COLORADO STATE UNIVERSITY
EXTENSION

Drinking Water Quality and Health

Fact Sheet 9.307 Food and Nutrition Series | Food Safety

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What is water quality and why is it important?

Water is essential for all life. In its purest form, water is two parts hydrogen to one part oxygen but the presence of other components determines the quality of water. Water quality is defined as the suitability for consumption based on physical, chemical, and biological characteristics. Poor water quality can pose health risks for humans and ecosystems. Across Colorado and the country, the quality and characteristics related to water can vary widely depending on location, environmental exposures, and how the water has been treated and handled. Water covers 71% of the earth's surface and comprises up to 60% of the human body, so understanding water quality is vitally important for protecting our health and the health of all ecosystems.

Humans can survive weeks without food, but only a few days without water. Water is necessary for a wide range of metabolic processes, including digestion, circulation, regulation of body temperature, and elimination of waste. Water can be hard or soft, bottled or tap, carbonated or still. Adequate water intake depends on exposure to heat and an individual's activity level.

Sufficient daily fluid intake is estimated to be about 15.5 cups per day for men and 11.5 cups per day for women. Someone working outdoors in the summertime without shade may need to consume greater amounts of water to be adequately hydrated. Colorado is an arid, high elevation state, so staying hydrated is crucial for health. Although most of this liquid comes from beverages, food also provides water for us. During digestion, water is released as a by-product in the conversion of fats, sugars, and proteins to energy.

Whether drinking water is bottled or from the tap, there are many factors that may influence the quality. It is important to understand how water quality and composition change due to natural or human causes. Across the state, water quality can vary tremendously, so it is helpful to know characteristics of the water in your area.

Drinking Water Sources

The quality of water is dependent on where it is sourced and other impacting factors. The Safe Drinking Water Act was passed in 1974 to regulate water quality and protect public health. Geographic region plays an influential role in water quality. The Rocky Mountains have helped Colorado earn the reputation of having some of the best tasting tap water in the U.S. Being close to the source of snowmelt and mountain surface water impacts water quality and has several advantages.

Quick Facts

- Access to safe water is essential for health.
- Many characteristics influence the quality of drinking water.
- Public water systems and bottled water are regulated by state and federal agencies.
- Private water wells are not regulated by national standards, so it is important to test well water annually.

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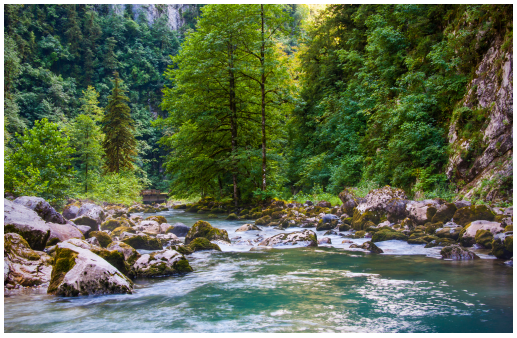
To better understand water quality, it is important to be familiar with your water source and how quality is checked.

Municipal water: public water supplies that are monitored, tested, and treated to meet specific guidelines regulated by the U. S. Environmental Protection Agency (EPA).

Private Well water: water from private wells that are not subject to federal drinking water regulations. This means it is the owner's responsibility to have the water regularly tested and treated according to need.

Bottled water: commercially bottled water sourced from wells, springs, or tap water. The U.S. Food and Drug Administration (FDA) regulates bottled water products in accordance with the Federal Food, Drug, and Cosmetic Act which requires manufacturers to be responsible for producing safe, wholesome, and truthfully labeled products.

Backcountry: water in isolated wilderness often used during recreational activities and differs from other sources of drinking water because it is untreated and the safety and quality is unknown. Before consuming, water in the backcountry should always be treated according to guidelines.



Other Types of Water

- Graywater: wash water that has been used in a home or business, except water from toilets. This includes water from kitchen sinks, dishwashers, and non-laundry utility sinks. It is usually considered "relatively clean" compared to black water and may have a secondary application for conservation purposes.
- Black Water: water from toilets and urinals.
- Wastewater: water that has been used domestically, for businesses, or for industrial processes. This can include any process that decreases the water quality. In a municipal water system, this is the water that flows through sewage pipes.

