Technical brief

WaterAid

Wastewater treatment

Part of a series of WaterAid technology briefs.

Available online at **www.wateraid.org/technology**

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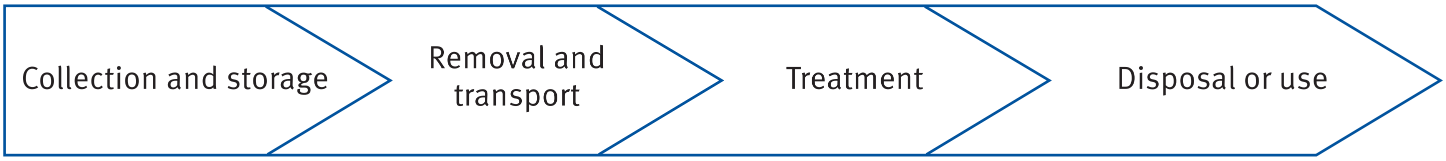
Introduction

Wastewater treatment is essential to prevent pathogens from entering the environment and causing disease. While traditional wastewater treatment often thinks of sewage as a waste, there are also opportunities for it to be viewed as a valuable resource, with biogas created from sludge providing cheap, clean energy and composted faeces making a highly effective fertiliser. This technology note gives an overview of these methods, in order to encourage a holistic view towards 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 one household to a small community. This technical note deals with 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 and it is important to consider them all, as different treatment processes can occur at different steps in the chain.



Collection and storage

This technology note discusses the collection and storage of wastewater. For discussion on the collection and storage of faeces and sludge (e.g. in pit latrines, dehydration vaults and composting toilets) please refer to the technology notes *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/treatment works. In rural areas, septic tanks can also drain into leach fields.

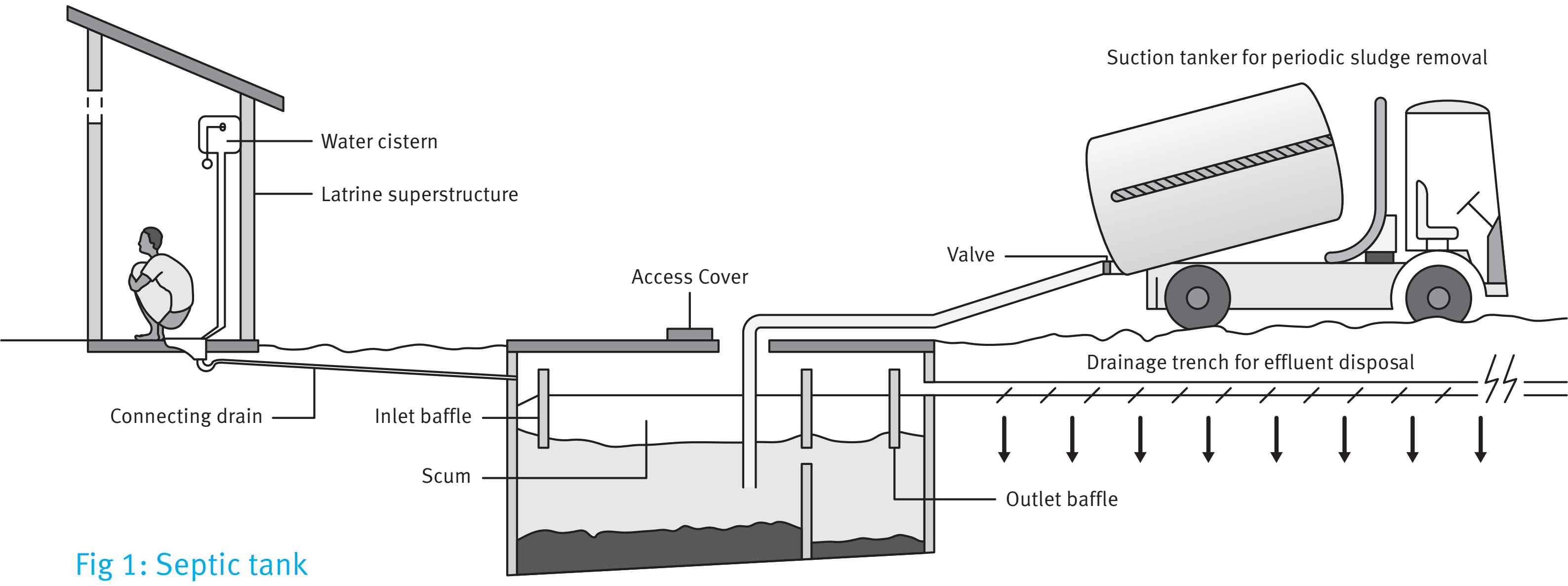


Fig 1: Septic tank

Septic tanks are generally constructed 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 desludged to remove the latter (about once every 4 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 that thought is given to what should be done with the effluent. Commitment to proper maintenance is also essential, as an overflowing or leaking septic tank in a densely populated area can pose a serious health hazard.

