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Solid waste and faecal sludge management in situations of rapid, mass displacement[1]

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Question

What lessons and evidence is there from situations of rapid, mass displacement into sites and/or camps with limited space and limited physical access options for solid waste and faecal sludge management?

Contents

[1] Part of a series of queries relating to the Bangladesh Rohingya refugee crisis (WASH series)

The K4D helpdesk service provides brief summaries of current research, evidence, and lessons learned. Helpdesk reports are not rigorous or systematic reviews; they are intended to provide an introduction to the most important evidence related to a research question. They draw on a rapid desk-based review of published literature and consultation with subject specialists.

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1. Overview

Solid waste and faecal sludge management in situations of rapid mass displacement are important to public health and providing for a better environment. Despite this, both have been neglected in WASH programmes, which tend to have a focus on water. However increasing efforts are being made to find solutions to challenges in solid waste and faecal sludge management in difficult circumstances in humanitarian emergencies.

A recent systematic review looking at short term water, sanitation and hygiene (WASH) interventions in emergency response found that '[d]espite regular use, emergency WASH strategies have a limited evidence-base' and as delivering assistance has generally been prioritised over research, much of the available literature is about 'best practice' rather than 'evidence based' programming (Yates et al, 2017, p. i). As a result 'evidence remains low and lacking' (Yates et al, 2017, p. iii). An analysis of emergency WASH looking for gaps and spaces for innovation found that 'sanitation issues were identified as the major area with gaps and potential for innovation' (Bastable & Russell, 2013, p. ii). Both solid waste and faecal sludge management fall under sanitation within WASH. Key gaps are around 'excreta disposal issues such as latrines in areas where pits cannot be dug, desludging latrines, no-toilet options and the final treatment or disposal of the sewage' (Bastable & Russell, 2013, p. iii).

Most of the available literature uncovered by this rapid review is grey literature, offering guidance on solid waste and faecal sludge management, rather than peer reviewed papers. It is not always clear what evidence the guidance papers used in this rapid review are based on. However, they have been written and produced by people and organisations who have worked extensively on WASH in emergencies.

Findings include:

Solid waste management

- It is important to immediately clear any toxic materials, remove blockages to thoroughfares or drainage channels, and remove dead bodies.
- Humanitarian aid generates a lot of waste which must be dealt with.
- Good management and systems are essential; this involves proper assessment of the waste systems and support for local capacity.
- It is important to involve the local community in planning and implementation.
- Communal waste bins can be useful for waste collection in the early stages of an emergency, and regular collection of waste for disposal is essential.
- Transport of waste will depend on waste generation rates, issues of access, and the distance between collection and disposal points.
- Existing waste infrastructure should be used. If it is lacking, a temporary solution may be communal disposal pits, or household pits if the space permits, but better and safer long-term solutions for final disposal should be found.
- Recycling can reduce the amount of waste for disposal and in some cases be a source of local income. Informal recycling is likely to occur naturally, even though formal recycling is often difficult in the early stages of an emergency due to the high level of organisation and manpower needed.
- It is important to ensure the safety of those collecting waste.

Faecal sludge management

- Indiscriminate defecation is usually the main health hazard of the first phase of an emergency and the main objective of faecal sludge management should be to prevent this.
- The specific needs of children, women, the elderly and those with disabilities need to be considered.
- Proper planning with communities for excreta disposal is important from the start of an emergency and should aim to meet the Sphere Standards on excreta disposal.
- Immediate responses include building latrines, providing biodegradable bags, and designated defecation areas.
- Local contractors are usually used to desludge and dispose of faecal sludge, yet local capacity is often lacking and should be supported.
- Innovative solutions are being developed for desludging in difficult areas; although it is likely that a combination of equipment is required in difficult to reach contexts.
- Efforts are being made to find ways to reduce the rate at which latrines fill up with faecal sludge and need to be emptied, including through the use of chemical additives, biological additives, and composting worms. Some of these experiments are showing positive results in reducing levels of faecal sludge in emergencies, including tiger worm toilets.
- Ecological sanitation (Ecosan) methods, such as urine diverting dehydration toilets, biodegradable bags, and composting toilets, aim to promote safe reuse rather than disposal of excreta, and can be helpful in flood-prone areas and locations where excavation is not possible.
- Efforts are being made to find ways to help sanitise faecal sludge and help prevent the spread of diarrhoeal diseases in emergencies, through the addition of lactic acid fermentation, urea, and lime to faecal sludge.

