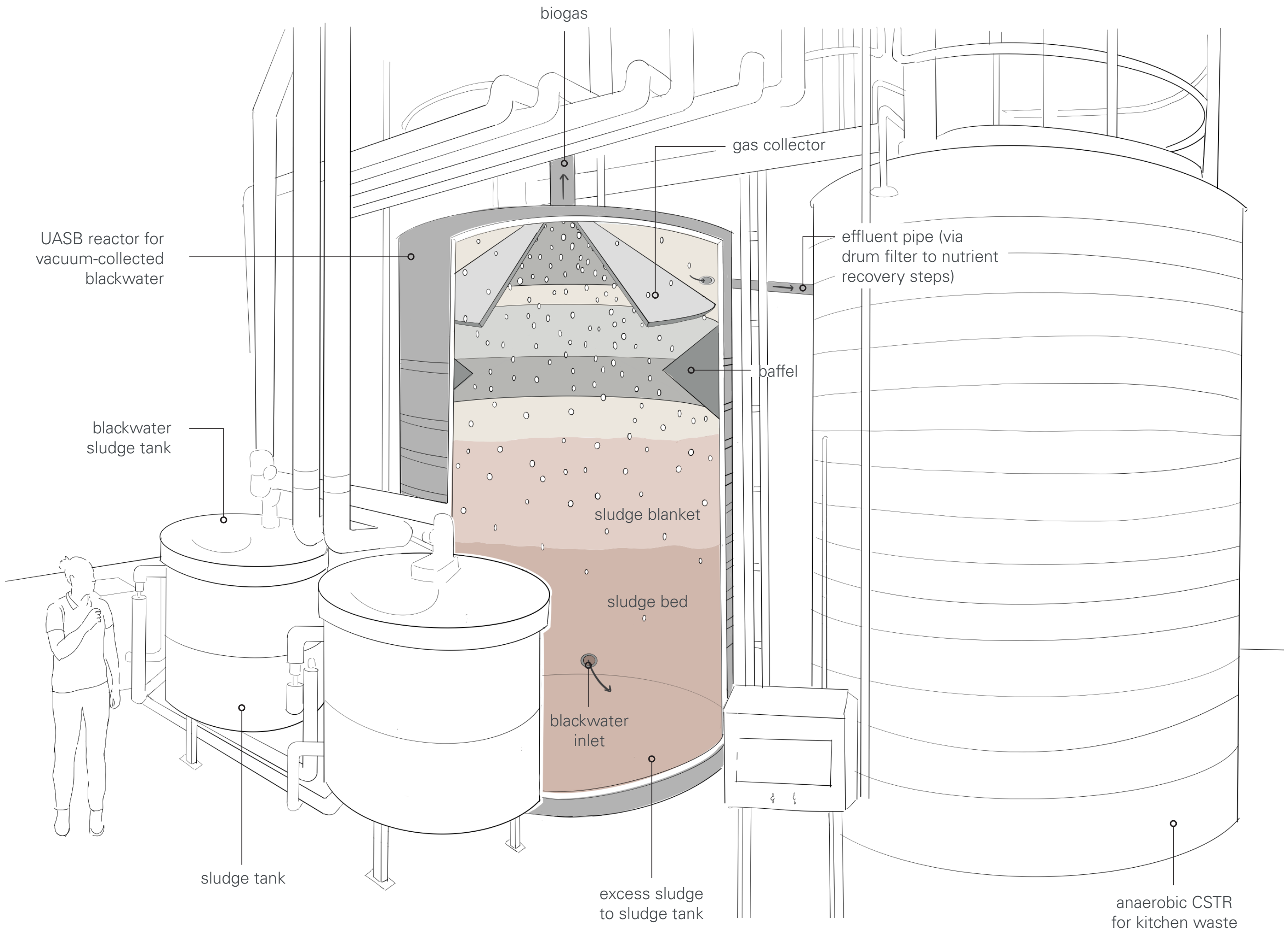
T.23 ANAEROBIC DIGESTION

TECHNOLOGY



Anaerobic digestion is the degradation of organic matter by microorganisms in the absence of oxygen. The technology is well-suited for wastewater and wastes with high levels of organic matter, yielding biogas, a mix of 50-75 % methane (CH_4) and 25-50 % carbon dioxide (CO_2), a reduced and stabilised sludge volume and an effluent. Anaerobic digestion spans a four-stage process in which different bacteria work to break down the carbohydrates, proteins and fats into sugars, acids, and finally, biogas. Temperature, sludge retention time (SRT) and pH are determining parameters for process performance. Typical anaerobic reactor configurations for concentrated separated household streams include Upflow Anaerobic Sludge Bed (UASB) reactors, Anaerobic Baffled Reactors (ABRs) and Continuous Stirred-Tank Reactors (CSTRs). These anaerobic reactors vary in design, operation, retention time, and biogas production.

Biogas can be used as a renewable energy source (heat and electricity). Methane is a greenhouse gas 28 times more potent than carbon dioxide. Recovering it can avoid its emission to the atmosphere.

INPUT STREAMS

- BW Blackwater
- MW Dewatered mixed wastewater

TARGET OUTPUT(S)

- Biogas
- Solid fraction, sludge
- Liquid fraction, effluent

OCEANHAMNEN, RECOLAB

Helsingborg, Sweden | 2021

Two anaerobic digesters to treat blackwater and kitchen waste

This waterfront development that has a "three-pipes out" collection of greywater, vacuum-collected blackwater and kitchen waste scaled for 2100 p.e., treated at the Recolab building. The blackwater is anaerobically treated in a UASB. The sludge is sent to the wastewater treatment plant next door for further treatment. The effluent undergoes struvite precipitation and ammonia stripping for nutrient recovery; in the future, the effluent will join the greywater treatment.

SPECIFICATIONS

INFRASTRUCTURE

