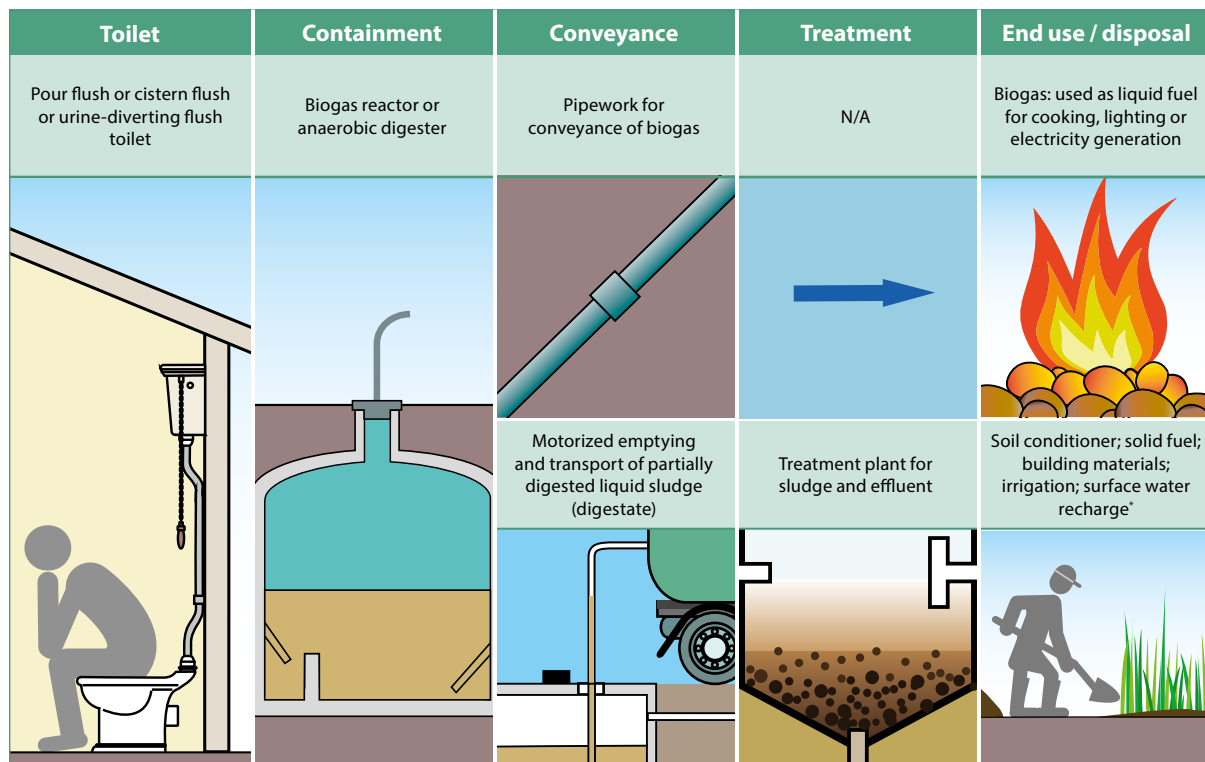


## Fact sheet 6

# Flush (or urine-diverting flush) toilet with biogas reactor and offsite treatment



\* Sludge: treated and used as soil conditioner, solid fuel or building materials. Effluent: treated and used for irrigation or surface water recharge.

## Summary

This system is based on the use of a biogas reactor to collect, store and treat the excreta. Additionally, the biogas reactor produces biogas, which can be burned for cooking, lighting or electricity generation. Inputs to the system can include urine, faeces, flushwater, cleansing water, dry cleansing materials, organics (e.g., market or kitchen waste) and, if available, animal waste.

The system requires a pour flush toilet or, if there is a demand for the urine to be used in agriculture, a urine-diverting flush toilet. A urinal could additionally be used. The toilet is directly connected to a biogas reactor, which is also known as an anaerobic digester. If a urine-diverting flush toilet is installed (and/or a urinal), it will be connected to a storage tank or jerry cans for urine storage.

