Taste and Odor Control

The typical water-system customer judges the quality of the water by its color, sparkle, and taste. If the customer is satisfied with these qualities, he or she assumes the water is safe to drink. However, if the taste of the water changes, the customer often will call the supplier and complain that the water is contaminated.

In reality, it is unlikely that any harmful contaminants in the water could even be noticed because of their taste or smell. Pollution caused by human and industrial waste and the ever-increasing reuse of water is the greatest challenge to the water-plant operator; however, the majority of customer complaints will continue to be as a result of changes in the taste and odor of the water.

SOURCES OF TASTE AND ODOR 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

Simple forms of plant life that exist in relatively clean water, algae 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, more than water operators could possibly be familiar with. The most common types that cause taste and odors are:

> Cyanophyceae
> More than any other, these types are responsible for taste and odor complaints. They are blue-green in color and float at or near the surface of a surface 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. Analysis of algae have shown that as much as ten 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.

In addition to algae, several other organisms and microorganisms can cause tastes and odors in water. They include:

<u>Protozoa</u>
These organisms belong to the simplest form of animal life. Some forms have the characteristics of both the animal and plant kingdoms. Odors and tastes caused by protozoa have been described as fishy, aromatic, cucumber-like, or muskmelon-like.

<u>Schizomycetes</u>
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.

<u>Actinomycetes</u>
Closely allied with microscopic plants, actinomycetes are uni-cellular, filamentous organisms 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

Although some inorganic materials, such as some metal ions, will impart taste and odor to 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 of a few parts per billion.

Many different compounds are used in industrial operations that, even at very low levels, can cause problems for the operator. Chemicals that can create taste and odors in water include:

	Concentration at which taste or odors are detected
Formaldehyde	50,000 parts per billion (ppb)
Phenolic	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 identity 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. Zinc, copper, and other metals produce characteristic taste in water. Wastes from a metal industry can cause taste, but not odor, problems. On the other hand, refinery waste from a paper mill can cause a distinctive odor. The 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.

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

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

SOURCES OF TASTE AND ODOR IN GROUNDWATER HYDROGEN SULFIDE

This is a very common contaminant of groundwater in Minnesota. It may be caused by iron or sulphur-reducing bacteria in the well. It is detected by a rotten-egg smell. It is most commonly removed by aeration.

METHANE GAS

When dissolved in water, methane gas from the decomposition of organic matter tastes like garlic. The biggest danger from the presence of methane is its explosiveness. It can be removed by aeration.

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.

CONTROL MEASURES

1. Wellhead protection

Wellhead protection, or groundwater source management, involves the prevention of contaminants from entering the source. Groundwater may become contaminated by pollutants such as gasoline, industrial solvents, and a wide variety of volatile organics. The need for prevention of groundwater contamination has been recognized only in recent years. The removal of contaminants from groundwater is costly and may involve the use of aeration, powdered activated carbon, or both.

2. Removal at the treatment plant

If preventive measures used on the water sources are ineffective, the taste and odor must be controlled at the treatment plant. Three measures can be used: they are oxidation, aeration and adsorption.

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, the chemical most often used. The chemical 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 mg/l has been found to be able to control taste and odor problems.

Ozone is also effective in the oxidation of 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 have been used with 5 mg/l being the extreme. Several pilot studies have shown that the combination of ozone and hydrogen peroxide may be superior to the use of ozone alone.

Chlorine dioxide has been effective in the past, although it's use is now discouraged by the U. S. EPA due to potential harmful effects on human health. Similarly, chlorination is also an effective method of taste and odor control, but its use as a control chemical must be evaluated carefully due to the formation of THMs and chlorophenol when any 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. Examples of aeration processes include diffused, mechanical, nozzles, spraying cascade trays and the tower type. For additional information see the chapter on aeration.

Adsorption: The two best adsorption methods for removal of taste and odor are the addition of powdered activated carbon to the water or the use of granular activated carbon in the water filter. The use of powdered activated carbon is the preferred method when the taste and odor is moderate and infrequent.

The two basic types of powdered carbon feed systems are dry storage and dry feeding. The rule of thumb dictates that, if the hourly feed rate is less than 150 pounds, the feed system should be used in conjunction with a solution tank. If the hourly feed rate exceeds 150 pounds, the use of 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 (GAC) 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. The filter rate for GAC 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 from used GAC by heating and reburning it to destroy the material it removed.

REMOVAL OF HYDROGEN SULFIDE

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.

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. The effective air-to-water flow ratio should be in the range of 80-100: 1; the hydraulic loading for the tray-type aerator should be 7 - 15 gpm/ft^2.

Hydrogen Sulfide (H_2S) + ½ Oxygen in Air (0_2) <----> Water (H_20) + 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_20)
----> Sulfuric Acid (H_2S0_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. When it is removing hydrogen sulfide, this reaction takes place:

4 Potassium Permanganate ($KMnO_4$) + 3 Hydrogen Sulfide (H_2S)
---> 2 Potassium Sulfate (K_2S0_4) + 3 Mangarous Oxide (MnO)
+ Mangarous Dioxide (MnO_2) + 3 Water (H_20)

The equation illustrates that 6.2 parts of potassium permanaganate are required to oxidize one part of hydrogen sulfide. Once again, the pH of the water plays an important role in the oxidation with a pH of 6.5 to 7 being optimal.

CONTROL IN THE DISTRIBUTION SYSTEM

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, within 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 the Corrosion chapter.)