# Aeration Pretreatment for Commercial Restaurants

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## INTRODUCTION

A major environmental concern centers on the pollution emitted by existing single home/small business septic tank systems. This source is particularly serious in those low-lying land areas (Gulf Coast wetlands) with water-flow drainage problems. Small municipalities, as well as rural developments, cannot afford construction of municipal sewer systems but must seek economical solutions for up-grading existing waste removal facilities. Aeration is not a new method as attested in the literature (See EPA Summary Manual, 1985), however, accurate estimation of oxygen transfer efficiency (Ashley et al., 1991) within systems has not been forthcoming since diffusers were first used in 1916 (Tchobanoglous and Burton, 1991; EPA Summary Report, 1985).

Oxygen transfer efficiency and oxygen uptake rates are the key measuring components (Huibregtse et al., 1983; Hwang and Stenstrom, 1985) of aerator effectiveness and are used to determine the capabilities of aeration equipment. Aeration systems characteristically require air compressors, hoses, air filters, diffusers (or similar), motors (with high energy usage), filters (water and air), and special housing facilities. Studies (Bohman et al., 1991; Kyosal and Rittman, 1991; Godfrey, 1987) indicate that aeration units with high oxygen flow demands are in vogue for sludge and municipal activated waste treatment. Concurrent with this method is a high cost factor for the compressed air supply providing 2000cfm for each diffuser. Over 0.6 billion dollars (Mueller and Boyle, 1988) is spent each year for energy to operate these large aeration units.

Major operating waste treatment costs center on energy requirements needed to operate aeration units that provide oxygen transfer levels that meet mixed waste liquor oxygen demands (Mueller and Boyle, 1988). Accurate oxygen transfer prediction under field conditions has been a challenge (Barnhart, 1985; Bass and Shell, 1977) to aerator design, development, and selection for standardized clean-water aeration test and evaluation procedures (ASCE Standard ISBN 0-87262-430-7) that provide a more valid basis of comparison, but still has some workers suggesting more precise methods (McWhirter and Hutter, 1989; Ashley, et al., 1991). This renewed emphasis on energy efficient aeration has promoted interest in small scale, low energy consuming aeration units that handle gas volumes more efficiently than larger systems (Ashley, et al., 1991; Godfrey, 1987). Mueller and Stensel (1990) note that BOD bottle test methods are inaccurate by overestimating oxygen uptake rates (OURs) when oxygen limitations exist in a tank and significantly underestimates OURs when the substrate controls biological reactions. They further conclude that field testing of aeration units should be conducted using non-steady state techniques to better determine the oxygen transfer rates in unique aeration systems. Fine bubble aeration systems have been classified as to pore size and not bubble size when evaluations were conducted in the past (EPA Summary Report Fine Pore [fine bubble] Aeration Systems, 1985) and subsequent studies on fine bubble oxygen transfer characteristics have been neglected (Ashley et al., 1991). The latter authors contend that lower air flow and smaller bubbles are functions of increased gas transfer during bubble formation. Their conclusion indicates reduced bubble coalescence occurs with fine bubbles and this provides uniform, stable bubble dispersion, as seen in vacuum microbubble aeration.

The previous data lead to the conclusion that a small, low power unit that transfers low, dense gas volumes into high microbubble frequency would produce small scale waste treatment tanks with an effective water purification treatment. In a variety of tests, the following results were obtained from the AEROB-A-JET™ model 100 vacuum microbubble system that reflects many of the hypothesized values stated in the literature cited above. The only available aeration of this type is the AEROB-A-JET™.

## EXPERIMENTAL

Bubble Size: Ashley et al. (1991), emphasized bubble size limitations placed on forced air diffusers with 40 microns to 140 micron orifices. Minimum bubble averages were 4.0mm and 4.2m diameters and air flow rates had no effect in decreasing bubble diameters. Recommendations were for low flow rates and increased numbers of diffusers to promote the highest level of oxygen transfer rates. McWhirter and Hutter (1989) introduced a mathematical model using a two parameter base that efficiently estimated fine bubble utilization in tap-water versus process design systems. The system evaluated and described herein uses microbubble gas transfer through vacuum collapse of air in a partial vacuum.

A Model 100 AEROB-A-JET™ microbubble aerator was installed in a 55 gallon glass tank with 50 gallons of tap water. A water tight plastic rectangle large enough to hold a Polaroid camera was mounted with a clear plastic grid of 9nan squares. The aerator was placed 24 inches away from the grid with the orifices 12 inches below the surface of the water. The aerator plate was two inches in diameter and had ten Z38mm orifices. As the propeller withdrew water from the 12" column, a partial vacuum interface formed between the plate and propeller, causing water to collapse in the partial vacuum, thus forming bubbles. The aerator was activated for 60 seconds, shut off and a Polaroid negative taken of the bubbles accumulated on the surface of the submerged 9mm square grids. This image was enlarged 3.1X from 3" x 4" film to an 8" x 11" photograph which was examined using a Bausch and Lomb dissecting microscope at 60X magnification. A micrometer slide with 0.01mm scales was used to measure the diameters of 15 randomly chosen bubbles in three randomly chosen grid squares for each of three one-minute sample periods (see Table 1).

