Aeration

Aeration brings water and air in close contact in order to remove dissolved gases (such as carbon dioxide) and oxidizes dissolved metals such as iron, hydrogen sulfide, and volatile organic chemicals (VOCs). Aeration is often the first major process at the treatment plant. During aeration, constituents are removed or modified before they can interfere with the treatment processes.

Aeration brings water and air in close contact by exposing drops or thin sheets of water to the air or by introducing small bubbles of air (the smaller the bubble, the better) and letting them rise through the water. The scrubbing process caused by the turbulence of aeration physically removes dissolved gases from solution and allows them to escape into the surrounding air.

Aeration also helps remove dissolved metals through oxidation, the chemical combination of oxygen from the air with certain undesirable metals in the water. Once oxidized, these chemicals fall out of solution and become particles in the water and can be removed by filtration or flotation.

The efficiency of aeration depends on the amount of surface contact between air and water, which is controlled primarily by the size of the water drop or air bubble.

Oxygen is added to water through aeration and can increase the palpability of water by removing the flat taste. The amount of oxygen the water can hold depends primarily on the temperature of the water. (The colder the water, the more oxygen the water can hold.)

Water that contains excessive amounts of oxygen can become very corrosive. Excessive oxygen can also cause problems in the treatment plant, e.g., air binding of filters.

CHEMICALS REMOVED OR OXIDIZED BY AERATION

Constituents commonly affected by aeration are:

- Volatile organic chemicals, such as benzene (found in gasoline), or trichloroethylene, dichloroethylene, and perchloroethylene (used in dry-cleaning or industrial processes)
- Ammonia
- Chlorine
- Carbon dioxide
- Hydrogen sulfide
- Methane
- Iron

Carbon Dioxide
Surface waters have low carbon dioxide content, generally in the range of 0 to 2 milligrams per liter (mg/l). Water from a deep lake or reservoir can have high carbon dioxide content due to the respiration of microscopic animals and lack of abundant plant growth at the lake bottom.

Concentration of carbon dioxide varies widely in groundwater, but the levels are usually higher than in surface water. Water from a deep well normally contains less than 50 mg/l, but a shallow well can have a much higher level, up to 50 to 300 mg/l.

Excessive amounts of carbon dioxide (above 5-15 mg/L) in raw water can cause three operating problems:

- Increases the acidity of the water, making it corrosive. Carbon dioxide forms a "weak" acid, H_2C0_3 (carbonic acid).
- Tends to keep iron in solution, thus making iron removal more difficult.
- Reacts with lime added to soften water, causing an increase in the amount of lime needed for the softening reaction.

Most aerators can remove carbon dioxide by the physical scrubbing or sweeping action caused by turbulence. At normal water temperatures, aeration can reduce the carbon dioxide content of the water to as little as 4.5 mg/l.

Hydrogen Sulfide
Hydrogen sulfide can present dangerous problems in water treatment. Brief exposures (less than 30 minutes) to hydrogen sulfide can be fatal if the gas is breathed in concentrations as low as 0.03 percent by volume in the air. The "Immediate Dangerous to Life and Health" level for hydrogen sulfide is 300 ppm.

Hydrogen sulfide occurs mainly in groundwater supplies, and may be caused by the action of iron or sulphur reducing bacteria in the well. The rotten-egg odor often noticed in well waters is caused by hydrogen sulfide. Hydrogen sulfide in a water supply will disagreeably alter the taste of coffee, tea, and ice. Occasional disinfection of the well can reduce the bacteria producing the hydrogen sulfide.

Serious operational problems occur when the water contains even small amounts of hydrogen sulfide:

- Disinfection of the water can become less effective because of chlorine demand exerted by the hydrogen sulfide.
- Corrosion to piping systems and the water tanks, water heaters, and copper alloys.

Aeration is the most common choice for removal of hydrogen sulfide from water. Hydrogen sulfide has a low boiling point and vaporizes easily. The turbulence from the aerator will easily displace the gas from the water; however the designer of the system needs to consider how the gas is discharged from the aerator. If the gas accumulates directly above the water, the process will be slowed and corrosive conditions can be created.