Although the sludge has undergone anaerobic digestion, it is not pathogen free and must be removed with caution and transported for further treatment, where it will produce both effluent and sludge. Depending on the end use, these fractions may require further treatment prior to end use and/ or disposal.

The biogas produced must be constantly used, for example as a clean fuel for cooking or for lighting. If the gas is not burned, it will accumulate in the tank and, with increasing pressure, will push out the partially digested sludge (digestate) until the biogas escapes to the atmosphere through the digestate outlet.

A biogas reactor can work with or without urine. The advantage of diverting urine from the reactor is that it can be used separately as a concentrated nutrient source without high pathogen contamination (see Fact sheet 4 for more details).

## Applicability

**Suitability:** This system is best suited to rural and peri-urban areas where there is appropriate space, a regular source of organic substrate for the biogas reactor and a use for the partially digested sludge (digestate) and biogas.

The reactor itself can be built underground (e.g., under agricultural land, and in some cases roads) and, there-

fore, does not require a lot of space. Although a reactor may be feasible in a dense urban area, proper sludge management is essential as the digestate production is continuous and requires year-round emptying and transport away from the site.

**Cost:** For the user, the capital investment for this system is considerable (excavation and installation of a biogas tank), but several households can share the costs if the system is designed for a larger number of users. The maintenance costs may be considerable, depending on the frequency and method of biogas tank emptying<sup>2,3</sup>. However, these costs are somewhat offset by the generation of a constant supply of liquid fuel.

The capital cost of the treatment plant may also be considerable, while the treatment plant maintenance costs will depend on the technology chosen and the energy required to operate it.

## Design considerations

**Toilet:** The toilet should be made from concrete, fibreglass, porcelain or stainless steel for ease of cleaning and designed to prevent stormwater from infiltrating or entering the biogas reactor<sup>2,3</sup>.

**Containment:** The biogas reactor can function with a large range of inputs and is especially suitable where a constant source of animal manure is available, or where market and kitchen waste is abundant<sup>4</sup>. On farms, for example, large quantities of biogas can be produced if animal manure is co-digested with the blackwater, whereas significant gas production would not be achieved from human excreta alone. Wood material or straw are difficult to degrade and should be avoided in the substrate. Achieving a good balance between excreta (both human and animal), organics and water can take some time, though the system is generally forgiving.

Most types of dry cleansing materials and organics can be discharged into the biogas reactor, although to accelerate digestion and ensure even reactions within the tank, large items should be broken or cut into small pieces.

However, care should be taken not to overload the system with either too many solids or too much liquid. For example, greywater should not be added into the biogas reactor as it substantially reduces the hydraulic retention time; a separate greywater system is therefore required.

**Conveyance:** As the digestate is not pathogen free, human contact and direct agricultural application should be avoided<sup>4</sup>. Instead, it should be transported to a dedicated sludge treatment facility. The conveyance technologies that can be used include both manual or motorized emptying and transport. In the event that a treatment facility is not easily accessible, the sludge can be discharged to a transfer station. From the transfer

station it is then transported to the treatment facility by a motorized transport technology.

**Treatment:** Treatment technologies produce both effluent and sludge, which may require further treatment prior to end use and/or disposal. For example, effluent from a faecal sludge treatment facility could be co-treated with wastewater in waste stabilization ponds or in constructed wetlands.

**End use/disposal:** Options for the end use and/or disposal of the treated effluent include irrigation, fish ponds, floating plant ponds or discharge to a surface water body or to groundwater. Treated sludge can either be used in agriculture as a soil conditioner as a solid fuel or as an additive to construction materials<sup>5</sup>.

## Operation and maintenance considerations

**Toilet and containment:** The user is responsible for the construction of the toilet and the biogas reactor, but they are most likely to pay a mason to carry out the work. The user will be responsible for cleaning of the toilet and employing an emptying service provider to empty digestate from the biogas tank periodically.

At shared facilities, a person (or persons) to clean and carry out other maintenance tasks (e.g. repairs to superstructure) on behalf of all users needs to be identified as well as an emptying service provider.

