FACTSHEET

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# SURFACE AERATION

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## Introduction

Aeration is used during water treatment to increase dissolved oxygen (DO) in the system. Increasing oxygen will enhance biological processes and chemical decomposition; this can assist with removing dissolved nutrients. Surface aeration occurs in conjunction with a holding tank or pond as a final treatment prior to discharge to the environment.

## Description

*Surface Aeration*

Surface aeration systems consist of a float and a water pump. The systems float on the surface of tanks or ponds and add oxygen to water by disturbing the surface. Water surrounding the aerators is pumped into the air, much like a fountain. The disturbance caused by the water movement allows for gas venting and oxygen transfer (Coke, 2008).

Surface aerators function best in tanks or ponds with depths not exceeding 2.5 to 3 m (8 to 10') deep (Coke, 2008; ADS, 2014). There is an uneven distribution of oxygen through the water column when using these aerators due to the water only being drawn from the surface. The highest concentration of oxygen is in the pumped water and decreases in a circular manner to the area where the water is drawn (Stenstrom & Rosso, 2010). However, surface aeration will not impede solid settling or disturb sediment at the bottom of settling tanks which may be advantageous in some situations.

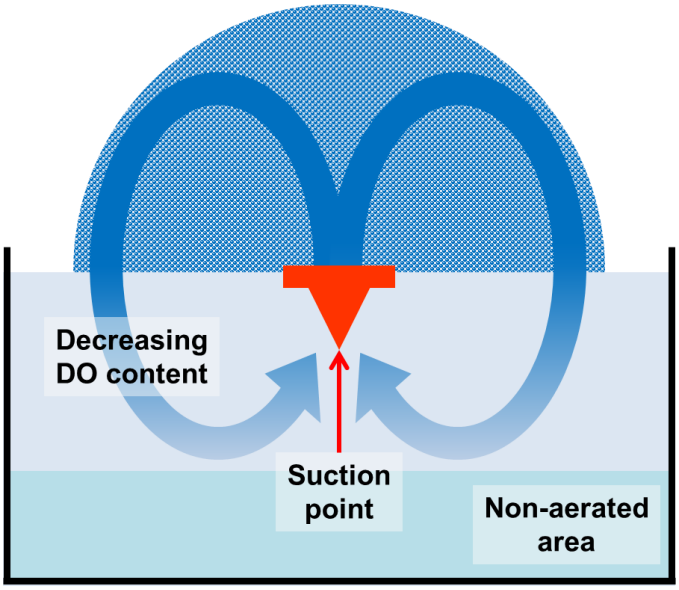


*Figure 1: Water movement demonstrated by the arrows and oxygen concentration shown by the colour gradient of a surface aerating unit.*

The performance of the aerators can be evaluated several ways. They are commonly marketed using standardized values such as Standard Oxygen Transfer Rate (SOTR; lbs or kgs per hr), Standard Oxygen Transfer Efficiency (SOTE; %), or Standard Aeration Efficiency (SAE; lbs of oxygen per horsepower unit per hour). With all of these measurements, the higher the value is, the more efficient the unit.

*Riffles*

A riffle is a structure that enhances gas exchange by disturbing the surface of the water. Riffles consist of an uneven surface formed by coarse substrates and are placed

just below the water surface. The combination of the irregular surface and water movement creates a turbulent flow with a high velocity. Partially submerged objects, such as rocks, cause the water surface to become agitated, and act as riffles. This allows for gas exchange and increases the dissolved oxygen levels through aeration.

Riffles, while occurring naturally, can also be constructed. They can be built during stream reconstruction using rocks and boulders, but their effect can be mimicked in water treatment systems using shaped concrete, such as shown in Figure 2.

