

Blue Frog TM System Case Study: Dairy Manure Lagoons

Dairy lagoon influent is a mixture of fiber, sand, urine and fecal matter. The undigested fiber is recalcitrant; the sand is non-digestible. Fiber and some solids are removed with parallel wire screens. The solids are composted; the supernatant is passed to a sand settling channel and then to the lagoon.

3-Star Dairy is a 1,600head dairy in McCook, NE. The NE regulations specify the amount of N&P that can be in the soil. Run-off to adjacent streams is not permitted.

This project was initiated 7years ago with these objectives:

1. Reduce manure odor.
2. Eliminate nozzle plugging on pivot spray heads.
3. Stop irrigation water run-off.

Actual Results include:

1. N&P at the 8 and 24inch depths were significantly reduced over 5 years.
2. The solids removed by the screens increased 50%.
3. Malodor was virtually eliminated.
4. Pivot nozzle plugging was eliminated.
5. Somatic cell count of the raw milk was reduced 28% (cleaner milk)
6. Copper sulfate footbaths were replaced with soda ash footbaths.
7. Sand dropped out faster, initially plugging upstream channels, but transferring less sand to the lagoon.
8. Sludge is digested in situ such that end-of-summer pump-out was no longer viscosity-limited
9. Irrigation water historically beaded-up and ran off the land. Now water is wetter (surface tension reduced 39%) and soaks in where sprayed.
10. E. coli were reduced 99% (by sinking bacteria in the clarifier section).

Design

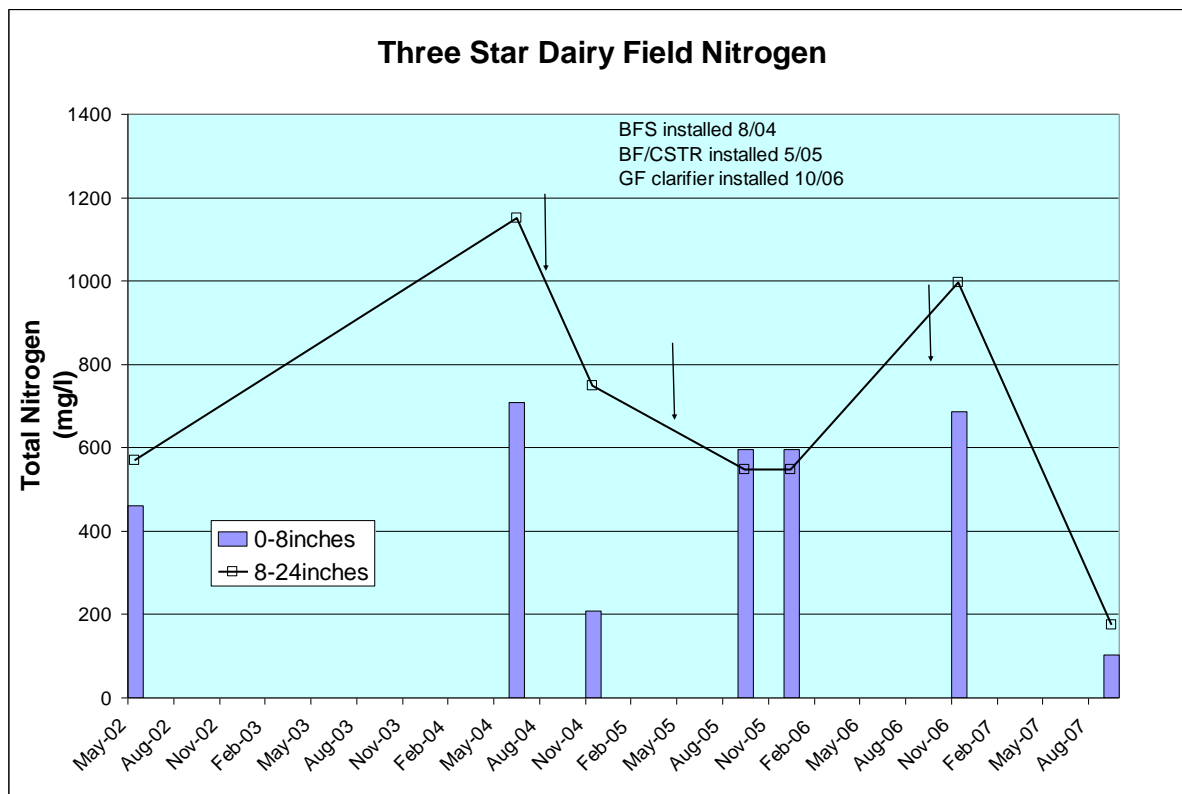
1. The lagoon is designed around the seasonal holding capacity which is a function of the number of animals. The treatment needs are embedded within this design.
2. Inlet BF/CSTR to select for sludge digesting organisms.
3. Free-standing BF every 200ft of longitudinal lagoon length with a minimum of at least one BF/lagoon.
4. Outlet GF₄/CSTR to clarify returning flush water.
 - a. Return flush water withdrawn from within the GF/CSTR at the surface
5. The system design has a fixed component (BF/CSTR and GF/CSTR) and a variable component (free-standing BFs).
 - a. The BF/CSTR selects for facultative organisms.
 - i. Where there are multiple lagoons in series, a BF/CSTR is installed at the inlet to each lagoon.
 - b. The GF/CSTR is a clarifier, sinking solids (including pathogens) and returning “iced tea” water to the flush alley.
 - i. The GF/CSTR is installed at the outlet of the last lagoon.
 - c. The free standing BFs gently circulate water to bring nutrients and bacteria into intimate contact.
 - d. The pond is always anaerobic.
6. Irrigation rate must be controlled
 - a. There is a low-viscosity sweet layer over the lagoon surface. When irrigation water is removed, this layer thins. Too aggressive irrigation will expose previously-submerged foul layers and the lagoon will smell until the sweet layer is re-established.
7. Although not part of the BFS, every dairy-to-date had to initiate sand separation earlier in the process
 - a. Fatty acids are produced in the GF/CSTR; the fatty acids reduce the surface tension of the water.
 - b. The wetter water drops the sand out earlier in the process.
8. Every dairy has increased solids separation.
 - a. The fatty acid also sequesters free calcium as a soft, calcium soap.
 - i. Calcium scale is a major source of blinding parallel wire screens.
 - ii. When blinding is eliminated, tighter screens can be deployed and more solids are removed.
9. Seasonal Issues
 - a. As the water cools to 10°C, biological activity slows dramatically.

