What every operator should know about anaerobic digestion

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Knowledge	Principle	A practical consideration
Volatile acid (VA)	VAs are fatty acids (organic acids) that are soluble in water. VA test results are expressed as milligrams of equivalent acetic acid and indicate the health of the digester. In a normal or healthy digester, the VA will be used as the food for the methane formers.	The production of organic acids depends on the volume of solids fed to the digester. The typical range for VAs in a primary digester is between 50 and 300 mg/L. When VA concentrations climb above 300 mg/L, the digester could be overloaded or experiencing other problems.
Alkalinity (ALK)	ALK is the buffering capacity of water to neutralize acids. ALK is a measure of carbonates, bicarbonates, hydroxides, and, occasionally, borates, silicates, and phosphates. It is expressed in milligrams of equivalent calcium carbonate per liter.	The methane formers (methanogens) in anaerobic digestion are affected by small pH changes, while the acid producers can function satisfactorily across a wide range of pH. Digestion stability depends on the buffering capacity of the digester contents. Higher ALK values indicate a greater capacity for resisting pH changes. ALK value in an anaerobic digester can range between 1500 and 5000 mg/L.
VA/ALK ratio	VA and ALK, when examined together, can measure and control the digestion process. VA and ALK concentrations are used in a formula to provide a single number that provides a snapshot of digester operation.	Maintaining a consistent VA/ALK ratio of less than 0.35 ensures that conditions are correct for proper digester operation. $\text{VA/ALK ratio} = \frac{\text{VA (mg/L)}}{\text{ALK (mg/L)}}$ The ratio in a well-operated digester ranges between 0.1 and 0.35. If the ratio exceeds 0.35, it indicates such issues as increased organic loading, hydraulic overloading, etc.
Mesophilic digestion	Mesophilic organisms grow optimally in a temperature range of approximately 30°C to 38°C (85°F to 100°F).	Most anaerobic digestion processes at wastewater treatment plants operate in the mesophilic range. It is important for operators to maintain temperatures within a narrow range – typically, 35°C to 37°C (95°F to 98°F). The temperature within a digester must not be changed more than 0.6°C (1°F) per day. The solids retention time for a mesophilic digestion system ranges between 10 and 30 days.

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Thermophilic digestion	Thermophilic organisms grow optimally in a temperature range of 50°C to 60°C (122°F to 140°F). Temperature variations are especially hard on thermophilic microorganisms.	A digestion system that operates in the thermophilic temperature range requires a shorter solids retention time than an anaerobic digester operating in the mesophilic temperature range. The solids retention time for a thermophilic digestion system ranges between 5 and 12 days.
Organic loading	Anaerobic digesters are fed based on a measurement of mass or weight of volatile solids per unit of digester volume per day. The units kg/m³•d and lb/1000 ft³•d are most common.	Anaerobic digestion systems designed today usually are high-rate systems with loadings of 1.6 to 6.4 kg/m³•d (100 to 400 lb/1000 ft³•d). Digesters should be fed at a consistent and constant rate to operate properly.
Gas production	A benefit of anaerobic digestion is the production of methane gas, which can be used as a fuel to heat the digesters or another process, such as a dryer. The gas also can be used to fuel an electrical cogeneration system. Gas production in an anaerobic digester is estimated between 0.8 and 1.1 m³/kg of volatile solids destroyed (13 and 18 ft³/lb of volatile solids destroyed). Digester gas contains approximately 65% methane and 35% carbon dioxide. The heat value of the digester gas is between 19 and 23 MJ/m³ (500 and 600 Btu/ft³).	Operators should visually monitor the color of the flame at the waste-gas burner to determine the quality of gas produced. A predominantly blue flame indicates good methane production; an increase in yellow indicates more carbon dioxide. An increase in carbon dioxide could indicate a digestion process issue. An increase in carbon dioxide also will affect the operation of the equipment using digester gas as a fuel source.
Mixing	Anaerobic digesters are mixed to ensure constant temperature and that incoming solids are well dispersed.	One key to successful digester operation is good and thorough mixing. Types of mixing systems used in anaerobic digesters include gas mixing, internal mixing, and external mixing. Internal and external mixing systems are hydraulic and/or mechanical.
Foaming	Foaming in an anaerobic digester can result in poor process performance, safety issues, and damaged equipment and/or structures.	Foaming typically results from poor mixing, temperature variations, and/or improper/inconsistent feeding. Sometimes, filaments transferred from the liquid process stream to the digesters can cause foaming.
Toxicity	Anaerobic digestion processes cannot tolerate elevated levels of several compounds, including heavy metals, sulfides, volatile acids, alkali/alkalines, and even ammonia–nitrogen. A properly operated digester requires the optimal balance of such parameters as organic loading rate, pH, mixing, and temperature.	Heavy metals, such as copper, inhibit digestion at a soluble concentration greater than 0.5 mg/L. Metals entering a digester may be coming from an industrial user. Ammonia concentrations of 50 to 200 mg/L are beneficial, but ammonia levels of 1500 to 3000 mg/L (pH greater than 7.4) are inhibitory. An ammonia concentration higher than 3000 mg/L is toxic. As an operator, if you notice that the ammonia levels are climbing steadily, you may need to reduce the organic loading rate.
Struvite	Struvite, or magnesium ammonium phosphate ($MgNH_4PO_4$), accumulates in scale deposits in anaerobic digestion systems and in the downstream dewatering system. Typically, it causes maintenance problems by clogging pipes, valves, heat exchangers, etc., with a white residue.	Once struvite deposits have formed, they are difficult to remove. Acid washing is an effective cleaning method but is time consuming, costly, and can be a safety issue. Some facilities feed ferric chloride or ferrous chloride to digester feed lines to reduce the potential of forming struvite deposits.

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