Technology brief

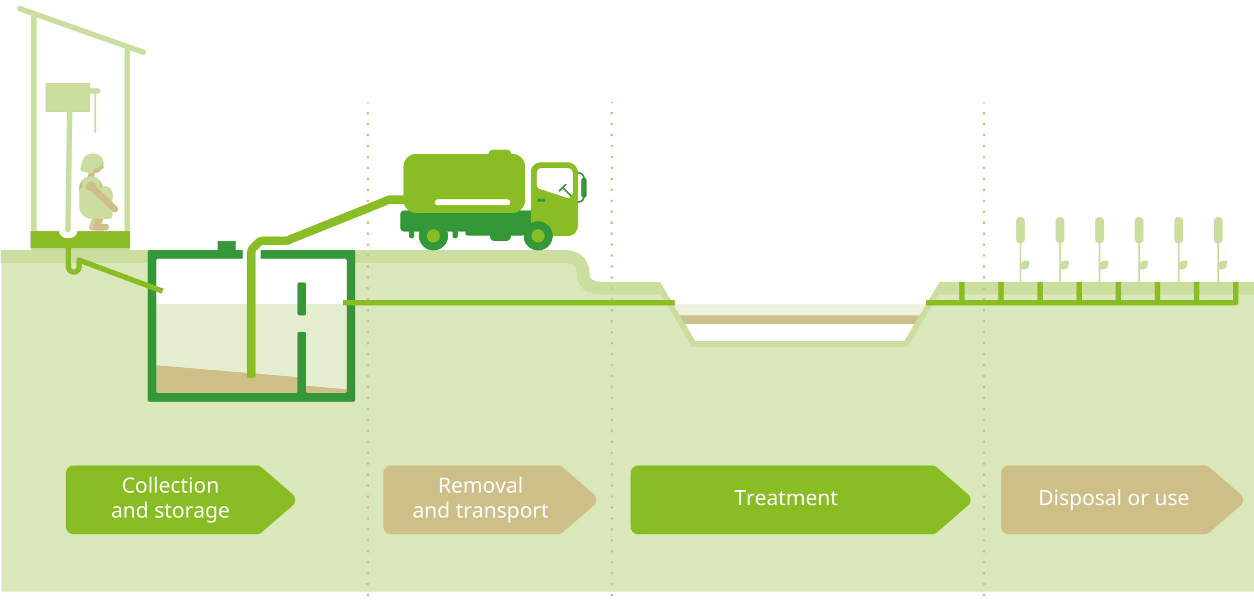
Wastewater treatment

Introduction

Wastewater treatment is essential to prevent pathogens from entering the environment and causing disease. While traditional wastewater treatment often addresses sewage as waste, there are also opportunities for it to be viewed as a valuable resource. For example, biogas created from sludge can provide cheap, clean energy, and composted faeces can make a highly effective fertiliser. This technology brief gives an overview of these methods to encourage a holistic view of wastewater treatment.

Treatment can be roughly divided into centralised and decentralised systems. Centralised systems gather wastewater from a large population and treat it simultaneously. Decentralised systems serve smaller populations, ranging in size from a household to a small community. This technology brief focuses on decentralised systems, which have often been found to be more affordable and appropriate for low-income urban communities.

There is a chain of steps in the journey of wastewater from collection to disposal or use, and it is important to consider them all, as different treatment processes can occur at different steps in the chain.



WaterAid

Collection and storage

This technology brief discusses the collection and storage of wastewater. For information on the collection and storage of faeces and sludge (for example, in pit latrines, dehydration vaults and composting toilets) please refer to the technology briefs *Household latrines* and *Urban pit waste management*.

Septic tank

A septic tank is a water-tight chamber for the primary treatment of wastewater and greywater. It can function as a holding tank – in which case the contents must be periodically removed – or drain into any type of sewer system or treatment works. In rural areas, septic tanks can also drain into leach fields.

Septic tanks are generally made from concrete, fibreglass, PVC or plastic, and contain at least two chambers. Within the septic tank, solids settle to the bottom and scum rises to the top. Baffles keep the sludge and scum within the tank and let the water pass out for further treatment. The final products of the septic tank are therefore water (requiring further treatment before it becomes safe), sludge and scum. The septic tank will need to be periodically de-sludged to remove the latter (about once every four years).

Septic tanks are generally installed underground, and are therefore good for areas with limited land available. They are used in conjunction with flush toilets and require a regular supply of water, and are therefore not suitable for areas where water is in short supply.

