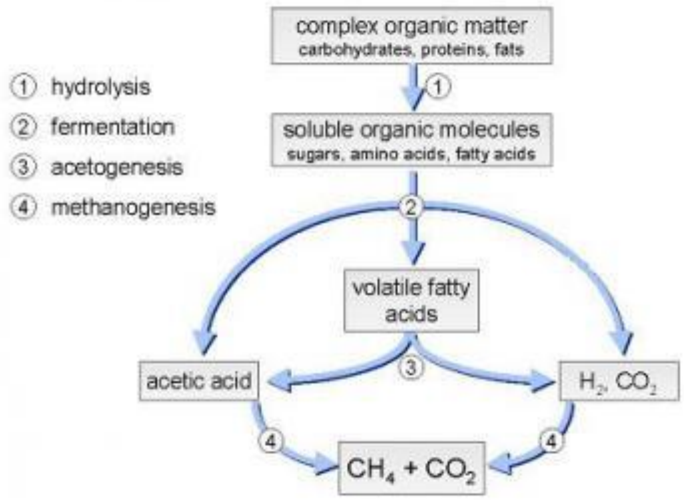
Anaerobic Digester

Defining characteristics	Narrative
General	Anaerobic digestion refers to multiple processes by which micro-organisms break down organic in the absence of oxygen. Quite prominent in some natural settings, these processes can also be replicated in controlled environments to manage waste. The technology to do this is an anaerobic digester/digestion unit which uses the design principle of physical containment to exclude gaseous oxygen from in-vessel reactions (Igoni et al, 2008; Monnet, 2003). Anaerobic digesters are particularly appropriate for wet wastes, and thus used to treat sewage sludge and various organic wastes such as slaughterhouse waste, household waste, etc. Indeed, almost all organic feedstock can be processed with anaerobic digestion; but the putrescibility of waste is an important decision factor if biogas production is one of the key reasons for deployment of the technology (Holm-Nielsen et al. 2009).
Siting and land use	Subject to social and environmental impact assessment guidelines and regulations in force, anaerobic digesters/digestion units, may be suitably located in mixed-residential and industrial areas. Land requirements for installation of these units depend on the size of individual units or cluster of units operated under local or central government authorisation.
Design (components) and Operation	Anaerobic digesters can be designed and engineered to operate using a number of different configurations. Batch-type digesters are the simplest to build. Their operation consists of loading the digester with organic materials and allowing it to digest. Continuous digesters, as the name implies, accommodates a continuous in-stream of feedstock, making the specific technology better suited to wastes capable of flowing on their own, or forming slurries with water (Igoni et al, 2008). To kickstart a digester, common practice is to introduce anaerobic micro-organisms from materials with viable populations in a process known as "seeding" the digesters. This is typically accomplished with the addition of sewage sludge or cattle slurry. Under typical conditions, characteristic micro-organism communities break down complex molecules through hydrolysis,[81] acetogenesis, and acidogenesis to intermediate products, and finally into methane (CH_4), carbon dioxide (CO_2) and digestate (Monnet, 2003). A multi-stage digestion unit permits a greater degree of control of hydrolysis and methanogenesis phases. After sorting or screening to remove physical contaminants from digester feedstock, the latter is often shredded, minced, and pulped in order to speed up digestion processes. Waste characteristics can be altered as well by simple dilution or bulking with compost. Total solid content not only determines the type of pumping technology and energy needed to operate a digestion unit, but also its biogas production. A high degree of control over rate-limiting variables such as temperature, pH, carbon-nitrogen (C/N) ratio, loading rate and moisture content amongst others, is required to achieve optimal performance of an anaerobic digester (Igoni et al. 2008). In a typical digestion system, feedstock residence time takes around 14 days in a one-stage unit, and between 10 and 40 days in a two-stage unit (Uni Idaho, 2014; Holm-Nielsen et al., 2009). Batch reactors are loaded with feedstock that is allowed to ferment and degasify before being unloaded of digestate and a fresh batch of feedstock uploaded (Verma, 2002). Feedstock with a low solid concentration, typically in the form of slurries, is stirred with mixers to create a homogenous mixture, and heated by heat exchangers to accelerate complex breakdown processes, in tanks fitted with outlets for biogas and effluents. High-solids anaerobic digestion units catering for low moisture and high solid wastes not only require lower heating costs, but also less process water delivered through hot water piping. Feedstock is added each day at one end of digester and is decomposed as

