BIOGAS PRODUCTION FROM FARM MANURE: TRAINING AND OPERATION

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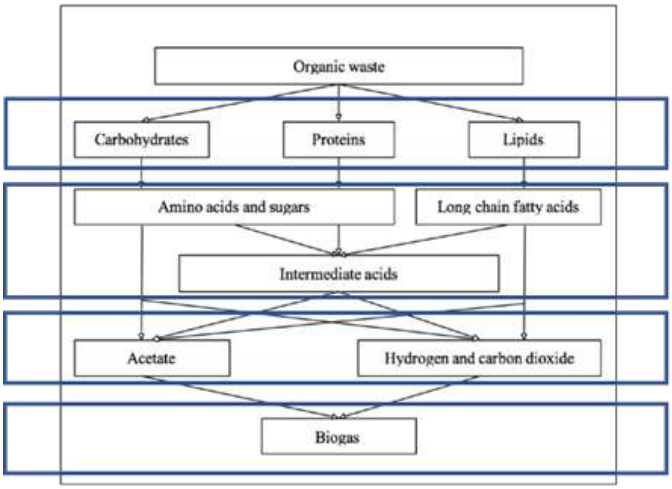
The water authorities in Australia have stringent regulations for industries regarding the management and treatment of the wastewater discharged from their processing facilities. These rules are enforced to ensure that the industries do not discharge their untreated wastewater which may contain harmful substances that can detrimentally affect the environment.

Wastewater can be treated by either anaerobic or aerobic process. The anaerobic treatment, as it implies, utilizes microorganisms to break down the organic compounds in the wastewater in the absence of oxygen. The anaerobic digestion process produces high-value biogas that can be used as fuel and source of renewable energy to generate electricity as well as solid products such as digestate that can be used as horticulture products, animal bedding or fertilizers. By implementing proper treatment systems into their plant, industries are lessening the environmental impact of wastewater and saving on operational costs by improving their operational efficiency.

The conceptual design of the anaerobic digester is simple. It has been around since the tenth century where biogas from nature decomposition was used to heat bath. However, there is a wide range of styles, sizes and variations depending on the applications. Therefore, it requires thorough planning to ensure that the anaerobic treatment process is suitable for your requirement.

HOW ANAEROBIC DIGESTION TAKES PLACE?¬



Anaerobic digestion involves anoxic bacteria to convert organic matter in wastewater sludge into biogas through a series of biological processes. The bacteria break down the organic matter in the sludge in the absence of oxygen to reduce the contamination load in wastewater. Therefore, the procedure generally takes place in an airtight container.

As the microorganism generally takes a significant period to be fully effective, operators typically seed the sludge by adding sewage sludge or farm manure to introduce the existing microorganism population from other material. The digestion process takes place in a sealed vessel or reactor, designed in different shapes and sizes to accommodate specific feedstock conditions.

The choice of feedstock can be any biomass or biodegradable materials, such as food and plant waste, farm manure, slurries or sludge. The biomass materials are treated to ensure that it can continuously flow into the digester with smooth consistencies. The anaerobic digestion process involves four conversion stages; hydrolysis, acidogenesis, acetogenesis and methanogenesis. The entire process can be simply described in a chemical reaction where organic material such as glucose is converted into carbon dioxide and methane.

The product of anaerobic digestion is mainly composed of biogas and residual materials, known as digestate. The generated biogas is primarily methane and carbon dioxide, and contains hydrogen sulfide, water vapor and traces of other gases. It can be used as energy source, purified to produce commercial-grade RNG (renewable natural gas) or fed to advanced bioprocessing facility to produce value-added bioproducts.

IS ANAEROBIC DIGESTER SUITABLE FOR YOUR FACTORY?

The efficiency of the anaerobic digestion depends on the feedstock suitability to generate biogas with a high methane concentration (above 60%). Therefore, the feedstock should contain easily degradable carbohydrates such as sugar and protein, and low amount of hemicelluloses and lignin.

The availability of ready-to-use feedstocks is also crucial for the digestion process. The factory should regularly collect waste and produce a large amount of them to ensure the viability of the process. The aim is to generate sufficient energy to power the equipment which gears a positive return of investment.