Anaerobic digester types span simple to more complex configurations and require expert design and construction. Digesters can be built in prefabricated tanks, or in steel, concrete or brick tanks. They can be placed below or above ground. Low-rate reactors (e.g., ABRs, CSTRs) often have larger footprints compared to high-rate reactors (e.g., UASB). Depending on the type of reactor and amount of inoculum, reactors may require a start up time of several months to establish the microorganisms for treatment. For most configurations, inflow and outflow design is specifically crucial, to regulate influent distribution, optimize hydraulic retention times (HRTs), safely collect produced biogas, and remove sludge. For configurations that require mechanical mixing, running pumps or heatoing, access to energy is necessary. The biogas produced can often be used to heat and power the digester, as well as the building.

OPERATION & MAINTENANCE

Anaerobic systems rely on skilled operators to monitor the reactor and/or repair parts. Operational activities include: temperature, pH and gas production monitoring to ensure stable microbial activity, biogas system cleaning and inspections to prevent leaks and corrosion, and periodical digestate/sludge removal and safe handling. Digester maintenance include periodic servicing per manufacturer schedules, calibration of sensors and safety systems, and replacement or repair of parts (often minimal if well-designed).

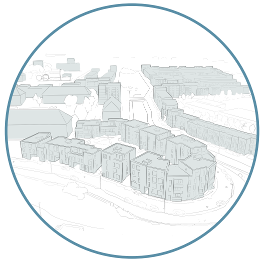
TARGET OUTPUTS

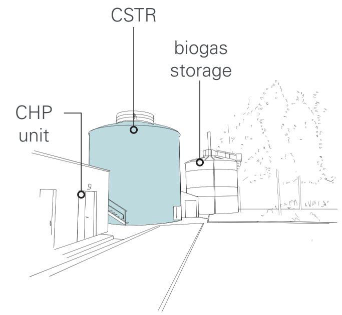
Anaerobic digestion yields biogas, sludge and effluent. The produced biogas can be converted into heat in a burner or used in combined heat and power (CHP) systems for electricity and heat. The digestate or sludge, rich in organics and nutrients, can be used as a soil amendment, however further treatment is recommended (e.g., composting, drying, pasteurization) before soil application to inactivate pathogens. The effluent can be treated for nutrient removal or nutrient recovery, and water reuse. Struvite precipitation, for phosphorus recovery, or ammonia stripping, for nitrogen recovery, allows for targeted nutrient extraction from the effluent; aerobic treatment, filtration and disinfection to achieve a water quality suitable for reuse.

