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OF SCIENCE AND TECHNOLOGY

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Report

Evaluation of a Fine Bubble Aeration System
"Advanced Aeration Process (AAP)"

This should say ...

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Tele/Fax (414) 794-7248

See notes from Blue Diamond "MARAVEN E-6 Pilot"

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Date: September 1995

Diffused air systems by diffusing compressed air can be used to aerate a manure tank. The rising bubbles when strategically placed will induce mixing currents. The amount of air required varies with the degree of treatment desired, the size of bubbles, the effluent temperature, the depth of the basin and the extent of additional mixing. Work has shown that coarse bubbles greater than 3 mm are only half as efficient as fine bubbles with a bubble size less than 1.5 mm.

The Blue Diamond Water Treatment Company with their "Advanced Aeration Process" (AAP) system, developed and patented by JLBD, Inc., produces micro-fine bubbles that range in size down to 0.5-5 microns in diameter by the use of an injector. The stated air entrainment by Blue Diamond is at 10 cfm. A one horsepower electric motor was used to circulate the manure and for entraining the air into the manure slurry.

Calculations show that approximately 4.25 Kg-O_2 were produced per KWH of 0.5 to 5 micron bubbles. Typically 0.8 to 1.0 Kg O_2 /Kwh can be achieved from rotor aerators.

Project Description

The project consisted of a 1 horsepower electric motor and pump, an injector, a HYDRO-SPARGING TM process distribution grid and a 500 gal tank. Four hundred gallons of fresh manure at 1/2 percent solids were put in the tank. The injector was initially run intermittently and then on a continuous basis during the latter part of the experiment. Prior to the increased activity of the aerobic bacteria, it took 12 minutes to reach a DO of 7.75 mg/l. Time was recorded as shown in the attached table.

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Operational Evaluation

The system operated without any plugging. There was no indication of algae growth on the aerator during the 3.5 days of operation.

Results

- Dissolved Oxygen

In general, the dissolved oxygen content was planned to be operated between 2 mg/l and 4 mg/l; however as shown it would continue to slightly rise after the unit was shut off and to decline after the unit was turned on due to lag effect. The oxygen content was set to maintain odor control. In the first six hours, the unit was able to keep the dissolved oxygen level desired by operating intermittently, but the pump running time increased and the time between runs decreased gradually. After six hours, the pump had to run continuously to keep the dissolved oxygen content above 2 mg/l and then fluctuating between 2 mg/l and 5 mg/l.

- Total Solids and Volatile Solids

The manure used was from a finishing building using scrapers. The initial solids content was only 112 percent which was very low. This might be due in part because of using sprinklers in the building for cooling the pigs, but the main cause of this could be the pre-screening treatment to the manure using a fine metal screen with pore size of about 1132". The graphs show that the contents of both total solids and volatile solids decreased with aeration time. The reduction for total solids was 883 mg/l (18.9%) and that for volatile solids was 870 mg/l (35.4%) after operation of about 93 hours. Also from the graphs of TS and VS, it can be seen that the contents of both total solids and volatile solids reached their minimum after 75 hours of running time. Then, instead of continuing to decrease, they had a small increase.

- Ammonia and pH

The variation of ammonia level in the manure liquid during the entire test period was shown in the graph which demonstrated a fact that the levels were higher both at the beginning and end of the test than in the middle period. However, the pH values did not show the same trend as ammonia and basically took on a rising shape towards the end of the test. In addition all the pH values were larger than 7.0 which indicated that the manure liquid was generally in basic conditions.

- Chemical Oxygen Demand

Although there were some fluctuations at the beginning of the test, according to the graph, the COD content virtually decreased with the running time. After the operation of 93 hours, COD level decreased by about more than 213 of the original level, i.e., from 2965 mg/l to 980 mg/l (which showed a reduction of 66.9%).

Discussion and Summary

According to the above mentioned test results, it can be seen that the AAP system can efficiently entrain air into the liquid by generating fine air bubbles through the patented injector that makes it possible for providing an intimate contact between air and liquid. Because liquid is pumped to mix with air, traditional design of lagoons with large surface areas, in order to absorb more oxygen, is no longer

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needed. In fact, the surface area can be limited to any given volume in this case and in some sense, it is advantageous to keep the surface area to a minimum to reduce heat loss from convection, evaporation, and radiation. A further advantage of the treatment system used is to allow more flexibility in applying the manure. The manure can be spread either by surface or gun discharge without generating an odorous problem. This adds flexibility to the farmer's schedule as well as reducing the overall disposal cost.

