The Use of an Induced Aspiration Aeration Device for Winter Operation of Unprotected Aerated Lagoons
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- A Case Study

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Introduction

Vacuum Bubble® Technology (VBT™) creates micro bubbles of air that are neutrally buoyant. The bubbles are created under a partial vacuum and, as a result, the internal pressure of the bubbles is lower than that of the surrounding water. Consequently, the bubbles collapse to an average dimension of 0.25 mm in diameter. Because of their small size and neutral buoyancy, the bubbles remain in the water for many minutes. These micro bubbles increase the oxygen transfer potential in the water which, in turn, enables aerobic bacteria to consume the organic waste in the water.

Summary

Two induced aspiration-type floating aerators were installed in aeration basins on University farms. One received waste from a dairy parlor and milk house; the other was intermittently loaded with finishing hog waste slurry. They both operated successfully through the winter with no ice or freezing problems. They maintained an adequate environment for some aerobic biological degradation of the waste.

Background

Where animal wastes are treated out in the open in an aerobic system, it is desirable to maintain a biologically active state throughout the year. This requires maintaining temperature and dissolved oxygen at such levels that some bacterial action can take place. These animal waste systems usually involve low flow rates and long detention times. Under these conditions, our experience with conventional floating surface aerators that introduce oxygen by forcing a fine spray of liquid up into the air has shown that they ice-up rapidly in the fall when the temperatures first drop below freezing. They must then be removed to protect the motors. The treatment basins freeze over and all bacterial action stops for the remainder of the winter. The wastes fed to the basin, however, continue throughout the winter and the oxygen demand builds to very high levels. When the aerator is then re-installed in the spring, a considerable time may be required to return the system to an aerobic state and to bring the chemical and biochemical oxygen demands back to a stable level. During this period, offensive odors may be emitted. Also, during the winter and spring start-up, the effluent is much more objectionable if it is to be discharged or recycled.