Septic tanks do not generally smell, and are easy to use. However, when installing a septic tank, it is vital to think about what should be done with the effluent. Committing to proper maintenance is also essential, as an overflowing or leaking septic tank in a densely populated area can pose a serious health hazard.

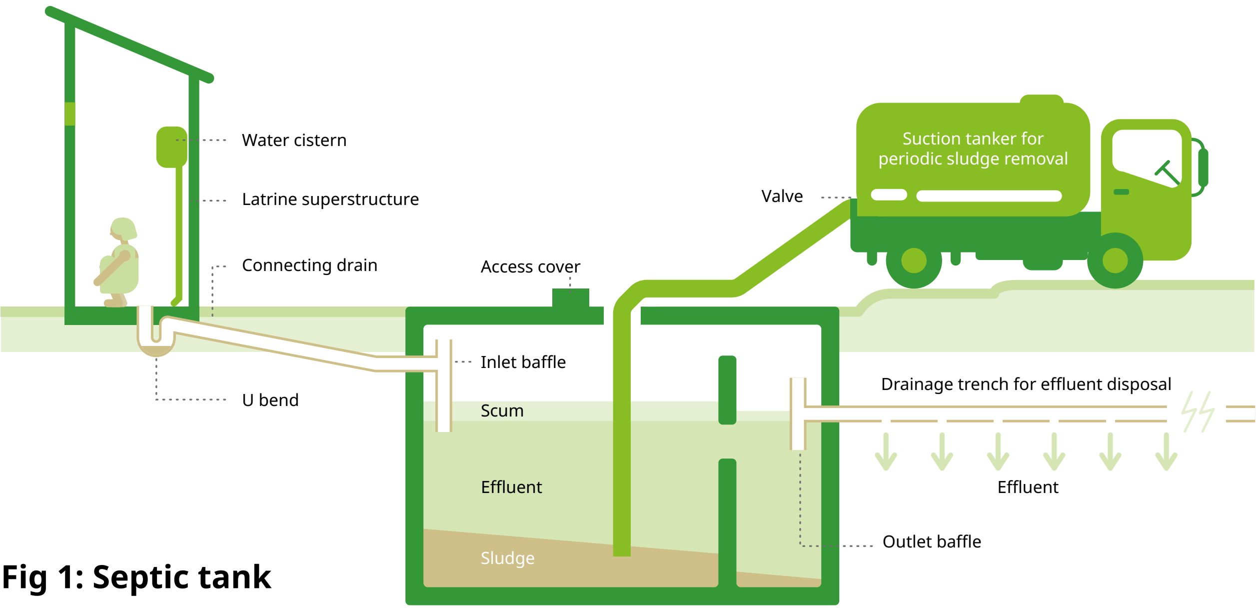


Fig 1: Septic tank

Anaerobic baffled reactor

An anaerobic baffled reactor (ABR) is similar to a septic tank, except that after the settling tank the wastewater is forced to flow slowly through a series of baffles. The increased contact time with bacteria in the sludge means that very high reductions in pathogens are possible. Like a septic tank, the final products are effluent and sludge. WaterAid uses ABRs as a means of primary wastewater treatment, in combination with constructed wetlands.

Like septic tanks, ABRs require a regular supply of water or wastewater. It can take several months for an ABR to reach full treatment capacity, as the bacteria take time to colonise the tank. This process can be sped up by 'seeding' the tank with bacteria from another ABR.

A note on greywater

Wherever possible, greywater (from washing clothes or other domestic uses) should be collected and treated in a controlled way. The amount of greywater produced by a household will vary greatly by location, income and cultural practices. Any standing pools of domestic water can create a potential breeding ground for mosquitoes, and should be discouraged.

A simple soak pit will provide a decent method of dealing with greywater; however, it is important to consider the soil type, water table depth, quantity of greywater and the space available. Where kitchen gardens exist, greywater can be safely used for irrigation if diluted with an adequate amount of clean water.

WaterAid

Removal and transport

This technology brief focuses on the transport of wastewater. For information on transfer stations and manual and motorised emptying of pit latrines please refer to the technology brief *Urban pit waste management*.

Simplified sewerage

Simplified sewerage is a relatively cheap sewer design that has been used extensively in Brazil. Cost savings are made over conventional sewer design by laying small diameter sewers in shallow trenches under pavements or in yards, where they are protected from heavy traffic loading. This also allows savings to be made by shortening the connection distance from the house to the sewer line. Simplified sewers can connect households to a main sewer line or a decentralised treatment works.