The advantage of aeration is to provide enough oxygen to microbes in the liquid to be treated for their biological activities. The removal of odor from the manure is largely dependent on the performance of all kinds of bacteria existing in the manure liquid, which greatly rely on dissolved oxygen content in the liquid. Thus, to maintain an odor-free environment, the dissolved oxygen concentration in the liquid should be at least above 1 mg/l. Furthermore, to retain the minimum BOD level, the dissolved oxygen concentration should be at least above 1.5 mg/l. As is shown in the results section, the AAP system can generally keep the dissolved oxygen level beyond 2 mg/l in the entire test period so it helps reduce the odor release to a very low level. This is also evidenced by the olfactometry test based on the air samples collected from the test tank.

According to the test results, the system brought the COD all the way down from 2965 mg/l to 980 mg/l, which accounted for about 67% reduction. Since BOD is part of COD, it can be inferred that BOD level was also reduced in this case. This gives rise to a possibility that the manure waste can be disposed right after treatment, saving storage expenses.

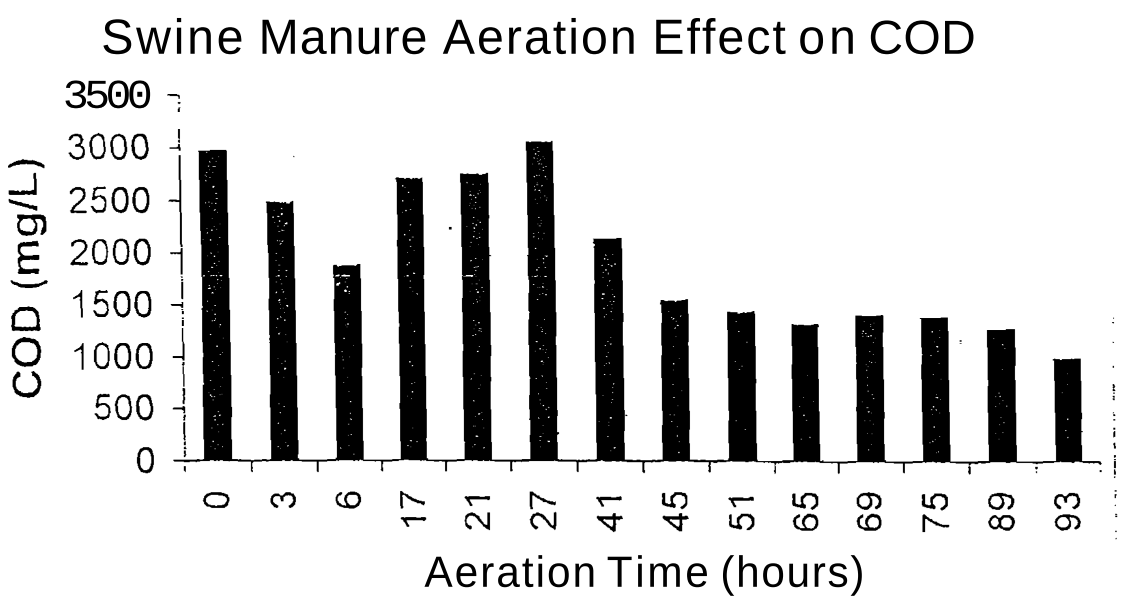
Although the initial solids content was low, it can still be seen from the attached graph that the efficiency of removing solids (including both total solids and volatile solids) by this system is apparent, which is conducive to improving the aeration of the manure liquid.

