The 3rd KESSA International and Interdisciplinary Conference, held at Multimedia University of Kenya Hotel, June 22-25, 2016 Nairobi, Kenya. Pp. 366-374. ISBN: 978-9966-1933-9-1

DESIGN OF AN ECOSAN TOILET MODEL FOR KENYAN SCHOOLS

Abel N. Mayaka[1], Dickson Andala[2], Kezia N. Ngugi[3], Moses Mwangi[4]

1. Department of Mechanical and Mechatronics Engineering, Multimedia University of Kenya Box 15653 – 00503 Nairobi. Emails: abnmayaka@yahoo.com
2. Department of Chemistry, Multimedia University of Kenya Box 15653 – 00503 Nairobi, Kenya. E-Mail: andalad@gmail.com
3. South Eastern Kenya University, P.O Box 725, 01000 Thika, Email: chayvo@yahoo.com
4. South Eastern Kenya University, Email: mnmwangi2000@yahoo.co.ke

Abstract

An increasing awareness worldwide on the environmental problems associated with inappropriate sanitation implementation has led to the development of Ecological Sanitation Technology (Ecosan). It has been promoted for environmental reasons as well as for issues such as economics which include water conservation, management of water resources pollution and outbreaks of waterborne diseases, recycling of nutrients to arable land, easy operation, negligible maintenance costs, dignity and convenience. Urine Diversion Toilet (UDT) (Ecosan toilet), has been found to be more hygienic and sanitary acceptable human waste management systems but have not been well received in Kenya. The aim of this component of study was to improve the design of current Ecosan toilet used and increase their uptake. The study involved literature review, designing and fabrication of an Ecosan toilet with ash dispensing and toilet hole opening and closing mechanisms. An ash dispensing unit that is operated as a water cistern has been designed to eliminate direct handling of ash in Ecosan toilets. Also an opening and closing mechanism of toilet hole attached to the pan has been designed to eliminate exposer of human feaces. This improvement of the designed UDT is expected to improve the uptake of these toilets and is recommended for use by the communities and government and non-governmental institutions charged with sanitary management, environment, water and agriculture in Kenya.

1. INTRODUCTION

An increasing awareness worldwide on the environmental problems associated with inappropriate sanitation implementation has led to the development of Ecological Sanitation Technology (ECOSAN). It has been promoted for environmental reasons as well as for issues such as water conservation, recycling of nutrients to arable land, easy operation, negligible maintenance costs,

dignity and convenience. In rural areas the use of pit latrine is common which normally fills up and one has to relocate and put up another new structure which is done at a cost. Ground water contamination through open defecation and penetration pollutants from pit latrines into water wells leading to the transmission of water borne diseases has been reduced. Ecosan toilet technology has been implemented successfully in many countries and among communities of different socio-economic strata, religions, cultures and practices. (Jenkins, 2005, Jothimani and Sangeetha, 2012, Esrey, 1998).

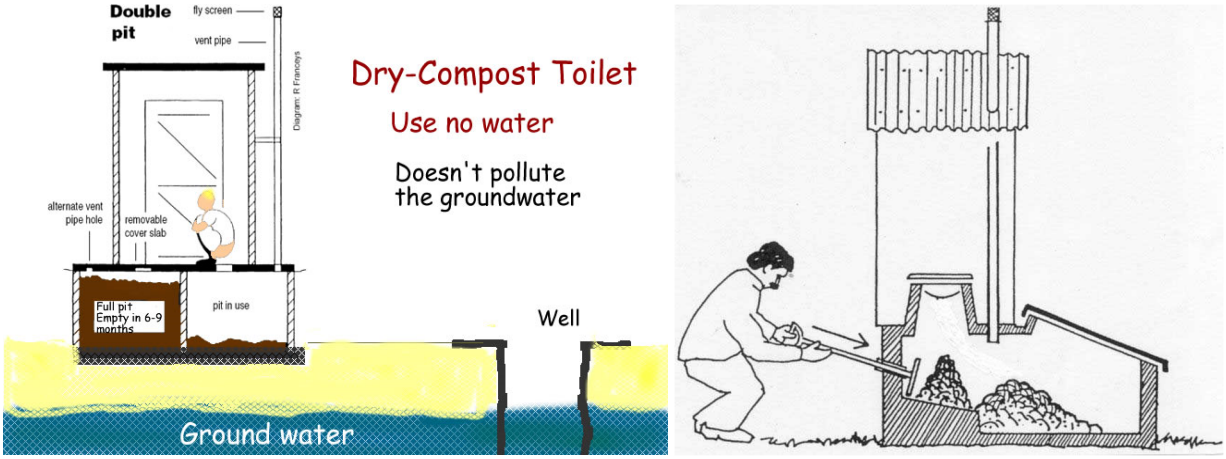
Sustainable Organic Integrated Livelihoods (SOIL) has been building Ecosan toilets and composting waste treatment sites in Haiti *(WRI. 2006)*. The adoption of Ecosan toilets has been well received in India. The compost obtained from Ecosan compost chambers are odourless after six months and free from pathogens. On top of that they favor the Eco-San toilets, as only a third of the water needed in a normal toilet is enough to keep it clean (Hogund, 2002).