This method achieved success in the Orangi Pilot Project, carried out in Karachi, Pakistan; however, it requires a great deal of community participation to be effective. People must understand the importance of not flushing anything that could block the small-diameter sewers, and excellent design and engineering are essential. It also requires a regular supply of water for flushing, so might not be appropriate in water-stressed areas. Most critically, simplified sewers can only work if the topography of the area lends itself to gravity-driven pipes.

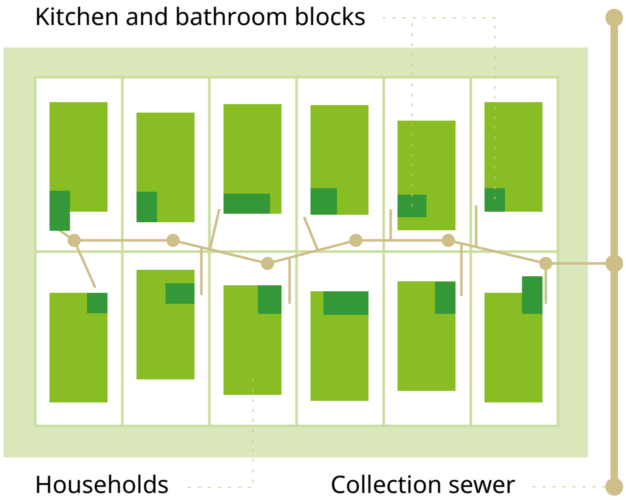


Fig 2: Simplified sewerage

Solids-free sewerage

A solids-free sewer is similar to a simplified sewer, except that they do not convey solid material. Household wastewater drains into a septic tank, settling tank or other primary treatment method, before entering the sewers. This means that the sewers are very unlikely to clog, and can be laid at very flat or even negative gradients (provided that the final downstream end is lower than the upstream end).

In addition to the criteria described for simplified sewers, this method also requires frequent maintenance, as the septic tanks or settling tanks require periodic emptying. However, the gradient flexibility means that topography is less of a critical factor.

WaterAid

Treatment

Constructed wetlands

Constructed wetlands, also known as reed beds, use wetland plants (or, more specifically, micro-organisms within the roots) to remove pollutants from wastewater. There are various constructed wetland designs, lying above or below the ground surface, but all require a large area of land. They also require some form of preliminary and primary treatment to take place (as they cannot deal with large solids or sludge). They can range in size from a household treatment option to a large, centralised facility.

Operational costs for constructed wetlands are low and, although careful design is necessary, there is no need for skilled supervision.

Waste stabilisation ponds

Waste stabilisation ponds (WSPs) are large pools where wastewater settles and decomposes because of naturally occurring bacteria. A carefully designed series of at least three linked ponds provides the best treatment. It is not necessary to screen the wastewater before it enters the pond. WSPs work in most areas, but are most efficient in warm, sunny climates. They are especially appropriate for communities that have ample, inexpensive space away from homes and public spaces. It is important that the ponds have an impermeable liner and are protected by a fence to stop people bathing in or using the water. The ponds require desludging every 10-20 years and need to be expertly designed for the maximum removal of pathogens.

