

WC CUBICLE

L. Kelly¹, P. Kopp², L. Pedrosa³, R. Vallès⁴

¹Institute of technology Sligo, Ireland

²Lund University, Faculty of Engineering

³Universidade Presbiteriana Mackenzie

⁴EPSEVG

Abstract - This article is a part of the IDPS project that took place during spring 2013. The project is collaboration between the project group at UPC and the bathroom fitting firm Roca.

Roca aims to be at the forefront of defending the environment and caring for water why they have collaborated with UPC in order to design a WC Cubicle for developing countries, more specific India. Some parts of the world still face the problem of poor or lack of sanitation why the project is seeking to show that it is both worthwhile and possible for everyone to take care and conserve the planet in the context of human waste treatment. Research about India, their culture habits and beliefs, and also current solutions and techniques of handling and recycling waste gave a profound base to establish an innovative and adequate concept. The project result outlined in a new two hole pan which besides separating solids from liquids, also provides an odour barrier due to an innovative flap system. The solids are treated in a bio digester in order to create biogas and fertilizer and the urine is stored for six months to convert to fertilizer.

Keywords – sanitation, India, waste treatment, bio-digester, fertilizer, separating toilets, rural environment

1. INTRODUCTION

The aim of the project is to develop a WC cubicle for people that have no access to proper sanitation, specifically families from rural areas in India that correspond at 70% of the total population of this country [1]. In other words Roca and the group from UPC work to create safe, effective, and inexpensive sanitation services for people without access or resources.

At least 626 million of Indian people don't have access to toilets or proper sanitation services, electricity, sewage system or even potable water [2].

Fresh water pipelines and sewage systems don't always reach city slums or rural areas. People living in those areas end up using poorly built pit latrines and even open defecation. Those habits result in poor quality of life, contamination of the environment and ultimately, infections spreading over.

Keeping in view all the problems and restrictions that were taken into consideration in the development of this project it is possible to conclude that the WC Cubicle is more than a project specific to India. This project can be developed in any country or region that has the necessary conditions for its construction and maintenance. Roca is looking for the "toilet of the future", in other words, to come up with the best solutions for capturing and processing human waste and transforming it into useful resources with the less cost per use possible. Families can improve their lives through reusing waste that would usually just be discarded. However, only India data was analysed in this project.

2. DEVELOPED CONCEPT – ECOPAN

After analysing all possibilities and treatments for the waste it was possible to choose the fixed bio digester for the process to reuse the solid waste and make fertilizer from the urine as an overall concept, shown in Fig. 1.

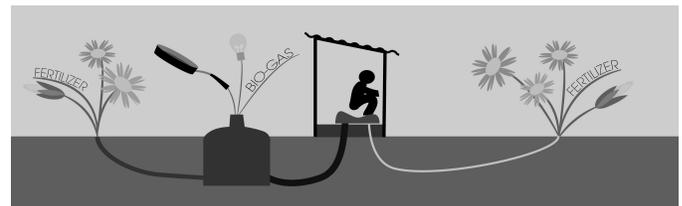


Fig 1 Overall process

The designed system inside the cubicle consists of a developed squatting pan connected to a trap system. Urine storage and solid waste collection were outlined. The flooring in the cubicle includes a draining system around the squatting pan. Fig. 2 shows a general picture over the concept.

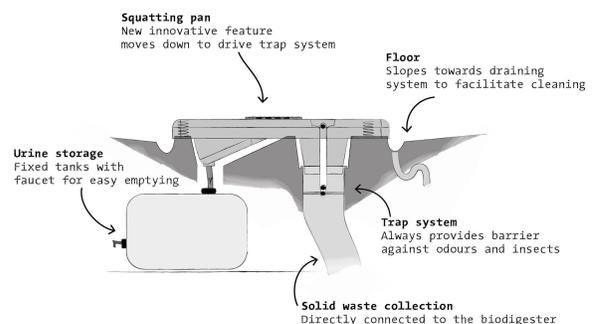


Fig 2 System inside cubicle

2.1. USE OF TWO HOLE PAN

The idea is to design a two-hole squatting pan, having in mind that the bio-digester needs water to work. So, the use of the 2 holes would be: the first hole for urine, the second for solid waste and grey water as the grey water will go directly to the bio-digester to help the process of the production of biogas.



