Taste and Odor

Most customers judge the quality of drinking water by taste and odor. If the customer is satisfied with these qualities, it is assumed the water is safe to drink. Many harmful contaminants in water cannot be detected due to taste or smell and many of the contaminants found in drinking water that have a detectable taste or odor are not harmful. Sources of taste and odor problems can be found in surface water and groundwater.

Source water protection involves the prevention of contaminants from entering the source. Surface water or groundwater may become contaminated by pollutants such as gasoline, industrial solvents, or a wide variety of volatile organics. The removal of contaminants from surface water or groundwater is costly and may involve the use of aeration, powdered activated carbon, or both.

If taste and odor must be controlled at the treatment plant, oxidation, aeration and adsorption can be effective in reducing taste and odor, and can improve coagulation filtration.

ODOR MEASUREMENTS

One of the most common methods for measuring odor in water is the threshold odor test. It involves a series of flasks presented to an observer, who is told that some of the samples contain odors and that the series is arranged in order of increasing concentrations. The observer is also given a known odor-free blank for reference during the test.

The observer compares the flasks in ascending order with the blank and then notes whether an odor is detected in any sample flask. Individuals vary in their reactions to certain types of odors. An odor stimulus that is agreeable to one may be disagreeable to another. Such differences complicate the attempts to predict the odor intensity of the mixtures.

METHANE AND HYDROGEN SULFIDE IN GROUNDWATER

Methane gas from the decomposition of organic matter tastes like garlic, and the biggest danger from the presence of methane is its explosiveness. It can be removed by aeration.

Hydrogen sulfide (H_2S) in water is a common problem that is therefore discussed separately from the other taste and odor problems. The most common method of removing hydrogen sulfide from water is by aeration. Carbon adsorption is also effective, but more expensive.

ALGAE AND MICROORGANISMS IN SURFACE WATER

Most taste and odors in surface water are organic and derived from algae blooms. Algae growths can be influenced by the pollution from domestic waste, run-off from fertilizer, and animal, domestic, and industrial waste.

Algae are simple forms of plant life that exist in relatively clean water, are widely distributed in nature, and usually present in lakes, ponds, and streams. Most are microscopic in size and vary from single cells to filaments, chains, or groups of cells. Their presence normally does not constitute a health risk. There are thousands of types of algae species; however, the most common types that cause taste and odors are:

- Cyanophyceae - These types are responsible for most taste and odor complaints. They are blue-green in color and float at or near the surface of the source.
- Diatomaceae - These are one-celled plants, which reproduce by splitting. The cell walls contain green and brown coloring matter. Dead organisms produce a fishy or geranium odor in the spring and fall.
- Chlorophyceae - These are one-celled green algae that are mostly free floaters which produce a grassy or fishy odor or taste.

Since algae are aquatic plants, they require the same conditions (sunlight and nutrients) as land plants. Algae analysis has shown that as much as 10 percent of the weight is nitrogen and that they contain significant amounts of phosphorus. Nitrogen and phosphorus are important components of fertilizers. The amount of run-off from farms and city lots may be the reason that some bodies of water support heavy algae growths while others do not. Other factors, such as a water surface's size, shape, and depth also influence the growth of different types of algae.

- Protozoa - These microorganisms belong to the simplest form of animal life and some forms have characteristics from both the animal and plant kingdoms. Odors and tastes caused by protozoa have been described as fishy, aromatic, cucumber-like, or muskmelon-like.
- Schizomycetes - These microorganisms, known as iron and sulfur bacteria, cause hydrogen sulfide to be found in water supplies. They include crenothrix and beggiatoa. Most often found in groundwater supplies, they produce an offensive odor of decaying matter.
- Actinomycetes - Closely allied with microscopic plants, actinomycetes are one-celled, filamentous microorganisms occupying a separate group between fungi and bacteria, but more closely associated with the latter. They account for a large part of the microbial population of soils and bottoms of lakes and rivers. Odors associated with this group have been described as earthy or musty.

INDUSTRIAL WASTE IN SURFACE WATER

Most compounds that pollute surface water are organic. These materials can, under certain conditions, cause persistent difficulties even when present in only trace amounts. Many compounds used in industrial operations can cause problems for the operator even at very low levels. Chemicals that can create taste and odor in water include, at these concentrations:

Formaldehyde	50,000 parts per billion (ppb)
Phenols	250 – 4,000 ppb
Xylene	300 – 1,000 ppb
Refinery hydrocarbons	25 – 50 ppb
Chlorinated phenols	1 – 100 ppb

Even small concentrations of these compounds can cause problems. In most cases, the consumer will not be able to identify the exact chemical that is causing the problem, but will instead report a specific type of taste, such as medicinal or metallic. Phenols and related compounds are often the source of the medicinal taste.

The taste of phenols is intensified by the addition of chlorine. Refinery waste from a paper mill can cause a distinctive odor. Hydrocarbons from this waste form an oily film on the water; the waste of a paper mill using the sulfite process will have that characteristic paper-mill smell.

Zinc, copper, and other metals produce characteristic tastes in water. Wastes from a metal industry can cause taste, but not odor, problems.

