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Dry Toilets in Urban Crises Scenarios

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ABSTRACT

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An increasingly urbanizing planet that struggles with a shifting climate has called for new technologies and methods for transportation, power production, housing etc. Aging and overtaxed sanitation infrastructures are seeing pressure to change as well. As man-made and natural disasters increasingly affect urban communities the need for effective emergency sanitation has never been greater. Based off the continued success of the NGO SOIL found in Haiti (2006-present), this thesis suggests that the most effective sanitation solutions both logistically and in terms of design are those that implement dry toilet technologies. Design and construction of dry toilets that encourage community involvement and local materials along with the management and operation of composting sites is arguably the most realistic approach to long-term urban community disaster relief. This thesis considers many of the current actors and standards within the field of emergency response as is it concerns sanitation. Basic design and techniques for composting large amount of human waste are also discussed. Finally, the authors own attempts at dry toilet design and building are presented.

Key words: ecological sanitation, emergency sanitation, composting toilet, dry toilet, urine diversion dry toilet, wash

CONTENTS

ABBREVIATIONS AND TERMS

C:N –Carbon to Nitrogen ratio

Eco San –Ecological Sanitation

ICRC –International Committee of the Red Cross/Red Crescent

SOIL –Sustainable Organic Integrated Livelihoods

UD –Urine Diversion

UDDT –Urine Diversion Dry Toilet

UNHCR **–**United Nations High Commission for Refugees

WASH –Water, Sanitation, and Hygeine

WHO – World Health Organization.

1 FORWARD

“Thou shalt have a place also without the camp, whither thou shalt go forth abroad: and thou shalt have a paddle upon thy weapon; and it shall be, when thou wilt ease thyself abroad, thou shalt dig therewith, and shalt turn back and cover that which cometh from thee” (Deuteronomy 23:12-13).

The proper disposal of human waste cannot be overestimated or stated. Verses not unlike the Old Testament scripture fabove can be found in many religious texts, and world literature offers some intriguing observations.

The French classic novel, *Les Miserables*, includes a chapter called “The Intestines of the Leviathan” in which author Victor Hugo bemoans the waste of Paris’ sewer system, citing the traditional use of night soils in China as fertilizer and the inefficiency of using anything other than what courses through the bowels of Paris.

The dilemma of what to do with human waste has typically been relegated to obscure verses in scripture and omitted from polite public discourse and artistic ventures. Nevertheless, sanitation has lost none of its relevancy. As developing nations urbanize, the need for cost-effective forms of sanitation will continue to grow. Dry and composting toilets may one day be common and desired technologies. However, for that to happen a paradigm shift must occur.

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2 INTRODUCTION

The use of human waste as a fertilizer is a practice dating back millennia. Nevertheless, the taboo of handling or working with faeces has created many broke down or aging waste-treatment infrastructures that either need refurbishment or a complete overhaul. In a rapidly urbanizing planet, this comes with unfortunate consequences. We have seen cities hit by natural disasters, only to incur a second wave of devastation caused by the spread of faecal-oral diseases. Even the industrialized, ostensibly prepared countries have fallen victim to poor waste management during moments of crises. The provision of safe and clean drinking water is of the utmost importance, but what this thesis wishes to illustrate is that for the continuing safety of any water supply; an engaged and effective waste management program, not unlike the one pioneered by SOIL in Haiti, must be implemented.

The invention, use and spread of the flush toilet, along with waste treatment infrastructures has all but eliminated cholera in industrialized countries. While the flush toilet is seen as the highest attainable point of sanitation, they require a tremendously complex system of pipes, sewers, waste-treatment plants and people with highly specialized skills and knowledge to operate all these mechanisms. Such infrastructure is often far beyond the grasp or capability of many rapidly growing urban areas in the developing world. Open defection for many societies is the only method of sewage disposal, as are flying toilets (refuse filled plastic bags that are thrown away). Poorly maintained and expensive public toilets only compound frustrations and ultimately lead inequitable outcomes in sanitation and hygiene. The core of sanitation problems cannot be completely solved by feats of engineering. While the act of providing fresh and clean water to these communities can be achieved, in part, by newer technology and advanced engineering techniques; sanitation, at its core, is a social issue. While the demand for clean, safe water is universal, as is its method of consumption, the practices by which human beings treat and dispose of their wastes are wide and varied with each culture operating by its own set of taboos.

The success of a sanitation project begins and ends with the community. Facilities constructed in partnership with agencies and using the skills and knowledge of those in the community provide an infinitely more effective and long-term means of sanitation than would (hypothetically) chemical latrines for every family.