[81] Hydrolysis or liquefaction of insoluble materials is the rate-limiting step in anaerobic digestion of waste slurries

	it moves through the unit. Leachate is collected in chambers under the reactors and recycled to the top of each reactor. Waste is kept in reactors until biogas production stops. Gas is piped auxiliary units or storage tanks. Biogas production depends on putrescibility of feedstock, operational parameters of digester and retention time. Impurities found in biogas (i.e. CO_2, H_2S) can be removed by a wide array of physical and chemical measures. Feedstock residues known as digestate is transferred to the storage tanks, which are usually covered with a gas proof membrane for the recovery of the remaining biogas production (Holm, Nielsen et al., 2009). Water from dewatering of digestate is recycled into the reactor and the excess is treated in a wastewater treatment plant. (Levis and Barlaz, 2011)
Costs	Digester sizing and process design directly affect capital cost (Igoni et al (2008), with a batch-digester design being generally less costly. Monnet (2003) indicates that capacity-cost relations are non-linear. According to the author, a plant with processing of 3,000 tonnes/day processing predominantly agrciultural wastes has a capital cost between 100,000 GBP and 200,000 GBP, whereas putting up a 100,000 ton/year plant costs around 500,000 GBP, suggesting cost advantages of larger plants. Source-disaggreagted MSW digestion plants could be several-fold more expensive with a 5,000 tons/year plant costing .2.5 million GBP, and a 100,000 ton/year plant costing up to 12.7 million GBP. Operating costs range from 125,000 GBP 1 million GBP per annum.
Supporting infrastructure	Biogas holder with lightning protection rods and backup gas flare Effluent treatment Waste separation at source
Advantages	Anaerobic digesters have multiple advantages. Crucially, the technology can be deployed on a variety of scales (household, community, municipal). By offering the possibility of diverting biodegradables from dumpsites/landfills, the technology has the potential to reduce landfill requirements, transportation costs, emissions and odours from primitive dumpsites. Furthermore, digestion processes produce recyclable nutrient-rich digestate and effluents that could be used as organic fertiliser. Commercial sales of biogas and digestate could thus offset long-term operating costs. Compared to landfills, digesters produce significantly higher yields of biogas on due to continuous re-circulation of the leachate and higher operating temperatures within a closed system (Verma, 2002)
Disadvantages /Challenges	At least two challenges are associated with the operation of anaerobic digesters. First, health and safety concerns have been raised over explosion risk (Monnet, 2003; Verma, 2002), and second, the reliability of feedstock supply chains, itself linked to uncertainties/weaknesses related to availability and collection of waste streams. Both concerns/challenges could be tackled with adequate fire safety measures in place one hand, and integration of performance metrics with facility size and location factors at the feasibility study stage, on the other.
Abatement potential	An anaerobic digester operated under conditions of biogas recovery and use as a source of energy has high abatement potential compared to other waste management technologies, especially when waste is segregated at source and contains or contains a large fraction of biodegradables. Levis and Barlaz (2011), in a life-cycle assessment, report 395 $kgCO2_e$ in avoided emissions from conventional electricity power plants and soils, as a result of operating a digestion unit processing 1.5 tonnes of food and other biodegradable waste. In comparison, composting led to GHG abatement ranging from 64 to 148$kgCO2_e$, whilst the best result for landfill alternatives was 240 kg $CO2_e$ reduction.
Level of penetration	20 small units built under Peri-urban Smallholder Project with mixed results (AF-MERCADOS, 2013)



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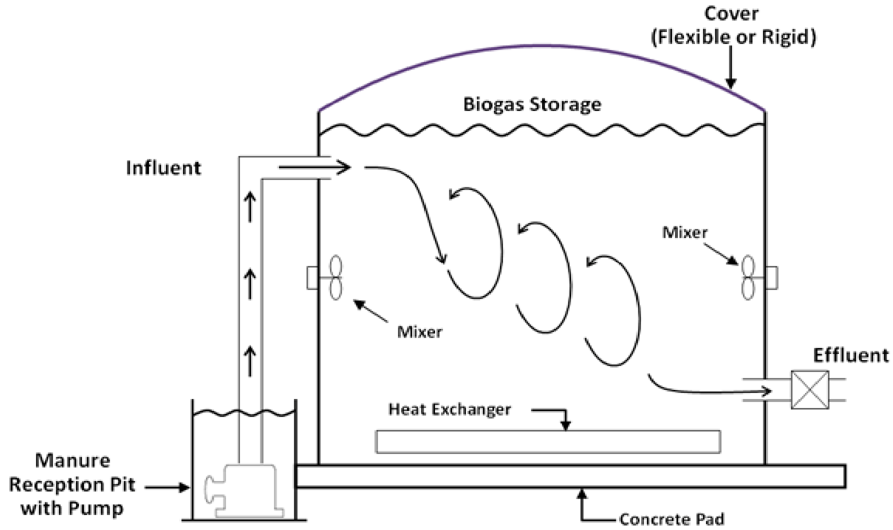

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Further Reading

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