Industrial Design Center
Project II

Low Cost Toilet for Rural Household

By:- Tu'umay Allene
ID NO.:- 126132002
Product Design

Under the supervision of
Prof. U.A. Athavankar
Prof. R. Sandesh

Out lines

- 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 introduces 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 (can not 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

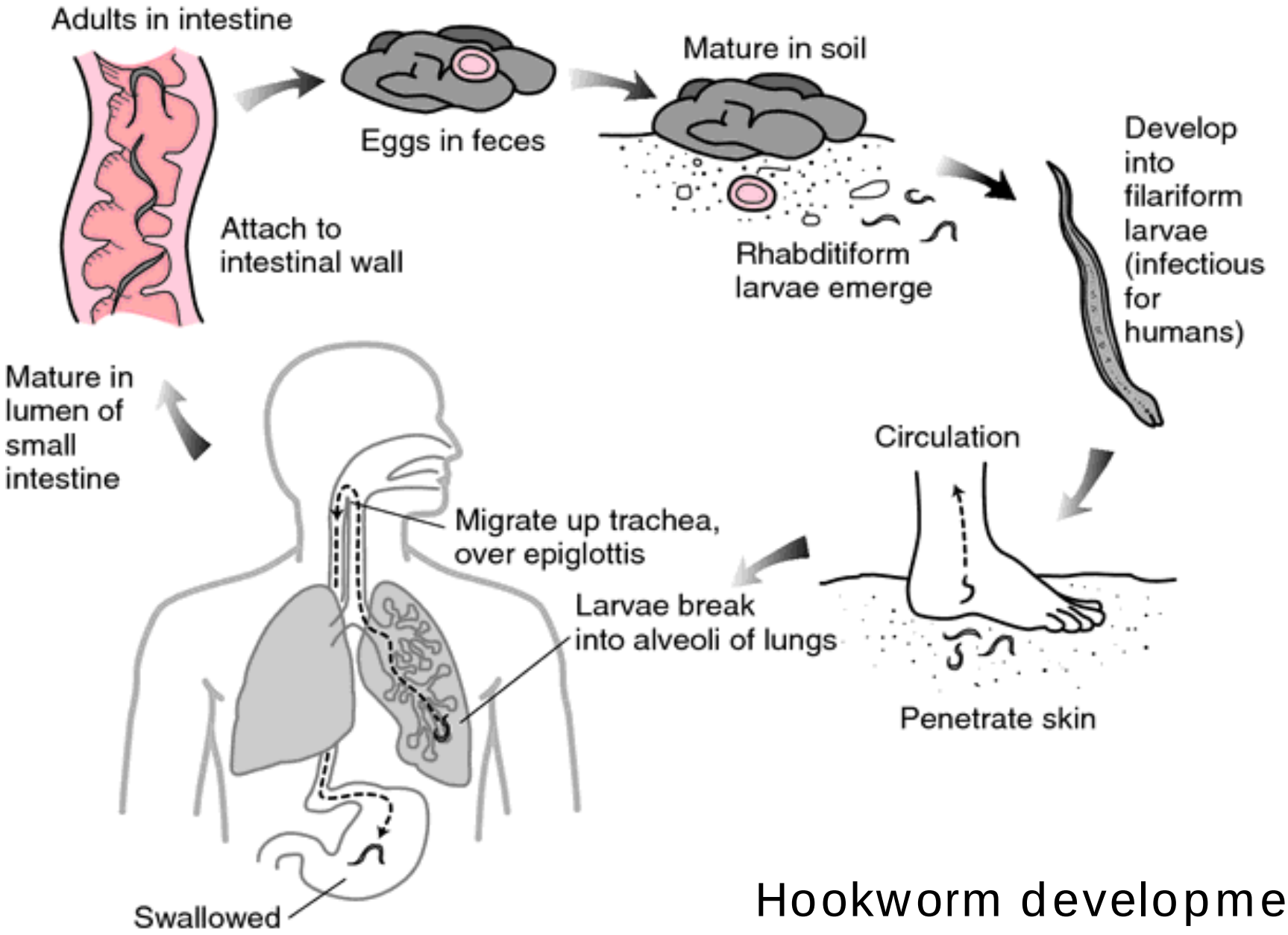
- This is limited to rural areas in Indian tradition,(Squatting position and use of water for cleaning)
- Since the waste materials are used for compost making, it needs to separate the solid from the liquid wastes to get dry compost
- Develop / redesign the current toilet (Eco-San toilet)

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..



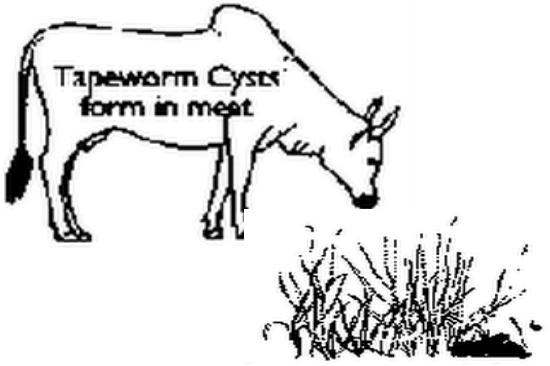
Hookworm development

Source:-http://medical-dictionary.thefreedictionary.com/hookworm, As of Sept. 18. 2013

Human may eat /drink raw Milk/ meat

Meat, Milk product

The Grass may eaten by animals/cow



Parasitism /tapeworm

Human poops on a field

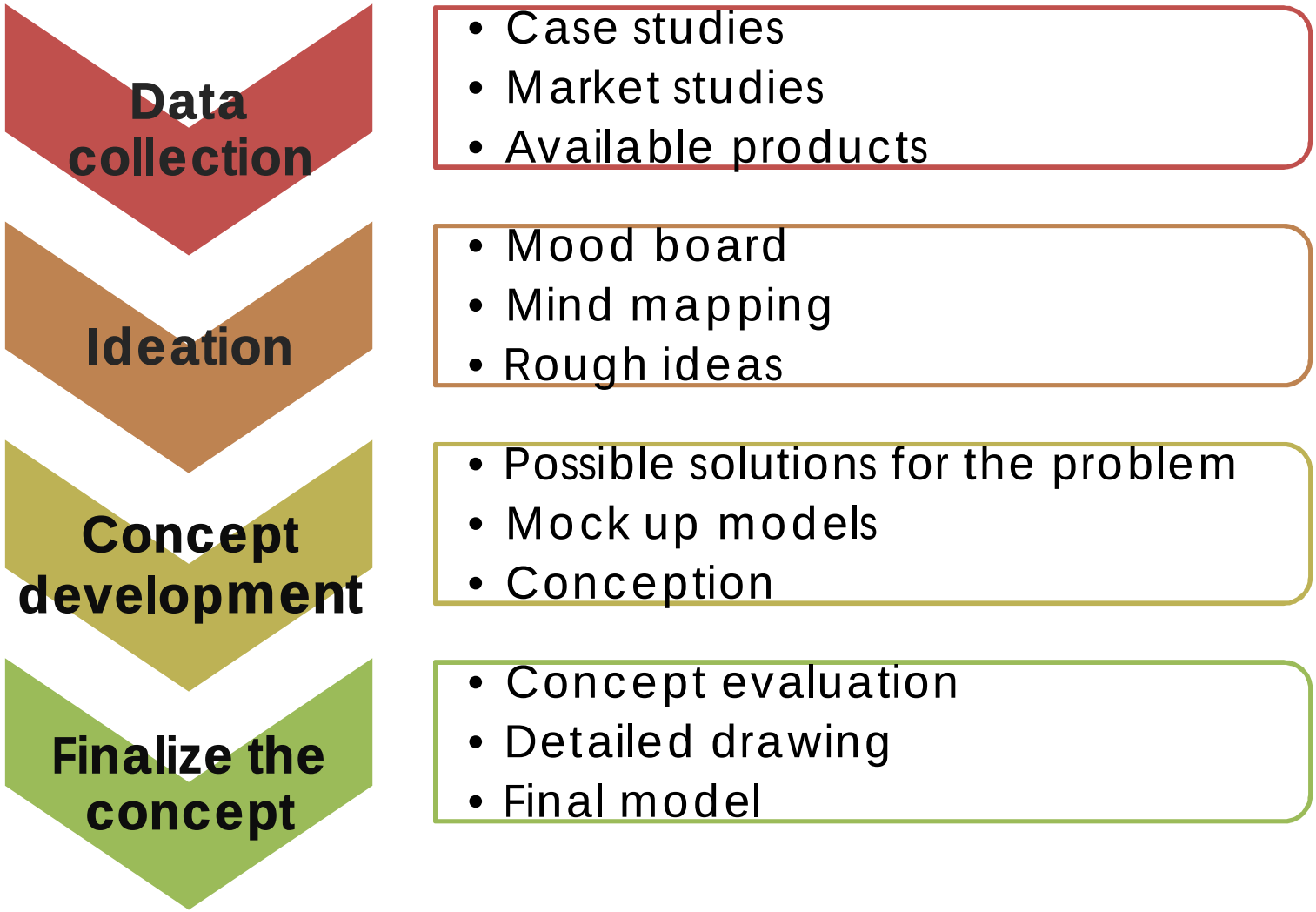
Parasites may grown in the grass

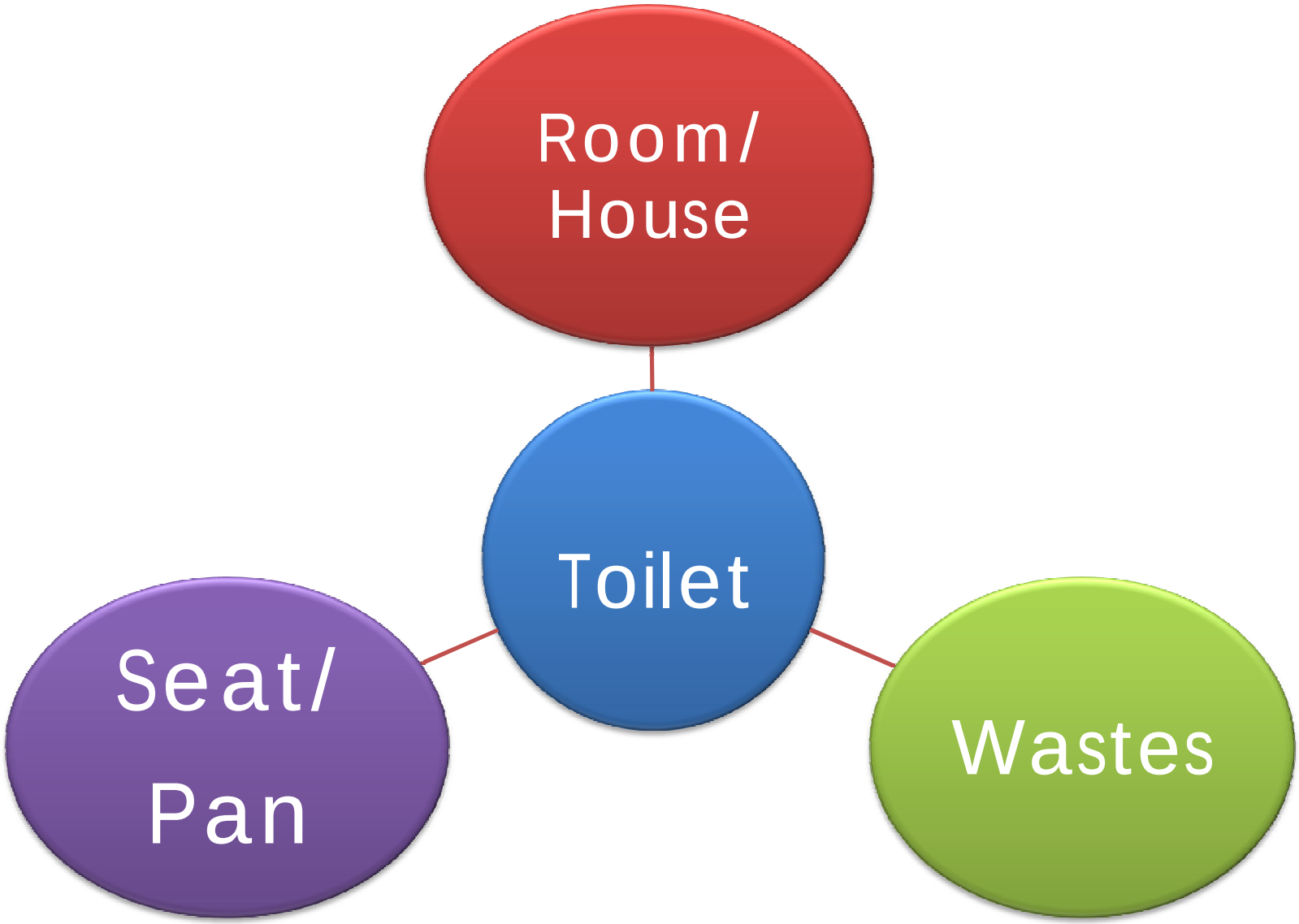
Source:- www.cd3wd.com as of September 15/2013

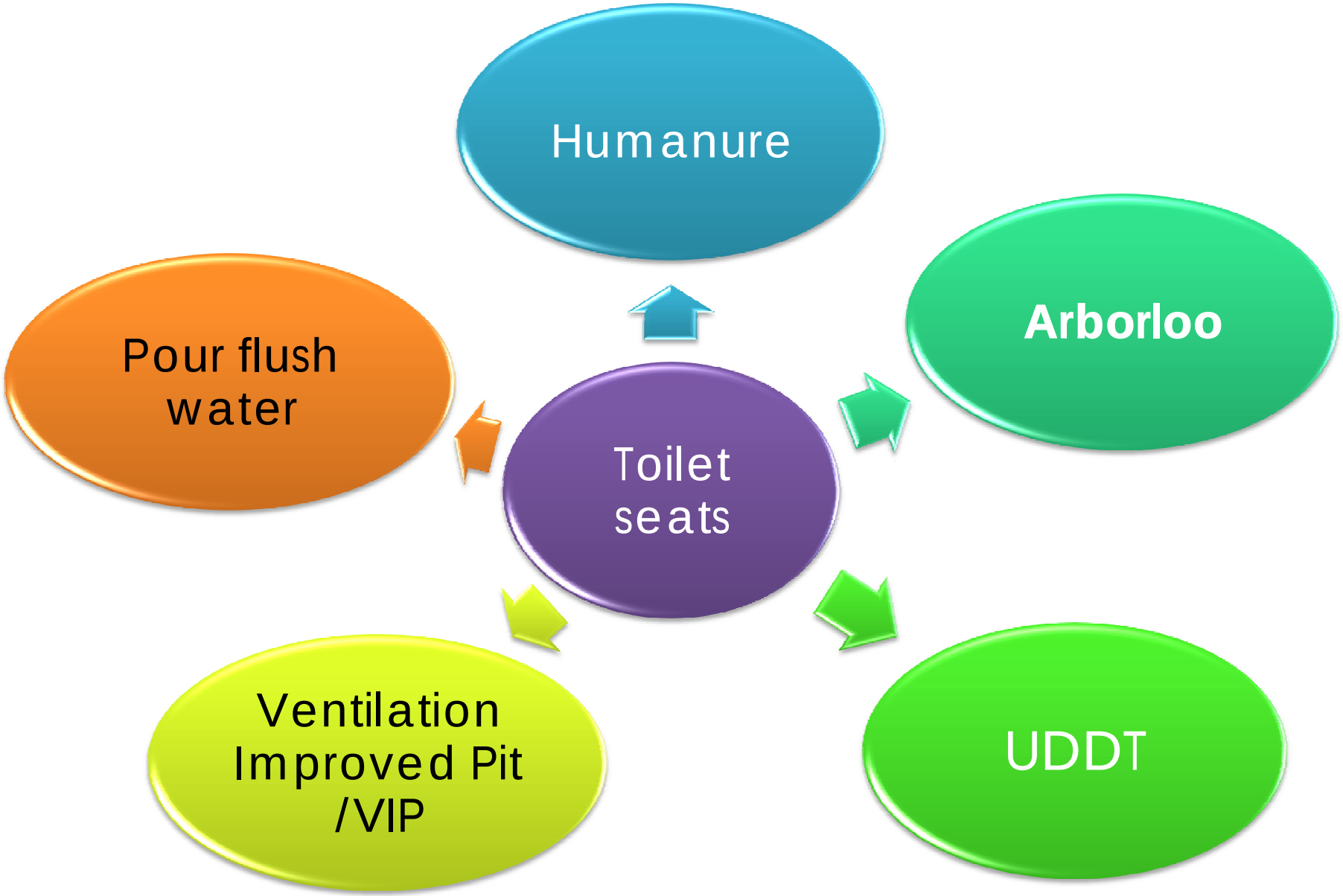
Why low cost toilet for rural household?

