# Hygienic Rural Toilet
## (dry sanitation system)

*Sponsored*
*By:*

Ministry of Drinking Water & Sanitation
Government of India,

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September 2013


Bhayandar
8
Thane
Sanjay Gandhi
National Park
Vihar Lake
Mangroves
Thane
Creek
Sahar
Airport
Uarashi
Reef
Mumbai
Mahim Bay
Pir Pau
Deep
Elephanta
Island
Butcher
Big Reef
Malet Shelf
DP World
Nhava Sheva
Cross
Island Reef
Bombay
Nhava

# IDC
# IIT Bombay
*offers a 2-year program*
*M Des*

Industrial Design
Visual communication
Interaction Design
Animation Design
Mobility & Vehicle Design

*The program is meant to develop Knowledge, skill & aptitude to become creative problem solvers and to bring about innovation in the manufacturing and communication industry*

# Industrial Design Centre
# IIT Bombay

## Premier Institute for Education, Research & Consultancy

## Mobility & Vehicle Design – *unique program*

*MISSION:*

*The term 'Mobility & Vehicle Design' includes all modes of transport – human, goods, wheeled, non wheeled, motorized, electric powered, human powered, mass transport, individual transport and associated systems. It will be research Programme for all issues regarding the above to develop unique solutions suitable for our economy and ecology.*

Emphasis on socially relevant projects



Innovation
Development
Company

# 4 M Strategy ..... ????

CTECH
A Sine IITB Company

www.ctechlab.com

**Methodology** *Introducing **Methodologies** & product development strategies (analytical tools, creativity tools etc.) to achieve high certainty of success*

**Mentoring** *Mentoring for new product development, leading teams of developers. Hand-holding till the prototypes are made*

**Monitoring** *Monitoring product development process to create products for high productivity of design effort*

**Motivating** *Motivating & Challenging for higher levels of creativity*















# Hygienic Rural Toilet
## (dry sanitation system)

**for areas:**

**Where there is no water**

**Where there is no power**

**Where there is low awareness**

**Where there is no organised disposal system**

# The Need

**Where there are no latrines people resort to defecation in the open.**
*-UNEP Report*

665 million **Indians** practice open defecation, more than half the global total.
1,000 **children** younger than 5 years die every day in **India** from diarrhea, hepatitis- causing pathogens and other sanitation-related diseases
*-the United Nations Children's Fund*

**The crisis is especially acute for girls:**
Many drop-out of school once they reach puberty because of inadequate lavatories, depriving the country of a generation of possible leaders
*- UNICEF*

**The toll on human health, due to unhygienic sanitation conditions is grim.**

# The Need

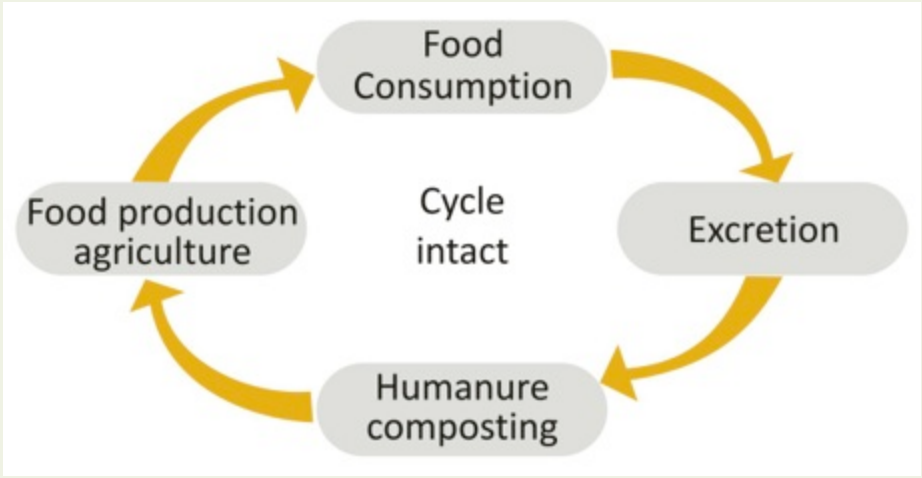
## Water (Flush) latrines and sewerage systems

- needs huge infrastructure
- have high maintenance costs
- cannot ensure a clean environment.
- **greater risk to public health and environment in case of failures.**

Water – valuable resource

## Human nutrient cycle

Utilization of composted human feces and urine (separated from feces) as organic fertilizers completes the human nutrient cycle by enriching the farming soil with nutrients.



# Benefits

## Benefits of using hygienic dry sanitation system

- Eliminates the spread of diseases by treating excreta and other waste, converting this waste into a valuable resource; and avoiding contamination of water and food.

- Composted human excreta and urine could be utilized as organic fertilizers which completes the human nutrient cycle by enriching the farming soil with nutrients. Also eliminates or reduces the need to buy industrial fertilizers.

- Avoids Contamination of scarce water resources.

- Helps save water for other purposes - drinking, washing, cleaning etc.

# The Objective

The primary goal to design **hygienic dry sanitation system (**which avoids direct discharge of excreta into the nearby water bodies or on to the open lands)**.** To come up with a sanitation solution catering specifically to the needs of rural India with water shortages which is cost effective, manageable, modular, (i.e. portability, flexibility, ease of manufacturing, deployment and maintenance) and sustainable (derive economic benefit by making fertiliser for their fields)

*Pilot Installation of the proposed toilet units at the key rural sites will* ***create awareness*** *among the people at these sites as well as neighboring communities about benefits of using the dry toilet. They will* ***get habitual*** *to toilet usage when it becomes a part of their daily necessities.* ***Feedback from these users*** *will be valuable* ***for further refinements in the design****.*

# The methodology

**Design Research and analysis**
- Literature review
- Field study
- Data collection & documentation
- Data analysis

**Concept Generation and evaluation**
- Design concepts & selection
- Virtual modeling / physical modeling trials

**Design Integration and development**
- Design development
- System Integration

**Design Evaluation**
- Working model /Prototype building for lab trial
- Field trial, validation

**Design Implementation, Deployment and Maintenance**

# Current Indian scenario

Public toilets available in **near rural & semi-urban** areas are not maintained properly and thus unhygienic to use.

- Cracked toilet pans
- Broken tiles
- Broken doors
- Accumulation of dirt at corners, joinery
- Difficult to maintain

for public use

***Resulting in very short work life and disuse***

Village Uttanpada

Contractor Labour colony toilet, IITB

Village Sai Bangoda

Indiranagar village

# Current Indian scenario

**Remote rural areas** do not have access to or affordance for ceramic tiles and ceramic WCs. Local material is used for shelters.
**Dry Toilet** is therefore norm.
**These are in fact good aspects.**

But they **lack the technology for disposal and decomposition**
So the **conditions are unhygienic.**

- Inexpensive
- Exposed and dripping fecal matter and urine - unhygienic
- Difficult to maintain
- Cleaning not possible


Uttarakhand


Assam

Himachal


Ladakh

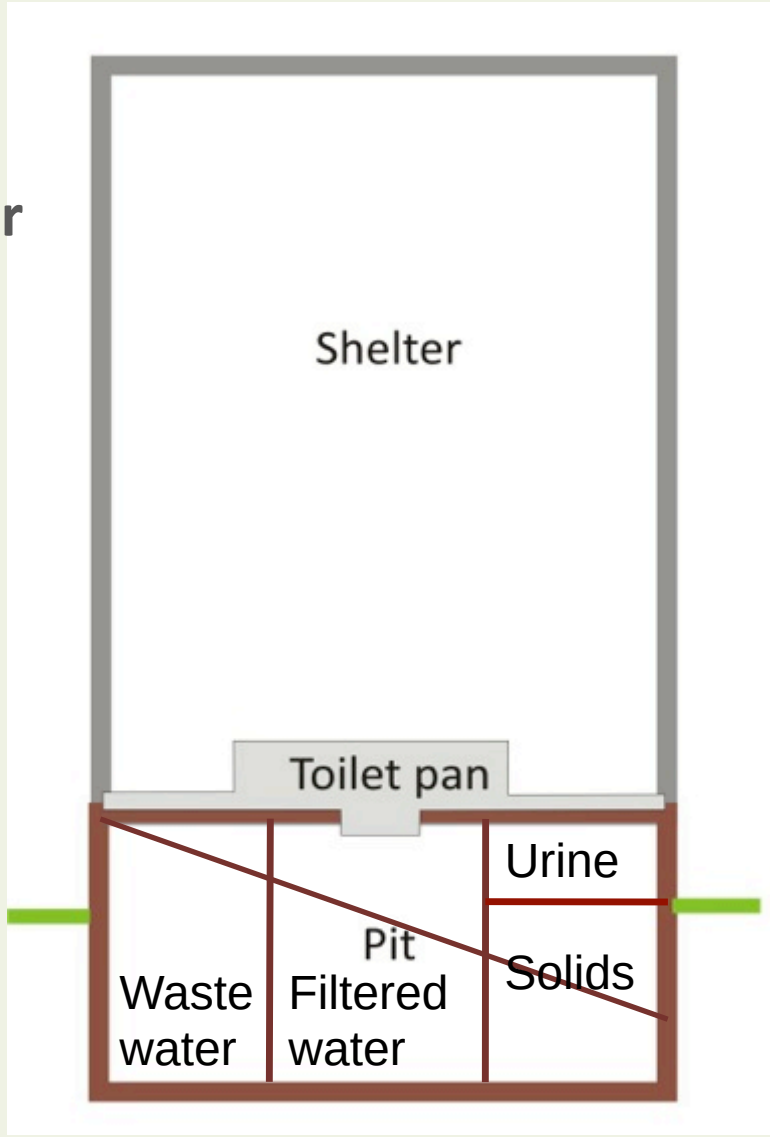
# The Design brief

**The hygienic dry sanitation system**
with arrangement for separation of
**Solid Waste, Urine & Washing Water**

- Squat type **toilet pan with three exclusive ports** for solids, urine and washing water
  --- comfortable, cleanable, unbreakable