2. Solid waste management

Solid waste is non-liquid waste generated by human activity and includes general domestic rubbish and emergency waste from the packaging of emergency supplies, for instance (Reed & Mena-Moreno, 2016, p. 9, 19; Rouse & Reed, 2013, p. 27; Care International & ProAct Network, n/d a, p. 1). In emergencies domestic waste is likely to be limited but waste from humanitarian agencies can be significant, especially plastic bottles (Reed & Mena-Moreno, 2016, p. 18, 29). Solid waste management is part of ‘environmental sanitation’ and thus falls under the WASH cluster in humanitarian response, although there are overlaps with shelter and settlement (Reed & Mena-Moreno, 2016, p. 15). The objectives of solid waste management are ‘satisfactory storage, collection and disposal of solid wastes, as well as cleaning of streets and other public places’ (Reed & Mena-Moreno, 2016, p. 16).

Safe disposal of solid waste is critical for public health, as insects and animals which may carry diseases are attracted to rubbish; piles of rubbish can pose a fire risk; and loose rubbish can wash into and contaminate water supplies, and block water courses, causing flooding; while visible waste also lowers the morale of communities (Rouse & Reed, 2013, p. 27; Reed & Mena-Moreno, 2016, p. 15; Care International & ProAct Network, n/d a, p. 3). However, initially, in refugee or internally displaced persons (IDP) camps there are unlikely to be any arrangements in place to deal with solid waste management, and it is often a neglected area of environmental

sanitation (Rouse & Reed, 2013, p. 27; Reed & Mena-Moreno, 2016, p. 9). Discussions with those working in the humanitarian sector suggest that solid waste management is low priority due to a combination of factors such as lack of knowledge and expertise within the WASH sector; not being an immediate (health) threat; lack of basic equipment such as proper bins; experience of failure (e.g. waste collection vehicles breaking down); and inappropriate standards (Reed & Mena-Moreno, 2016, p. 34).

Reed & Mena-Moreno's (2016, p. 9) review of solid waste management in emergencies finds that very little innovation is taking place, despite the reporting of failures being common. They identify three areas where efforts could be encouraged: better processes for humanitarian agency waste; better communication to change perceptions and behaviour around the ownership of public space and waste; and better technology to reduce waste volumes, especially from humanitarian organisations (Reed & Mena-Moreno, 2016, p. 9-10, 35-36; Care International & ProAct Network, n/d b, p. 2).

The components of solid waste management systems

Solid waste management involves a series of interrelated operations, including (Reed & Mena-Moreno, 2016, p. 16):

- Storage of waste in household or communal containers;
- Waste collection from the storage containers (varies by methods and frequency);
- Transfer of waste from smaller containers to larger ones;
- Haulage of waste to a disposal site;
- Processing of any waste that can be recycled;
- Management of the disposal site.

Key considerations for solid waste management

Immediate response

In the first days of an emergency response the most urgent tasks in solid waste management involve clearing any toxic materials, removing blockages to thoroughfares or drainage channels, and the removal of dead bodies, as well as the clearing of scattered waste and the setting up of an onsite disposal system (Reed & Mena-Moreno, 2016, p. 12). After the emergency phase, solid waste management 'increases coverage of facilities, frequency of collection, and improvement of final disposal in a gradual manner' (Reed & Mena-Moreno, 2016, p. 13).

Assessment

Emergency solid waste management 'depends upon an efficient operational system being established from the very outset' (Reed & Mena-Moreno, 2016, p. 16). Rouse & Reed (2013, p. 28), in guidance provided by the World Health Organisation (WHO), suggest that it important to carry out an assessment of the current waste streams and problems before beginning work. This involves asking questions about the types and volume of waste being produced each day; current disposal and responsibility therefore; and whether current waste disposal systems are coping, for instance (Rouse & Reed, 2013, p. 28; Care International & ProAct Network, n/d a, p.

5). However, Reed & Mena-Moreno (2016, p. 13) points out that these assessments need to be rapid as a prompt response is required.