The production process of humanure involves collection of human solid (faeces) waste, decomposition harvesting of the decomposed waste, granulation, treatment and mixing and then packaging ready for distribution. All these stages require some processing facilities, and tooling which include: Ecosan toilet, decomposing shed, granulation and mixing machines and a packaging machine (Joenssen *et.al*. (2004). The Ecosan Toilet consists of the following components: structure (Substructure construction starting from the foundation up to Pan Level and superstructure construction), container for solid waste collection and urine disposal system. Plate 1 (a) and (b) shows the external structure and the inside with the ash, squatting pan and finished toilet paper respectively of Ecosan toilet in Khaimba Primary school in Kenya. The side section view Ecosan toilet for Double Vault toilet and Single Vault toilet are presented in Figure 1 below.

(a)

(b)

Plate 1: Ecosan toilet: (a) Ecosan single Vault toilet, (b) Side section view



(a) **(b)**

Figure 1: Ecosan toilet side section view: (a) Double Vault toilet, (b) Single Vault toilet

The ECOSAN are considered to provide Waterless Toilet Solution. They have the following advantages:

i) The capacity to save space/land
ii) Plumbing-free solution, no sewage pipe network and sewage treatment plants required,
iii) Completely closed system, no effluent seepage into underground water resources,
iv) Indoor or outdoor installation,
v) Saving money, minimum monthly operating costs, water free toilet system
vi) Generating income through sells of humanure
vii) Durability and safety
viii) Status symbol and prestige, no obnoxious odours

From our field study and other studies we noted that since 2006 to date a number of organizations and government department including: Water Services Trust Fund (WSTF), German Financial Cooperation (KfW) and the German Development Cooperation (GIZ) in partnership with the Bill and Melinda Gates Foundation (BMGF), the Kenyan Rainwater Association (KRA), Barclays Bank Ngong branch Kenya, The Ministry of Public Health & Sanitation (MoPHS) and Secretariat of the Sustainable Sanitation Alliance (SuSanA) located at GIZ among others have been involved in the establishment and use of Ecosan toilet in various part of the country especially in schools (GTZ 2005, Schuster-Wallace, 2016, UNICEF and WHO, 2015,WSP, 2015)

However there have been some problems in the uptake of this technology associated with beliefs of some communities and general design of the toilets in Kenya. The existing Ecosan toilet usually has open pans and given the shallow depths one can see the faeces which for many Kenyan communities is not acceptable (taken as a Taboo). On the other hand fresh human waste deposit has to be covered with coarser materials such as ash, sawdust, leaf mould, peat moss, or rice hulls, hay, weeds, straw, or

leaves. Enough cover is applied so that there is no excess liquid build-up in the toilet (bad looks) and possible visit by insects. Currently this is done manually using cup and scoping cover materials for a packet placed in the toilet which is not hygienic. There is need to improve this technology in these aspects in order to Ecosn Toilet improve the uptake.

2. RESEARCH METHODOLOGY

The study involved literature review, field study and designing and fabrication of an Ecosan toilet with ash dispensing and toilet hole opening and closing mechanisms.

3. DESIGN OF ECOSAN (UDT) TOILET

3.1 Introduction

The problems of the uptake of the Ecosan Toilet are majorly related to their design. Special attention has been given to the design of the toilet opening shutter/cover mechanism attached to the pan and ash/dust dispenser mechanisms are presented which have not been incorporated in the existing Ecosan toilets.