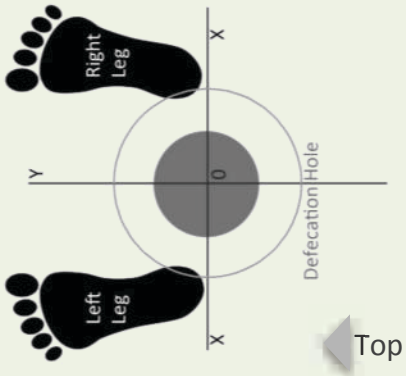
- **Arrangement of pits** below it for collection of solids, urine and washing water
  --- for decomposition & utilization as manure

- **Shelter** for housing the toilet pan
  --- for privacy

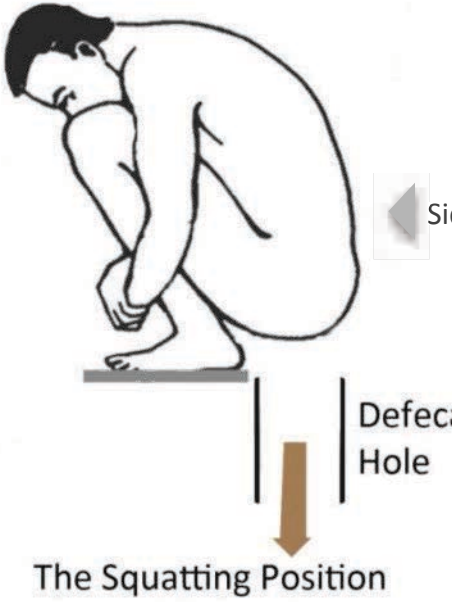


# Ergonomic research

- The Indian squatting position for defecation was simulated with various users to get the suitable dimensions for the toilet pan.
- Tape drawing of the plan view was done. to define the position for defecation.
- The parameters for the comfortable position were measured and noted down.
- Users were asked to sit comfortably in a squatted position and their opinions recorded to confirm the above to confirm the above.



Top View



Side View

The Squatting Position

The figure shows the basic rig used for measurements for user position. The center of the pit for defecation was taken as the center with X and Y axis defined as shown.

# Ergonomic Design - Toilet Pan

Squatting user

Tape drawing on the ground

**Based on**
**Anthropometric studies**

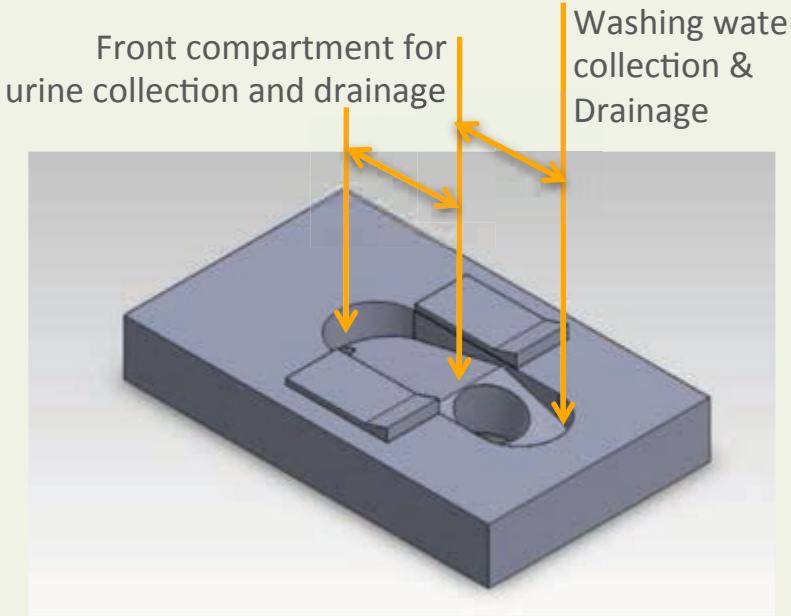
Determination of cabin size

# Toilet Pan – Engineering Design

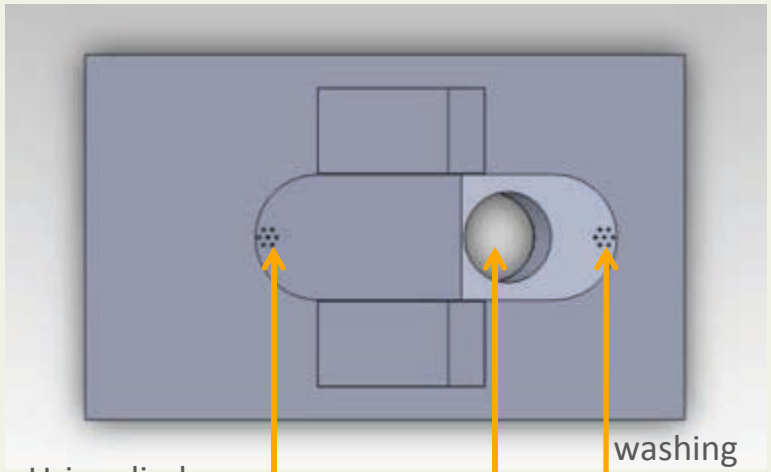
## Unique pan design with 3 ports

1. Front compartment for urine collection and drainage
2. Centre large hole for defecation
3. Washing water collection & Drainage

Inclination at heel aids in easy getting up from squatting position -Helpful for the elderly