Biogas can be safely burned for cooking, lighting or electricity generation but as it is explosive when mixed with air, precautions should be taken when a reactor is opened for cleaning, when biogas is released to repair a reactor, or when there is a gas leak in a poorly ventilated room. In such cases, sparks, smoking and open flames should be avoided.

**Conveyance, treatment and end use/disposal:** The digestate conveyance and treatment part of the system is typically operated and maintained by a combination of private and public service providers working together; for example, emptying and transport may be done by private and/or public service providers who deliver the digestate to treatment plants operated by public service providers.

Importantly, for this system, all machinery, tools and equipment used in the conveyance, treatment and end use/disposal steps will require regular maintenance by the service providers.

## Mechanisms for protecting public health

**Toilet and containment:** The toilet separates users from excreta and the biogas tank isolates the brownwater and pathogens within it from physical human contact.

During rains, the slab and the impermeable biogas tank contain the fresh excreta and prevent it from being washed away into surface water bodies, while the water seal reduces disease transmission by preventing disease carrying vectors from entering and leaving the biogas tank.

**Conveyance:** The conveyance step removes the pathogen containing digestate from the neighbourhood or local community to a treatment plant. Motorized emptying using vacuum trucks (or similar) fitted with long-reach hoses is the preferred method, as this reduces direct contact by emptiers with the sludge. Nevertheless, emptying and transport workers must wear personal protective equipment and follow standard operating procedures. For instance, the wearing of boots, gloves, masks and clothing that cover the whole body is essential, as well as washing facilities and good hygiene practices. The emptiers should not enter a biogas tank but use long handled shovels to remove any hard to shift sludge at the bottom <sup>6</sup>.

**Treatment:** If correctly designed, constructed and operated, treatment technologies can be combined to reduce the pathogen hazard within the effluent or sludge by removal, reduction or inactivation to a level appropriate for the intended end use and/or disposal practise. For example, sludges require dewatering and drying followed by co-composting with organics before use as a compost-type soil conditioner, but for use as a solid fuel or building material additive, they only require dewatering and drying. Effluent will require stabilization and pathogen inactivation in a series of ponds or wetlands before use as crop irrigation water.

In order to reduce the risk of exposure of the local community, all treatment plants must be securely fenced to prevent people entering the site; to safeguard workers' health when operating the plant and carrying out maintenance to tools and equipment, all treatment plant workers must wear appropriate protective equipment and follow standard procedures <sup>6</sup>.

**End use/disposal:** Provided the workers responsible for operation and maintenance of the biogas reactor follow standard operating procedures, the burning of biogas presents no health risk to the consumers of end products generated using biogas <sup>4</sup>.

## References

The text for this fact sheet is based on Tilley, et al. <sup>1</sup> unless otherwise stated.

1. Tilley E, Ulrich L, Lüthi C, Reymond P, Schertenleib R, and Zurbrügg C (2014). *Compendium of Sanitation Systems and Technologies. 2nd Revised Edition*. Swiss Federal Institute of Aquatic Science and Technology (Eawag).
2. Brikké F, and Bredero M (2003). *Linking Technology Choice with Operation and Maintenance in the Context of Community Water Supply and Sanitation. A reference document for planners and project staff*. Geneva, Switzerland.
3. Reed R A, Scott R E, and Shaw R J (2014). *WEDC Guide No. 25: Simple Pit Latrines*. WEDC, Loughborough University, UK.
4. Stenström T A, Seidu R, Ekane N and Zurbrügg C (2011). *Microbial exposure and health assessments in sanitation technologies and systems*. Stockholm Environment Institute (SEI).
5. Strande L (2017). *Introduction to Faecal Sludge Management*. Online Course available at: [www.sandec.ch/fsm\\_tools](http://www.sandec.ch/fsm_tools) (accessed March 2017). Sandec: Department of Sanitation, Water and Solid Waste for Development Eawag: Swiss Federal Institute of Aquatic Science and Technology.
6. World Health Organization (2015). *Sanitation Safety Planning – Manual for safe use and disposal of wastewater, greywater and excreta*. Geneva, Switzerland.