Our design is based on a single vault which requires use of containers positioned in the chambers in the substructure and is frequently removed once filled to three quarter. This takes at least one week of usage. It is modeled for Musa primary school located in Isinya Kajiado County, Kenya. The school has a pupil population of two hundred and forty eight (248) students

In designing the components of the Ecosan toilet the following factors were considered:

i) Social/cultural: the customs, beliefs, values and practices that influence the design of the social components of a sanitation system, its acceptability by a community
ii) Students population which was 248 students in this case,
iii) The availability of materials/resources,
iv) Structurally reliability and decent,
v) Robust, simple and easy to use,
vi) Technical capacity: the level of technology that can be supported and maintained by local skills and tools.
vii) Economic: cheap with low operating costs the financial resources of both individuals and the community as a whole to support a sanitation system, and
viii) Clean, environmentally and acceptable.

3.2 Design and Construction of the Ecosan Toilet structure

The site of the Ecosan toilet was selected where there was no swamp. The position of emptying hole, urine container and effective use of space was designed for easy accessibility. The emptying hole is located at the backside of entrance with adequate space for emptying. The designed Ecosan toilet structure is shown in Figure 2 below. Plumbing include urine container, vent pipe, waste pipe,

galvanized iron and plastic fitting works among others. Pipe to convey urine and hand wash water is concealed in slab whereas Tee for the vent pipe is fitted just under the slab. Pipe fitting should not allow leakage neither into the chamber or the surrounding. A urine container will be installed at the side of the toilet to collect urine and water used during hand wash or, a soak pit or constructed wetland for the waste water will be constructed.

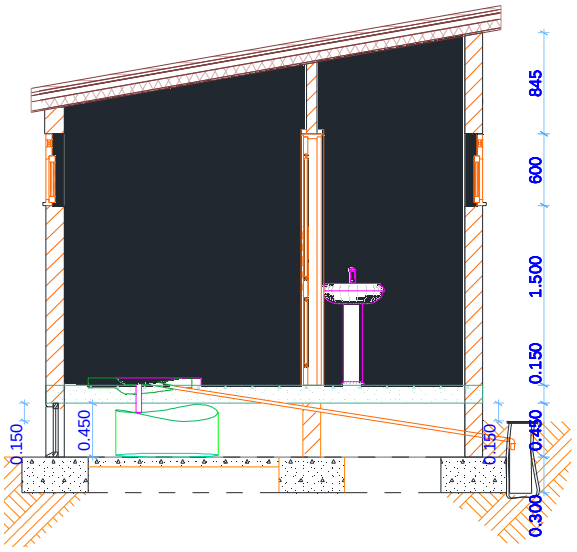


Figure 2: Designed structure of an Ecosan toilet

Superstructure (above pan level) construction

3.3 Design of Ecosan UDT Pans

In the school that was being piloted there were 248 pupils with almost 50% boys and 50% girls. Eight Ecosan toilet four for girls and four for boys were proposed to be constructed. This means on average thirty one (31) students could use one toilet. In one day they could deposit 4.34 litres of faeces and 21.7 litres in one week. The height of the container (h_c) of the solid waste chamber was determined to be 80 cm and hence chamber height adopted (H_{ca}) was 100 cm. A cylindrical plastic container with top opening of 40 cm is recommended. The collection compartments are covered by a roof to prevent rainwater and insects from entering.

Currently there are various types of pans already in use. Below Plate 1(a) to 1 (d) are some of the existing pans most of which are produced in Kenya, Uganda and India (GTZ 2005, WSP, 2015). An opening and closing mechanism of toilet hole attached to the pan was considered in the design to

eliminate exposer of human feaces. Three design options were developed and analysed and one selected, see Figures 3-5.

In the first design proposed design the cover opens outwards when someone steps on the pan peddles and closes after use and moving away. The second design is similar to the first one except that the cover is to opens inward. The third mechanism is opened by sliding a lever attached to the cover to the side horizontally using a foot. The cover returns back to position on removal of the foot.