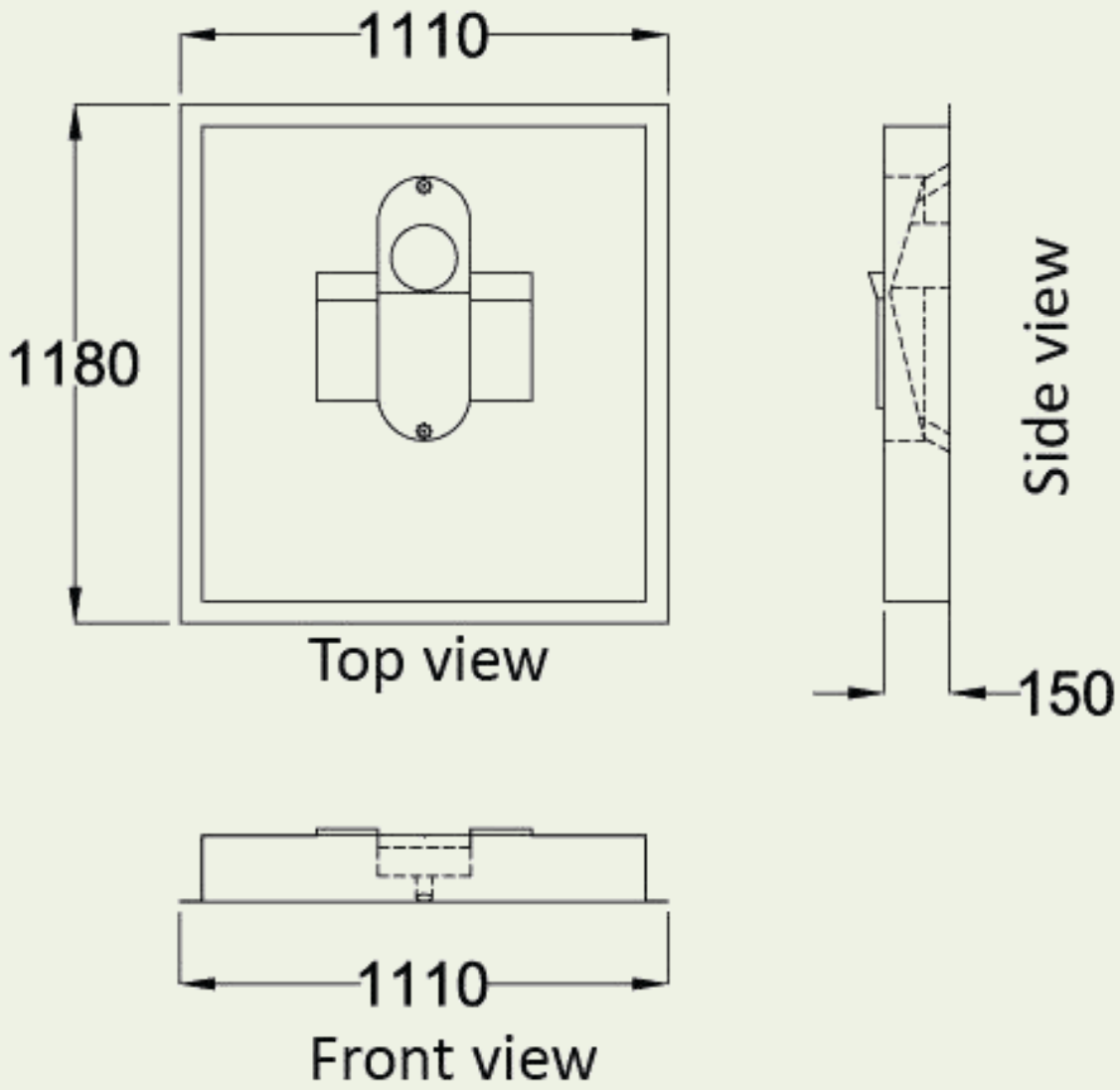



Digital Model Snap Shots



# Toilet Pan Design

OPTIMISED
DIMENSIONS



# Toilet Pan - Design highlights

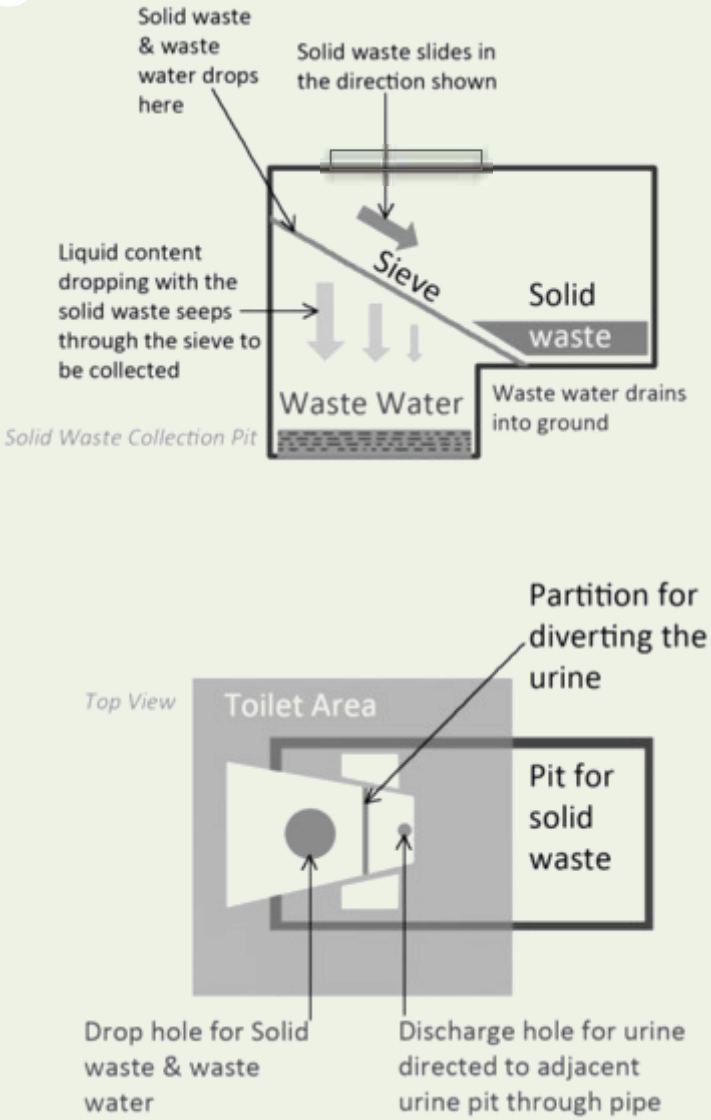
- **Separation of washing water** at the source with exclusive port in the pan at the back.
- **Separate urine collection** port in the front
- **Unique heel support** aids in getting up from squat position, especially for elderly.
- **Stainless Steel pan is durable, unbreakable** and can last more **than 20 years – long useful life**
- Cleaning and maintaining the pan is easier as SS **resists chemicals** and removes accumulated dirt easily.
- Can be **scrubbed** if required.

## Features to be added in pan design

- ***Self closing hinged flap*** for fecal discharge port to keep it closed when not in use
- ***Built in bidet*** arrangement for anal cleaning.

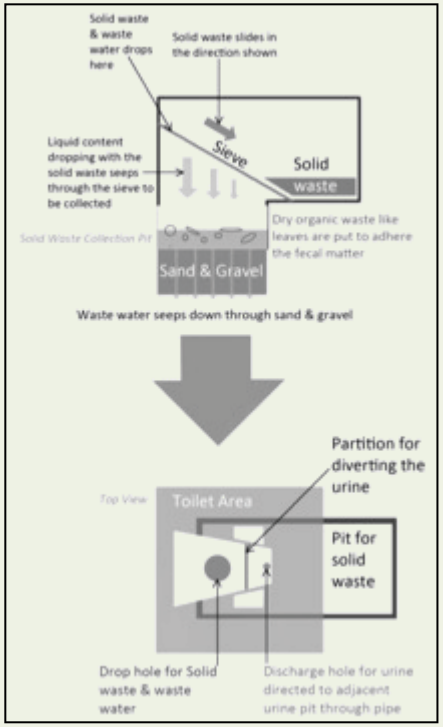
# Dry Toilet - Pit Design

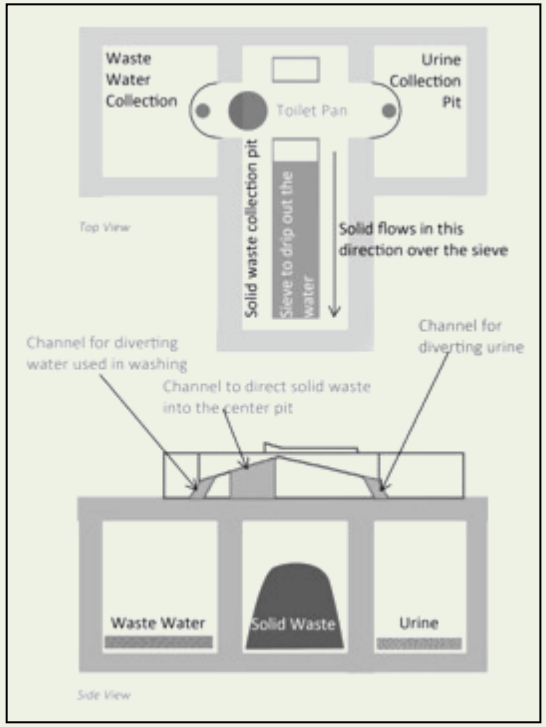
- The solid waste pit consists of a stepped depression in the ground lined with bricks / cement blocks as shown in the figure
- The bamboo mat is placed at an angle so as to ensure rolling of the solid waste to the far end.
- Bamboo mat is being used as a sieve to filter the washing water from solid waste
- The washing water seeps through the mat and gets collected in the deeper part of the pit.
- Waste water will eventually drain into the ground after getting filtered through sand, lime and gravel bed
- Solid waste disintegrates through self generated bacterial action and converts into manure.