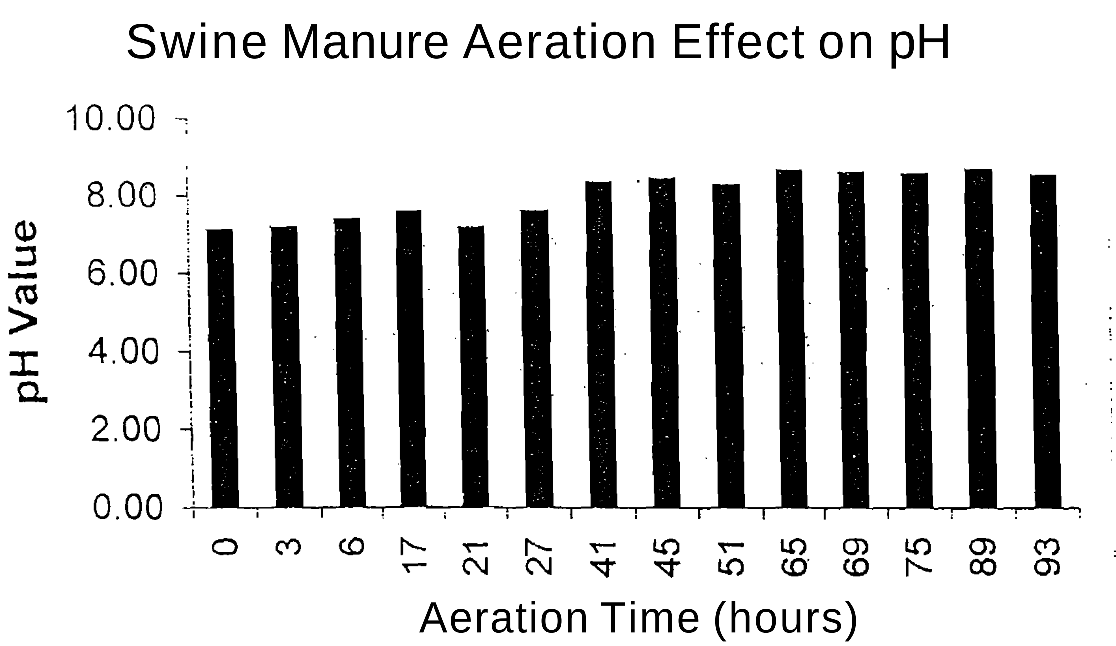
During the entire test period, the ammonia concentration in the liquid fluctuated from time to time, while pH values of the liquid moved more and more towards the basic side. This indicated that the increase in pH in the liquid was not mainly related to the ammonia level in the liquid. It was probably due to microbial biological activities. Therefore, the system indirectly affected the ammonia concentration in the liquid by providing oxygen to microbes so the reduction of odor was achieved.

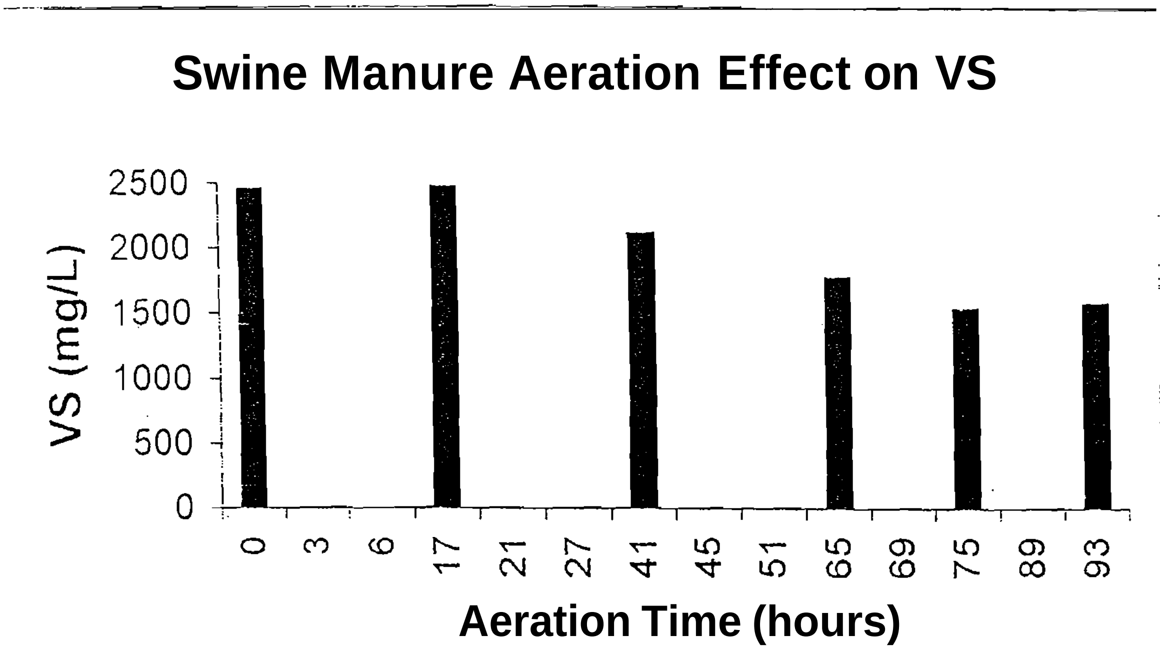
	Dissolved Oxygen Content											
Time(min)	Run 1 (on)	Run 2 (on)	Run 3 (on)	Run 4 (on)	Run 5 (on)	Run 6 (on)	Run 7 (on)	Run 8 (on)	Run 9 (on)	Run10(on)	Run11(on)	Run12(on)
1	0.51	not	15 Secs.	1	1	1	1	1	1	1	1	1
2	2.04	recorded	to 4.28	30 Secs.	30 Secs.	10 Secs.	32 Secs.	38 Secs.	40 Secs.	40 Secs.	55 Secs.	48 Secs.
3	4.18			to 4.22	to 4.03	to 4.61	to 4.07	to 4.10	to 4.04.	to 4.01	to 4.09	to 4.03
4	5.87											
5	6.53											
6	6.97											
7	7.29											
8	7.44											
9	7.58											
10	7.68											
11	7.74											
12	7.75											
shut off	shut off	shut off	shut off	shut off	shut off	shut off	shut off	shut off	shut off	shut off	shut off	shut off
1	7.8	6.04	5.8	5.78	'5.71	5.64	5.56	5.6	5.47	5.41	5.49	5.31
2	7.63	6.17	5.76	5.76	5.61	5.54	5.51	5.56	5.43	5.28	5.32	5.14
3	7.31	5.97	5.46	5.53	5.27	5.24	5.12	5.23	5.1	4.89	4.87	4.64
4	6.97	5.74	5.18	5.27	4.87	4.82	4.75	4.74	4.51	4.34	4.33	4.14
5	6.67	5.42	4.84	4.84	4.54	4.45	4.32	4.25	3.99	3.82	3.7	3.41
6	6.4	5.1	4.46	4.42	4.02	3.96	3.86	3.72	3.39	3.14	2.89	2.44
7	6.08	4.7	4.03	3.96	3.34	3.33	3.03	2.88	2.64	2.03	2.01	1.93
8	5.69	4.2	2.94	2.93	2.16	2.37	1.96	1.61	1.15			
9	4.78	3.3	1.95	2.01	1.61	1.9						
10	4.1	1.93										
11	2.89											