- 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

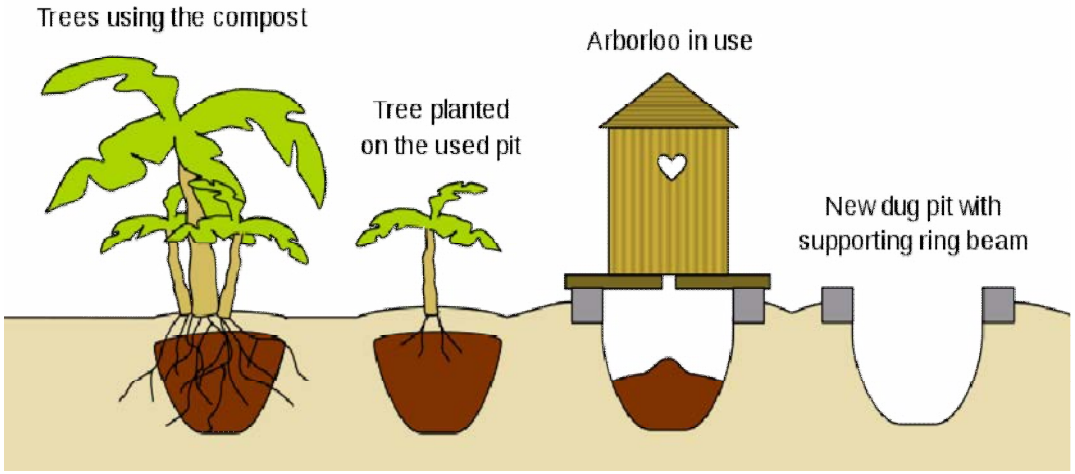



Room/
House
Toilet
Seat/
Pan
Wastes


Humanure
Arborloo
Pour flush water
Toilet seats
Ventilation Improved Pit /VIP
UDDT

1. Arborloo

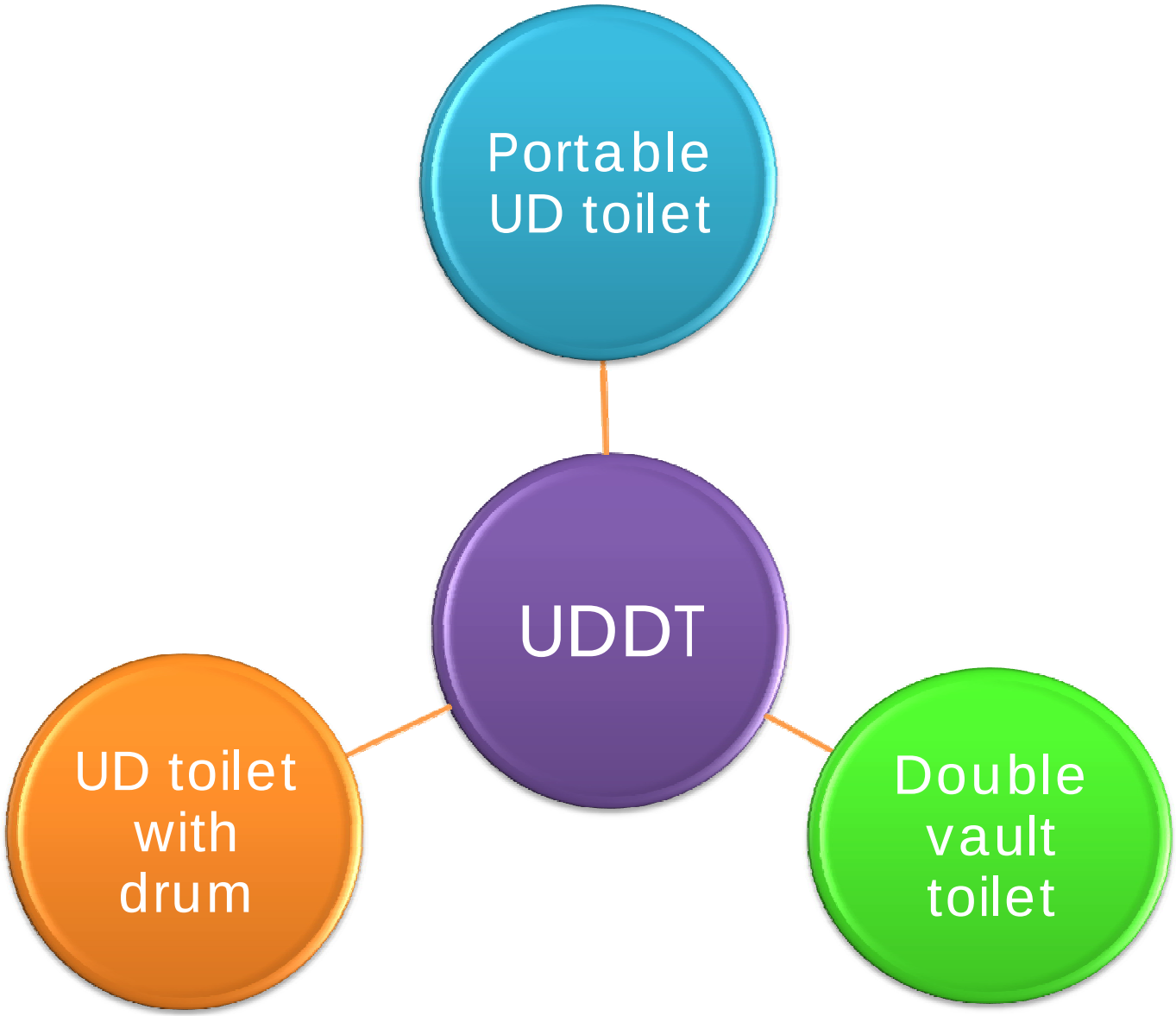
- An Arborloo is a simple and ecological type of toilet.
- Its concept is to compost directly the feces in a pit, and to grow subsequently a fruiting tree on this very fertile soil.



http://en.wikipedia.org/wiki/File:Arborloo-en.svg /assessed on 8/31/2013

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


Portable UD toilet
UDDT
UD toilet with drum
Double vault toilet

Types of UDDT Seats and Pans

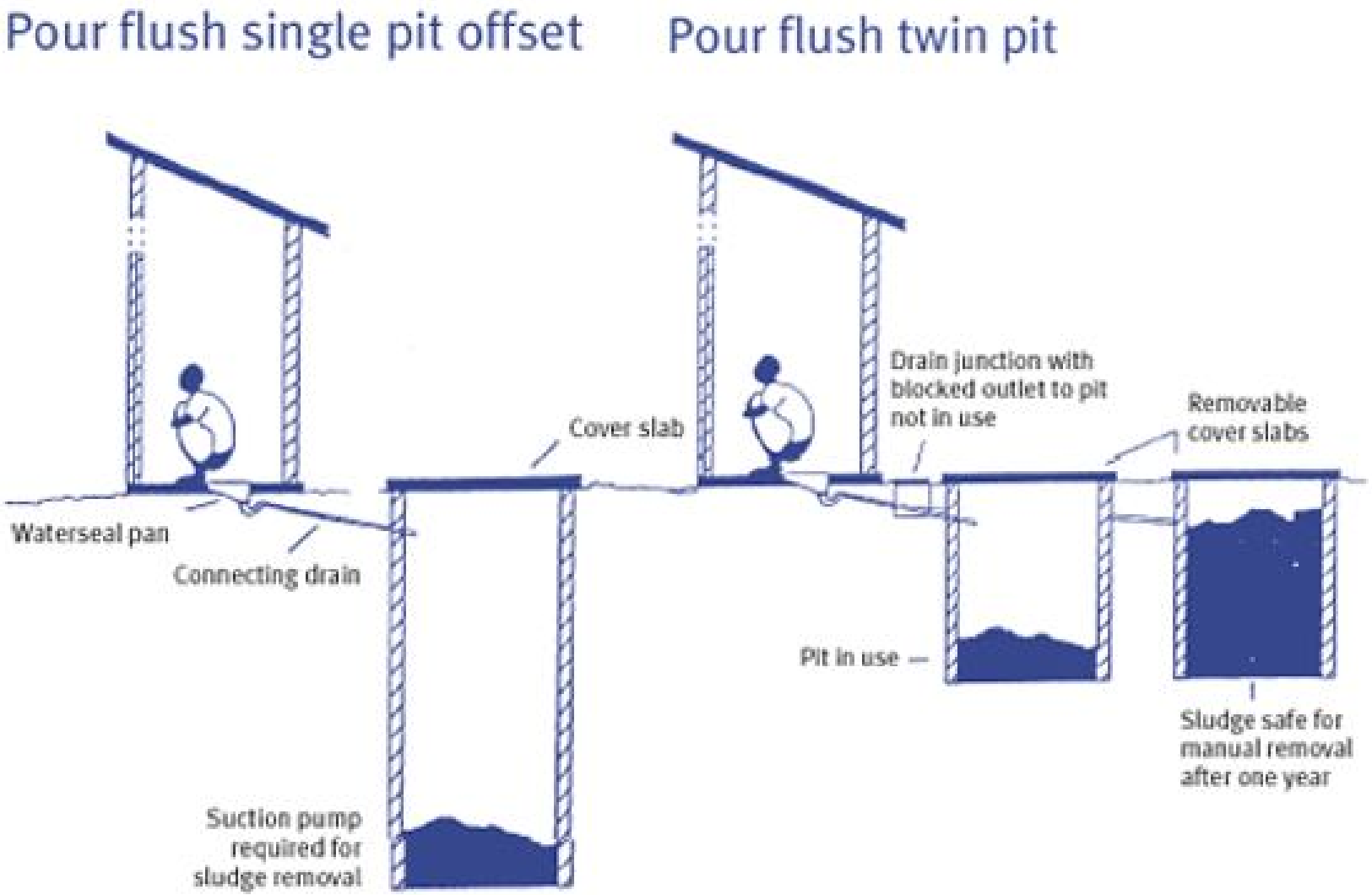
Source: http://www.wecf.eu (assessed: 31/8/2013

3. Humanure toilet

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

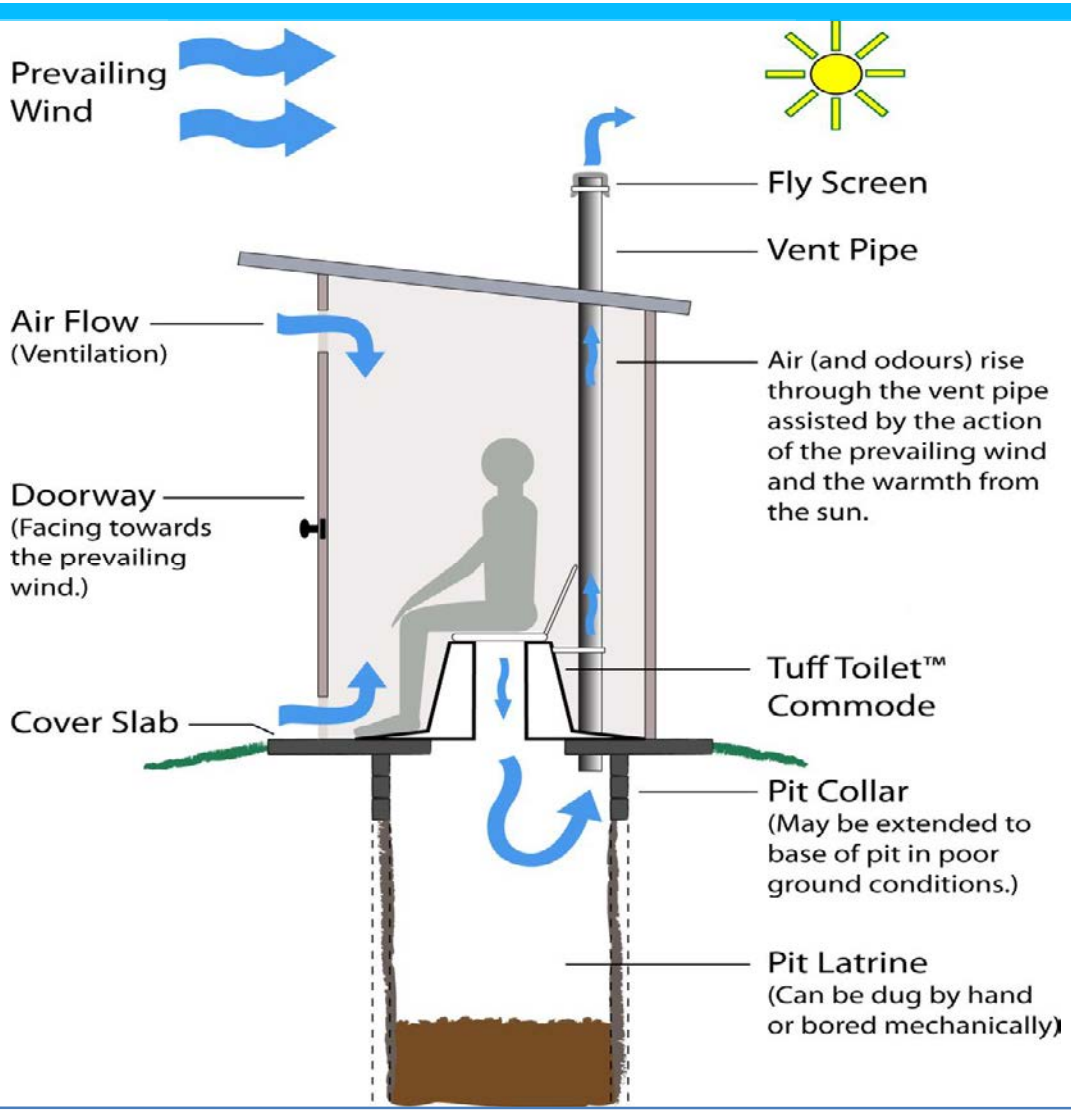
Source: (http://plantingmilkwood.files.wordpress.com)

4. Pour flush Water Seal Latrine



Source: - www.wateraidaustralia.org as of September 14/2013

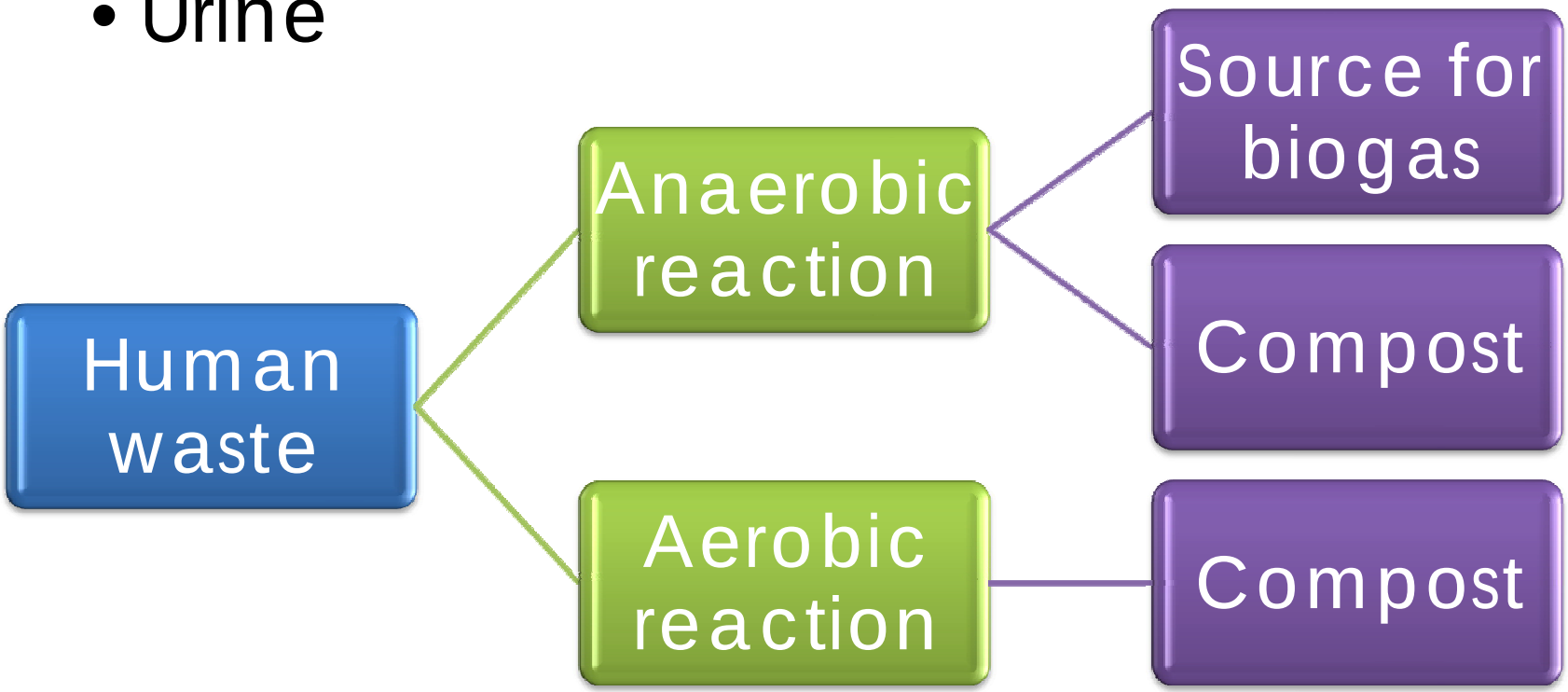
5. Ventilated Improved Pit Latrine(VIP)



Source:- www.bellatrines.co.nz as of Sept. 14/2013

Human wastes

- Feces
- Urine



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 container

Out let of the waste water came form the wash area and collected in a peculation

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)

Closed chamber in the current toilet

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

Cont'd

- Urine and washed water are collected out side 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 inclosing 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)