Oxygen Transfer Evaluation: An AEROB-A-JET™ Model 100 was fitted to a net 750 gallon concrete septic tank system and fitted with an influent pump generating a 400+ gallon/day flow of municipal sewage carrying in excess of 200ppm BOD, 220ppm SS, and 200ppm VSS per day. Samples extracted from the influent pipe, aeration chamber, and effluent pipe were tested for pH, temperature, BOD, SS,

VSS, and dissolved oxygen as a measure of oxygen transfer efficiency. Sample collections were conducted Monday through Friday starting October 6, 1991 and continuing through January 15. 1992. Variable influent concentrations were regulated to meet NSF Schedule 40 parameters. The test tank was buried 18 inches from the surface and during the colder weather, the frost-line covered the top 12 inches of the tank, resulting in very low fluid temperatures.
Occasional influent flow interruptions occurred due to the reduced temperatures.

## FIELD TESTS OF VACUUM MICROBUBBLE EFFICIENCY

In December 1991, a project was initiated through cooperative efforts between the TRA Lake Livingston Project and Sam Houston State University. A two-tank anaerobic system was set up using the Southland Wastewater System (Hoage and Hoage, 1992) as a source. The two 500-gallon fiberglass tank system was set up to process 300 gallons of wastewater per day in an anaerobic mode. This 14 week run was sampled twice each week, and the samples taken and tested by TRA for BOD, TSS, pH, Temp., DO, and coliform counts. At the end of 14 weeks, an aeration unit was placed in the first tank just in front of the effluent tee and the waste cycle continued for another ten weeks with TRA taking and testing samples. With no other alteration than the addition of vacuum microbubble aeration in the first chamber, there was a 50% greater reduction in BOD and TSS with coliform counts reduced by 90% over the previous anaerobic action.

A second experiment was set up using a single 500 gallon fiberglass tank with a baffle separating one-third of the waste mass just in front of the effluent tee. A vacuum microbubble aerator was placed in front of the baffle and 300 gallons per day of raw sewage from the Texas landing Development (Hoage et al., 1993) was pumped from the wet well into the tank each day. The effluent was directed into a 30 square feet free access sand filter which was designed to handle ten gallons of aerated wastewater per square foot of surface area. In this arrangement, the filtered wastewater was tested for BOD, TSS, DO, Coliform, and Ammonia/Nitrites. In this test, the BOD was reduced by 90%, TSS reduced by 85%, Coliform reduced by 96%, and the DO in the filtered water averaged 5.2ppm Tests were conducted by Eastex Environmental Labs according to the EPA Standard Manual.

A third test conducted at Texas Landing produced the same level of reduction as measured previously. After these results were analyzed, TRA approved the installation of this innovation in the Bob Nelson property (Hoage et al., 1993) which had a failed system with reduced absorption area that was occluded with solid wastes. Septic Hydro-Tec flushed the field lines using bacterial digestion and restored the absorption field. The innovation design stipulated an aerator in the first of two septic tanks with a modified clarifier and filter designed to retain suspended solids for digestion. The second tank was fitted with a submersible pump that lifted water to a holding tank that regulated water flow into a flee access sand filter designed to landscape specifications. The water from the sand falter was then routed into the cleaned field lines. After three years of operation, there has been no odor, no line obstruction, no overflow into the holding tank, and no field absorption problems even after heavy holiday and summer occupation. A 30" rain in October of 1994 failed to affect this or any of the aeration systems installed.

## LoneStar Charlie's

A commercial restaurant on Highway 59 south of Livingston, Texas, was opened in August of 1993. Polk County Health authorities approved the installation of a system incorporating two 1500-gallon Hydro-Flo aeration units to handle the kitchen waste as well as the blackwater waste of the restaurant. It was designed to serve 85 chairs with potential for growth to double that number. The accepted design began with a 1250-gallon two-chambered trash tank that emptied into a 500-gallon clarifier/mixer which also received the blackwater from the restaurant toilets through a 500-gallon digester tank. The mixer tank emptied into the distribution box which split the volume into two 1500-gallon Hydro-Flo aeration units (Figures 1-4). The aerated effluent was then distributed using surface spray units in a pasture area behind the restaurant.

