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The study on ecological sanitation systems in Dar-es-Salaam (Tanzania)

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Abstract

The study was on two wards of Dar-es-Salaam namely Karakata and Majumbasita. This study was based on; studying the existing situation of the systems, determining the systems´ performance in pretreatment of human-excreta, and checking the safety associated with human-urine re-use in agriculture. The parameters analyzed were pH, temperature, COD, VSS for methanogenic activity, and stability test in faecal material, and in urine, the parameters were pH and faecal-coliforms. The laboratory findings are as follows; (1) the faecal material from the eco-san toilets showed; 85% and 91% decrease in COD and in ascaris eggs, respectively compared to normal pit latrines, 92 mgCOD/gVSS/day methane gas production rate, 80-100 stabilization days, 8.8 average pH (2) the urine from the eco-san toilets showed 50-600 faecal-coliforms (counts/100ml) and 9.3-11.8 average pH. The conclusion drawn from these findings is; Ecosan toilet when properly used is the best sanitation system in pathogen destruction and organic matter reduction.

Keywords: Ecosan system; Faecal material; Performance; Urine; Ecosan toilet

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1. Introduction

Many uban and peri-uban cities of Tanzania use polluted water for domestic activities and this subject people to water borne diseases. Improperly treated wastewater discharges from municipal wastewater treatment systems pollute surface water and discharges from pit toilets and soak away pits of septic tanks pollute groundwater. Conventional technologies for wastewater treatment and disposal cannot solve the problem in urban and peri-urban areas lacking necessary resources such as water, money, electricity and institutional capacity (Franceys et al., 1992).

The ecological sanitation is the new approach introduced recently in Tanzania hence it was necessary to study the existing situation and evaluate the performance of the ecosan system in pre-treatment of human-excreta. The study on performance of ecosan systems in pre-treatment of human-excreta focus on: reduction of organic matter, rate of production of methane gas, biodegradability of human faecal material, and reduction of parasites *as compared to normal pit latrines*. The study also focused on checking the safety associated with reuse of human urine in agriculture.

2. Existing situation on ecosan systems in Dar-es-Salaam

2.1. Description of the study area

The study was conducted at Karakata and Majumbasita wards in Dar-es-Salaam. The areas are one of the unplanned settlements at the peri-urban part of Dar-es-Salaam City in Tanzania. It is about 11 km. from the city centre and it is closer to the Dar-es-Salaam International Airport in Kipawa ward, Ilala Municipality; with a population of about 23,000 inhabitants (Chaggu and John, 2002). Houses are mostly occupied by owners, with few inhabited by tenants. The piped water supply from the city network is inadequate for the inhabitants; 85% depend on well water (John, 2001) and are forced to use hand-dug wells although the quality is doubtful (Chaggu et al., 1993; Mato, 2002). Intermittency of water supply per week; that is, supplied for 2-4 hours only per supply was noted by Mahenge (2002). Only 5% of the residents get it once per week, 63.2% two days/week, 28% three days/week, 2% four days/week and 1.2% manage to get water for >4 days/week. The underground water table is about 0.5m below the ground-surface.

2.2. Description on existing situation of ecosan systems

There are 95 ecosan toilets built at the study area. Almost all people (about 96%) accept the ecosan systems. The Ecosan system involves the separation of urine at the source of production using urine separation toilets (Photos 1-7). 20 litres containers are used for storage of urine based on the easiness of lifting by one person for emptying purposes. For a household of 5-7 people commonly found at the study area, the storage tanks has to be emptied each 3-4 days. The urine is presently used as fertiliser in the gardens. A handful of charcoal or firewood ash is used as additive in the toilets once per day everyday.

2.3. Problems faced by ecosan systems` users

The Ecosan users face the following problems; (1) they do not know the actual amount of ashes to be added into faecal material, (2) For those who do not have gardens, they do not know what to do with their urine, (3) Most children under 8 years old misuse the toilets, that is, they mix urine and faeces in faecal chamber or in urine container, also they sometimes add anal cleaning water into the faecal chamber.

3. Materials and methods

3.1. Materials

Human faecal material and urine were the samples taken from the ecosan systems for the study.

3.2. Questionnaires

Questionnaires were conducted with the ten (10) users of ecosan systems to get information on the existing situation.