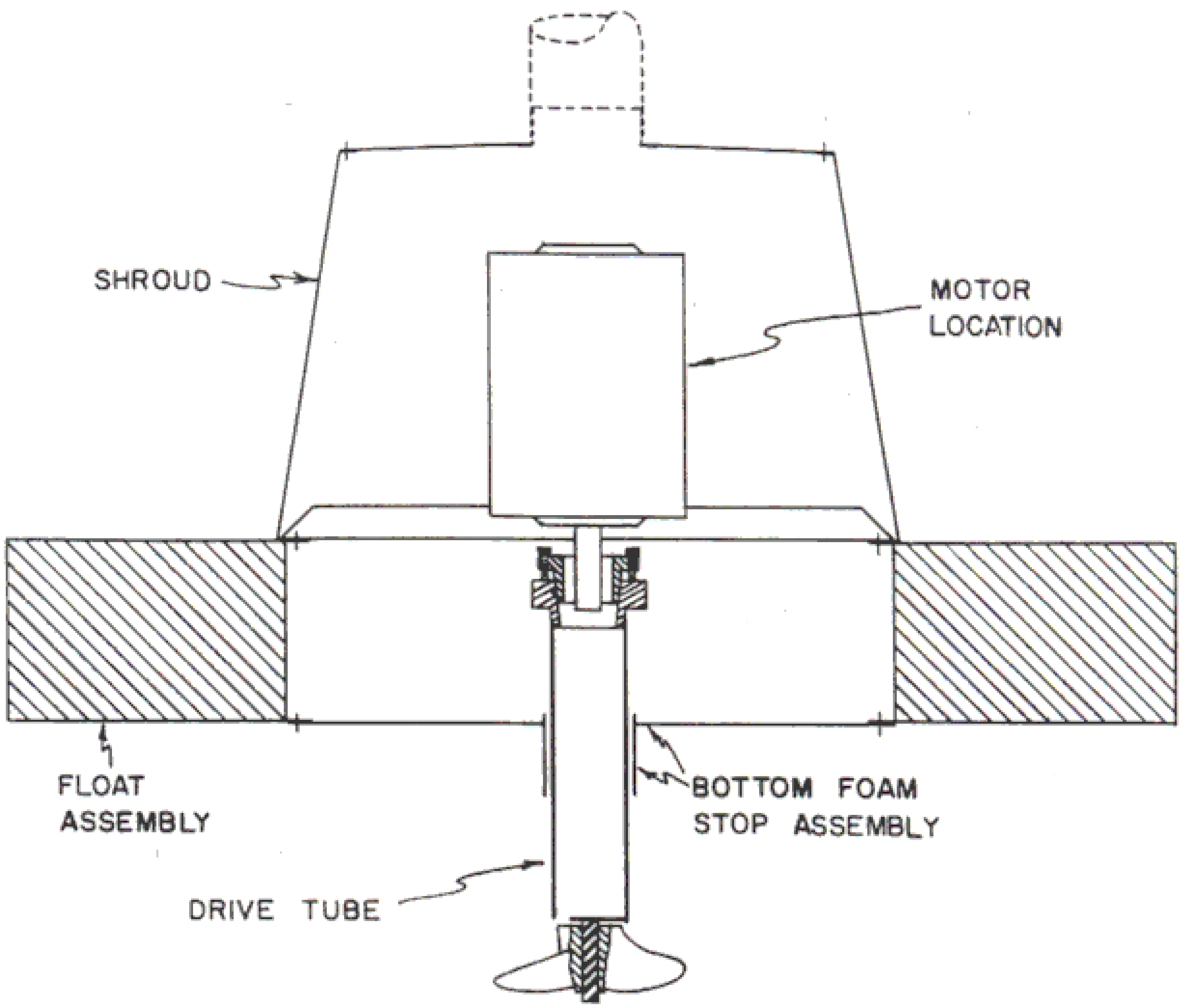
Objective

The purpose of this study was to determine if a different type of aerator could be successfully operated unprotected throughout the winter. The criteria for success were to maintain temperature and dissolved oxygen at such a level as to facilitate some detectable biological degradation of the waste.

Equipment

The aerator used is a floating surface aerator which pulls air down into the liquid and disperses it as Fine bubbles. A hollow shaft turns a boat propeller, forcing the liquid vertically down. The vortex formed at the propeller pulls air down through this hollow shaft where it is broken into small bubbles and forced downward. The oxygen transfer efficiency of this method of aeration is claimed to be comparable to, or even better than, that of the conventional type. This aerator also has the merit of pulling air past the motor where it picks up heat which is largely transferred to the water. Newer models now out have a shroud around the motor with a ventilation pipe extending approximately 4 ft vertically into the air. The motor cooling fan has been relocated to keep a positive pressure within the motor enclosure, increasing air transfer into the vortex and transferring practically all heat produced by the motor into the liquid. This modification would also eliminate the electrical problems associated with foam intrusion into the motor junction box. A shop drawing of this aerator is shown in figure 1**.**

Figure 1: A facsimile of a shop drawing, showing the aerator used for this test. The shroud shown is on the newer model. The shroud on the test model was less elaborate.



Similar aeration devices have been used for some time at a fixed position in underfloor oxidation ditches for swine confinement buildings. In this situation, where heat losses are small, stable liquid temperatures have been maintained in the thermophilic range of 110°F to 120°F. Such temperatures have been maintained throughout the winter without the addition of supplemental heat to the liquid. Ritter (1970) noted that aerobic digestion using diffused air prevented the digestor contents from freezing, whereas in previous reports on mechanically aerated aerobic digestion, aeration had to be stopped because of freezing conditions.

In early November of 1972, two of these aeration devices were installed on University farms. (One week later, a conventional aerator in a similar basin had to be removed due to freezing problems). With help of the manufacturer, one of these units was installed in a 40 ft diameter by 10 ft deep concrete aeration basin which had been receiving the waste from a 30 unit swine farrowing facility. Waste had been recycled from the aeration basin through the farrowing building where it was flushed down the manure collection gutters and returned to the basin. This system has been described in an earlier work by Person (1972). A conventional water-spray aerator had been in operation on this basin for the past year. There is a constant level overflow from this basin into a small anaerobic lagoon. Final disposal then takes place from this lagoon. At the time of installation, the farrowing units were unoccupied.