a) Ndarugu Primary School, Nakuru, Kenya

b) ARIES 169, Govindpura Industrial Estate, Bhopla, Madhya Pradesh, India

(c) Prakash Ceramic, Thangadh, India

d) Mythri Sarva Seva Samithi, New Thippasandra, Bangalore, India

Plate 2: Types of existing Ecosan pans

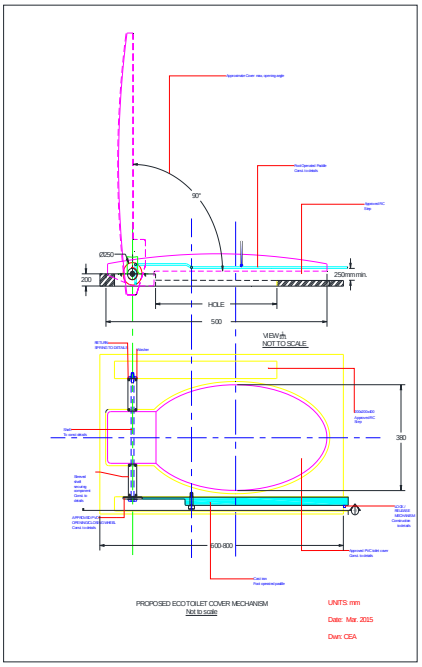


Figure 3: Designed pans with a cover opening outwards

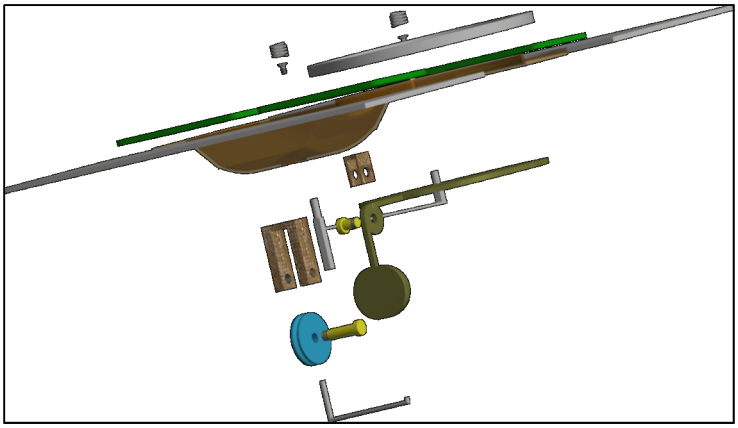


Figure 4: Designed pans with a cover opening inwards

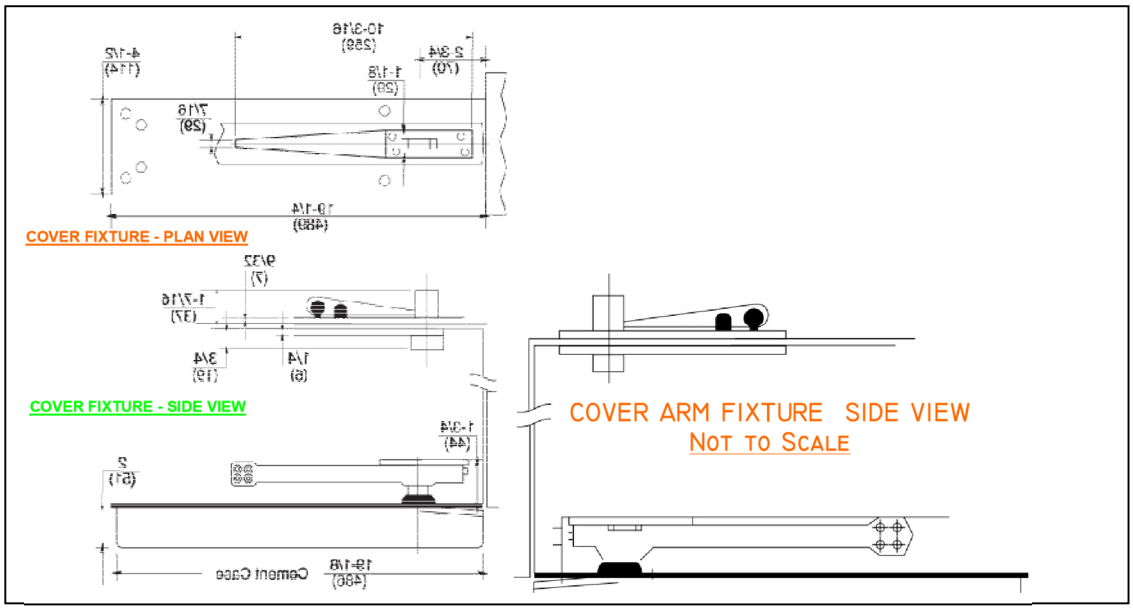


Figure 5: Designed pans with a cover opening outwards

The proposed first and the second mechanisms are relatively complicated mechanism and expensive to fabricate and maintain. The first mechanism also obstruct during usage since. It can hurt a person while squatting. The second mechanism can be splashed with feaces. The third mechanism is simple to operate and maintain and it does not interfere with the deposition of the waste.