A significant amount of sanitation development and treatment revolves around human defecation. Devising a method of containment is initially the best response. Containment methods isolate the risks associated with human waste to a specific region or facility, which in the short term is an effective method. But as many humanitarian projects have shown, internal displacement and refugee-camps are hardly ever short term and may remain for years. The short-term solution implemented at the beginning becomes overrun, ill-maintained and presents potential sources of embarrassment for both the community and any humanitarian agencies involved.

The taboo associated with human defecation is one of the largest hurdles. Taboos function differently in different cultures. In the West, the encyclopaedic list of neuroses and bathroom related issues has been the fuel and fodder of comedians for years. In Western public bathrooms, stalls are erected between toilets to afford the user privacy. However, in many places, exchanging morning pleasantries in an open field with one's neighbour is not uncommon.

Everyone poops, no one is exempt, so addressing the subject of proper sanitation is not something to be shunned or avoided. Community participation is ultimately the deciding factor of whether a sanitation project is or is not successful. Toilets should be constructed by members of the community in a design they have chosen and with which they are comfortable.

Since humanitarian agencies operate largely by means of private and public donations, their presence in the wake of a disaster or in an emergency camp is temporary, both financially and by the nature of the emergencies themselves. Relief work for disasters and emergencies have a fiscal expiration dates, and past this point affected communities are often left on their own. When this happens, projects may go unfinished, unsupervised, and unused if community participation has not been encouraged from the very beginning.

In this thesis I will describe the sanitation methods recommended and most used in disaster scenarios, as well as the organizations and actors from whom much of the information is drawn. I will illustrate the benefits and successes of dry toilet and composting methods and how they improve upon the strengths of non-dry toilet and composting technologies. Included at the end of this thesis will be a simple design for a composting toilet to be used by first responders in emergency situations. The title of this thesis refers to urban settings, but much of the information found here originates from rural applications. The impetus for the thesis comes from the increasing incidence of urban disasters. In a rapidly urbanizing and changing planet, communities with ill-prepared infrastructures for large increases in population are even less prepared for when it comes to potential crises that may emerge, natural or otherwise.

Rural camps, communities, or populations have the advantage of space and often loose soil. Urban settings are crowded, concrete jungles that are ideal environments for the spread of disease and infection. With the increased frequency of both disasters and large urban populations, new methods need to be introduced to effectively deal with the inevitable build-up of human waste, post crises.

Dry toilet and composting technologies have many detractors when it comes to their application in urban environments. Urine Diversion toilets especially prove to be difficult because they require some user training. During emergency situations there is often no time to train the user how to properly use an unfamiliar toilet technology – for this reason it is important to initially integrate older, more familiar technologies with innovative dry toilet and composting technologies.

The number of organizations that have begun to experiment with dry toilet and composting technologies is gradually increasing. The majority of these organizations have “Water, Sanitation and Hygiene” programmes, commonly referred to as WASH.

WASH or WSH is the standard acronym used by aid and humanitarian organizations to signify these procedures and standards for sanitation. The best summary of WASH, its goals and procedures is contained in the The Sphere Project Handbook: Minimum Standards in Water Supply, Sanitation and Hygiene Promotion (2011, 84):

"The main objective of WASH programmes in disasters is to reduce the transmissions of faeco-oral diseases and exposure to disease-bearing vectors through the promotion of:

- Good hygiene practices
- The provision of safe drinking water
- The reduction of environmental health risks
- The condition that allow people to live with good health, dignity, comfort and security"

I will argue that there is no better technology that satisfies and goes beyond the goals of any WASH than dry and composting toilets. In this thesis I will demonstrate the practicality of dry and composting toilet technologies and advocate their increased use in emergency scenarios; with a special emphasis on urban settings.

2.1 ORGANIZATIONS

Providing safe and adequate sanitation alone can be an enormous undertaking, in emergency scenarios the demand for such services can become exponential. But there are an increasing number of organizations that do take sanitation seriously; not only providing clean drinking water but ensuring its continued cleanliness and safety by providing proper sanitation facilities.

2.1.1 International Committee of the Red Cross/Red Crescent (ICRC)

Since 1863 the Red Cross has worked worldwide to provide humanitarian help and aid to people affected by conflict, armed violence, and disaster. It is an independent and neutral organization that received its mandate from the Geneva Convention in 1949. The International Committee of the Red Cross/Red Crescent employs some twelve thousand people in eighty countries. It is financed by government donations and donations from the various national Red Cross/Red

Crescent Societies. In crisis situations the Red Cross/Red Crescent conducts 'appeals' to the world public for aid.

