Increasing Anaerobic Digester Performance with Codigestion

September 2012

Anaerobic digestion is a process where bacteria break down organic matter, such as manure, in the absence of oxygen. The anaerobic digestion process generates biogas that is composed mostly of methane, which can be used as an energy source (e.g., heat or electricity generation). Codigestion refers to the simultaneous anaerobic digestion of multiple organic wastes in one digester. **Codigestion** is used to increase methane production from low-yielding or difficult to digest materials (i.e., feedstocks). For the codigestion process, care must be taken to select compatible codigestion feedstocks that enhance methane production (and to avoid materials that may inhibit methane generation). In addition, an existing anaerobic digester system must be able to handle the significant increase in methane output that is common with codigestion.

In agriculture, codigestion is often used to increase methane production from the anaerobic digestion of manure. There are multiple choices for codigestion feedstocks, including restaurant or cafeteria food wastes; food processing wastes or byproducts; fats, oil and grease (FOG) from restaurant grease traps; energy crops; crop residues; and others. Exhibit 1 (on the following page) provides a list of some common feedstocks for codigestion. Codigestion of various organic feedstocks may enhance the biogas and methane production from an anaerobic digester; thus, each of the factors shown in the following text box should be considered when selecting a feedstock.

Does my anaerobic digester have enough capacity to add a codigestion feedstock?

Additional feedstock loading volume may affect the retention time in an anaerobic digester. Longer retention times allow the feedstocks to fully digest, which maximizes biogas production and minimizes odors. For existing anaerobic digesters, farmers must consider whether there is enough capacity in the anaerobic digester to handle a feedstock, in addition to the current quantity of manure fed to the digester. Another capacity consideration is whether the biogas system can handle the increased biogas and methane gas produced from codigestion, particularly if a significant increase in methane is anticipated.

How much will the feedstock cost, and how will I transport it to my farm?

Both the availability and cost of codigestion feedstocks are important factors to consider. Farm operations may have multiple types of appropriate codigestion feedstock materials in the local area and should select materials that are abundant and consistently available. Farmers also should consider drawing up a long-term contract (5 to 10 years) with the feedstock supplier that guarantees the organic quality of the feedstock, the volume or weight that the supplier can provide, and how frequently the feedstock can be delivered. Other items farmers could include in a contract would be who will pay the transport cost to deliver the feedstock to the digester and whether the supplier will pay a tipping fee; and whether the feedstock is free or the rate the farmer will pay. Farmers should also consider a back-up plan for a substitute feedstock in case the material suddenly becomes unavailable.

What environmental regulations and permitting requirements must I meet?

In some jurisdictions, codigesting multiple feedstocks may require an anaerobic digester system to obtain additional air, water, or

Things to consider when choosing codigestion feedstocks:

- √ Local availability and cost
- √ Moisture and total solids
- √ Mixing and particle size
- √ Gases that suppress bacteria
- √ Nutrient balance (C:N ratio)
- √ Digester capacity
- √ Permitting
- √ Biodegradability
- √ pH

solid waste permits. Also, if the effluent is land applied, the farm may have to update its nutrient management plan. Check with applicable local or state agencies before adding codigestion materials to a digester.

How do codigestion feedstocks compare with the biodegradability and volatile solids (VS) of manure?

In general, animal manures digest (or biodegrade) more slowly than other organic matter. The addition of codigestion feedstocks can increase the biodegradability and the VS in the digester. Volatile solids are the digestible organic matter that can be converted into methane gas. An increase in VS means an increase in biogas and methane production. Some crop residue feedstocks that contain a significant amount of lignin (which is not digestible) may be difficult to break down in the digester.

How will the feedstock affect the moisture and total solids (TS) levels in my anaerobic digester?

The mixing of liquid manures with drier feedstock materials may increase the TS content of the digester feedstock, so it is important that farmers maintain enough moisture to sustain anaerobic activity, as well as consider the type of anaerobic digester being used and the TS content it can handle. When adjusting the moisture and TS content of feedstock material, farmers should ensure that the TS content allows ease of pumping and mixing with the current equipment.

How important is mixing for codigestion?