3.4 Design of Ash Dispenser Mechanism

The design of Ash Dispenser Mechanism (ADM) with the design similar to that one of the water cistern has been designed. The ADM is supposed to dispense 250cm^3 volume of ash per usage and it is supposed to serve 31 to a maximum of 50 pupils a day. That means the dispenser container should have a capacity of 12500cm^3 of ash. The internal volume of the dispenser container should be 12500cm^3 or slightly more. There were two designs developed and analysed.

In the first design the dispenser if push type. The dispenser mechanism is attached to the lower end of the cistern. The knob is attached onto a metal rod that carries the ash cup. The return of the push knob is achieved using a return spring. The ash cup has an opening at the top to receive the ash from the cistern and on the lower end to release the ash through the lower opening on the casing into the release pipe. The outer diameter of cup was determined to be 73.025mm and the diameter (D_2) of outer casing to be 3" (89mm) whose thickness t_{ca} = 5.48mm = 5.5mm adopted. Hence, the internal diameter d2 is 78mm.

In the second design option the ash is dispensed by twisting the shaft carrying the ash container. Taking the internal hole diameter to be 60mm, from the tip of the circular prism from where the dispensing cup is formed. Then the height (hs), of the dispensing cup was calculated using the equation below and found to be 30 cm.

$$^1/_3\pi r^2 h = 250, \text{cm}^3$$

The thickness of the dispenser is 20mm all through. The dispenser has a tapered shape to allow easy flow of the ash down into the cup. In this system 250cm^3 of ash to be dispensed is to be held in the spherical ash cup. The spherical ash cup is designed fit inside drainage socket. From the volume equation below, the radius of the ash cup, r was determined to be 5.7cm.

$$V = 4/3\ \pi\ r^3 = 250, \text{cm}^3$$

Both designs are simple to fabricate, operate and maintain. It is therefore recommended to fabricate either of them or all of them and get them tested.