Chemical Components of Water that can Affect Quality

The chemical composition of drinking water can be quite different whether you turn on a tap, unscrew a bottle cap, or filter from a mountain stream. Water can be changed by human activity as well as natural processes, such as weathering and erosion, or by changes in temperature and acidity. Industry and agriculture have a profound effect on the quality of our water supply. Discharges, whether accidental or intentional, can unexpectedly change the chemical characteristics of our water supply. Some of Colorado's water sources are affected by the following natural or human-made chemical components.

Ammonia/Ammonium

Ammonia is a compound made of the elements nitrogen and hydrogen. There are two forms of ammonia. One is an uncharged molecule which is one part nitrogen and three parts hydrogen (NH_3). However, when ammonia dissolves in water, the chemical gains another hydrogen and becomes positively charged, or ionized (NH_4^+). The ionized form of ammonia is called the ammonium ion. Ionization is highly dependent on the temperature and pH of the surrounding environment. When temperatures are warm, more of the charged form will be present.

Ammonia is sometimes added to drinking water as an ingredient in the disinfection process. Some municipalities add ammonia along with chlorine during disinfection to increase the longevity of the treatment, so that the water stays clean as it moves from the treatment plant to the tap. This process also decreases the chance of formation of more harmful disinfection by-products (see Disinfection By-Products).

Ammonia is a major ingredient in many widely applied fertilizers so levels of ammonia in the water can increase due to runoff from agricultural operations. Therefore, rural areas may have higher levels of ammonia in the water. The imbalance of ammonia to ammonium can have harmful effects on humans and the environment.

Aquatic species are especially vulnerable to ammonia poisoning. Since ammonia contains nitrogen, higher amounts can contribute to eutrophication, or enrichment of nutrients. Drinking water containing ammonia is not directly toxic to humans, however it may be unpleasant due to foul taste and odor. Although safe to drink, increased levels of ammonia cause nutrient imbalances that decrease water quality. The EPA has not set an acceptable limit or Maximum Contaminant Level (MCL) for ammonia content in drinking water. Nonetheless, it is important to be aware of ammonia content in water sources because of its indirect and direct effects on the environment.

Ammonia Sources	Health Effects	MCL, CDPHE Recommendation or Applicable Regulation
• Agriculture (fertilizers) • Wastewater • Decomposition • Disinfection with chloramines	Human health effects limited, but toxic to aquatic life	Currently no MCL set by the EPA

Selenium

Selenium is a naturally occurring element that is essential for humans, playing a critical role in reproduction, thyroid hormone metabolism, DNA synthesis, and protection from oxidative damage and infection. Eating breads/grains, meat, poultry, fish, and eggs can provide adequate selenium intake. However, excessive selenium intake can lead to adverse health effects, including brittle hair and nails, fatigue, and damage to the nervous system. An early sign that you may be consuming too much selenium is a metallic taste in your mouth and breath with the odor of garlic. Toxicity from the diet is unlikely, but chronic exposure to drinking water containing too much selenium can result in poor health outcomes. The major sources of selenium contamination are discharges from petroleum refineries and erosion from natural deposits or mining operations. Certain areas of Colorado have higher levels of selenium in the water due to irrigation discharges, notably the Arkansas River Basin. Coloradans consuming water in this area should be aware of possible selenium contamination.

Selenium Sources	Health Effects	MCL, CDPHE Recommendation or Applicable Regulation
• Glass and alloy manufacturing • Mining • Natural deposits • Petroleum refineries • Agriculture	• Hair and nail loss • Nausea • Endocrine disruption • Liver damage	50 ppb MCL

Metals in the Water Supply

Certain metals are especially concerning in drinking water supplies because they are toxic, including cadmium, lead, mercury, and arsenic. Old metal pipes can corrode, leaching small amounts of these metals into the water supply. Additionally, mining, agricultural runoff, paints, treated wood, burning coal, and emissions from vehicles are all often sources of toxic metal contamination that may be deposited in water sources. Some nutritional elements that are classified as metals, like iron, cobalt, and zinc, are essential to human health but in very small amounts. However, consuming too much of these metals in drinking water can be harmful to human health.

