SATNET ASIA
Innovation network for food security and poverty reduction

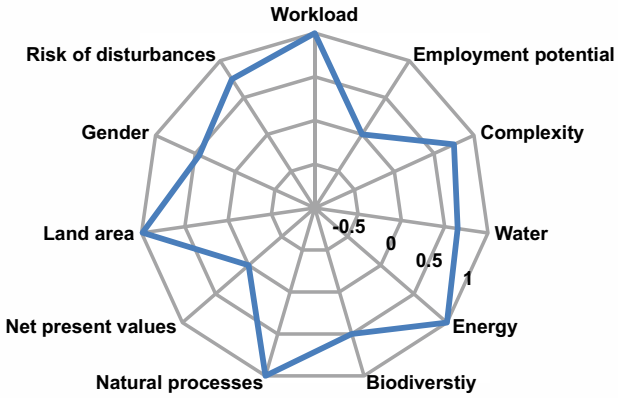
Urine-diverting Dry Toilet (UDDT)

An ecologically beneficial and productive sanitation system[1]

Technology fact sheet | 13 / March 2015

Key facts

- An odourless and integrated sanitation method for individual households and other public locations. Works without the need for flushing, hence saving water and protecting groundwater from faecal contamination.
- Urine and decomposed human faeces (also referred to as 'humanure') are used as crop fertilizer and soil conditioner. The safe and productive recycling of nutrients, instead of treating excrement as waste that must disappear, makes UDDT an ecological sanitation system.
- Offers constant access to a sanitation facility providing improved hygiene and privacy as well as improved security, especially for women and adolescent girls; saves time[2], promotes closed local nutrient cycles and reduces fertilizer costs.
- Links sanitation with agriculture and livelihood.
- Particularly suited for areas prone to flooding, having high water tables, subject to water shortages, with rocky soils or in fragile ecosystems.



This graph summarizes the results of a sustainability assessment conducted for this technology. The closer the line is to the outer edge of the diagram, the better the technology performs in terms of the particular criterion.

What is Urine-diverting Dry Toilet (UDDT)?

- An ecological sanitation (ecosan) approach, using the principle of urine diversion and recycling of decomposed human excreta in local agriculture and horticulture. The technology follows the drop and store practice, with human faeces and urine collected separately using an innovative toilet design.
- A household toilet use in which urine, faeces and anal wash water are separated, stored, and used.
- On average, a human being discharges about 500 l of urine per year and 100-150 kg of faeces per year equivalent to 50 l of faeces per year (Centre of Excellence in Ecosanitation, 2009; UNICEF, 2011). The average annual excreta from a person contain 4.56-5.6 kg of Nitrogen, 0.55-0.7 kg of Phosphorous and 1.2-1.28 kg of Potassium (MPA, 2008; UNICEF, 2011).
- The toilets are built with a brick/cement substructure with two chambers for excreta collection, a urine outlet and two anal wash water outlets.
- Faeces are collected in cement chambers and covered immediately with soil, ash, rice hulls, sawdust, or similar material to get them out of sight, control odour and flies, and to absorb moisture. When one excreta chamber is full, it is sealed and the excreta are left to decompose over a period of six months[3] or more, while the second excreta chamber is used. Urine is directly collected in gallon containers (jerrycans) for easy access and use, although it can also be distributed immediately and by gravity via perforated hoses buried in the ground among fruit and other trees.
- The superstructure (privacy walls) of the toilet can be of low-cost bamboo, wild grass, thatch and mud (see Figure 2) or made with bricks and cement which is more costly (see Figure 1).
- The technology is designed to withstand floods, with a brick/cement base structure, but can also be used in areas that are not prone to flooding.

