Monday 19 January 2015 – CONFERENCE DAY 1 – Program

Room 3

13.45 – 14.30 **Lightning Panel Poster Session** – Innovation in FS treatment, Session I

The Nano Membrane Toilet - Damian Seal, Cranfield Water Science institute, Cranfield University, Bedford, United Kingdom

Real scale evaluation of a urine diverting dry toilet: Operational and hygiene perspectives - Maria Elisa Magri, Federal University of Lavras, Brazil

DRDO biotoilet: an eco-friendly appropriate and affordable sanitation solution for flush toilet system - Soumya Chatterjee, Defence research Laboratory, Defence R&D Organization, Ministry of Defence, Government of India, Tezpur, Assam, India

Important factors of on-site sanitation management in urban slum area (A case study of Greater Bandung Area, Indonesia) - Iendra Sofyan, Faculty of Civil and Environmental Engineering, Bandung Institute of Technology, Bandung, Indonesia

The Nano Membrane Toilet

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Keywords: toilet, membranes, nanotechnology

Current toilet designs are not meeting the needs of 2.6 billion people on earth who currently lack access to safe and affordable sanitation. Many of these also have non-existent or unreliable water, sewage and electricity supplies. The team at Cranfield University has proved the concept for a Nano Membrane Toilet which will be able to treat human waste on-site without external energy or water, allowing it to be safely transported away and reused. The toilet is designed for single-household use (equivalent to 10 people) and will accept urine and faeces as a mixed stream. The toilet flush uses a unique rotating mechanism to transport the mixture into the toilet without demanding water whilst simultaneously blocking odour and the user's view of the waste.

Solids separation is principally accomplished through sedimentation. Loosely bound water (mostly from urine) is separated using low glass transition temperature hollow-fibre membranes when a sweep gas is applied. Figure 1 shows the fluxes achieved. Commercially available dense and microporous membranes have been trialled. Water is transported in the vapour state rather than as a liquid state which yields high rejection of pathogens and some odorous volatile compounds.

Glass beads coated in either hydrophilic or hydrophobic silver nanoparticles enable water vapour recovery through encouraging the formation of water droplets at the bead surface. Once the droplets form a critical size, the water drains into a collection vessel for reuse at the household level in washing or irrigation applications.

Following release of unbound water, the residual solids (around 20-25% solids) are transported by mechanical screw press which drops them into a gasifier, developed by RTI International. The gasifier converts the solids into ash and energy. The energy will power the membrane processes, and there may be extra energy for charging mobile phones or other low voltage items.

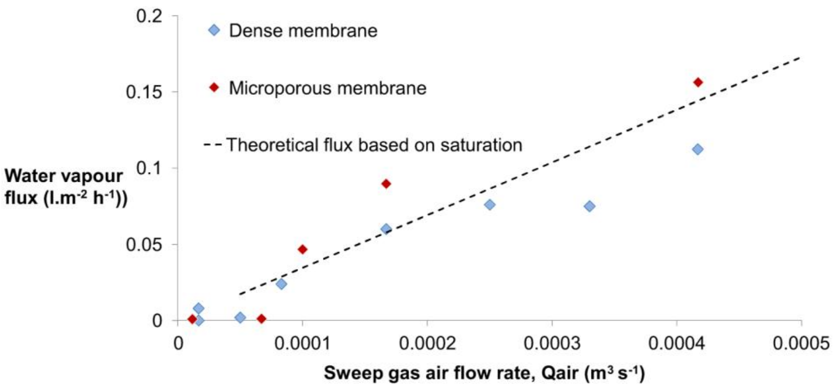

Figure 1: Flux against sweep gas flow rate for two different commercially available membranes

Figure 2: The prototype toilet

The toilet will be rented by the households and maintenance will be undertaken with a trained operative responsible for the franchised area. Overall the toilet has small footprint and incorporates all the components within an aspirational design (figures 2 and 3)