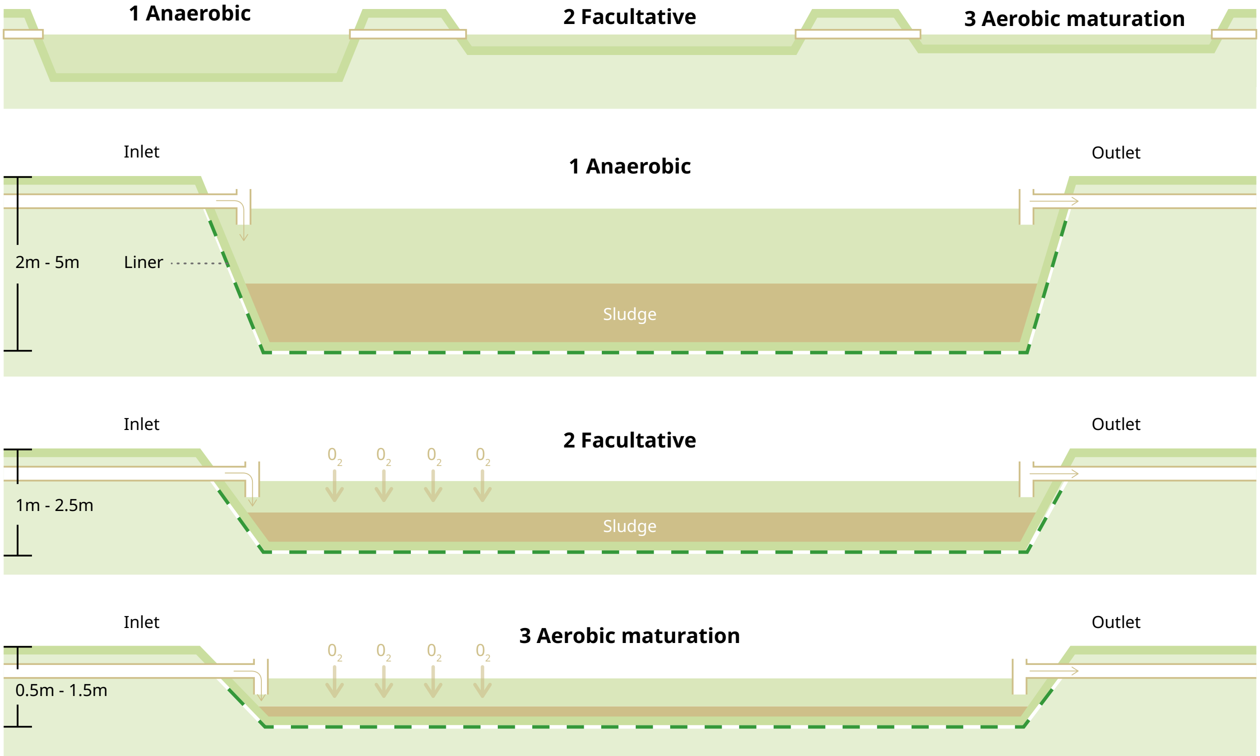


Fig 3: Cross-section of waste stabilisation ponds

Anaerobic biogas reactor

An anaerobic biogas reactor produces gas from the fermentation of sludge, which can be collected and used to fuel engines for electricity, or burned for light and cooking. They can be built for a single household or for a whole community, and require expert design and careful monitoring for optimum performance.

Biogas reactors usually have a domed shape. Wastewater flows in and sludge settles to the bottom. Sludge fermentation creates gas, which collects in the dome at the top of the reactor. The dome can be fixed or floating, rising and falling with the production of gas. Biogas reactors produce sludge that is not safe to handle, and must therefore be disposed of carefully.

While biogas reactors are commonly used to treat wastewater from communities, they can also be successfully used on a smaller scale at the household level. For maximum efficiency and gas production, families can supplement their household wastewater with animal manure.