Types of waste and their disposal that need to be considered include: construction waste; organic waste; combustibles; non-combustibles; bulky waste; ashes/dust; and hazardous waste (Reed & Mena-Moreno, 2016, p. 20). Medical waste is usually dealt with at source by the non-governmental organisations (NGOs) generating it (Reed & Mena-Moreno, 2016, p. 32). Care International & ProAct Network (n/d a, p. 8) recommend steps to take depending on the type of hazardous waste. One thing to consider if hazardous wastes are left to be part of general waste streams, is that people, including children, risk coming into contact with them when unofficially hand sorting waste to find useful items (Care International & ProAct Network, n/d b, p. 2).

Support local institutions

Good management is said to be key to effective solid waste collection and disposal (Rouse & Reed, 2013, p. 30). As a result it may be necessary to support existing local institutions for solid waste management with funding and capacity development to rehabilitate them and enable them to meet their responsibilities (Rouse & Reed, 2013, p. 30; Reed & Mena-Moreno, 2016, p. 16; Care International & ProAct Network, n/d a, p. 8). Care International & ProAct Network (n/d a, p. 8) warn external organisations engaged in solid waste management to consider handover and an exit strategy from an early stage to ensure sustainability (see also Care International & ProAct Network, n/d b, p. 4-5).

Work with communities

Lack of ownership has been flagged as an issue relating to solid waste (Reed & Mena-Moreno, 2016, p. 31). Consulting potential users of waste management systems in displaced populations before and during its design, construction and use is both beneficial and important (Rouse & Reed, 2013, p. 30; Care International & ProAct Network, n/d a, p. 6). Rouse & Reed (2013, p. 28) suggest that giving affected people tasks to do, such as clean-up of their areas, can help them ‘overcome their trauma’. Employing people helps bring money into communities and strengthens their links to their areas (Rouse & Reed, 2013, p. 28).

However, even with the involvement of the community problems can persist, as Di Bella (2015, p. 2) details, with examples of the waste collection points used in IDP camps in Myanmar and the problems with them. Problems included the materials used being unsuitable for the rainy season, the design being unsuitable for keeping out animals, and waste collections not being regular (Di Bella, 2015, p. 2-3).

Collection and transport

Rouse & Reed (2013, p. 28) suggest providing communal storage bins in the early stages of an emergency. Transport of collected waste for disposal will depend on the waste generation rates, issues of access, such as narrow alleys or uneven paths, and the distance between collection and disposal points (Rouse & Reed, 2013, p. 28-29; Reed & Mena-Moreno, 2016, p. 17). Transportation vehicles can range from wheelbarrows to tractors and trucks, and several different types of transport may be needed to get the waste from collection points to the disposal site (Rouse & Reed, 2013, p. 29; Care International & ProAct Network, n/d a, p. 5). Daily collection is ideal, particularly from food preparation areas, but if this is not possible, collection at

least once a week is suggested to be essential to minimise insect breeding (Reed & Mena-Moreno, 2016, p. 17, 23).

Disposal

If there are not already established waste disposal sites to use, Rouse & Reed (2013, p. 29) suggest setting up temporary disposal sites such as communal pits, or if there is enough room a family solid waste pit similar to those used in rural communities, in the initial response (see also Reed & Mena-Moreno, 2016, p. 26). Communal pits or storage bins should not be located too far away or the affected population may not use them regularly and dump their waste elsewhere (Reed & Mena-Moreno, 2016, p. 27). Onsite waste pits can create contamination legacies and may impact on groundwater (Care International & ProAct Network, n/d a, p. 5). Other disposal systems such as composting, incineration and sanitary landfill can be considered once the situation stabilises (Rouse & Reed, 2013, p. 30; Reed & Mena-Moreno, 2016, p. 28). The burning of waste, which is common in some cases, is 'not recommended as it can cause localised health, nuisance and environmental issues' (Care International & ProAct Network, n/d a, p. 5).

Final disposal

Reed & Mena-Moreno (2016, p. 24) point out that safe and controlled final disposal of solid waste is also important for the protection of both public health and the environment. In emergencies, the most common method of final disposal is landfill, although Reed & Mena-Moreno (2016, p. 24-25) point out that it is rarely done properly, which can pose health and environmental risks. Steps to be taken include digging drainage ditches around a landfill site, keeping the waste as dry as possible during collection, regularly covering it with an impenetrable layer, or installing an impermeable membrane at the base of the landfill, as well as locating the site as far as possible downwind from homes, with fencing around it (Reed & Mena-Moreno, 2016, p. 25).

