Taste and Odor-Causing Compounds in Drinking Water

The primary sources of taste and odor problems in drinking water are algae and bacteria. However, other anthropogenic sources such as wastewater discharges and chemical spills also act as sources of chemicals that cause off tastes and odors. Such chemicals can affect both groundwater and surface water.

TYPES OF TASTE AND ODOR PROBLEMS

There are four basic taste types: sour, sweet, salty and bitter. There are also a variety of odor types including earthy, musty, chemical, and chlorinous. The table on the reverse side lists several taste and odor types and their potential causes.

THE CAUSES OF TASTE AND ODOR PROBLEMS

Some species of algae and bacteria naturally produce odorous chemicals inside their cells. Geosmin (trans-1, 10-dimethyl-trans-9-decalol) and MIB (2-methylisoborneol) are common odorous chemicals. The earthy and musty odors generated by geosmin and MIB are detectable by many people at concentrations of 5 to 10 parts per trillion. When large numbers of algae and bacteria flourish in a water body (an "algae bloom"), taste and odor-compound concentrations increase to levels above this threshold and cause taste and odor problems.

Cyanobacteria (Blue-Green Algae)

Cyanobacteria are known by several names, including "blue-green algae", "blue greens", and "cyanophyta". To the biologist, they are not technically algae (a multi-celled plant), but bacteria. This was not known until the advent of high-powered microscopes, however, the common name "blue-green algae" has remained. Cyanobacteria are photosynthetic bacteria. In addition to the blue-green color of many inferred by the name, other species can be red, brown, or yellow. Cyanobacteria are most commonly found in eutrophic waters (waters with high levels of nutrients) and shallow reservoirs, and can occur as surface scum, benthic (bottom) mats, and on aquatic weeds (Hoehn, 2002). In the 1960's and 1970's, it was discovered that cyanobacteria produce geosmin and MIB as intracellular by-products. As a bloom progresses, bacteria die, releasing these odorous chemicals into the water.

Actinomycetes

Actinomycetes are spore-forming bacteria that grow as branching filaments in water. Closely related to cyanobacteria, they have simple cells. Actinomycetes also live in soil. In fact, it is the geosmin-producing soil variety that causes soil to smell "earthy." Other species produce antibiotics. Aquatic actinomycetes grow in aerobic mud, on decaying vegetation, and in the excrement of zebra mussels. The bacteria help to degrade cellulose and other plant parts, and for this reason thrive as a result of an algae bloom (Hoehn, 2002). Actinomycetes, like cyanobacteria, produce geosmin and MIB.

Other Algal and Natural Sources

Green algae blooms in a reservoir can produce a grassy or fishy odor. Golden-brown algae, particularly the species Synura, can produce a cucumber, melon, or fishy odor. Biological activity in surface waters can produce 2,4-heptadienal and decadienal, which have a fishy, rancid odor. In addition, dissolved metals such as zinc, manganese, copper, and iron can produce a metallic taste.

Man-Made Chemicals

Man-made chemicals are another source of taste and odor-causing chemicals in drinking water. For example, methyl tertiary butyl ether (MTBE), a gasoline additive persistent in groundwater and recreational surface waters, has an odor threshold as low as 5 parts per billion. Dissolved in water, it smells oily and like turpentine. Industrial phenols can create odor problems. Hydrocarbons and volatile organic compounds such as fuels and solvents produce oily, paint-like, and medicinal odors.

ALGAE AND BACTERIA BLOOM PATTERNS

A bloom occurs in a surface water body when light, temperature, and nutrient conditions are favorable for one type of algae or bacteria over another. This combination allows one organism to become dominant. It is an ecological imbalance often triggered by pollution. Nitrates, organic phosphorus and ammonia are discharged into the water body from water treatment plants or are carried in by watershed runoff (including runoff from pig and cattle feed lots and fertilizer from agricultural fields). The conditions favorable to blooms are seasonal. Spring and winter conditions favor golden brown algae and fishy, cucumber odors. Summer and fall conditions favor geosmin and MIB-producing bacteria and earthy and musty odors. Generally, the most common bloom month is September.

MEASUREMENT AND REGULATION OF TASTE AND ODOR QUALITY

There are several methods of taste and odor quality measurement and very few regulations.

FACT**SHEET**

TASTE OR ODOR	SOURCE
Earthy	Geosmin
Musty	MIB, isopropylmethoxypyrazine (IPMP), isobutylmethoxypyrazine (IBMP)
Turpentine, oily	Methyl tertiary butyl ether (MTBE)
Fishy/rancid	2,4-Heptadienal, decandienal, octanal
Chlorinous	Chlorine
Medicinal	Chlorophenols, iodoform
Oily, gas-like, paint	Hydrocarbons, volatile organic compounds (VOCs)
Metallic	Iron, copper, zinc, manganese
Grassy	Green algae

The most frequently used measuring system is the Total Odor Number (TON), a method based on the persistence of an odor after dilution. Other methods include Flavor Profile Analysis and analytical measurement of chemical concentrations. Regulatory limits are few. The United States Environmental Protection Agency (USEPA) has issued a secondary maximum concentration limit (MCL) limiting the TON to 3. Iron, manganese, copper, and zinc have USEPA MCLs ranging from 0.5 to 5 parts per million. However, the primary regulator with respect to taste and odor is the consumer.