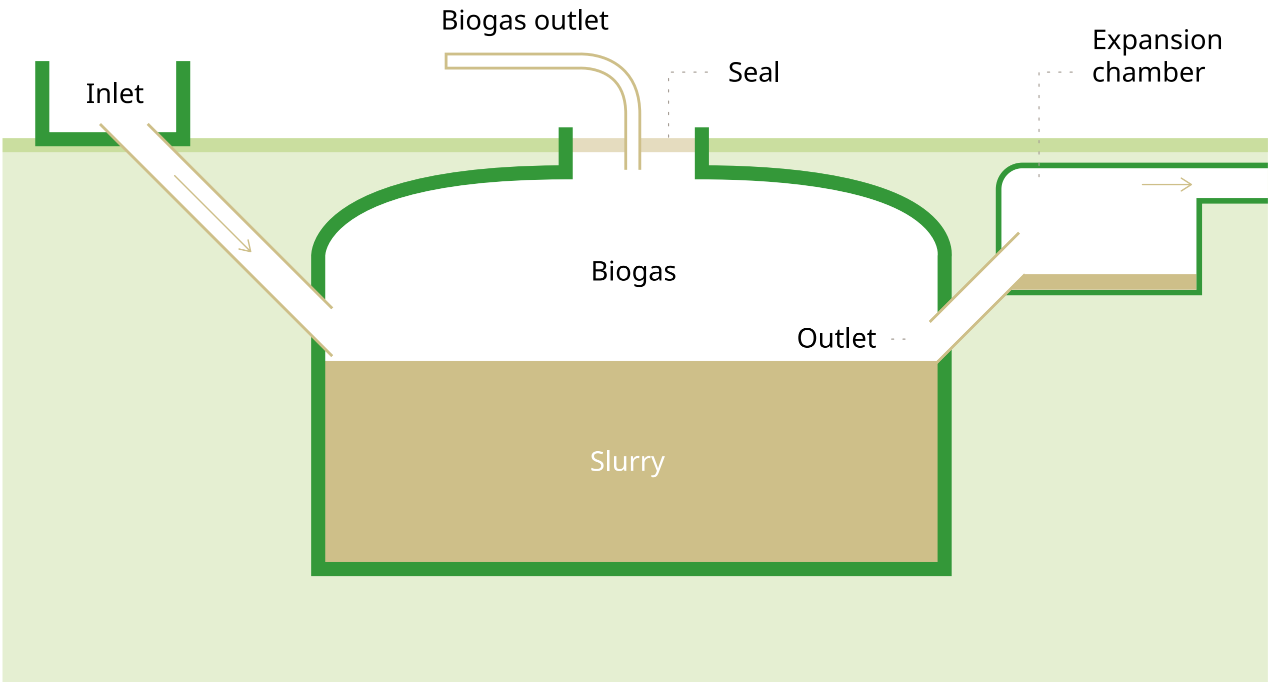


Fig 4: Anaerobic biogas reactor

WaterAid

Case study

Cooking on biogas

Eva Eugene Millinga, 42, cooks over her biogas stove in her house in Dar es Salaam, Tanzania.

In Dar es Salaam, Tanzania, most residents use pit toilets, which are difficult and expensive to empty once full. Mattius Millinga, who previously had a business removing solid waste, has also ventured into a new business emptying pits, using a low-cost pump called a Gulper, motorised tricycles to transport the extracted sludge, and a small treatment plant near his home.

The decentralised wastewater treatment system (DEWATS) includes a sludge discharge station, which receives a maximum of 40m^3 of sludge per day, and a baffled anaerobic reactor that digests sludge and produces biogas, contained by a dome. The biogas is used in the Millingas' home, while the sludge is dried on drying beds and used as soil conditioner, and the effluent goes onto planted beds for final treatment.

Ecological sanitation

Ecological sanitation (ecosan) latrine systems are designed to biodegrade waste into a humus-like soil which is safe to handle, rich in nutrients and can be used to increase agricultural production. In this system, urine and faeces are seen as resources rather than waste.

Urine-diverting composting toilets separate urine and faeces using a specially designed slab. The faeces are safely left to compost in vaults before being removed and applied to land as fertiliser. Urine can be diluted with water and applied to land after only a few days, as it is sterile. This system can be highly beneficial in agricultural areas where artificial fertiliser is expensive or hard to obtain, and the improvements in agricultural production can be impressive. The ecosan system also does not require water, which makes it suitable for water-stressed areas; however, it does require adequate amounts of soil and ash, and a large handful should be thrown into the faeces vault after each use (to prevent the latrine from smelling).

Ecosan can be extremely beneficial, but it is very important that the system is correctly managed. Latrines can be constructed and maintained by families without much outside help, but require ongoing commitment for proper care and use. It is therefore essential to provide education on correct use and ensure there is a demand for the end product. Fertiliser use is usually seasonal, and thought should be given as to where urine and compost can be stored during times of low requirement.

It is very important that the dehydrating vaults are kept dry; ecosan latrines are therefore not appropriate for the disposal of greywater or those who use water for anal cleansing. The vault system also requires slightly more space than a standard pit latrine. Some communities are unwilling to accept the reuse of faeces and careful sensitisation may be necessary.

Disposal or use

Some of the treatment processes listed above do not provide a complete solution, with effluent or sludge still needing to be disposed of. Some processes for dealing with these end products are listed below. They also give an indication of the value that is to be found in human waste, and many sanitation systems can be easily adapted to give these end results.

Drying

If sludge can be dried on site after treatment it can then be transported off site more cheaply, or used as fuel or compost. There are relatively few tried and tested methods for drying faecal sludge.

Solar drying

Simple and cheap solar driers have been trialled in Malawi. These use a glass panel above a black absorber plate to capture solar energy, a bit like a greenhouse. The sludge is spread over the perforated absorber plate and is heated to temperatures of up to 57°C.

Compost

Biodegraded sludge can produce valuable compost, which can be used to increase agricultural production. Organic matter, such as dried leaves, should be added for optimum results. The more liquid the sludge, the more organic matter should be added.

