

Aeration

Aeration is the process of bringing water and air into close contact in order to remove dissolved gases, such as carbon dioxide, and to oxidize dissolved metals such as iron. It can also be used to remove volatile organic chemicals (VOC) in the water.

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.

HOW AERATION REMOVES OR MODIFIES CONSTITUENTS

In water treatment the aeration process brings water and air into close contact by exposing drops or thin sheets of water to the air or by introducing small bubbles of air and letting them rise through the water. For both procedures the processes by which the aeration accomplishes the desired results are the same:

- Sweeping or scrubbing action caused by the turbulence of water and air mixing together
- Oxidizing certain metals and gases

Undesirable gases (e.g. hydrogen sulfide) enter the water either from the air above the water or as a by-product of some chemical or biological reaction in the water. The scrubbing process caused by the turbulence of aeration physically removes these gases from solution and allows them to escape into the surrounding air.

Aeration can help remove certain dissolved gases and minerals 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 suspended material in the water. The suspended material can then be removed by filtration.

The efficiency of the aeration process depends almost entirely on the amount of surface contact between the air and water. This contact is controlled primarily by the size of the water drop or air bubble.

DISCUSSION OF CHEMICAL SUBSTANCES AFFECTED BY AERATION

Aeration of water removes gases or oxidizes impurities, such as iron and manganese, so that they can be removed later in the treatment process. The constituents that are commonly affected by aeration are:

- Volatile organic chemicals, such as benzene, found in gasoline, or trichloroethylene, dichloroethylene, and perchloroethylene, examples of solvents are used in dry-cleaning or industrial processes.

- Carbon dioxide
 - Hydrogen sulfide (rotten-egg odor)
 - Methane (flammable)
 - Iron (will stain clothes and fixtures)
 - Manganese (black stains)
- Various chemicals causing taste and odor

CARBON DIOXIDE

Carbon dioxide is a common gas produced by animal respiration. Apart from being naturally present in the air, it is produced by the combustion of fossil fuels. It is used by plants in the photosynthesis process.

Surface waters have a low carbon dioxide content, generally in the range of 0 to 2 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 a range of 5 to 15 mg/l in raw water can cause three operating problems:

- It increases the acidity of the water, making it corrosive. Carbon dioxide forms a “weak” acid, H_2CO_3 (carbonic acid).
- It tends to keep iron in solution, thus making iron removal more difficult.
- It 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 carbon dioxide per liter.

HYDROGEN SULFIDE

A poisonous gas, 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 (IDLH) level for hydrogen sulfide is 300ppm.

Hydrogen sulfide occurs mainly in groundwater supplies. It 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. Hydrogen sulfide gas is corrosive to piping, tanks, water heaters, and copper alloys that it contacts. 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 the chlorine demand exerted by the hydrogen sulfide.
- There could be corrosion of the piping systems and the water tanks.

Aeration is the process of choice for the removal of hydrogen sulfide from the water. The turbulence from the aerator will easily displace the gas from the water. 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 gas 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 is a colorless gas that is highly flammable and explosive.

When mixed with water, methane will make the water taste like garlic. The gas is only slightly soluble in water and therefore is easily removed by the aeration of the water.

IRON AND MANGANESE

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

Iron in the ferrous form and manganese in the manganous form are objectionable for several reasons. 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.

Manganese in water, even at levels as low as 0.1 mg/l, will cause blackish staining of fixtures and anything else it contacts. Manganese concentration levels that can cause problems are 0.1 mg/l and above.

If the water contains both iron and manganese, staining could vary from dark brown to black. Typical consumer complaints are that laundry is stained and that the water is red or dirty.

Water containing iron and manganese should not be aerated unless filtration is provided.

TASTE AND ODOR

Aeration is effective in removing only those tastes and odors that are caused by volatile materials, those that have a low boiling point and will vaporize very easily. Methane and hydrogen sulfide are examples of this type of material.

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.

DISSOLVED OXYGEN

Oxygen is injected into water through aeration. This is, in most cases, beneficial. It increases the palatability of the water by removing the flat taste. The amount of oxygen that the water can hold is dependent on the temperature of the water. The colder the water, the more oxygen the water can hold.

However, water that contains excessive amounts of oxygen can become very corrosive. Excessive oxygen can cause additional problems in the treatment plant by, for example, causing air binding of filters.