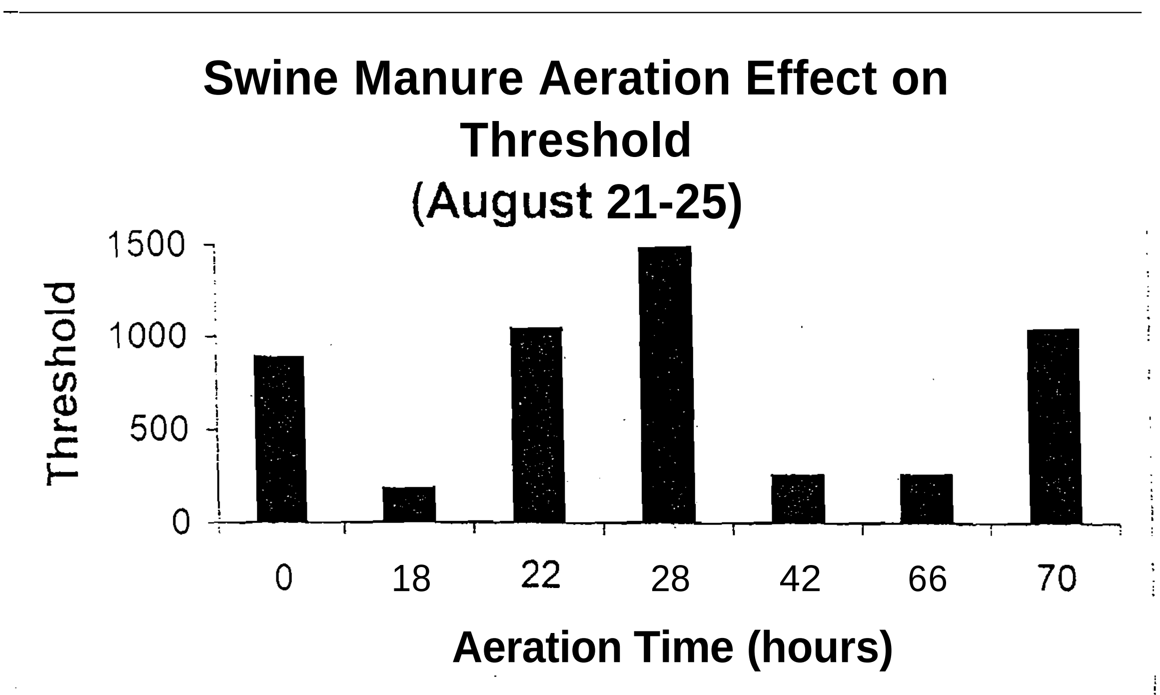
						Dissolved Oxygen Content						
Time(min)	Run13(on)	Run14(on)	Run15(on)	Run16(on)	Run17(on)	Run18(on)	Run19(on)	Run20(on)	Run21(on)	Run22(on)	Run23(on)	Run24(on)
1	2	2	2	2	2	2	2	2	2	2	2	2
2	to 4.06	5 Secs.	15 Secs.	10 Secs.	15 Secs.	20 Secs.	25 Secs.	28 Secs.	30 Secs.	35 Secs.	40 Secs.	40 Secs.
3		to 4.08	to 4.11	to 4.07	to 4.02	to 4.05	to 4.03	to 4.09	to 4.08	to 4.07	to 4.02	to 4.02
shut off	shut off	shut off	shut off	shut off	shut off	shut off	shut off	shut off	shut off	shut off	shut off	shut off
1	5.43	5.29	5.29	5.28	5.22	5.22	5.17	5.11	5.1	5.02	5.02	4.96
2	5.25	5.06	5.05	4.95	4.86	4.77	4.69	4.6	4.58	4.48	4.49	4.35
3	4.71	4.48	4.43	4.26	4.17	4.06	3.97	3.93	3.54	3.6	3.53	3.25
4	4.16	3.8	3.69	3.58	3.41	3.3	3.17	3.04	2.84	2.69	2.55	2.35
5	3.41	3.12	2.96	2.75	2.62	2.35	2.29	1.98	2	1.99	2	1.96
6	2.41	1.99	2.02	1.94	1.98	1.96	1.96					
7	1.98											

