Blue Frog™ System White Paper: **High Sugar Waste Treatment Strategy**

Aerobic treatment of high sugar waste water is different from normal industrial or municipal waste precisely because it is "too easy" to process.

The root cause of the issue is that sugar is metabolized so rapidly that it is impractical to add oxygen at a high enough rate to keep the water column oxygenated.

Anaerobic digestion of high sugar waste is also problematical, but for a different reason. Anaerobic digestion takes place in four sequential interactive steps:

1. Hydrolysis – Conversion of organic polymers into sugars, amino acids and long chain fatty acids
2. Acidogenesis – Conversion of sugars et al into short chain, volatile fatty acids (VFAs)
3. Acetogenesis – Conversion of short chain fatty acids into acetic acid, hydrogen and carbon dioxide. The pH falls.
4. Methanogenesis – Conversion of acetic acid and hydrogen into methane and carbon dioxide. The pH rises.

The acetogenesis and methanogenesis reactions are interdependent and interactive with each other. If either is out of equilibrium with the other, the situation is toxic (excess hydrogen is toxic to acetogenesis; $pH<6.2$ is toxic to methanogenesis).

Sugar skips the first step in the sludge digestion process and thus the process cannot be rate limited by hydrolysis of organic polymers. In practice, the pH falls below 6.2 and the digestion stops.

An expensive and environmentally unattractive approach to control pH is to add caustic, carbonate or ammonia. The inorganic bases increase the salt content of the discharge; ammonia requires difficult biological steps (in a lagoon) to remove.

There are two other approaches with merit: slow down the rate of sugar removal so that the acetogenesis and methanogenesis processes stay in equilibrium and recycle clean, buffered water back to the headworks.

Slowing Down the Process; Buffer the pH

Sugar-water is completely soluble and has a specific gravity > 1. To slow the process down, sugar has to be kept low in the water column and any upper-layer sugar needs to be made into sludge.

Practically this means introducing sugar-water at the bottom of the water column and making the lagoon facultative with an aerobic cap over an anaerobic lower portion. Most of the sugar-water will stay anaerobic. Entropy driving forces will push some sugar into the aerobic cap. The added oxygen in the cap will convert the sugar into low pH short chain fatty acids and sludge. This sludge will sink and be slow to digest. The pH will fall. It is important not to drive this process so the pH does not get too low.

Carbon dioxide is generated as the sludge digestion process proceeds. There are three important moieties of CO_2 in water. Carbonic acid prevails at pH 4, bicarbonate buffers at pH 7-9 and carbonate predominates @ pH>10. To keep the pH in the 7 range, alkalinity levels must be high. In wastewater treatment systems, the alkalinity is primarily bicarbonate.

In a once-through system there is very little alkalinity because the bicarbonate has yet to be formed. In a system with significant recirculation from the back of the system to the front, previously formed alkalinity is added to the influent.

The recirculated alkalinity is a pH buffer. When the pH is buffered near 7, the kinetics of the acetic acid-consuming step (methanogenesis) is maximized. Methanogenesis removes acid from the system and keeps the pH in the bicarbonate buffering range.

Normally, waste treatment systems try to maximize the rate of reaction and minimize the hydraulic retention time. In sugar systems, this is undesirable. Anaerobic digestion is slower than aerobic digestion. To slow the overall kinetics down, oxygen is intentionally withheld from the process to force the digestion into the anaerobic zone. With less oxygen available, it is harder to make CO_2.

Practical Application

In a high sugar system, the first process step is a Blue Frog/CSTR. A small amount of oxygen is added, but not enough to deliver measurable DO. The CSTR selects for anaerobes and facultative organisms and selects away from aerobes.

A series of Gold Frog aerators are added, in series, downstream of the BF/CSTR. Once again, they add insufficient oxygen; the DO is zero. There is no smell because the sulfur reducing bacteria are consumed in the CSTR. Thus one root cause of malodor is eliminated.

Finally, a Gold Frog/CSTR is placed at the end of the process. The GF/CSTR is a clarifier. A 10hp pump drives 8 venturis which provide the density difference for clarification. Half of this flow (.4MGD) is returned to the headworks through a manual control valve. If the BF/CSTR pH >8, the valve is closed slightly. A target of 6.8 to 7.0 is ideal.