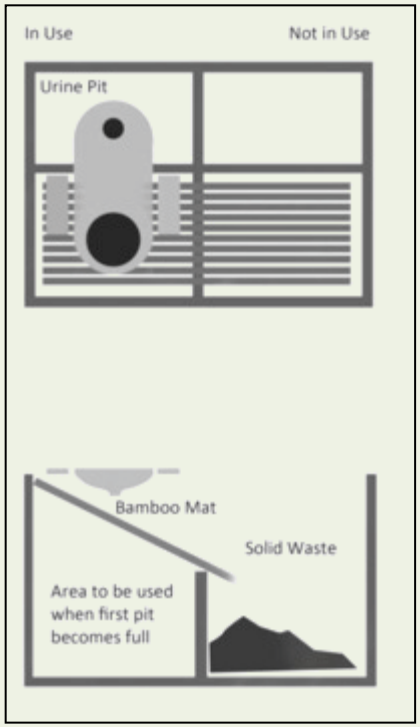



Schematic diagram of the pit

# Pit configurations- explorations



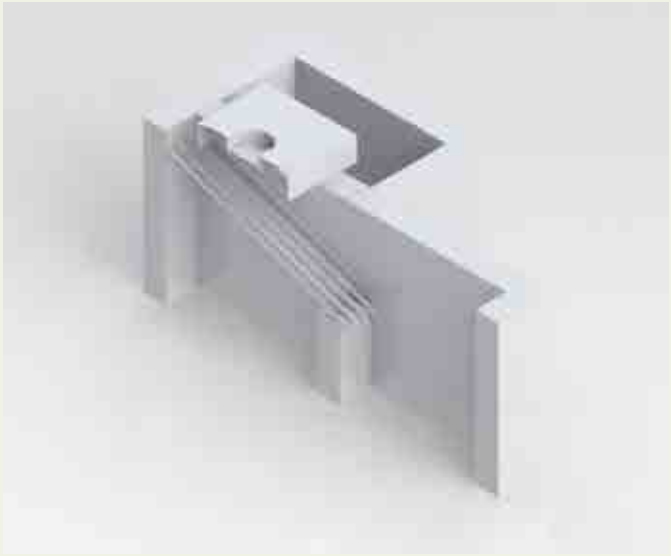



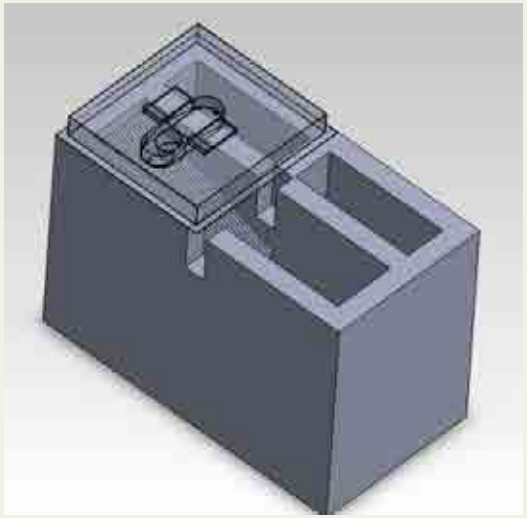



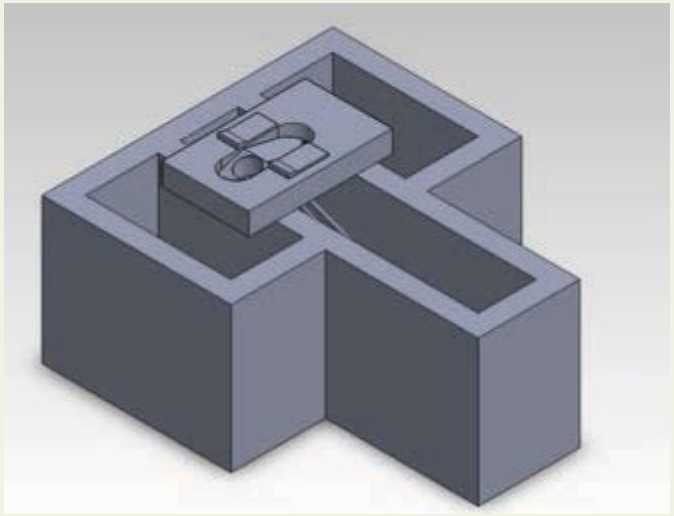

**Challenges:** Waterless – No flush system
No use any chemicals, enzymes – No external additives
Aid & accelerate natural process of decomposition
Women friendly – help in disposing sanitation pads
Elderly friendly
Bring science to empirical level – easy understanding (No mystery)

# Digital Models of Pit Design

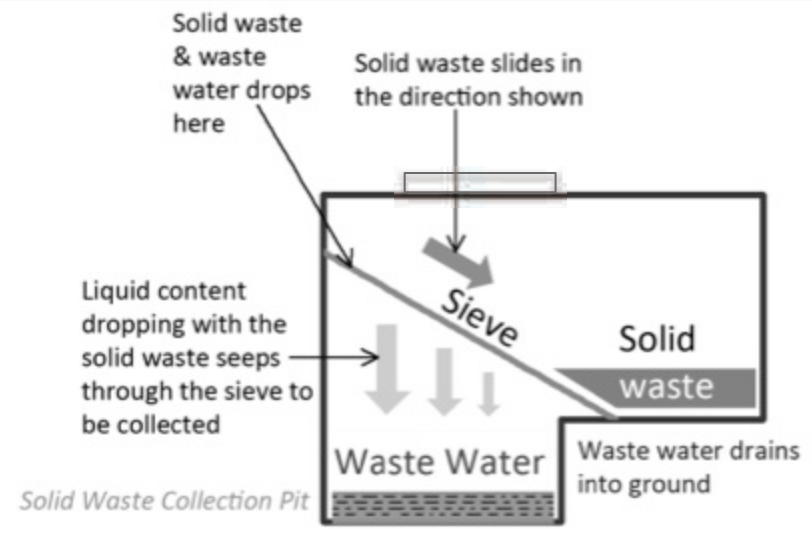
- The design consisted of 3 chamber pits
- One chamber each for: waste water, solid waste and urine.
- There are 3 separate discharge point in the toilet pan.
- The front port is for urine.
- The middle port which is largest in size is for solid waste.
- The rear port is for waste water utilized in cleaning.







# Prototype 1




Schematic section of solids pit,.
There is separate pit for urine collection


Prototype 1 - in usage



Pits under construction

# Prototype 1 – Observations

## After 6 months of usage (Jun 2012-Dec 2012 )

Solids were found in advanced stages of decomposition acquiring a black colour, having minimal amount of odour. The solids disposed could have been further composted to make it suitable to be used as organic fertilizer.

- Solids pit (approx. 600x700x600 mm) **was not full even after 6 months**. It was being used by 30 users (only females and children) daily.
- There was inadequate drying of the solid waste in the pit specifically in the rainy season due to rainwater seepage into the pit. The users were using buckets of water to keep the toilet clean thereby keeping the water content in the solid waste too high for satisfactory decomposition and drying. This was taken care of in the next design iteration for making Prototype 2.
- Urine collected in the pit was soaked into the ground.

Solids disposal site

After 2 months

Solids looked like part of soil.

# Prototype 1 - Observations

## After next 8 months of usage (Jan 2013 – Sep 2013)

**Solids pit**
The pit was not full after next 8 months of usage.
Collected solids were found black in colour and dry. It was in advanced stage of decomposition.

**Urine pit**
Urine pit was dry. Collected urine was soaked up in the soil.

**Toilet pan after a year of continuous usage by about 30 users daily, was in usable condition. Users were satisfied. The plywood panels of shelter needed replacement.**

# Prototype 2

## Stainless Steel Pan & FRP Enclosure


# Prototype 2

Pits under construction

Sieve placed in inclined position

Prototype 2 – in usage

**The toilet is used by 20-25 users daily.**

# Prototype 2 - Observations

## After 9 months of usage (Dec 2012 – Sep 2013)


**Solids pit**
The pit (885x550x1000mm$^3$) was not even quarter-full after 9 months of usage.

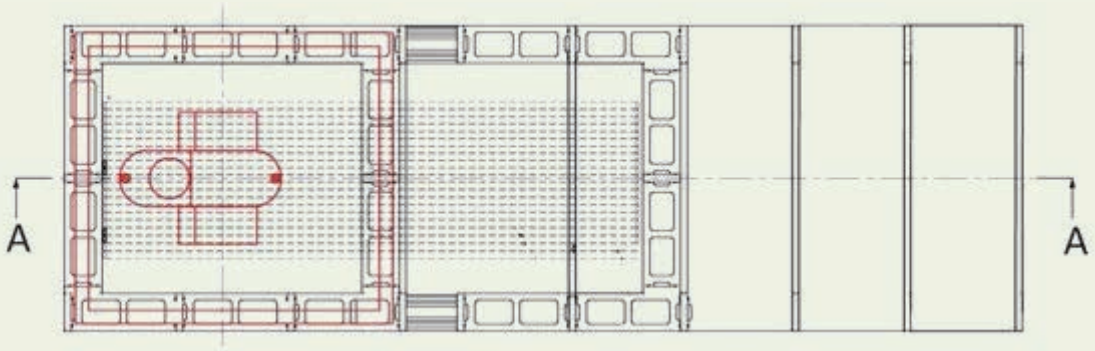
**Urine pit**
Urine pit was dry. Collected urine was soaked up in the soil.

The pit was less than 1/4$^{th}$ full with daily usage by **20-25 users in 9 months**, It could be easily **used for 4-5 years** or even more without need for emptying. **The solids get shrunk as they decompose.** There is about 80-90 % volume reduction in the process. It could be said that the pit of this size could be utilized by a **family of 6 for more than 10 years without emptying**