Anaerobic digestion is most suitable for a plant or a farm that regularly collect their sludge. This continuous sludge production is important to prime the growth of the microorganism to promote the digestion process. Alternatively, the digester can also be fed with multiple types of feedstock. It may improve biogas production but will require additional processing steps and holding tanks. Besides, the factory should also review its effluent management plan as codigestion can also increase the amount of nutrients in the water effluent

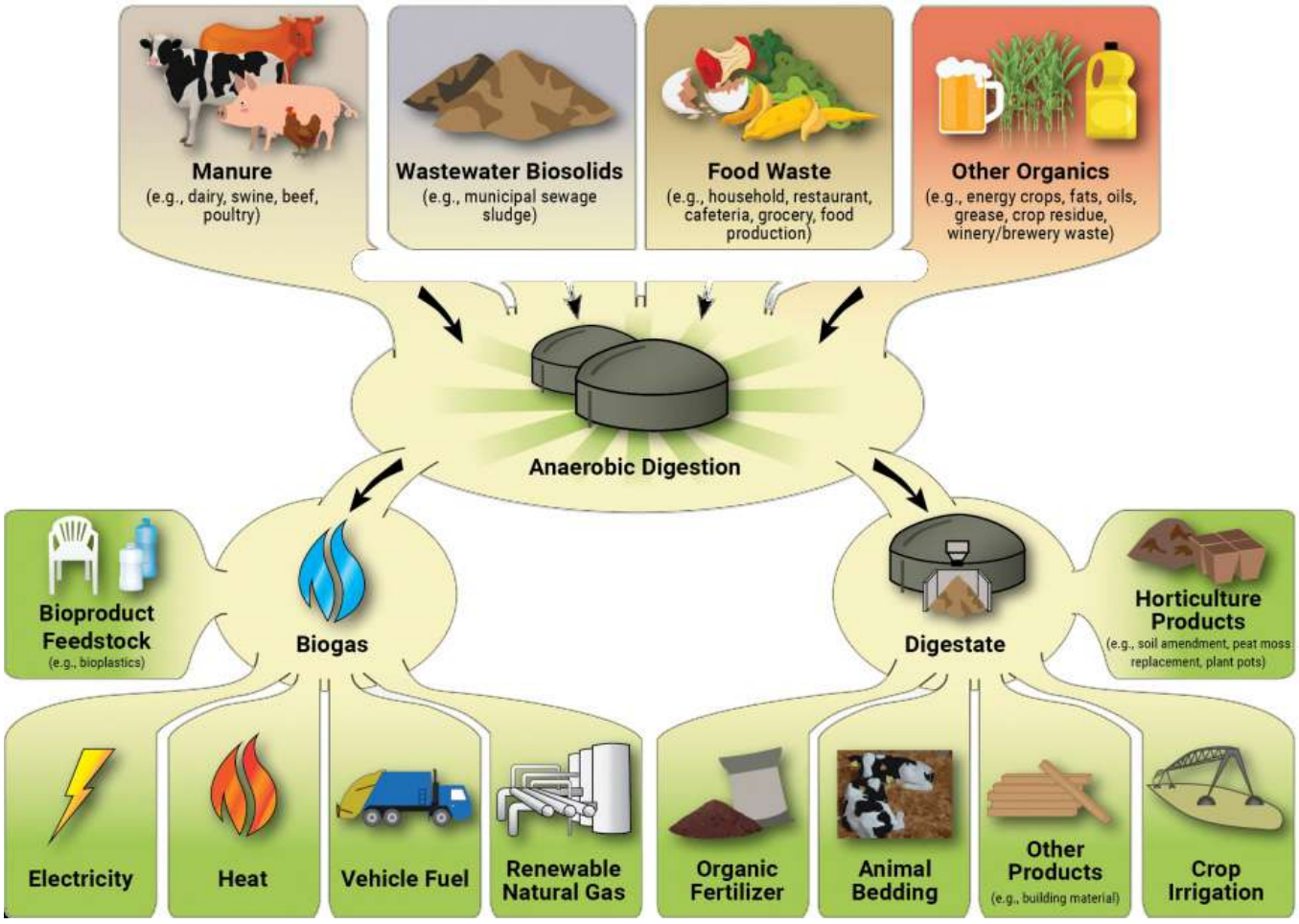


Figure 1. Anaerobic Digstion Process (Sourced from US EPA)

WHAT OPERATOR NEEDS TO KNOW

Feedstock contamination

The level of contamination in the proposed feedstock is the key consideration for choosing between wet digestion or plug-flow digester. Feedstock with significant levels of physical contaminants such as plastics, glass or metals must be preprocessed before it is fed into the digester. They may block the digester and cause it unable to function if not removed.

Pretreatment Process

Some feedstocks may need to be pretreated before being fed into the digester. The process may be biological, chemical, mechanical or thermal. The pretreatment process promotes hydrolysis, which will reduce the time required for complete digestion and improve the conversion rate to the final products.

pH and Alkalinity

Operators should monitor the concentration of the volatile acid and alkalinity in the digester. When the concentration of the volatile acid climbs above 300mg/L, it can potentially overload the digester and cause other problems. The alkalinity refers to the capacity of the solutions to neutralize acids. It is also an important control parameter as a slight change in pH affects the production of methane. Therefore, it is recommended for operators to maintain a consistent ratio of volatile acid : alkalinity at between 0.1 and 0.35.

