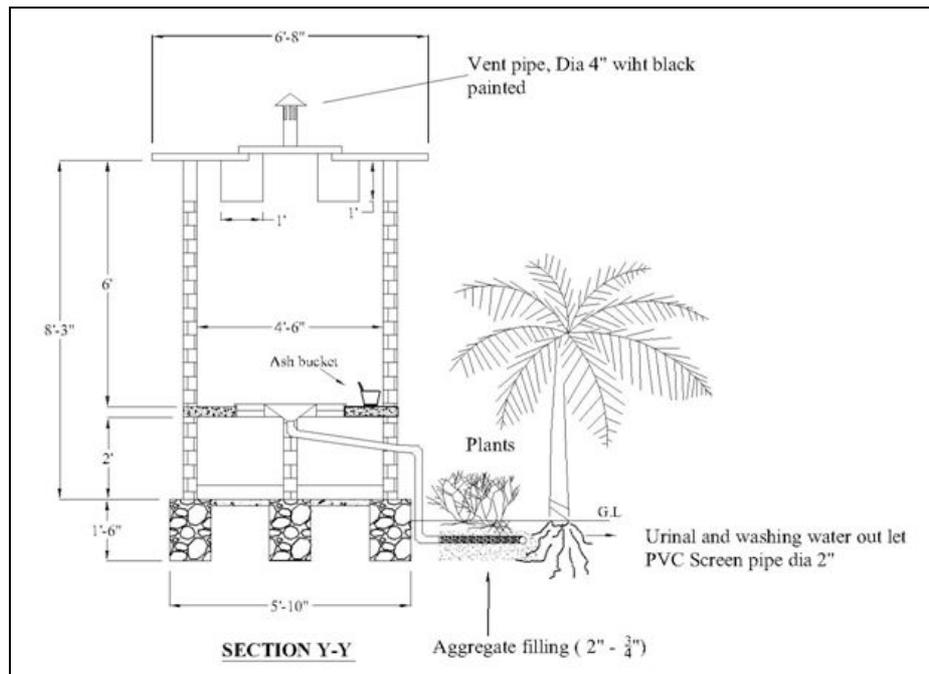


Figure 4: Example of dry compost toilet with soil infiltration bed (Source: K. Pasupathiraj 2006)

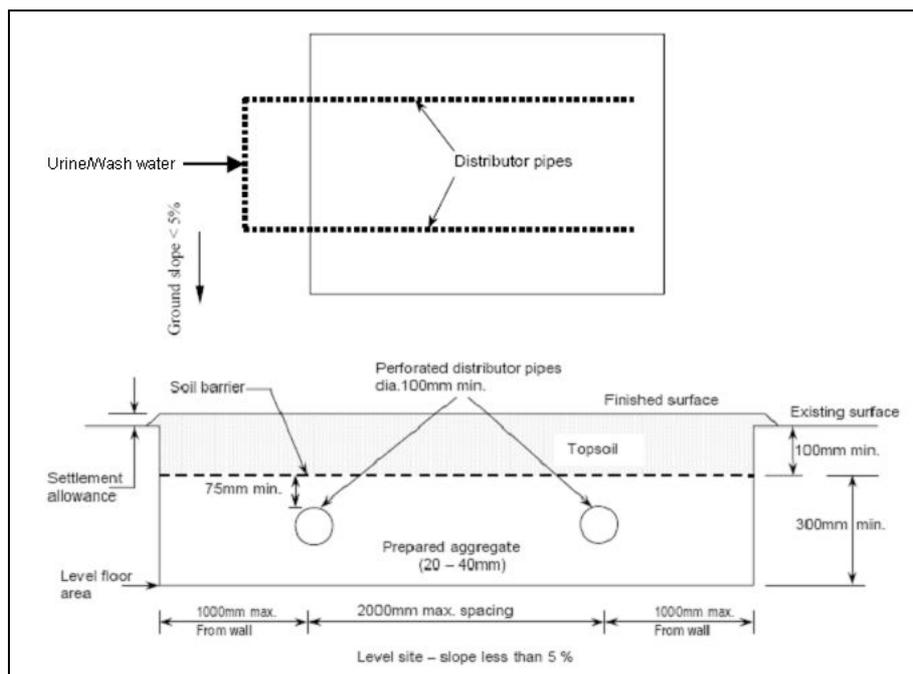


Figure 5: Typical Arrangement of a seepage bed adapted from SLS 745, Dimensions are not applicable for the connection to UDDT systems (Source: SLS 745)

Constructed Wetland (no reuse)

The urine / wash water flow can be drained to a constructed wetland. The dimensions of the constructed wetland (CWL) have to be adapted to the high nutrient load.