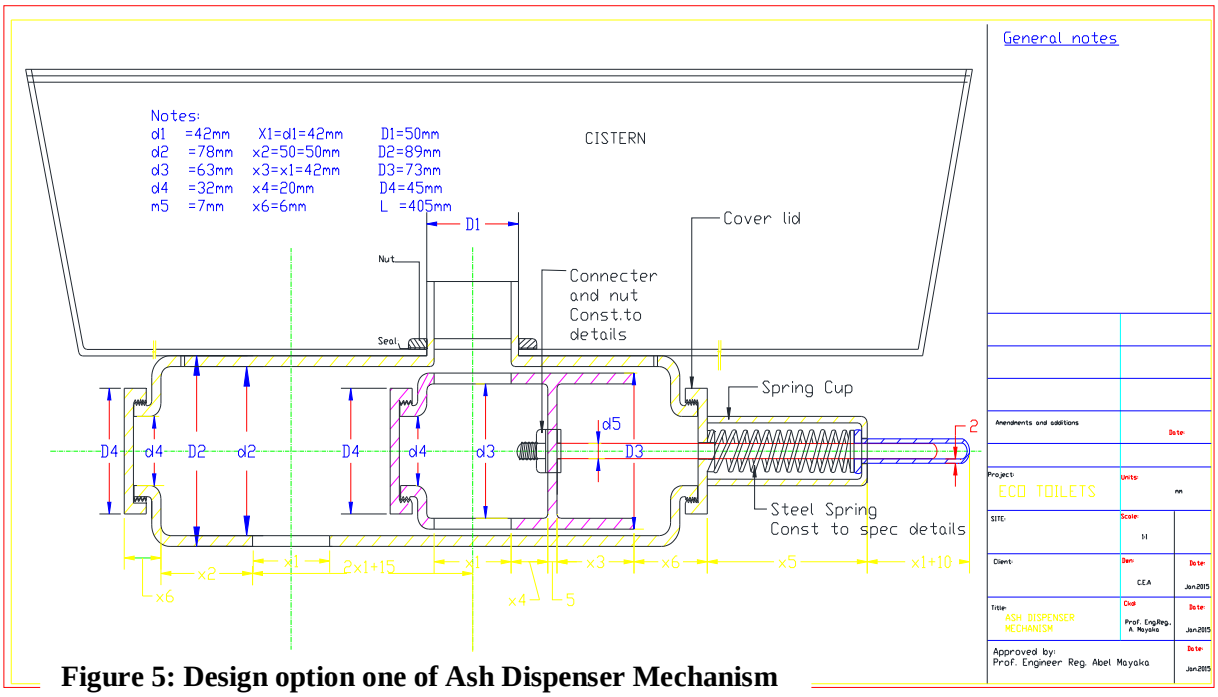


Figure 5: Design option one of Ash Dispenser Mechanism

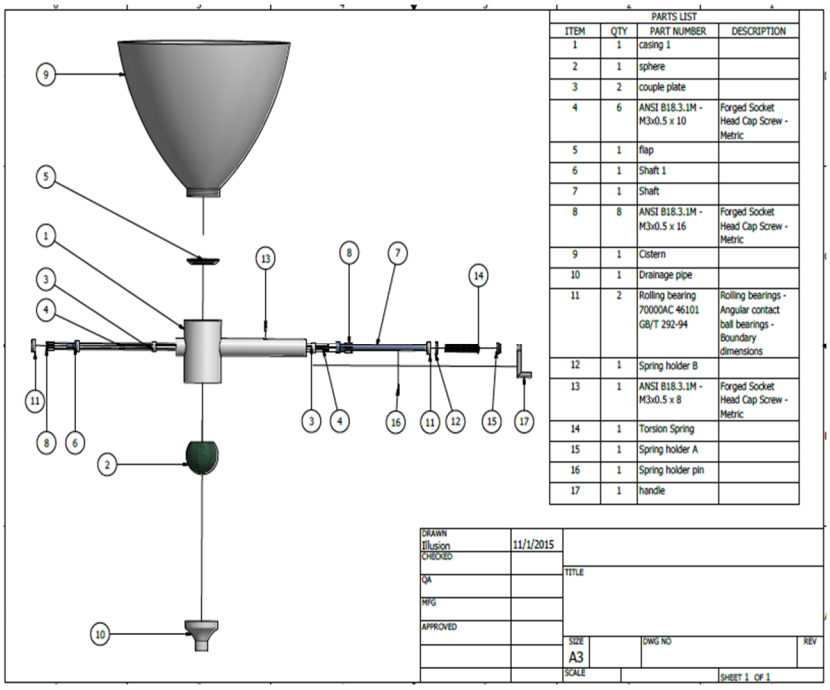


Figure 5: Design option one of Ash Dispenser Mechanism

Conclusion and recommendations

The Ecosan toilets are gradually being absorbed in Kenya especially among the lowest income communities for improved sanitation, new income opportunities and cleaner, safer toilets. The

Ecosan toilets have low cost due to the fact that they can be used for a long time since they never get filled up. In order to improve the Ecosan toilet uptake an ash dispensing unit that is operated as a water cistern has been designed to eliminate direct handling of ash in Ecosan toilets and an opening and closing mechanism of toilet hole attached to the pan to eliminate exposer of human feaces.

The technology for Ecosan is recommended for use by the communities and government and non-governmental institutions charged with agriculture, environment, water and sanitary management in Kenya.

REERENCES

1. Esrey, Steven A. (2001). Ecological Sanitation: Closing the loop to food security. New York
2. GTZ (2005). Urine diverting dry toilets programme dissemination (data sheet), GTZ, Germany. Available: www.gtz.de (General overview of Dehydration Chambers with some dimensioning and materials lis
3. Hogund Caroline, (2002). Evaluation of microbial health risks associated with the reuse of source-separated human urine
4. Jenkins Joseph (2005).The Humanure Handbook. Third Edition. A Guide To Composting Human Manure ISBN: 13: 978-0-9644258-3-5; ISBN-10: 0-9644258-3-1Library of Congress, Inc.143 Forest Lane, Grove City, PA 16127 USA
5. Joenssen et al. (2004). Fertiliser value of urine and faeces excreted per person per year in different countries.
6. Jothimani P. and Sangeetha R. (2012), Ecosan compost – A Potential resource of organic manure. International Journal of Advanced Life Sciences (IJALS), Vol.2. Feb – April, 2012
7. Schuster-Wallace, C. (2016) Waste to Wealth: Helping to Close the Sanitation Financing Gap in Rural Communities and Small Towns. Solutions for Sustainable and Future, Volume 6 , Issue 6, Page 60-69, Feb 2016
8. UNICEF and WHO. Progress on sanitation and drinking water: 2015 update and MDG Assessment (2015) http://www.wssinfo.org/fileadmin/user_upload/resources/JMP-Update-report....
9. Water and Sanitation Program. Economic impacts of poor sanitation in Africa: Uganda (2012) http://water.worldbank.org/sites/water.worldbank.org/files/publication/W....
10. WRI. 2006. Agriculture and Food Country Profile: Haiti. Washington, DC