A second similar unit was installed in a 20 ft diameter by I0 ft deep metal aeration basin which was receiving the waste from a dairy milking parlor and milk room. This unit also overflows into an anaerobic lagoon but has no recycling. At the time of installation of this aerator, a floating cover of 3 in. thick expanded polystyrene foam was placed over the remaining exposed surface of the basin.

Experimental Procedure

The flow rate into the basin in the dairy farm was about 3,000 gal/day. This was distributed principally over two 4-hr periods during and immediately following milking. Since this loading was fairly uniform and consistent, only minimal samples were taken to determine the strength of the influent waste and that in the basin. The temperature and dissolved oxygen content of the water were periodically checked, as well as air temperature. The site has been visited frequently and a close watch kept on the functioning of the aerator and ice formation on the tank surface.

At the swine farm site, no farrowing activity was expected between November and February 1973. Therefore, it was decided to load this basin with frequent additions of finishing-hog slurry from two different types of slurry storage on the farm. The first was a large pit into which the manure from a finishing building was flushed with fresh water. The liquid portion was then allowed to overflow into a large lagoon while the solids settled out. The second system was a shallow pit beneath the slatted floor of a small finishing building. When weather permitted, 100 cu ft loads were transferred to the aeration basin in a liquid manure tank. Samples were taken of the slurry and the mixed liquor from the aeration basin before the loading and within 6 to 24 hours after the addition. The dissolved oxygen content and temperature of the water were measured before and after addition of slurry. In December, a continuous recording thermograph was set up to record liquid and air temperatures. With this, we were able to note the changes in temperature attributable to the additions of the slurry in more detail.

Operation

The first problem we encountered at the swine farm site was the weather. At temperatures below 20°F, the slurry wagon would not function prope rly. Also, it required three or four warm days to thaw the slurry under the slatted floor sufficiently for it to be pumped. Therefore, our loading interval was very spasmodic. We managed to load the basin only 9 times by the end of February. Then in February, when we expected to be loading the basin from the farrowing units, the fear of disease problems prevented us from flushing as hoped. In early January, a pin on the propeller of the aerator sheared and required that we take the aerator out for a week while we waited for repair parts. Other mechanical problems with the aerator have been very few.

The sewer line feeding the aeration basin on the dairy farm was 6 in. in diameter and laid on a 1.8% slope. The sewer line approached the tank 1 1/2 ft below the level of the liquid surface, dropped vertically 3 ft and entered the tank 4 1/2 ft below the liquid surface. The waste coming down the sewer line had a very high content of heavy, rapidly settleable corn particles from whole corn silage. The flow rate was slow enough, with no surges, that these particles tended to settle out in that portion of the sewer line that was submerged. This was about the last 80 ft of length. The sewer, therefore, plugged up a couple of times and had to be "rooted" out. A third time when this happened, in January, the plug could not be removed. In an effort to expose the last few feet of sewer line, the tractor-digger slipped into the hole and broke the line. A trench was then dug, bypassing the waste directly into the lagoon. So feed to this aeration basin ceased.

A considerable amount of foaming was observed at both sites. On the dairy farm, the Styrofoam suppressed the foaming to some extent but considerable foam was present as long as the basin was being fed. The foam was about 1 ft deep wherever there were openings in the Styrofoam. At the swine farm site, the foam correlated well with the loading. Just after loading, foam would build up overnight and then slowly recede over a day or two. At times, there was over 3 ft of foam covering this basin.

Results and Interpretation

At the dairy farm installation, mixed liquor samples were taken from the basin and from the sewer line feeding the basin. These samples were tested for COD, BOD, Total Solids, and Suspended Solids. The results of these tests are shown in table 1.