2.1.2 United Nations High Commissioner for Refugees (UNHCR)

Established on December 14, 1950 by the United Nations General Assembly, the agencies mandate is to protect and resolve refugee problems worldwide. After six decades the UNHCR has a staff of 7,685 working in over 125 countries helping some 34 million people. The UNHCR is governed by the UN General Assembly and the Economic and Social Council (ECOSOC).

2.1.3 Oxfam

Oxfam can trace its roots back to the l940's when committees in Great Britain under that name lobbied the government to ease the Allied Blockade in Europe so that vital supplies could reach civilians. Since then, Oxfam has grown into an international confederation of over seventy organizations networked together in ninety countries. Oxfam receives its income from a variety of sources: sales from charity shops, donations by individuals, fundraisers, and bequests.

2.1.4 The Sphere Project

The Sphere Project is a voluntary association of humanitarian agencies (governmental and non-governmental). Sphere seeks to set standard for humanitarian work in crises situations. It provides training for aid workers and publishes a handbook for emergency response situations. Sphere has two founding principles:

(a) that those affected by conflict or disaster have the right to a life with dignity and therefore a right to assistance

(b) that possible steps should be take to alleviate human suffering arising out of disaster or conflict (The Sphere Project, 2018)

These have become the two founding principles of SPHERE, principles they continually seek to achieve and improve upon. The SPHERE Project Handbook is one of the most reliable sources of information for standardized humanitarian aid work. Each section of the book deals with different humanitarian tasks. These tasks are further broken up into subsections. Every subsection, whether it be excreta disposal is assigned certain minimum standards, corresponding key actions to achieve these and indicators to measure.

2.1.5 Sustainable Organic Integrated Livelihoods (SOIL)

SOIL is a non-profit organization based in Haiti that was founded in 2006 by Doctor Sasha Kramer (PhD). Initially a rural development organization aiming to slow and eventually reverse Haiti's problems with deforestation, SOIL relocated to Port Au Prince following the 2010 earthquake to help with emergency reconstruction. Oxfam and SOIL quickly partnered to develop a project that would use the UD (Urine Diversion) toilets of SOIL as a method of sanitation in Haiti's internal displacement camps. The success of this effort, using a method originally thought inappropriate, has inspired a multitude of organizations.

Since the 2010 earthquake and their collaboration with Oxfam to provide Eco-San toilets to displacement camps, a paradigm shift has evolved. The cholera outbreak in October 2010 made headlines all over the world, to date affecting over 600,000 people and causing the deaths of nearly 10,000 people. In the months after the earthquake SOIL built over 200 public toilets in 31 camps, providing sanitation to over 20,000 people (Kramer, Sasha. 2011)

2.2 COMPOSTING

The composting of human faeces in an urban environment presents a unique challenge and its own set of problems. Ecological sanitation is by no means a simple method of sanitation. There is no single technology that would allow humanitarians, aid workers, and those affected to focus on other, less unpleasant things. Every emergency, disaster, culture, setting, requires its own solution specific to the difficulties presented; composting toilets just satisfies a great scope of them. The information found in the following tables is found in the WHO Guidelines for the Safe Use of Wastewater, Excreta, and Greywater (2006).

2.2.1 Pathogens

Human faeces contain a variety of pathogens. These pathogens cause many illnesses – some chronic and others fatal. The following (bacteria, viruses and helminthes) are examples of the most common pathogens found in faecal matter and their potential consequences if handled improperly.

2.2.2 Bacteria

Bacteria are single celled organisms measuring several micrometers in length. They come in a variety of shapes and sizes and can be found everywhere, including the world's most uninhabitable environments. The biomass of the world's bacteria outweighs that of its plants and animals. Bacteria make up 80%-90% of the billions of microorganisms usually found in a gram of compost (Cornell University , 1996)

Bacteria	*Diseases*
Aeromonas spp	*Enteritis*
Compylobacter jejuni/coli	*Campylobacteriosis*
Escherichia coli (EIEC, EPEC, ETEC, EHEC)	*Enteritis*
Plesiomonas shigelloides	*Enteritis*
Salmonella typhi/paratyphi	*Typhoid, Paratyphoid fever*
Salmonella spp.	*Salmonellosis*
Shigella spp	*Shigellosis*
Vibrio Cholera	*Cholera*
Yersinia spp.	*Yersiniosis*

2.2.3 Viruses

Viruses are microscopic organisms that can only replicate themselves within the cells of a host. They are comprised of remnant DNA and RNA strands.