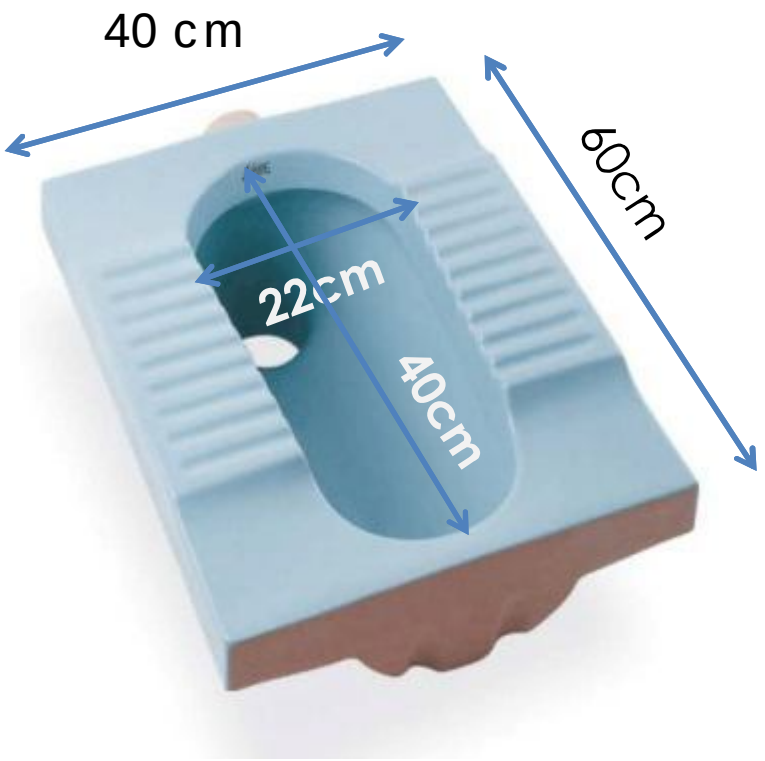


Image source :- www. Indiamart.com, as of Oct. 25/2013

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

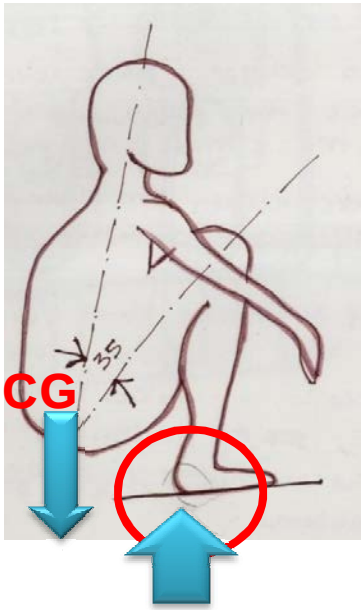
- Lift the toilet seat cap
- Tack down your pants
- Sit on the toilet seat
- Poop/ pee
- Wipe/clean your self
- Put the wiper in the trash bin(not in this case)
- Stand up

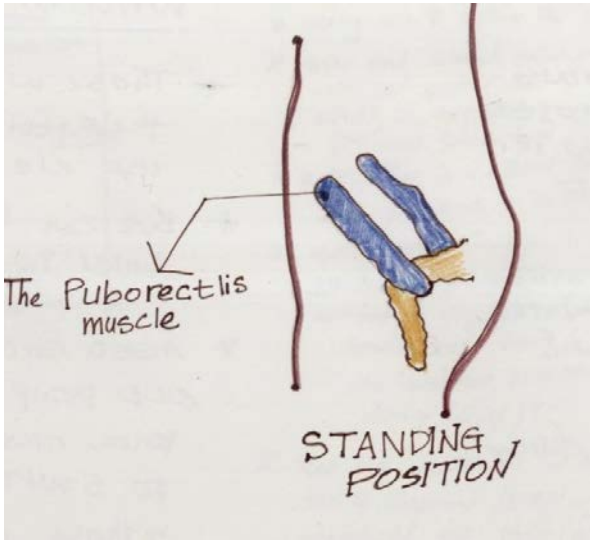
Cont'd

- 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

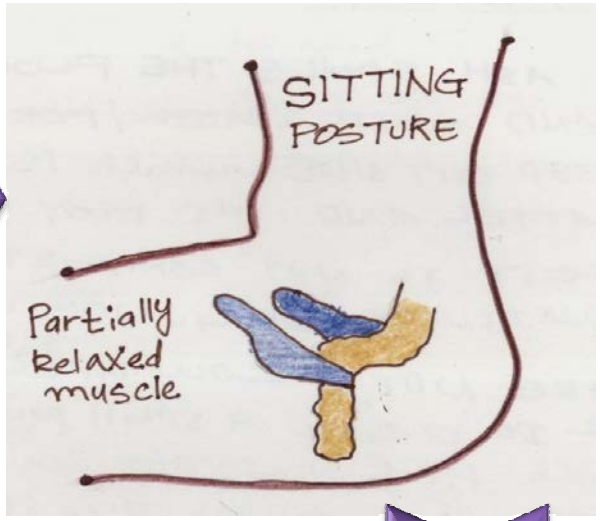
❖ In short "Poop, pee, carbon, lime, ash or sawdust"

Positioning of colon in squatting

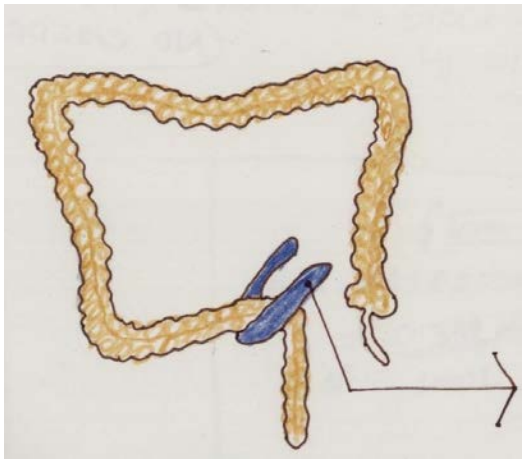




Standing position

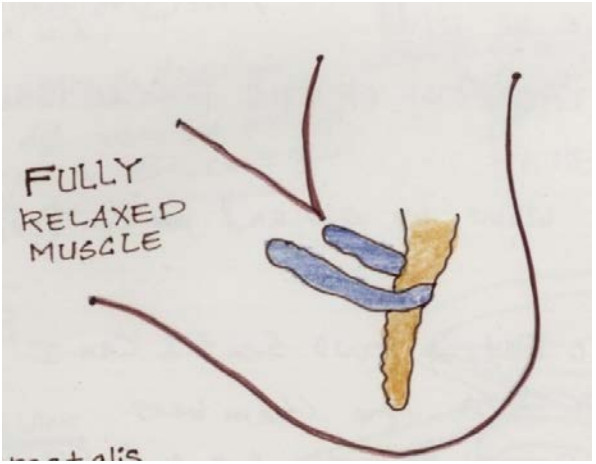


Sitting position



The colon 3-6 feet long

Puborectails muscle



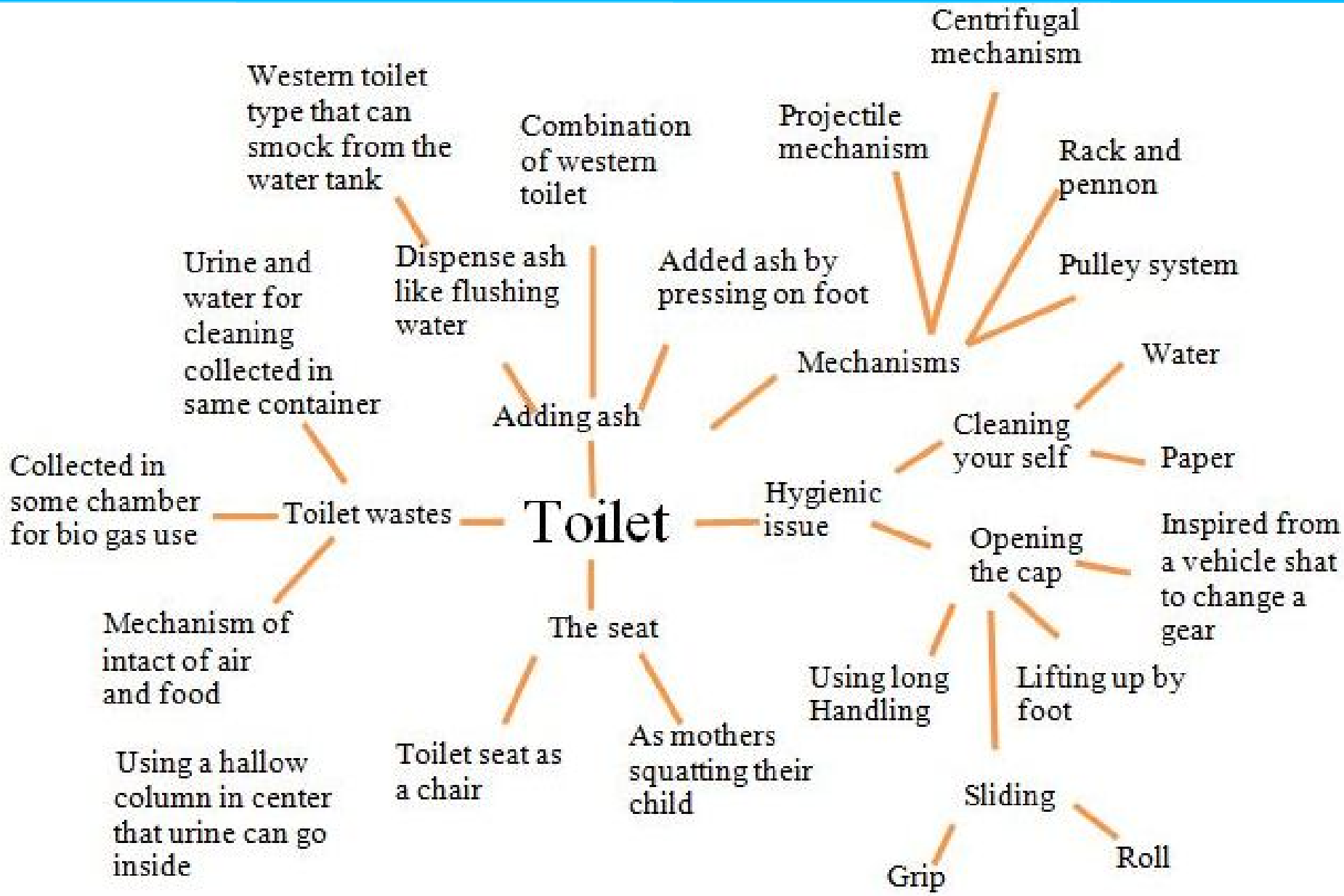
Fully relaxed position @ 35^0

Design Brief

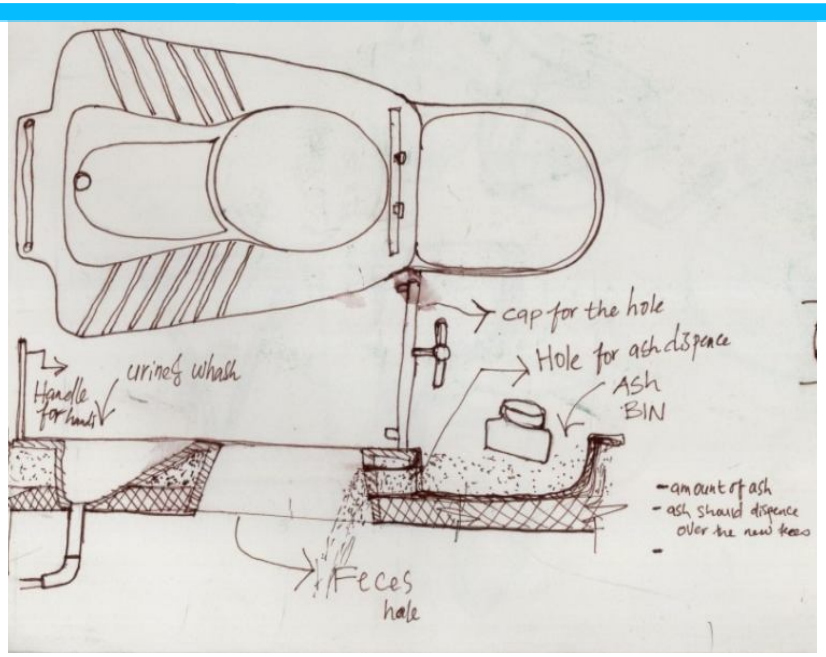
Design a low cost toilet for rural household:

- 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

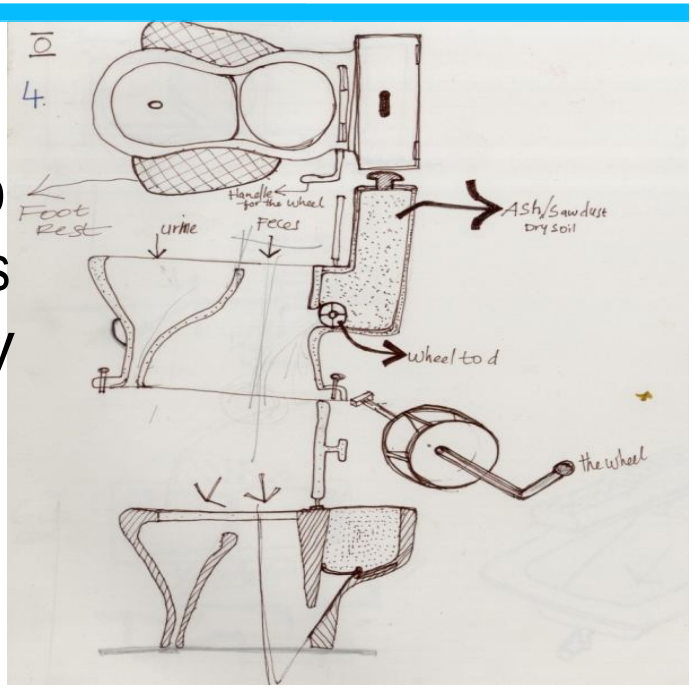
Mind mapping

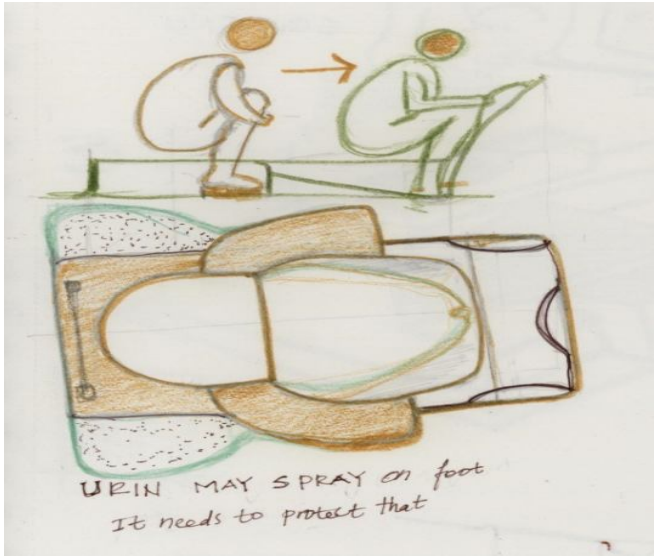


Ideation



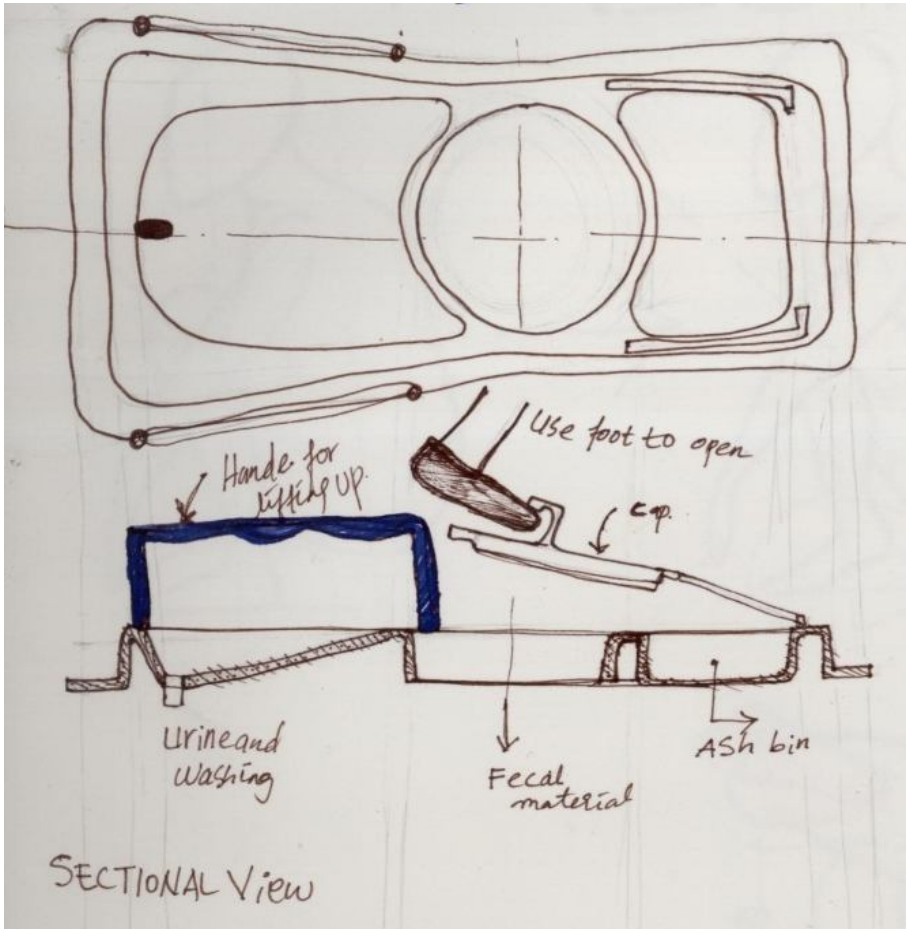
Fixed cap and ash is added by pushing from the back