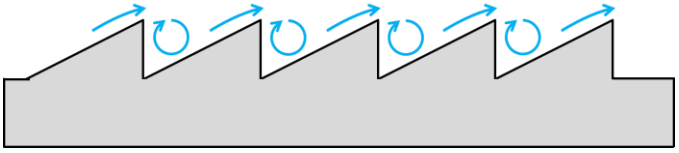

*Figure 2 Water movements over a riffle*

*Weirs*

Weirs are a waterfall structure where oxygen is introduced through the turbulence where the falling water meets the surface water. This is another system that can occur naturally or be constructed.

## System Placement

Aeration is meant to be placed near the end of treatment prior to discharge. It is paired with tanks or ponds, or can be used to connect two tanks like in the case of riffles or weirs.

## Considerations

Mechanical aeration can occur on the water surface or from the bottom of tanks. When choosing between them, there are several factors to consider. Surface aerators cause an uneven distribution of oxygen within the water column with the largest concentration at the surface whereas bottom aerators provide uniform aeration through the depth of the tank. Solid settling is uninterrupted by surface aeration however bottom aerators will disrupt settling. The depth of tanks is important as it impacts the efficiency of systems.

Riffles and weirs can be placed between two tanks or ponds in place piping. These types of aeration are non-mechanical systems so they can be useful if there is no available electricity and they require little maintenance. However, once it is installed, the amount of oxygen added to the water cannot be controlled and is limited. They cannot be relied on to address a large dissolved oxygen deficit and will require a large footprint to make a measurable increase.

Aeration will promote bacterial activity that will digest dissolved nutrients in the water. Some settling will occur due to this process and require regular cleaning of the tanks or structures.

*Figure 3 (from left to right) installed surface aerator, surface disturbance, and fountain-style aerator*

## Performance

It is difficult to accurately measure the performance of weirs and riffles as the amount of oxygen they add is minimal. They are useful structures but should not be relied on as the only source of oxygen addition.

The HMGA Water Project evaluated the aerator shown in Figure 3 (left and middle) in a three tank settling system in two different locations (Figure 4). Samples were taken for water quality parameters including total suspended solids (TSS), kjehdahl nitrogen (TKN), phosphorus (TP), and carbonaceous biological oxygen demand (CBOD) at the inlets and outlets of each tank during the tests to provide pre- and post-aerator measurements. The dissolved oxygen (DO) content was tested at the inlets and outlets as well as at the aerators to confirm the amount of oxygen added to the water.

The results show that aeration equipment's performance is tied to its location within the overall system. The best results came when the aerator was placed in the tank directly before discharge.

When the aerator was placed in Tank 2 it promoted aerobic decomposition of the solids and nutrients present in the tank. This activity accounts for the drop in oxygen content following the aerator. In an installed system another aerator should follow in Tank 3 to add oxygen prior to discharge.

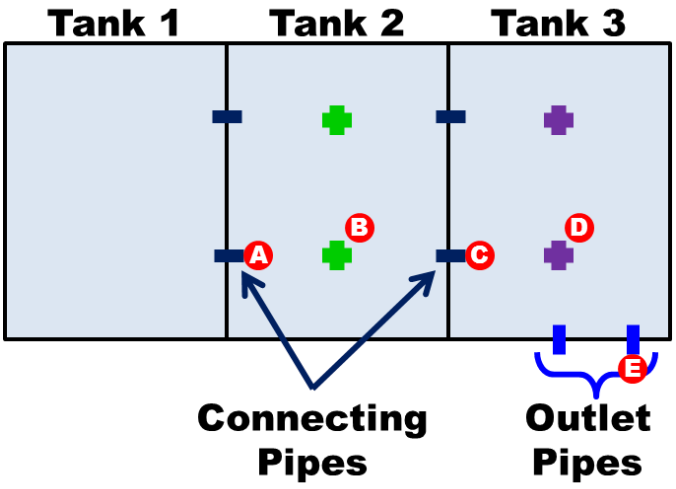


*Figure 4: Diagram of the surface aerator test; the aerators were evaluated in both tank 2 (green) and 3 (purple) and the red dots indicate sampling points*