Viruses	*Diseases*
Enteric Adenovirus 40 and 41	*Enteritis*
Astrovirus	*Enteritis*
Calcivirus(including norovirus)	*Enteritis*
Coxsackievirus	*Various respitory illnesses; Enteritis; virus meningitis*
Echovirus	*Aseptiv meningitis; encephalitis; often asymptomatic*
Hepatitus A	*Hepatitus*
Hepatitus E	*Hepatitus*
Poliovirus	*Poliomyelitus*
Rotavirus	*Enteritis*

2.2.4 Parasites

Parasites are organisms that live on or in a host and get their food at the expense of the host. Protazoa are single-celled microscopic animals, they act much in the same way as bacteria in feeding off organic matter but will also act as secondary consumers by eating both bacteria and fungi.

Parasitic Protazoa	***Diseases***
Cryptospoidium Parvum	*Crypstosporidiosis*
Cyclospora Cayetansis	*Often Asymptomatic; diarrhea, abdominal pain*
Entamoeba Histolytica – Amoebiasis	*often asymptomatic; dystentery, abdominal discomfort, fever, chills*
Giardia Intestinalis	*Giardiasis*

2.2.5 Helminthes

Helminthes are any sort of parasitic worm. They are transmitted through eggs found in human faeces and are found in soil where sanitation is poor.

Helminthes	***Diseases***
Ascaris lumbrioides (roundworm)	*Ascariasis; enteritis, pulmanary eosinophilia*
Taenia solium/saginata (tapeworm)	*Taeniasis*
Trichuris Trichiura (whipworm)	*Trichuriasis*
Ancylostoma duodenale/Necator americanus (hookworm)	*Itch, rash, cough, anaemia, protein deficiency*
Schistosoma spp. (blook fluke)	*Schistosomiasis, bilharzia*

2.2.6 Purpose of Composting

The purpose of composting is to reduce the pathogens contained in human faeces. While urine is sterile, faeces contain many harmful pathogens. Uncontaminated urine (no presence of faecal waste) can be used immediately as a source of fertilizer because of its high nitrogen content. Faecal matter however must be treated by composting rid it of any harmful pathogens. The resulting product is an excellent source of fertilizer that can be used to reduce a developing economies dependency on expensive, nitrogen-based artificial fertilizer. Finished compost bears very little risk to humans and can be utilized, or not, by a variety of means. Most importantly though is the fact that any future risk that could be associated with untreated faeces is now virtually non-existent.

2.2.7 SOIL Method of Composting

The method described here is what is currently being used by SOIL in Haiti. Much of the procedure was developed through trial and error and some of it was still in its earliest stages of development upon publication of their guide in 2011. All methods though are based off of common composting practices, though every situation calls for some degree of ad-hocism. The following procedures can be found in greater detail in the SOIL Guide to Ecological Sanitation (2011, 86 – 92)

2.2.8 Phase 1

Phase 1 requires the use of a purpose-built composting structure. The composting structure has an inclined cement bottom so that any runoff can be directed towards a containment system to prevent ground water contamination and/or potential loss of nutrients through leaching into the surrounding soil. The sides of the composting structure are permeable to allow air to circulation throughout the composting material. A cover - tarpaulin or roof – alongside good drainage are important to prevent anaerobic conditions that often arise when compost is so wet that oxygen is unable to move through the material with ease. Many industrial composting applications will use fans and blowers to facilitate oxygen flow throughout the process. However, moisture is still an important component to a healthy compost. Too much creates anaerobic conditions, too little will dry out the compost, causing a loss of valuable nutrients. During hot and/or dry spells, compost piles may need an additional moisture to properly work.

Faeces collected from the UDDTs in Haiti are picked up three times a week by truck and brought to a secondary composting facility in Pernier, Haiti. SOIL uses 15 Gallon (57 Litres) drums as receptacles in their toilets. This method allows for easy collection and transport of faeces from the collection points to composting facilities. A 57 litre drums can weigh up to 50kg, depending upon the moisture content of the waste.

The waste is then dumped into a cement bottomed structure for composting. Any leachate runoff is monitored, collected, and returned to the compost pile.