Potential reasons for diverting urine and wash water to a CWL could be:

- The main interest is the reuse of faecal material as compost or biogas.
- Water scarcity. Flushing only urine and wash water requires a minimal amount of water.
- The urine reuse should be introduced at a later stage.
- A family CWL is cheaper than a soak pit system.

For information on constructed wetlands see SLS 2003 and Huba et al. 2006.

References:

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Question o: What is the possibility for this toilet to be included into a bathroom, together with the wash basin and the shower or any other modern facility? If it is possible what is the space requirements?

There is no problem to include UDDTs in a modern bathroom. No specific space is required. The space needed in the bathroom is the one for the seat riser or squatting slab. Therefore the space requirements are the same as for a conventional toilet. The faecal chambers or storage containers could either be placed on ground level or underground. If placed on ground level the seat riser/squatting slab has to be raised (see Photograph 20). If the chambers or storage containers are underground or on a different floor (see Question p) the seat riser/squatting slab do not have to be raised (see Photograph 21).



Photograph 20: In house UDDT, China
(Photo: A.Rosemarin)



Photograph 21: In house UDDT, South Africa
(Photo: R.Holden, 2004)

Question p: Can we use this toilet for multi-storied buildings? (flats & Apartment buildings)

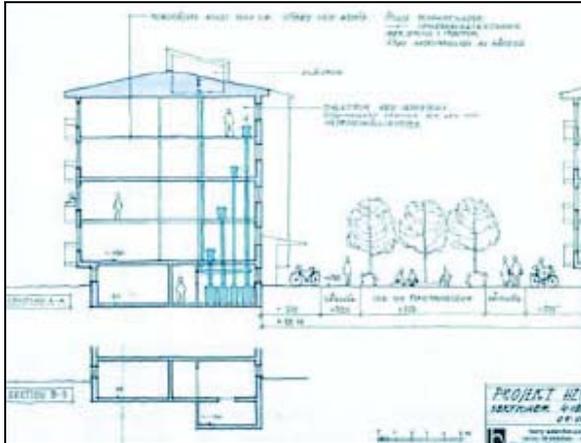
Urine Diverting Dry Toilets (UDDTs) can be used for multi-storied buildings. There are several installations in different countries, e.g. Sweden (2 storeys), China (4-5 storeys), India (2 storeys), Uganda (2 storeys), and Ethiopia (3 storeys). With the growing acceptance of ecological sanitation approaches worldwide large scale applications are possible and needed. The two major projects at the time of writing are in China and Ethiopia. More detailed information on the ecosan project in Dong Sheng, China is given below.

Dong Sheng, Inner Mongolia, China

An ecosan project has been initiated by the City of Dong in Erdos Municipal District, Inner Mongolia, China. This project is a private-public partnership in collaboration with the EcoSanres Programme. A private developer adapts a sustainable sanitation approach in a real estate business venture in return for access to a particular parcel of land and a government tax rebate. A new town with four and five-storey buildings, nursery school and service centre will be developed. Phase 1 including 824 apartments and onsite ecostation and greywater treatment system will be completed by the end of 2006. (Ecosanres 2006)

The apartments are equipped with modern porcelain urine diverting dry toilets and urinals. "Urine is collected and stored on site in underground brick and cement tanks made with local materials and subsequently used in local agriculture. Faecal material is retained in dry form in bin containers, removed from the building basements and composted and sanitized along with household organics in the onsite ecostation for reuse as soil improvement. Thus, the community is offered sanitation services that work without water, while the water and nutrient cycles are being closed." (Ecosanres 2006) More information can be found at www.ecosanres.org. The following figures and photographs provide an understanding of the installation of UDDTs in multi-storied buildings. Box 10, shows the layout, the apartment buildings and faeces collection bins and ventilation system of the above mentioned project in China. Box 11 illustrates a two storey application. "Gebbers" is a collective housing project and located in Orhem, a southern suburb of Stockholm. The site comprises 32 apartments and facilities for collective use. Around 80 people live at Gebbers (GTZ 2005).