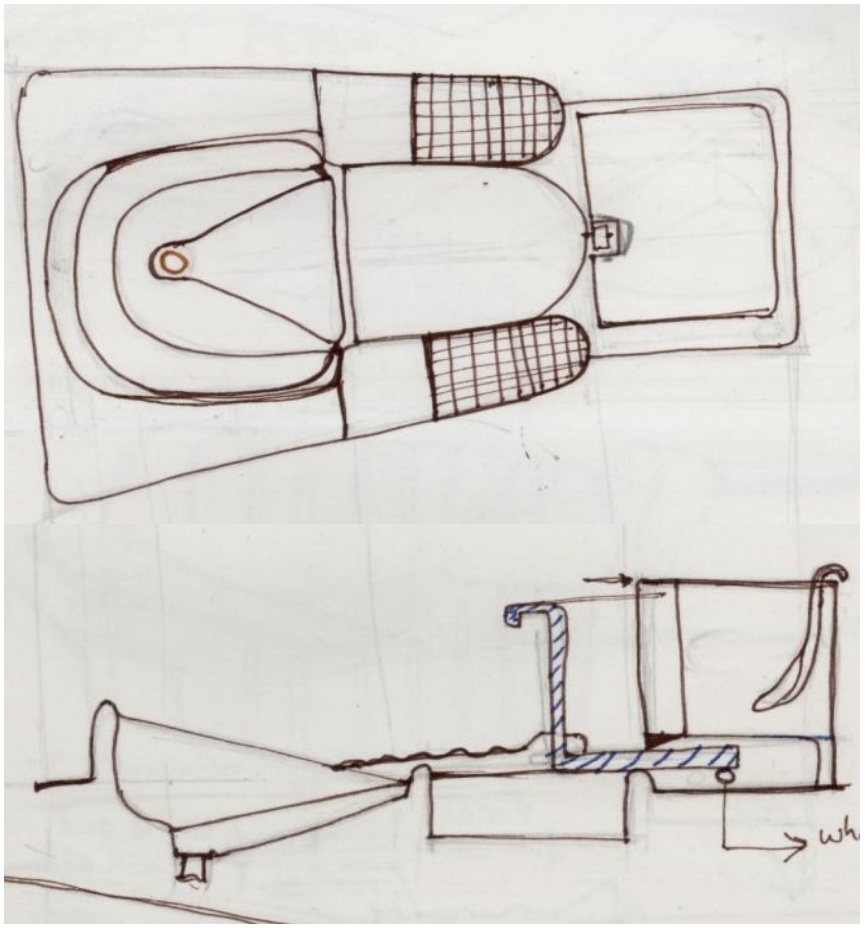




Moving forward after pooping for cleaning

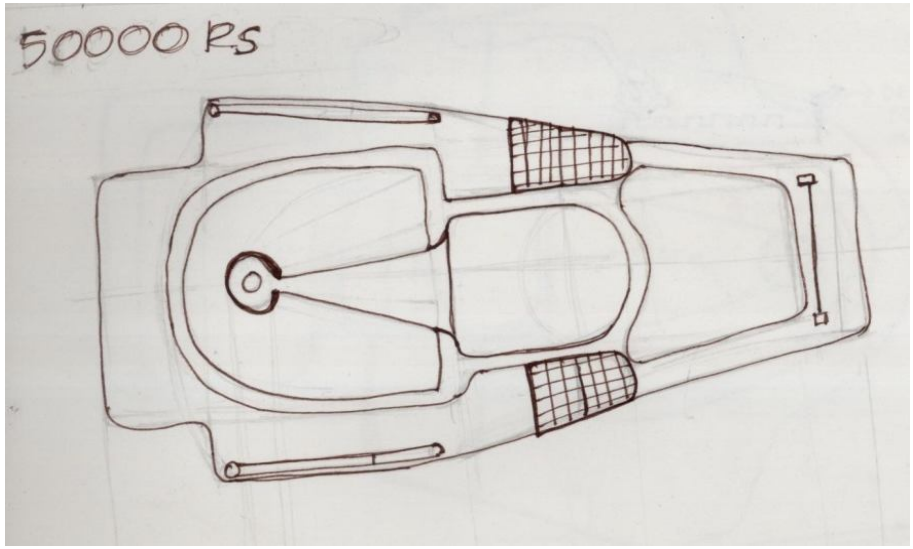
Concept of western toilet ash flushing instead of water

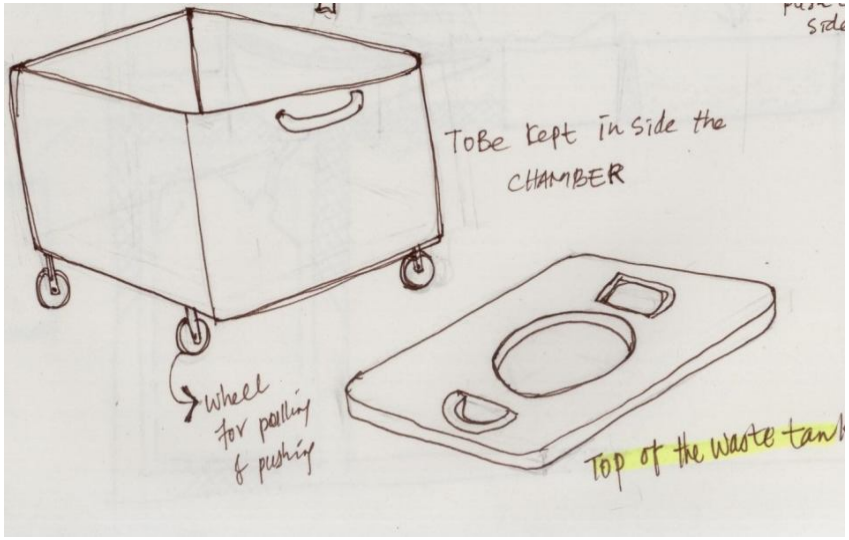


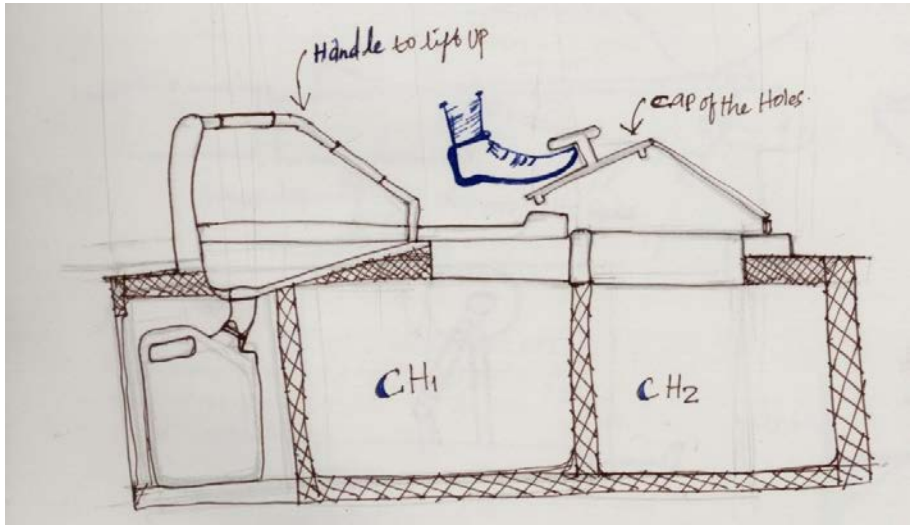


- Lifting the cap by foot,
- Adding ash by scooping
- Handle to lift up

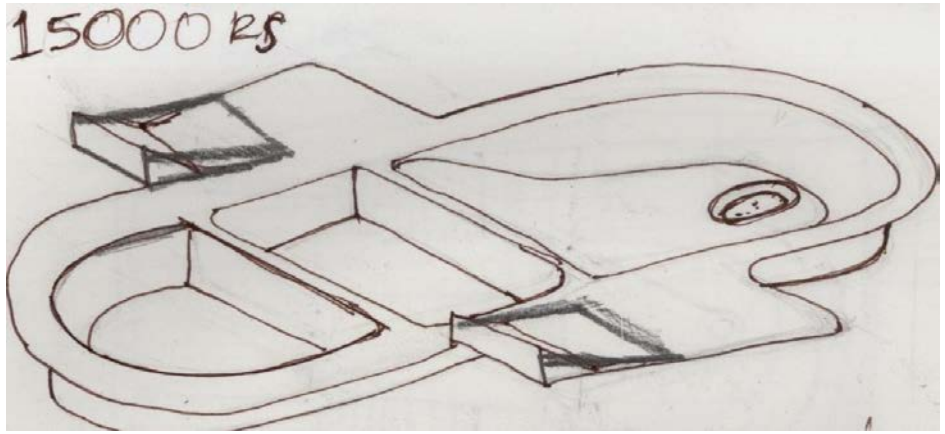
- Roller cap to close the hole
- Add ash by scooping
- Moving forward to clean

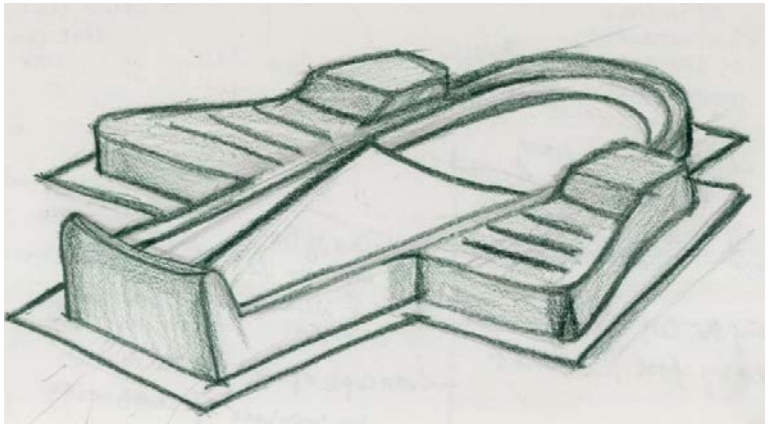


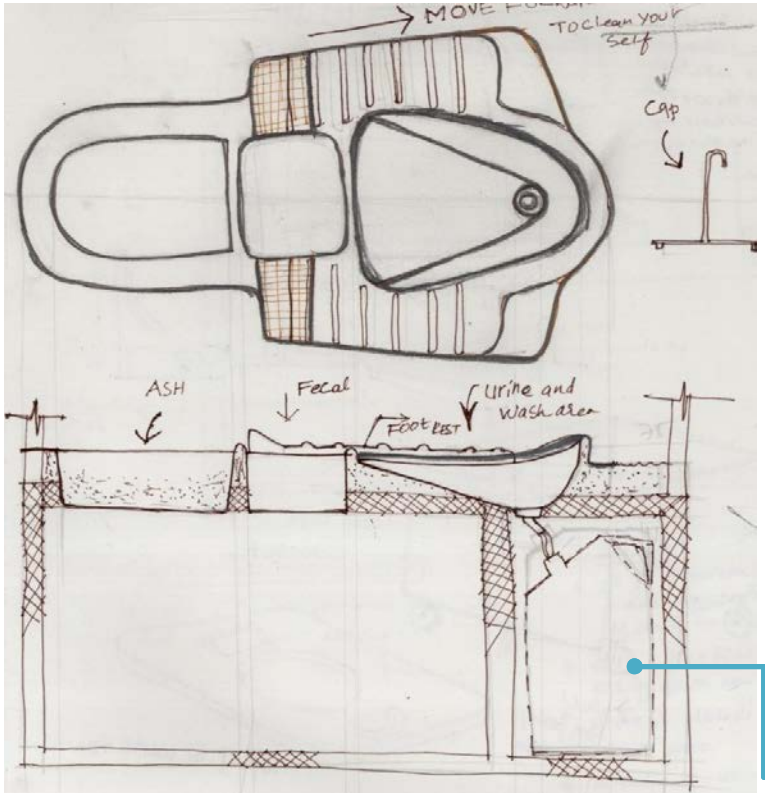




- Use movable chamber
- Lift by foot to open
- Handle for lifting up

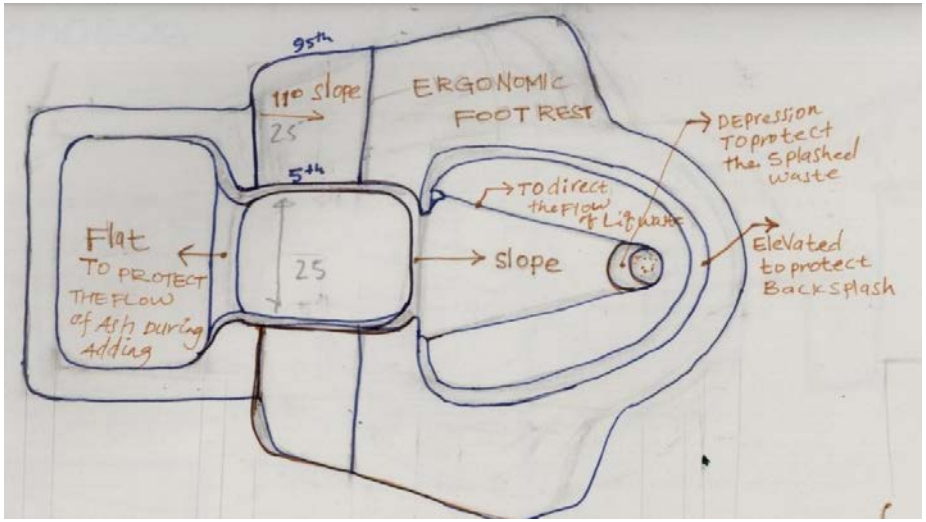




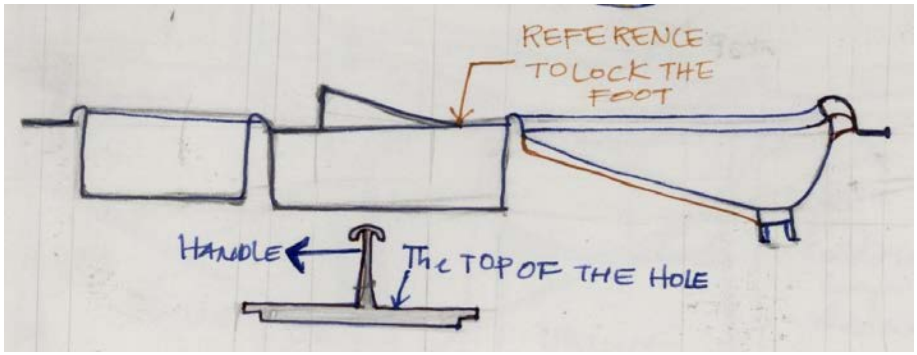


Ergonomic footrest and elevated to some height to prevent splash back of urine

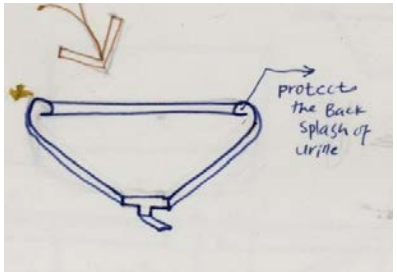
Urine and waste water for washing collected in some Jeri can

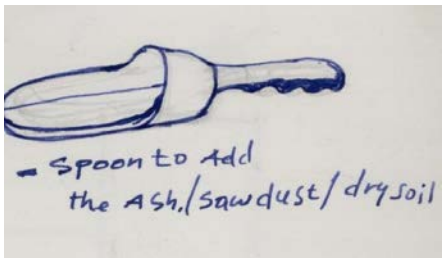


Ergonomic seat and prevents urine splash back

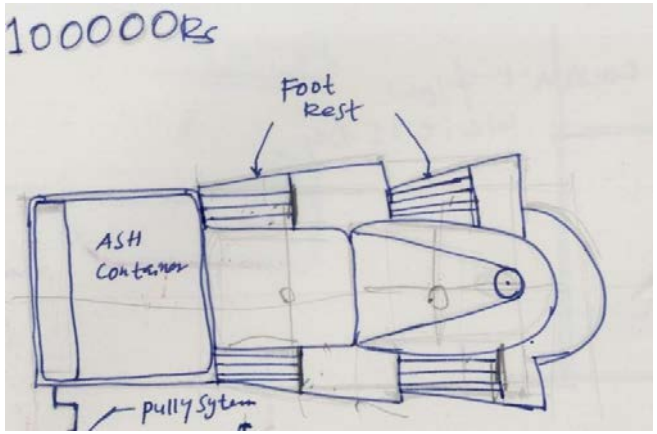


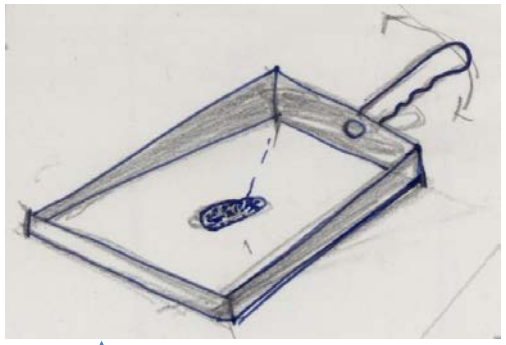
Some height for the cover to lift easily