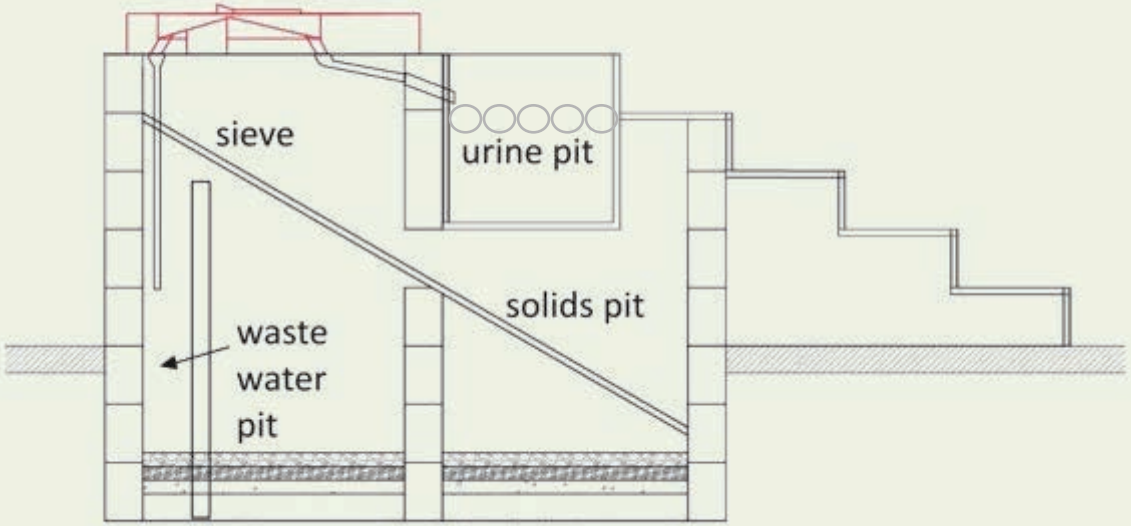
# Pit Design - Final

OPTIMISED CONFIGURATION 1

There are 3 different pits for collection of solids, urine and washing water



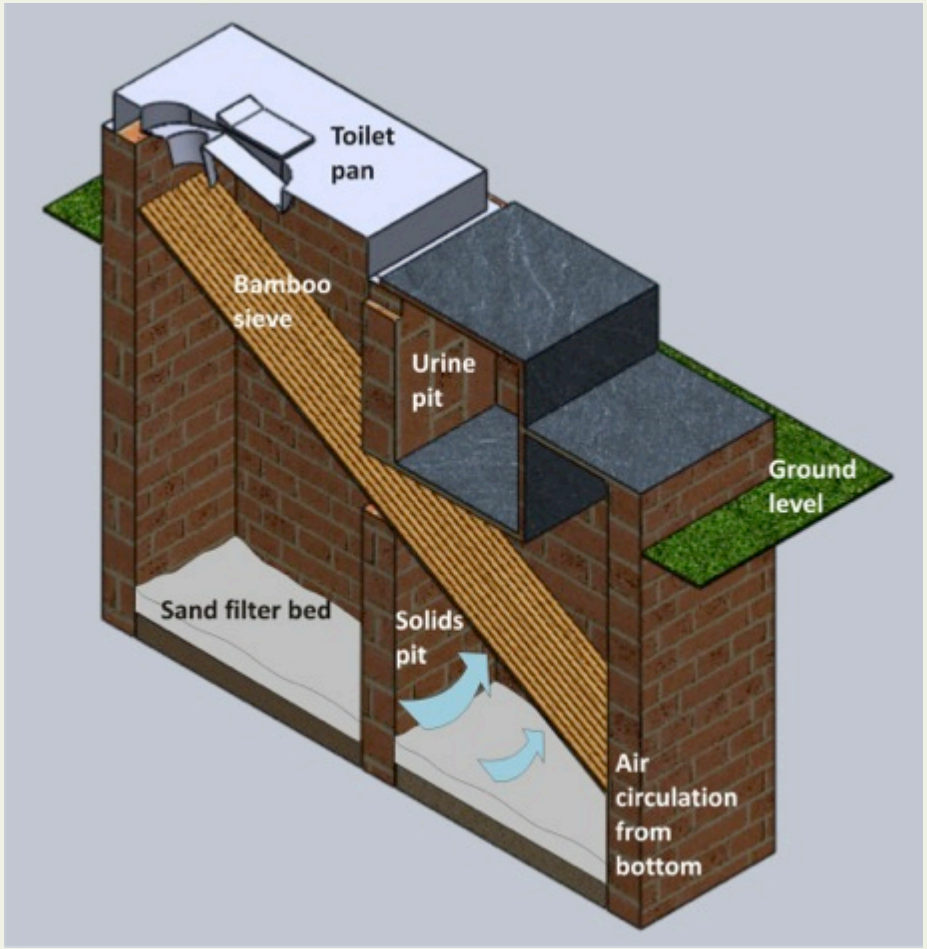

Top View

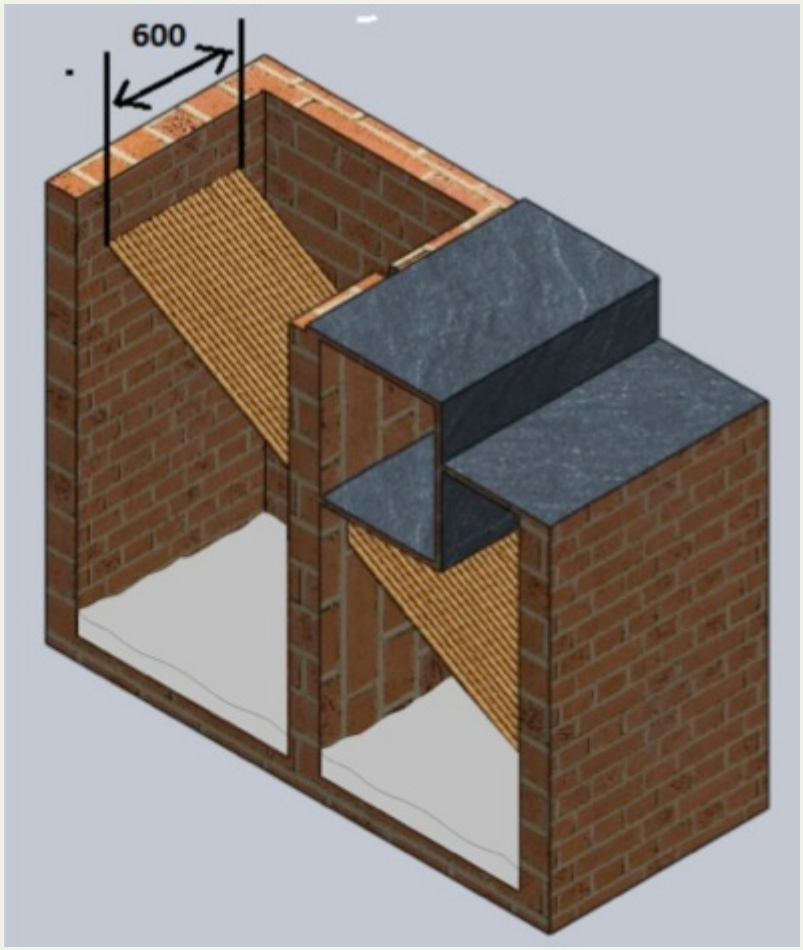



Section A-A

# Pit Design - Final

DETAILED MODELING



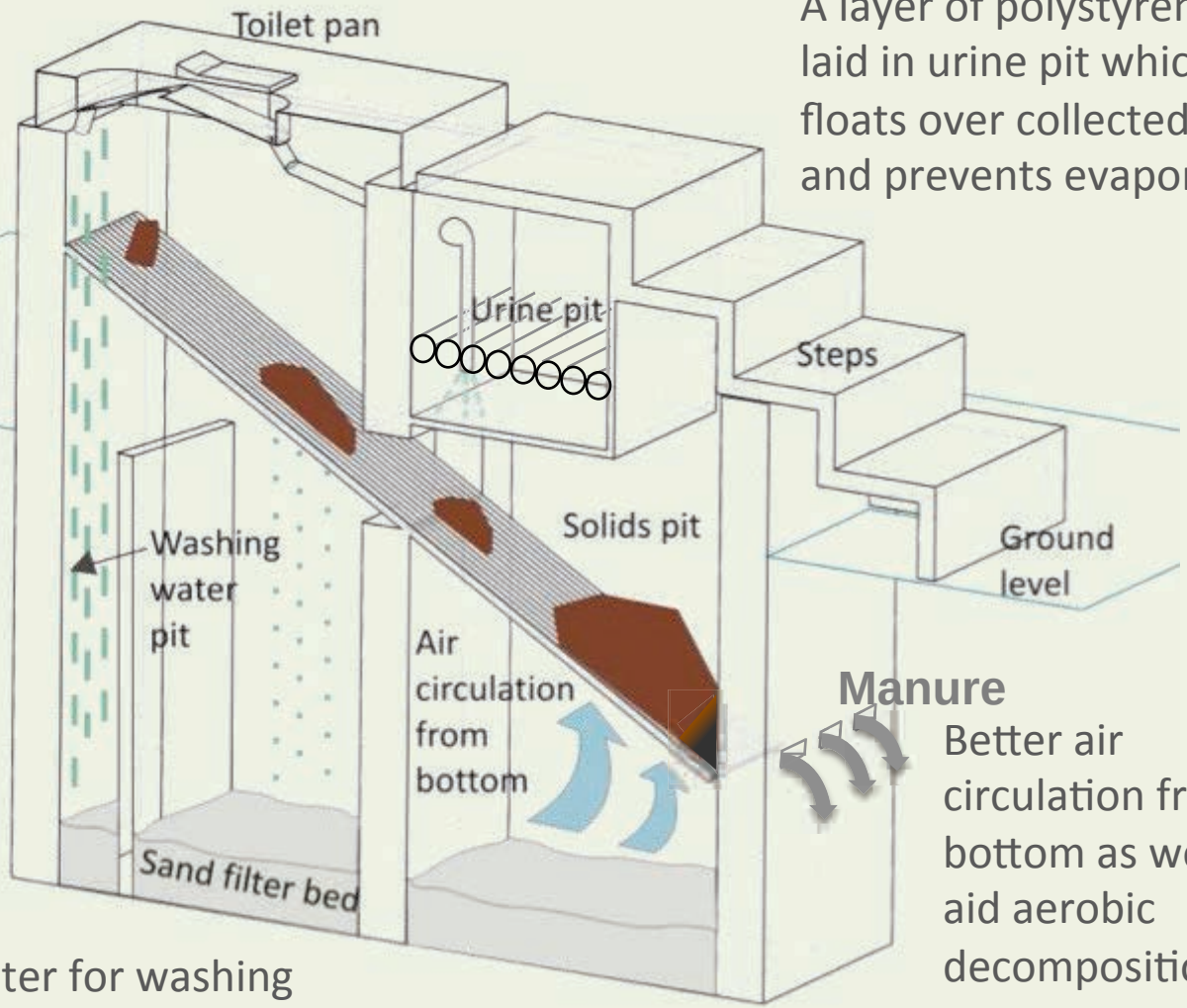



# Pit Design

OPTIMISED CONFIGURATION 2

A layer of polystyrene balls is laid in urine pit which always floats over collected urine and prevents evaporation.

The solid matter slides over the inclined sieve and collects at the edge of the sieve in the lower part of the front pit.




**Sanitary Pads**

**Kitchen waste**

**Manure**

Better air circulation from the bottom as well to aid aerobic decomposition.