- i. Because the pond is lowered seasonally, the reduced activity just refills the pond during the winter. When the water warms in the Spring, activity increases and the wintertime inventory accumulation is digested without external process input.
- b. Separation increases as water cools.
 - i. Biological activity is visible in these ponds, particularly in low light conditions. Billions of “champagne bubbles” indicate the intensity of the sludge digestion.
 - ii. As the temperature cools, activity slows, and the amount of uplifting gas is decreased; settling increases.

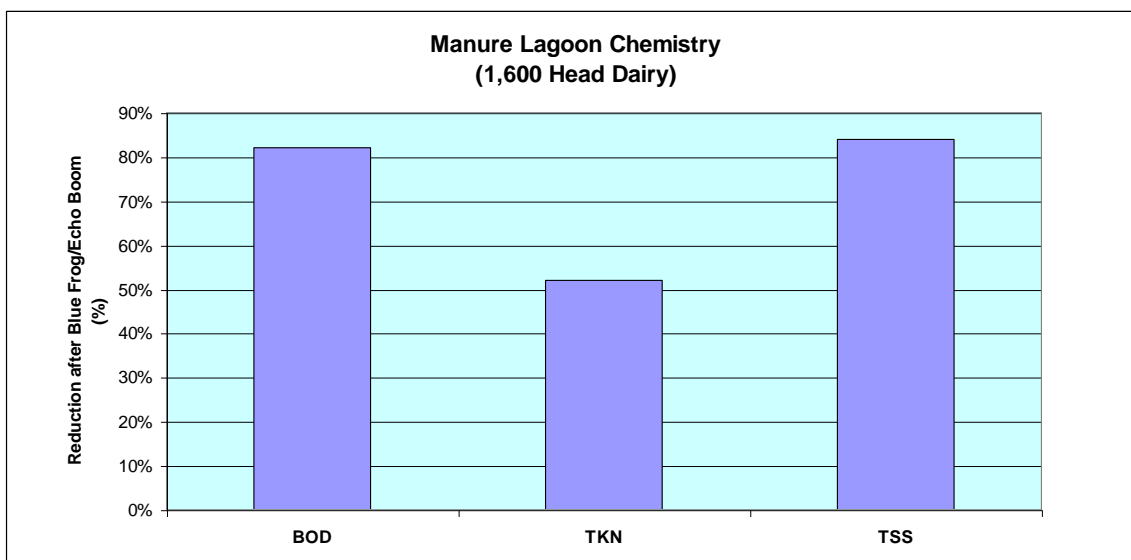
Retrofits

1. Existing dairy designs are typically:
 - a. Screened solids separation
 - b. Gravity sand separation
 - c. Holding lagoon
 - i. Capacity is typically 365 days of manure production.
 - ii. Solids separate in the pond; supernatant is irrigated on fields during the summer.
 - iii. 180 days remain in the pond at the beginning of winter.
 - iv. There is no attempt to treat the lagoon

Appendix



The reductions in N&P are due to increased screen efficiency, not biological removal in the lagoon.



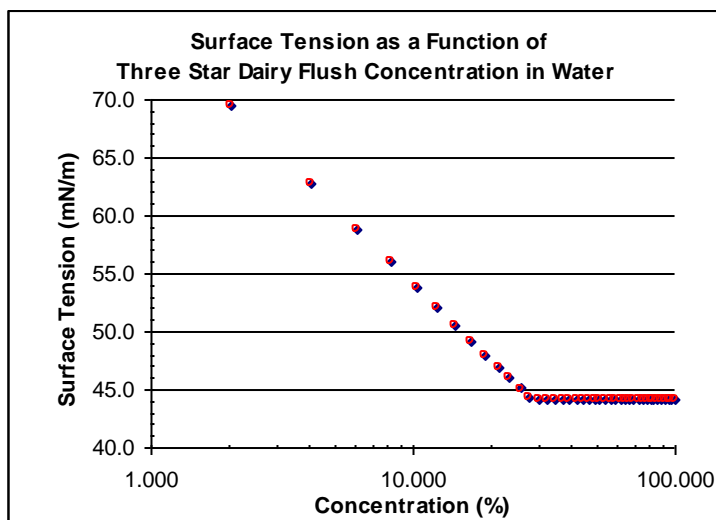
This chart determines the extent of the surface tension reduction.