Phase 1 composting encourages the development of thermophilic temperatures. A thermophilic temperature is between 50-60 degrees Celsius. Preceding the thermophilic stage is the mesophilic, which is anywhere from 20 degrees Celsius, to just above 40 degrees. The mesophilic stage lasts normally for two to three days, where mesophilic organisms break down soluble and readily degradable organic matter, thus creating heat. The corresponding rise in temperature marks the transition from the mesophilic to the thermophilic stage. As the temperature rises past 40 degrees Celsius mesophilic organisms become less competitive allowing for thermophilic organisms to take over. Thermophilic organisms like actinomycetes, fungi, protozoa, and rotifers aid in the die-off of the otherwise harmful viruses and bacteria found in human waste by raising the temperature beyond habitable temperatures. At the end of two months of composting at thermophilic temperatures many of the harmful bacteria found in faecal matter will have died off.

The first phase of composting is the phase that requires the greatest deal of attention and technical know-how. These initial stages of decomposition require oxygen, moisture, and an ideal Carbon to Nitrogen ratio (30:1).

For thermophilic conditions to begin the growth of oxygen loving bacteria is required. To accomplish this, the compost pile is ‘bulked up’ with vegetative matter. SOIL used bagas (a sugar cane production by-product) in a 3:1 ratio, 3 drums of human waste to one drum of bagas. This 3:1 approach allows for the even flow of oxygen to pass through the pile.

The ideal Carbon to Nitrogen (C:N) ratio for composting is 30:1 but oftentimes the C:N ratio present in faeces is 5-10:1, too low to provide adequate food for the microbes responsible for thermophilic conditions. Bagas is the secondary source of vegetative carbon that is added, other sources maybe sawdust, leaves, grass-clippings, or food scraps. It is important to note that many wood-products take a longer time to decompose and may have been chemical treated, which can alter and/or hinder the decomposition process. Finding an adequate and reliable source of carbon to use is important in composting faeces. Once the composting structure has been filled it is left for two months and Phase 1 has been completed.

2.2.9 Phase 2

The second phase of SOIL’s composting process involves emptying the composting structures and organizing the compost into windrows. A windrow is a row of compost material heaped together to dry in the open. After two months in the composting structure the volume of compost waste has decreased by 40% to 80% (Jenkins 2005 according to SOIL 2011, 91). It is now a dense and heavy mound that must be removed from the composting structure and placed into windrows. Manual transport of compost in this state is time consuming and physically taxing exercise when producing large quantities. It is easier to use machinery for this part of the process, although machinery can be expensive to rent or transport where it is needed. Phase 2 composting takes 4-6 months. The windrows require less control and infrastructure than composting pens. SOIL's dimensions for the size of windrows are 1.30m high by 4m in wide. They may be up to 50m in length (SOIL 2011, 91).

It is important to introduce oxygen into the windrows to encourage aerobic decomposition. This can be accomplished by turning the windrows but this requires heavy machinery or an unreasonable amount of manual labour. A 6-month period for phase two is recommended without turning. But if heavy machinery is available perhaps the time required to produce a finished product can be reduced. It should be noted that any method in which oxygen can be introduced into the windrows would be beneficial.

The occasional introduction of water from a rain shower is often a welcome addition to the windrows. By this point the harmful bacteria have died off and contamination from runoff is much less of a risk. Heavy showers, however, can cause nutrient loss and deplete the value of the final product. When continuous rain threatens the compost, plastic sheeting may be placed over windrows to protect them. It is also possible to construct drainage channels to collect any runoff. Channels can be directed to a basin filled with an absorbent but compostable material that can be reapplied to the windrows.

3 TOILET DESIGN

Toilet design has a long and rich history. The mechanics alone required for the first rudimentary flush toilets found in Roman ruins that required feats of engineering years ahead of their time. The eventual development of the flush toilet and their use in a public capacity went through many revisions and adaptations. Finally, the toilet design we find ourselves with today, particularly in western countries, has not changed or improved a great deal in more than a century. Attempts made to improve upon toilet design in many developed countries are often considered peculiar and unnecessary. While overall toilet design has not seen many improvements, the application and accessibility of toilets has often become a hot button political issue.

The squatting toilet is perhaps the most feared method of toilet to westerners. But proponents and converts to the squatting toilet laud its hygiene (it being infinitely easier to clean than a seated toilet), and the benefits of its user mechanics. The seated toilet is perhaps the more comfortable of the two designs, but it fights the body's natural and evolutionary tendency to squat. Humans control their bowels largely through holding and releasing their sphincter, but that alone does not guarantee continence. The bend between the rectum and the anus – where faeces is gathered and ejected respectively – is what controls the continence we so highly value. The puborectalis muscle controls the bend between the rectum and anus, which while standing can reach an angle of 90 Degrees. Squatting relaxes the puborectalis muscle and straightens the bend allowing for easier passage. Open defecations fields are often recommended, but rarely used, method of first-response sanitation. This is due to the large amount of space that is needed for an open defecation field (0.25m^2/person/day, plus access paths)(UNHCR 2007, 267), and the necessity for proper maintenance and security.