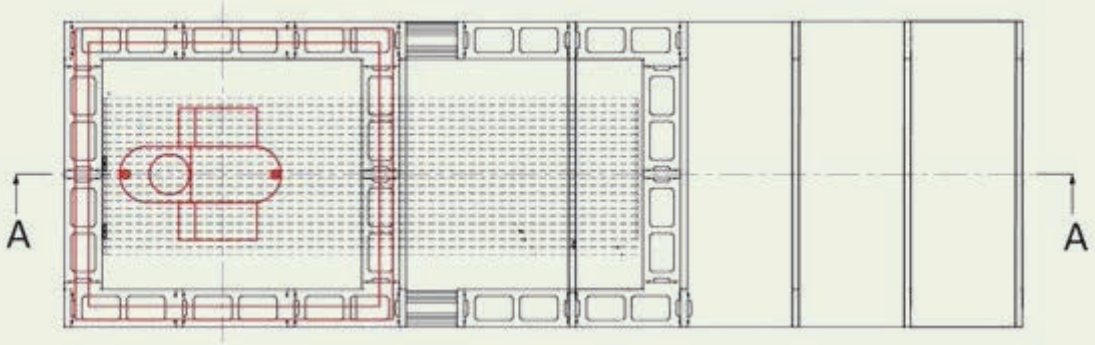
Gravel bed acts as a filter for washing water, which trickles down to the soil.

patent application no. 3711/MUM/2013
Patent Application no. 645/MUM/2014.

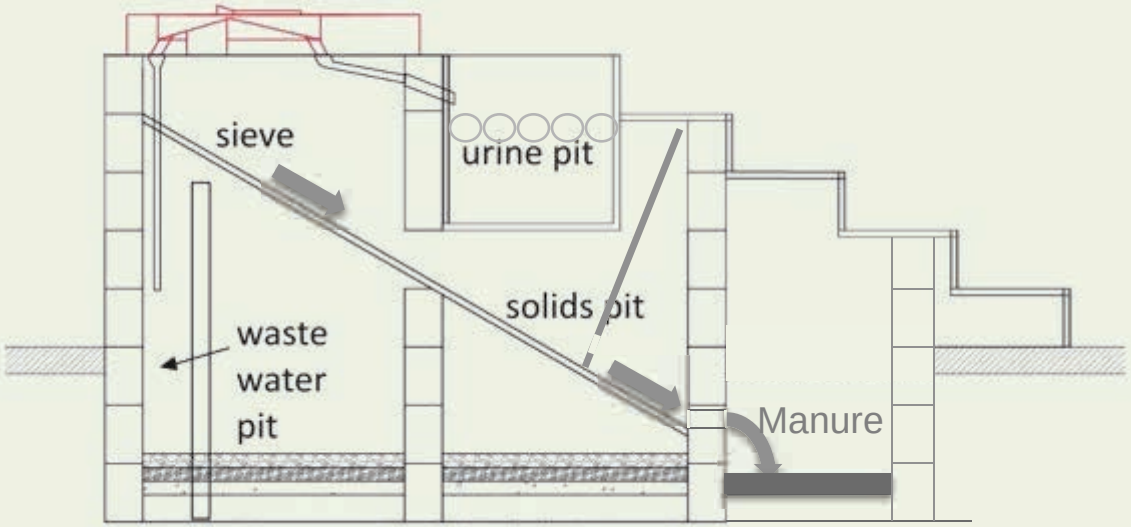
# Pit Design - Final

OPTIMISED
CONFIGURATION 3

There are 3 different pits for collection of solids, urine and washing water




Top View




Section A-A

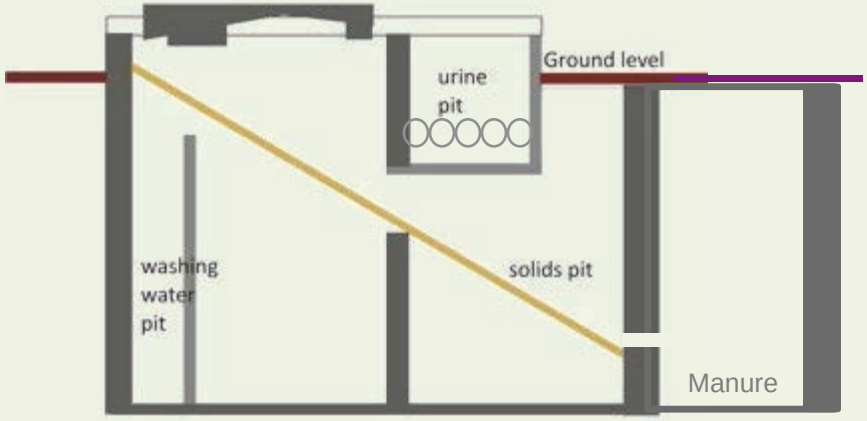
patent application no. 3711/MUM/2013
Patent Application no. 645/MUM/2014.

# Pit Design

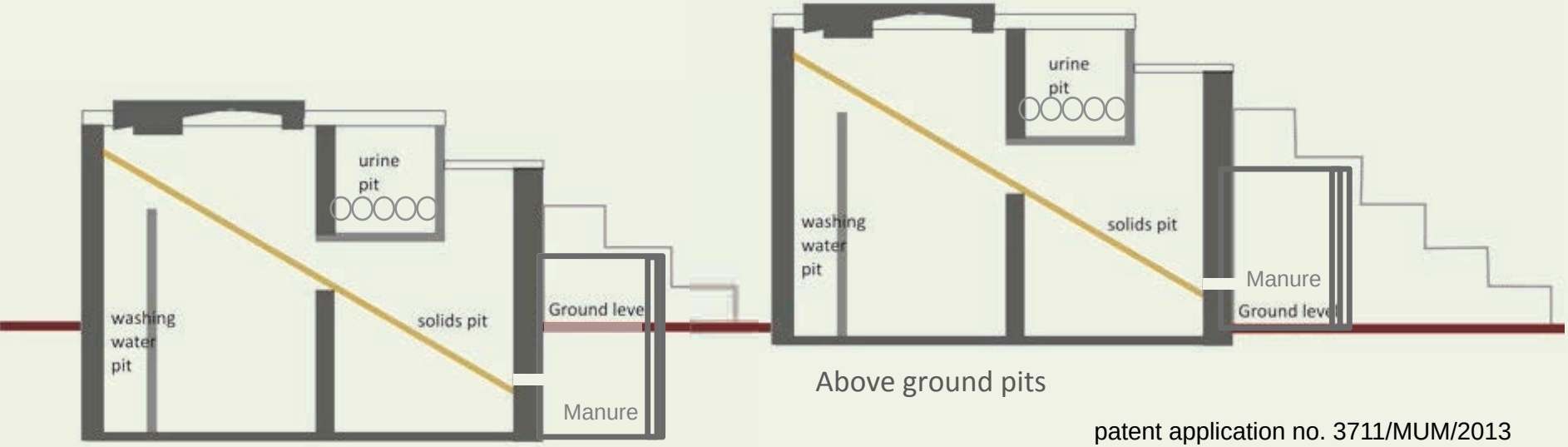
OPTIMISED CONFIGURATION

Pits can be

- underground
- Partially underground
- Above ground




Underground pits




Partially underground pits

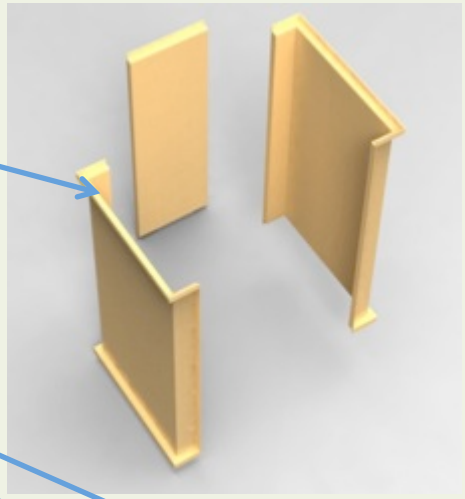
Above ground pits

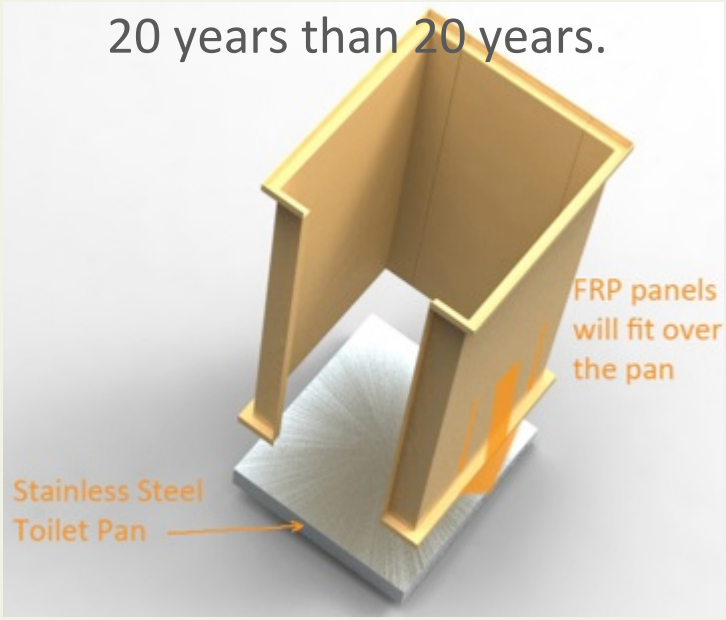
patent application no. 3711/MUM/2013
Patent Application no. 645/MUM/2014.