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 an effluent and sludge. WaterAid has therefore used ABRs as a means of primary wastewater treatment, in combination with constructed wetlands.

Like a septic tank, ABRs require a regular supply of water/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 clothes washing or other domestic uses) should be collected and treated in a controlled way. The amount of greywater produced by a household will vary greatly with 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 consideration should be given to the soil type, water table depth, quantity of greywater and space available. Where kitchen gardens exist, greywater can be safely used for irrigation if diluted with an adequate amount of fresh water.

Transport

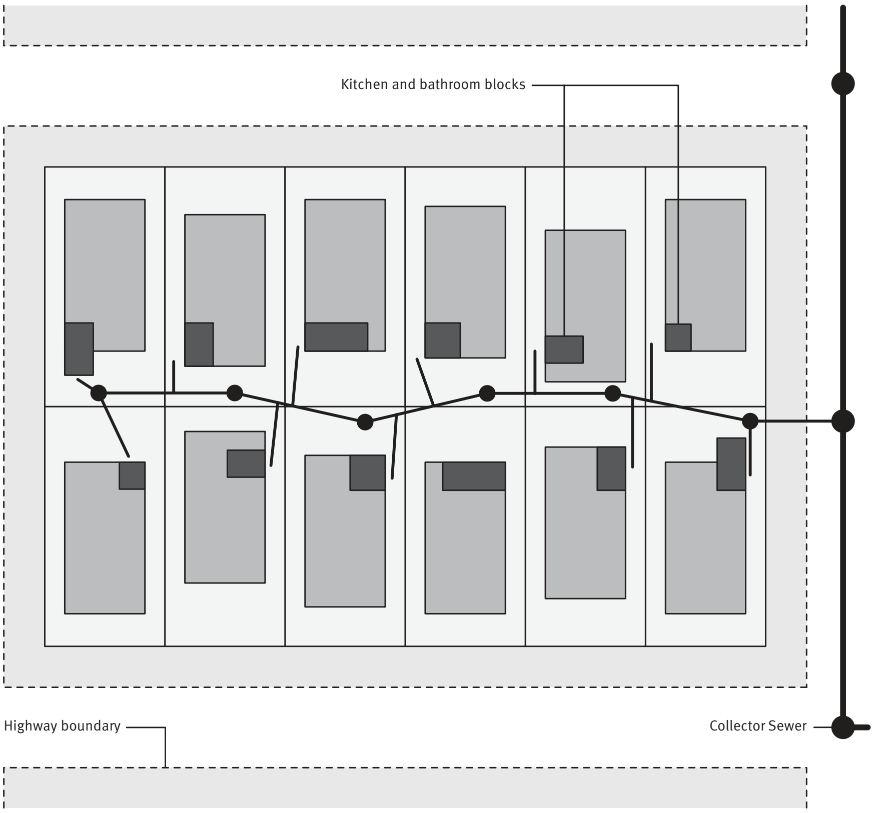
This technology note deals with the transport of wastewater. For transfer stations, human emptying and motorised emptying of pit latrines please refer to the technology note *Urban pit waste management.*

Simplified sewerage

Simplified sewerage is a cheaper and more appropriate version of 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 to 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 engineering design is essential for good operation. It also requires a regular supply of water for flushing, and 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 will require periodic emptying. However, the gradient flexibility means that topography is less of a critical factor.

Case study

Constructed wetlands in Nepal

Constructed wetlands were introduced to Nepal in 2000 with support from WaterAid, UN-HABITAT and the Asian Development Bank. The treatment plant, which is designed to cater for 200 homes and covers an area of 300m2, was constructed on an old open defecation site which was prone to landslides and dumping. The treatment plant is completely managed and run by the community with users paying a tariff of five rupees per month.

Wastewater from the municipality flows through centralized pipes to a sedimentation tank, and then into an anaerobic baffled reactor, before flowing into the first reed bed. There are three reed beds in total, with horizontal flow through the first and vertical flow through the second and third. The final products are water and sludge: water is discharged into a river and adheres to environmental standards, while the sludge is dried in beds and used by local farmers for fertilizer. In an interview with WaterAid, the plant caretaker said “Local people are very much appreciating this plant; the area is much safer and there are no longer landslides and it is cleaner. The communities have been involved in every stage of building and are very proud of the project.”