History

- Open defecation is a common practice in many areas (rural and urban) of India. The "Total Sanitation Campaign" launched by the government in 1999 had covered 73 per cent of the rural population by 2011. However, sanitation

[1] Water saving toilets range from low to high cost options like compost toilets, enclosed long-term composting, UDDTs or water-saving vacuum sewage systems. For more detailed information, see UNICEF (2011) and UNESCO, IHP, and GTZ (2006).
[2] Users don't have to walk long distances to find a suitable, secure and private location for defecation.
[3] Or 12 months if no lime or ash is added (according to the WHO (2006) guidelines).

coverage is uneven across the country and in May 2014, only 58 per cent of households below the poverty line (BPL) in Bihar State owned a latrine.

- The UDDT as described here has been promoted in Bihar since 2007 by the civil society campaign Megh Pyne Abhiyan (MPA), which translates into Cloud-Water Campaign. An informal network of local organizations and professionals, MPA was registered as a Public Charitable Trust in 2012. MPA was first introduced to Ecosan by Mr S. Vishwanath of Biome Environmental Solutions Pvt. Ltd. during a water workshop titled Jal Manthan Shivir (Water Brainstorming Camp) organized by MPA.
- Ecosan was promoted in north Bihar using a participatory process of adapting the concept to local conditions and needs, followed by training and support to interested households. A total of 78 households adopted the UDDT and use it. The project also received technical and financial support from the Stockholm Environment Institute (SEI) and WASH Institute (SEI, 2013).

Where it works

- The UDDT described here is used in Bihar, where about 73 per cent of the total area faces regular monsoon floods.
- Unsafe sanitation practices spread water-borne diseases during the floods, with increased use of higher land such as embankments, for open defecation.
- This UDDT is particularly suited to flood-prone areas due to its solid and, if necessary, elevated construction. However, in areas not affected by floods or waterlogging, lower-cost systems applying the ecosan approach can be used. (UNICEF, 2011; UNESCO, IHP and GTZ, (2006; Canaday, 2011).
- The technology requires users to be sensitized to the benefits of ecological sanitation and committed to adopt, use and maintain the toilet properly, making safe use of the treated urine and faecal matter.

Technological aspects

- The construction and use of the toilet involves the following steps: 1) choose the location, 2) construct and compact a solid soil elevation, depending on observed flood levels, 3) prepare the substructure with bricks and cement, 4) prepare the squatting pan which covers the substructure, 5) construct the superstructure, 6) use the toilet daily and advise children and visitors in the correct use of the toilet, 7) remove the collected urine before the collection container is full and use as fertilizer for the home garden, 8) use the decomposed faecal matter as fertilizer or soil conditioner.
- The material needed for the construction of the UDDT is listed in the economic section.

1) **Planning**: Before starting construction, choose an area i) close to or even attached to the house, ii) close to the kitchen garden, iii) exposed to direct sunlight to enhance decomposition of the excreta and iv) preferably elevated to protect from floods.

2) **Flood-proofing**: If the site floods, construct a solid and well-compacted soil hill of sufficient height to ensure that the upper edge of the toilet substructure will not be submerged, based on the highest level of flooding in the past. The sides of the hill should be planted with grass or other plants.

3) **The dimensions of the toilet**, in particular the collecting chambers, vary according to 1) the space available for the construction and 2) the size of the household. In deciding the toilet size, future needs should be taken into account as children grow and become adult producers of faecal matter. The toilet design, with the chambers either side by side (see Figure 7) or in a row (see Figures 8 to 14), depends on space availability and household preferences. To choose the appropriate dimension, take into account the amount of faeces and urine produced per person per year. For a household of five persons, the minimum volume should be 750 l. However, for the reasons mentioned below, the recommended volume of the two chambers is 2,546 l (dimension per chamber of 100 x 119 x 107 cm). This is more than three times the volume of the theoretically required minimum volume. The larger size is recommended, based on practical experience in a flood-prone area like north Bihar and takes into account 1) space for guests using the toilet and 2) special requirements for the final height of the toilet surface being above the highest possible flood level and 3) the possibility of the temporary unavailability of one chamber due to repairs. In the latter case, the remaining chamber will have to be used alone.