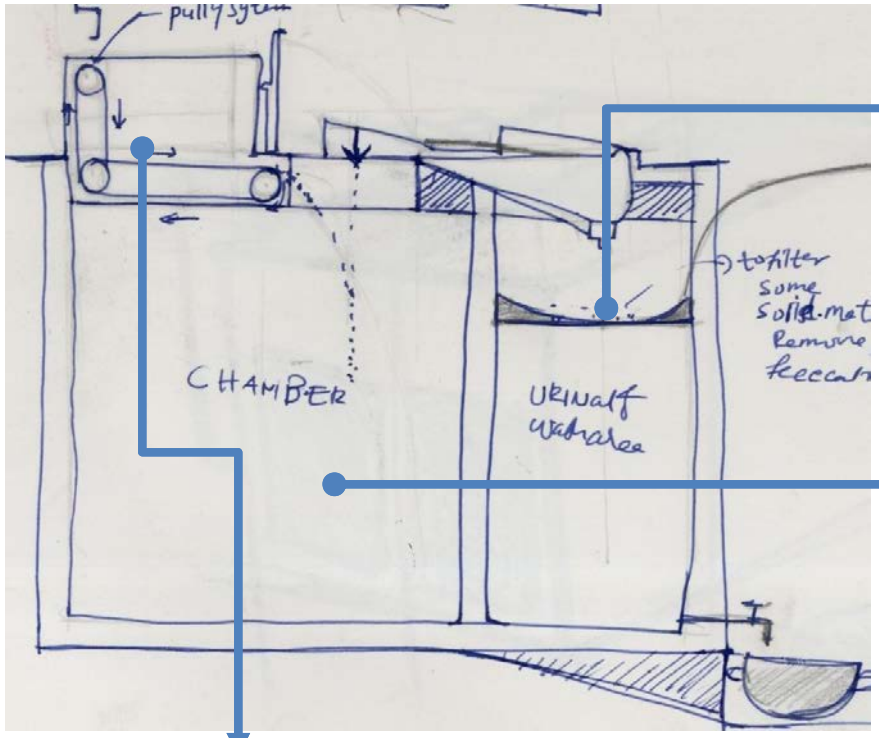


Scoop, for adding ash/saw dust

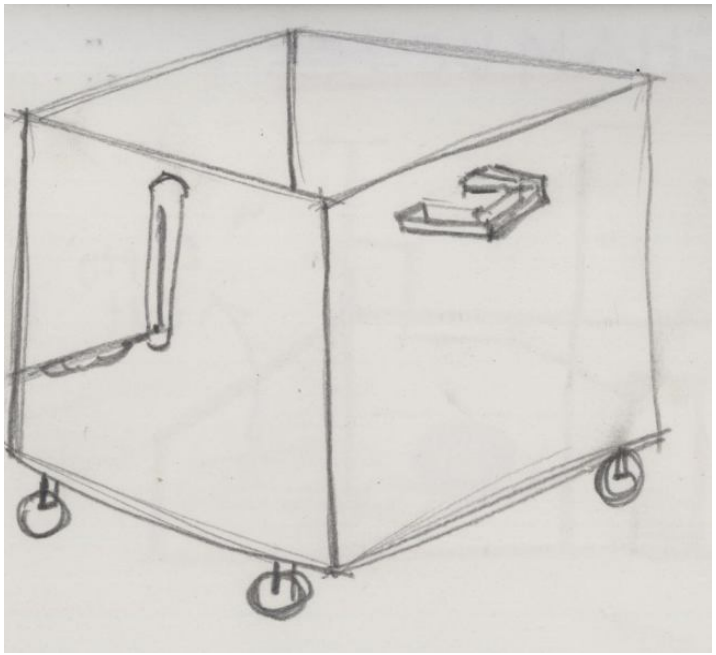




Filters



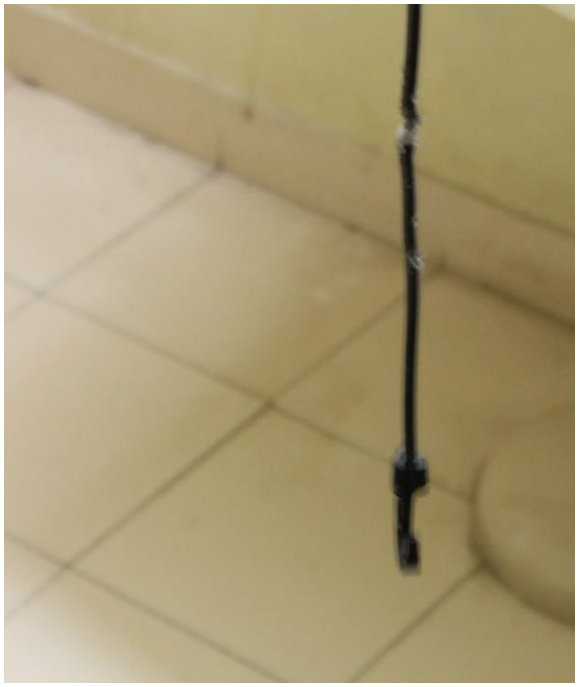
Pulley system to add ash



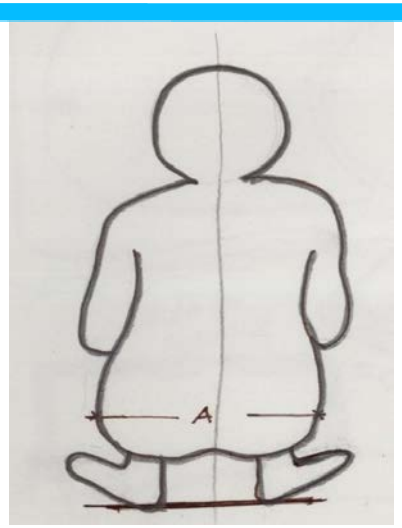
Movable chamber

	Adding ash	Lifting up/ elderly	Opening the cap of the pan
Possible ways of	Gravity	Wooden handle	Using foot
	Mechanically (pulley method)	Bars from both sides	Long handle
	scooping	Pillar in center of the toilet that help as a stick	Rolling back and front
	Ash in a rolled paper	Rope hanging from the ceiling	Sliding
		Build brick wall to a side	Lifting up
Cheapest and convenient way	**Scooping**	**Rope hanging from the ceiling**	**Long with 'U' shape handle**

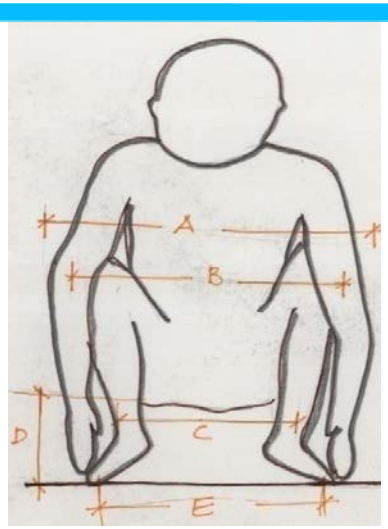
Lifting up using ceiling hanging rope and a rod of wood/ metal



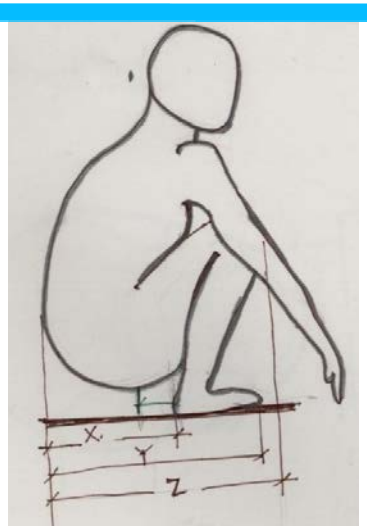
Squatting positions views



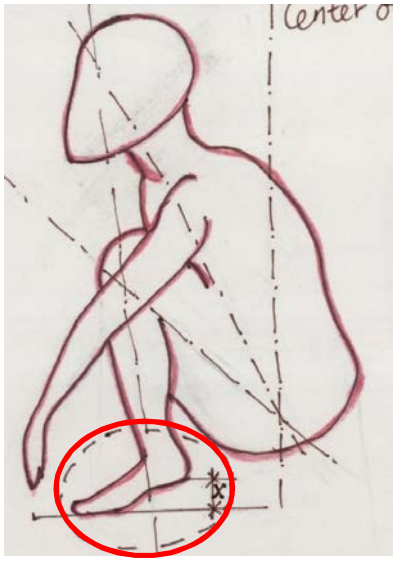
Buttock width

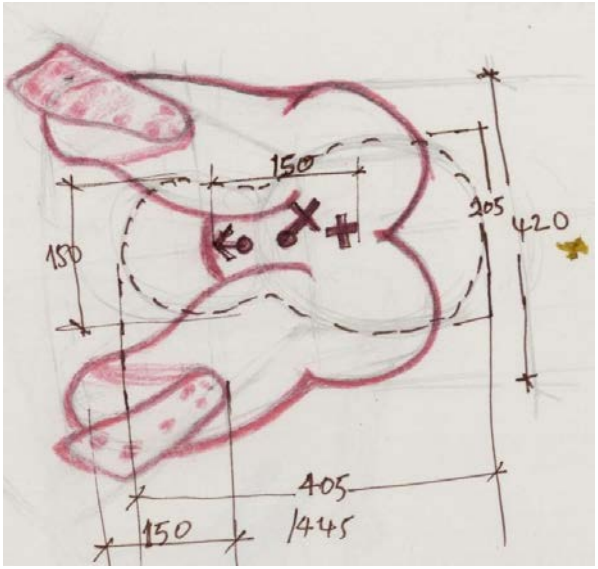


Front View



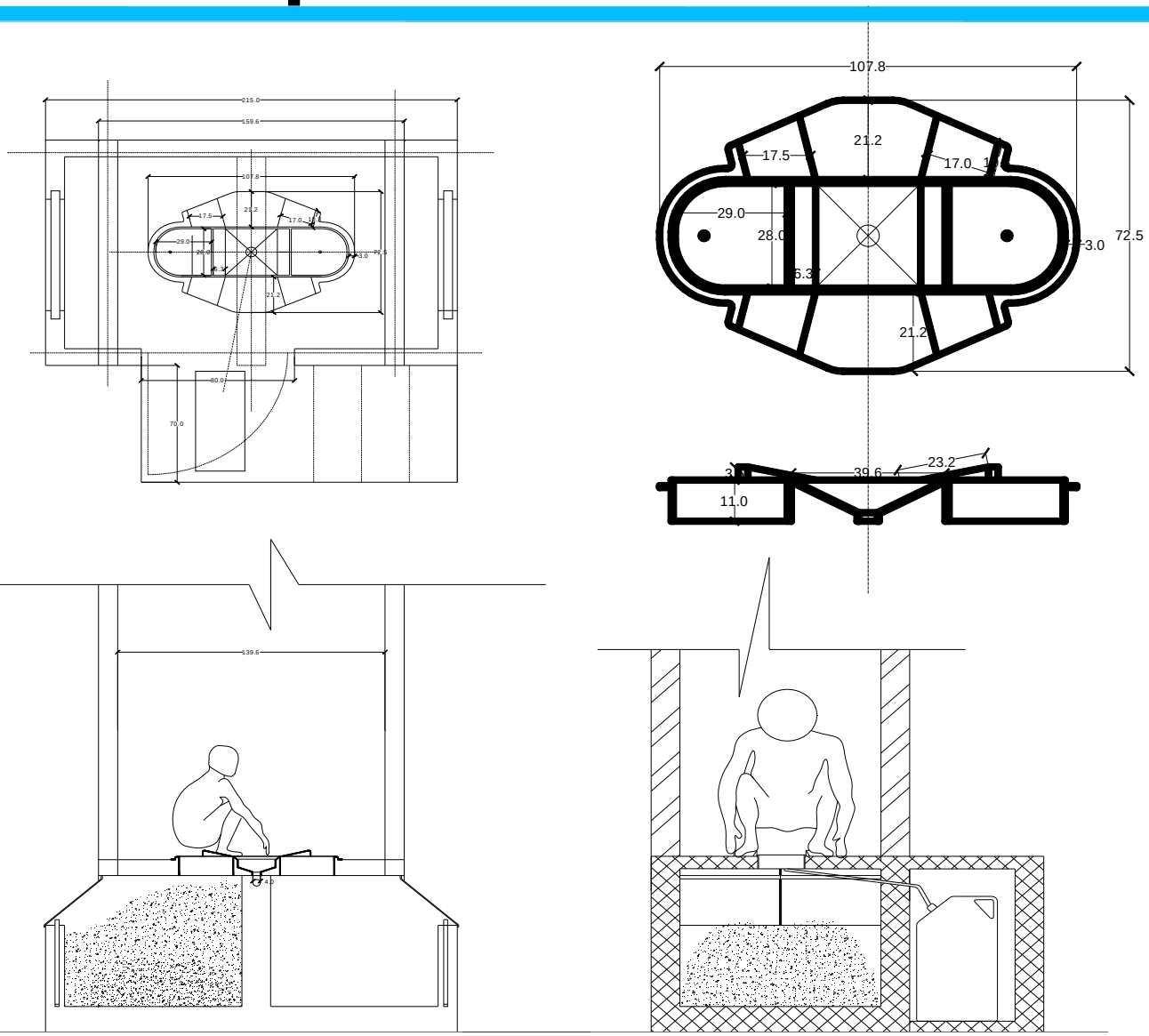
Side view





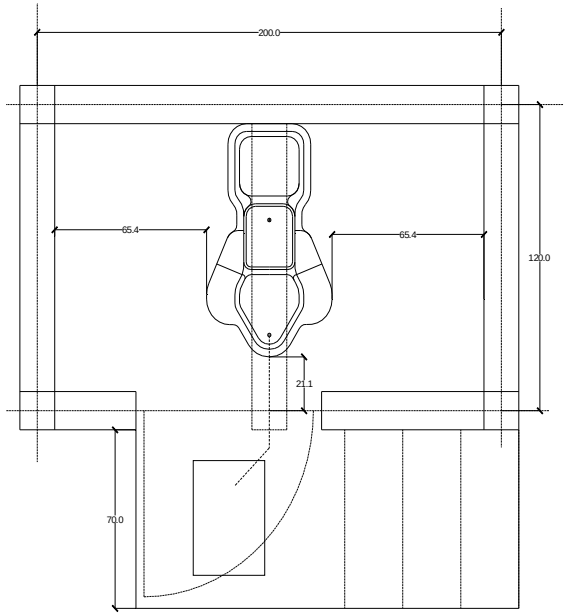
Top/bottom view

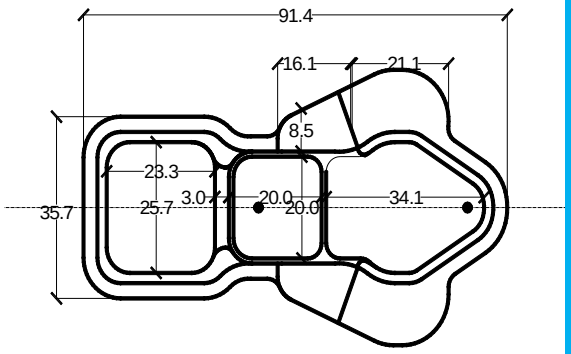
Concepts 1

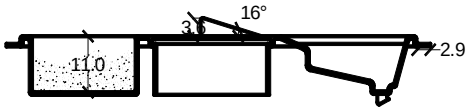


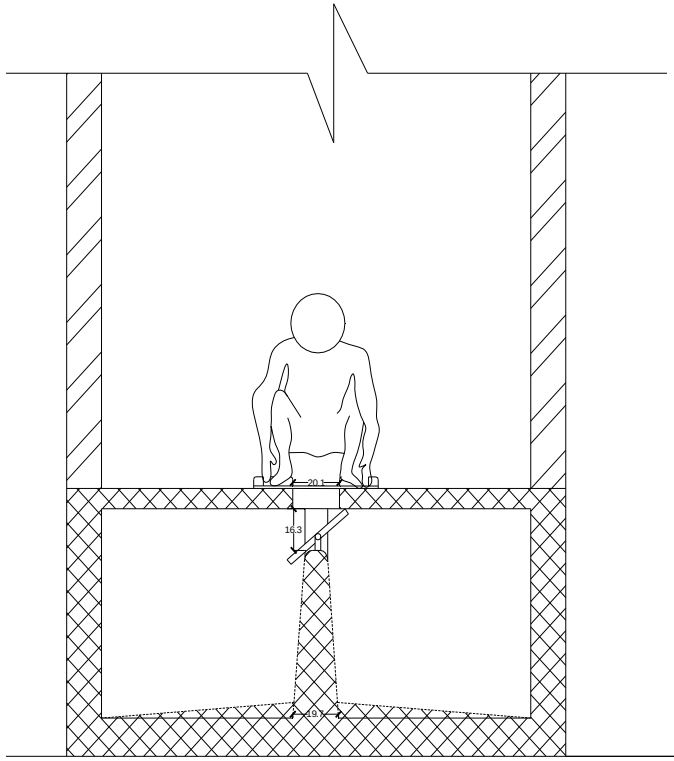
Advantages

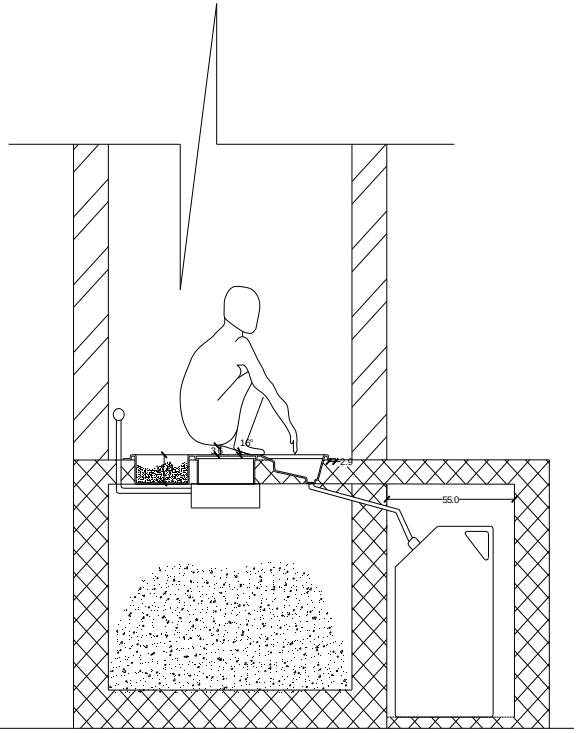
- Easy to empty the chamber
- Cost effective
- Ergonomic footrest
- Urine and waste water collected in safe, but container may fill in short time
- One seat for two chambers