Box 10: Dong Cheng, Inner Mongolia, China
(Source: EcoSanRes 2006)



Straight-drop urine diversion toilet design

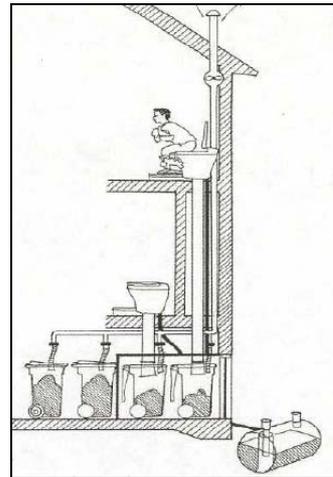


Apartment buildings (Photo: EcoSanres)



Faeces collection bins and ventilation system
(Photo: EcoSanres)

Box 11: Gerbers Stockholm, Sweden
(Source: GTZ 2005)



Straight-drop urine diversion toilet design



Apartment buildings (Photo: VERNA)



UDDT installed in flat at "Gebers"
(Photo: EKBO)

References

EcoSanRes (2006) *China-Sweden Erdos Eco-town Project, Dong Sheng, Inner Mongolia, China*, Fact sheet 11, Stockholm
 GTZ (2005) *Data sheets for ecosan projects, 008 Gebers collective housing project Orhem, Sweden*. Gesellschaft für technische Zusammenarbeit, Germany

ANNEX 1

- Estimation for the Construction of Dry Compost Toilet and Pour-Flush Toilet
- Underlying design of Dry Compost Toilet and Pour-Flush toilet

Annex 1: ESTIMATION FOR THE CONSTRUCTION OF DRY COMPOST TOILET AND POUR FLUSH TOILET

Material Cost

Dry Compost Toilet = DCT, Pour Flush Toilet= PFT

Date : 15/10/2006

No	Work Description	Unit	DCT	PFT	Rate /Rs	DCT	PFT
			Qty	Qty		Total in LKR	Total in LKR
1	Base work						
1.1	Excavation for foundation 1' wide, 1.5' deep	Cu.ft	24	21	8.50	204.00	178.50
1.2	Random Rubble Masonry work with 1:5 cement-sand mortar	Cu.ft	36	31.5	100.00	3,600.00	3,150.00
1.3	Floor concreting 1:2:4 3/4 agg , 3" thick	Cu.ft	5	5	188.00	940.00	940.00
1.4	Reinforcement T10mm bars	ft		36	15.38	-	553.85
1.5	Rendering and smooth finishing in Floor and plinth 3/4" thick, 1:3 cement - sand	Sq.ft	27.25	27.25	23.00	626.75	626.75
2	Step					-	-
2.1	Random Rubble Masonry work	Cu.ft	13.5	3.44	100.00	1,350.00	344.00
2.2	Rendering and smooth finishing 3/4" thick, 1:3 cement - sand	Sq.ft	14	5.85	23.00	322.00	134.55
2.3	Handrail GI pipe 1.5"		1	0	350.00	350.00	-
3	Super Structure/ Room					-	-
3.1	Brick work, 4" thick, with 1:5 cement - sand	Sq.ft	94.5	94.5	60.00	5,670.00	5,670.00
3.2	Plaster, 3/4" thick, 1:1:5 cement - lime - sand	Sq.ft	189	189	18.50	3,496.50	3,496.50
	Roof Slab					-	-
3.3	Concrete 1:2:4 3/4"agg	Cu.ft	9.25	9.25	188.00	1,739.00	1,739.00
3.4	Reinforcement Tore steel bar dia 10mm	ft	104	104	15.38	1,599.52	1,599.52
3.5	Door, with frame 6'-3" × 2'-9" (externally) of 4" × 3" class 2 timber, with sash (brazed) of 3/4" thick Class 2 timber, with 1 no. 4" brass barrel bolt, 3 nos. 4" × 3" brass but hinges, including 2 coats of Aluminum primer and 2 coats of enamel paint	No	1	1	2,600.00	2,600.00	2,600.00
4	Painting work					-	-
4.1	Applying 2 coats of slaked lime and two coats	Sq.ft	252	226	8.00	2,016.00	1,808.00
5	Pit / Chamber					-	-
5.1	Excavation	Cu.ft	0	133	8.50	-	1,130.50
	<i>Slab septic tank bottom slab</i>					-	-
5.2	Concrete 1:2:4 3/4" agg	Cu.ft	5	5.95	188.00	940.00	1,118.60
5.3	Reinforcement Tore steel bar dia 10mm	ft	44	103.24	15.38	676.72	1,587.83
5.4	Brick work, 4" thick, with 1:5 cement - sand	Sq.ft	38	77	60.00	2,280.00	4,620.00