Fig. 3 Rendering of the squatting pan

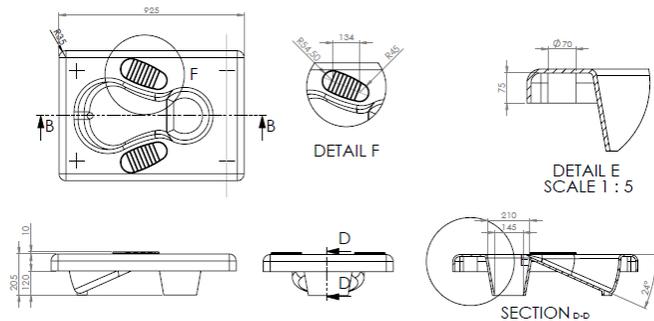


Fig. 4 Technical drawing of squatting pan

2.2. FLAP SYSTEM

Considering that one of the biggest problems rose to the utilization of the bathroom is the bad smell and thinking of improving hygiene, through not handling the cover for the second hole, it was decided to attach a flap. The flap is designed to keep flies and insects away and improve the smell of the cubicle.

2.2.1. MECHANISM

The system will make use of the weight of the person to work. The flap, the squatting pan and the ground will be connected together by the mechanism. The pressure made when one person steps on the squatting pan makes the flap, that is closed when not in use, open making it possible to use the toilet properly. Fig. 5 shows one of the ideas of how the flap works.

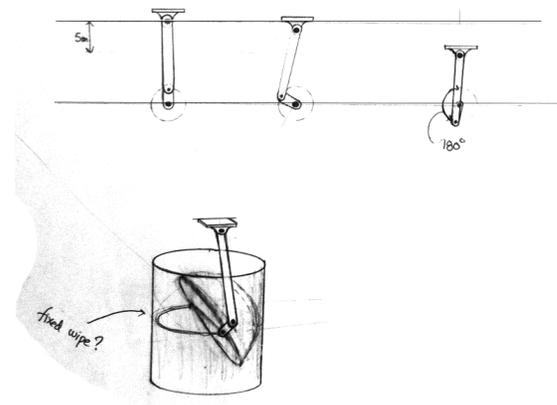


Fig. 5 Flap concept

With the vertical movement of the squatting pan converted to a circular one through a crankshaft one flap is turning 180° when the user enters the squatting pan. This leaves one side of the flap clean all the time.

2.3. SOLID WASTE TREATMENT: BIO-DIGESTER

A bio-digester is a natural system that takes advantage of the anaerobic digestion (in the absence of I oxygenate) of the bacteria that already lives in the dung, to transform this into biogas and fertilizer. Biogas can be used as fuel in the kitchens, or illumination, and in great facilities it is possible to be used to feed a motor that generates electricity. The fertilizer, biol, initially considered as a secondary product, but at the moment is being considered of the same importance, or major, that biogas since it provides farmers with a natural fertilizer that strongly improves their yield on harvests. [3]

The project is based on a WC Cubicle consisting of two squatting pans one for men and the other for women. The usage of each squatting pan is calculated for 25 persons a day. So, each block will cover a total of 50 persons in a daily basis. The specifications are the same for both. The decision of the separation was due the necessities and differences between both genders.

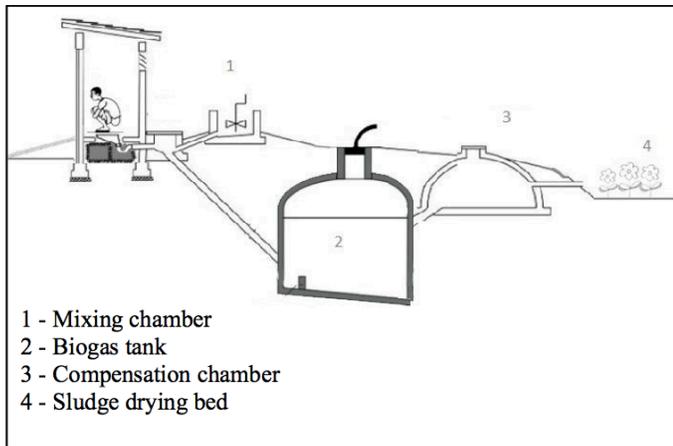


Fig. 6 Bio-digester system

The toilets will be placed near the villages for which people can use to contribute to the production of the biogas and the manure-mixing chamber allows for farmers and villagers to dispose of their livestock waste into the biogas plant. Once gas begins to be produced the sludge can then flow into the compensation chamber and eventually into the drying bed, where now almost pathogen free is harmless to humans. Once left in the drying bed for approximately a month, it can then be used as a nutrient rich fertiliser.