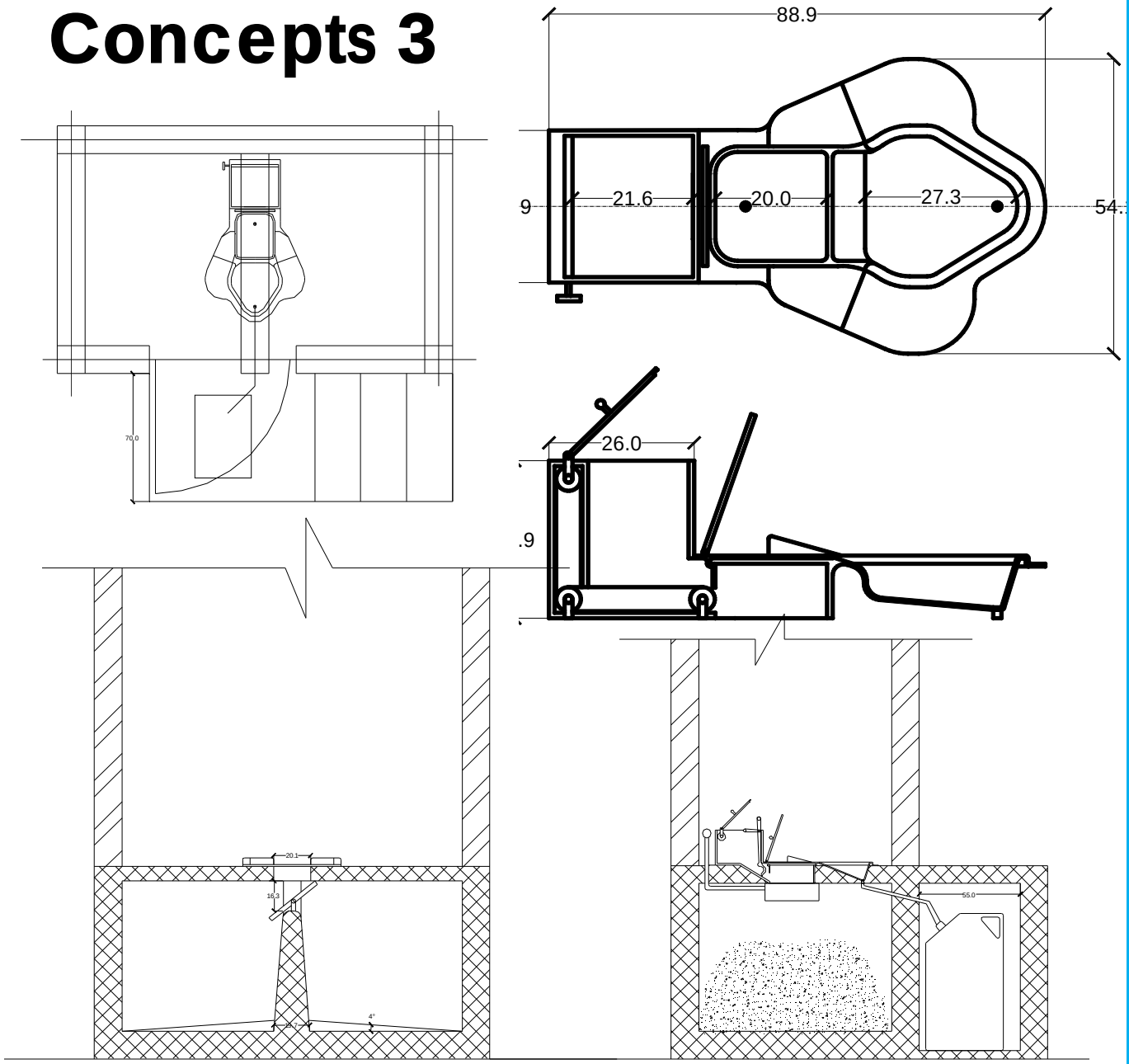
Advantages

- 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

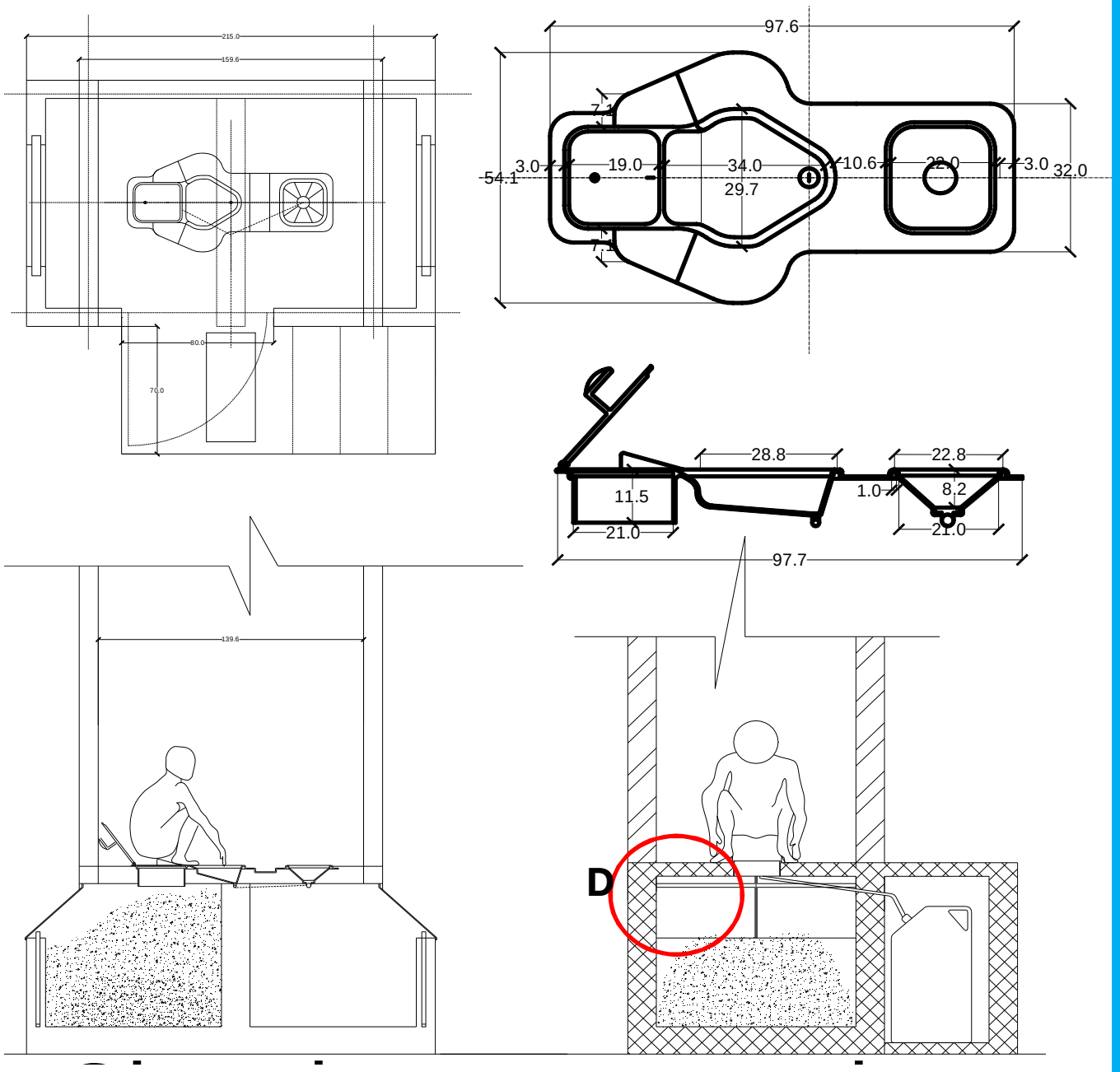


Advantages

- Ash can be added easily with no touching the it
- Hygienic and ergonomic

Disadvantages

- Difficult to install by rural people
- Relative costly



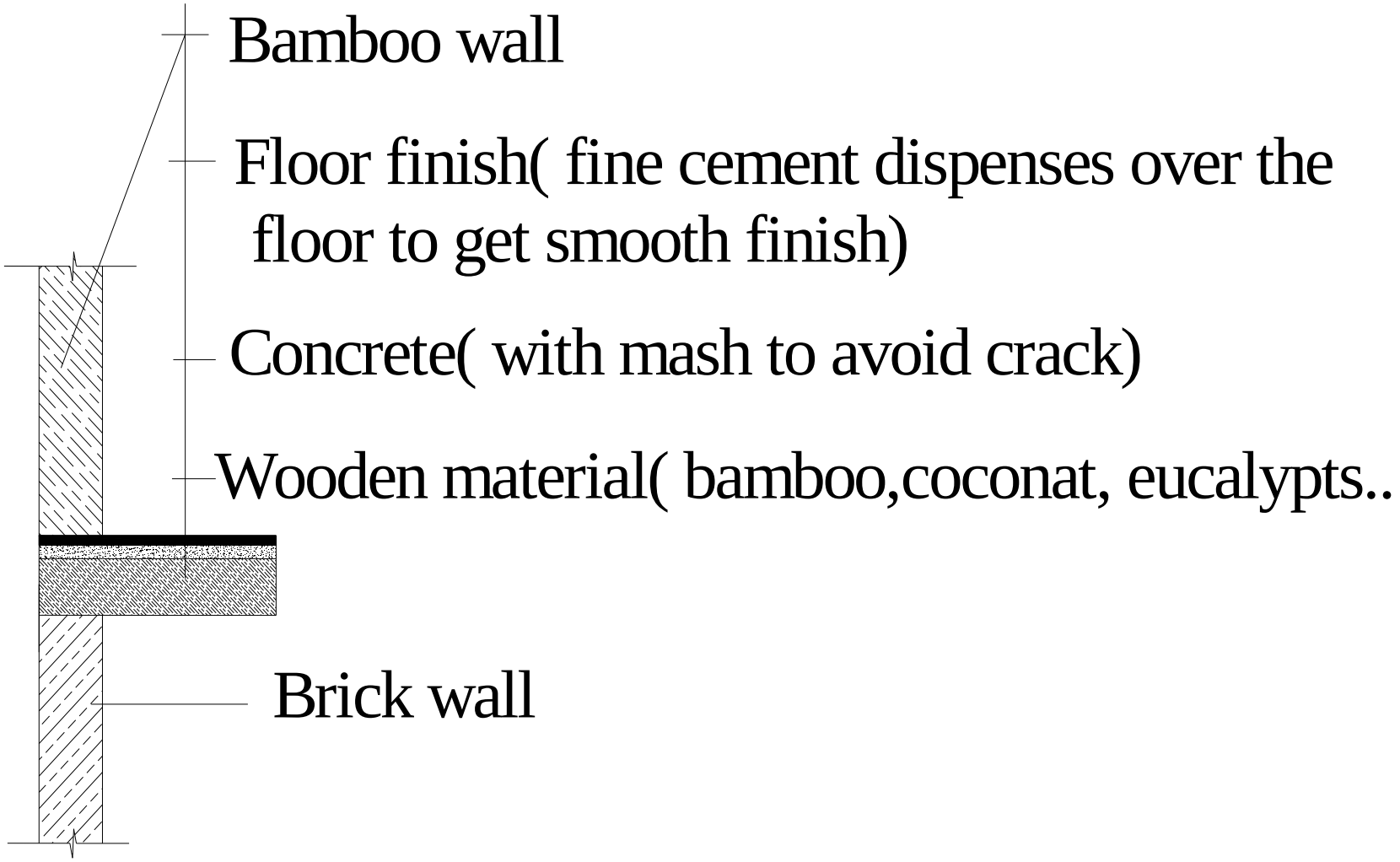
Advantages

- 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

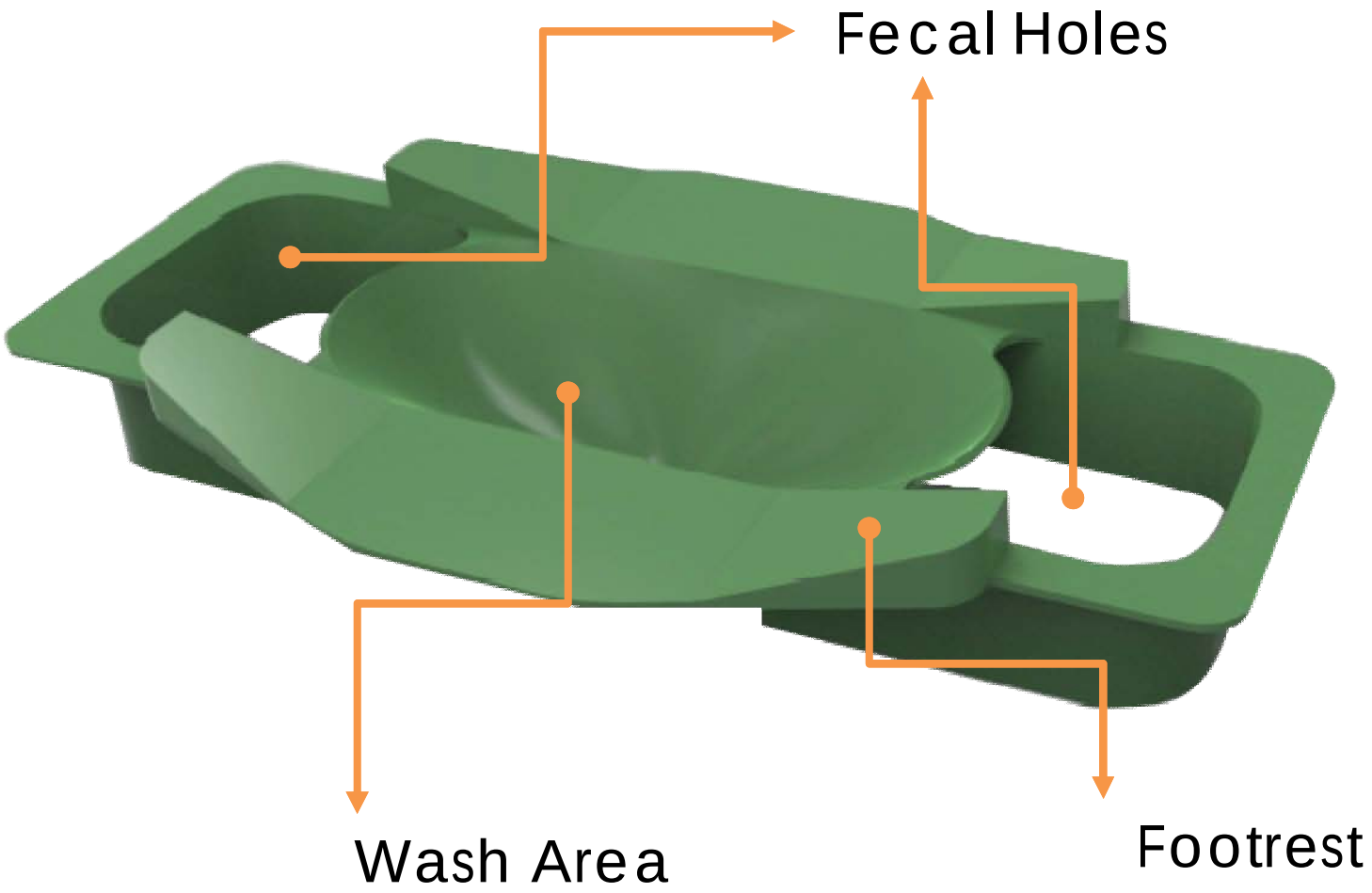
- Adding ash and open the cap is till a problem

Construction detail of the room

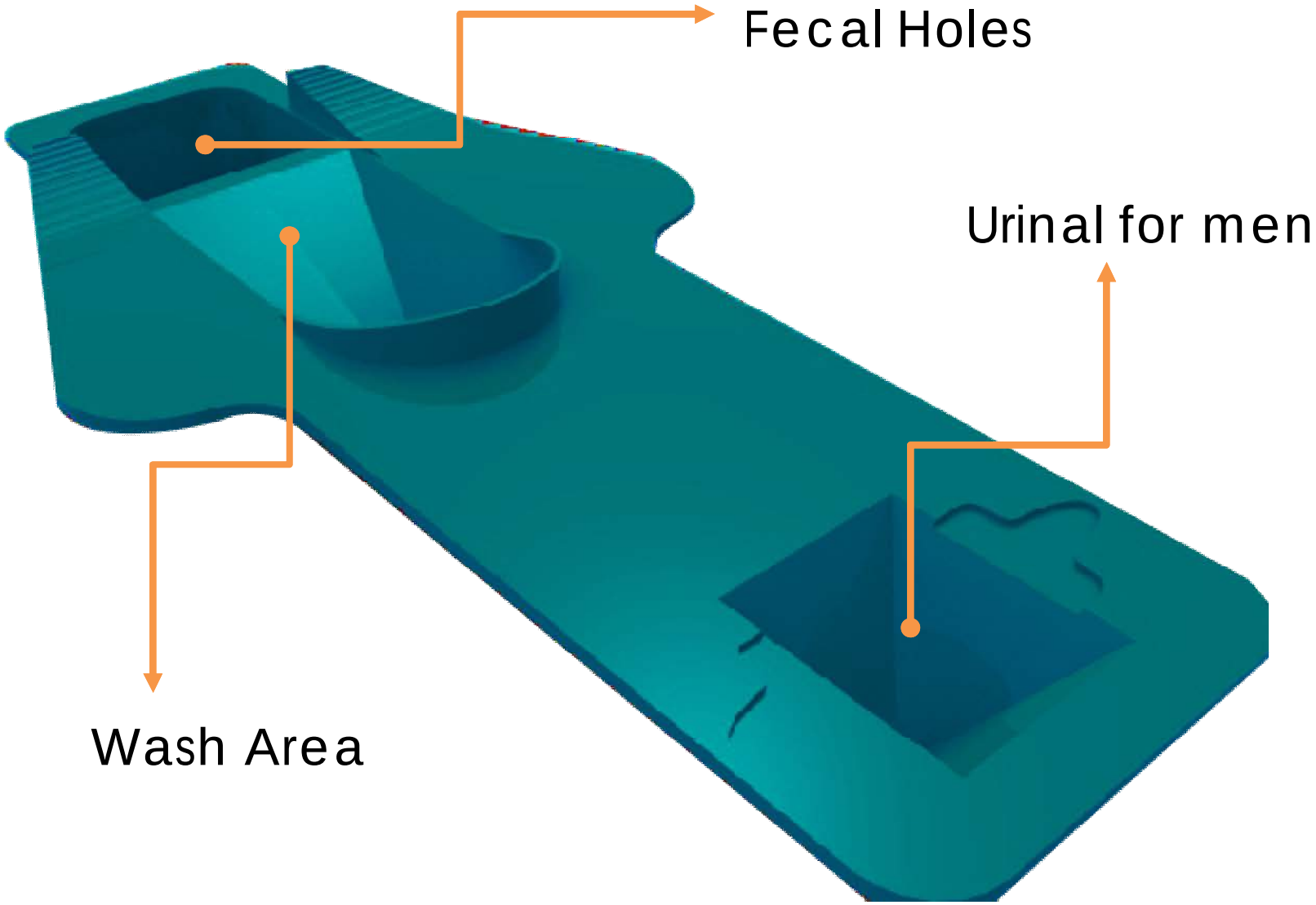


Wall, Slab and chamber detail(D)