No	Work Description	Unit	DCT	PFT	Rate /Rs	DCT	PFT
			Qty	Qty		Total in LKR	Total in LKR
5.5	Plaster, 3/4" thick, 1:3 cement -sand	Sq.ft	38	50	23.00	874.00	1,150.00
	<i>Cover slab - Septic tank and soakage pit</i>					-	-
5.6	Concrete 1:2:4 3/4" agg	Cu.ft	0	6.73	188.00	-	1,265.24
5.7	Reinforcement Tore steel bar dia 10mm	ft	0	119.24	15.38	-	1,833.91
5.8	Mild steel bar dia 6mm	ft	0	20	3.33	-	66.67
5.9	R/f concrete precast cylinder - Soakage pit height 2', internal diameter 2'	No	0	1	1,070.00	-	1,070.00
5.10	R/f concrete, Covers for openings on top slab, 1' 3" x 1' 3", 1.5" thick, with 1:2:4 - 3/4" agg., reinforced with 2" x 2" GI wire mesh and hook for lifting	No	2	2	350.00	700.00	700.00
5.11	Supplying and placing 4" rubble at the bottom, height 2', diameter 2' to form a porous packing as per drawing	Cu. ft.	0	6.28	35.00	-	219.80
	<i>Urinal and waste water trap</i>						
5.12	Brick work, 4" thick, with 1:5 cement - sand	Sq.ft	12	0	60.00	720.00	
5.13	Plaster, 3/4" thick, 1:3 cement -sand		12	0	23.00	276.00	
5.14	Concrete 1:2:4 3/4" agg	Cu.ft	1.2	0	188.00	225.60	
6	Plumbing work					-	-
6.1	Supplying and installing ceramic squatting pan, colour white, including ceramic trap placed on 6" x 6". 2" thick concrete pad	No	0	1	1,500.00	-	1,500.00
6.2	Supplying and installing 4" PVC pipes of type 400	L. ft.	10	15	200.00	2,000.00	3,000.00
6.3	Accessories Supplying and installing 4" PVC Tee and elbow of Type 400	No	3	2	85.00	255.00	170.00
6.4	ECO pan	No	1	0	1,350.00	1,350.00	-
6.5	Mesh cloth for vent	item	1	1	25.00	25.00	25.00
6.6	Supplying and installing PVC pipe 1.5" Dia vent pipe / urinal and waste water outlet	ft	10	7	74.00	740.00	518.00
6.7	Bucket 5 l	No	2	1	120.00	240.00	120.00
6.8	Wooden spoon	No	1	0	15.00	15.00	-
6.9	Plants(Banana, Papaya)	item	1		75.00	75.00	-
						-	-
	ESTIMATED MATERIAL COST in LKR					35,906.09	42,936.22
	TOTAL ESTIMATED COST (MATERIAL + LABOR*)					46,943.59	56,686.22

