Understanding Anaerobic Digestion

In this white paper Element's engaged expert, John Rigdon, will guide you through the natural process of anaerobic digestion which involves three sets of bacterial interactions: bacterial hydrolysis, obligate hydrogen-producing bacteria, and methanogenic archaea

Bacterial Hydrolysis

The anaerobic process begins with naturally occurring polymer waste. Examples of these polymers include carbohydrates such as sugars and alcohols; cellulose or glucose; lignin; proteins like amino acids and peptides; and fatty acids. These polymers are attacked by hydrolysing and fermenting microorgan-isms, the first set of bacteria involved in the process.

These organisms excrete enzymes that break down the polymers and produce shorter chain compounds. By products of this reaction include acetate and hydrogen, in addition to volatile fatty acids like propionate, butyrate and alcohols.

Obligate Hydrogen-Producing Bacteria

After the acetate, hydrogen and fatty acids are formed from the initial reaction, a second group of bacteria continue the digestion process. Hydrogen-producing acetogenic bacteria break down the compounds further, converting them into acetic acid, additional hydrogen, and carbon dioxide. This is a slow process, as the acetic acid is formed by the metabolic reactions of the bacteria.

Environmental conditions play an important role in this stage. Because the hydrogen producing bacteria are sensitive to changes in chemical and physical condition, major changes in the immediate environment could be detrimental to the process. However, once this stage is completed, the resulting acids are transferred to two different groups of methogenic archaea bacteria.

Methanogenic Archaea

Consisting of acetoclastic (acetate degrading) and hydrogenotrophic (hydrogen utilizing) groups, the methogenic bacteria complete the final stage of digestion. The acetoclastic group produces 2/3 of the methane formed in this reaction, but the growth rate is slow and the bacteria is sensitive to environmental factors. The hydrogenotrophic group produces only 1/3 of the resulting methane, but has a higher growth rate and is less sensitive to environmental considerations.

Once this stage is completed, the process is finished. After being converted to acetate and hydrogen, then to acetic acid, the polymers are finally released as methane, and are ready to be harnessed for use in a variety of applications.

Environmental Conditions

Because of the sensitivity of several bacteria vital to this process, different environmental conditions can affect the rate at which the digestion is completed and methane is produced. In addition to physical and chemical factors, such as feedstock structures, pH levels, trace element nutrients and liquid gas transfer, external factors like the type of waste being digested, temperature, presence of toxic materials, rate of digester loading, and the competition and synergy between microorganism groups all affect the speed at which the process occurs.

While an ideal environment does not always exist, there are optimal conditions for efficient digestion including a neutral pH level. For example:

- pH range should be between 5-7 for hydrolysis and fermentation.
- pH range should be between 7-8 for methanogen bacteria.
- The process can occur between 6.5-8.5.

The types of ammonia and feedstock can also affect digestion rage; for example, ammonium is more desirable than free ammonia.

Additional considerations include the concentrations of nitrogen and hydrogen, and the combination of hydrogen producers and hydrogen consumers involved in reactions. The total amount of ammonia nitrogen produced is also a factor, as too much NH_3 can inhibit the digestion process.

Temperature is also an important factor on the amount of methane produced by digestion.

The ideal temperature range is between 95-105°F (35-40°C); higher or lower temperatures will decrease the total methane output. Higher temperatures specifically have a greater detrimental effect on the digestion process as a whole.

Conclusion

Anaerobic digestion is a complex, multi- stage process that requires three distinct groups of bacteria. In this process, organic matter is stabilized and converted through three different processes, eventually being released as methane. Because of its dependence on its surroundings, this process is heavily dependent on environmental considerations, including pH, nitrogen and hydrogen concentrations, temperature, and more.

The more we understand the process and output of anaerobic digestion, the more we can harness it as an alternate energy source and a tool for environmental regulation. To learn more about how Element is supporting testing in this field, contact us today

Contact Us

328 Ley Rd
Suite 100
Fort Wayne, IN 46825

888-786-7555
www.element.com