Simple urine-diverting dry toilets built with recycled or readily available materials

This paper describes how UDDTs can be made very economically, using easily accessible things, like plastic bottles, sacks, buckets, and planks

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Abstract

Three different models of simple and inexpensive Urine-diverting Dry Toilets (UDDTs) are described: a portable one for squatting made from a barrel, another portable one made from wood and linoleum, and a permanent one for squatting made with palm wood. A simple, portable urinal made from two plastic bottles is also described. These can be made at very low cost, with abundant natural materials, salvaged post-consumer waste, and items that are readily purchased almost anywhere. They may be especially applicable in poor communities, slums, farms, disaster relief camps, and temporary events, plus they may be used to train and screen users before building more elegant UDDTs. With these designs, conversion to UDDTs may be more a matter of paradigm shift than capital investment..

Introduction

Diseases transmitted via faeces, including diarrhea, hepatitis, typhoid, and intestinal worms, constitute one of the biggest threats to human health (Conant and Fadem 2008). Especially vulnerable are the people who live in large agglomerations under unsanitary conditions. In Developing Countries, most wastewater goes straight into the environment without treatment and many people do not even have access to the piped water needed to make such wastewater, so the fecal contamination of their environment is even more direct. Globally, an estimated 40% of people live without basic sanitation (UN-Habitat, 2003).

Urine-diverting Dry Toilets (UDDTs) have much to contribute in improving this situation, especially if they are:

- Very low in cost
- Easily made from abundantly available (often recycled) materials
- (in some cases) Portable

The UDDT is one technechnology often used in Ecological Sanitation (EcoSan), a concept in which excrement can be used as a resource for improving the soil, while applying natural processes to control the potential transmission of diseases (Winblad et al. 2004, Esrey et al. 1998). One of the least logical aspects of modern life is that of taking and purifying huge amounts of water, defecating in a large proportion of it, spending great sums of money to then try to purify it again, but never returning the nutrients to farmland, thus depending more and more on chemical fertilizers that are made and transported with non-renewable fossil fuels. To make things worse, pathogens develop resistance to the chemicals used to treat sewage and substances like antibiotics and artificial hormones cannot reliably be removed or degraded. These are the results of an irrational fear of our own excrement that leads us to do irrational things with it. In contrast, EcoSan is a way to control the real risks involved, and make our excrement safe to be added to the soil. In the case of water, everyone wants it clean, so it is best to simply not contaminate it with excrement.

The goal of this paper is to show that conversion to using UDDTs can be more a matter of shifting paradigms than capital investment. People can learn the concept and apply it on their own, with materials that they already have access to.

Key factors:

- Urine may be diverted with standard plastic funnels or with ones cut from plastic bottles
- Urine may be stored in bottles for later use as fertilizer or it can be dispersed immediately via perforated hoses (at least in the Amazon)
- Faeces may be collected in sacks or buckets

The simple, and economical models presented here may have wide application in:

- Poor communities, including slums (especially those applying Community-led Total Sanitation, CLTS)
- Farms
- Disaster relief camps
- Temporary agglomerations of people from any economic strata (e.g., fairs, conferences, summer camps, sporting events)

They could also be provided temporarily to families scheduled to receive more permanent and elegant UDDTs, as a means of educating and screening them to make sure that they understand the concept and will use the toilets properly, before building them, thus greatly reducing the number of units that are later abandoned or misused.

Technical Principles of the UDDT (Winblad et al. 2004)

- Urine and faeces are kept separate to reduce smell and to facilitate appropriate management of each.
- Urine is normally sterile and, even when not, transmits no diseases if dispersed on the soil (my conclusion). It is also a nitrogen-rich fertilizer for plants. (If there is concern for possible fecal contamination of the urine, it may be stored for a number of months before use.)
- Faeces transmit numerous diseases and therefore should be contained for treatment, which consists of being covered with a dry absorbent material and stored long enough for disease organisms to die of desiccation and destruction by soil organisms (or they can be composted). Afterward, the decomposed faeces may be used to enrich the soil or to cover freshly deposited faeces in the UDDT.
- In order to keep the fecal chambers dry, they are usually established aboveground, unless the soil is dry and absorbent.
- Ventilation may be arranged to take any minor odors away from the users.

Urine Management

Urine is kept separate via a strategically placed funnel toward the front, while the faeces are collected simultaneously farther back. The plugging of urine hoses with refuse or cover material may be prevented via placement of plastic meshes.