ALGAL TOXINS

In addition to producing chemicals that impact the aesthetic quality of water, certain species of cyanobacteria produce toxins ("cyanotoxins") that can cause harm to animals and humans. Toxic cyanobacteria are indistinguishable from non-toxic cyanobacteria under a microscope and both types may be present in a bloom. Multiple classes of cyanotoxins exist, including microcystin, cylindrospermopsin, and anatoxin-a. Cyanotoxins can be present wherever blooms occur and as a result, several regulating agencies worldwide have issued guidance regulations. Research in the U.S. and Canada has shown that a high percentage of raw water taken from water supplies undergoing a cyanobacteria bloom contained cyanotoxins, in addition to other taste and odor-causing chemicals (Carmichael, 2001). In the U.S., the USEPA has listed freshwater cyanobacteria and their toxins on the Contaminant Candidate List. In addition, New Zealand, Germany, and the World Health Organization (WHO) have established microcystin guidelines of 1.0 ppb, while Canada has established a 1.5 ppb guideline.

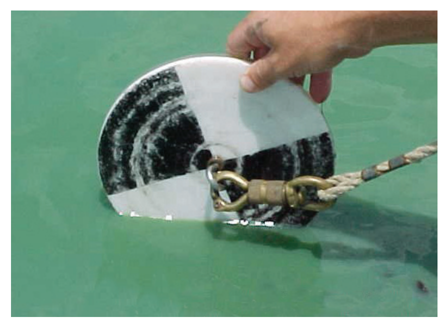
TREATMENT ALTERNATIVES – UV LIGHT A KEY

Many utilities use powdered activated carbon (PAC) to treat taste and odor problems. However, large doses of PAC are required to treat geosmin and MIB, making it impractical, especially for larger utilities. Chlorine is widely used for the oxidation of taste and odor-causing chemicals, but itself can produce chlorinous odors and disinfection by-products such as THMs and HAAs. Ozonation is also used, but is expensive, complex to operate, and can form bromate, a harmful by-product. However, UV-photolysis and UV-oxidation using UV light and hydrogen peroxide is a cost-effective alternative for treating a wide variety of taste and odor problems. MIB, geosmin, MTBE, phenols, VOCs, and many others contaminants can be treated with UV-oxidation. This technology requires the photolysis of hydrogen peroxide with UV light to generate hydroxyl radicals. The hydroxyl radical is one of the most powerful oxidizing agents known and reacts rapidly with organic constituents in the water, including taste and odor compounds, breaking them down into their elemental, non-odorous components. Trojan's UV-oxidation reactors provide a reliable barrier to taste and odor compounds and do not form bromate. In addition, the same UV system used for taste and odor control simultaneously performs disinfection. This reduces or eliminates the source of unpleasant chlorinous odors resulting from the use of chlorine as a primary disinfectant.

TREATING MULTIPLE CONTAMINANTS WITH ONE UV SYSTEM

As a further benefit to taste and odor control and microbial disinfection, the Trojan UV system will disinfect *Cryptosporidium* and *Giardia*. The process will also treat many other dissolved organic compounds present in the water, including endocrine disruptors, *N*-nitrosodimethylamine (NDMA), pesticides, and algal toxins.

For over 30 years, Trojan has specialized in UV applications for water treatment and wastewater disinfection. Over 6,500 Trojan UV systems are treating municipal wastewater in more than 80 countries around the world. Tens of thousands of industrial and residential Trojan UV treatment systems are in operation in industries and households worldwide. Now, Trojan offers the industry standard in Environmental Contaminant Treatment (ECT). Trojan's UV-photolysis and UV-oxidation systems are capable of cost-effectively removing environmental contaminants from a variety of water streams. With its optimized technology, Trojan is the leader in ECT, offering the most cost effective, highest quality UV solutions available.



Cyanobacteria Bloom in Lake Manatee, Florida
(Photo courtesy of Bruce MacLeod)

References:

Hoehn, R.C. 2002. Odor Production by Algae. Conference Workshop Presentation: Understanding and Controlling the Taste and Odor of Drinking Water. AWWA Annual Conference, New Orleans. June 16, 2002.
Carmichael, W. W. 2001. Assessment of Blue-Green Algal Toxins in Raw and Finished Drinking Water. AWWA Research Foundation, Denver. 179 pgs.

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