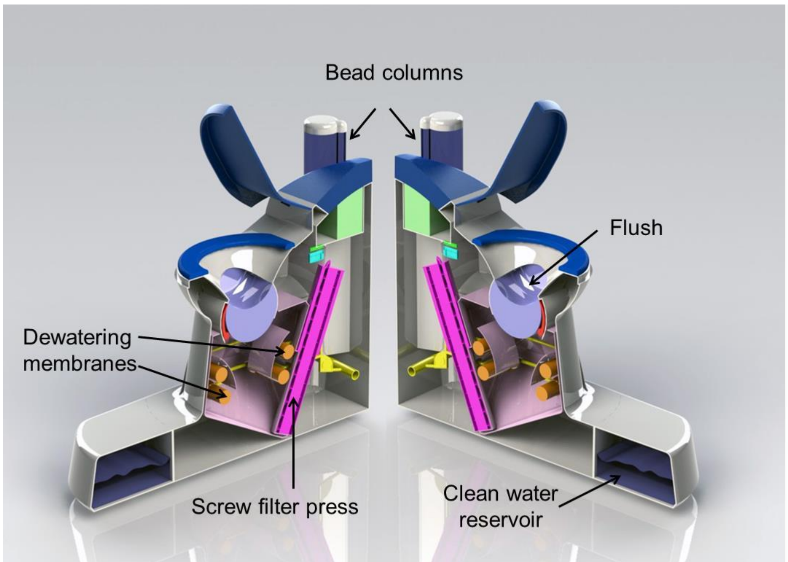

Figure 3: Configuration of the toilet components

Real Scale Evaluation of a Urine Diverting Dry Toilet: Operational and Hygiene Perspectives

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Key words: Urine Diverting Dry Toilet; Faeces; Hygiene.

1. Introduction

The ecological sanitation approach is being widespread. The benefits and advantages of the ecological sanitation are well known: improving health, nutrients recycling, resources conservation and contribution to soil fertility (JÖNSSON e VINNERÅS, 2013). Sanitation technologies with an ecological and low-cost perspective must efficiently reduce pathogens carried in fecal material to safe levels, and provide a stable material in terms of organic matter (MAGRI et al., 2013). Urine diverting dry toilet (UDDT) are considered a good sanitation device to improve sanitation particularly in rural areas. The handling of diverted material as dry faeces has low risks if the material presents low levels of pathogens.

The aim of the study was to evaluate the operational aspects of a UDDT and for the efficiency in "generating" a good quality faecal material. A combination of chemical treatment and storage was evaluated for faeces sanitisation. The quality of the material was measured in terms of organic matter stabilization and the presence of pathogens (*Enterococcus faecalis* and *Salmonella* sp.) and indicator microorganisms (*Escherichia coli* and somatic coliphages).

2. Materials and Methods

2.1 Characterization of study area and UDDT

The research was conducted in Southern Brazil – city of Florianópolis, Santa Catarina State. The region has sub-tropical climate and high air moisture content. One real scale UDDT was built in a guest house of an NGO for 10 people. The diverting pedestal was produced onsite with fiberglass. The urine was collected din a 20 liter container, emptied once a week, and faeces in a 50 liter container, emptied every two months. A ventilation pipe (enclosed with a net on top to prevent the entry of insects) of 100mm diameter was connected to the faeces container.

The treatment of the faeces was done by addition of a dry covering material (additive) composed by ash, limestone and urea (1:1:0.02). The use of materials such as ash and limestone is relatively widespread, and the use of urea is being described as a promising alternative to improve the efficiency in reducing pathogens by increasing the ammonia content (NORDIN et al., 2009; MAGRI et al., 2013).

The amount of additive used was 420 ml (volume) or 300 g (mass) after each defecation. So the idea is that the material acts covering the faeces, but also treating it, by increasing pH and unionized ammonia concentration. Once the container is full it has to be storage and kept closed, so the treatment process can continue. There is no need of mixing the material. The treatment time required to reduce pathogens to safe levels was evaluated.