3.3. Sampling and analysis

Human faecal materials and urine from 10 ecosan toilets were sampled twice per week for three months. One kilogram of faecal material and one litre of urine were collected per latrine for laboratory analysis. The pH was determined both in-situ and in the laboratory. Other determined parameters were ambient temperature of the samples (in-situ and the in laboratory), COD, TSS, VSS, Volume of Methane Gas produced, Stability test; all determined using Standard Methods (APHA, 1992).

3.4. Schematic presentation and functioning of ecosan toilets

The schematic presentation of Ecosan system at Karakata and Majumbasita is as presented in Fig 1 with dimensions and other details shown in Table 1.

4. Results and discussion

4.1. Faecal material

4.1.1. pH

The pH results ranged from 6.0-10.4 due to addition of ashes. The correlation by ANOVA between pH and age of faecal material is highly significant at $P<0.001$.It was furthermore evident that, the pH increases with increasing age of faecal material in the faecal chamber.



Figure 1. Front view of the toilet



Figure 2. Rear side of the toilet

4.1.2. Total COD

Average total COD concentration in faecal material from ecosan toilets and normal pit latrines are 5500 mg/L and 35,000 mg/L, respectively. The average decrease in total COD is equivalently to 85. The lower COD concentrations in faecal material from ecosan toilets could be of the following reasons; (i) Urine Diversion:– Urine also contains organic matter with COD concentrations of about 2500 mg/L, so due to its diversion it means decrease of COD in faecal material. (ii) Additional of ashes in faecal material:– The ashes they are using contain higher amounts of oxygen in oxide forms, like Calcium Oxides, Magnesium Oxides, Silicate e.t.c. The Oxygen present in Oxide form may be used in Oxidation of organic matter, hence lower COD concentrations in faecal material from ecosan toilets.

Table 1. The Dimensions of Ecological Sanitation Toilet in Dar-es-Salaam

Component		Dimension (m)			
		Length	**Width**	**Height**	**Depth**
Superstructure	General	2	1.2		-
	Front-View	-	-	2.0	-
	Back-View	-	-	1.7	-
Squatting-Slab (pre-cast)		0.97	0.88		
Floor Slab		2	1.2	-	-
Pit ($2.4m^3$)		2	1.2	1.0	-
Pit relative to ground-level		-	-	1.0	0*
Openings for removing dehydrated faecal material		0.6	0.45	-	-
Urine and anal cleaning pipe		25cm. (1") PVC at a slope of 1:75 to 1:110			
Vent pipe		100mm. PVC pipe with a plastic cap** with holes on top (protrusion~0.5 m. above the roof cover)			
Angle of foot-rest		30^0 from normal direction of the foot			
Size of the hole		20cm diameter			
Urine container		20–60 litres (but mostly 20 litres for easy lifting)			

*The table raw data was from EEPCO [9] *Zero depth indicates that, the pit structure is above ground with an exception of some cm. for foundation*.

4.1.3. Ascaris eggs

The average number of ascaris eggs in faecal material from ecosan toilets and sludge from normal pit latrines are 280 number/1000gm and 4000 number/1000gm, respectively. The % decrease in number of ascaris is equivalent to 91. This reduction in number of ascaris is mainly caused by; (i) Dehydration of faecal material in ecosan toilets caused by urine diversion:– dehydration deprive the moisture that ascaris need to survive hence lower numbers of ascaris in ecosan toilets. (ii) Higher pH values in faecal materials of ecosan toilets:– Higher pH values cause alkaline conditions in the toilets of which it speeds up the death of ascaris and other pathogens.

4.1.4. Methanogenic Activity (MA)

MA defines Rate of Methane Gas Production. Average methanogenic activity in faecal material from ecosan toilets and in sludge from normal pit latrines is 92 mg-COD/g-VSS/day and 201 mg-COD/g-VSS/day, respectively. The decrease in rate of methane gas production is equivalent to 31. The slower MA in ecosan toilets might be due to lower COD concentration values found in faecal material of these toilets.