Urine may be managed in two different ways. The first (and most conventional) way is to store it in plastic bottles (e.g., 4 to 20 litres) and carry it to agricultural fields, where it may be applied pure, diluted with water, or mixed with other elements, according to what is best for the particular species of plant, given local climatic conditions. The second way is to have it drain immediately to the agricultural soil, or among fruit trees, via perforated hoses, especially in wet, tropical climates, where abundant rainfall helps to disperse the urine, avoiding excess dosage for any individual plant. This is a very convenient option in many cases, as the urine goes to the plants without anyone having to deal with it and this occurs before it has time to ferment and produce bad odors. Many EcoSan practitioners state that this is not feasible due to a precipitate (Struvite) that plugs the holes, but the author has done this in the Amazon for 10 years and the holes do not get plugged. This may be due to the greater biodiversity found here, as tiny innocuous black ants are often seen running along the hose and presumably eat the precipitate before it accumulates. It may also be a matter of soil microbes. Wild animals sometimes chew holes into the hose to consume the urine; this may be avoided by covering the hose with sand, gravel, sawdust, or other similar material. One convenient way to perforate the hose is to insert pieces of plastic lollipop sticks (from candies, inner diameter roughly 2 mm) into holes punctured with sharp tools, every 50 cm, preferably spiraling around the hose.

Especially at high-use toilets, it is convenient to place an upside-down 3-litre disposable PET-plastic beverage bottle, with the beginning of the hose glued into its mouth and the pipe from the toilet fitting into a hole cut into its side. This allows urine to flow quickly from the toilet and then slowly, if necessary, into the perforated hose.

Faeces Management

The faeces are kept dry and are covered with a cup of dry material after each use, to get them out of sight, to control odors, to keep flies away, and to dehydrate them. The best dry material is wood ash, since it is very absorbent and alkaline. Other acceptable materials include sawdust, rice hulls, leaves, and soil, all of which must be as dry as possible and may be mixed or used alternately. Mineral lime (calcium carbonate) is sometimes used as a cover material, but is more expensive and causes more environmental impact through its extraction and transport.

Faeces may be stored in:

- buckets;
- standard, woven, polypropylene sacks (as used to transport grains, fertilizer, etc.); or
- (if the site has dry, absorbent soil) one-metre-deep holes in the ground where trees may later be planted (see the “ArborLoo” in Morgan 2007).

These receive a layer of dry material before use, to absorb liquids and reduce potential for odors. Faeces may also be deposited in two, alternating chambers, but that involves more investment.

Advantages of sacks include evaporation of water outward through the cloth and infiltration of oxygen, in addition to their extreme low cost and accessibility. Another advantage of sacks and other interchangeable containers is that when there is a problem with flies or smell (due to insufficient or improper cover material), they can be closed and replaced, thus immediately resolving the problem.

Experience has shown no problems in storing faeces in sacks, after initial collection in buckets or via direct deposit into the sacks. One may imagine that some animal would break the sack to get to the contents, but this has not occurred. In the odd event that moisture appears on the outside of the sack, ashes may be applied to it. Ultra-violet radiation deteriorates their plastic fibers, so sacks should not be kept in direct sun, in addition to being protected from the rain.

These different strategies may also be combined. For example, a toilet could function with a bucket, which when full is emptied into a sack, which when full is emptied into a hole for planting a tree. Once built, the portable UDDT may be used with any of the three options.

Toilet paper may be processed together with the faeces, as it helps to absorb excess moisture. Leaves or other organic materials used for wiping may also be put together with the faeces. If water is used for cleansing, separate arrangements should be made for dealing with the contaminated water, which would be easiest in the Palm Wood UDDT for Squatting (c, below), and this water should go to a Constructed Wetland or be dispersed below the surface of the soil.

Four Practical Examples

The following examples comprise three of simple UDDTs, plus a urinal to reduce demand for the toilets. The elements used in each may be recombined as desired.

a) Barrel UDDT for Squatting

Materials:

- Half of a discarded 208-litre plastic barrel
- 20-litre plastic bucket
- Two 4-litre plastic bottles
- Tape, string and/or wire

Figure 1: Simple, portable UDDT made from a discarded plastic barrel, a bucket, and two plastic bottles. Note the marks for placement of the feet.

The half barrel is cut at a height such that the 20-litre bucket (usually 39 cm high) can stand precisely inside it, optimally providing support to this end of the barrel, which will now becomes the floor of the toilet. An 18-cm-wide drop hole is cut across the entire end of the barrel (Figure 1). Although not normally necessary, it may be made more stable by driving a few stakes or nails around its base.

The bucket is placed on the ground, the cut barrel is placed over it, a Portable Urinal made from two plastic bottles (see d) is put in place, and the toilet is ready for use. The urinal is lifted out, emptied on agricultural soil, rinsed with water, and is ready to be used again. When the bucket is full, the cut barrel is lifted off for it to be changed or emptied.