2.2 Evaluation of faecal material from UDDT

Three containers with faeces and additives were evaluated. Once the containers were full they were kept closed (air tight). The sampling was done in intervals of 10 days, giving 10 samples during 100 days. A set of sterile materials was used for sampling from vertical sections in the containers.

For evaluating the stabilization of faecal material Total Solids, Volatile Solids, Ash content and pH was measured (APHA, 1998). The hygienic quality of the material was evaluated by the presence of *Salmonella* sp. (EPA n°1682, 2006), counting of *Escherichia coli*, *Enterococcus faecalis* (Most Probable Number IDEXX® methodology) and somatic coliphages (ISO 10705-2, 2000).

3. Results and Discussion

The moisture content decreased substantially when comparing the faecal material while receiving fresh faeces (moisture of 70%) and 100 days after (37%). The drying process is related to the natural drying and to the cover material. Another important condition was the reduction of volatile solids content by degradation (42% to 15% after 100 days), which contributes to the stability of the faecal material avoiding bad odors. The pH of fresh faecal material was 6-7, which after treatment increased to10.1±0.8. This increase was related to the added limestone and ash, and also to the degradation of urea into ammonia.

Concerning the reduction of microorganisms in the faecal material, Table 1 presents their concentration at the beginning of treatment, the time for one log reduction and the inactivation coefficients. Data used was the average counting of viable microorganisms from the 3 containers.

Table 1 Results of analysis for bacteria and coliphage in the beginning of the treatment, inactivation coefficient (k) and decimal logarithmic reduction (Dr value) calculated based on collected data from the monitoring.

Microbiological analysis	Concentration in the beginning of treatment (day 1)	Dr value (days)	k (day^{-1})[a]
E. faecalis ($MPN.g^{-1}$)	2,8E+10	7,9	-0,127
E. coli ($MPN.g^{-1}$)	9,5E+08	9,9	-0,101
Somatic coliphages ($PFU.g^{-1}$)	2,3E+03	14,7	-0,068

a - determined in a linear regression according to a first-order exponential decay.

The faecal material in the three containers was positive for *Salmonella* sp. at the beginning of the treatment period, but after 10 days all samples taken were negative, which characterizes that microorganism as the most susceptible to the proposed treatment. The other bacteria indicators (*E.coli* and *E.faecalis*) had similar inactivation rates that end up in decimal reduction times between 8 to 10 days. *E.coli* is more sensitive to ammonia treatment while *E.faecalis* is more sensitive to elevated pH (OTTOSON et al., 2008). The coliphages could be considered a more conservative indicator, as it is less sensitive to chemical treatment than animal viruses (EMMOTH et al., 2011) thereby a surrogate for viruses, with slightly slower rate, approximately 15 days to one log reduction.

The inactivation of pathogens could be related to a combination of factors, which were the effect of high pH, low moisture content and high concentration of uncharged ammonia (140 mM in average), which was possible by the addition of urea.

4. Conclusion

The proposed type of toilet studied can be indicated as a promising ecological sanitation technology to be used as an alternative to latrines. According to our data, using the mixture of ash, limestone and urea as additive, the necessary treatment time for 3 log reduction of bacteria and phages would be 30 and 44 days respectively. Using urea as a component of the additive improved the sanitization of the material. Simple storage or just by adding ash or limestone normally require one year of contact to reduce pathogenicity of faecal material to safe levels.