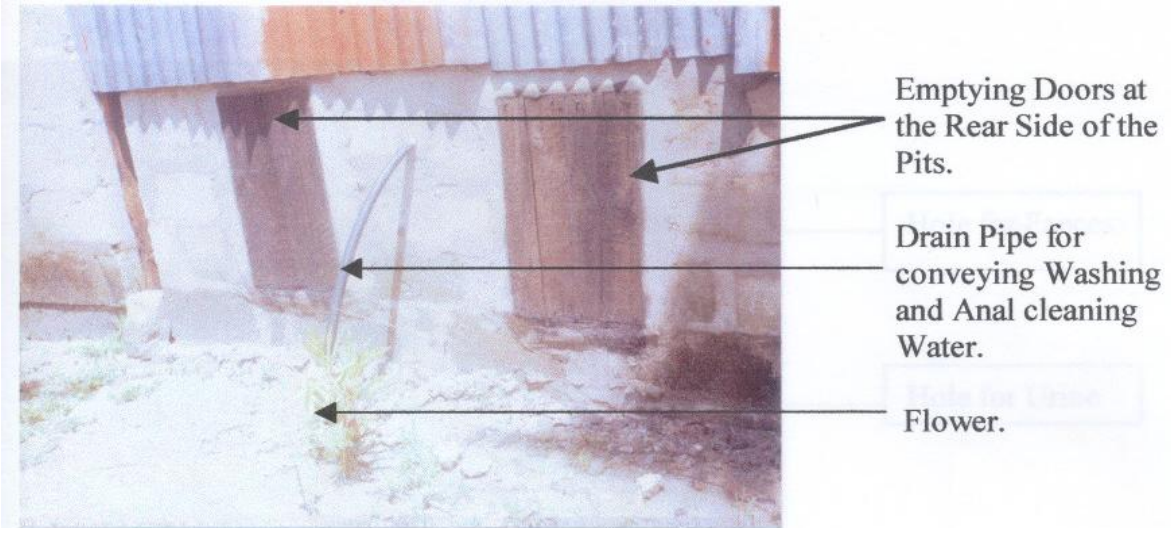


Figure 3. Detail A: Rear side of the pits

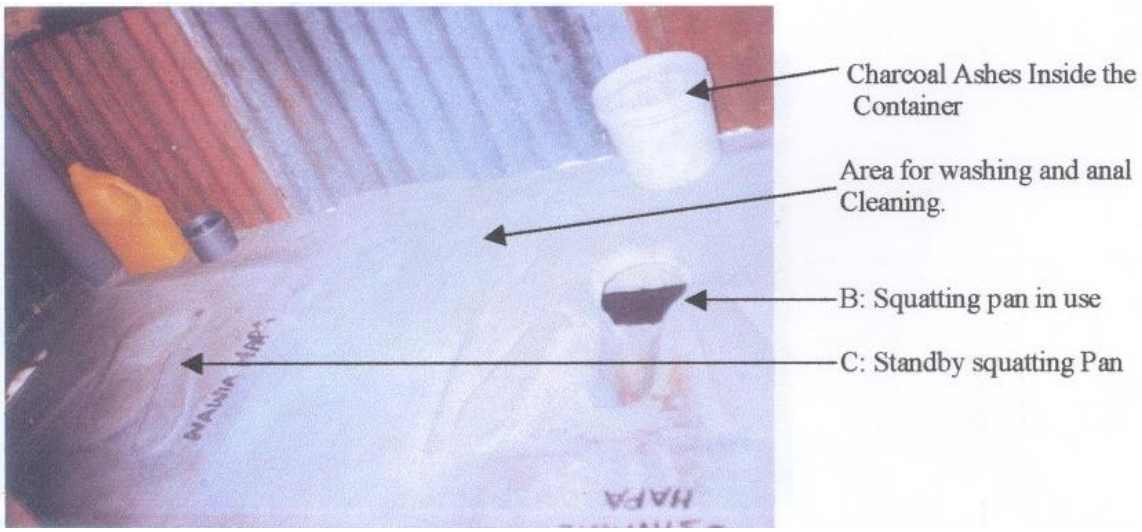


Figure 4. Inside of the toilet

4.1.5. Stability test

It takes around 80–100 days and 70 days for the methane gas to stop its production in ecosan toilets and normal pit latrines, respectively. Ecosan systems take longer time to stabilize because; much time is consumed in lowering of the pH at the acidogenesis stage. Acidogenesis is a second stage in anaerobic decomposition of organic matter. In this stage, the acid formers first become active reducing the pH to below 7 and then they start to decompose the dissolved organic matter present in their cells. Since the faecal materials from ecosan toilets have higher pH about 8.8 and above, then much is consumed to lower the pH.