Building a dry toilet in an emergency scenario, particularly in an urban setting, may seem more than necessary – but when it comes to sanitation, any preventative measure is worth ten-fold of any cure. This thesis will go on to show the basic functions and mechanisms of a dry toilet, illustrating the relative ease of their design and construction. It may be theorized that a dry toilet can be constructed by a single person, in a day's time, using readily available or found materials and basic tools. A rudimentary dry toilet, when properly maintained, can serve a family unit, or more, indefinitely, with greater effectiveness and speed than a pit-latrine.

3.1 Problems with Toilet Design

The problems and issues with building a toilet in any scenario are numerous. When building a composting toilet in an urban setting there are a few important things to consider. First and foremost is whether it will be a sit or squat toilet; this affects the overall design of the superstructure. If the toilet design is to be squatting, it is important to know if the use of toilet of paper is customary or if users practice anal washing (the anus is washed by hand using water), which will increase the amount of liquid waste going into the toilet itself. Liquid waste one of the larger hurdles and what causes the most difficulty. It should be reduced in any way possible (providing standing urinals for men); liquid wastes add to the weight of the overall toilet and can contribute to its unpleasant smell if left stagnate. Urine diversion dry toilets (UDDT) divert urine from the solid waste receptacle into a separate container. In emergency scenarios a UDDT is an impractical technology to begin with because users unfamiliar with the design will have to be trained in its proper use.

In most scenarios, organizations would encourage the use of pit or trench latrines, as they are easier to construct and maintain. These kinds of latrines are vulnerable to flooding and ground water contamination. They also need space and malleable soil that is not usually available in urban settings. In urban environments many aid organizations will bring chemical latrines, these however are difficult to maintain and require specialized septic trucks to be emptied.

3.2 Materials

A dry toilet can be made or repurposed from a variety of materials. Many people and organizations (including the author) have experimented with turning Chemical Latrines into functioning dry toilets. This section will give a brief overview of how one might go about retrofitting a chemical latrine. As well, how someone might use a bucket or similar containers to build a dry toilet.

Materials that are used to build emergency toilets can be either found or locally sourced. This takes advantage of local knowledge, skills, economy and encourages community participation. Local materials, tools and skills speed up the response time to meet the needs those building toilet, as opposed to waiting for tools and materials to be provided by outside sources.

A container, more often a bucket or any sort of waterproof and lightweight container, will be used as the main receptacle for both solid and liquid wastes. A 15 gallon or 57 litre buckets will be used as an example, since this is the same sized bucket SOIL uses. Many have also experimented with converting chemical latrine toilets into functioning Eco San toilets, this method will also be described. Seated or squatting, waste will fall into the toilet the same way, but care needs to be taken to ensure that the toilet is not so close to the seat or squatting plate that the user experiences splash-back. The elevated structure of a seated or squatting toilet requires that it be able to bear a great deal of weight and it is important to note the user mechanics (sitting or squatting) of in each scenario.

In this design, there will be a sieve towards the bottom of the receptacle that will allow for liquid wastes to drain through the faeces and into the bottom of the toilet. The sieve can again be made from a variety of materials, but care should be taken that it remains at a designated height, allowing room for liquid wastes at the bottom. Draining off the liquid wastes more frequently, because of their higher rate of production, a waterproof spout, faucet, or plug should be attached to the bottom of the toilet. This allows for the liquids wastes and urine to be drained into a separate container. Due to frequent handling of the waste container, any drain mechanism should be sturdy to avoid any damage that frequent handling might cause.

The container should be a water-proof and sealable receptacle that can be easily emptied and transported. This can be either a bucket or the toilet in a chemical latrine.

Chemical Latrine toilets are normally emptied by vacuum because the combination of liquid wastes and the chemicals used liquify all wastes collected;

this is something that is not the case of composting technologies. Therefore a Chemical Latrine toilet container need to be refurbished to open and close, as if it were a suitcase. Buckets and toilets can be sealed and taken to a secondary composting site or emptied into another container at the site of the toilet. However, this will create an unfavourable odour to those living nearest to the toilet.