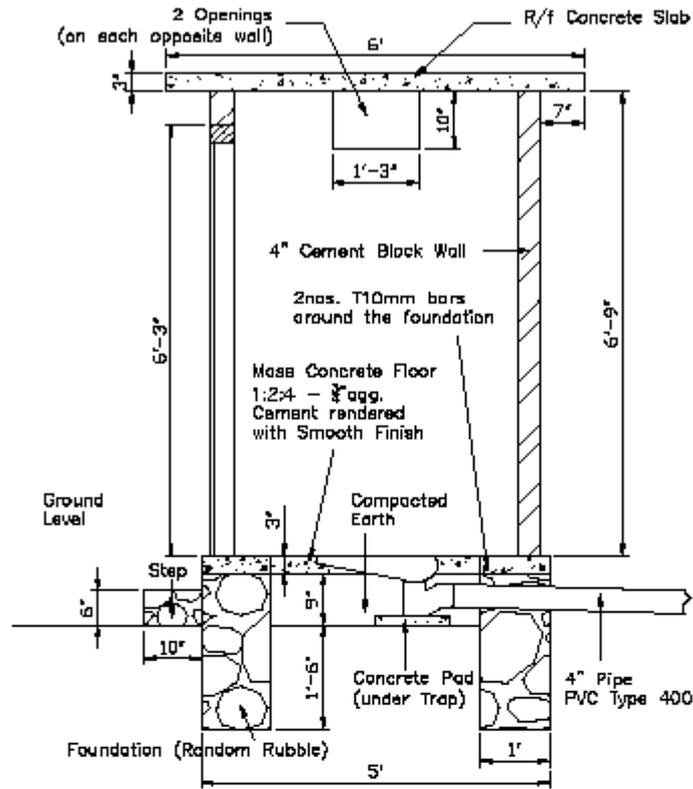
* see below

Cost of Labor

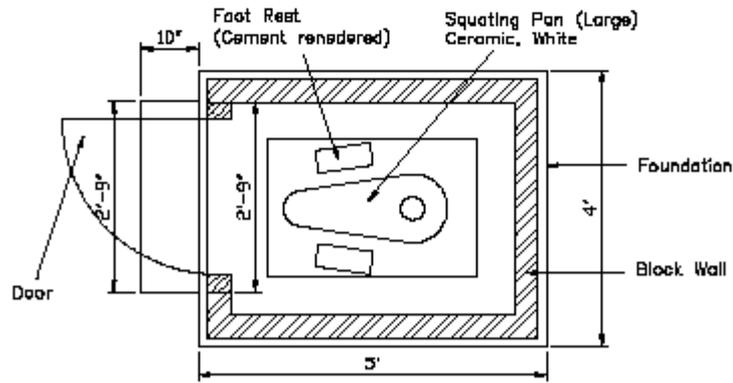
Date : 15/10/2006

No	Description	Dry Compost Toilet		Pour flush Toilet	
		Skilled Labor in Days	Unskilled Labor in Days	Skilled Labor in Days	Unskilled Labor in Days
1	Base work	2	3	2	3
2	Step	1	1	0.5	0.5
3	Super Structure/ Room	5	7	4	6
4	Painting work	0.5	0	0.5	0
5	Pit / Chamber	1	1	4	7
6	Plumbing work	0.75	0	0.5	0
Total Days		10.25	12.00	11.50	16.50
Rate LKR / day		550.00	450.00	550.00	450.00
		5,637.50	5,400.00	6,325.00	7,425.00
TOTAL LABOR COST		11,037.50		13,750.00	