Krishna Lal Shrestha, chairman and Krishna Shrestha, caretaker, at the waste water treatment plant in Sunga, Thimee, Kathmandu, Nepal

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 several variations on constructed wetland design, depending on the movement of the flow and whether it lies above or below the ground surface, but all require a relatively large area of land. They also require some form of preliminary and primary treatment to take place (i.e. 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. See the case study for more information about constructed wetlands in Nepal.

Waste stabilisation ponds

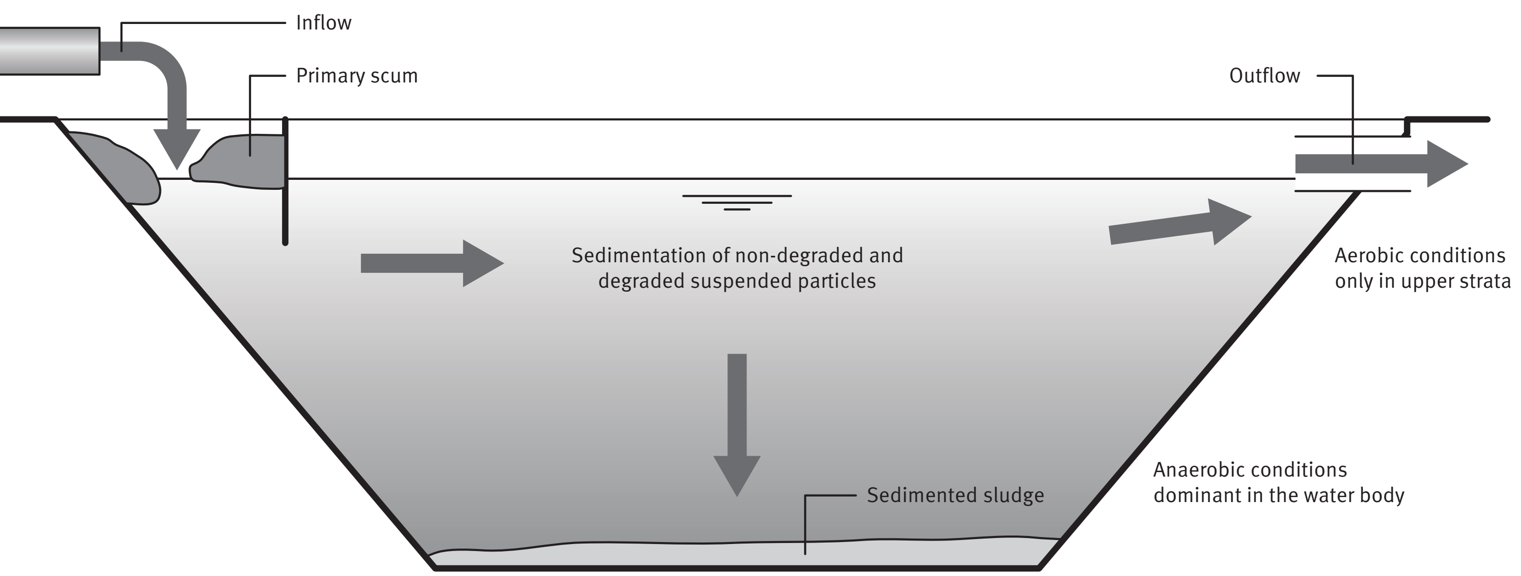
Waste stabilisation ponds (WSPs) are large pools where wastewater settles and decomposes due to naturally occurring bacteria. A carefully designed series of at least three linked ponds provides the best treatment. It is not necessary to screen the wastewater before it enters the pond. WSPs work in most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

Anaerobic biogas reactor

An anaerobic biogas reactor produces gas from the fermentation of sludge. This gas 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, where it will rise and fall with the production of gas. Biogas reactors produce sludge which is not safe to handle, and must therefore be carefully disposed of.