Table 1. Amount of faecal matter and urine produced

	Amount of urine produced	Amount of faeces produced
Per person	500 l/year	100 to 150 kg/year (Centre of Excellence in Ecosanitation, 2009) or 100 to 150 l/year (UNICEF, 2011)
5-member household (2 adults, 3 children)[1]		**Theoretical minimum volume required per UDDT**
		750 l
	Recommended volume of urine collecting container[2]	**Recommended volume of single collection chamber[3]**
	15-25 l	1 273 l per chamber (100 x 119 x 107 cm)

Note:
[1] Children and adults should be considered equally.
[2] Urine collecting container is emptied before it is full. Smaller containers have to be emptied more frequently.
[3] Each collecting chamber for faecal matter in the two-chambered UDDT is emptied once a year.

The substructure is constructed from bricks and cement, with a cemented lower surface (see Figures 4 to 7).

The chambers must have an impermeable floor to prevent leaching and assure dry conditions for faeces decomposition (UNICEF, 2011).

The gaps on the upper edge of the wall are for the pipe that drains anal wash water (left hole) and for the urine pipe (right hole). The arrangement for placing the pipes depends on location and available space.

If the superstructure is constructed with bamboo and plastered grass mats, then four holes of 2.5 feet (76 cm) depth to fix the bamboo poles in the four corners of the toilet, have to be pre-installed in the substructure (see Figure 8).

4) **The substructure**: the top of the substructure is covered with three pre-cast concrete elements - two simple and flat elements that cover the sides and one element shaped as shown in Figures 9 to 15. Preparing the top part with three separate elements makes it easier to lift each element to the top of the substructure.

The ground surface is first levelled and either covered with very fine sand or with a plastic sheet. The pre-cast method produces the elements upside down. This means that the surface of the concrete that touches the ground during the production process will be the visible surface of the final toilet pan. Steel rods are prepared and tied to each other as shown, to support the concrete. The middle element has three basin-like spaces with sloped sides to collect urine and back wash water. The slopes have to be prepared by elevating and shaping sand on the ground. The steel rods have to follow this shape.

The three elements are separated from each other by wood blocks or bricks. The outer edges of the elements are framed with bricks.

The concrete should be mixed using one part cement, two parts sand, three parts gravel with an approximate diameter of 0.25 inch (0.64 cm) and not more than two parts water. Avoid adding too much water because this will lead to cracks when the concrete dries.

Steel buckets with a bottom diameter of 10 inch (25.4 cm) can be used to shape the holes for excreta passage. These are put at places foreseen for excreta passage while inserting the concrete in the casting mould and removed out of the hole after five hours to avoid the buckets being fixed in the dried concrete. Tubes of 1-inch (2.5 cm) diameter are held on top of the sand elevation while inserting the concrete. These serve as passage for the urine and wash water in the pan.

The element in the middle shows two round holes for passage of faeces and three small holes (tubes sticking out from the concrete) for urine and wash water collection.

The bricks and wood can be removed after 5-6 hours, once the mix partially solidifies. The three concrete elements can be fixed with cement on top of the substructure after drying for approximately two weeks. The pan elements are then plastered smoothly with a mixture of one part cement and five parts red oxide, after placing the pan on the chamber. The surface of the plastered pan will absorb less urine than an un-plastered pan and will look smoother and nicer. Plastering reduces the holes for excreta passage to approximately 9 inch (22.9 cm).

Urine and anal wash water collection pipes must be fixed tightly to prevent leakage of urine and water into the faeces. Three pipes, each with a minimum length of 5 feet (152 cm) and minimum width of 1 inch (2.5 cm) are required: two for draining anal wash water and one for the urine. The pipes are fixed to the three projections in the pan. In order to fix a pipe, one end is first softened by warming it on slow heat. It is then pushed over the piece of tube that is fixed in the pan. The other ends of the pipes are guided outside the chamber through the gaps in the wall that are foreseen for this purpose (see Figure 6) - wash water pipes towards the side and the urine pipe towards the front of the toilet.