Recycling

Rouse & Reed (2013, p. 30) recommend encouraging recycling as it 'provides a local source of income and reduces the amount of waste for disposal', although formal recycling may only be economically viable in certain circumstances (see also Reed & Mena-Moreno, 2016, p. 9; Care International & ProAct Network, n/d b, p. 2). Recycling can be difficult in the early stages of emergencies due to the high level of organisation and manpower needed, although informal recycling is likely to naturally occur (Reed & Mena-Moreno, 2016, p. 28). For example, in the Sittwe IDP camps in Myanmar, small scale reuse and recycling were common practices, both for practical uses and refashioned as toys (Di Bella, 2015, p. 3). Annex 1 of Care International & ProAct Network's (n/d b, p. 7) paper on reuse and recycling presents methodologies for the prevention, reuse and recycling of organic waste, plastics, excreta, paper and cardboard, glass, and debris and rubble. Care International & ProAct Network (n/d b, p. 5) warn that the 'key to successful reuse and recycling projects is a market for the collection of materials'.

Protect the workforce

Those clearing solid waste should be provided with protective clothing such as masks, overalls, gloves and boots; informed of the risks involved; and vaccinated against common diseases such as tetanus (Rouse & Reed, 2013, p. 28; Care International & ProAct Network, n/d a, p. 2-3; Care International & ProAct Network, n/d b, p. 4).

3. Faecal sludge management

During the first phase of an emergency, 'indiscriminate defecation is usually the main health hazard in refugee camps', as well as a challenge to the privacy and dignity of the people affected (Reed, 2013, p. 55; Grange, 2016, p. 16; Harvey, 2007, p. 2). Grange (2016, p. 16) notes that this is a particular challenge for children, women, the elderly and those with disabilities (see also Johannessen et al, 2012, p. 4). Faecal-oral diseases account for more than 40% of deaths in the acute phase of an intervention (Anderson et al, 2015, p. 13872).

Faecal sludge management is the 'process of storing, transporting and disposing of excreta' (Grange, 2016, p. 9). Grange's (2016, p. 12) review of the literature on faecal sludge management finds that currently 'there is a lack of available equipment and technical guidelines on how to manage excreta in emergencies'. Some of the key challenges in WASH in emergencies were found to be desludging issues, including lack of appropriate equipment; how to extend the use of latrines through desludging; and how to treat the sludge or use it to advantage (biogas, compost etc. and recycling of wastewater) (Bastable & Russell, 2013, p. 6). In addition, Johannessen et al, (2012, p. 1) argue that insufficient resources have been invested in sanitation; sustainable solutions have not been prioritised; and not enough attention has been given to sanitation in disaster risk reduction.

Key considerations for faecal sludge management

Immediate emergency excreta disposal

In the immediate aftermath of an emergency excreta disposal programmes main objective should be to 'minimise contamination related to high-risk practices and reduce exposure and faecal-oral disease transmission' (Reed, 2013, p. 51; Johannessen et al, 2012, p. 4). If left unaddressed it could lead to serious public health problems and spread serious diseases such as diarrhoea and cholera (Grange, 2016, p. 11; Harvey, 2007, p. 2). It is important to take immediate steps to prevent indiscriminate defecation, especially in areas likely to contaminate the food chain or water supplies, such as the banks of water sources and agricultural land planted with crops (Reed, 2013, p. 55).

Planning

Reed (2013, p. 51-54) emphasises the importance of proper planning for excreta disposal in emergencies from the start of the emergency, with a rapid assessment and priority setting to see if an intervention is necessary. This includes involving communities in the planning and design process, which Reed (2013, p. 52) argues promotes self-respect and self-reliance. In addition, he suggested that in order for emergency excreta disposal to work, the technical options used need to be understood and supported by the community (Reed, 2013, p. 55; Johannessen et al, 2012, p. 3). Questions to ask in the rapid assessment include current beliefs and traditions concerning excreta disposal, especially regarding women and children's excreta; where are people prepared to defecate, and can disabled and elderly people use these facilities; and what are the environmental conditions to consider, for instance.