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DRDO BIOTOILET: AN ECO-FRIENDLY APPROPRIATE AND AFFORDABLE SANITATION SOLUTION FOR FLUSH TOILET SYSTEM

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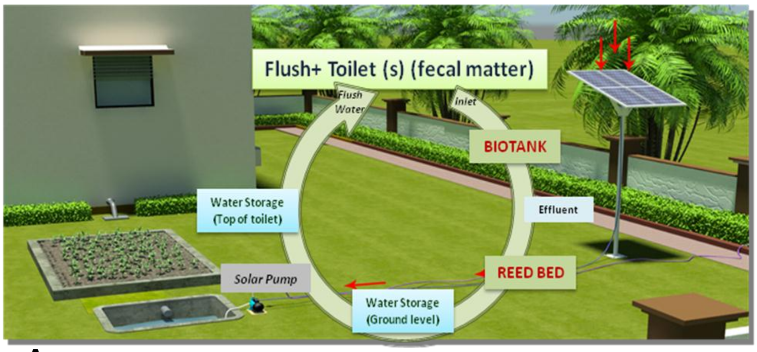
Abstract

Poor sanitation deteriorates public health. Safe disposal of human fecal matter is an important issue of immense concern. Extensive open defecation and improper disposal not only creates esthetic nuisance, but can do more harm by pathogen contamination of drinking water sources, which often leads to outbreak of waterborne diseases like diarrhea, gastroenteritis, typhoid, cholera, hepatitis.
Generally, flush toilets are used both for urine and fecal matter disposal throughout the world, where excreta is drained into open pits or septic tanks through an outlet pipe. The outlet pipe from the squat area usually have a ‘J’, ‘P’, ‘S’, or ‘U’ shaped bend that holds water in the toilet bowl and stop foul gases from sewer line. Therefore, a large amount of water is required to flush the toilet either through pouring or using a cistern. Thus, 6-8 liters of water is required to flush the squat area before leaving. Toilet once get soiled, is hard to use by others until it is properly cleaned. This problem is more serious in case of community

toilets which are not owned by any individual. Again, frequent cleaning of such storage pits or tanks is required. Therefore, development of eco-friendly, appropriate sanitation solution is required to treat the waste completely without or little maintenance and reuse toilet effluent water. Concerning these issues, meticulous research was carried out to develop an appropriate sustainable sanitation solution which can be adopted far and wide.

DRDO Biotoilet technology involves anaerobic biodegradation of human fecal matter in a specially designed anaerobic tank (biotank). A highly efficient microbial consortium of hydrolytic, acidogenic, acetogenic, and methanogenic bacteria digests human fecal matter and produces biogas, carbon dioxide and effluent water. Effluent water from the tank is secondarily cleaned using natural Reed bed, which may be reused for flushing, gardening etc. Reed bed along with reed plants clean the effluent from the tank in terms of leftover smell, BOD, COD, suspended solids, fecal coliforms and other pathogens and color. Reed bed, which may be adjusted on the top of the fully sealed tank, is a smaller and efficient than the conventional reed beds. Approximately seven days of HRT is being proposed for this rectangular shaped tank (size may vary according to the number of users), with bacteria housing matrix (BHM), longitudinal baffles to provide slow zigzag movement of toilet slurry for efficient biodegradation. Bacterial consortium may be incorporated once initially into the tank which later multiplied and work synergistically to degrade human fecal matter. Metagenomic analysis of consortium using next generation sequencing platform (Illumina GAIIX) and analyzing through metagenomic analyzing tools like MG-Rast revealed it as a highly efficient bacterial consortia. Further, the whole system is having diverse group of bacteriophages to control pathogens in effluent water to be further cleaned by rhizosphere of reed plants. This technology has various advantages like: simple, easily adoptable design and construction; customized for individual family or community level; wide application under different climatic conditions; smaller size than conventional septic tank; maintenance free (in terms of sludge cleaning); reduction in organic waste and pathogen by 99%; minimizes water consumption/ loss through reuse of water; biogas may be harnessed as an alternative energy source; reduced load on sewage system (if water is drained). Thus DRDO Biotoilet is an appropriate, affordable and lucrative sanitation solution for different climatic conditions. Reflush of water can be done by using small conventional hand pump or other energy driven pump-based system, thereby saving clean, potable water which otherwise is used for flushing. This technology is well accepted in India and large scale implementations are going on in different parts of India through public-private partnerships.