Figure 3: Cross-section through a waste stabilisation pond



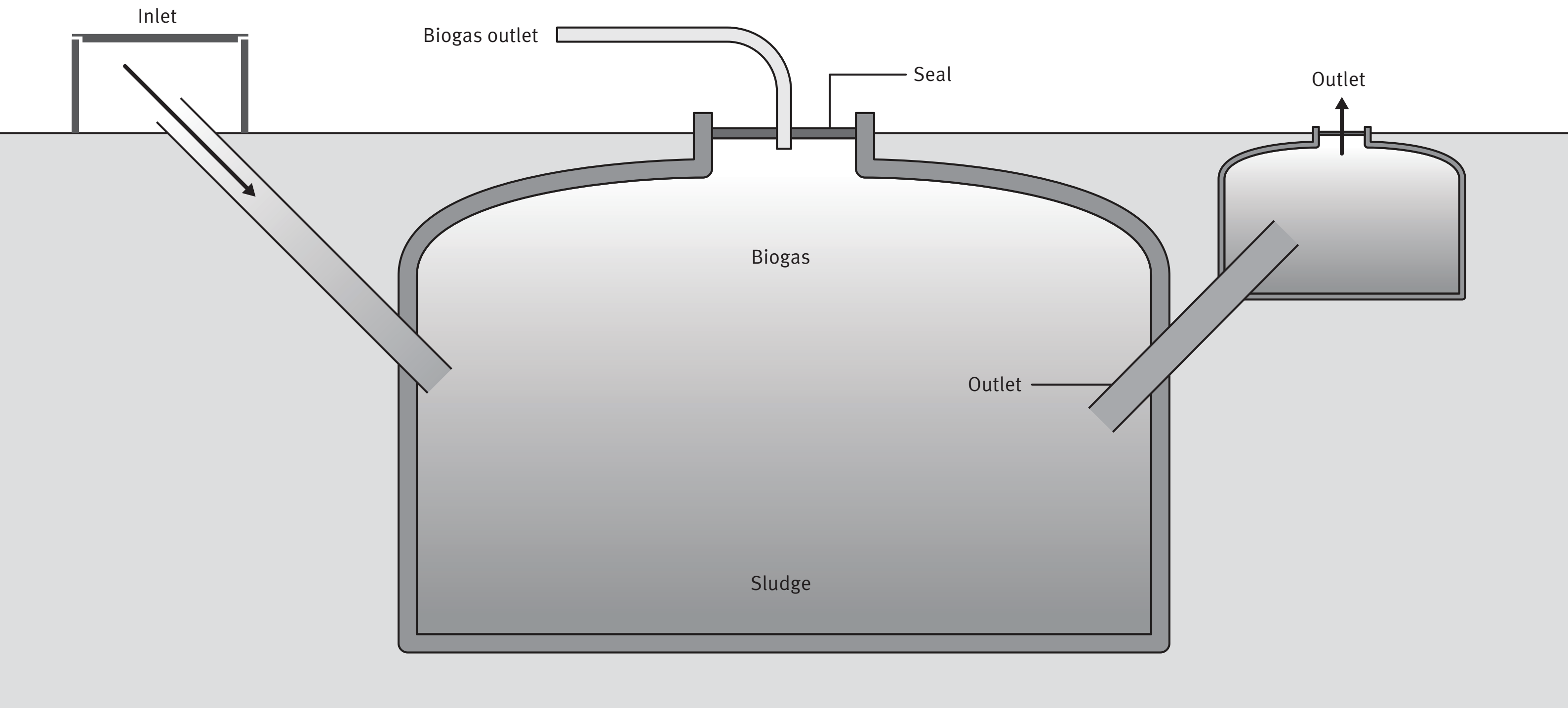


Figure 4: Anaerobic biogas reactor

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

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 a resource rather than a waste.

Urine diverting composting toilets separate urine and faeces via a specially designed slab, which are then 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 theoretically 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 (this prevents 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 an ongoing commitment for proper care and use. It is therefore essential that education on correct usage is thoroughly carried out and 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 grey water 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 sensitization may be necessary.

Disposal or use

Some of the treatment processes listed above do not provide a complete solution, with final effluent or sludge still 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 be transported off site for less cost or it can be used as fuel or compost. There are relatively few tried and tested methods for drying faecal sludge but some of the concepts are outlined below.

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 is, 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 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 the 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 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 concentrated sludge into sewers because the shock-loading can cause problems at the wastewater treatment centres downstream.

References

1. Eawag/Sandec (2008) Compendium of Sanitation Systems and Technologies
2. Elson, R. and Shaw, R.J. (1999) 'Wastewater treatment options', in Running Water, pp.41, IT Publications, London
3. Water, Engineering and Development Centre (WEDC), Loughborough (1991). The Worth of Water – technical briefs on health, water and sanitation.

Useful resources

Sanitation portal of Akvopedia
http://www.akvo.org/wiki/index.php/Portal:Sanitation

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 at:
http://www.personal.leeds.ac.uk/~cen6ddm/WSP.html

The United Nations Environmental Programme – International Source Book on Environmentally Sound Technologies for Wastewater and Stormwater Management. Available at:
http://www.unep.or.jp/ietc/Publications/TechPublications/TechPub-15/main_index.asp

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

WaterAid

WaterAid transforms lives by improving access to safe water, hygiene and sanitation in the world's poorest communities. We work with partners and influence decision-makers to maximise our impact.

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UK: Registered charity numbers 288701 (England and Wales) and SC039479 (Scotland)
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