Arsenic

Arsenic is a naturally occurring toxic metal that is tasteless, odorless, and colorless and therefore only detectable by chemical analysis. The toxicity of arsenic is well established. Consuming small amounts over time can lead to disruption of the nervous, cardiovascular, skin, and developmental systems. There are two forms of arsenic, categorized as inorganic and organic. The inorganic form readily dissolves in water. Both types are classified as carcinogens and are particularly harmful if consumed over a lengthy period of time. Significant research evidence has established arsenic's role in the development of lung, bladder, and skin cancer.

Although toxic to human health, arsenic has a vast number of industrial applications. It is a key component in wood preservation, electronics manufacturing, and in the processing of glass, paint, pigments, paper, and textiles. In the past, arsenic was used as an ingredient in pesticides, and remains in agricultural soil in many areas. Groundwater can be contaminated by inorganic arsenic via weathering and erosion. Some environmental conditions increase the mobility of natural deposits, making the availability of inorganic arsenic higher in certain areas. Mining operations may also increase exposure to natural deposits. Former or active mining towns in Colorado are more likely to have higher levels of arsenic in their drinking water.

The Maximum Contaminant Level for arsenic is 10 parts per billion. Boiling and chlorination do not remove arsenic from drinking water. An alternative treatment method is recommended for wells contaminated with arsenic, such as reverse osmosis, ultra-filtration, distillation, or ion exchange.

Arsenic Sources	Health Effects	MCL, CDPHE Recommendation or Applicable Regulation
• Copper smelting • Mining • Coal burning • Processing of glass, pigments, alloys, and textiles • Pesticides, feed additives, pharmaceutical production • Tobacco smoke	• Thickening and discoloration of skin • Numbness/tingling in extremities • Vomiting, abdominal pain • Reproductive effects • Bladder and lung cancer	10 ppb MCL

Cadmium

Cadmium is used to coat other metals to prevent them from breaking down so it protects commercially produced products from corrosion. It is isolated from the extraction and purification of metal ores, including zinc and copper. The Earth contains about 0.1 parts per million (ppm) of cadmium. Although rare, cadmium is a critical component in many products. In fact, over 80% of isolated cadmium is used in the production of nickel-cadmium batteries.
How does cadmium make its way into our drinking water? Water that is acidic can mobilize natural deposits of cadmium, increasing its concentration in some drinking water sources. Galvanized water pipes are another source of cadmium contamination in drinking water. After years of use, the protective zinc coating of water pipes can corrode, leading to leaching of toxic metals like cadmium and lead. Certain types of fertilizers also contain tiny amounts of cadmium and residues can persist in agricultural soil for years. The MCL for cadmium is 5 ppb. Frequent exposure to cadmium can cause damage to the kidneys, bone, and blood.

Cadmium Sources	Health Effects	MCL, CDPHE or Applicable Regulation
• Smelting • Fertilizers • Sewage • Nickel-cadmium batteries • Pigments, plating, and plastics	• Vomiting, diarrhea, nausea • Kidney disease • Liver injury • Cardiovascular effects	5 ppb MCL