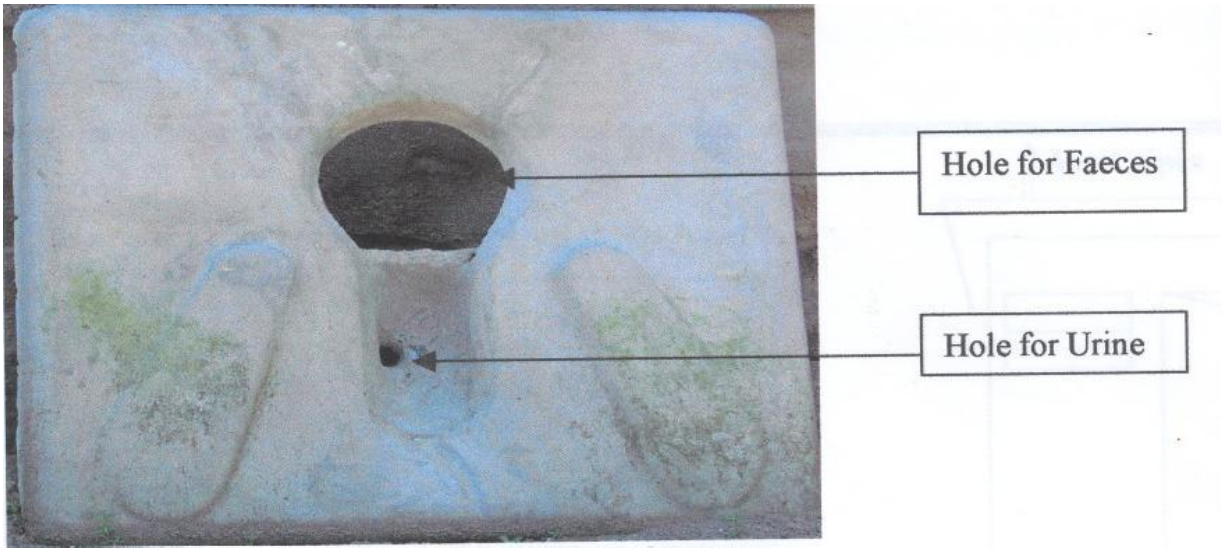


Figure 5. Detail B: Squatting-pan



Figure 6. Urine-Container

4.2. Urine

4.2.1. Faecal-Coliforms

Approximately 50% of ecosan toilets (10 samples) their urine are contaminated by faeces and the average faecal-coliforms counts were 2780 counts/100 mL urine. The other 50% of ecosan toilets were out of the maximum WHO Guidelines for unrestricted reuse in agriculture (1000/100ml.). Presence of faecal-coliforms in urine implies continued advocacy on use and separated urine can be re-used in tree growing, not for fertilising food crops consumed raw, but with adequate separation, the "pure" urine is expected to be free of pathogens (Esrey, 2001).

4.2.2. pH

The assessed pH of the collected urine ranged between 6.27-11.80 (±1.9501) and the temperature from 26.1-31.7 (±1) ^{0}C. From the fact that, the urine pH was 6–7 when excreted, but during its storage would raise to between 9-9.4 because of the degradation of urea (Johansson, 2000), the higher values found in our measurements implies that, there is a certain amount of ashes that went into the urine tank.

5. Conclusion

From the information collected, we can draw the following useful conclusions:

- By using the ecosan toilets, such as those installed at the study area, groundwater contamination can be avoided, since they are constructed above ground.
- More information needs to be collected as to the amount of ash (es) to be added to the faecal chamber.
- A complete separation of pure urine seems to be difficult for users as evidenced by faecal-coliforms observed in urine.
- The separated urine can be used directly as fertiliser in tree growing, but not for fertilising food crops that are consumed raw, due to presence of pathogens.
- The extent of biological faecal material stabilization likely is small in view of the prevailing high pH values.
- A lot of urban agriculture needs to be developed in order to enable the reuse of all the collected faecal material and urine. Otherwise, transport for reuse outside the city is necessary.
- *Ascaris eggs* are efficiently removed in ecosan toilets due to high pH.
- Advocacy on the use of ecosan toilets improves the separated urine quality.



Figure 7. Garden that uses human urine as fertilizer

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