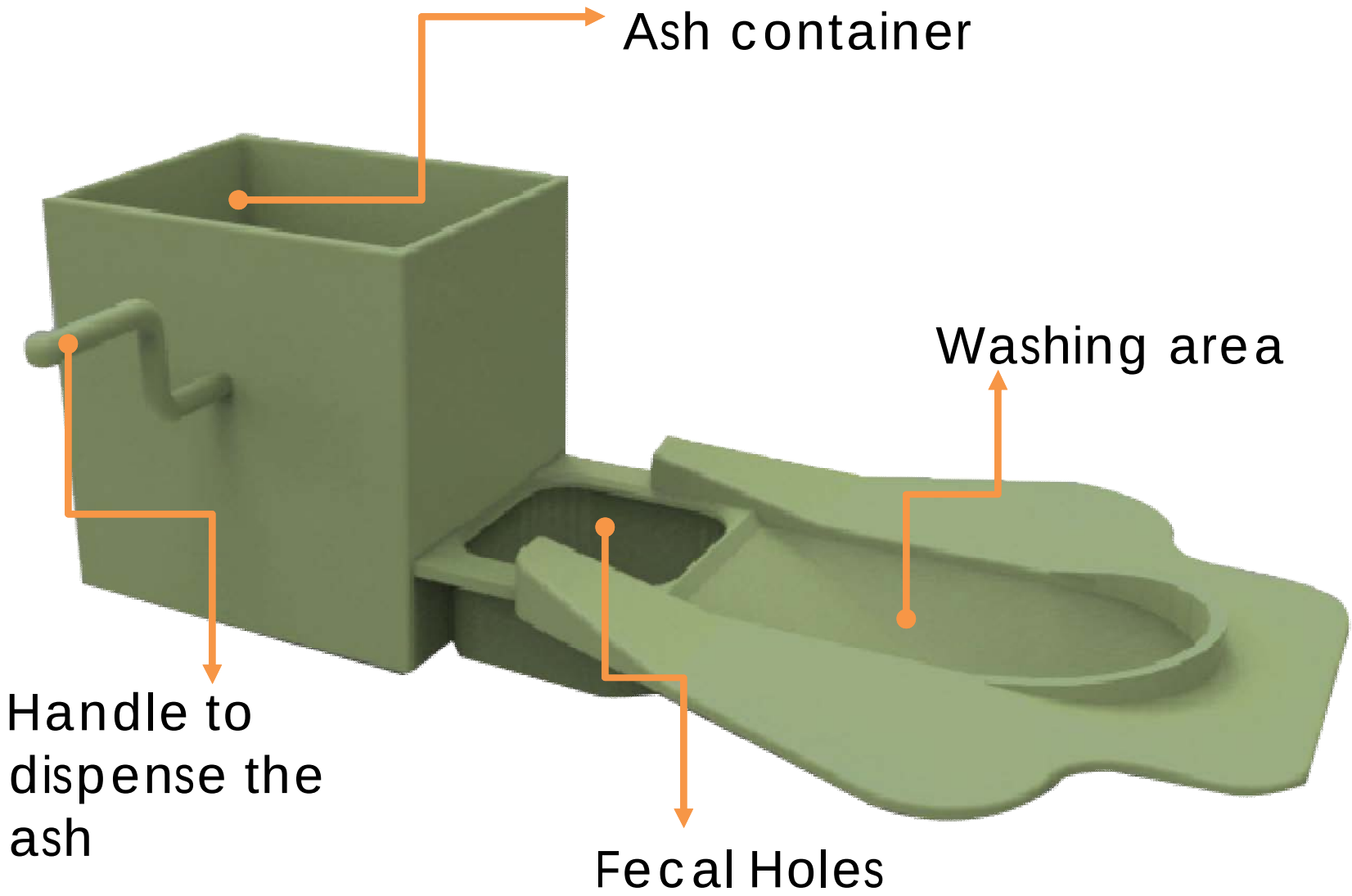
Concept 1



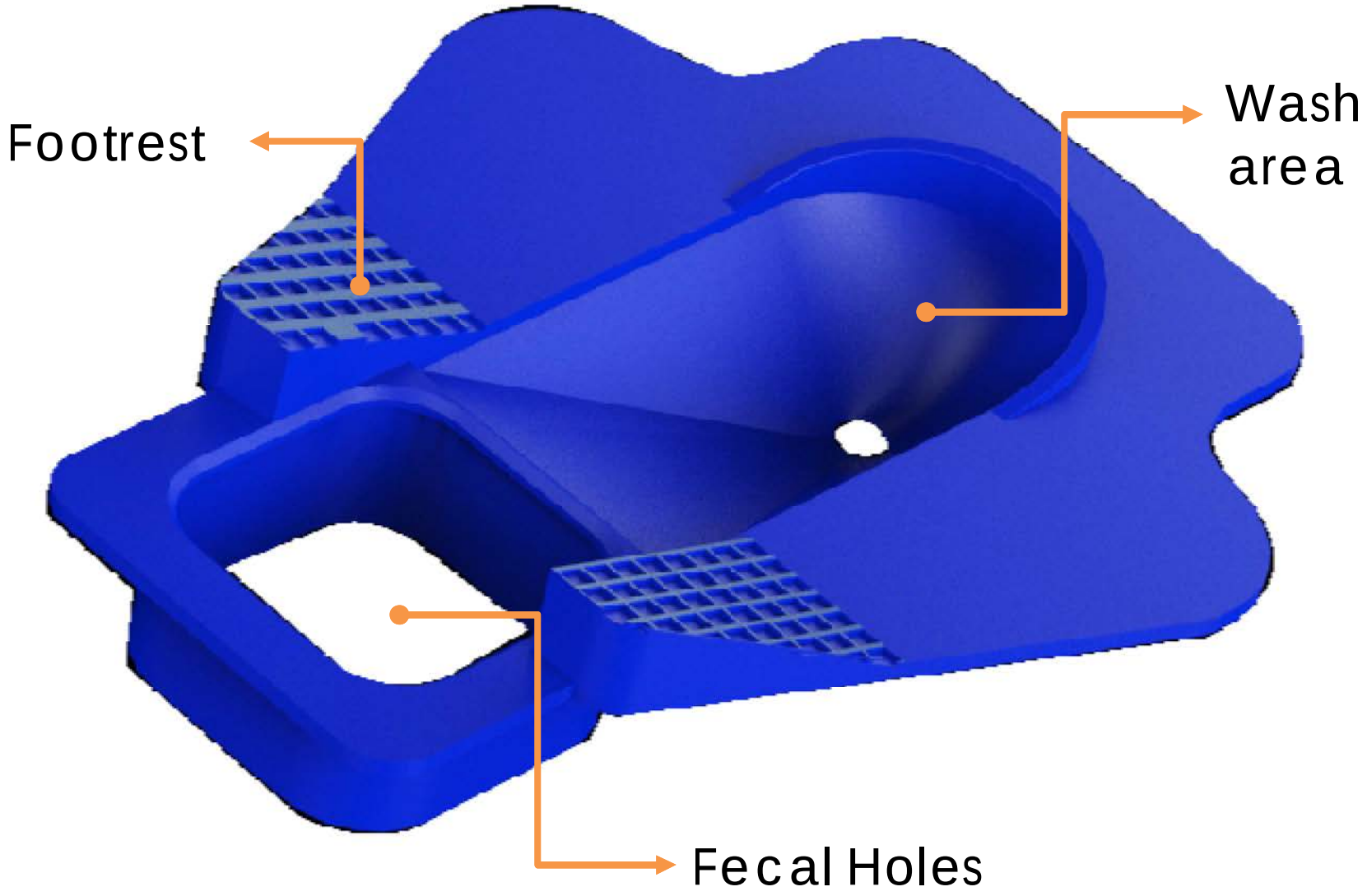
Concept 2



Concept 3


Ash container
Washing area
Handle to dispense the ash
Fecal Holes

Concept 4



Concept Evaluation

Parameters /to evaluate	Concept 1	Concept 2	Concept 3	Concept 4
Portability	2nd	3rd	4th	1st
Low cost	2nd	3rd	4th	1st
User interaction	4th	3nd	2nd	1st
Simplicity	3rd	2nd	4th	1st
Functionality	4th	1st	2nd	3rd
Manufacturing	2nd	3rd	4th	1st
Compatibility	2nd	3rd	4th	1st

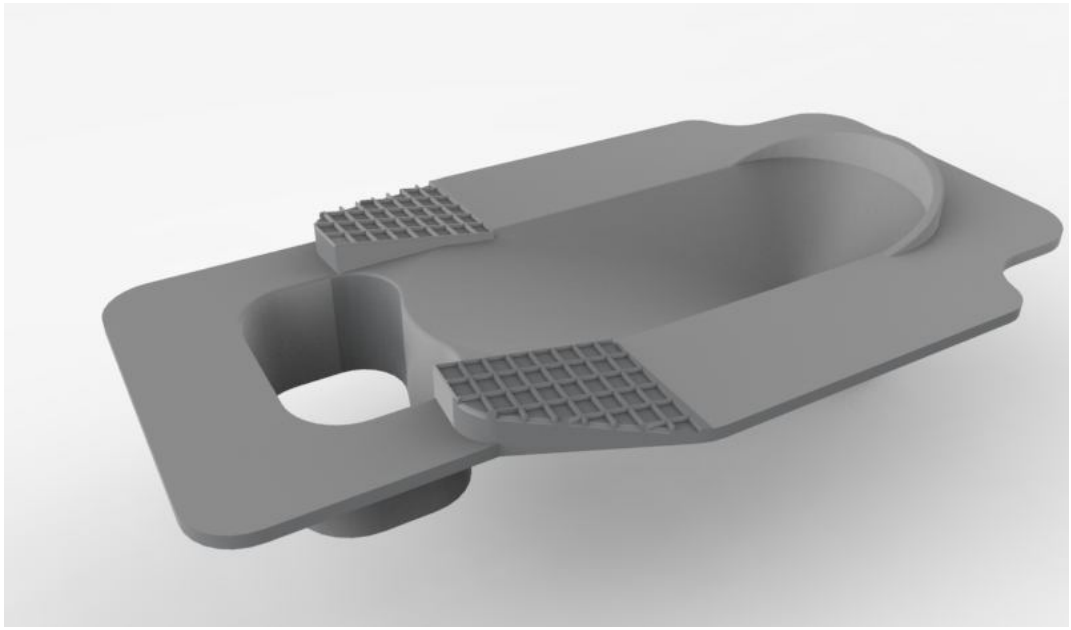
Selected anthropometric dimensions(cm)

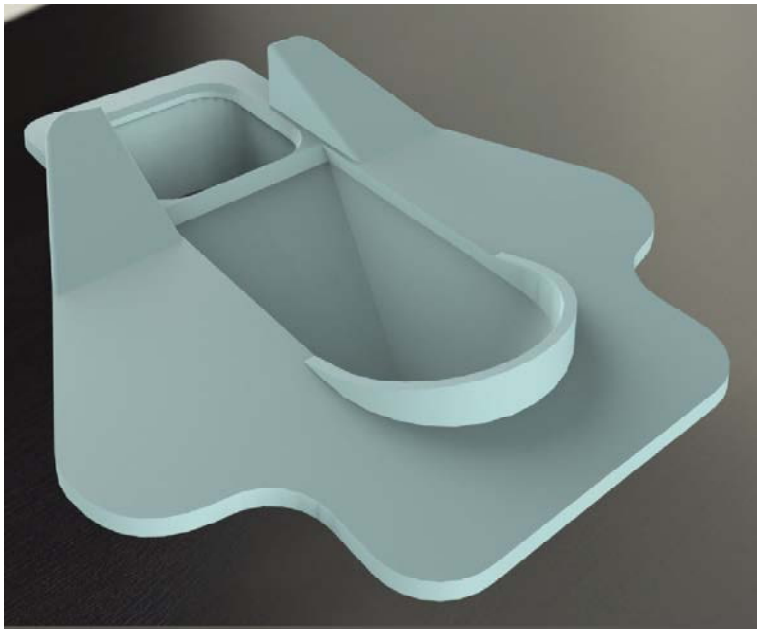
Seat parts	Body parts	5%	95%
Foot rest	Toe to toe	13.2	41
	Out side Heel to heel	9.9	29.7
	Lifted heel	3.7	12.37
	Foot length	19.4	25.81
	Heel width	4.48	6.2
	Toe width	9.42	11.5
Washing area	Buttock to urethra	20.01	28.81
	Buttock width	31.69	41.29
Fecal hole	Opening	3.46	9.7
	In side toe to toe	7.13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

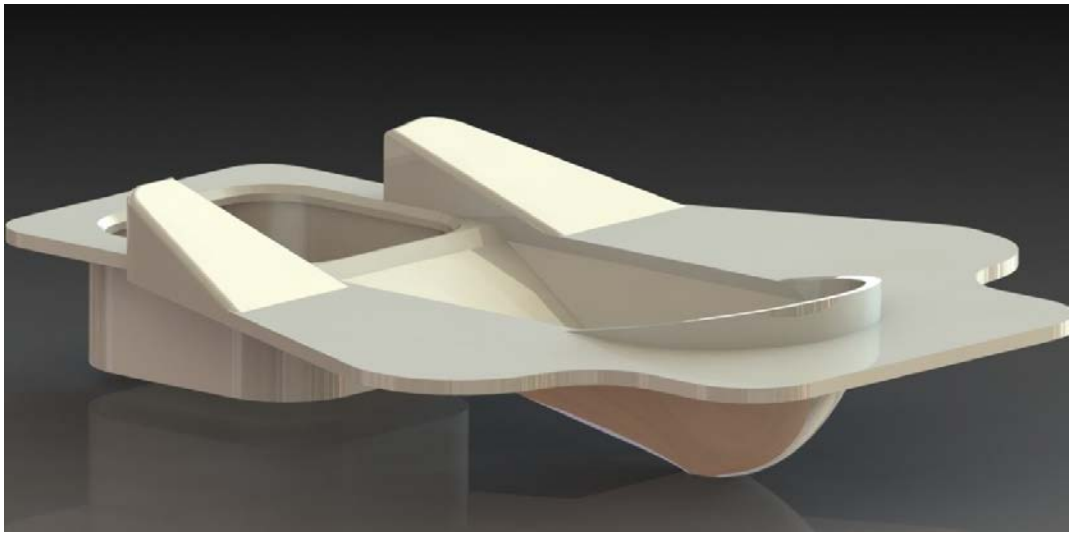
Indian Anthropometric dimension for Ergonomic design use, Debkhmar Chakrabarti, NID,

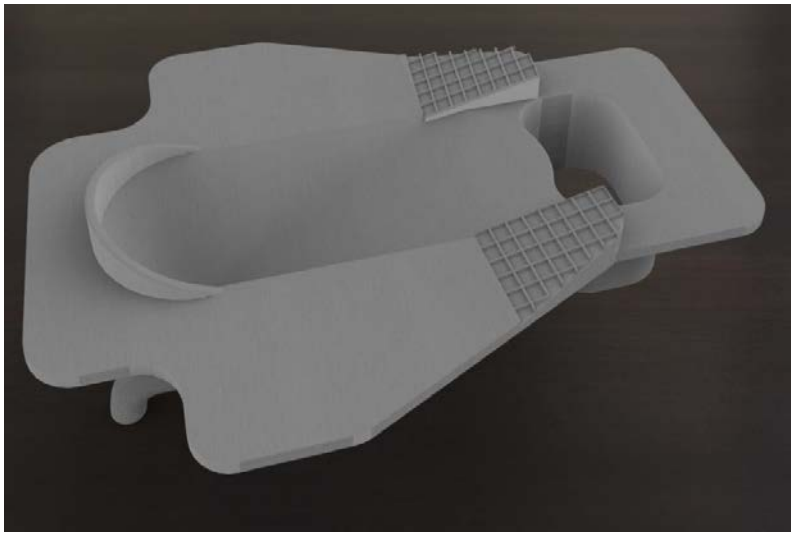
Ergonomic Evaluation and Design Consideration for Indian Sanitary wares, G G Ray, IDC, IIT Bombay

