service in ACTION

Colorado State University Cooperative Extension

no. 9.307

Drinking water quality and health

[1]Pat Kendall

Quick Facts

Water is our most essential nutrient.
Water contains different amounts of dissolved inorganic and organic compounds.
The Environmental Protection Agency regulates public water systems.
The Colorado Department of Health regulates bottled or vended water if the water does not leave Colorado. The Food and Drug Administration regulates if the water is involved in interstate commerce.

People can survive days, weeks or months without food, but only about four days without water. The body uses water for digestion, absorption, circulation, transporting nutrients, building tissues, carrying away waste and maintaining body temperature.

The average adult consumes and excretes about 10 cups of water daily. Adults should drink 6 to 8 cups of liquids per day. Although most of this liquid should come from beverages, food supplies some water. Our bodies "make" water as a by-product in the breakdown of fats, sugars and proteins to energy.

Water is always two parts hydrogen to one part oxygen. Water can be hard or soft, natural or modified, bottled or tap, carbonated or still. About one-half of our water comes from underground water tables (groundwater) and one-half from surface water in rivers, lakes and reservoirs.

Hard vs. Soft Water

The hardness of water relates to the amount of calcium, magnesium and sometimes iron in the water. The more minerals present, the harder the water. Soft water may contain sodium and other minerals or chemicals; however, it contains very little calcium, magnesium or iron. Many people prefer soft water because it makes soap lather better, gets clothes cleaner and leaves less of a ring around the tub. Some municipalities and individuals remove calcium and magnesium, both essential nutrients, and add sodium in an ion-exchange process to soften their water. The harder the water, the more sodium that must be added in exchange for calcium and magnesium ions to soften the water. This process has drawbacks from a nutritional standpoint.

First, soft water is more likely to dissolve certain metals from pipes than hard water. These metals include cadmium and lead, which are potentially toxic. Second, soft water may be a significant source of sodium for those who need to restrict their sodium intake for health reasons. Approximately 75 milligrams of sodium is added to each quart of water per 10 g.p.g. (grains per gallon) hardness. Finally, there is epidemiological evidence to suggest a lower inci-

---

[1] *Pat Kendall, Ph.D., R.D., Colorado State University Cooperative Extension food science and human nutrition specialist and associate professor, food science and human nutrition (5/91)*

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Kenneth R. Bolen, director of Cooperative Extension, Colorado State University, Fort Collins, Colorado. Cooperative Extension programs are available to all without discrimination. To simplify technical terminology, trade names of products and equipment occasionally will be used. No endorsement of products named is intended nor is criticism implied of products not mentioned.

dence of heart disease in communities with hard water. The Environmental Protection Agency (EPA) doesn't set a mandatory upper limit for sodium in water, but suggests an upper limit of 20 milligrams per liter (quart) to protect individuals on sodium-restricted diets.

If you use a water softener, two ways to avoid excess sodium in drinking water are: 1) use low sodium bottled water, and 2) install a separate faucet in the kitchen for unsoftened water.

Giardia and Other Microorganisms

Along with differences in mineral composition, water contains different levels of microorganisms. Bacteriological tests are available to determine if water is bacteriologically safe for human consumption. Contact the county health department for information on how and where such tests are performed.

Chlorination and filtration are effective controls for most bacteria. However, a tiny one-celled parasite not readily killed by chlorination, *Giardia lamblia*, deserves special discussion. Over the past several years, giardia has become an increasingly common problem in rural and mountain communities with inadequate filtration systems. Giardia is mostly found in surface waters such as mountain streams and lakes, not groundwater. Because one cannot see, taste, or smell giardia, it is best not to drink water directly from mountain streams or lakes.

Once ingested, the giardia cyst develops into a trophozoite that attaches to the wall of the small intestine. Disease symptoms usually include diarrhea with cramping and gas, dehydration, weakness and loss of appetite. Symptoms may take seven to 10 days to appear and last up to six weeks. Most people are unaware at the time of ingestion that they have been infected.

Laboratory identification can confirm the disease by diagnosis of the organism in the stool. The disease is curable with prescribed medication. If untreated, the symptoms may disappear on their own and reoccur intermittently over a period of months.