Table 1. Strength of the waste at the Ankeny Dairy Site (mg/L)

Date	COD	BOD	Total Solids	Suspended Solids
Influent				
	300-2,000	50-900	1,000-2,600	900-2,400
Effluent				
November 30	2,300	--	2,428 1,292*	--
January 3	1,100	300	2,010 910*	1,376 384*
January 10	1,088	240	1,876 816*	1,392 416*
January 17	1,286	400	2,236 1,056*	1,588 512*

*Volatile portion

The first problem to develop was trying to get a representative sample from the sewer line. First of all, the quality changed considerably during the 4-hr milking period. Secondly, since the sewer discharged below the water surface, the sample had to be taken from the pipe in mid-stream. This made it difficult to get a uniform sample; therefore, these data are shown in the first part of table 1 simply as ranges. When the broken sewer line is repaired, it will be designed to discharge above water level. We hope then to get more representative data. The data in the lower part of table 1 indicate that after the aerator was installed, the oxygen demand dropped somewhat and then stabilized. Not having good data on the strength of the input to the basin, it is hard to determine how much, if any, waste degradation was present. The suspended solids rose continually throughout the test period.

Preliminary results from the temperature data tend to show that, with a continuous feed of waste into this basin, a liquid temperature in the range of 45°F to 50°F could be maintained throughout the winter. The necessity of using expanded polystyrene insulation in the basin may be questionable. At the swine farm, a continuous recorder was started just before loading the basin and was run until a few hours after a second loading. The resulting graphs on two different occasions are shown in figure 2. Preliminary indications tend to show that there is a temperature rise due to the loading but it diminishes within a 48-hr period. The peaks do give us evidence to draw the same conclusion as at the dairy farm, that under continuous loading, stable temperatures could be maintained above 45°F. Our data were not conclusive as to how much of the heating effect was due to the loading and how much was due to transfer from the air. This merits further study. In a Dow Chemical Company (1971) study of the trickling filter it was noted from several sources that the production of heat by biological oxidation was significant. This heat raised the temperature of the sewage by 2°-7°, depending upon the exposure of the filter.