Any planning should use the internationally-recognised Sphere standards which set out the minimum service levels for excreta disposal (Reed, 2013, p. 53; Grange, 2016, p. 11). For instance, in the early stages of an emergency the maximum number of people per toilet should

be around 50, falling as more sanitation facilities can be built (Grange, 2016, p. 16). Challenges arise even when minimum standards are met however, as toilets, usually pit latrines, fill up very quickly and need to be emptied as soon as possible, with faecal sludge needing to be safely transported to a dumping site for disposal (Grange, 2016, p. 11). Grange (2016, p. 12) also finds that 'there is a lack of standardisation of safety protocols and equipment to strengthen the desludging, transporting and disposal of faecal sludge'.

Environmental challenges to consider when planning include high water tables, unstable sandy soils and crowded urban areas (Johannessen et al, 2012, p. 2-3). Displacement into urban areas is challenging as there is often a lack of available space to implement suitable sanitation infrastructure, with potential obstructions including asphalt roads, concrete structures, buildings, and service pipes for water and sewage (Grange, 2016, p. 16). In addition, existing sanitation system often are also not working well before the disaster (Johannessen et al, 2012, p. 2). If left unaddressed, these challenges can result in overflowing, leaking, malfunctioning, or unused toilets (Johannessen et al, 2012, p. 2).

Emergency sanitation infrastructure

Grange (2016, p. 16) finds that emergency sanitation infrastructure often consists of 'dug pit latrines, raised pit latrines, deep trench latrines (where digging is possible), bucket latrines, packet latrines, portable chemical toilets, cat method (where faeces are rolled in sand or dirt), and as a last resort, designated defecation areas', as well as biodegradable pee-poo bags.

Reed (2013, p. 58) points out that many of these options should only be temporary and as soon as it becomes obvious that the community is likely to remain in their new location for any length of time then longer-term solutions, such as some form of onsite sanitation, should be sought.

Latrines

Latrines, such as pit latrines, shallow family latrines, shallow trench latrines, and deep trench latrines, are a common form of emergency sanitation infrastructure (Reed, 2013, p. 56-57; Grange, 2016, p. 11). Local markets can usually supply relevant construction material to quickly build pit latrines, although if the necessary materials are not available it can have significant effects on the sanitation coverage for the affected population (Grange, 2016, p. 11).

However, the latrines fill up quickly and can be very labour intensive and require constant supervision to ensure that the contents of each latrine are covered each day, emptied as soon as possible, new latrines prepared, old ones filled in, and regularly-used latrines cleaned in order to prevent them becoming smelly and fly infested (Reed, 2013, p. 56-57; Grange, 2016, p. 11, 17). They are also unsuitable if the ground is rocky or the water table high, in which case the latrines need to be raised above the ground (Reed, 2013, p. 58). They need to be placed a suitable distance from ground water sources, and the bottom should be high enough off the water table (Johannessen et al, 2012, p. 6). The faecal sludge that is removed (manually or by sewer truck) also must be safely disposed to prevent contamination and excreta-related diseases breaking out (Grange, 2016, p. 17). Latrines or toilets should also be equipped with hand washing facilities (Johannessen et al, 2012, p. 4).

Biodegradable bags

Bastable & Russell (2013, p. 22, 8) found suggestions from WASH practitioners for immediate excreta waste management to include non-toilet options such as biodegradable bags which people defecate into; which could also be useful in impossible to dig contexts and for children (see also, Reed, 2013, p. 58). It is important that the bags are strong, water-tight, have a sealable top, and are collected regularly and taken away for burial (Reed, 2013, p. 58).

The Peepoo or biodegradable bags solution has been found to be successful in the preliminary trials, and is felt to be a 'good solution when desludging trucks are unable to access the congested camps, or for use at night' (Johannessen et al, 2012, p. 5). However, Kinstedt (2012, p. 1) voiced some concerns relating to cost effectiveness and user-friendliness (for example the elderly and people with disabilities may struggle to squat into a bag), while proper burial or collection for composting is needed to make it a hygienically safe system (Johannessen et al, 2012, p. 5).

Designated defecation areas

Designated defecation areas involves selecting areas where defaecation can be safely allowed, such as a number of small fields for open defecation where small strips with shallow trenches are used at a time (Reed, 2013, p. 55-56). However, defecation fields have a short life and are difficult to manage, so should be replaced with more sustainable solutions as soon as possible (Reed, 2013, p. 56).