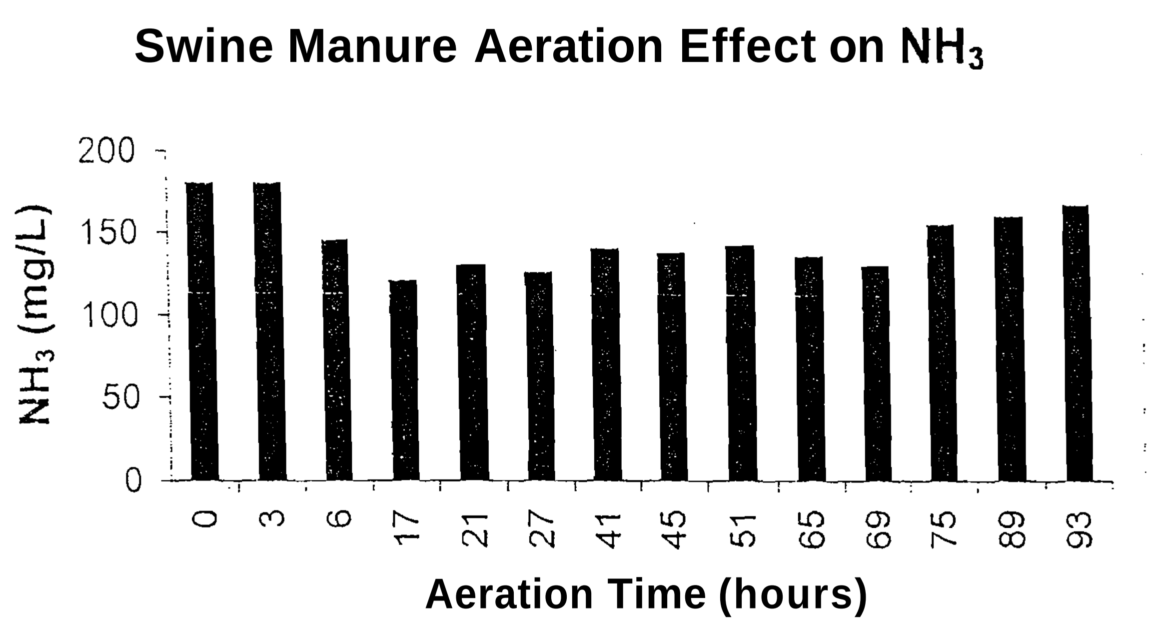
Time(min)	Run25(on)	Run26(on)	Run27(on)	Run28(on)	Run29(on)	Run30(on)	Run31(on)	Run32(on)	Run33(on)	Run34(on)
1	2	2	2	3	3	3	3	4	4	4
2	52 Secs.	54 Secs.	52 Secs.		5 Secs.	15 Secs.	30 Secs.			30 Secs.
3	to 4.08	to 4.11	to 4.01	to 4.05	to 4.03	to 4.05	to 4.08	to 4.15	to 4.05	to 4.10
shut off	shut off	shut off	shut off	shut off	shut off	shut off	shut off	shut off	shut off	shut off
1	4.98	4.9	4.78	4.67	4.64	4.59	4.55	4.49	4.27	4.1
2	4.15	4	3.9	3.72	3.6	3.5	3.29	3.14	2.87	2.38
3	3.25	3.07	2.81	2.56	2.5	2.24	2	1.84	1.9	
4	2.12	1.98	1.96	1.96	1.95	1.94				