Surface Tension Data for Three Star Dairy Flush Water Dilutions

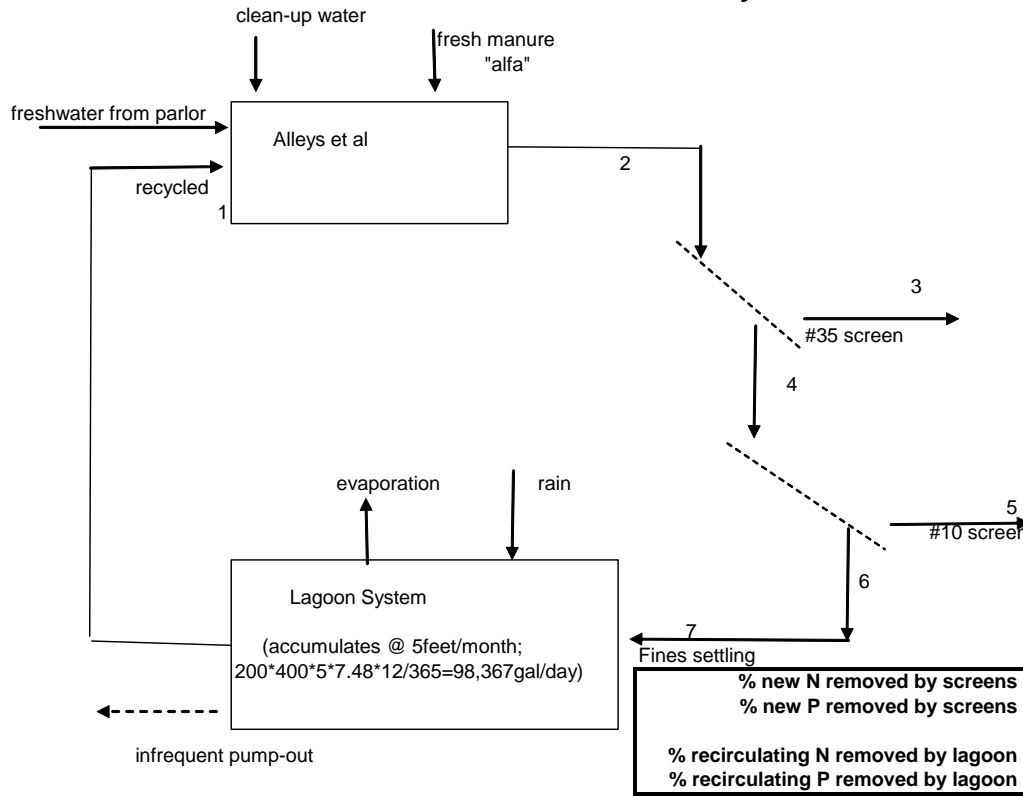
performed 10/18/07 by Augustine Scientific by Wilhelmy Plate Method

5 ml of Three Star Dairy Flush was taken and measured for surface tension (100% value) - then pure water was repeatedly dosed into the Flush to decrease its concentration while measuring surface tension after each successive dilution.

There is a 39.4% reduction in surface tension.



Three Star Dairy



milking cows	1,150	cows	
manure/cow	2.90	ft ³ /cow	
manure weight	46.50	lb per	5 gal
	7.48	lb water/ft ³	
	8.34	lb water/gal	
#35 bucket weight	4,200	lb/bucket @	70%
#10 bucket weight	3,900	lb/bucket @	30%
	13	buckets/day	
flush valve capacity	2,500	gpm	
	2,000	lb/ton	
1 mg/l = 1 lb per	1,000,000	lbs	

Laboratory Analyses

Flow Point	N	P
alpha	6105.4 mg/l	841.8 mg/l
1	1151.5 mg/l	78.1 mg/l
2	1829.4 mg/l	
3	5.0 lb/ton	0.8 lb/ton
4	N/A	
5	4.2 lb/ton	0.6 lb/ton
6	1137.8 mg/l	
7	1117.4 mg/l	85.0 mg/l
clean-up	0.0 mg/l	0.0 mg/l

valve open time	lb/day	lb N/Day	lb P/day
	27,817	170	23
24.43 min/day	509,366	587	40
	38,220	96	15
	15,210	32	5
	500,433	569	-
	500,433	559	43
0.8 min/day	16,680		

Comments

- N & P% removal based on N/P from cows minus N/P off screens
- Calculated lagoon influent (7) is based on overall material balance
- Observed added flow = 98,367g/day
- % N/P removed from lagoons based on mat bal around lagoon