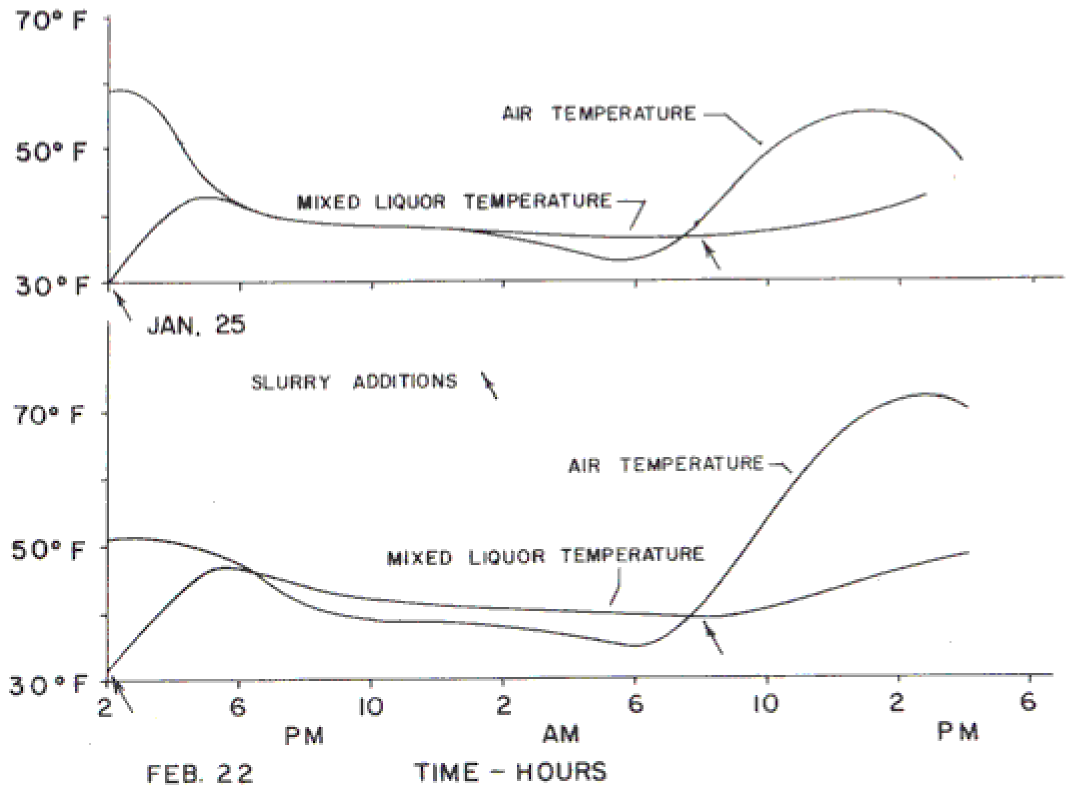


Figure 2: A graph of temperature vs. time for the mixed liquor in the aeration basin at the Bilsland Swine Farm and of the surrounding air. The time period covered in each case is from immediately before an addition of waste slurry to a few hours after a second addition. The amount of each addition is shown in Table 2.

The samples taken from the slurry and aeration basin at the swine farm were evaluated for COD, BOD, Total and Suspended Solids. The results of these tests appear in tables 2 and 3. The COD of the basin is shown graphically in figure 3. From this, we can see a definite degradation of the COD between loadings. The BOD shows the same trends. Clark, Viessman, and Hammer (1971) note in their text that cold wastewater can reduce BOD removal efficiency of biological processes; however, low-loaded extended aeration systems operating at low temperatures showed good efficiencies. Extended aeration at a reduced BOD loading and resultant long aeration time compensates for the low metabolism rate of microorganisms. The total and suspended solids concentration, as at the dairy site, built up continually through the winter and did not show signs of leveling off appreciably.

Except for the period when the one aerator was out with a sheared pin, there was no problem keeping the surface of both basins free of ice. Some ice formed around the edge of the 40 ft diameter basin on the swine farm during the coldest days; however, if it had been fed with wastes on a uniform continuous basis, even this might not have happened.

The dissolved oxygen content of both basins remained at or near saturation the entire winter. The 3 hp motor on the aerator supplied more than sufficient aeration power capacity for the light loading received by these basins. Because of this aerobic state throughout the winter, there was little or no odor escaping from this system.

Table 2. Strength of waste added to the aeration basin at the Bilsland Swine Site (mg/L).

Date	**Waste Added (cu ft)**	**COD**	**BOD**	**Total solids**	**Suspended Solids**
Nov.21	100	80,000	10,150	--	11,000 6,520*
Dec. 15	200	140,000	30,000	161,200 129,900*	26,000 15,000*
Dec. 19	200	45,000	6,750 3,150*	35,820 30,000*	7,050 4,020*
Dec. 28	200	200,000	27,750	121,900 90,300*	37,000 23,800*
Jan. 3	200	115,000	17,800	87,390 71,250*	11,560 6,200*
Jan. 25	100	55,200	10,600	55,760	5,920 2,320*
Jan. 26	700	171,000	61,000	180,000 135,960*	47,640 30,240*
Feb. 22	350	76,800	23,200	56,520 43,080*	9,120 4,800*
Feb. 23	500	65,660	34,600	82,360 57,000*	<24,120 12,080*

*Volatile portion

Table 3. Strength of waste in the aeration basin at Bilsland Swine Site (mg/L).

	Before Loading				After Loading			
Date	COD	BOD	Total Solids	Suspended Solids	COD	BOD	Total Solids	Suspended Solids
Nov. 3	360	100	--	--	--	--	--	--
Nov. 15	109	20	1,420 340*	1,340 292*	--	--	--	--
Nov. 21	125	17	1,740 570*	1,310 248*	340	>100	1,810 605*	1,350 280*
Dec. 15	--	--	--	--	1,300	--	3,040 1,270*	2,250 670*
Dec. 19	--	--	--	--	1,120	680	2,675 1,123*	2,150 670*
Dec. 28	500	130	1,950 530*	1,760 360*	1,320	460	2,600 1,030*	2,120 2,020*
Jan. 3	680	190	2,028 648*	1,760 412*	200	280	2,116	1,884
Jan. 25	--	--	--	--	1,060	340	2,104 772*	1,696 432*
Jan. 26	1,060	340	2,104 772*	1,692 432*	2,665	1,360	4,204 2,172*	2,592 1,008*
Feb. 22	--	--	--	--	1,440	445	2,364 1,032*	1,812 624*
Feb. 23	1,440	445	2,364 1,032*	1,812 624*	1,460	700	2,764 1,312*	1,956 744*

