

Blue Frog™ System

N and P reduction

Dairy nitrogen and phosphorous reduction

Three Star Dairy is located in McCook NE and milks 1,100 cows three times per day. The waste collects on a sloped concrete alley and is flushed periodically to a surge tank. From the surge tank, the waste and flush water is pumped over two in-series screens (.035 and .010inch parallel wire screens). The separated waste is collected and composted; the screened liquid flows over a wide spot where sand and other fines drop out. The supernatant flows into a 200ft x 600ft x 25ft single lagoon. Discharge from the lagoon is returned to the flush valve.

Lagoon water is pumped through a series of pivots and land applied. By 2004, the pounds of N per acre exceeded the crop uptake and the dairyman decided to take action. The Blue Frog System (BFS) was installed in stages from 2004 to 2007.

The results are exceptional:

1. Pounds of N per acre at the 8-24inch depth were reduced 85%.
2. 75% of N and 85% of P are removed mechanically by the screens and composted.
3. Copper sulfate was replaced by soda ash with no change in animal hoof health.
4. Somatic cell counts were reduced 28%.
5. E coli in the flush water were reduced 99%.
6. Malodor from the lagoons was eliminated.
7. Lagoon sludge is digested in situ, allowing the dairyman to pump his lagoon as low as needed to handle wintertime accumulation.
8. Water soaks into irrigated fields without pooling or run-off.

The basic microbiology of the lagoon was changed by the BFS.

1. Facultative bacteria population increased by adding a small but finite amount of oxygen to the lagoon. ORP is always negative, so aerobes are selected against.

- a. The facultative organisms liquefy sludge and make it available to methane generators.
 - b. As the facultative population increases, they consume sulfur reducing bacteria.
 - i. When the bacterial root cause of malodor is eliminated, malodor is eliminated.
 - c. The facultative organisms also clean the grooves on the alleys as they multiply in the oxygen-rich, thin-film environment.
 - i. The alleys look like they were power washed with clean water. They are not slick.
2. The flush return pump is surrounded by a gassy clarifier which sinks suspended solids.
- a. The flush return water has a TSS of only 21mg/l, practically solids-free.
 - b. Pathogens are part of the suspended solids population. Pathogens which are sunk stay in the lagoon where they are eventually liquefied by the facultative bacteria. Hoof health and milk quality improve.
3. The surface tension of the flush water is reduced by 39% (to 44.2mN/m)
- a. In an oxygen-limited environment, it is believed that the natural triglycerides (tallow fats) are split into C₁₈ fatty acids (soap) and glycerin. The flush water is wetter.
 - i. Wetter water scrubs the screens clean, keeping them from fouling.
 - ii. Wetter water allows pivot water to soak in rather than run off.
 - iii. Wetter water improves the rate at which sand and fines drop out in the trench.
4. The N & P exiting the animal is naturally insoluble. N & P become soluble biologically after a finite, but short amount of time.
- a. Retention time in surge tanks is minimized to allow N & P to be separated mechanically while still insoluble. This strategy is only successful with wetter water which keeps the screens from clogging.
 - b. N & P entering the lagoon pass through the lagoon with little change in concentration.
 - i. Since sludge is digested in situ, accumulated sludge does not inventory N & P.
 - c. The sand and fines are rich in nutrients (@55% moisture).
 - i. Total N = .26% (2,600mg/l); 81% of this N is organic
 - ii. Total P = .09% (900mg/l)
 - iii. Total K = .2% (2,000mg/l)

The Blue Frog System

The BFS is a patented and patents pending low horsepower system which uses simple hydraulics and limited oxygen availability to “tilt the microbiological playing field”.

Raw water enters a floating-boom-confined area. A circulator adds a small amount of oxygen as it sends a radial outflow to the circumferential boom. The ORP is -150. The out-flowing water is redirected by the boom to the sludge water interface. The circumferential “waterfall” ricochets off the bottom and flows back to the circulator inlet, three feet deep.

The surface current incubates facultative organisms in the limited oxygen environment and induces a subsurface anaerobic current. Subsurface ORP is -300. The anaerobic current brings anaerobes and nutrients into intimate contact. The anaerobic population grows as fast as its genetics allows.

Flow out of the contained area is at the sludge water interface.

Free standing circulators are placed every 200ft to keep the lagoon in slow but constant surface circulation. The anaerobic subsurface flow is plug flow from inlet to outlet.

A larger boom-contained area is created around the flush return pump and a circulator. The circulator is fitted with two pairs of patented impinging venturis such that bubbles are made so small that they do not float out of the water column. The specific gravity of the surface current falls to 0.97 due to remaining nitrogen gas. The ORP is still negative. The density difference between suspended solids and the nitrogen-gassy water is such that the suspended solids precipitate rapidly. Gassy, low TSS water is returned to the flush valve.

The alley is covered with fresh manure when the flush begins. As the flush ends, the surface and grooves have a thin film of facultative-rich water. The oxygen encourages facultative growth; this growth consumes the carbon in the grooves. The surface has a high coefficient of friction because the previously-attached foodstuff is consumed and the bacteria flourish. Traditionally this surface is slick because the bacteria were anaerobic and died in the presence of toxic oxygen.

It is not known where the soap is being formed, but results improved dramatically when the clarifier was installed. Since the water recirculates, the concentration of surfactant gradually increases until the critical micelle concentration (CMC) is exceeded. Over 28% of the surfactant is held in micelles. The excess above the CMC is excess soap inventory available to clean particularly dirty surfaces.

The results speak to the effectiveness of tilting the microbiological playing field.

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