Many buckets or even chemical latrine toilets narrow towards their bottom, a sieve of sorts can be placed with relative ease and stability, with enough room to collect liquid waste. A sieve can be made from a variety of materials and can be as simple as a cut-to-size piece of sheet metal or hard plastic with holes drilled through. Liquid waste invariably will settle towards the bottom. A sieve will allow this waste to be separated from the solids and emptied with greater frequency (through a plug, valve, or faucet of some sort) than the solid wastes. This will help reduce the odours that come naturally toilets, as well as the collection weight of the receptacle.

4 DISCUSSION

The structure illustrated in the Appendix shows simply a method of collection. The collection of faeces allows users to control what then happens to the faeces in the long term. As with any method of sanitation, the often ignored second act of sanitation – what eventually happens to faeces - is what determines the effectiveness of any system. Whether that be a system involving extensive underground pipes and a sewage treatment plant, or the manual transport of collected faeces to a secondary composting site.

Waste collected in any receptacle will begin to compost almost immediately. The rate at which a toilet is filled and eventually emptied, assuming that it is properly maintained (provided with a steady supply of easily composted carbon materials, and the draining of liquid waste), determines how much composting will occur. Waste must then be taken to a secondary composting site or facility. Depending on the number of users, the location, and availability of space, a secondary composting site can be anywhere from a few meters away to several kilometres. Secondary composting facilities then treat wastes through Phase 1 and 2 (see 3.2 Composting). The result of composting should be a viable source of fertilizer.

There are other methods of sanitation more commonly used in emergency scenarios that will compost faeces, albeit without any human intervention and encouragement. Trench, pit, and borehole latrines all collect faeces in holes dug into the earth. None of them separate solid from liquid wastes and once the holes are full they are covered up and abandoned. While the faeces collected will eventually compost, the environment they are left in does nothing to accelerate process and leaves the collected waste along with all of its pathogen vulnerable to flooding, soil collapse and groundwater contamination.

The benefit of Ecological Sanitation is that faeces are treated from beginning to end. From the moment waste falls into the receptacle, it is covered in carbon (ideally vegetative) matter to dampen the smell and discourage flies. Liquid waste is either captured upon release (often by way of an ergonomically placed funnel) or drained through the solid waste. When toilets are full they are then collected and taken to secondary site where they are composted and monitored until any pathogens present become inert. Because waste is collected in sealed containers they are not as vulnerable to flooding and ground water contamination as other methods are.

5 CONCLUSION

In almost all the source material, any directions given concerning the engineering of toilets is prefaced by long recommendations about gathering community interest and participation. Toilets, no matter their form or eventual function must still gain popularity over older, perhaps archaic, forms of relieving oneself. Many organizations have grand openings for new facilities, encouraging the local community to come and celebrate as well learn how to properly use and maintain a composting toilet. Others may simply try to appeal to the user’s aesthetic and hygienic values by offering a more attractive, cleaner alternative to other methods of sanitation.

Active participation and enthusiasm for any sanitation project, particularly ecological sanitation, needs to be present from the very beginning. Because of this, work for pay is unavoidable. The need for manual labour by the community is necessary and because the nature of the work is normally reserved for the lowest caste members in many cultures, an effort should be made to ensure that isn't the case. Overall Ecological Sanitation should be favoured over most emergency methods because it creates a functioning system of sanitation from the very beginning, as opposed to simply a method of containment.

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APPENDICES

Appendix 1. Ecological Sanitation Bucket

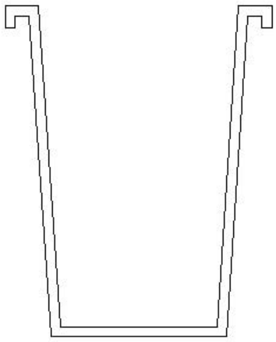


FIGURE. A bucket or any water-tight container that could be conceivably refurbished into a composting toilet can be used. A bucket such as the one illustrated can be sealed and transported, or simply emptied, with relative ease.

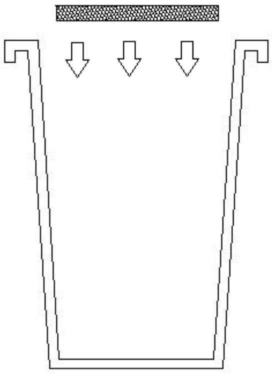


FIGURE. A sieve placed into the bucket will separate solid and liquid waste. The function of the sieve is to drain off the liquids that add to the overall mass and smell of feaces. This allows for the bucket to be used for longer periods between emptying.