Disposal

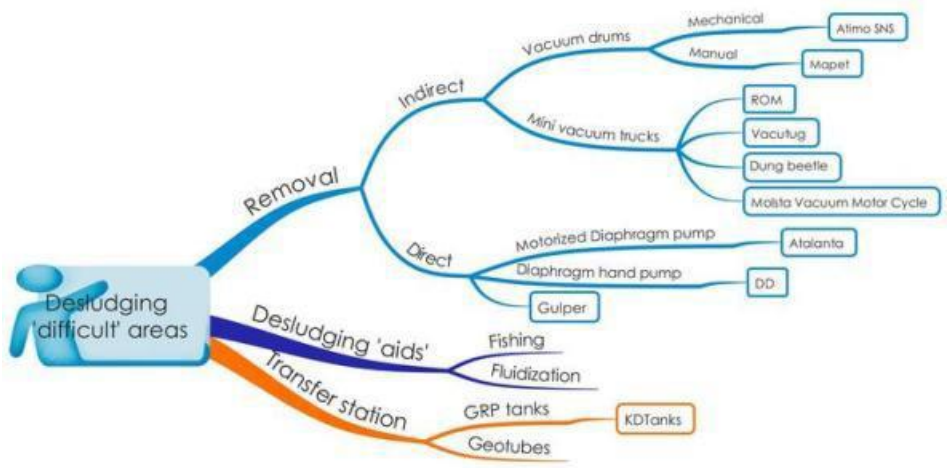
Local disposal of faecal sludge

Local contractors are usually used to undertake the response for desludging and disposal of faecal sludge, however the 'efficacy of the faecal sludge disposal will often depend on the number of local sewer trucks available, their condition and their transport capacity', which is often lower than necessary (Grange, 2016, p. 11, 18). If the capacity is lacking, this can present serious challenges as pit latrines which are not emptied regularly can result in people resorting to open air defecation (Grange, 2016, p. 11). Physically access issues can also be a problem, as can solid objects thrown into pits which can block the desludging pumps (Grange, 2016, p. 18; Johannessen et al, 2012, p. 6). Local disposal areas may also struggle to accept the large volumes of faecal sludge collected from the pit latrines and efforts should be made to secure and improve the dumping site, especially to prevent it contaminating water sources (Grange, 2016, p. 12, 18).

Desludging in 'difficult' areas

The Emergency Sanitation Project has also been working to find innovative solutions to sanitation problems such as alternative toilet options, desludging, and latrine slabs, for use by the humanitarian community (IFRC et al, 2015). Figure 1 shows some of the technologies for desludging 'difficult' areas:

Figure 1: Technologies which can be used to desludge 'difficult' areas



Source IFRC et al, 2015, p. 17.

A number of technologies were tested such as the ROM2 and the Vacutug, and it was suggested that it is unlikely that one desludging unit would be suitable for all contexts (IFRC et al, 2015, p. 19). In difficult to reach contexts it is likely that using smaller units for collecting sludge from less passible areas and bringing it to a collection point for transport to the final disposal site, might work best (IFRC et al, 2015, p. 19).

Treatment and control of faecal sludge accumulation

Reducing the volume of faecal sludge

As managing traditional onsite sanitation systems, such as pit latrines, cesspits and septic tanks, can be costly and difficult in isolated areas, efforts are being made to find ways to reduce the rate at which latrines fill up with faecal sludge and need to be emptied, as well as ways to improve excreta disposal in emergencies in quicker and safer ways (Furlong et al, 2017, p. 1; Grange, 2016, p. 12). Such efforts include experiments with additives, such as chemical additives (strong acids and alkalis, organic solvents, ammonia), biological additives (organic microorganisms, lactic acid), and biological external concepts (earthworms with vermifilters[2] and black soldier fly larvae), to reduce faecal sludge (Grange, 2016, p. 23-24; IFRC et al, 2015, p. 23). Some of these experiments are showing positive, conclusive results (Grange, 2016, p. 12, 25-31). Work by IRFC et al (2015, p. 23, 25-26) suggests that anaerobic digestion is unlikely to be a complete solution for large scale sludge disposal due to the time it takes; while the use of worms has shown promising results for refugee camps.