Domestic wastewater contains a mixture of organic material. In wastewater treatment, some of these compounds may be partially oxidized and produce an odor. When wastewater effluent chlorinated to control bacteria, it may develop a chlorine odor from the formation of chlororganic compounds.

Domestic wastewater may also contain a relatively high concentration of nitrogen compounds. During stabilization of nitrogen, ammonia is produced which will produce chloramines when combined with chlorine. These compounds have a very persistent swimming-pool odor.

TASTE AND ODOR REMOVAL

Oxidation

In most cases, oxidation is the best method for controlling taste and odor problems. Oxidation can be carried out with the following chemicals:

Potassium permanganate is most often used and is a very strong oxidant. According to the California Department of Health Services Water Treatment Plant Operation, a dosage range of 0.1 to 0.5 milligrams per liter (mg/l) can control taste and odor problems.

Ozone is also effective in oxidizing taste and odor compounds. Ozone changes the characteristics of the taste and odor in addition to reducing the level of the odor-producing compound. Ozone dosages of 2 mg/l to 5 mg/1 have been used. Several pilot studies have shown that the combination of ozone and hydrogen peroxide may be superior to the use of ozone alone.

Chlorine dioxide or chorine are also effective methods of taste and odor control, but use as a control chemical must be evaluated carefully due to the formation of THMs and chlorophenol when organics are present.

Aeration

Aeration is a practical solution for taste and odor control when the problem is caused by volatile compounds, such as hydrogen sulfide. It is generally not the best method for controlling taste and odors that are caused by algae. (See Aeration Chapter)

Adsorption

Adding powdered activated carbon to water or using of granular activated carbon (GAC) in the water filter can remove taste and odor. Powdered activated carbon (PAC) is the preferred method when the taste and odor is moderate and infrequent.

Two basic types of PAC feed systems are dry storage and dry feeding. If the hourly feed rate is less than 150 pounds, the feed system should have a solution tank. If the hourly feed rate exceeds 150 pounds, a slurry system should be considered.

The powdered activated carbon dosage will vary from 1 to 50 mg/l. A dosage of 25 mg/l is considered by many industry experts to be the maximum dosage.

Granular activated carbon filters should be considered when moderate-to-severe taste and odor problems exist frequently. GAC is similar to normal filters; however, the bed contact time is very important. The contact time should range from 3-to-10 minutes for purposes of taste and odor control and the filter rate will range from 3 to 6 gpm/ft^2. When the GAC is exhausted, the total volume of the bed must be replaced with new or regenerated GAC, which can be created by heating and re-burning used GAC to destroy the material it removed.

HYDROGEN SULFIDE REMOVAL

Aeration

Aeration is both practical and effective in removing hydrogen sulfide if the total level of sulfides is less than 3 to 4 mg/l. It is essential to adjust the pH of the water to a level below 7 prior to aeration. Air-to-water flow ratio should be in the range of 80-100: 1 and hydraulic loading for the tray-type aerator should be 7 - 15 gpm/ft^2.

Hydrogen Sulfide (H_2S) + ½ Oxygen in Air (O_2) <----> Water (H_2O) + Sulfur (S)

Chlorination

Chlorine is often used to oxidize hydrogen sulfide in groundwater. The following is the reaction that takes place:

Hydrogen Sulfide (H_2S) + 4 Chlorine (Cl_2) + 4 Water (H_2O) ➔ Sulfuric Acid (H_2SO_4) + 8 Hydrochloric (Muriatic) Acid (HCL)

Therefore, 8.3 parts of chlorine are required to oxidize one part of hydrogen sulfide. Factors that affect this reaction are temperature, pH, and reaction time.

Potassium Permanganate

Potassium permanganate is a common oxidant that is often used in water treatment processes. This reaction takes place to remove hydrogen sulfide:

4 Potassium Permanganate ($KMnO_4$) + 3 Hydrogen Sulfide (H_2S)
➔ 2 Potassium Sulfate (K_2SO_4) + 3 Mangarous Oxide (MnO)
+ Mangarous Dioxide (MnO_2) + 3 Water (H_2O)

As a result, 6.2 parts of potassium permanganate are required to oxidize one part of hydrogen sulfide. pH of the water plays an important role in the oxidation, with pH 6.5 to 7 being optimal.

TASTE AND ODOR REMOVAL FROM DISTRIBUTION

Taste and odors occurring in the distribution system are primarily the result of corrosion of pipe material and/or growth of iron bacteria, such as crenothrix and leptorix, in the water main. If the water has high sulfates and is allowed to stand in dead ends, taste and odor problems may be compounded by sulfate-reducing bacteria.

These problems can be rectified only by proper design of the system, such as eliminating dead ends and providing adequate means of flushing the system. Maintenance crews must keep the water lines clean by regularly flushing out deposits and the microorganisms that accumulate within these deposits.

Water treatment plants can also minimize taste and odor problems by maintaining an adequate residual of chlorine to combat the growth of bacteria in the system and by using anti-corrosion measures, either by adjusting the pH of the water or by adding corrosion inhibitors to the finished water (See Corrosion Chapter).