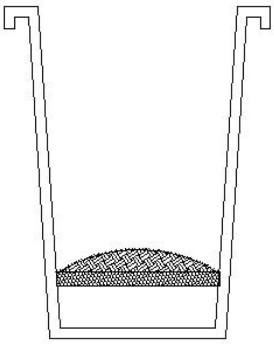


FIGURE. Once a sieve is in place it is a good idea to place a small about of composting or “bulking” material overtop insure only liquid waste makes it through the sieve.

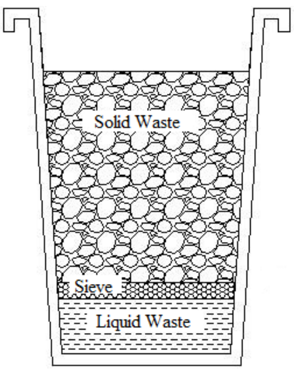
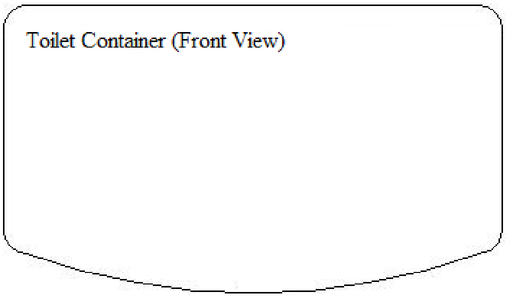
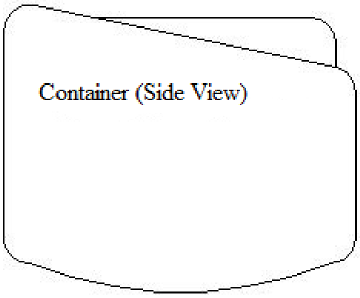


FIGURE. . This diagram shows how a Eco-San bucket would work. Solid waste gathers on top and liquids drain to the bottom.

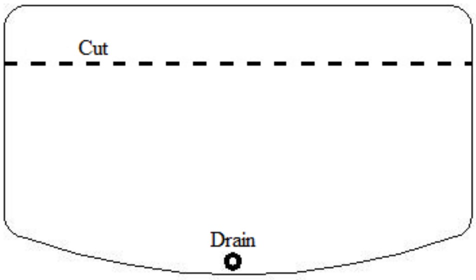
Appendix 2. Refurbished Chemical Latrine

Most chemical latrines come with a container like the one here. It is only access points are through its toilet seat and ventilation hole. In order for it to function as a dry toilet the waste must be more accessible. So the container will need a large access point.

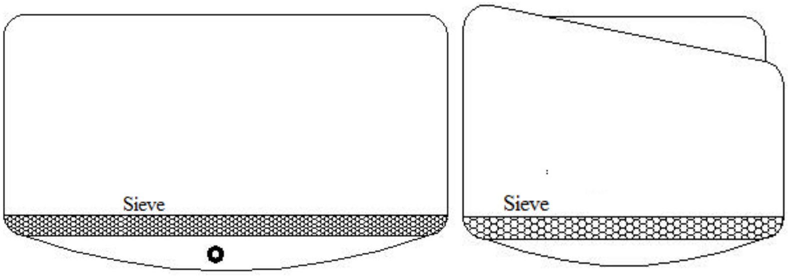




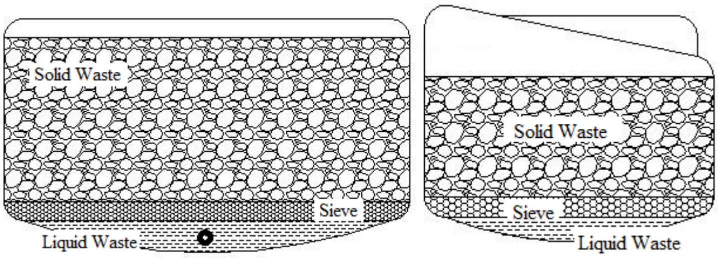
This particular toilet has a rounded bottom, which makes it ideal for a sieve to be placed at the bottom to separate solid and liquid waste.



Cutting along pre-existing seams will help maintain some structural integrity. Still, additional structural compensation and support will be needed in order for the toilet to maintain its shape.



A sieve placed along the bottom will allow liquids to drain out of the solid wastes. A drain, spigot or plug can be used to empty liquid waste with great frequency than the



This diagram shows how the dry toilet should function when in use. As the toilet is used solid waste will gather and begin composting, liquid waste will migrate to the bottom of the toilet through the sieve and intermittently drained.

The authors finished dry toilet was able to make use of the chemical latrines super-structure. The toilet itself could be open and closed like using a hinged lid, or withdrawn from a panel in the back of the toilet.