*Table 1: The percent decrease in total suspended solids (TSS), kjehdahl nitrogen (TKN), phosphorus (TP), and carbonaceous biological oxygen demand (CBOD) with aerators in two locations measured at various points shown in Figure 4.*

| | Tank 2 | | Tank 3 |
|---|---|---|---|
| | **Point A to C** | **Point A to E** | **Point C to E** |
| **TSS** | -5 | 25 | -9 |
| **TKN** | -14 | 20 | -58 |
| **TP** | 1 | -2 | 10 |
| **CBOD** | 12 | -1 | 82 |

*Table 2: Dissolved oxygen content in mg/L prior to aerator, after aerator and at the outlet of the settling tank with aerator in two different locations; tank 2 aerator was sampled at points A,B,E and tank 3 aerator at points C,D,E as shown in Figure 4.*

| | **Pre aerator** | **Post aerator** | **Outlet** |
|---|---|---|---|
| **Tank 2** | 0.72 | 0.38 | 1.06 |
| **Tank 3** | 0.10 | 1.90 | 2.31 |

A different test was completed in a one-cell tank with two fountain-style aerators shown in Figure 3. Samples were taken at the inlet to the tank, beside the aerator unit, at the edge of the fountain's spray, and at the outlet. The results are shown in Figure 5; the DO, TKN, TP, CBOD, and TSS, dropped by 69%, 40%, 45%, 47%, and 56%, respectively. The aerators were able to maintain an environment where nutrients could be reduced. The oxygen content at the outlet was low, but there were sections of the tank that were not being aerated. Additional units would increase the oxygen in the outflow.

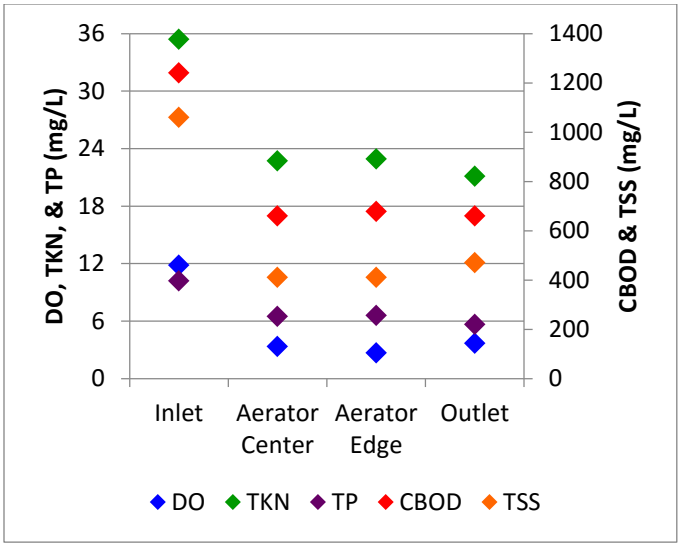


*Figure 5: The dissolved oxygen (DO), total kjehdahl nitrogen (TKN), total phosphorus (TP), carbonaceous biological oxygen demand (CBOD), and total suspended solids (TSS) contents at four sampling points in a tank with two surface aerators*

## Cost

There are minimal capital costs associated with riffles and weirs as they require limited maintenance and no ongoing costs. The main costs are constructing the structures. Cleaning may be necessary depending on the quality of water travelling through or over them. Surface aerators a low cost item but will have an ongoing electrical need and cost.

## Conclusion

Riffles and weirs are a simple method to add minimal oxygen to a system with little to no effort; however they cannot be used to correct a large shortfall of DO content. Mechanical surface aerators will increase DO but proper location and operation is necessary. Both surface and bottom aerators may be needed in some treatment systems to ensure the entire tank is aerated.

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*A discussion on aerating from the bottom is available in Factsheet #011 'Bottom Aeration'.*


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