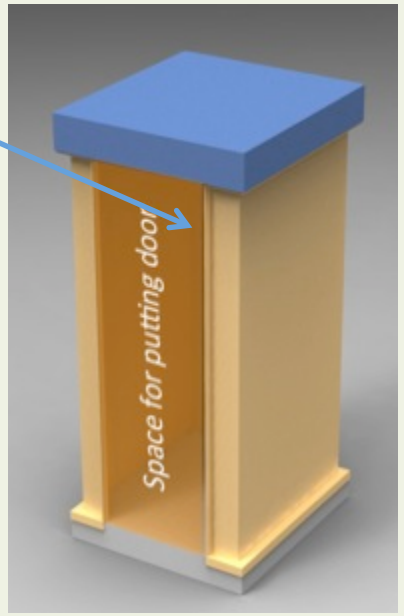
# Shelter Design 1

**Modular FRP panels**

- Modular FRP panels are clipped together to make a shelter unit.
- Provision of built in overhead water tank (70-80 lit capacity).
- Life span could be more than 20 years than 20 years.



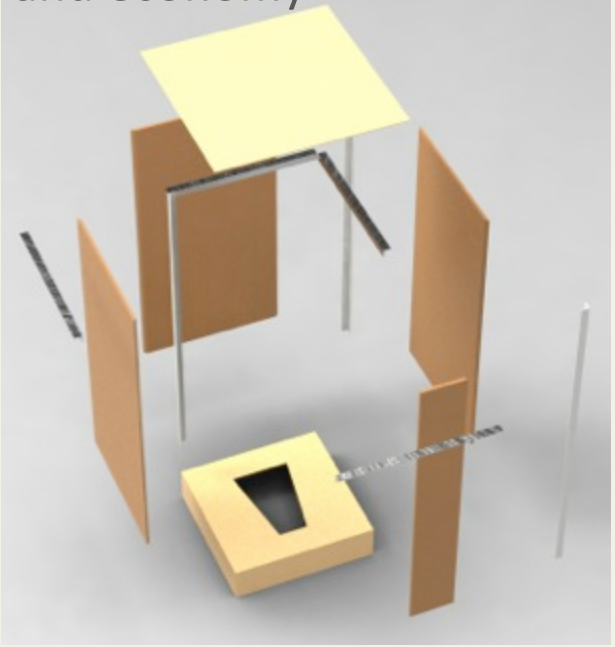


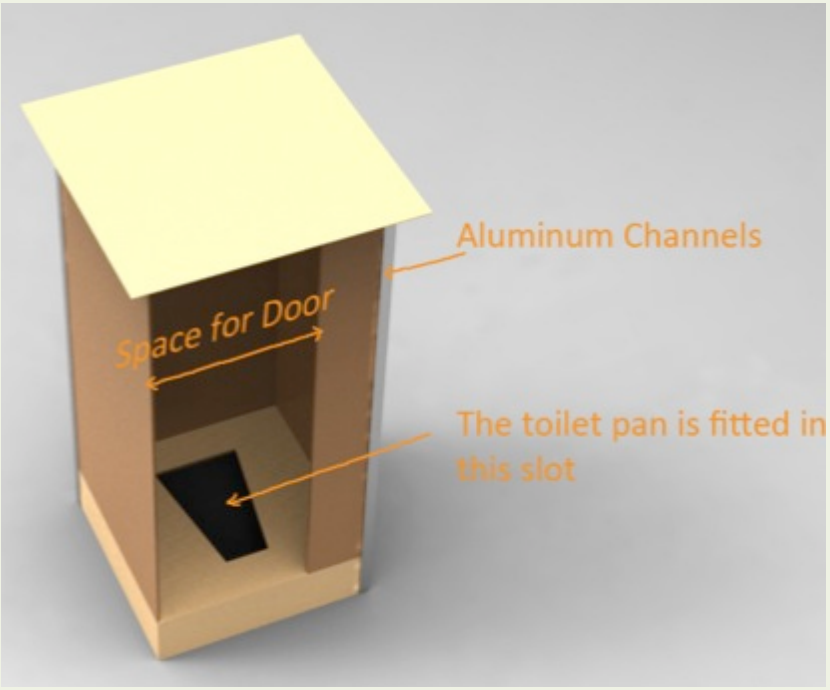



# Shelter Design 2

**Aluminum channel and plywood**

- Basic structural framework is constructed using aluminium channels. Marine plywood is used as wall panels and roof.
- Life span can be 3-4 years for marine plywood.
- Jute phenol composite sheets could be used in place of plywood.
- Cement or Siporex boards can also be used depending on local availability and economy

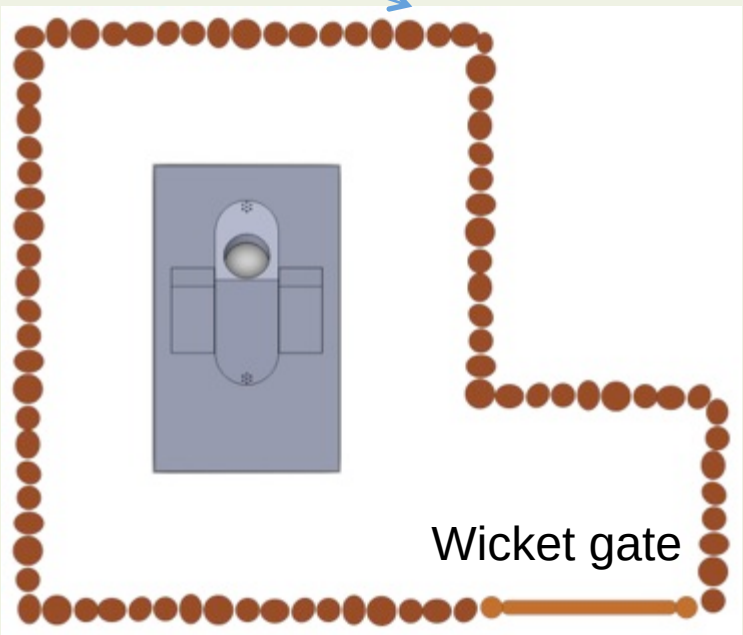


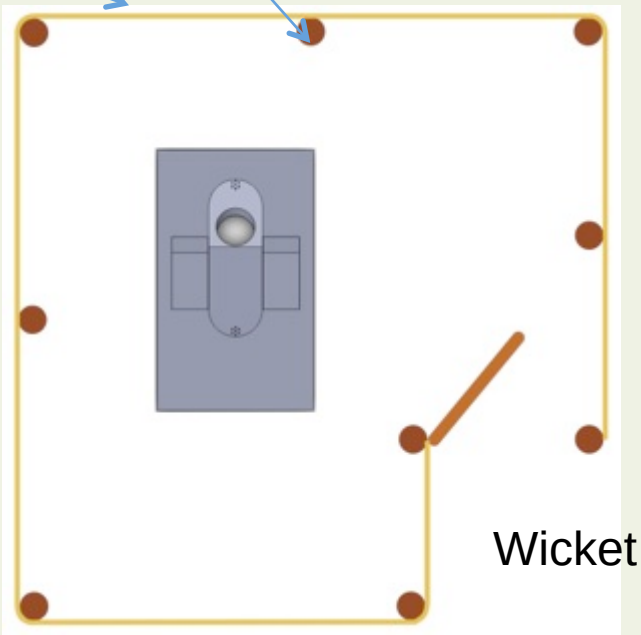


# Shelter Design 3

**Bamboo, jute cloth**

- Structural framework using **bamboo supports** and for paneling woven **bamboo mats**, jute cloth can be used.
- Life span of such structure would be 1 season. It would need further repairs or replacement of cloth.
- A **hedge like structure** can be created using bamboo around the toilet pan and pit area.