Some consideration must be given to mixing of feedstocks to create a homogenous (i.e., consistent) feed to the digester. Depending on the source and type of codigestion feedstock, the material or particle size can vary widely. For example, food wastes, such as rotten produce, could vary significantly in size. Small particle size has been shown to increase biogas yield because methane-producing bacteria have better contact with the VS (i.e., digestible organic matter) and any barrier created from the fibrous portions of the feedstock is eliminated. Some shredding or grinding of the material may be necessary in addition to mixing to create a homogenous feed to the anaerobic digester. Installation of a holding tank for feedstock may also be necessary. A holding tank allows testing of the material before it is sent to the digester and also allows the operator to control the feed rate of the material to the mixer and digester, thereby ensuring consistency in operations.

Exhibit 1. Methane potentials (m^3 CH_4/ton feed) for common feedstocks[a]

Feedstock	Methane potential
Food wastes[b,c]	
Potato pulp	50
Brewery waste	75
Food waste	210
Molasses	230
Cereal waste	300
Potato chips	540
Fats, oils, and greases (FOG)	
Food grease	250-340
Crop residues[d] and energy crops[e]	
Lawn clippings	125
Corn residues	150

a. For frame of reference, cow manure in liquid form has a methane potential of 20 cubic meters of methane gas per ton of feedstock (m3 CH4/ton feed) and solid cow manure a potential of 40 m3 CH4/ton feed.

b. Food waste may include wastes from restaurants, cafeterias, etc.

c. Food processing waste may include potato, beets, corn, cheese whey, etc.

d. Crop residues may include oat straw, wheat straw, etc.

e. Energy crops may include grains, grasses, miscanthus, etc.

http://www.biogas-renewable-energy.info/waste_methane_potential.html

http://www.bcfarmbiogas.ca/Feedstockenergy/feedstock

What effect will the feedstock have on the pH of the anaerobic digester?

The necessary pH for anaerobic digestion ranges somewhere between 6.8 to 8.5 and varies depending on which stage of the anaerobic digestion process is occurring. Lower pH (i.e., more acidic) conditions inhibit biogas production because the methane bacteria cannot survive (i.e., die off). Most food waste feedstocks tend to decompose quickly and can decrease the pH of the digester. The addition of a buffer such as sodium bicarbonate (i.e., baking soda) to the digester may be needed to balance the initial high acidity caused by decomposing food waste and would be an extra operating expense.

Does the feedstock contain contaminants that will suppress the methane bacteria?

The feedstock must not be toxic to the digester's methane-producing bacteria or create an environment where gases that are toxic to bacteria are produced. Often, because of the high nitrogen content of manure and the presence of sulfur, ammonia gas and hydrogen sulfide gas are easily formed. With the increased nutrients in the digester from codigestion feedstock, there could also be an increase in these gases. The presence of too much ammonia gas or hydrogen sulfide gas can inhibit the production of methane.

How does codigestion affect the balance in nutrients, i.e., the C:N ratio?

The ideal carbon to nitrogen (C:N) ratio for anaerobic digestion ranges from approximately 20:1 to 30:1. Dairy manures typically contain a C:N ratio of approximately 9:1, and swine manure contains a C:N ratio of approximately 6:1. The addition of codigestion materials with higher carbon contents than manure feedstocks can improve the C:N ratio, thereby increasing methane production. For example, the C:N of the dairy and swine manures may be enhanced by adding food processing residues such as potato waste with a C:N ratio of 28:1, or crop residues, such as oat straw with a C:N ratio of 48:1. See AgSTAR's Codigestion webpage for typical C:N ratios of feedstocks.

How do I determine the quality of a potential feedstock?

Laboratory testing can be performed to determine the quality of a feedstock. Laboratory tests might include a biochemical methane potential (BMP) test, anaerobic toxicity assays (ATA), total solids, volatile solids, alkalinity (or pH), and chemical oxygen demand (COD) (see AgSTAR's Codigestion webpage for test methods and laboratories that perform analysis). Ideally, a farmer may want to test each load of feedstock before adding it to the digester; however, laboratory testing is an extra operating expense. At a minimum, a farmer would want to test any time a new feedstock is selected and prior to entering into contract with a waste supplier.

Is the net energy balance positive?

The last thing to consider when making the decision to codigest a feedstock is whether the anaerobic digester will produce more energy with codigestion than the amount of energy needed for transporting the feedstock to the farm, grinding and mixing the feedstocks, and operating the digester. If the energy balance is positive, then codigestion may be an appropriate option.

Find Out More

AgSTAR offers a variety of tools, resources, and events to increase the use of AD systems. More information on AD system funding, development, and operation is available on the AgSTAR website at www.epa.gov/agstar.

EPA United States Environmental Protection Agency

Office of Air and Radiation
Mail Code 6207J
www.epa.gov