For example, Oxfam has been trialling the use of **tiger worm toilets** in camp settings, including in Myanmar (Furlong et al, 2017, p. 1). Tiger worm toilets are an affordable, low maintenance, on-site system that treats human waste using composting worms, who digest the faecal matter, which reduces the pathogen load and the frequency of emptying (T'Kint et al, 2014, p. 1). The

[2] Vermifilter is a filter containing worms, which consists of an organic bedding layer (e.g. coconut husk or woodchip) and a drainage layer. The vermifilter is typically contained in an open bottomed tank which is attached to a flushing toilet (Furlong et al, 2016, p. 1).

system is smaller than a septic tank, and the by-product, vermicompost, is safe and easy to handle (T'Kint et al, 2014, p. 1). In evaluating their trials, Oxfam found that while they are not the solution to all sanitation problems 'they have been proven to work well at the household level' and help reduce the volume of sludge (Furlong et al, 2017, p. 1; IFRC et al, 2015, p. v). User acceptance in the camps in Kachin Myanmar was found to be high (Furlong et al, 2017, p. 3). Users appreciate the lack of smell and flies, and lower emptying requirements (Furlong et al, 2017, p. 5). Worm breeding on site can help overcome worm supply issues (Furlong et al, 2017, p. 5). As the system requires a certain amount of water to keep the worms moist they may not be appropriate for water scarce communities (Furlong et al, 2017, p. 5; T'Kint et al, 2014, p. 2). The soil needs to have the capacity to absorb effluent infiltrating directly into the ground as oversaturation will kill the worms (Furlong et al, 2017, p. 5; T'Kint et al, 2014, p. 2). Sourcing the low-volume pour-flush pans to reduce the water requirements of the system has been a challenge (Furlong et al, 2017, p. 5). Community engagement and buy-in is critical, and has benefited from a focus on the benefits of the technology (Furlong et al, 2017, p. 6).

Ecological sanitation (Ecosan)

Ecological sanitation (Ecosan) are 'sanitation methods and technologies which promote the safe reuse rather than the disposal of excreta' and have been mostly implemented in disaster relief for flood-prone areas and locations where excavation is not possible (Kinstedt, 2012, p. 1). Different forms of Ecosan used in emergencies include urine diverting dehydration toilets (UDDT), Arborloo, biodegradable bags, and composting toilets, for example (Kinstedt, 2012, p. 1). Kinstedt (2012, p. 1) found that the flexible design of UDDTs makes them a good option for areas where excavation is difficult or there is a high chance of groundwater pollution. Users have also suggested they are less smelly than pit latrines, although it can be a challenge to ensure they are used correctly (Johannessen et al, 2012, p. 5). Composting toilets are suggested to offer the best success with reuse of excreta but the composting processes are quite complicated and do not necessary provide groundwater protection (Kinstedt, 2012, p. 1). The Arborloo was found to provide a simpler solution with resource reuse, but this design is not appropriate in regions where either excavation is not possible or where high groundwater is present (Kinstedt, 2012, p. 1).

Treating faecal sludge to help sanitise it

Other experiments have looked at faecal sludge treatment options that could be rapidly deployed upon the event of an emergency and are effective under challenging physical site conditions to help sanitise faecal sludge and prevent the spread of diarrhoeal diseases (Anderson et al, 2015). Anderson et al (2015) investigated the sanitising effect of lactic acid fermentation, urea and lime faecal sludge treatment methods. They found that while all three can be reduce E.coli to below detectable limits, treat both liquid and solid waste, and are low tech and readily available, rehydrated lime treatment is less sensitive to environmental conditions, and the most effective treatment in terms of time, so may be marginally more suitable for sanitation in emergency contexts (Anderson et al, 2015, p. 13881-13882). However, it produces highly alkaline sludge which has limited reuse potential and would require neutralisation in addition to stabilisation prior to being discharged safely into the environment (Anderson et al, 2015, p. 13881). Further testing is recommended (Anderson et al, 2015, p. 13882).

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Key websites

- SuSanA forum – search Refugees: http://www.forum.susana.org/forum/search and the Emergency & reconstruction situations Working Group: http://www.susana.org/en/working-groups/emergency-reconstruction-situations
- The Emergency Sanitation Project: http://www.emergencysanitationproject.org/
- Oxfam – WASH technical briefs: https://policy-practice.oxfam.org.uk/our-work/water-sanitation-and-hygiene/wash-technical-briefs
- The Global Wash Cluster: http://washcluster.net/
- Knowledge Point forums – search faecal sludge management: https://knowledgepoint.org/en/questions/scope:all/sort:activity-desc/page:1/query:Faecal%20sludge%20management/

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