The length of the anal wash water pipes should be adjusted according to the distance to the place where the water can be discharged safely. Pipes longer than 5 feet might be required. Faeces and the wash water contain pathogens. However, the quantity of wash water and the quantity of faecal matter in it is minimal. If the pipes are installed properly, with perforations 10 or 20 cm under the soil among plants that do not need to be dug up, the wash water is absorbed by the soil and faecal matter, including pathogens, is degraded in the soil. Wash water should not be allowed to stagnate on the soil surface. If drainage is properly arranged, the risk of human contact with the wash water is avoided.

Rounded lids are prepared in moulds that can be dug in fine soil or sand with a bottom diameter of 9 inch (22.9 cm) and a top diameter of 10 inch (25.4 cm). A bent steel rod can be used as handle.

5) **The superstructure** can be constructed using bricks and cement which is more expensive, but longer lasting, or with woven mats made of bamboo, ropes and local grasses that can be plastered with mud. This is cheaper but needs to be replaced every second year and requires frequent plastering with mud.

Tips for constructing a bamboo superstructure

The length of the bamboo poles should be chosen in function of the size of the toilet substructure and the desired superstructure height.

Recommended treatment of bamboo to ensure longevity:

1) Dip up to 3 feet (90 cm) in boiling water for 1-2 hours to kill germs and insects living inside.
2) Apply liquid coal tar to prevent termite attacks.
3) Wrap in plastic cover, tying with nylon rope.

Insert the ends of the four treated bamboo poles in the four holes in the corners of the substructure and fill the holes with mud. A bamboo frame can be constructed with grass mats fixed on it and plastered with mud. The roof should have a slope and protrude by 12 inch (30 cm) on all sides of the toilet walls.

Care should be taken to keep rain out of the toilet and collection chambers. When the structure is ready, the vent pipe can be installed. It facilitates aeration of the chamber and prevents the development of odour inside the toilet. The diameter of the vent pipe is at least 3 inch (7.62 cm) and can be as wide as 16 cm. One vent pipe can be fitted to both chambers using couplers and elbows, although more ventilation is achieved with one straight pipe per chamber. PVC pipes are generally used and should be fixed vertically without bends for best effectiveness. Their upper end should be 20 inch (50 cm) above the roof and be fitted with a cowl and screen to prevent rain and flies from entering. These can be painted black for better absorption of solar radiation (UNICEF, 2011), which reinforces the ventilation.

Wide steps (ideally 1.5 feet wide) and railings on both sides ensure secure access to the toilet, especially for children, elderly and pregnant women. For the safety of women and adolescent girls, it is recommended to have a door with a latch on both sides.

6) **Use of the toilet**: Use the toilet on a daily basis and instruct children and visitors in its correct use. It is important that the urine and the excreta are collected in separate containers and not mixed. The faeces decompose best when kept as dry as possible. Mixing faeces with urine or water will promote the development of bad odour and attract flies. After each use, it is recommended to sprinkle a handful of dry ash and dried Neem (*Azadirachta indica*) leaves, saw dust or soil over the faeces to absorb excess moisture, repel insects and prevent bad smell. This also increases the carbon-nitrogen ratio, which is good for the composting process and improves the quality of the final humanure as crop fertilizer. The material used to cover the faeces should be collected during the dry season and stored in a dry place, inaccessible to insects.

After each use of the toilet, it is important to wash hands with soap.

7) **Use of urine**: Use the collected urine once the collection container is full, to fertilize crops or the home garden. If used for agricultural crops to be marketed, the urine should be stored for at least one month to ensure safe reuse.

