Industrial Design Center
Project II

Low Cost Toilet for Rural Household

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Product Design

Under the supervision of
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Outlines

• Introduction
• Objective
• Scope of the project
• Design process
  ▶ Data collection
  ▶ Ideation
  ▶ Concept development
  ▶ Final concept and models
Introduction

• Toilet is the part of human hygiene which is a critical concern in the history of human civilization

• J.F Brondel introduced the valve type of toilet in 1738 and Alexander Cummining improved the technology in 1775

• According Dr. Binderswar Pathak, in 1556 the institute of Gushalkhana (bathroom) was established which is for rich people only

• In 1970 Sulabh international (NGO) was established waste as a source of energy (biogas).
Objective

- Design a low cost dry toilet for rural household to those who have scarce of water supply (cannot use water for flushing)

- Treat waste management and effective use of the wastes as a compost making

- Design toilet pan that diverts solid waste from liquid wastes
Scope of the project

- This is limited to rural areas in Indian tradition, (Squatting position and use of water for cleaning)

- Since the waste materials are used for compost making, it needs to separate the solid from the liquid wastes to get dry compost

- Develop / redesign the current toilet (Eco-San toilet)
Why toilet for rural areas?

- According to UNICEF, a gram of human feces has 10 million viruses, 1 million bacteria and 12,000 parasites.

- People walking on the urinated ground can catch by worms/Hook worm, which can enter through their feet and then enter the blood.

- Most rural people use ‘every man for himself’ latrine and affected by Cholera, Dysentery, Diarrhea, Typhoid and Stomach complication..
Hookworm development

Parasitism / tapeworm

Human may eat / drink raw Milk/ meat

Meat, Milk product

The Grass may eaten by animals/cow

Parasites may grown in the grass

Human poopson a field

Source: www.cd3wd.com as of September 15/2013
Why low cost toilet for rural household?

- Financial challenges
- High cost for sanitation toilet
- Water scarce for cleaning (flushing)
- Poor awareness in hygiene
- Very scarce information and documents (books, guidebooks, manuals, etc.)
Design process

Data collection
• Case studies
• Market studies
• Available products

Ideation
• Mood board
• Mind mapping
• Rough ideas

Concept development
• Possible solutions for the problem
• Mockup models
• Conception

Finalize the concept
• Concept evaluation
• Detailed drawing
• Final model
Toilet seats

Humanure

Arborloo

Pour flush water

Ventilation

Improved Pit/VIP

UDDT
1. Arborloo

- An Arborloo is a simple and ecological type of toilet.
- Its concept is to compost directly the feces in a pit, and to grow subsequently a fruiting tree on this very fertile soil.

2. Urine diversion dry toilet (UDDT) Eco-San toilet

- More hygiene toilet for rural
- No bad smell
- Improved health and nutrition
- Relatively simple explanations
- Can be built and repaired with locally available materials
- No water required for flushing
- Multiple designs possible (sitting/ squatting)
- Wet/dry cleaning
Types of UDDT Seats and Pans

Source: http://www.wecf.eu (assessed: 31/8/2013)
3. Humanure toilet

- Consists of a wooden box with a 15 gallon receptacle toilet below the toilet seat.
- Very low cost and can be made with local materials.
- This toilet does not separate urine and feces.
- Very good for children and handicapped/disabled users.

Source: (http://plantingmilkwood.files.wordpress.com)
4. Pour flush Water Seal Latrine

Pour flush single pit offset  Pour flush twin pit

Source: - www.wateraidaustralia.org as of September 14/2013
5. Ventilated Improved Pit Latrine (VIP)

- **Prevailing Wind**
- **Air Flow** (Ventilation)
- **Doorway** (Facing towards the prevailing wind.)
- **Cover Slab**
- **Fly Screen**
- **Vent Pipe**

Air (and odours) rise through the vent pipe assisted by the action of the prevailing wind and the warmth from the sun.

- **Tuff Toilet™ Commode**
- **Pit Collar** (May be extended to base of pit in poor ground conditions.)
- **Pit Latrine** (Can be dug by hand or bored mechanically.)