*Volatile portion

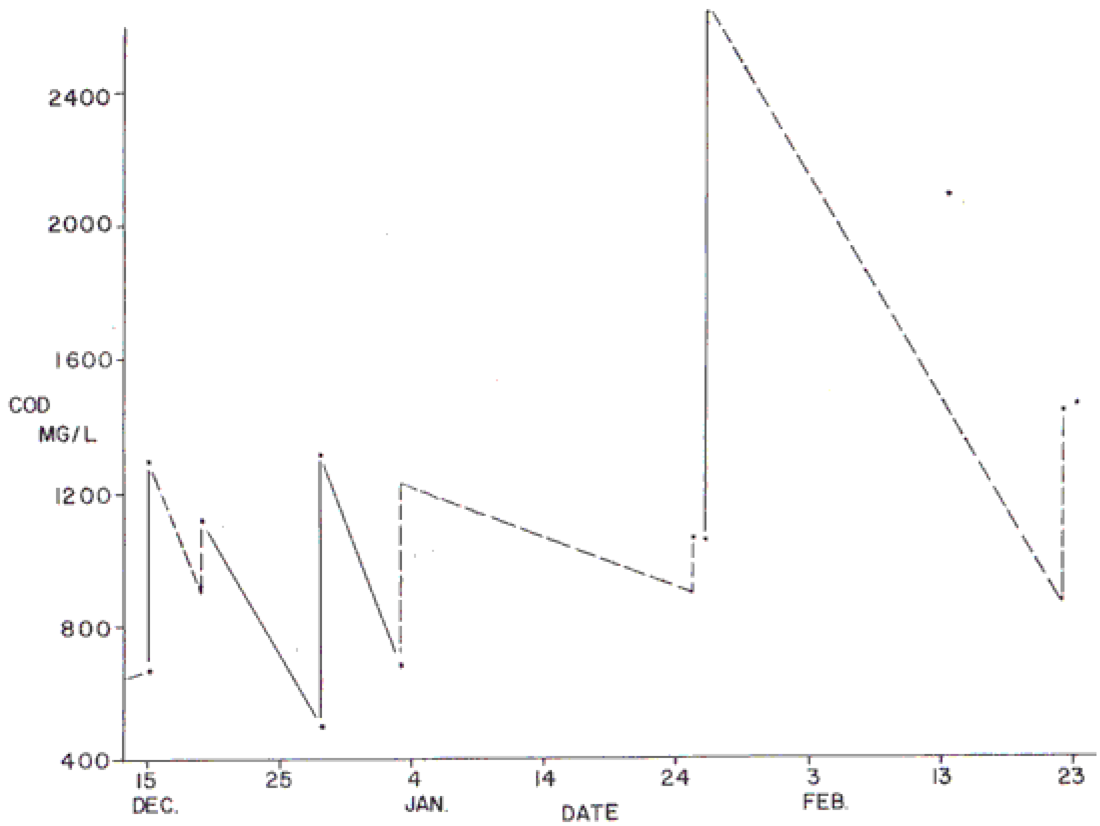


Figure 3: A graphical presentation of the COD vs. time of the mixed liquor in the basin at the Bilsland Swine Farm. The dotted lines show estimates where concrete data was not available.

Summary

In summary we found evidence to show that these induced aspiration-type floating aerators will indeed maintain an aeration basin saturated with oxygen and nearly ice-free throughout the winter. With sufficient waste material fed into the basin, it should be possible to maintain a liquid temperature near 48°F and achieve some aerob ic biological activity. Any spring start-up problem associated with re-aerating a system which had been fed throughout the winter, but allowed to go anaerobic, would be significantly ameliorated. We hope to continue this study through a second winter and substantiate many of our initial preliminary findings.

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