In September of 1993, a strong odor was detected in each tank, including the pump tank to the surface spray units. Inspection determined that fats and grease were spread throughout the system and that the bacterial flock was not well developed. The system was pumped, cleaned and refilled. It was noted that the temperature of water from the kitchen was about 186 degrees F and that this temperature was transported directly through the tank system to the aeration units and that the high temperature depressed the bacterial population in the digestion chamber resulting in low digestion rates and an increase in anaerobic activity and odor production. To alleviate this temperature problem, Mr. Johnson installed a second 1250-gallon trash tank in series between the first 1250-gallon tank and the 500-gallon mixing tank, and introduced a cooler between the kitchen port and the first digester/trash tank. This cooler was a submerged coil of 4" PVC that gave over 20 feet of cooling surface prior to entry into the first tank. Throughout 1994 and 1995 there was a persistent odor associated with the anaerobic trash tanks. This was generated by the heavy grease load that was carded through the system. Because of the grease content, the aerobic digestion was slowed due to the thick scum that formed in each tank of the system, including the pump tank.

The cooler system (Figures 5-6) did not eliminate fats, oils, and grease from the subsequent tank units; instead a gradual accumulation occurred, creating an oxygen-absorbing barrier. This continuous build-up necessitated repeated pumpings (every 30 to 40 days) with complete pumping and cleaning required due to the collapse of the aerobic bacterial population. The entire system required cleaning three times in 1994, four times in 1995, and two times in 1996. The last cleaning occurred on June 10, 1996 and an extensive pumping was done in July, 1996. At that time it was decided to place a vacuum microbubble aerator in the first trash tank to digest the fats, oils, and grease that continued to overload the system. The Model 100 Aerob-A-Jet™ unit was placed in the second chamber of the first trash tank on August 10, 1996 (Figure 7). Within 48 hours, the odors associated with the tanks had been eliminated. On September 1, 1996, the scheduled pumping time determined from previous problems, only a skimming of trash tanks was needed. There was no scum in any of the other tanks. In October, only the first chamber of the first trash tank was skimmed and all other tanks were clear and odorless. Through January, 1997 no further maintenance has been needed since the BOD, TSS and FOG levels were readily handled by the Hydro-Flo units.

To further alleviate the stress on the downstream aeration units, the aerator is being moved to the first chamber of the first tank and a second aerator added to the second trash tank's first chamber. This eliminates the need for pumping the trash tank periodically and reduces the load to the forced air diffuser aerators used for surface spray effiuent~ The vacuum microbubble aeration process provides an economical and efficient method to solve concentrated waste digestion. Applications of the vacuum bubble to a waste lagoon in North Carolina has resulted in the removal of lagoon sludge in a 100' x 300' x 6 lagoon at a rate of three inches per week. During a test period from October 15, 1996 through January 15, 1997, compacted sludge was reduced from five feet deep to less than 20 inches at the time the demonstration was concluded. This reduction occurred at the same time that wastes from 250 feeder hogs were emptied daily into the lagoon. Throughout the test odors were eliminated in the lagoon. Vacuum microbubble aerators removed all lagoon odors within 48 hours along with a scum layer that covered the lagoon surface. Sludge depths were measured weekly and recorded for consistency. The compacted sludge first became porous, then became jelly-like, and then began to disperse to the surface of the lagoon. At the surface the particulate matter was digested in a few hours. The current status of the lagoon relates to the termination of the feeder hog cycle and the closure requirements of the North Carolina Agricultural Department. Complete remediation of the lagoon can be accomplished by continued use of the vacuum microbubble aeration system.

## Paradise, California Restaurant

In Paradise, California, a restaurant was tested by city environmental officer and found to be discharging waste with 2400mg/1 BOD, 6100mg/l TSS, and 4090rog/1 FOG on January 30, 1995 and was freed for violating city standards. To eliminate the problem, and Aerob-A-Jet vacuum microbubble aerator was Installed on February 6, 1995. Test samples collected on February 8, 1995 and tested by Monarch Laboratories showed 250mg/l BOD, 150mg/l TSS and less than 1mg/l of FOG. Weekly city tests confirmed this continued low emission rate with normal operation of the restaurant.

## CONCLUSIONS

These data reflect real-time continuous treatment values of the vacuum microbubble exposure to high concentrations of municipal and septic tank conditions. The NSF data show the reduction of BOD, TSS, and VSS consistently m the 80O/O+ range at doses far m excess of those seen in septic tank conditions. Conversion of a two tank anaerobic system to an aerobic system resulted m a 50% or greater reduction over what the anaerobic system produced. The single tank system showed 80%+ reduction of BOD, TSS, and over 96% reduction of fecal coliform bacteria. Effluents demonstrated levels of dissolved oxygen at 4ppm or better m most tests. In a comparison of Class I and Class II schedule forty values, the retrofitted vacuum microbubble aerator exceeded the values in six of eight standards. Oxygen transfer efficiency exceeded 90% in all tests and reached 96% during the overload of the NSF evaluation loading sample. Single tank systems with a baffle for clarifying, efficiently handled household waste loads, as indicated In the data from the Texas Landing Waste Water treatment plant, cycled through a vacuum microbubble aeration chamber. Restaurant studies at Busch Gardens, Florida, Paradise, California, and now at LoneStar Charlie's, Texas, show dramatic removal of heavy FOG levels to easily managed concentrations.

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