ABSORPTION AERATOR – COST-EFFECTIVE AERATION SYSTEM

An aeration system is among the most energy-intensive operations in wastewater treatment systems and is responsible for between 50-90% of total energy consumption in typical municipal installations. The optimum bubble size for aeration with compressed air and no mechanical mixing typically is considered to be 1 to 2 mm in diameter. This range of bubble diameter provides a compromise between the conditions for good mass transfer and efficient mixing. Gas transfer technologies that are able to produce bubbles in the range of 10 to 1000 μm require a high power input, such as fine bubble aeration, jet aeration, etc. For standard submerged aerators, the bubble formation on the surface of aerator undergoes three stages: expansion stage, detachment stage, and coalescence due to bubble-bubble combination, which results in larger bubbles.

The transfer of oxygen from the air bubble to the water depends on wastewater characteristics: (1) concentration of soluble salts (Total Dissolved Solids or TDS), water temperature, water depth, total suspended solids (TSS), presence of surface active agents, etc.; (2) tank geometry, bubble size, kinetic energy of the fluid, etc.; and (3) extent and type of liquid mixing with the bubbles, which determines the path length of the air bubble.

The Actual Oxygen Transfer Rate (AOTR) = Standard Oxygen Transfer Rate (SOTR) x α x β x φ

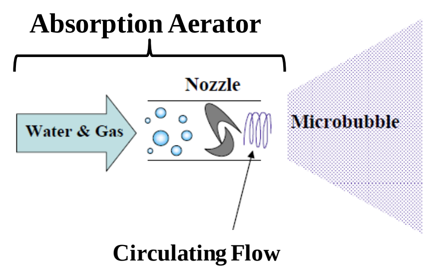
where SOTR is the oxygen transfer rate for pure water, α is the parameter that depends on the type of aeration device, intensity of mixing and tank geometry, β is the parameter that corrects for TDS, TSS, concentration of surface active agents, and φ is the parameter that adjusts for the oxygen solubility as a function of water temperature.

Table 1 lists the SOTR values for typical aerators, including the Absorption Aerator aeration system.

Type of Aeration System	SOTR Value
Surface Aerator with draft tube	1.2 – 2.1
Surface high speed	1.2 – 2.0
Submerged turbine	1.0 – 2.0
Submerged turbine with sparger	1.2 – 1.8
Surface brush and blade	0.8 – 1.8
Fine bubble diffusers	0.5 – 1.5
Coarse bubble diffusers	0.3 – 0.8
Absorption Aerator	2.7 – 3.1

The Absorption Aerator's basic mechanism is to pump liquid water through a specially designed nozzle in which the high velocity of the liquid combined with swirl flow creates a negative pressure that draws in ambient air which is dispersed in the form of microbubbles (less than 50 μm in diameter). Figure 1 shows the basic schematic of the Absorption Aerator with its microbubble generation mechanism.

Figure 1. Basic mechanism of the Absorption Aerator.



The Absorption Aerator has a high oxygen transfer efficiency due to the following factors: (1) high gas/liquid ratio = 2.2:1.0;
(2) high intensity of mixing in the nozzle system; (3) no external blower required, which has major maintenance requirements;
(4) the microbubbles have a large residence time within the water, thereby allowing the dissolved gases in the water, such as carbon dioxide, hydrogen sulfide, etc. to be effectively stripped out; and
(5) 50 μm or smaller bubbles ultimately dissolve completely, creating an implosion that creates hydroxyl radicals; these radicals effectively treat the contaminants in the water, such as hydrolysis of fats and oils, oxidation of ammonia, which promotes biological activity.

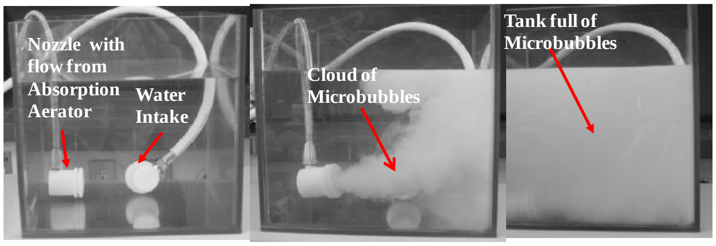
Table 2 compares the ordinary bubbles, created by sparging, surface aeration, etc with microbubbles created by the Absorption Aerator.

Table 2. Comparison of the Absorption Aerator's Microbubbles with Sparging Bubbles.

Bubble Size (μm)	Production Method	Properties
> 50	Submerged aeration, sparging, surface aeration, etc	Bubble coalesce into larger bubbles, rise quickly and break on the surface; oxygen transfer efficiency is less than 10% in clean water and less than 6% in wastewater
< 50	Absorption Aerator	Negatively charged surface of bubble prevents coalescence and bubble spends enough time within the water to achieve enhanced oxygen transfer; Once the bubble size becomes smaller than 10 μm due to air dissolution, the bubble does not rise to the surface, since its mass is balanced by its buoyancy; Microbubbles smaller than 10 μm effectively attach to submerged surfaces, thereby never rising to the water surface