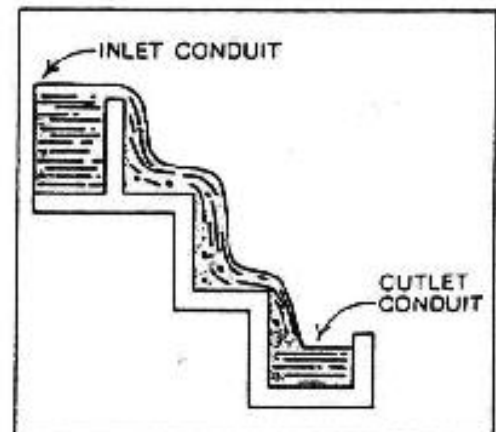
TYPES OF AERATORS

Aerators fall into two general categories. They either introduce air into the water or water into the air. The water-to-air method is designed to produce small drops of water that fall through the air. The air-to-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 the air and water to enhance the transfer of the gases.

WATER INTO AIR

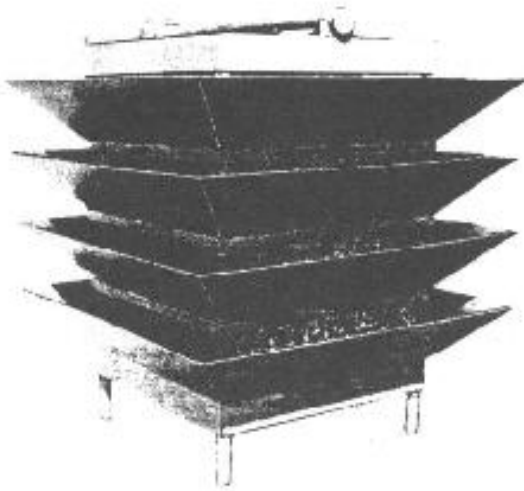
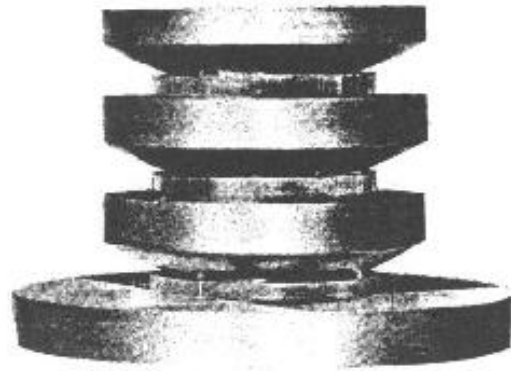
Cascade Aerators

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



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.

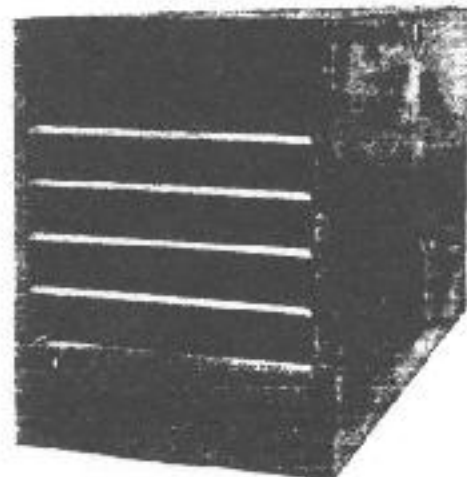


Slat and Coke Aerators

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

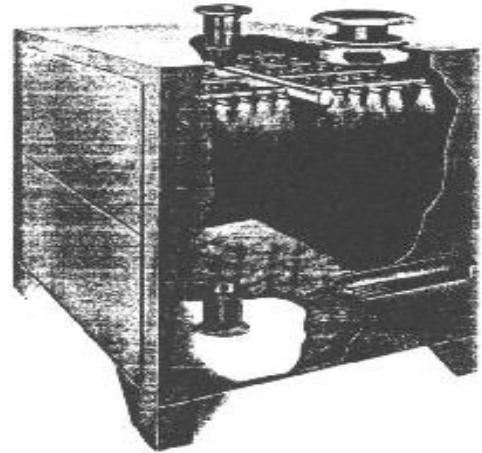
Draft Aerators

A draft aerator is similar to the others except that the air is induced by a blower. There are two basic type 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.



Spray Aerators

This type of aerator has one or more spray nozzles connected to a pipe manifold. Moving through the pipe under pressure, the water leaves each nozzle in a fine spray and falls through the surrounding air, creating a fountain affect. In general, spray aeration is successful in oxidizing iron and manganese and is successful in increasing the dissolved oxygen of the water.