If buckets are not available, one may use sacks held in place with four stakes driven into the ground, or by being tied to four holes made in the platform.

Advantages of this design include: it may be made in advance of events or emergencies; it is lightweight and robust for transport; it may be used immediately upon arrival; and surfaces are easy to clean and not susceptible to deterioration.

b) Wooden Box UDDT for Sitting

Materials:

- Several wooden planks
- Piece of wood 5 x 5 x 240 cm
- Linoleum, 1 m2
- 2” nails
- Upholstery tacks for linoleum
- 4-litre plastic bottle
- Plastic mesh
- Nylon fishing line, 30 cm
- 1-inch hose for electrical conduits, 1 m
- ½-inch hose for electrical conduits, 15 m
- 20-litre bucket
- Plastic toilet seat

The box is constructed 60 cm high x 60 cm long x 50 cm wide, with the 5 x 5 cm pieces of wood only in the four vertical corners. The top, made with two length-wise planks, is nailed last, after cutting a pentagonal hole into it. The pentagon is drawn as large as possible within the inside and outside edges of the toilet seat that were traced onto the planks. The thin front edge of the pentagon is most conveniently cut from a separate piece of wood 5 cm wide, thus facilitating the sawing of the rest of the pentagon. This shape allows for a large hole which is unlikely to get soiled, and for folding the cut linoleum inside where it is tacked. Small pieces of linoleum, the width equal to the thickness of the planks, are placed at each of the five corners, under the main piece of linoleum, so that no wood shows at all. If linoleum is not available, or is too expensive, a thick sheet of plastic may be used, especially those with colorful designs sold for use on dining room tables.

The planks of three sides should optimally reach all the way to the ground; if not, the gap may be covered with plastic mesh to keep flies and other creatures out. The back side is left open, for taking the bucket out and for ventilation, and is also covered with a plastic mesh, which may be firmly nailed down on the one side and pushed over several nails with small heads on the other side. On the other hand, if a vent pipe is used, the box should be as air-tight as possible, so that all draft generated only pulls air into the seat hole.

A step is made about 36 cm down from the top, for the user's feet to be in a comfortable position. The height of this step may be adjusted to the average size of the users. Small children should be instructed to sit as far back as possible, so that their faeces do not fall in the urine funnel. As compared to a flush toilet, this design is safer and more comfortable for children and handicapped persons to use, since they may support and position themselves with their hands on the bench surface, which is absent from the flush toilet.

The wood may be treated with used motor oil, to act as a preservative, before the linoleum is put on. Everything is a resource when in the right place and the contaminants in used motor oil prevent insects, fungus and bacteria from attacking the wood, thus helping it last longer and reducing deforestation. This also allows for more effective use of the weaker wood from fast-growing species of trees. (Motor oil does not affect linoleum.)

The funnel is made from an empty four-litre plastic bottle (29 cm high, 15 cm diameter), cut diagonally through its cylindrical part (Figure 2). Plastic mesh is cut into an oval that fits into the "mouth" of the funnel, and is sewn onto it on the lower half of its "lip" with fishing line, every 1.5 cm, 5 mm below the edge, going in and out (not around the "lip"). The purpose of the mesh is exclude debris (e.g., toilet paper, sawdust), while allowing urine to pass without splashing. If the mesh is woven or knitted, its edge should be melted, passing it by a candle flame, before being sewn, to prevent it from coming apart. A portion of the urine flows down the mesh, tending to keep it relatively clean. Surprisingly, the droplets of urine held in the mesh do not produce noticeable bad odor, possibly because they have so much air around them. The mesh also deters the escape of any minor odors that may be present farther inside.

The funnel is held in place, just under the drop hole, by a string tied to one nail, passed through the handle of the bottle, and with a loop tied at the other end to be put around a second nail (Figure 3). The connection to the one-inch hose, which is permanently attached to a block of wood nailed inside the box to hold it in just below the spout of the funnel, is made with a simple sheet of plastic wrapped around and tied to the spout, then inserted several centimetres into the hose. In this way, the funnel may be easily removed for cleaning, repairs, or replacement.

Figure 2: UDDT made with wooden planks and covered with linoleum, showing juxtaposition of urine-diverting funnel and faeces-collecting bucket. (Planks were later nailed vertically on all three sides of the step, to keep the whole box from tipping when stepping on it.)

This toilet could also be made with a cut-off, discarded plastic barrel, instead of the wooden box (as in a, above).