Temperature

The operating temperature controls the type of microorganism that thrives in the digester. Generally, the anaerobic digester operates in the mesophilic range (30-38^{o}C) and thermophilic range (49-57^{o}C). For example, wastewater treatment plant typically operates their anaerobic digester in the mesophilic range with the solid retention time between 10 to 30 days. When operating the digester in this range, the operators must maintain the temperature in the narrow range such that the temperature variation is less than 0.6^{o}C per day. On the other hand, the process can be expedited when operating at higher temperature as the solid retention time for thermophilic digestion is significantly shorter, from 5 to 12 days. However, thermophiles bacteria is even more susceptible to environmental variation than mesophiles bacteria, making it harder to maintain.

Gas Production

If the biogas product is used as an energy source in the factory, operators should visually monitor the color of the flame to determine the quality of the biogas. The blue flame shows that sufficient methane gases are generated, indicating that the digester operates at optimal conditions. Separately, yellow flame is evidence of the increased concentration of CO2, suggesting an operational issue in the digester. This issue should be immediately addressed as it may affect the performance of the equipment that used biogas from the digester as a fuel source.

IMPORTANCE OF TRAINED & KNOWLEDGEABLE OPERATOR

The anaerobic digestion process has been around for many years. In fact, some households may even own anaerobic digester at home. This waste management concept is popular in many countries, especially in European countries.

Safety should be the most important aspect to be considered in any industrial processing. Although the concept of anaerobic digestion is simple, the staff in charge of operating the industrial-scale digester needs to be trained and knowledgeable to work on the equipment. There have been some implications when the process didn't go as it should be. For example, increased production of CO_2 impacts the quality of biogas and an increased concentration of Hydrogen Sulfide (H_2S) in the confined space causes fatalities. The increased concentration of the H_2S is expected in the first 24 hours as the sulfide is converted into the H_2S. It is only a major issue if there is a leak from the digester which releases the toxic gases to the environment. The operators need to be trained to learn how to respond and take action in such situations.

The elevated concentration of Hydrogen Sulfide in the air can be fatal. Above 100ppm, it poses an imminent danger to the health. The H_2S concentration above 500ppm can cause immediate loss of consciousness and death. It is a dangerous gas as it can cause fatality at a much lower concentration than other toxic gases. Besides, the working environment in the digester is generally in the confined space, which further increased the risk of asphyxiation, fire and explosion due to the presence of flammable gases such as methane.

TRAINING AND EXPERIMENT WITH PILOT SCALE ANAEROBIC DIGESTER

Bestech Australia has partnered with PIGNAT S.A.S to supply and support the delivery and applications of pilot-scale educational teaching equipment in Australia. With this partnership, we extend our capability to support the educational needs in the water and sustainability field, in addition to our sensors and instrumentation portfolio.

The TME/3000 pilot-scale anaerobicdigester mimics the industrial-scale anaerobic digester with all the risks that present in the real-life operation. The equipment can be continuously operated 24/7 for weeks or months. It allows the trainee to experience operating an industrial anaerobic digester in a controlled laboratory environment with minimized risks.

The 100L digester tank is equipped with pH and temperature probe for continuous monitoring and an industrial heating coat for temperature control. The fixed-speed peristaltic pump is used to feed the sludge to the digester and to recirculate the sludge. The gaseous products is evacuated from the tank to the gas meter.

This educational unit allows the users to experiment with different operating parameters such as flowrate, pH, temperature, and solid retention time to study digestion efficiency. It also allows the student to conduct a complete mass balance calculation to predict the maximum amount of methane produced and calculate the conversion efficiency. In addition, operators can also use this unit to learn the habit and correct operating procedures, such as pH adjustment, introducing sludge and cleaning the tank.

ABOUT US

Founded in 2002, **Bestech Australia** is an ISO9001 certified company. We specialize in supplying, designing and manufacturing sensors and instrumentation for measurement of physical parameters, data acquisition systems and technical teaching equipment for teaching and training of vocational and engineering education.

We are one of the fastest growing company in Oceania and we provide efficient solutions which could be an individual product or a complete turn-key system. We are constantly expanding our product portfolio to support the industry requirements for test and measurements as well as workforce upskilling. Our products are sourced from world leading suppliers and we complement this by own design and manufacturing capabilities backed by local technical support, service and calibration.

Our customers come from both industries and academia in the fields of engineering, mining, automotive, process & chemical, railway, food & beverages, aerospace, manufacturing, defence, energy and condition monitoring utilise our sensors and measuring instruments for monitoring processes, model validations, optimise products and gain insights from the measurement data as well as use our training equipment for developing and upgrading their on-site employee training program.

Our services include project consulting, sensors design, implementations, test and commissioning, specialists deployment, customer-specific design and development as well as system integration. Bestech consistently provide high-quality services to support your high-end test and measurement requirement.

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Bestech Australia Pty Ltd
Unit 14, 44 Garden Boulevard, Dingley, VIC 3172
P: 03 9540 5100 F: 03 9551 5541
E: enquiry@bestech.com.au
www.bestech.com.au

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