Treatment also can help prevent spread of the disease between people and between pets and people. For example, in a Colorado Department of Health study, person-to-person contacts within families or between small children in day care centers were responsible for 46 percent of the 360 cases investigated. In fact, only 15 percent of the respondents had ingested stream or lake water in the three weeks prior to the onset of symptoms.

Prevention is the best solution. Always wash your hands after changing diapers and performing other hygiene activities. Wash children's hands frequently. Thoroughly clean change surfaces after diapering.

It's best to carry your own water on camping or backpacking trips. If this is not practical, the next best solution is to boil the water. Although giardia cysts are killed at temperatures of 131°F, boiling for one minute at sea level and up to five minutes at 10,000 feet is recommended to eliminate other microorganisms that might be more heat resistant than giardia. Giardia also will not survive in water held at 59°F for 30 minutes if one iodine tablet has been added per quart. Filters are available, but are expensive and inconvenient. Furthermore, many products marketed for backpackers are not effective in filtering out the tiny giardia cysts.

Protecting others is key to the control of giardiasis. Since feces can contain the organism, bury waste 8 inches deep and at least 100 feet away from natural waters. Dogs, like people, can get infected with giardia. Unless carefully controlled, dogs can contaminate the water and continue the chain of infection from animals to humans.

Fluoride

Fluoride is found naturally in Colorado water supplies in different amounts. The dental benefits of fluoridated water are well documented. Fluoride concentrations of 1.0 milligrams per liter or greater will reduce the incidence of dental caries. However, concentrations over 2.0 milligrams per liter can darken tooth enamel causing fluorosis.

The American Dental Association and the American Medical Association endorse fluoridation. Yet, after more than 40 years of fluoridation, nearly 40 percent of tap water remains unfluoridated. Opponents have long argued that fluoridation violates individual rights, certain religious beliefs that ban medications, and does not prevent tooth decay. They also claim it promotes a variety of ills. A recent study in which male (but not female) rats given water with high levels of sodium fluoride developed a rare bone cancer, added fuel to their concerns. Proponents counter that fluoridation is not a form of medication, but an adjustment of an essential nutrient to a level favorable to health. What that level is and whether or not it should come from fluoridated drinking water will be at the crux of the next round of debates.

Tooth decay is on the decline in the United States (50 percent decline in the last 20 years). The decline is occuring in fluoridated and to a lesser extent in non-fluoridated areas. Fluoride treatments, fluoridated toothpaste, better diets and improved oral hygiene are all factors.

Like most elements, fluoride appears to be both beneficial to health and potentially toxic. The goal is to determine the optimum level and then decide how best to achieve that level. The EPA currently sets the maximum allowable level of sodium fluoride in drinking water (natural or added) at 4 milligrams per liter (4 parts per million) and the maximum recommended level at 2 milligrams per liter. The EPA reviews drinking water standards every three years.

Lead

Lead is a toxic heavy metal known to turn up in drinking water. Recent data indicate that levels formerly considered safe may threaten health, especially among infants and children. In an 1986 EPA survey, an estimated 40 million Americans (one in five) were using drinking water that contained potentially hazardous levels of lead.

Acute lead poisoning can cause severe brain damage and death. The effects of chronic, low-level exposure, however, are more subtle. The developing nervous systems of fetuses, infants and children are particularly vulnerable. Recent studies show that

lead exposure at a young age can cause permanent learning disabilities and hyperactive behavior. Low-level lead exposure also is associated with elevated blood pressure, chronic anemia and peripheral nerve damage.

Natural water usually contains very little lead. Contamination generally occurs in the water distribution system or in the pipes of a home or facility. Lead pipes, brass faucets and lead solder used to join copper pipes are the culprits. If your home was built before 1986 when a nationwide ban on lead pipes and lead solder went into effect, it is likely to have lead-soldered plumbing.

The severity of lead contamination depends in part on how "corrosive" your water is. Soft or acidic water is more likely to corrode plumbing and fixtures, leaching out lead. According to the EPA, about 80 percent of public water utilities deliver water that is moderately or highly corrosive.