Soil application of sludge/digestate are beneficial for soil fertility, structure, water retention and microbial activity. Pathogen and heavy metal risks remain. These are often lower compared to sewage sludge or animal manure application and can be mitigated through additonal treatment and appropirate application measures. Persistent micropollutants also need to be considered before application.

SELECTED CASE STUDIES

JENFELDER AU
Hamburg, Germany | 2013



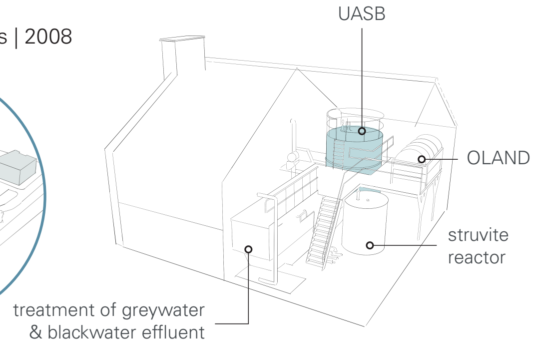


CSTR for digestion of blackwater and grease trap sludge

Vacuum-collected blackwater from this neighborhood (~2000 residents) is transported through a 3.7km underground vacuum sewer network to a treatment facility. It is fed fed into a 900m³ CSTR, together with grease trap sludge from commercial kitchens. The biogas is converted by an onsite combined heat and power (CHP) unit into ~450,000 kWh of electricity and 690,000kWh of heat per year. This is enough to meet the electricity demand of ~225 Hamburg households and heat demand of 70 households. The digestate is sent to sewer as reuse in agriculture is currently not permitted.

BW — COLLECTION TANK — T.23 CSTR — (digestate) — GAS STORAGE — CHP UNIT

NOORDERHOEK
Sneek, the Netherlands | 2008

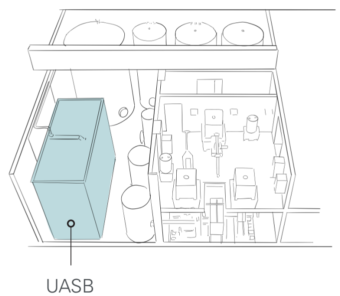


Flagship anaerobic treatment of blackwater and kitchen waste

In a neighborhood of 232 households (~400 residents), blackwater from vacuum toilets and kitchen waste, collected via kitchen grinders, are transported together via a vacuum sewer to a centralized treatment facility. The concentrated stream is digested in a UASB. The effluent from the digester flows through an OLAND (Oxygen Limited Autotrophic Nitrification Denitrification) reactor for nitrogen removal and then struvite precipitation for phosphorus recovery. The effluent is treated together with the greywater in an activated sludge system.

BW — COLLECTION TANK — T.23 UASB — (biogas) (sludge) — OLAND REACTOR — T.4 STRUVITE PRECIPITATION — (struvite)

DE NIEUWE DOKKEN
Ghent, Belgium | 2020



UASB with struvite precipitation

The residential and commercial district (ca. 1200 p.e.) is situated in a former industrial area. The vacuum-collected blackwater is treated in an underground mechanical room in several UASB reactors, together with kitchen waste collected via communcal depots for grinding and conveyance. The aerobic sludge from the greywater treatment also goes into the anaerobic reactor. The produced biogas is converted to energy (~600 MWh/year) via a CHP and fed into the district heating network. The effluent from the digester undergoes struvite precipitation (~ 1.2 tons/y), for phosphorus recovery.

BW — T.23 UASB — (biogas) (sludge) — T.4 STRUVITE PRECIPITATION — (struvite)