8) **Use of humanure**: Once the first collection chamber is full, the faeces are left to decompose for at least 12 months, while the second chamber is used for defecation. When the material in the first chamber is decomposed, the collection chamber is opened from the side, humanure is taken out, used to fertilize crops and the wall of the collection chamber is closed again for the next use.

For further recommendation on application of dehydrated faeces, see Stenstrom *et al.* (2011) pages 86-87.

- Recommended dose of urine per acre of land for different crops.

Table 2. Amount of urine recommended for one acre (0.4047 ha)

Crop	Amount of urine (l)
Maize	23 000
Banana	61 000
French bean	8 400

Source: Centre of Excellence in Ecosanitation (2009)

Table 3. Urine application and yields in rice and pumpkin production

Area cultivated	Amount of urine applied (l)	Yield with urine application (kg)	Control: yield without urine application (kg)
Rice under the system of rice intensification (SRI)			
520 m^2	822 (3 x 274 l)	343	260-280
1 m^2	1.58 (3 x 0.53 l)		
1 acre (4046.86 m^2)	6 400 (3 x 2133 l)	2 670	2 023-2 180
Pumpkin production			
1 plant	2.25	340	250-260

For further recommendations on the application of urine as fertilizer, see UNICEF (2011), Case study 2, pages 157-158, Richert *et al*. (2010) and SEI (2014a).

Economic aspects

- Detailed material lists and costs to construct a two-chambered UDDT are shown in Tables 4 to 7.

Table 4. Material and labour costs for the foundation

Item	Quantity	Unit	Cost/Unit (₨)	Cost (₨)	Cost ($)
Earth material for foundation	160 - 180	cubic feet[1]		800	14.64
Brick chips	45	cubic feet[2]		500	9.15
Bricks	310	piece	6	1 860	34.03
Sand	30	cubic feet[3]	15	450	8.23
Mason	2	day	300	600	10.98
Labourer	2	day	200	400	7.31
Subtotal				**4 610**	**84.35**

Note:
[1] 160-180 cubic feet = 4.53-5.1 m^3
[2] 45 cubic feet = 1.27 m^3
[3] 30 cubic feet = 0.85 m^3

Table 5. Material and labour costs for the substructure including squatting pan

Item	Quantity	Unit	Cost/unit (₨)	Cost (₨)	Cost ($)
Bricks	540	piece	6	3 240	59.28
Cement	5	bag (50 kg)	350	1 750	32.02
Sand	50[1]	cubic feet	15	750	13.72
Crushed gravel/road metal (stone chip)	8[2]	cubic feet	60	480	8.78
Iron rod (diameter: 6 mm)	5	kg	48	240	4.39
Iron rod (diameter: 8 mm)	6	kg	50	300	5.49
Iron wire (to tie the iron rods)	0.5	kg	80	40	0.73
Nipple socket	3	piece	50	150	2.74
Urine pipe (diameter: 1 inch = 2.5 cm)	3 x 5 = 15	feet[3]	15	225	4.12
Gas pipe/vent pipe (diameter: 3 inch = 7.62 cm)	7	feet[4]	52	364	6.66
Cover for gas pipe (cowl and screen or elbow and cover)	1	set	75	75	1.37
Staircase	4	step	240	960	17.56
Plastic container for urine collection, plastic gallon	1	piece	60	60	1.10
Paint	0.2	kg	500	100	1.83
Red oxide	2	kg	25	50	0.91
Mason	4	day	300	1 200	21.96
Labourer	5	day	200	1 000	18.30
Subtotal				**10 984**	**200.97**

Note:
[1] 50 cubic feet = 1.41 m^3
[2] 8 cubic feet = 0.23 m^3
[3] 15 feet = 4.57 m
[4] 7 feet = 2.13 m

Table 6. Material and labour costs for superstructure made of bamboo and woven mats