Variations of the final concept

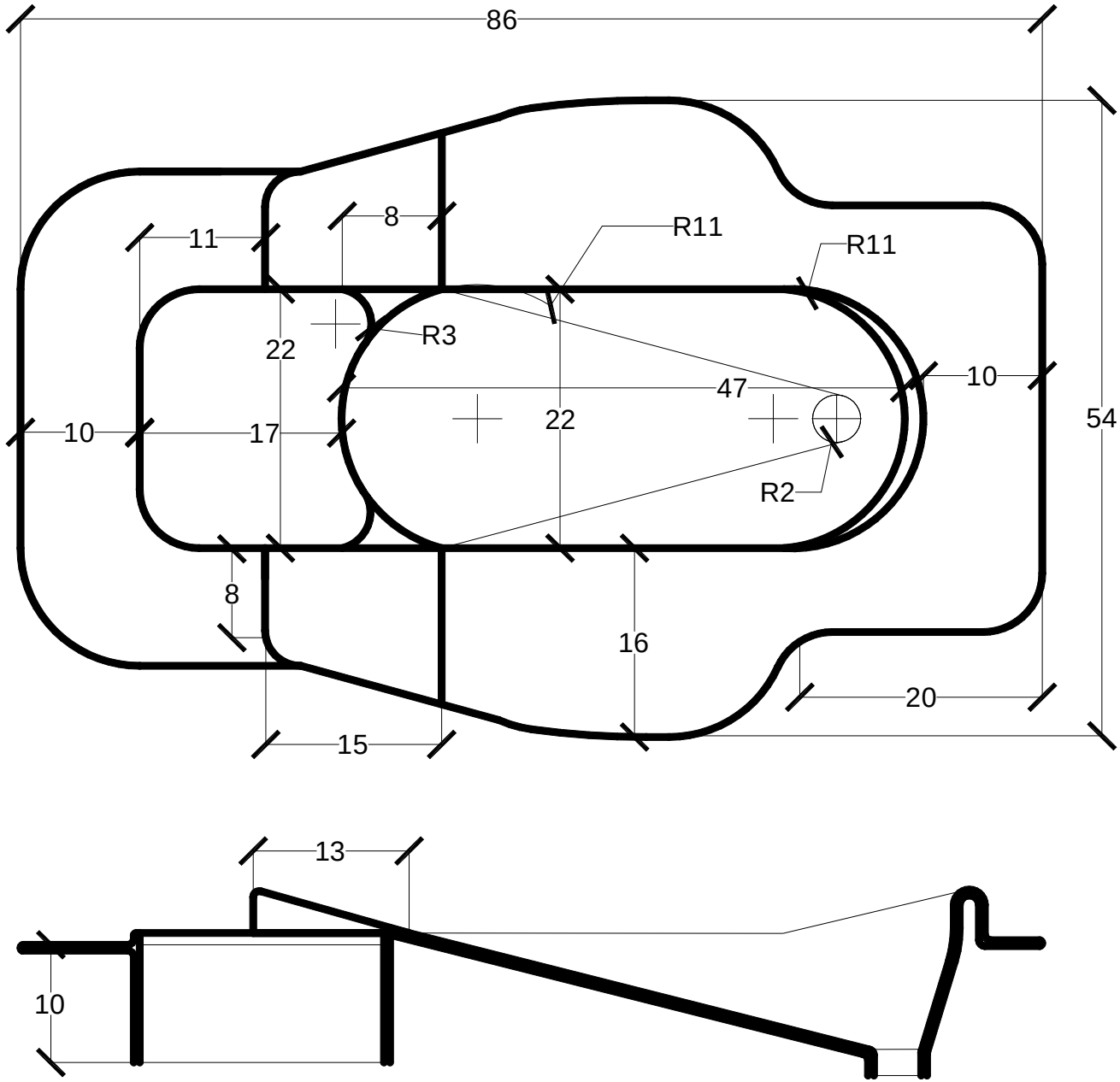




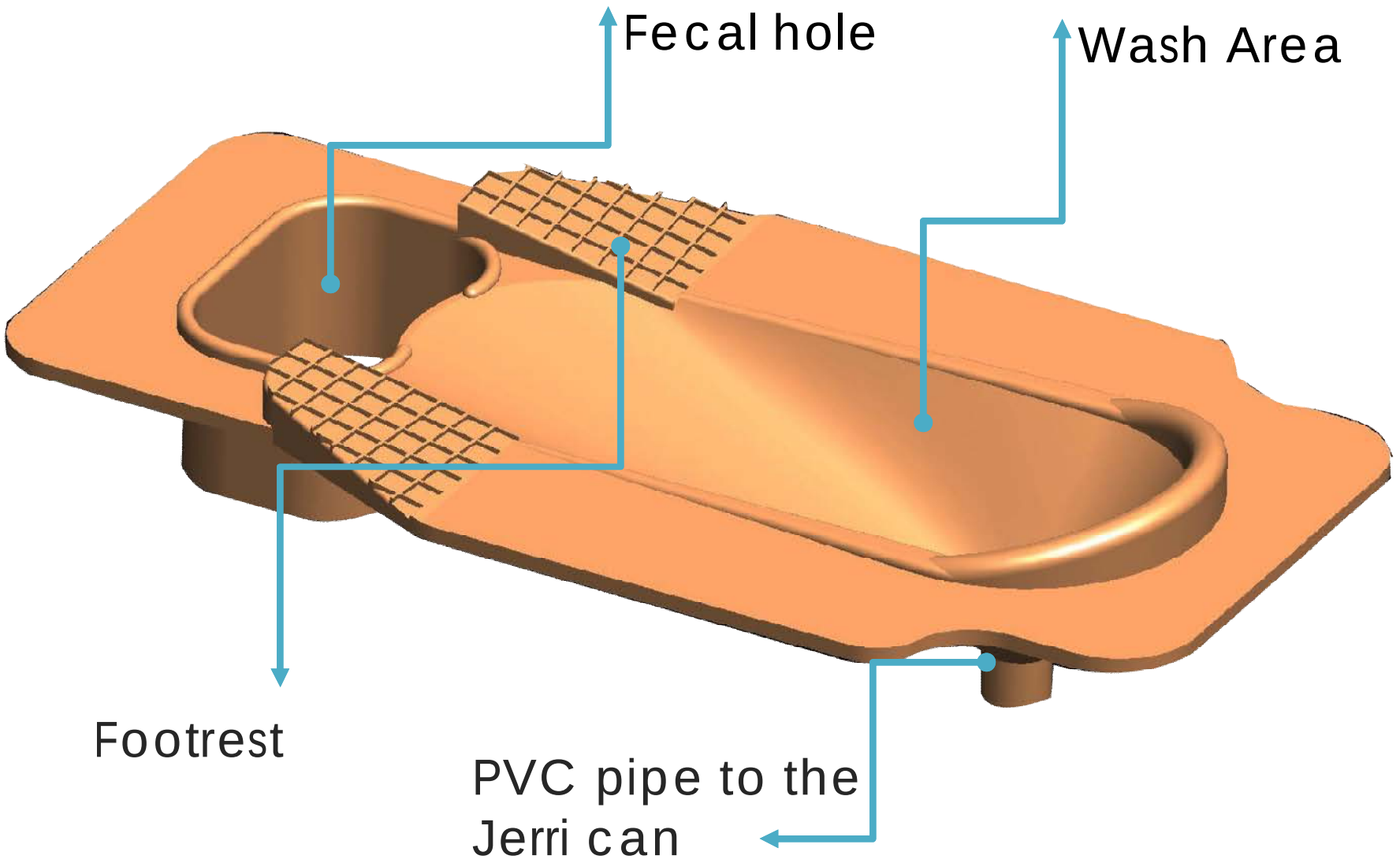


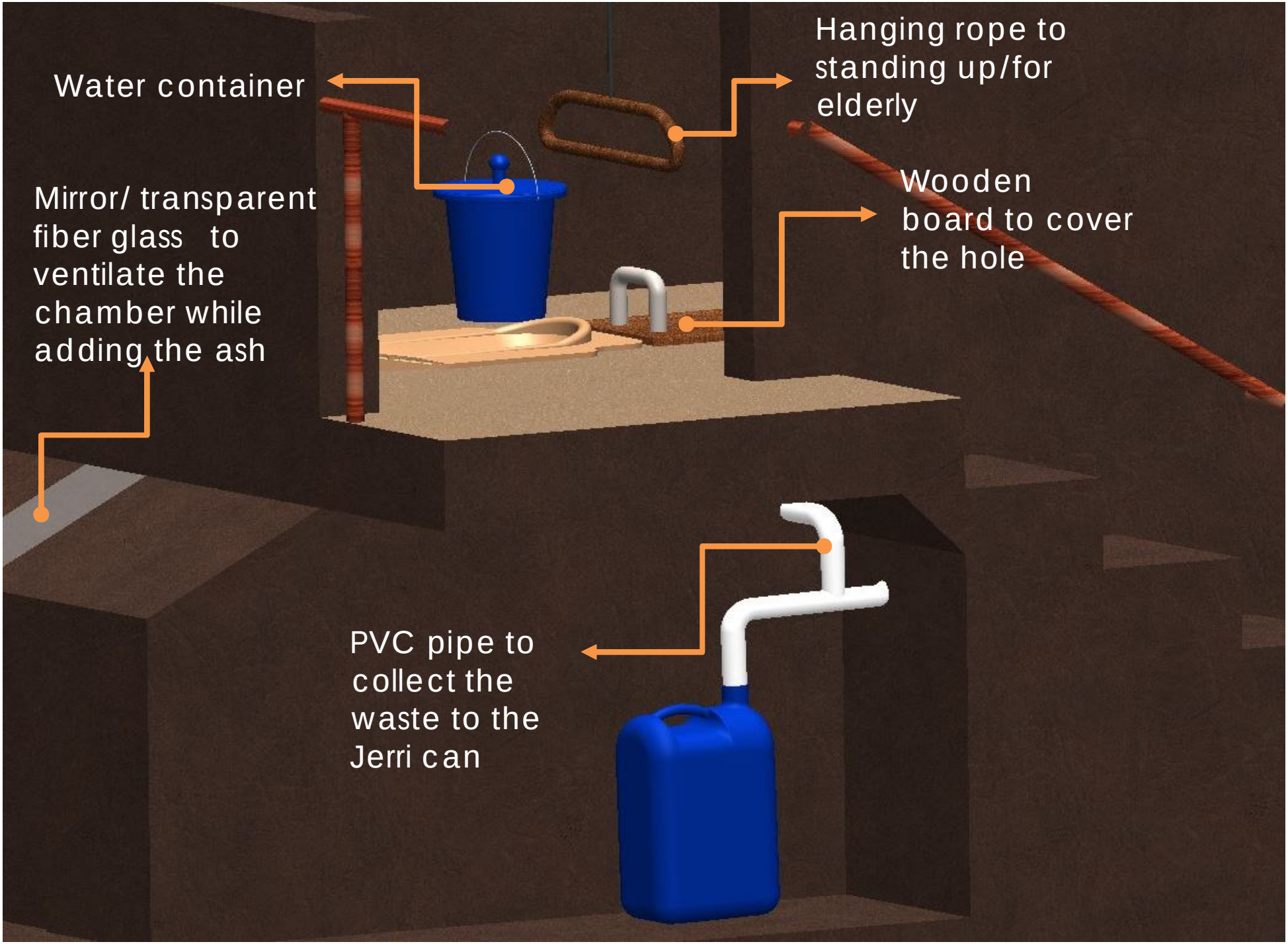


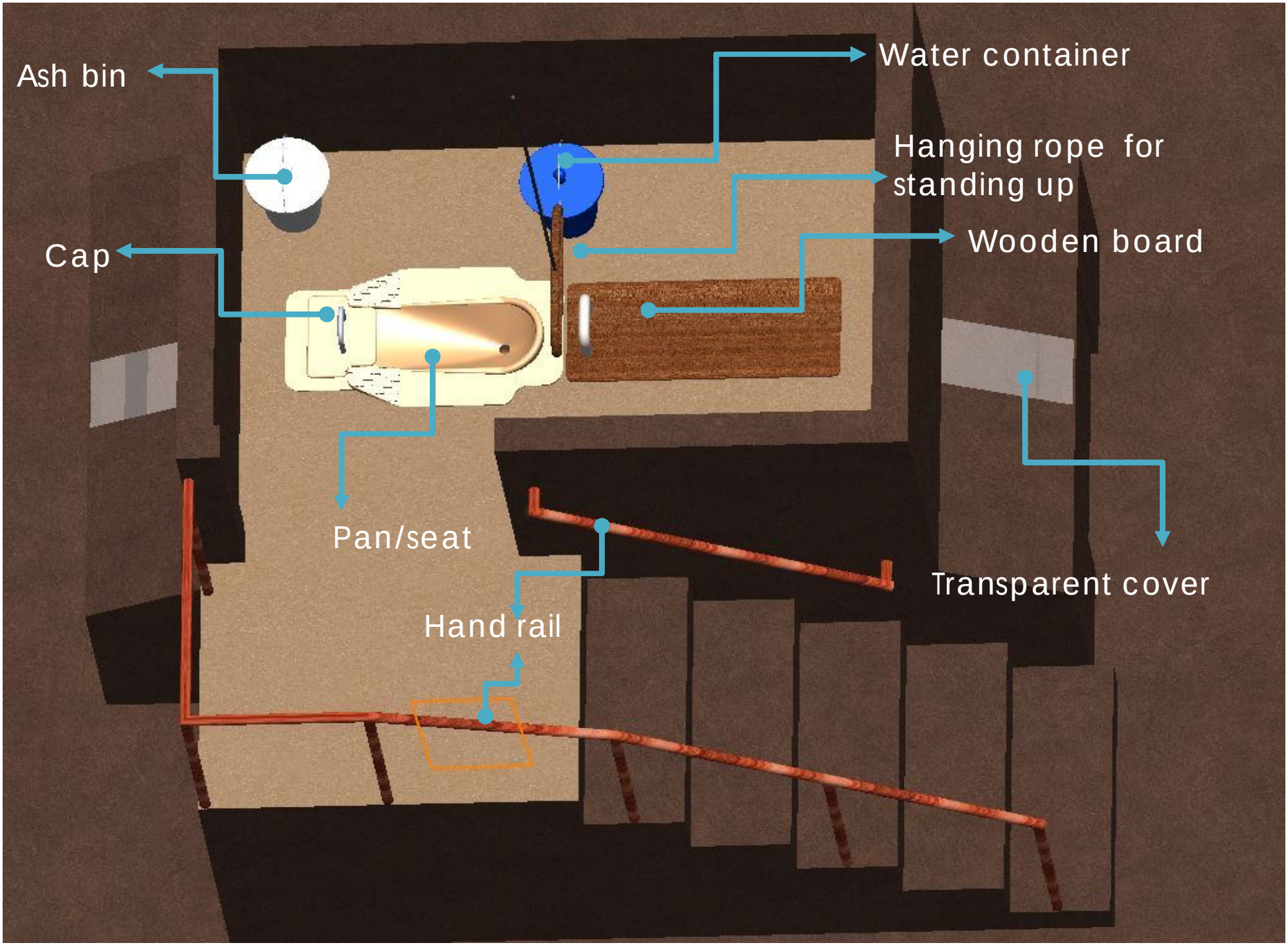
Final concept

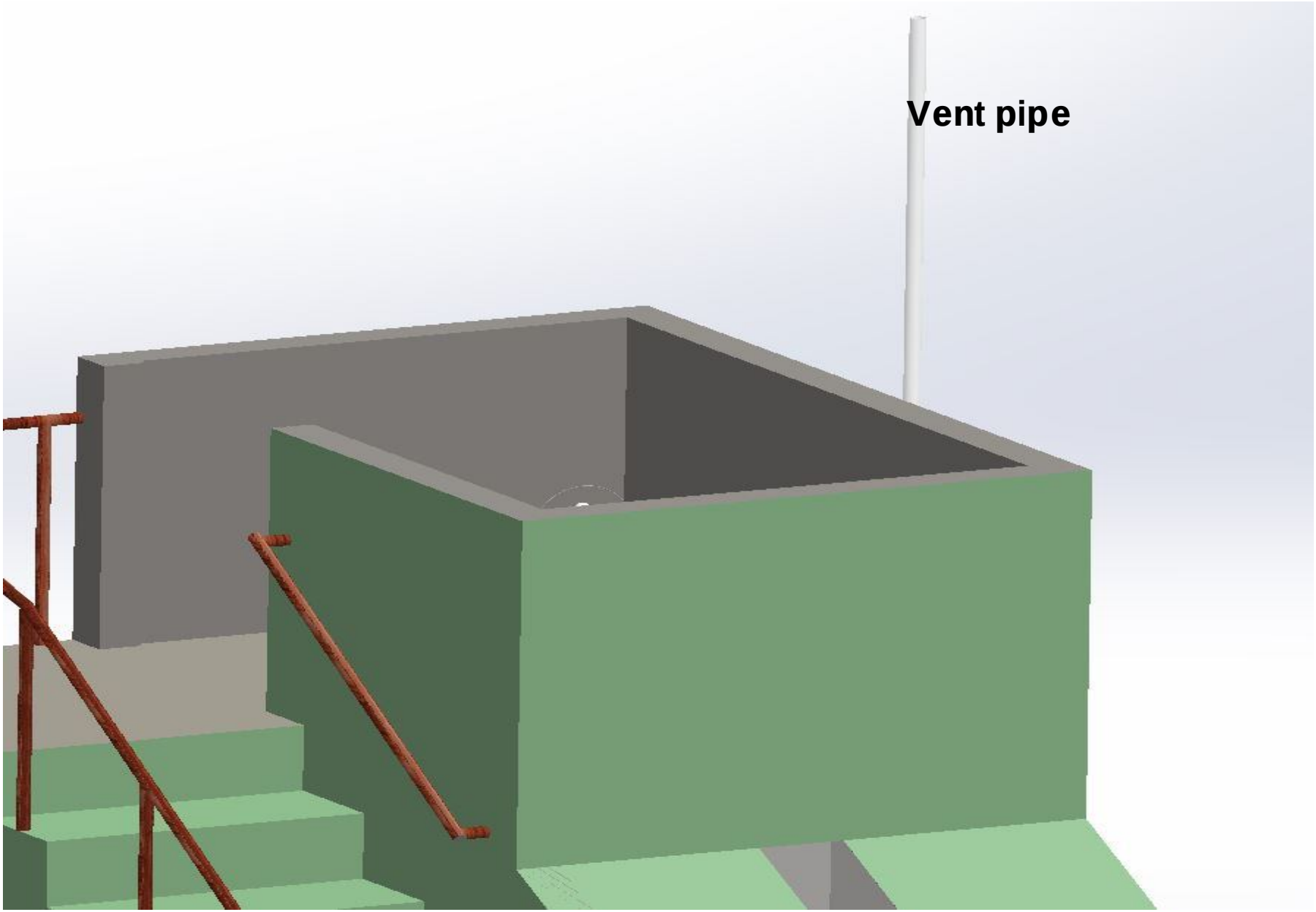


3D Final concept




Water container
Hanging rope to standing up/for elderly
Mirror/ transparent fiber glass to ventilate the chamber while adding the ash
Wooden board to cover the hole
PVC pipe to collect the waste to the Jerri can


Ash bin
Water container
Hanging rope for standing up
Cap
Wooden board
Pan/seat
Transparent cover
Hand rail


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^{0}C)to get wide range of color

Process

- 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

- I would like to express my gratitude to my Co- guide **Prof. U.A. Athavankar** for his constructive and useful feedbacks, comments, and remarks through the out my project work. I always had a terrific support from **Prof. U.A. Athavankar.**
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- Design can not be done with out helping others so I would like to thank **To all my classmates**

Thank you!