A

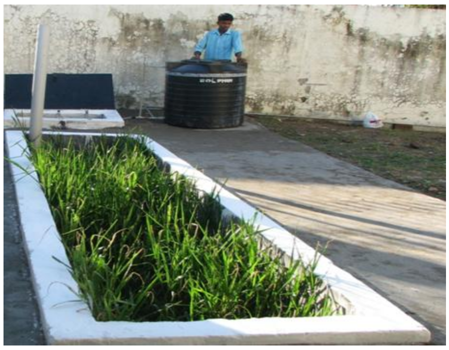

B

Fig: Representing the scheme of the DRDO Biotoilet system where, alternative energy (eg. solar) can be used to reuse the effluent water (A) and a functional unit of Biotank cum reed bed system for approx 50 users (B).

Importance Factors of On-site Sanitation Management in Urban Slum Area (A case study of Greater Bandung Area)

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Theme : Socio-cultural aspects of on-site sanitation

Keywords: community development;demand driven;important factors;sanitation; urban slum area

1. Foreword

Access to drinking water and sanitation are human basic needs (UN, 2010). WHO data (2013) in World Progress Report for Drinking Water and Sanitation stated that 768 million world inhabitants have no access for drinking water and 2,5 billion people have no sanitation facility. Indonesia Statistic Bureau (BPS) data stated that proper sanitation achievement is increasing from 51,19% in 2009 to 55,60% in 2011, while *Millennium Development Goals (MDGs)* target stated that 62,41% proper sanitation in Indonesia (RPJMN, 2010/2014). In West Java Province, which has the largest population in Indonesia, sanitation service existing is 62,5% and 2015 is aimed to reach 70% (RPJMD, 2008/2013).

Indonesian is one of developing country with population in 2011 has reach 230 million, mostly live in urban area and growing rapidly. There is over than 300 Ha urban slum areas in Greater Bandung. Lumanti (2004) define that slum area lack of sanitation and other basic facility, for instance: drinking water, drainage and solid waste management. From economical aspect slum area is categorized as poor area which indicated by large low income and unemployed inhabitants. Slum conditions put residents at a higher risk of disease, mortality and misfortune (WHO/UNICEF, 2004). The low sanitation service creates diarrhea and other disease which generated by poor sanitation, those conditions will continue to children growth disorder (Checkley et al., 2008), physical fitness and cognitive function (Guerrant et al., 1999; Niehaus et al., 2002). The factors limiting sanitation progress include low prioritization by stakeholders, inadequate funding, implementation of inappropriate (unsustainable) technologies, and difficulties of shared responsibilities (Isunju et al, 2011).

Indonesian government effort and policy is confirmed by initiate an National Program for Human Settlement Sanitation Development Acceleration (PPSP) for 2010-2014 which aim to stop open defecation practice or open defecation free (ODF) in 2014. There are two approaches for development scheme: first is supply driven by top-down program from government to the community, this scheme has been implemented for years. Second approach is demand driven based on community needs as users. Top-down approach, also known as conventional approach, has several characteristic which are: neglecting consumer aspiration, ineffective promotion, weak public awareness and limited stakeholder participation (Schertenleib, 2002). In opposite with second approach (demand driven) that conducted by involving various stakeholder particularly community as users, focusing active community participation to initiate and responsible for constructing sanitation facility, empowering community and dedicated to low income inhabitants (Dayal et al., 2000).

Based on above mentioned figures, this research is intended to identify the important factors that affect sanitation management in urban slum area in order to solve sanitation management .

2. Research Location

This research is conducted in the Greater Bandung Area which is a metropolitan area comprising 4 (four) city/regency that structuring West Java Province capital area. There are 12 locations taken for this research as shown in the following figure.

