THE OHIO STATE UNIVERSITY EXTENSION

FACT SHEET

Agriculture and Natural Resources

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Manure to Energy Through Anaerobic Digestion

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Manure is one of the most commonly digested materials to produce energy (EPA AgStar). (See Table 1.) The most desirable product of anaerobic digestion is biogas, which can be used for heating, lighting, electricity generation, and cooking. Biogas generally contains 60–70% methane and 30–40% carbon dioxide (Beck). The energy content of biogas with 60% methane content is about 600 Btu/ft^3 compared to natural gas at 1,000 Btu/ft^3 (Balsam). The effluent slurry from a biogas digester is another key by-product of anaerobic digestion. The effluent can be used as soil amendments and liquid fertilizers, and it can be composted and reused as a bedding material.

Table 1. Energy Production Estimates for Livestock Manure*

Per One Head	Electricity** (kWh/yr) Equivalent	Natural Gas (Mcf***/yr) Equivalent
Swine	32	0.55
Dairy Cow	385	6.6
Beef Cattle	230	3.9
Poultry	2.5	0.04

*(National Sustainability Agriculture Information Service. Balsam, 2006).
**20% combined generating efficiency
***Thousand cubic feet

Anaerobic digestion is a natural process that occurs in the absence of oxygen. A group of microorganisms working together perform several key digestion steps. Overall, anaerobic digestion is a two-step process (Figure 1).

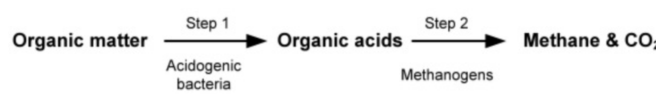

Figure 1. The two-step process of anaerobic digestion.

In the first step, organic matter in the waste is decomposed to organic acids via a group of resilient microorganisms called acidogenic bacteria. Organic acids have a strong, sour smell that many associate with decomposing sewage or manure. In the second step, the organic acids are further decomposed to methane and carbon dioxide. This second more sensitive group of microorganisms is called methanogens.

Anaerobic digestion occurs over a range of operating temperatures. Two operational temperature levels are typical for anaerobic digestion. Unheated digesters fluctuate with air temperature, and heated digesters (mesophilic digesters) operate near "body temperature" at 95–105°F. Generally, the higher the temperature, the faster the digestion and the greater rate of biogas production. Digesters can also operate at thermophilic condition (131°F).

The most common type of digesters are unmixed systems called plug-flow digesters (Figures 2a–2c). Plug-flow digesters account for 53% of the digesters in the United States (EPA AgStar). In a plug-flow digester, the materials flow as a plug in a horizontal direction, advancing toward the outlet whenever new materials are added. The reactors may be in-ground, tubular tanks or covered, concrete-lined trenches. This type of reactor can handle materials containing 11–14% total solids and can be insulated and heated to speed up biogas production. Most animal manure, when produced by the animal, is in this moisture range. Plug-flow digesters are best used when little to no bedding or flushing water is added. The average length of time that a material remains in the reactor is the hydraulic retention time (HRT) and ranges from 15–30 days (Penn State College of Agricultural Sciences).

Figure 2b. A covered plug-flow digester, to help maintain temperature and protect from the environment (Kryzanowski).

Figure 2a. A plug-flow digester (Solarberg).

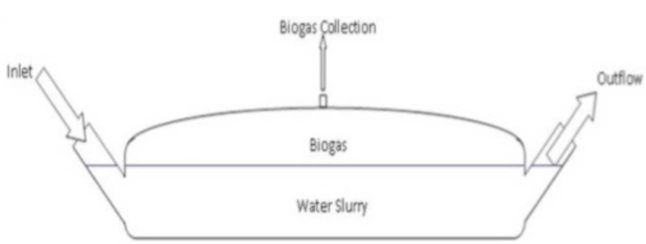

Figure 2c. A diagram of a plug-flow digester.

Complete-mix digesters (Figures 3a–3c), which account for 28% of the digesters in the United States (EPA AgStar), are mixed systems where the materials within the reactors are mixed either mechanically with effluent recirculation or with compressed biogas. This type of digester is usually made of a round tank that is insulated and heated. Complete-mix digesters process materials containing 3–10% total solids. Hydraulic retention times range from 10–20 days (Penn State College of Agricultural Sciences).

Covered lagoons are large anaerobic lagoons covered with a flexible or floating gas-tight cover designed to capture biogas (Figure 4). These lagoons are not heated and can only handle materials containing 0.5–2% total solids. Retention time for covered lagoons ranges from 30–45 days or longer depending on the size of the lagoon and the outside temperature. Covered lagoons are typically used with flush-style manure management systems. About 15% of the digesters in the United States are covered lagoons (Wilkie).

Anaerobic digestion has several environmental and economical benefits. This process significantly reduces or eliminates odors, inhibits pathogens in effluent, and reduces greenhouse gas emissions as well as nonpoint source pollution. Because methane is twenty-one times more effective as a greenhouse gas than carbon dioxide, capturing the methane from decomposing manure and burning it reduces emissions. The economic benefits of anaerobic digestion include the production of biogas, which can be used for heat and electrical generation; the reduction of cost for collection and treatment of waste; and possible greenhouse gas credits for the capture of methane.

As research continues, anaerobic digestion is becoming a viable method for waste treatment that can provide energy recovery from waste biomass as well as a beneficial use of all waste streams. Anaerobic digestion should have a great future among biological conversion technologies and will become important for future sustainable waste management. Anaerobic digestion can be used to convert waste materials such as animal manure, food wastes, organic industrial wastes, and sewage sludge into useable resources. Anaerobic digestion has the potential to play a pivotal role in the future of sustainable waste management and biological conversion technologies.

References

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Figure 3a. The F550 system, quasar energy group's complete-mix digester at The Ohio State University's OARDC campus.

Figure 3b. The complete-mix digester at Oklahoma State University's Swine Research and Education Center.

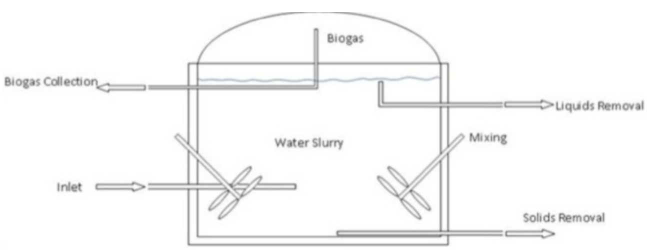

Figure 3c. A diagram of a complete-mix digester.

Figure 4. A covered lagoon at Oklahoma State University's Swine Research and Education Center

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This fact sheet has been reviewed by Drs. Harold Keener and Jay Martin.