The many flavors of drinking water

From Volume 31, Issue 5 - May 2008

Technical Pages

Your customers can detect some tastes and odors in parts per trillion.

by: Andrea M. Dietrich, Ph.D.

Consumers, utility personnel, water distributors and bottlers all use aesthetic evaluation as a critical tool for assessing the quality of their drinking water. In consumer surveys, the taste and odor of drinking water is an important factor for consumers, who associate good-tasting water with healthy and safe water.

For many consumer products, people are looking for consistency — that is, the product has a quality and quantity that is similar to what it was when they previously used it. Consumers do not want major variations in the flavor of their drinking waters.

The sensory properties of water are a combination of its chemical content and responses of a person's senses. Personal preferences for drinking water are based on both psychological and physiological factors. The human senses respond to taste-and-odor compounds in water at many different concentrations, from parts per trillion to parts per million.

Many nuisance organic odorants in water are present at nanograms per liter (ng/L, or parts per trillion) concentrations, while many mineral species evoke a taste at milligrams per liter (mg/L, or parts per million) concentrations. The intensity and descriptors of tastes and odors can vary with concentration, temperature, and an individual's senses and genetics.

What people detect

Flavor is composed of the five tastes (sour, sweet, salty, bitter and umami*), mouth-feel, and about 10,000 possible odors that are either inhaled directly by the nose or are directed to nasal cavities through the back of the mouth. Although consumers generally expect their water to have little or no flavor, people can detect variations in pH, mineral, and organic content of drinking water.

Several factors provide water with its flavor. These include: 1) the chemical and microbial content of the natural source water, which is most influenced by geology and ecology; 2) chemicals added or removed during treatment; and 3) inputs and reactions that occur during distribution and storage. These three factors contribute to water whether it is from a public water system, treated on-site, or bottled and sold.

Many 'natural' flavors

The mineral and organic matter contents of natural waters vary geographically because of regional geology, seasonal factors, and temperature variations. As a result, waters really do come in a lot of "natural" flavors, although the variations are not as great as for food.

Surface waters usually have higher dissolved oxygen, microbial, organic matter and particulate content; and temperature variations from near-freezing to warm. Naturally occurring algae in surface waters can produce compounds that add earthy, musty, fishy, grassy, fruity or other odors to the water.

Groundwaters tend to be at a constant and cool temperature, with higher mineral content. Minerals can add a salty, sweet, bitter, or sour flavor to water, and certainly they are responsible for much of a water's "mouth-feel."

Waters with little mineral content are frequently described as "slick" or "astringent."

Disinfectants and treatment

Chemicals added during treatment, especially disinfectants added to protect the public health, are noted for impacting the sensory properties of drinking water either directly as odorants or indirectly through formation of odorous byproducts.

Chlorine is the most-noticed chemical flavor in drinking water. Although chlorine is an odorant, it can be applied to destroy fishy odors. Chloramines produce a less-intense chlorinous odor than chlorine. Ozone, which is a powerful disinfectant, will remove earthy and musty odors, but may produce fruity odors.

Physical treatment of water, such as filtration through activated carbon, ion exchange resins, or membranes, is a well-established practice for both full-scale water treatment plants and point-of-use/point-of-entry (POU/POE) devices. Filtration through activated carbon and reverse osmosis membranes are particularly well-suited for removing odorous compounds but may alter the mineral composition by removing nutrients like copper and calcium.

Another form of 'packaging'

Materials used to convey water to consumers should be viewed as a form of "food and beverage packaging."

Publicly supplied water travels through pipes, valves, gaskets, storage tanks, etc. in a distribution system and into the home, where it contacts premise plumbing and home water treatment devices. As a result, utility personnel list the distribution systems as the No. 1 cause of taste-and-odor problems. While the food and beverage industry does much testing on the taste-and-odors effects of containers and wrappers, the manufacturers of water distribution system materials do not routinely test for the aesthetic qualities of their products.

Tastes and odors encountered in distribution and plumbing systems occur mostly as a result of (1) chemicals from pipe or lining materials that leach into water, and (2) further reactions of leached compounds in the water with the disinfectant residual within the distribution system.

Interestingly, many of these materials used in distribution systems do not smell when they are dry. However, when they are in contact with water, the chemicals "migrate" from the pipe to the water and produce odors. This migration phenomenon has long been known and controlled in the food and beverage industry.

Odors from leaching

There are many examples of aesthetic problems from distribution-system materials leaching into drinking water.

Chemicals leached from an acrylic coating used to line water storage reservoirs have resulted in "phenol/styrene" type odors. "Medicinal-smelling" compounds have been produced from the reaction of leached chemicals from liners with chlorine in bromide-containing water.

Installation of a new polymeric water main or pipes in the distribution system may result in "plastic," "chemical" and "paint/putty" tastes and odors. Lining materials for pipes and water towers can produce "chemical-, plastic- or gasoline-" type odors. Polyethylene materials can produce "sweet, fruity" odors depending on how they were extruded. Metal pipes can lead to "metallic" tastes and odors.

Some odorous volatile or semi-volatile organic compounds known to be associated with distribution and bottling materials and odors include aldehydes and ketones (usually with 2-12 carbon molecular structures); unsubstituted and alkyl-substituted aromatics including styrene and toluene; and many phenolic compounds.

Considering that there are hundreds of miles of pipe and many materials that contact most drinking waters, it is not surprising that the water distribution infrastructure can affect water quality.

Best detectors: your customers

In summary, there are many compounds that can cause taste and odor problems, and they can enter drinking water anywhere from the source water, the treatment process, or during distribution and delivery to the consumer. More studies are necessary to elucidate and identify the presence of these chemicals and their taste and/or odor properties.

A selected few chemicals that cause tastes and odors have US Environmental Protection Agency primary or secondary standards associated with them, but most do not, because although they may be annoying to the consumer, they are not associated with health problems. The human senses are the best detectors for taste and odor compounds, and therefore drinking water providers and treatment professionals should listen to their customers.

***Editor's note:** Umami is a recent addition to the basic tastes. According to the Umami Information Center (**www.umamiinfo.com**), it is "a savory taste imparted by glutamate and ribonucleotides, including inosinate and guanylate, which occur naturally in many foods including meat, fish, vegetables and dairy products." Umami was first identified in 1908 by Japanese scientist Kikunae Ikeda.*

Andrea Dietrich, Ph.D., is professor of civil and environmental engineering at Virginia Tech, Blacksburg, VA, where she has been a member of the faculty for 20 years. An internationally recognized expert in the area of sensory and consumer perception of drinking water, she recently has led research into the effects of plumbing materials on the odor of drinking water.