Composting can be done either by leaving the sludge outside for a period of a few months, or leaving it in a sealed container. Care must be taken to ensure that the sludge has been left for a long enough period that all harmful pathogens are destroyed. The time for this to happen will depend on the local climate and treatment of the sludge.

Fuel

It is possible to harness energy from sludge, as detailed in the two methods below.

Biogas

Biogas is produced by fermenting sludge, which is collected in anaerobic biogas reactors. Gas from fermenting sludge is a clean fuel that burns efficiently. Fuel is often a major part of a household's expenditure, and a clean, cheap supply can be good for both the household budget and health.

Cakes

Once dried, sludge can be compacted into 'cakes' or 'briquettes' and used as a fuel source.

Disposal to sewers

In some areas, it may be possible to obtain permission to dispose of final effluent into sewers. This provides a good solution for many small operators; however, caution should be taken when disposing of concentrated sludge into sewers because a sudden force can cause problems at the wastewater treatment centres downstream.

WaterAid

References

Tilley E, Ulrich L, Lüthi C, Reymond P and Zurbrügg C (2014) *Compendium of sanitation systems and technologies (2nd revised edition)*. Swiss Federal Institute of Aquatic Science and Technology (Eawag), Dübendorf, Switzerland. Available at: http://wsscc.org/resources-feed/compendium-of-sanitation-systems-and-technologies-2nd-edition

Morel A and Diener S (2006) *Greywater management in low and middle-income countries*. Swiss Federal Institute of Aquatic Science and Technology (Eawag). Dübendorf, Switzerland. Available at: https://www.sswm.info/sites/default/files/reference_attachments/MOREL%20and%20DIENER%202006%20Greywater%20Management.pdf

Water, Engineering and Development Centre (WEDC) (1991) *The worth of water: technical briefs on health, water and sanitation*. IT Publications, London, UK. Available to purchase at: http://store.lboro.ac.uk/product-catalogue/wedc/wedc-bookshop/the-worth-of-water-technical-briefs-on-health-water-and-sanitation

Useful resources

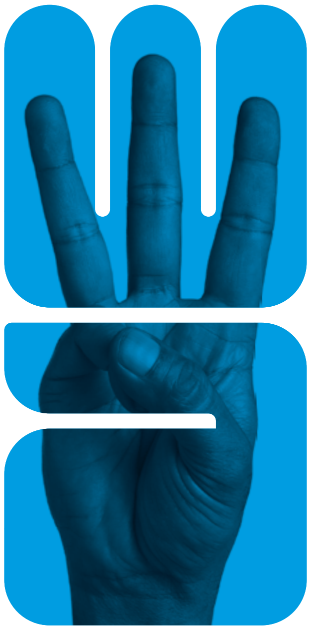
Akvopedia Sanitation Portal. Available at: http://akvopedia.org/wiki/Sanitation_Portal

The School of Civil Engineering at Leeds University has a large collection of information on waste stabilisation ponds. Available at Professor Duncan Mara's webpages: http://www.personal.leeds.ac.uk/~cen6ddm/WSP.html

Andersson K, Rosemarin A, Lamizana B et al (2016) *Sanitation, wastewater management and sustainability: from waste disposal to resource recovery*. United Nations Environment Programme and Stockholm Environment Institute, Nairobi, Kenya and Stockholm, Sweden. Available at: https://wedocs.unep.org/bitstream/handle/20.500.11822/8465/-Sanitation,_wastewater_management_and_sustainability_From_waste_disposal_to_resource_recovery-2016sanitation_wastewater_management_and_sustainabilit.pdf?sequence=2&isAllowed=y

The World Health Organization fact sheets on environmental sanitation. Available at: http://www.who.int/water_sanitation_health/emergencies/envsanfactsheets/en/index.html

Part of a series of WaterAid technology briefs available at www.wateraid.org/uk/technology



WaterAid is an international not-for-profit, determined to make clean water, decent toilets and good hygiene normal for everyone, everywhere within a generation.

2018

WaterAid is a registered charity:

Australia: ABN 99 700 687 141
Canada: 119288934 RR0001
India: U85100DL2010NPL200169
Sweden: Org.nr: 802426-1268, PG: 90 01 62-9, BG: 900-1629
UK: 288701 (England and Wales) and SC039479 (Scotland)
US: WaterAid America is a 501(c) (3) non-profit organization