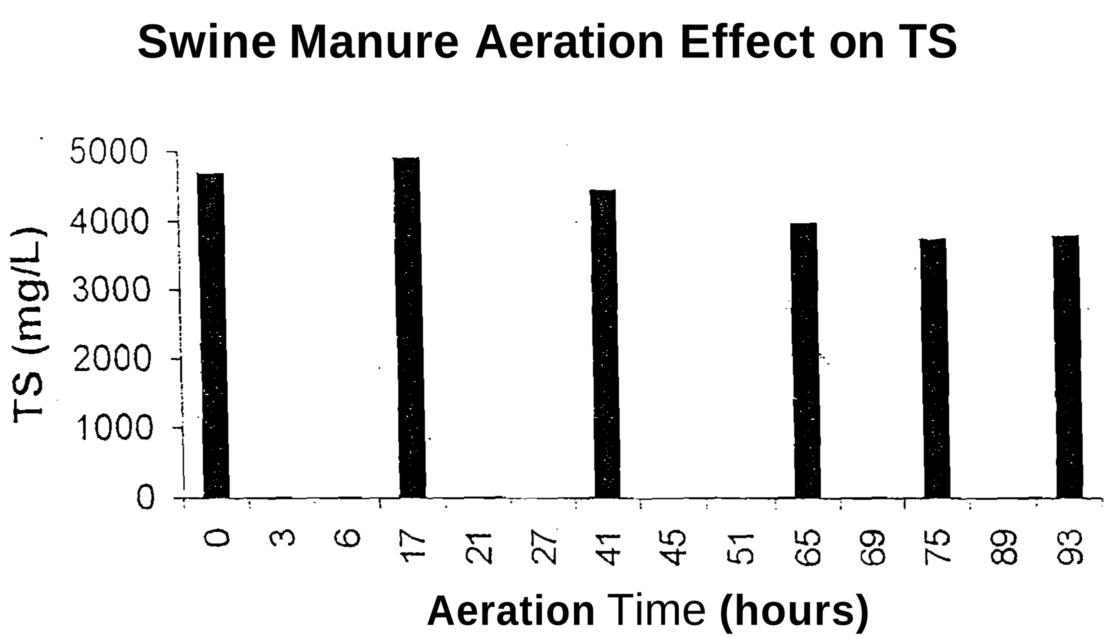

Swine Manure Aeration Effect on COD
COD (mg/L)
3500
3000
2500
2000
1500
1000
500
0
0
3
6
17
21
27
41
45
51
65
69
75
89
93
Aeration Time (hours)


Swine Manure Aeration Effect on pH
pH Value
10.00
8.00
6.00
4.00
2.00
0.00
0
3
6
17
21
27
41
45
51
65
69
75
89
93
Aeration Time (hours)


Swine Manure Aeration Effect on VS
VS (mg/L)
2500
2000
1500
1000
500
0
0
3
6
17
21
27
41
45
51
65
69
75
89
93
Aeration Time (hours)


Swine Manure Aeration Effect on Threshold
(August 21-25)
Threshold
1500
1000
500
0
0
18
22
28
42
66
70
Aeration Time (hours)


Swine Manure Aeration Effect on NH3
200
150
100
50
0
NH3 (mg/L)
0
3
6
17
21
27
41
45
51
65
69
75
89
93
Aeration Time (hours)


Swine Manure Aeration Effect on TS
5000
4000
3000
2000
1000
0
TS (mg/L)
0
3
6
17
21
27
41
45
51
65
69
75
89
93
Aeration Time (hours)