Methane

Methane is a colorless gas that is highly flammable and explosive and can be found in groundwater. It may be formed by the decomposition of organic matter. It can be found in water from aquifers that are near natural-gas deposits. Methane tends to make the water taste like garlic. The gas is only slightly soluble in water, has a low boiling point, vaporizes easily, and therefore is easily removed by the aeration of the water.

Iron

Iron minerals are commonly found in soil and rock and can dissolve into groundwater as it percolates through soil and rock.

Water containing more than 0.3 mg/l of iron will cause yellow to reddish-brown stains of plumbing fixtures or almost anything that it contacts. If the concentration exceeds 1 mg/l, the taste of the water will be metallic and the water may be turbid.

Oils and Algae By-Products

Many taste and odor problems in surface water could be caused by oils and by-products that algae produce. Since oils are much less volatile than gases, aeration is only partially effective in removing them.

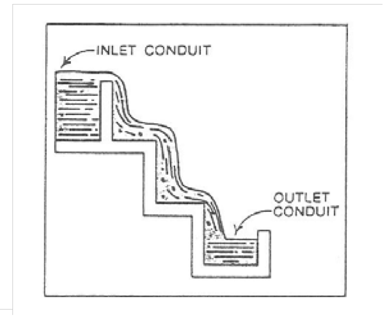
TYPES OF AERATORS

Aerators fall into two categories. They either introduce air to water, or water to air. The water-in-air method is designed to produce small drops of water that fall through the air. The air-in-water method creates small bubbles of air that are injected into the water stream. All aerators are designed to create a greater amount of contact between air and water to enhance the transfer of gases and increase oxidation.

Water-Into-Air Aerators

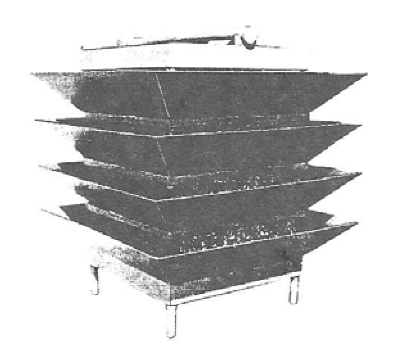
Cascade Aerators

A cascade aerator (one of the oldest and most common aerators) consists of a series of steps that the water flows over (similar to a flowing stream). In all cascade aerators, aeration is accomplished in the splash zones. Splash zones are created by placing blocks across the incline. (They are the oldest and most common type of aerators.) Cascade aerators can be used to oxidize iron and to partially reduce dissolved gases.



Cone Aerators

Cone aerators are used primarily to oxidize iron and manganese from the ferrous state to the ferric state prior to filtration. The design of the aerator is similar to the cascade type, with the water being pumped to the top of the cones and then being allowed to cascade down through the aerator.