The EPA is changing the focus of their lead regulation from a maximum contaminant level of 50 parts-per-billion at the tap to imposed treatment if more than 10 percent of collected samples from a water system exceed 15 parts-per-billion lead. Water systems that exceed such levels will be required to implement corrosion control measures to reduce leaching of lead into water. Techniques such as adding lime (calcium oxide) to reduce water acidity can greatly reduce lead levels at the tap. A number of other simple practices also can help reduce the level of lead at the tap.

1) Cook with and drink only cold water. Hot water tends to dissolve more lead from pipes.

2) Don't drink the first water out of your tap in the morning. Let the water run for about one minute until a change in temperature occurs.

3) For private wells, consider water treatment devices such as calcite filters that reduce acidity and make water less corrosive. Certain point-of-purchase treatment devices (e.g., some ion-exchange filters, reverse osmosis devises and distillation units) also can remove lead.

4) If lead levels remain high, consider bottled water for drinking and cooking purposes.

Nitrate

Nitrates may be found naturally in water or may enter water supplies through a number of sources (fertilizers, animal wastes, septic systems). High nitrate-containing water is a serious health concern for pregnant women and infants under the age of 6 months. Bacteria in the infants' digestive tracts may convert the relatively harmless nitrate to nitrite. In turn, the nitrite combines with some of the hemoglobin in blood to form methemoglobin that cannot transport oxygen. To protect those at risk, the Maximum Contaminant Level (MCL) for nitrate in water is 45 mg/l as nitrate (NO_3) or 10 mg/l as nitrogen (N). The MCL for nitrite is 1 mg/l.

Sulfate

Sulfates occur naturally in groundwater combined with calcium, magnesium and sodium as sulfate salts. Sulfate content in excess of 250 to 500 ppm (mg/l) may give water a bitter taste and have a laxative effect on individuals not adapted to the water.

Water that smells like rotten eggs has a high level of hydrogen sulfide gas. The gas may occur naturally in water near oil or gas fields or as the result of bacterial contamination. To test for bacterial contamination, contact the county health department or a commercial testing lab.

Organic Chemicals

The term "organic chemical" includes such products as pesticides, herbicides, petroleum products and industrial solvents. Although most have *not* been routinely monitored, hundreds of different organic chemicals have been found in drinking water from accidental spills, improper disposal or non-point movement through soils to groundwater. Today, municipalities are required to monitor an increasing list of organic chemicals under the Safe-Drinking-Water Act.

As with other contaminants, the danger from organic chemicals in water is hard to assess. In high doses and pure form some of these chemicals may promote cancer, impair the nervous system or damage the heart. In low doses, organic chemicals may have cumulative effects, but so far not much is known about their nature or magnitude.

Once groundwater is contaminated, cleanup of that groundwater is extremely difficult. If the water is unsuitable for human use, it also may be unsuitable for agricultural uses and alternative sources of water may need to be found. Organic chemicals and groundwater contamination is an area where much research is needed. In the meantime, the prudent use and disposal of all chemicals (agricultural, industrial, home and garden) can go a long way to protect the environment and groundwater from contamination.

Radon

Radon is a radioactive gas, a decay product of uranium, that can dissolve into water supplies. The gas also is found in rocks and soils that contain granite, shale, phosphate and pitchblende. It is odorless, colorless and tasteless.

The EPA considers radon to be a major potential health threat, causing an estimated 10,000 to 40,000 lung-cancer deaths each year. While most deaths are from radon accumulated in houses from seepage through cracks and holes in the foundation, 30 to 1800 deaths per year are attributed to radon from household water. Showering, dish-washing and laundering agitate water and release radon into the air.

The EPA estimates that at least 8 million people may have high radon levels in their water supply. Radon is most likely to be present in water from private wells or from small community systems. Large systems usually provide some kind of water treatment that aerates the water and disperses any radon gas that may be present.

Before you test your water for radon, test the air. If your indoor radon level is high and you use groundwater, test your water. If the air level is low, there is no need to test your water. Test results are

expressed in picocuries of radon per liter of water (pCi/l). In general 10,000 pCi/l of radon in water contributes roughly 1 pCi/l of airborne radon throughout the house. EPA currently advises consumers to take action at total household air levels of 4 pCi/l. For waterborne radon, a simple step is to make sure your bathroom, laundry and kitchen are well ventilated. At moderate levels, this may adequately reduce your exposure to waterborne radon. However if you use a private well that has high levels of radon, water treatment devices such as granular activated carbon units and home aerators may be warranted.