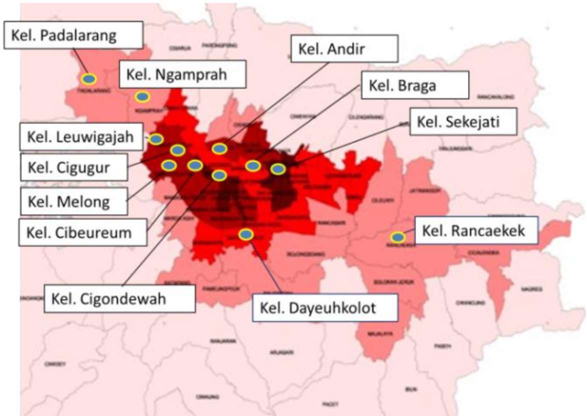

Figure 1. Research Location Map (Bappeda Jabar, 2010)

3. Method

This research is intended to explore importance factor for the community in on-site sanitation management that using Fishbein method and then following by Importance Performance Analysis (IPA) with Cartesius diagram. Design for this research is conclusive descriptive refer to explaining one or more characteristic of structured and specific variables for problem solving decision. Quantitative analysis shall be used.

3.1 Research Design

Design for this research is conclusive descriptive refer to explaining one or more characteristic of structured and specific variables for problem solving decision. Quantitative analysis shall be used (Firdaus, 2012). Research stages are showed in following Figure 1.

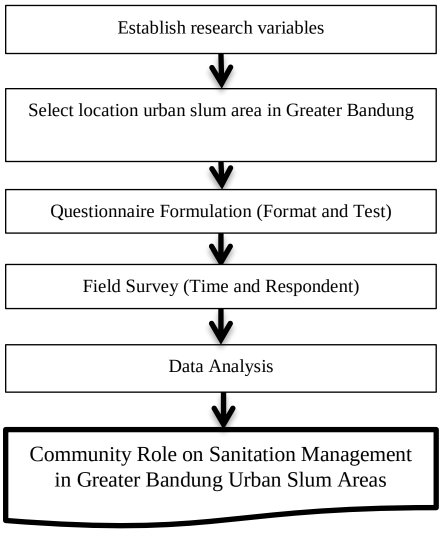

Figure 2. Research Stages Scheme

3.2 Research Variables

Survey variables shall comprise:

a. Respondent identity
b. Black water discharge
c. Septic tank
d. Others, for instance: sanitation perceptive and disease plague (diarrhea)

3.3 Research Location

Research location is Greater Bandung Area urban slum area. Selection criteria will refer to:

1. Population density. Ideal population density is 75 person/Ha (WHO, 2010), this research is aimed for density over 75 person/Ha/village.
2. Stated as slum area.
3. Prone Sanitation Area, according to Environmental Health Risk Assessment (EHRA) study which conducted by City/Regency to describe sanitation condition.
4. Urban area characteristic.

4. Result

The result is among ten requested importance factors, the financial factor becomes major importance factor that had to be improved (2,24;4,25), nevertheless community participation (2,86;4,05), environmental (2,79;4,07) and social impact factors (2,86;4,01) are satisfied important factors. This result concludes that the community has experienced their sanitation management to overcome environmental and social problems, in the other side financial factor still required to improve the better sanitation management. Therefore, all engineers and city managers must be carefull in designing the system of on-site sanitation management especially in urban slum area. Importance factors obtained and conclusion are shown in following table.

Table 1. Conclusion of Importance Factors for Sanitation Management

Quadrant	Factor	Conclusion
Quadrant I (important factor, not satisfied yet)	V3. Cost	Role improvement required
Quadrant II (important factor, satisfied)	V4. Community Involvement V9. Social Impact V10. Environmental Impact	Preserve

Quadrant	Factor	Conclusion
Quadrant III (unimportant factor, not satisfied)	V1. Institution V2. Regulation V5. Technology V6. Private Sector	Substantial for policy maker that these factors are important for every development sector, yet community has less concern about them mainly caused by less government attention or supervision.
Quadrant IV (unimportant factors, satisfied)	V7. Cultural Role V8. Gender Role	Ignorable

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