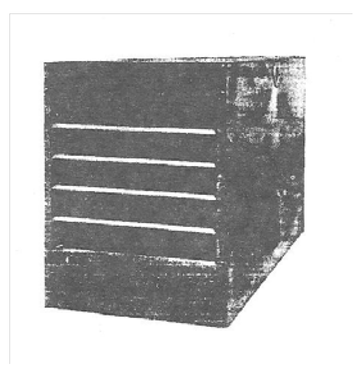


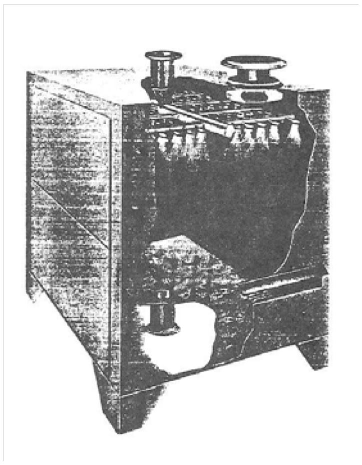
Slat and Coke Aerators

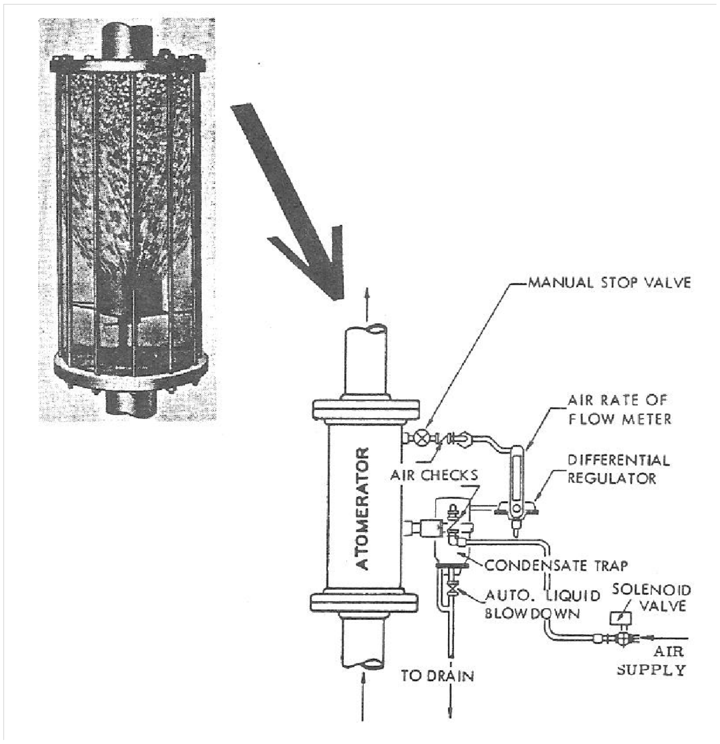
Slat and coke trays are similar to the cascade and cone aerators. They usually consist of three-to-five stacked trays, which have spaced wooden slats in them. The trays are then filled with fist-sized pieces of coke, rock, ceramic balls, limestone, or other materials. The primary purpose of the materials is providing additional surface contact area between the air and water.

Draft Aerators

Draft aerators are similar to other water-into-air aerators, except that the air is induced by a blower. There are two basic types of draft aerators. One has external blowers mounted at the bottom of the tower to induce air from the bottom of the tower. Water is pumped to the top and allowed to cascade down through the rising air. The other, an induced-draft aerator, has a top-mounted blower forcing air from bottom vents up through the unit to the top. Both types are effective in oxidizing iron and manganese before filtration.







<u>**Spray Aerators**</u>

Spray aerators have one or more spray nozzles connected to a pipe manifold. Water moves through the pipe under pressure and leaves each nozzle in a fine spray, and it falls through the surrounding air, creating a fountain effect. Spray aeration is successful in oxidizing iron and manganese and increases the dissolved oxygen in the water.

Air-Into-Water Aerators

<u>**Pressure Aerators**</u>

There are two basic types of pressure aerators. One uses a pressure vessel in which water to be treated is sprayed into high-pressure air, allowing the water to quickly pick up dissolved oxygen.

The other is a pressure aerator, commonly used in pressure filtration. Air is injected into the raw water piping and allowed to stream into the water as a fine bubble, causing the iron to be readily oxidized.

The higher the pressure, the more readily the transfer of the oxygen to the water. The more oxygen that is available, the more readily the oxidation of the iron and manganese.

Centrifugal Aerators

Centrifugal aerators create enhanced conditions for dissolving gas into liquid phase, including bubble size, and bubble size distribution and duration of interaction with liquid.

Centrifugal aerators combine several elements:

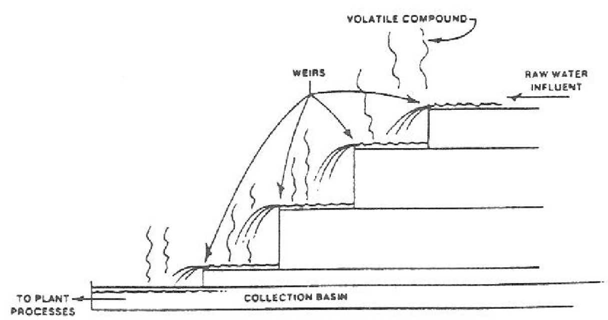
1. High turbulence swirling flow of liquid.
2. Orthogonal flow of liquid and gas.
3. Constant pressure inside the vessel;
4. Optimum flow velocity generating centrifugal forces, thereby extending diffusion rate within the vessel.
5. Very small pores, through which gas permeates into the liquid and is sheared off into liquid phase, thereby forming small bubbles.