LATRINE



SECTIONAL ELEVATION



SECTIONAL PLAN

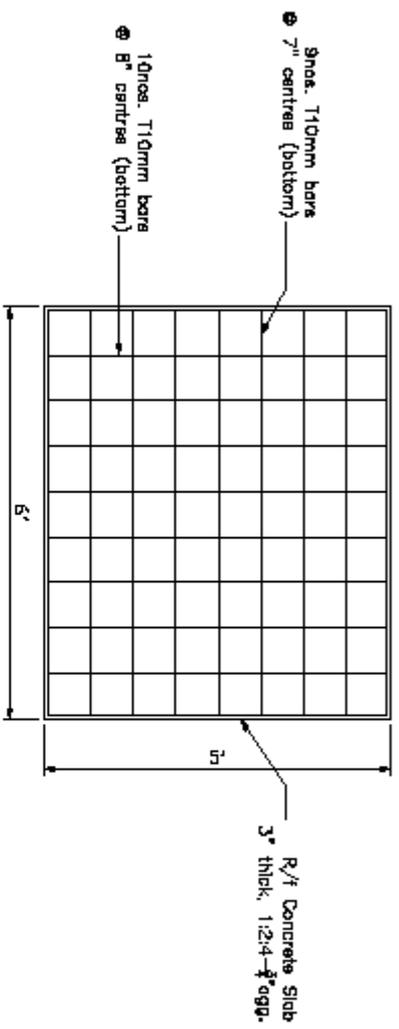
LATRINE FOR
AN INDIVIDUAL FAMILY

DRAWING NO.: HAB/LAT/01

DATE: 29/08/2006 SCALE: 1:25

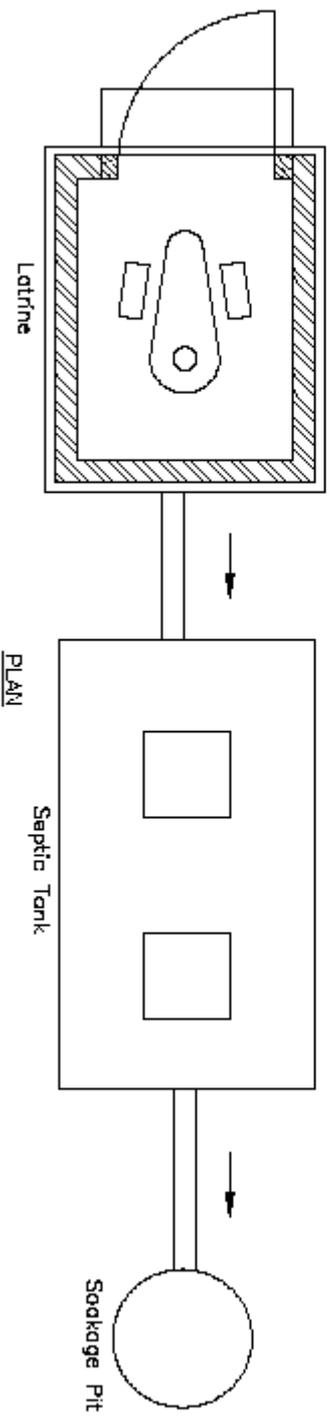
CAD BY:

LATRINE



REINFORCEMENT DETAILS OF ROOF SLAB

LAYOUT

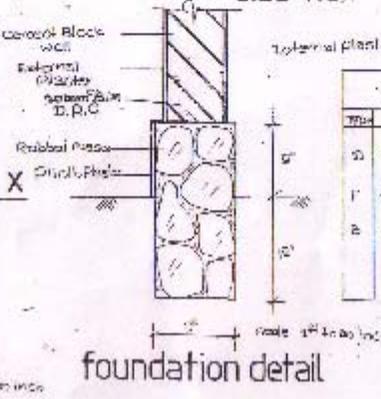
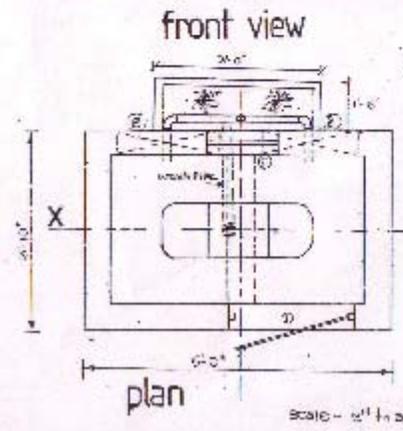
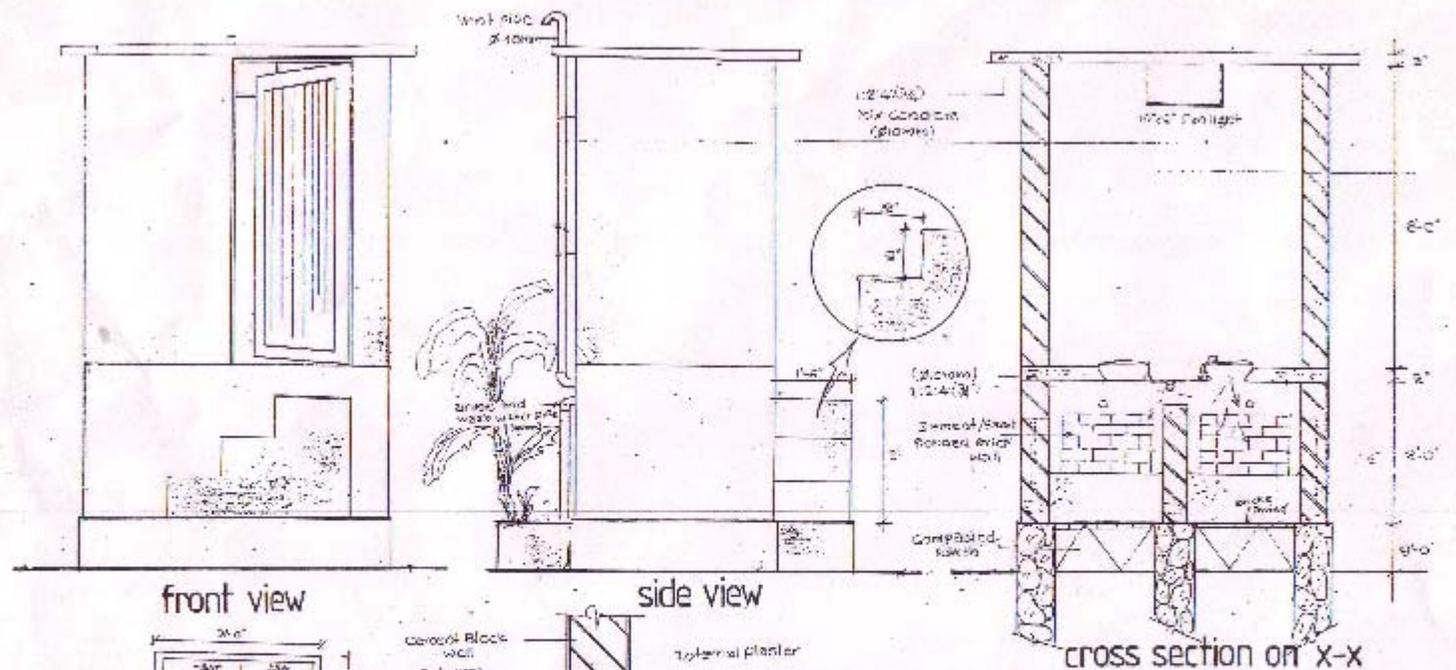