Source: [www.bellatrines.co.nz](http://www.bellatrines.co.nz) as of Sept. 14/2013
Human wastes

- Feces
- Urine

Human waste

Anaerobic reaction

Source for biogas

Compost

Aerobic reaction

Compost

Compost
Case study one

- First case study was conducted in Maharashtra, Darewadia /village name Garade 34km away to the west of Pune

- In this village there are 10 households currently use the Eco-San toilet constructed by the Eco-San service foundation

- Before using this toilet, they were using an open field and facing a problems especially for women

- They were affecting by Cholera, Dysentery, Diarrhea, Typhoid and Stomach complication
Rural toilet room in Garade

- Wastes are collected above the ground level in a chamber
- The toilet room is constructed in concrete/brick block
- Room Area 6.5 *4 Ft (2*1.2m)
- Total cost to built this toilet 36,000Rs
Eco-San toilet Pans

• Fiberglass Eco-San pan Size 90*31 cm

• Cost for single pan 1200Rs
**Ash / saw dust**

- They used Ash/sawdust/dry soil to protect bad smelling, to accelerate the reaction and to get dry waste

- They use sacks, bowl, and plates to contained the ash
Urine is collected in the Jerri can of 20-30 liter and used it to the garden as a compost.
Fecal chamber

- Made from concrete ratio of:-
  - Plain Cement Concrete (PCC) mixing ratio is 1:4:8
  - Reinforced Cement Concrete (RCC) is M15 and M20
  - Mortar mixing ratio is 1:4 and 1:6
  - Area of the toilet room 6.5ft *4ft (2m*1.2m)
Fertilizer from the toilet and cow dung
Plowing in the farm land and mixing the compost to the soil
Garden
General insights and observations from the case study

• It was a problem to introduce and convince the people to use the Eco-San
• Opening and closing the toilet pan is still unhygienic
• While ash is adding in to the chamber, it fall on the floor too
• No urinal for men
• Urine and washed water are collected outside the chamber which is exposed for children and cattle reach
• The material/Fiber glass/ of the seat is scratching while they cleaning it by local brooms
• Ergonomic design problem of the pan to squat
• Using two pans for a single toilet
Case Study 2, IDC

- Material: stainless steel,
- Cost including the fiberglass wall is around 45,000Rs
- Heavy to transport to rural areas

Foot is cantilevered from the foot rest
Market study

• The current price of the Indian toilet seat is 2499Rs. In Mumbai Home town and R-city malls (material is ceramic).

• Eco-san toilet seat is 1200Rs which is currently using by the user in the rural areas (material = fiber glass).

• The toilet seat in IDC is around 8000Rs (material stainless steel)

Image source: www.Indiamart.com, as of Oct. 25/2013
Problem identification

• There is no fixed space to put the ash container which spoils the floor as well as the pan while adding in to the chamber
• The ash/saw dust is a powder it may blown by air and spoils the floor
• Urine is collected outside the room which is exposed to children reach as well as cattle which can pour it easily
• Waste water which diverted out from the wash area is flowing to a peculation which allows to grow fly and mosquitoes
Cont’d

• Ergonomic design problem of the footrest for squatting
• Wastes are not flow fully to the expected container, there is few wastes stored over the wash area and urinals
• Pan scratches while they clean it.
• Opening the top of the fecal hole/cap is unhygienic to lift up by hand
• No need to buy two pans for a single toilet which is costly and confused the users which pan is currently in use
• Forcing men to squat for peeing
Activities in the toilet

• Lift the toilet seat cap
• Tack down your pants
• Sit on the toilet seat
• Poop/pee
• Wipe/clean yourself
• Put the wiper in the trash bin (not in this case)
• Stand up
• Pull up your pants/put down your skirt for ladies
• Tack same Ash or sawdust or Woodhaven or lime or carbon from the bucket and put in toilet
• Close the toilet
• Wash your hand

❖ In short “Poop, pee, carbon, lime, ash or sawdust“
Positioning of colon in squatting

- Standing position
- Sitting position
- The colon 3-6 feet long
- Puborectails muscle
- Fully relaxed position @ 35°
Design Brief

Design a low cost toilet for rural household:

• Which did not use water for flushing
• Separates solid waste from liquid wastes that can be used as a compost making
• Safe and hygienic environment
• Easy to use and accessible for users
Mind mapping

Toilet

- Western toilet type that can smock from the water tank
- Dispense ash like flushing water
- Added ash by pressing on foot
- Mechanisms
  - Centrifugal mechanism
  - Projectile mechanism
  - Rack and pennon
  - Pulley system

- Water
- Paper
- Inspired from a vehicle shut to change a gear

Toilet wastes

- Collected in some chamber for bio gas use
- Using a hollow column in center that urine can go inside
- Mechanism of intact of air and food

The seat

- As mothers squatting their child
- Using long handling
- Lifting up by foot

Opening the cap

Cleaning your self

Adding ash

- Hygienic issue
- Cloth

Collected in some chamber for bio gas use
Ideation

Fixed cap and ash is added by pushing from the back.

Moving forward after pooping for cleaning.

Concept of western toilet ash flushing instead of water.
• Lifting the cap by foot,
• Adding ash by scooping
• Handle to lift up

• Roller cap to close the hole
• Add ash by scooping
• Moving forward to clean
- Use movable chamber
- Lift by foot to open
- Handle for lifting up
Ergonomic footrest and elevated to some height to prevent splash back of urine

Urine and waste water for washing collected in some Jerican
Ergonomic seat and prevents urine splash back

Some height for the cover to lift easily

Scoop, for adding ash/saw dust
Pulley system to add ash

Movable chamber

Filters
<table>
<thead>
<tr>
<th>Possible ways of</th>
<th>Adding ash</th>
<th>Lifting up/ elderly</th>
<th>Opening the cap of the pan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gravity</td>
<td>Wooden handle</td>
<td>Using foot</td>
</tr>
<tr>
<td></td>
<td>Mechanically (pulley method)</td>
<td>Bars from both sides</td>
<td>Long handle</td>
</tr>
<tr>
<td></td>
<td>scooping</td>
<td>Pillar in center of the toilet that help as a stick</td>
<td>Rolling back and front</td>
</tr>
<tr>
<td></td>
<td>Ash in a rolled paper</td>
<td>Rope hanging from the ceiling</td>
<td>Sliding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Build brick wall to a side</td>
<td>Lifting up</td>
</tr>
<tr>
<td>Cheapest and convenient way</td>
<td>Scooping</td>
<td>Rope hanging from the ceiling</td>
<td>Long with ‘U’ shape handle</td>
</tr>
</tbody>
</table>
Lifting up using ceiling hanging rope and a rod of wood/metal
Squatting positions views

- Buttock width
- Front View
- Side view
- Top/bottom view
### Concepts 1

#### Chamber Construction

<table>
<thead>
<tr>
<th>Component</th>
<th>Dimension</th>
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<tr>
<td>Width</td>
<td>215.0</td>
</tr>
<tr>
<td>Height</td>
<td>159.6</td>
</tr>
<tr>
<td>Depth</td>
<td>80.0</td>
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</tbody>
</table>

#### Advantages

- Easy to empty the chamber
- Cost effective
- Ergonomic footrest
- Urine and waste water collected in safe, but container may fill in short time
- One seat for two chambers
Advantages

- Ash can be added easily by scooping,
- Cost effective

Disadvantages

- Waste space in the pit
- Two caps to open that is too much work,
Concepts 3

Advantages

• Ash can be added easily without touching it
• Hygienic and ergonomic

Disadvantages

• Difficult to install by rural people
• Relative costly
### Chamber construction

#### Advantages
- Low cost,
- Can use for two pits by changing the position,
- Provided urinals for men
- Easy to empty the chamber
- No space wasted in the chamber

#### Disadvantages
- Adding ash and open the cap is still a problem
Construction detail of the room

- Bamboo wall
- Floor finish (fine cement dispenses over the floor to get smooth finish)
- Concrete (with mash to avoid crack)
- Wooden material (bamboo, coconat, eucalypts...)