To make some calculations some data are needed, as found in Table 1, a household of 5 people produce 400 litres per month of solid waste (assuming waste density of 1.2kg/L) or 0.32kg/person/day. Keeping this in mind the, the toilet block will be provided with 16 kg/day.

Table 1 Solid waste and biogas data [4]

	Unit	Human Solid Waste
Number of humans	no.	5.00
Density	kg/L	1.20
Solid waste	kg/person/day	0.32
Daily waste input	kg	1.60
Daily biogas production (after processing)	m ³	0.04
Total weight of waste (40 days containment allowed to become fertiliser)	kg	64.00
Total volume of waste (40 days containment allowed to become fertiliser)	L	53.33
Total gas to be contained (3 days)	m ³	0.09

For instance, 2 or 3 blocks of toilets for a bio-digester (family usage) will be nourished with 32 to 48 kg/day of waste. In most biogas plants, the mixing ratio for dung and water amounts to 1:1, so the system will be

complemented with 32 to 48 litres of water per day. With a hydraulic retention time of 40 days it will be required, respectively, a 4-cubic meter plant and a 6-cubic meter plant.

This presumption was taken from the information in Table 2 below that gives some relevant data about the comparison of the average daily feedstock and the possible size of the biogas plants.

Table 2 Plant size and average daily feedstock [5]

Plant Size (m ³)	Daily Feedstock (kg)	Daily Water (L)
3	9 - 24	9 - 24
4	24 - 40	24 - 40
6	40 - 60	40 - 60
8	60 - 80	60 - 80
10	80 - 100	80 - 100

2.4. LIQUID WASTE TREATMENT CREATE FERTILIZER

Urine contains most (94%) of the NPK nutrients excreted by the human body and can be considered sterile in the point of view of pathogens. This makes the urine an excellent fertilizer for frayed lands of India. [6].

The urine tanks are fixed under the cubicle and the urine is collected to barrels with a tap on the outside. The emptying of the tank is going to be once every month. The barrels are cylindrical which make them possible to role if wanted. The barrels are to be stored for six months to be sterilized and converted into fertilizer, and then the content can be used for the crops and fields.

One person produces 1-2 litres of urine every day [7]. So, in one month with the use of 25 people/toilet this means that the dimensions of the urine tank should be:

$$2 \text{ litres} * 25 \text{ persons} * 30 \text{ days} = 1500 \text{ litres}$$

From the outside of the cubicle you will be able to see the amount of urine in the tank through a transparent bar.

To prevent odours from the tank to the cubicle different kinds of solutions are possible. One waterless way, and therefore congenial for the concept, is by using a thin rubber tube, see Fig. 7 [8]. The urine can pass through the membrane and when the flow stops it seals and prevents smells from coming up to the cubicle. A sieve at the inlet hole for the urine to prevent objects to get stuck in the rubber tube and restrain the function would preferably supplement this.



Fig. 7 Rubber tube solution

3. REFLECTIONS

The main concern of the team was to consult the local population in the making of each decision of the project, since their approval is one of the requisites for the usage. Processes and systems were analysed and modified in accordance with the observations and preferences of our interviewees. The goal then turned to the pursuit of the union between practicality and efficiency. Many creative and innovative ideas were discarded after conversations due to lack of previous knowledge on common procedures to western world, but that would require a campaign of massive disclosure and education of the population.

The correct use and the squatting pan will only be possible through messages and campaigns towards rising the awareness and knowledge for the population. Research indicates that one of the biggest faced problems of squatting pans is the weak and inappropriate messages linked to its use and subsequent reuse of waste [9].

3.1. FURTHER DEVELOPMENT

The concept imagined for the EcoPan is well established, however some processes are left open and still need further development, for example:

3.1.1.MECHANISM

Some ideas for the mechanism were thought of, however the time was not sufficient for the correct development. Further work on this would really embellish our idea as a product and continue to set it apart from other squatting pans.

3.1.2.PAN

Optimise for production. We have given suggestions for materials but further analysis could make it possible to be constructed by local people instead of a company.