This model is a variation of one the author developed for a portable tourist camp in Brazil. Due to space limitations, it did not have the step and the buckets used were shorter. Also, a 16-cm-diameter chimney was

Figure 3: View inside the toilet, showing solidly fixed 1" black hose and easily removable white funnel

put just behind the seat and went to above the roof of the tent where the tourists also sleep. There have been no problems with odors, as long as sufficient wood ash is available.

c) Palm Wood UDDT for Squatting

Materials:

- 1 palm stem
- 1 funnel, 18 or 25 cm diameter
- 15 m, ½" plastic hose for electrical conduits
- 5 m, wire
- 1 m, thin rope
- 6 poles, 4 m long
- Greenhouse plastic for roof, 4 x 3 m
- Privacy walls, as desired, possibly palm leaves

This model was designed to be simple, fast, and efficient, while minimizing the need for manufactured materials. It may be built by three people in one day.

The structure was built with a stem of Peach Palm (Bactris gasipaes), a tree cultivated for its nutritious fruit, which is difficult to harvest when the tree grows too tall, at which point the wood is very strong. It also provides one of the best "palm hearts" for eating. The first 3 metres from the bottom of the stem were cut and split into four pieces to make the posts. A platform was made 60 cm above the ground, using similar quarter-stem sections as rafters, tied with wire, on edge, in notches (cut into the posts with a saw and then knocked out with a hammer). The floor of the platform was made with eight similar quarter-stem sections of palm wood, although in this case from a stronger wild species, Chonta Pambil (Iriartea deltoidea, which also happens to be the most common species of tree in the Amazon). Half-stem sections of Peach Palm would have also worked very well. The floor measured roughly 130 x 130 cm, with a 15 cm gap in the middle to allow for use as a toilet. (This is normally 18 cm wide, but with the round poles it needed to be a bit narrower.) If preferred, sawed timber and planks could be used, covered with plastic or linoleum. Palm wood is fairly hard and smooth on its own.

At the center of this gap in the floor, the funnel is attached toward the front and the sack is attached toward the back. Attachment of the funnel is very simple: a thin rope is tied into a loop with a diameter to match that of the "throat" of the funnel (where the conical "mouth" joins the narrow spout) and then the rope is tied tightly around the two adjacent pieces of palm wood. With the loop on top, the tip of the funnel simply passes through the loop and is inserted into the perforated half-inch hose. Where this hose leaves the structure, it is tied firmly to a stake driven into the ground at the right place to maintain proper orientation of the mouth of the funnel. A small piece of plastic mesh is folded and inserted into the "throat" of the funnel to prevent entre of debris.

The edge of the sack is rolled down to adjust to the height of the platform and is wired or tied temporarily to four nails driven into the underside of the adjacent pieces of palm wood. If sacks are not available, baskets may be woven and lined with palm leaves.

Figure 4: Squatting model UDDT made of palm wood, a funnel and a sack. Privacy walls were added later. Larger funnels may also be preferred

If desired, plastic bottles may be cut to replace the factory-made funnel. Also, urine may be stored in bottles to be carried to agricultural fields.

d) Portable Urinal using 2 Plastic Bottles

Materials:

- 2 plastic 4-litre bottles
- Adhesive tape
- Plastic string and/or wire

Figure 5: Two positions for women to use this Portable Urinal. (Photos taken with the subject's knowledge and permission.)

This simple though useful implement is made with two plastic bottles, joined together at their mouths (Figure 5). The upper one is cut to serve as a funnel to catch the urine, while the lower one serves to store the urine. Very little odor is generated, as it must leave via the narrow mouth and air movement across that mouth is largely blocked by the upper bottle. As soon as is convenient, the urine is dispersed on agricultural soil as fertilizer. The urinal is then rinsed with water and is ready to be used again. In dry places, it is important to dilute the urine with water (which may be greywater), at a proportion of at least 3:1, water:urine, thus more water than urine.

The urinal is made in the following steps:

i. Carefully mark and cut one of the bottles diagonally through its cylindrical part, starting near the handle (see Figure 3).

ii. Connect the joined spouts of the two bottles with strong adhesive tape (e.g., duct tape). The top bottle may also be selected such that its mouth fits snugly into the mouth of the bottom bottle.

iii. Tie a loop of strong string between the handles of the two bottles, loose enough that it may be flattened against their mouths during the next step.

iv. Firmly affix the two bottles together with wire or string, tying tightly at the base of the threads shaped for screwing on the lid, strongly enough to withstand 4 kg.

v. Especially if wire was used, cover once again with tape.

vi. Wrap the entire connection in plastic string or fibers, for aesthetics and to prevent loosening of tape through exposure to water and urine.

A man may use it standing with the urinal held in the hand or set upon a platform that puts it at the proper height. A woman may conveniently use it in either a squatting or a semi-standing position (Figure 5). It is then set upright on the floor to await the moment to be emptied. There need not be any direct contact between the user's genitals and the urinal.

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