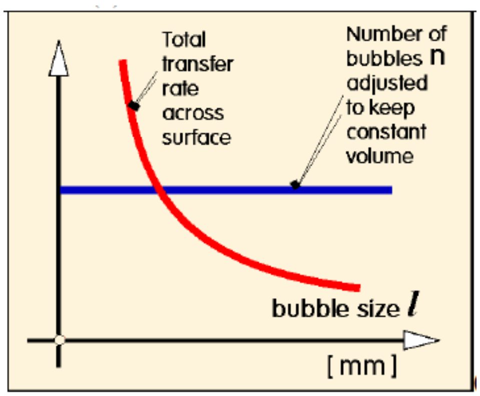
Figure 2 shows a time lapse photograph of a glass tank, in which there is water intake going to the Absorption Aerator, outside the tank, and not shown in the pictures, and the outlet nozzle, within the tank that discharges air/water mixture flow into the tank. The first picture shows the water intake and discharge nozzle, the second picture shows the onset of microbubbles leaving the discharge nozzle and the last photograph shows the tank filled with microbubbles of air.

Figure 2. Photographs showing the generation of microbubbles using the Absorption Aerator.



For a fixed volume of air, the surface area of the bubbles increases proportional to $1/\ell$, as the diameter of the bubble (ℓ) decreases, and this is shown in Figure 3.

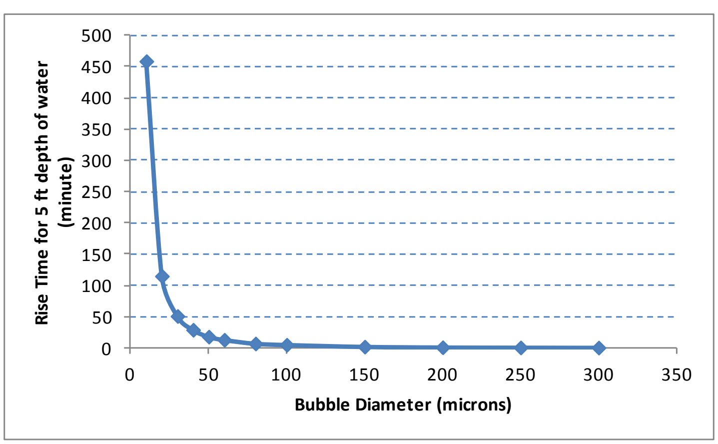
Figure 3. Increase in surface area as a function of bubble diameter (ℓ) for a fixed air flowrate.



Clearly, as the bubble diameter decreases, the total transfer rate of oxygen across the bubble interface increases, due to increases in bubble area.

The bubble rise (residence time) for a water depth of 5 ft has been calculated as a function of bubble diameter, and this is shown in Figure 4.

Figure 4. Bubble Rise Time through water depth of 5 ft. as a function of Bubble Diameter.



As the bubble size decreases below 50 microns (microbubbles), the rise time begins to increase rapidly for a tank with 5 ft depth of water. The above curve was constructed assuming that the water density is constant. However, as the bubble rise time increases, the density of the air-water mixture decreases, since at 70 deg F the density of air is 0.07 lb/ft3 while the density of water is 62.3 lbs/ft3. This decrease in air-water mixture density decreases the buoyancy of the bubble, and slows down its rise rate through the water.

Pond/Lake Aeration System

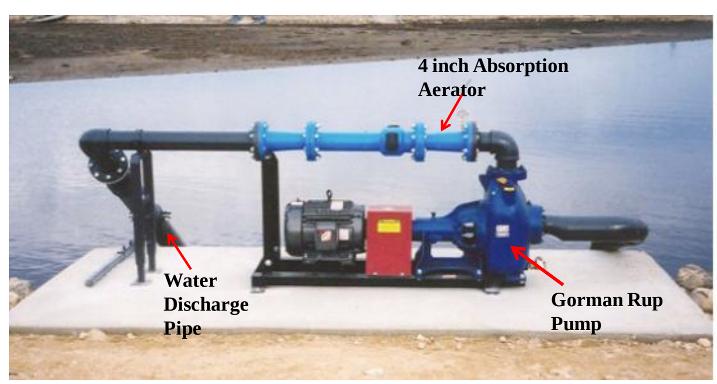
Anoxic conditions prevail in most ponds/lakes due to oxygen consumption by the microorganisms that are consuming contaminants from surface water run-off into the pond. These surface water run offs usually contain insecticides, fertilizers, etc. that result in a variety of growths within the water that consume oxygen. Typically, the rate of oxygen transfer from the water surface is small, unless the water is actively recirculated.

Figure 5 shows the intake of a pond/lake water aeration system, from which water is drawn in by a pump, located outside the water and on the side of the pond. This water intake pipe is usually perforated and located above the bottom to prevent the suction of bottom sediment.

Figure 5. Intake Manifolds (red color perforated pipes), located above the bottom of the lake/pond, for an Absorption Aerator System.

Figure 6 shows an Absorption Aerator system for a pond aeration, in which water is taken from one end of the pond through intake pipes (not shown in the photograph), and then pumped through the Absorption Aerator, wherein it mixes with the ambient air that is drawn in by the water flow, and then this water with microbubbles is discharged back into the pond through discharge nozzles (not shown).

Figure 6. Photograph of an Absorption Aerator system for a pond.



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