3.1.3.RAIN CAPTURE

The development would be that the rain capture idea that can collect water inside and outside the tank. This is the idea with real potential but needs more work to insure that it will work correctly.

3.1.4.ADDITIONAL ELEMENTS

Thinking about the cubicle as product, another added value is the possibility to add some other elements on the facilities to help the users e.g. handlebars.

3.1.5. TRANSPORT

Another point to take into account is the transport line between the cubicle and the bio-digester where data about people and geography will be needed to know how many bio-digesters will be required and the location of them.

4. CONCLUSION

The project came with many improvements in all parts of the process that can be implemented punctually. This design is ideal for Indian people as it eliminates several of their problems and replaces it with a renewable, useful and clean energy source. This is by the gas produced and the fertilisers that can help improve crop yields are some of the benefits that outweigh the costs of the project.

Some innovations like the flap system can be a good alternative to solve the problem of non-utilization of existing toilets in India because of the stench and dirt.

In a future project, with more time and assistance, it would be possible to develop the mechanism for the flap of the squatting pan. Beside of this, the group is really satisfied with the project and the positive feedback received.

Throughout the development process we have also been able to develop communication and teamwork skills, by incorporating multiple ideas into the design. Finally, we have learned to work with the complexities of working cross-culturally.

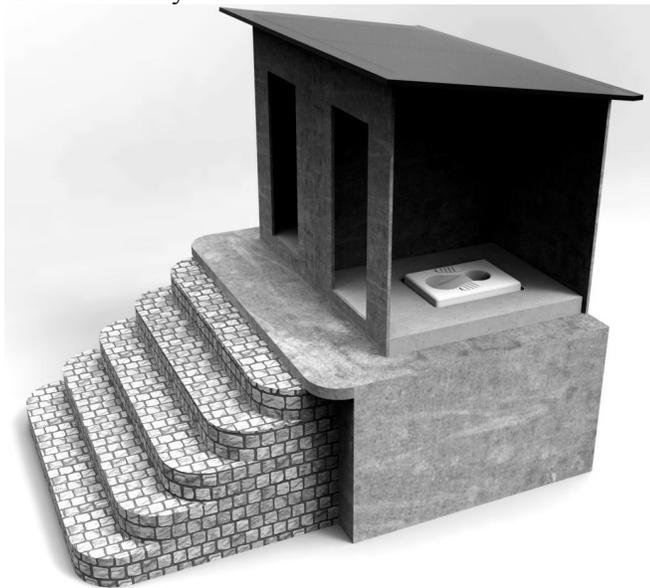


Fig. 8 New developed cubicle

Eco-Pan can be the beginning of a profound change in India. Not just a change in hygiene habits of the population but creating a better environment to live without the harms of the open defecation. Cultural and social changes as well as being an alternative source of funds.

5. REFERENCES

- [1] TRICKLEUP. 2013. "Rural Poverty" Accessed Apr 17. <http://www.trickleup.org/poverty/rural-poverty.cfm>
- [2] WHO. 2013. "Water Sanitation Health" Accessed Apr 17. http://www.who.int/water_sanitation_health/monitoring/jmp2012/fast_facts/en/
- [3] Solar Energy. 2011. "What is a Biodigester?" Accessed Apr 15. <http://www.gstriatum.com/solarenergy/2009/09/what-is-a-biodigester/>
- [4] Oldakowska I. et al (2011): *Preliminary Design for Fixed Dome Plants, Engineering without borders, Australia*
- [5] RWANDA UTILITIES REGULATORY AGENCY. 2012. "Biogas plant Operations guidelines" Accessed May 31. http://www.rura.gov.rw/docs/Biogas_Plant_Operations_guidelines.pdf
- [6] "Human Urine - an effective agricultural fertilizer" Accessed Apr 21. <http://chopwoodcarrywaterplantseeds.blogspot.com.es/2012/02/human-urine-effective-agricultural.html>
- [7] "How much urine is normal?" Accessed Mar 03. <http://www.sharecare.com/question/how-much-urine-is-normal>
- [8] "Urine Diversion Components" Accessed May 30. <http://www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/user-interface/urine-diversion-component>
- [9] "THE IMPORTANCE OF DELIVERING THE RIGHT EDUCATIONAL MESSAGE" Accessed May 20. <http://www.ecosanres.org/icss/proceedings/presentations/55--LeonardoSanabria--UNICEF-eco-san-latrines-v4.pdf>