Item	Quantity	Unit	Cost/unit (₨)	Cost (₨)	Cost ($)
Bamboo (diameter: 3 inch or 7.6 cm)	7-8	piece	100	750	13.72
Khar (dried wild grass)	10	bundle	50	500	9.15
Plastic sheet (in the size of the roof)	1	piece	40	160	2.93
Sign board – 2 feet x 1 feet (for the details of the construction and usage pattern)	1	board	300	300	5.49
Bamboo worker (*Dabiya mistri*)	2	day	250	500	9.15
Male and female labourers	3	day	220	660	12.08
Subtotal				**2 870**	**52.52**

Note: Instead of a roof made of grass and plastic sheet, a tin roof can be fixed (optional: 2 pieces at Rs500 each = Rs1,000)

Table 7. Total cost for one UDDT

Item	Cost (₹s)	Cost ($)
Foundation	4 610	84.35
Substructure including squatting pan	10 984	200.97
Superstructure	2 870	52.52
Total	**18 464**	**337.84**

- The use of urine as a fertilizer has been positively received in the village, with farms producing greener crops and higher yields.
- Use of urine has reduced urea purchase to one or two bags and the savings are used to buy clothes and other household necessities.

Environmental aspects

- The UDDT protects the environment and soil and groundwater from biological contamination through pathogens contained in excreta.
- The use of humanure can reduce mineral fertilizer and pesticide use. Leaching of excess mineral fertilizer into groundwater is also avoided.
- Decomposed human faeces show soil-improving effects when used in agriculture as fertilizer, in particular improving the soil structure and water retention capacity. In general, UDDTs allow almost complete recovery of nutrients and energy from human excrement.
- UDDTs save water in areas like north Bihar that face water scarcity during the summer.
- Cleaner habitations with open defecation reduced.

Social aspects

- Reduces open defecation and avoids associated problems such as restricted timing for defecation, especially for women and adolescent girls in the early mornings and late evenings. Women and girls can avoid physical and psychological harassment which open defecation subjects them to.
- Preservation of women's modesty and supportive of general and menstrual hygiene practices.
- UDDT users find they can save one to two hours a day by avoiding open defecation, time which is now used for household work or relaxation.
- Positive health impact for the family, especially during sickness and monsoon was also mentioned as a benefit and reason for adoption of the UDDT.
- UDDTs provide very poor households an additional source of income through selling humanure.
- Aversion towards urine and excreta has been removed by promoting its safe use for enhancing agricultural productivity.
- For further information on social aspects, see SEI (2014b).

Issues for replication

- Sanitation is a sensitive and personal issue. It requires changing defecation behaviour and changing attitudes toward human excreta and urine for use in agriculture. The success of any sanitation programme depends on the people who use it and appropriate approaches are needed to sensitize users about the benefits of this technology.
- The following parameters have to be given due consideration: 1) number of current and future users 2) suitable and convenient locations, 3) design suited to local environment and locally available resources, 4) user involvement and commitment, and 5) adapted sensitization of users with follow-up.

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Related topic

Vermitechnology fact sheet:
http://www.satnetasia.org/database/layout.php?id=7.

Useful links

- Sustainable Sanitation Alliance: www.susana.org/en/
- Online sanitation library of the sustainable sanitation alliance: http://www.susana.org/en/resources/library.
- Biome Environmental Solutions Pvt. Ltd.: http://www.biome-solutions.com/index.php.
- Wherever the Need, India: http://www.whereverthenеed.org.in/
- Society for Community Organisation and People's Education (SCDOPE): http://www.scopetrichy.com/
- Stockholm Environment Institute - SEI: www. sei-international.org.
- Online ecosan publications from SEI: www.ecosanres.org/publications.htm.
- Chris Canaday's English and Spanish blog on dry toilets: http://inodoroseco.blogspot.com/

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Figures

Figure 1. UDDT with cemented brick walls

Figure 2. UDDT with a cemented substructure and bamboo walls as superstructure

Figure 3. Soil is compacted to build a hill on which the UDDT is constructed

Note: Nearby banana plants benefit from regular fertilization by the anal wash water.