Brick wall

Wall, Slab and chamber detail (D)
Concept 1

- Fecal Holes
- Wash Area
- Footrest
Concept 3

- Ash container
- Washing area
- Handle to dispense the ash
- Fecal Holes
Concept 4

Footrest

Wash area

Fecal Holes
## Concept Evaluation

<table>
<thead>
<tr>
<th>Parameters / to evaluate</th>
<th>Concept 1</th>
<th>Concept 2</th>
<th>Concept 3</th>
<th>Concept 4</th>
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</thead>
<tbody>
<tr>
<td>Portability</td>
<td>2nd</td>
<td>3rd</td>
<td>4th</td>
<td>1st</td>
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<tr>
<td>Low cost</td>
<td>2nd</td>
<td>3rd</td>
<td>4th</td>
<td>1st</td>
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<tr>
<td>User interaction</td>
<td>4th</td>
<td>3rd</td>
<td>2nd</td>
<td>1st</td>
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<tr>
<td>Simplicity</td>
<td>3rd</td>
<td>2nd</td>
<td>4th</td>
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<tr>
<td>Functionality</td>
<td>4th</td>
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<td>3rd</td>
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<td>Manufacturing</td>
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<td>3rd</td>
<td>4th</td>
<td>1st</td>
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<tr>
<td>Compatibility</td>
<td>2nd</td>
<td>3rd</td>
<td>4th</td>
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### Selected anthropometric dimensions (cm)

<table>
<thead>
<tr>
<th>Seat parts</th>
<th>Body parts</th>
<th>5%</th>
<th>95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seat parts</td>
<td>Body parts</td>
<td>5%</td>
<td>95%</td>
</tr>
<tr>
<td>Foot rest</td>
<td>Toe to toe</td>
<td>13.2</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Out side Heel to heel</td>
<td>9.9</td>
<td>29.7</td>
</tr>
<tr>
<td></td>
<td>Lifted heel</td>
<td>3.7</td>
<td>12.37</td>
</tr>
<tr>
<td></td>
<td>Foot length</td>
<td>19.4</td>
<td>25.81</td>
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<tr>
<td></td>
<td>Heel width</td>
<td>4.48</td>
<td>6.2</td>
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<tr>
<td></td>
<td>Toe width</td>
<td>9.42</td>
<td>11.5</td>
</tr>
<tr>
<td>Washing area</td>
<td>Buttock to urethra</td>
<td>20.01</td>
<td>28.81</td>
</tr>
<tr>
<td></td>
<td>Buttock width</td>
<td>31.69</td>
<td>41.29</td>
</tr>
<tr>
<td>Fecal hole</td>
<td>Opening</td>
<td>3.46</td>
<td>9.7</td>
</tr>
<tr>
<td></td>
<td>In side toe to toe</td>
<td>7.13</td>
<td>30.59</td>
</tr>
<tr>
<td></td>
<td>In side heel to heel</td>
<td>7.68</td>
<td>22.9</td>
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<td></td>
<td>Buttock to heel</td>
<td>4.62</td>
<td>9.04</td>
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<tr>
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<td>Anal point to heel</td>
<td>-6.7</td>
<td>5.22</td>
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</tbody>
</table>

Indian Anthropometric dimension for Ergonomic design use, Debkhmar Chakrabarti, NID, Ergonomic Evaluation and Design Consideration for Indian Sanitary wares, G G Ray, IDC, IIT Bombay
Variations of the final concept
Final concept
Mirror/ transparent fiberglass to ventilate the chamber while adding the ash

Hanging rope to standing up for elderly

Wooden board to cover the hole

PVC pipe to collect the waste to the Jerry can

Water container
Vent pipe
Final model
Material selection

- Material for the pan is stainless steel by coating vitreous enameling which is drabble, scratch resistance, and free of corrosion

The process used to manufacture the pan:
- Make a final mold of the pan.
- Spray, or dipping in to vitreous enameling and put it in to a furnace up to (750-850°C) to get wide range of color
The process used to manufacture the pan is a process called fiber glass molding process in which fiber glass reinforced resin (tolling resin) plastics are formed into useful shapes.

It usually involves first making a mold from wood and/or clay and then using the mold to make the fiber glass pan.
Acknowledgement

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