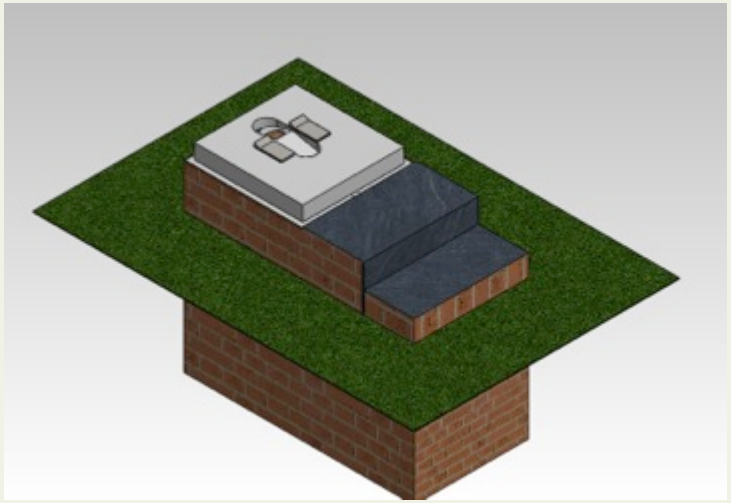


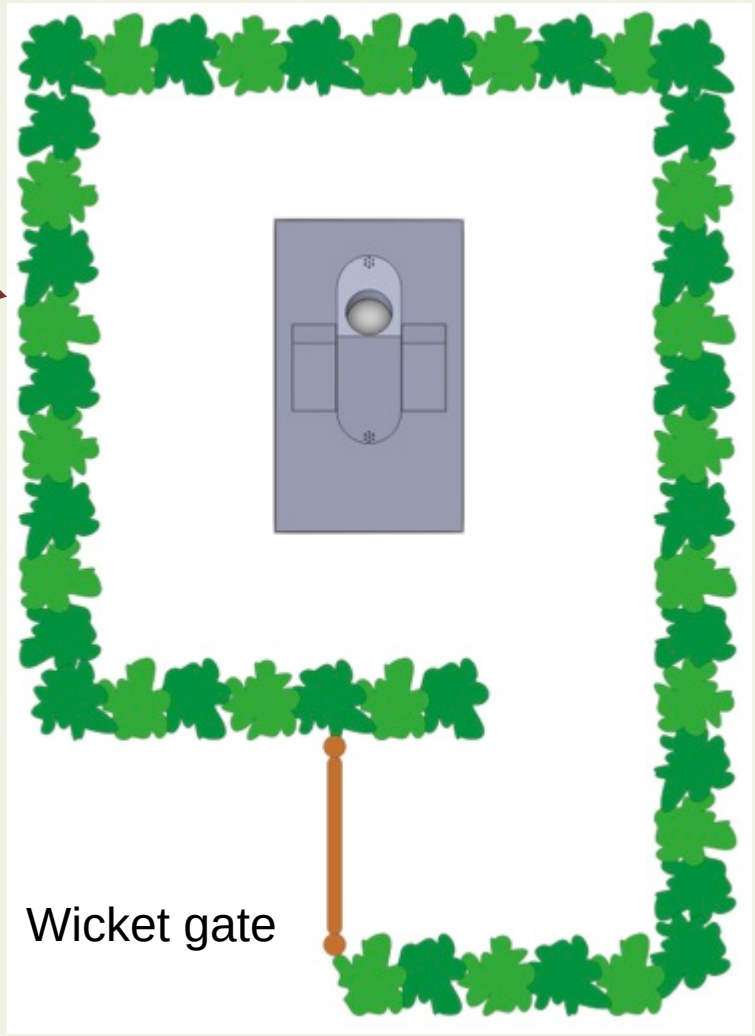



# Shelter Design 4

**Plants / Shrubs**

- Plantation of shrubs around toilet area as shelter.
- Most simple and cost effective alternative.





# Demonstration unit

Completed pits, ready for further toilet pan assembly

Glass window to monitor urine pit

Glass window to monitor solids pit


Vent pipe for solids pit

# Demonstration unit

# Demonstration unit

SS Toilet pan

Jet spray for anal cleansing

Louvers at top position of the shelter

Lighting switch for solar light

Door fixtures

Louvers at the bottom

# Demonstration unit

Aim:

- Creating awareness by letting people see and use the actual product.
- Creating awareness about the possibilities of generating useful products (manure / fertiliser) from waste (fecal matter / urine).
- Opportunity to keep the toilet clean with minimum effort, thereby getting used to a clean and hygienic toilet.
- People to get habitual to toilet usage.
- People could be educated about health & hygiene through actual usage of the toilet.
- The unit can act as a demonstrator for neighborhood communities.

**Social Inclusion Group of ILF&S Ltd**

**R&D of Tata Steel Ltd**

**Interested in trying it out and deployment**

# References


- Background Paper of the Millennium Project Task Force on Water and Sanitation, Millennium Project, April 2003. Available on the worldwide web: http://www.unmillenniumproject.org/documents/tf07apr18.pdf
- A guide to sanitation and hygiene for those working in developing countries, Available online at: http://www.drytoilet.org/pdf/Sanitation_Guide.pdf
- http://www.unmillenniumproject.org/documents/WaterComplete-lowres.pdf
- JENKINS. The Humanure Handbook. A Guide to Composting Human Manure. Grove City, USA 1999. [web document]. Available on the worldwide web: http://www.weblife.org/humanure/default.html [cited 15.5.2005]
- Guidelines for assessing the risk to groundwater from on-site sanitation. British Geological Survey and Robens Centre, Oxford, 2001. [web document]. Available on the worldwide web: http://lnweb18.worldbank.org/essd/essd.nsf/GlobalView/C16_ARG.pdf/$File/C16_ARG.pdf [cited 15.5.2005]
- Enwell – Water and Sanitation Project. The Finnish Red Cross.
- Ventilated Improved Pit Latrine. Construction Manual. UNICEF, Kenya.
- CONANT. Sanitation and Cleanliness for a Healthy Environment. Hesperian Foundation, Berkeley, USA, 2005. Available on the worldwide web: http://hesperian.org/pdf_files/EHB_Sanitation_EN_lowres.pdf
- (In Finnish). MALKKI. Kompostikäymäläopas. Työtehoseura, 1995. ISBN 951-788-221-1.
- (In Finnish). PAATERO, LEHTOKARI, KEMPPAINEN. Kompostointi. WSOY, Juva, 1984. ISBN 951-0-12502-4
- SCHÖNNING, STENSTRÖM. Guidelines for the Safe Use of Urine and Faeces in Ecological Sanitation Systems.
- EcoSanRes, Stockholm, 2004. ISBN 91-88714-93-4
- Introducing urine separation in Switzerland: NOVAQUATIS, 2nd international symposium on ecological sanitation, April 2003
- Water on Tap Improves Rural Quality of Life. (2009, September). Retrieved December 24, 2011, from IDA at work: http://web.worldbank.org/WBSITE/EXTERNAL/EXTABOUTUS/IDA/0,,contentMDK:22311356~menuPK:4754051~pagePK:51236175~piPK:437394~theSitePK:73154,00.html
- Chakraborty, P. (2008, November 4). Leach Pit Toilets for Rocky terrain- Experiences and Examples. Retrieved December 28, 2011, from Indian Sanitation Portal:
- Basic Principles of Composting available online at: http://www.lsuagcenter.com/nr/rdonlyres/1a247d4f-4e94-4021-b09e-2df1043e179e/2908/pub2622compost.pdf

# Costing in Rupees

| | Demo unit | Batch | Mass | per year |
|---|---|---|---|---|
| **SS Toilet pan** *(20 year life)* | **17-20 K** | **10-12K** | **4-5K** | **250/-** |
| Pit Construction *(20 year life)* | 10 K (Bricks) | 10K | 4-6K | **150/-** |
| | 20-25 K (Labor) | 5-7 K | 5-7 K | **350/-*** |
| | (Mumbai prices) | | | **750/-** |
| Shelter-FRP *(20 year life)* | 45-50 K | 30-32 K | 25 K | **1250/-*** |
| Super structure (Bamboo) | --- | ? | ? | |
| Super structure (Steel / Plywood / Jute / mud) | | ? | ? | |
| Revenue from manure produced | - | - | ? | **(?)** |

*** Scope of cost reduction in certain situations**

**Cost / person / day = Rs. 750 / 6 / 365 = Rs. 0.35 p**

**Cost / person / day = Rs. 750 / 30 / 365 = Rs. 0.07 p**

# Hygienic Rural Toilet (dry sanitation system)

2012 - 2014

The primary goal is to design hygienic dry sanitation system (which avoids direct discharge of excreta into the nearby water bodies or on to the open lands).

To come up with a sanitation solution catering specifically to the needs of rural India with water shortages which is cost effective, manageable, modular, (i.e. portability, flexibility, ease of manufacturing, deployment and maintenance) and sustainable (derive economic benefit by making fertilizer for their fields)

**Waterless – No flush system**

**No chemicals, enzymes – No external additives**

**Aids & accelerates natural process of decomposition**

**Women friendly – help in disposing sanitation pads**

**Elderly friendly**

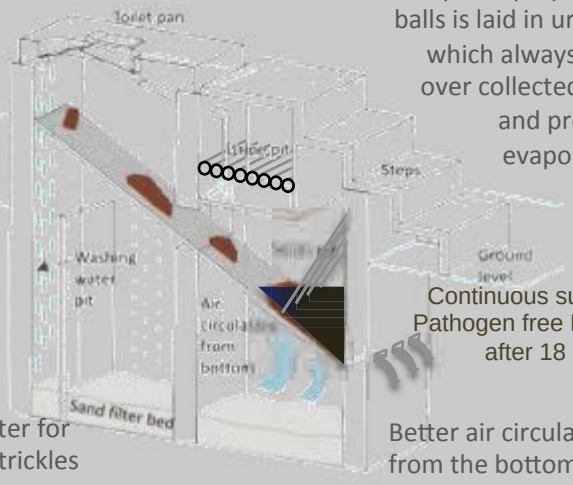
**Utilisation of waste as fertiliser**

**Bring science to empirical level – easy understanding**

**(No mystery)**

The solid matter slides over the inclined sieve and collects at the edge of the sieve in the lower part of the front pit.

A layer of polystyrene balls is laid in urine pit which always floats over collected urine and prevents evaporation.




**Sanitary Pads Kitchen waste can be disposed**

Continuous supply of Pathogen free Manure after 18 months

Gravel bed acts as a filter for washing water, which trickles down to the soil.

Better air circulation from the bottom as well, to aid aerobic decomposition.

patent application no. 3711/MUM/2013
Patent Application no. 645/MUM/2014.

# Design & Development Team

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***Longevity***
***Eco-Sustainability***

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# Thank You

## Hygienic Rural Toilet
### (dry sanitation system)

*For*

***Durability***
***Longevity***
***Eco-Sustainability***