Figure 4. Construction of the substructure

Figure 5. Construction

Note: Walls and ground are cemented from inside as well as outside. The wall inside the substructure separates the two collection chambers. The hole on the left upper corner holds the ventilation pipe.

Figure 6. Almost finalized substructure

Note: Mason marks where the collection chambers will be opened once faeces are decomposed. Future openings are not cemented permanently but closed with bricks and local mortar to withstand flash floods.

Figure 7. Finalized UDDT substructure without pan on top

Note: Solid, 1.5 foot (46 cm) wide steps assure safe access to the top of the toilet.

Figure 8. UDDT substructure with holes in the four corners for fixing bamboo superstructure

Note: The squatting pan was put on top of the substructure and is being fixed and plastered.

Figure 9. Sketch of a squatting pan for a two-chambered UDDT for users who wash with water

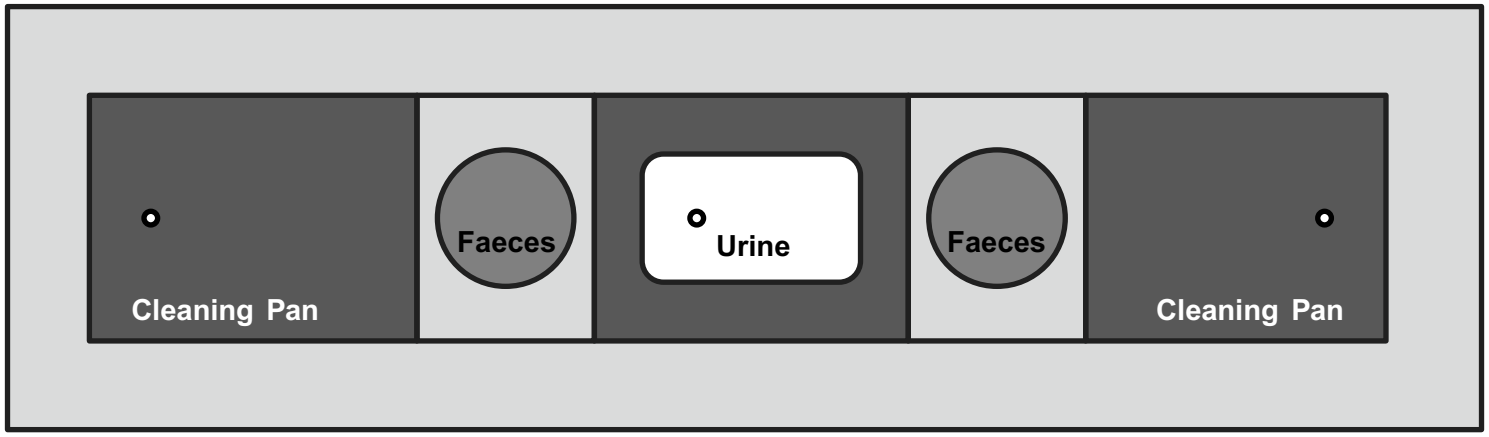

Figure 10. Preparing steel rods and surface

Figure 11. Preparing the casting mould

Figure 12. Inserting concrete in casting mould with plastic sheet on the ground

Figure 13. Drying pre-cast elements in the casting mould

Note: The side elements of this top element have right-angled edges in all four corners that allow the fitting of bamboo poles for a semi-permanent superstructure with woven mat walls.

Figure 14. Drying pre-cast elements in the casting mould with plastic sheet

Note: A completely rectangular toilet top can be used when the superstructure is built with bricks.

Figure 15. Removing bricks and wood when concrete is hardened

Figure 16. Preparing lids for the excreta passage holes

Figure 17. Bamboo poles fixed in substructure holes

Figure 18. Ready to use, sanitized and odourless humanure

Photos no. 1 and 2: J. Koknevics
Photos from no. 3 to 18: Megh Pyne Abhiyan and Water Action

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