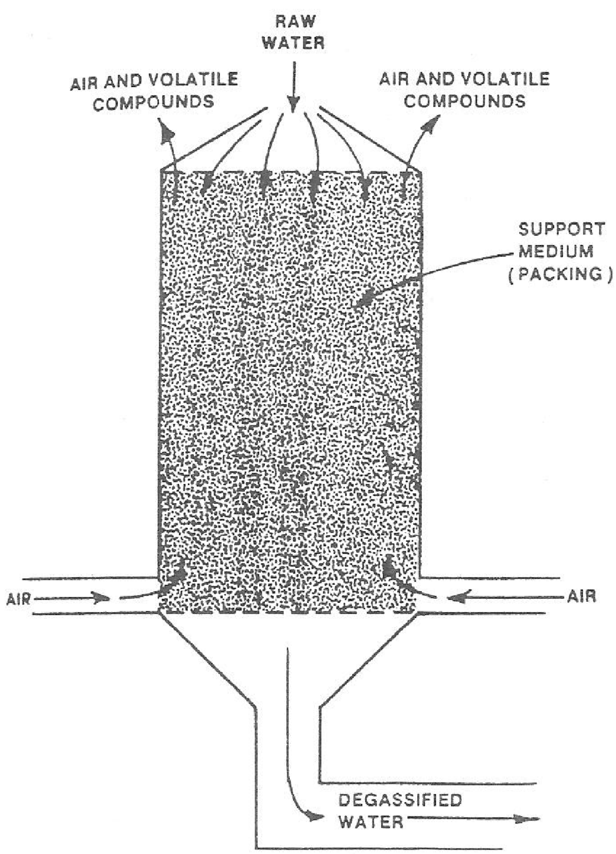
AIR STRIPPING

Air stripping can be quite effective in removing volatile organic chemicals (VOCs) from water.

Air stripping has been shown to be capable of removing up to 90 percent of the most highly volatile VOCs. Water flows over cascade aerators, or in specially designed air-stripping towers. In the air stripping towers, water flows down over a support medium or packing, while air is being pumped into the bottom of the tower.

OPERATING CONSIDERATIONS





Aeration raises the dissolved oxygen content of the water. If too much oxygen is injected into the water, the water becomes supersaturated, which may cause corrosion or air binding in filters. Other problems with aeration may include slow removal of the hydrogen sulfide from the towers, algae production, clogged filters, and overuse of energy in some aerators.

Corrosion

A certain amount of dissolved oxygen is present in raw and treated waters. However, dissolved oxygen can cause corrosion. Corrosion may occur when water and oxygen come into contact with metallic surfaces. Generally, the higher the dissolved oxygen concentration, the more rapid the corrosion. The solution to this problem is to not over-aerate. This may be difficult because no definite rule exists as to what constitutes over-aeration. The amount of aeration needed will vary from plant to plant and will also vary with the season.

False Clogging of Filters (Air Binding)

Filters in water containing a high amount of dissolved oxygen will have a tendency to release the oxygen in the filter as it passes through. The process can continue until the spaces between the filter media particles begin to fill with bubbles. Air binding, which does not occur in pressure filters, causes the filter to behave as though it is plugged and in need of backwashing. It can also cause loss of media.

Slow Removal of Hydrogen Sulfide

Hydrogen sulfide is most efficiently removed, not by oxidation, but by the physical scrubbing action of aeration. This removal is dependent on the pH of the water. At a pH of 6 or less, the hydrogen sulfide is easily removed. If the water has a high pH, the hydrogen sulfide will ionize, precluding removal by aeration.

Three basic control tests are required for aeration:

- Dissolved oxygen - The concentration of dissolved oxygen can be used to determine if the water is over or under-aerated. The pH test will give an indication of the amount of carbon dioxide removed.
- pH - pH increases as carbon dioxide is removed. pH can also be used to monitor the effective range for hydrogen sulfide, iron, and manganese removal.
- Temperature - The saturation point of oxygen increases as the temperature decreases. As water temperature drops, the operator must adjust the aeration process to maintain the correct dissolved oxygen level.