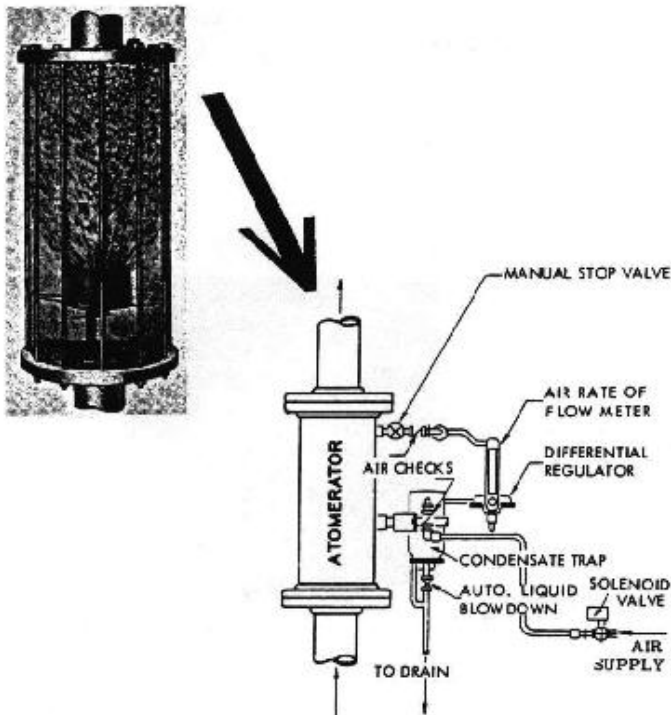


AIR INTO WATER

These are not common types used in water treatment. The air is injected into the water through a series of nozzles submerged in the water. It is more commonly used in wastewater treatment for the aeration of activated sludge.

Pressure Aerators

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

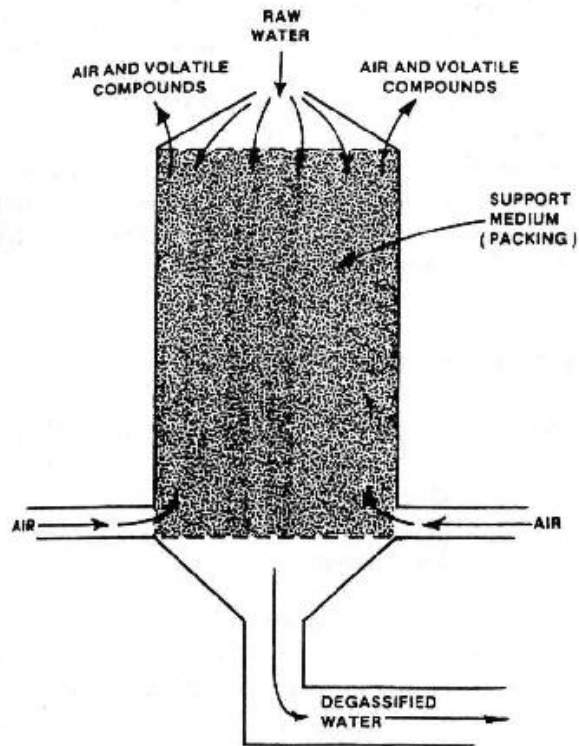
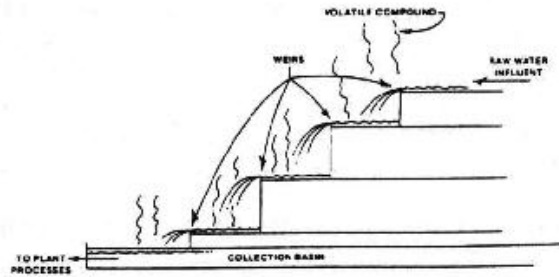


A pressure aerator commonly used in pressure filtration is a porous stone installed in a pipeline before filtration. The air is injected into the stone and allowed to stream into the water as a fine bubble, causing the iron to be readily oxidized. The higher the pressure, the more readily the transfer of the oxygen to the water. The more oxygen that is available, the more readily the oxidation of the iron or manganese.

AIR STRIPPING

If operated properly, a process called air stripping can be quite effective in removing volatile organic chemicals (VOCs) from water. The presence of VOCs, many of which are man-made or formed during industrial processes, is increasingly becoming a problem for public water suppliers. US EPA has set Maximum Contaminant Levels for many VOCs (see the Public Water Supply Regulation chapter). A major concern is that VOCs may be carcinogens. Example of VOCs are benzene from gasoline and trichloroethylene from dry cleaning establishments.

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



COMMON OPERATING PROBLEMS

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 are slow removal of the hydrogen sulfide from the towers, algae production, clogged filters, and overuse of energy.

CORROSION

A certain amount of dissolved oxygen is present in raw and treated waters. However, dissolved oxygen may cause corrosion. Corrosion can occur whenever 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. Called air binding, this causes the filter to behave as though it is plugged and in need of backwashing.

HYDROGEN SULFIDE REMOVAL

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.

OPERATIONAL TESTING

Three basic control tests are involved in the operation of the aeration process:

- Dissolved oxygen
- pH
- Temperature

The concentration of dissolved oxygen can be used to estimate whether the process is over or under aerated. The pH test will give an indication of the amount of carbon dioxide removal. pH increases as the carbon dioxide is removed. pH can also be used to monitor the effective range for hydrogen sulfide, iron, and manganese removal. The temperature is important as 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 DO level.