LATRINE FOR AN INDIVIDUAL FAMILY

DRAWING NO.: H4B/LAT/02

DATE: 29/08/2006 SCALE: 1:25

CAD BY:



Schedule of openings

Sl. No.	Description	Size	Qty
1	Ordinary door	3'6" x 7'0"	01
2	Fan light (ventilation)	1'0" x 1'0"	01
3	Window	3'6" x 7'0"	01

Design By - Y.H. Phyllis
 Date: 10/10/2023

Scale - 1/4" = 1'-0"

ANNEX 2

- Retail / Producer Margin for Selected Food Items,
Second Quarter - 2006

**Retail / Producer Margin for Selected Food Items
Second Quarter - 2006**

Item No (1)	Item (2)	Unit (3)	Producer's Price (4)	Retail Prices (Rs)		Retail Margin (%)	
				All Island (5)	Colombo City (6)	All Island (7) [(5) - (4)] / (4) X 100	Colombo City (8) [(6) - (4)] / (4) X 100
CEREALS							
1	Rice - Row Red	Kg	23.35	27.64	30.08	18%	29%
2	Rice - Parboiled	Kg	24.33	31.07	34.63	28%	42%
VEGETABLES							
3	Beans Butter	Kg	44.54	76.46	90.54	72%	103%
4	Beans Green	Kg	46.55	75.33	80.96	82%	74%
5	Cabbage Seed	Kg	23.53	54.10	65.45	130%	178%
6	Carrot	Kg	45.35	83.60	94.83	84%	109%
7	Beetroot	Kg	35.63	71.39	88.48	100%	148%
8	Raddish	Kg	12.57	36.77	51.38	192%	309%
9	Tomato Salad	Kg	34.04	66.71	86.43	96%	154%
10	Ash Plantain	Kg	23.54	49.03	68.66	108%	192%
11	Ladies Fingers	Kg	21.81	46.81	59.43	114%	172%
12	Bitter Gourd	Kg	28.84	53.25	68.93	85%	139%
13	Red Pumpkin	Kg	16.33	32.83	39.58	101%	142%
14	Brinjals	Kg	24.41	49.70	66.49	104%	172%
15	Green chillies	Kg	48.33	83.68	98.38	73%	104%
PULSES							
16	Green Gram	Kg	63.77	111.59	116.41	75%	83%
YAMS							
17	Potatoes (local)	Kg	51.54	73.71	75.44	43%	46%
CONDIMENTS							
18	Dried Chillies	Kg	113.30	154.27	164.78	36%	45%
19	Pepper	Kg	129.98	220.81	254.02	70%	95%
20	Limes	Kg	18.17	39.56	55.53	118%	206%
21	Cocount (medium)	Each	13.32	16.69	18.75	25%	26%
FRESH FISH							
22	Balaya	Kg	143.59	244.40	224.56	70%	56%
23	Salaya	Kg	70.12	113.11	110.01	61%	57%
24	Mullet	Kg	157.93	257.96	344.27	63%	118%

Source : Dept. of Census & Statistics