Improving Water Quality

The growing uneasiness over the purity of tap water has led many Americans to install water treatment devices, such as filters or distillers. See Service in Action sheet 9.728, *Drinking water treatment devices: filters* and 9.729 *Drinking water treatment devices: distillers.*

Bottled vs. Tap Water

Sales of bottled water have increased dramatically over the last few years. Bottled water companies and public water systems often battle over the relative merits of their products. EPA regulates public water systems. FDA regulates bottled water that crosses state lines. Bottled or vended water that stays in Colorado falls under the jurisdiction of the Colorado State Department of Health.

Public water systems generally are disinfected with chlorine. Bottled water is commonly disinfected by ozone treatment. Ozone is a high-strength oxygen that quickly reverts to normal oxygen. It is a strong oxidant, like chlorine, but does not add taste like chlorine does. The length of time chlorine and ozone remain active in water depends on many factors, including temperature. Chlorine usually provides residual disinfection throughout the public-water distribution system. Ozone provides a residual disinfection for a limited time. However, bottled water may be in distribution for several weeks and storage conditions, especially temperature, may adversely affect quality. In terms of bacterial content, it is questionable as to whether bottled water is better than most municipal tap water.

Bottled water often is purchased for its good taste. However, taste does not always indicate safeness. At the concentrations present in drinking water, most harmful substances (including some disease-causing microorganisms, nitrates, trace amounts of lead and mercury and some pesticides and organic materials) have no taste. Differences in taste among bottled waters generally are due to differing amounts of carbon dioxide, calcium, iron compounds, sodium, and other minerals and mineral salts. Differences also may be due to the amount and type of processing.

Mineral-free water or distilled water is treated to remove the minerals that occur naturally in water. Almost all sodium is removed by these processes. The resulting water is rather flat and tasteless for drinking because of the lack of minerals.

Drinking water comes from municipal water systems, wells or springs. It often is treated by reverse osmosis to remove bacteria and other pathogens and most pesticides. The resulting water is purified but still contains some dissolved solids.

Natural water comes from unprotected well or spring systems and is bottled without extensive treatment. Because it is almost exclusively groundwater, it usually contains a range of minerals and is, therefore, quite flavorful. **Spring water** is groundwater that has risen naturally to the surface. **Artesian spring water** also rises under its own pressure, but only after it has been reached by drilling.

Mineral water is simply water that contains minerals – which is true of virtually all water except distilled water. **Natural mineral water** contains just the minerals present in the water as it comes from the ground. Mineral water can be still or sparkling. The carbon dioxide that causes carbonation also can be natural or added during bottling.

As for contaminants, bottled water generally rates as good as but no better than municipal water supplies used for comparison purposes. If you do purchase bottled or vended water, purchase from a quality retailer who handles enough volume to rotate stock. If you have concerns about locally vended water, contact your county health department or the Colorado Department of Health, (303) 320-8333.

References

E.P.A. Lead in Drinking Water: Should you be concerned? Environmental Protection Agency, Public Information Center, Waterside Mall, 410 M St., SW, Washington, D.C.

Follet, R.H. and J.R. Self. Domestic water quality criteria. Colorado State University Cooperative Extension, Service in Action, .513, Fort Collins, CO 1989.

Fundingsland, S. and D. Lundstrom. Drinking Water and Health. Pub. 27 HEA, NDSU Extension Service, North Dakota State University, Fargo, ND 58105, June, 1988.

Shelton, T. Interpreting Drinking Water Quality Analysis – What Do the Numbers Mean? Pub. E127, Rutgers Cooperative Extension, Cook College, Rutgers University, New Brunswick, NJ 08903, 1989.

Stewartm J., A. Lemley, S. Hogan and R. Weismiller. Health Effects of Drinking Water Contaminants. Water Quality Fact Sheet 2, Cornell University and University of Maryland, Rev. 1988-89.

The Pollutants that Matter Most: Lead, Radon, Nitrate. Consumer Reports, p. 30-32, January, 1990.