Uranium

Uranium occurs naturally in Colorado's bedrock and may leach into groundwater that feeds private wells. In addition to natural deposits, uranium mining has contributed this element to some water sources in Colorado. Beginning in 1872, commercial uranium mines were established across the state. Over time, the worth of uranium has ebbed and flowed, but its impact on the state's economy is unmistakable. The development and adoption of nuclear technologies resulted in a significant increase in Colorado's uranium industry. While the impact of such operations can still be identified from abandoned mines on the side of the road to remote footpaths in the mountains, there are no active uranium mines or mills operating in the state. Unfortunately, the environmental impact of decades of uranium extraction and purification are posing a challenge to Colorado's historic mining towns. The half-life of uranium-238 is 4.5 billion years. As it ages, uranium transforms into other radioactive elements, releasing highly energetic alpha particles. Furthermore, its decay products, such as radon and radium, pose a health risk to living organisms. The disposal of uranium tailings, as well as the natural release of uranium from stores in rocks and soil, presents a concern for public health. The MCL for uranium is 10 ppb. Humans can be exposed to drinking water contaminated with uranium if they drink from untreated water sources in areas close to natural uranium deposits. Since uranium has no smell or taste, it would be impossible to know if water has elevated levels of uranium without a laboratory test. Ingesting contaminated water or inhaling decay particles can lead to a multitude of adverse health effects.

Uranium Sources	Health Effects	MCL, CDPHE or Applicable Regulation
• Natural deposits • Mining and milling • Nuclear waste	• Kidney damage • Increase risk of some types of cancer • Reproductive effects	30 ppb MCL

Lead

Lead is a toxic metal that has contaminated many piped water sources in the United States. Natural sources of water usually contain very little lead but when water that is acidic or contains low mineral content flows through lead-containing pipes, corrosion may occur, releasing small particles of metal from the pipes into the water source. Lead piping is often found in older buildings where service lines have not been replaced with less corrodible materials. Other sources of lead intake include exposure through paint, dust, soil, air, and food. In Colorado, discharges from mining operations have contaminated some surface waters, mostly nearby ponds and lakes. While such surface water is not typically used as a source for drinking water, uncontrolled release of mining sediment containing toxic metals into surface water can have detrimental effects on aquatic species.

No amount of lead is considered safe. To enforce a standard for lead, the EPA adopted the Lead and Copper Rule. This rule requires water treatment facilities to regularly test for lead concentrations. Any exceedance requires the facility to take action to alert the public of the violation and holds them accountable for replacing corroding pipes. Despite these standards, the EPA estimates that drinking water makes up approximately one-fifth of total lead exposure and even higher for infants whose diet is primarily infant formula. Bottled water, which is regulated by the FDA, is governed by a limit of 5 parts per billion (ppb). A survey conducted by the Natural Resources Defense Council in 2018 and 2020 estimates that about 61 million people (about ten times the population of Colorado) in the United States regularly consume water that exceeds the FDA standard. Long-term exposure to water containing lead greater than the maximum contaminant level can have profound consequences in children and adults. If you live in an older home supplied by a community water source, you should ask if your supply pipes contain lead. If so, there may be public assistance programs that can help with the replacement of outdated lines.

Lead Sources	Health Effects	MCL, CDPHE or Applicable Regulation
• Natural deposits • Mining and milling • Nuclear waste	• Neurological effects including memory and learning challenges • Kidney damage • Increase risk of bone and lung cancer	Action Level: 15 ppb

Pesticides

Pesticides have a critical role in protecting crops from pests. Extensive use and reliance on pesticides have increased dramatically since the rise of industrial agriculture and the effects of widespread distribution are significant. Runoff contaminated with pesticides can reach surface and groundwater, causing a variety of consequences. Hydrology, climate, and geology influence how pesticides move through the ecosystem, and influence their breakdown and deposition. Pesticides exhibit a wide range of toxicity, depending on their concentration and chemical makeup, and some common pesticide residue components impact several ecosystems across the state.

Nitrates and Nitrites

Nitrogen is the most common element in the atmosphere and it most often exists in water in the form of nitrate. Nitrate is a chemical compound with the formula NO_3^- (one nitrogen atom bound to three oxygen atoms), an ion that readily dissolves in water. Nitrates are important for plant and animal health, but too much nitrate in the environment can offset the natural balance in ecosystems, causing poor water quality. Agricultural inputs and various industrial sources dramatically increase the amount of nitrogen in the environment. Nitrogen-containing fertilizers are often applied to farmland to replace spent nutrients. When the land is irrigated or receives heavy rain, nitrates can seep into the groundwater. Other sources of nitrogen in water include nitrites (NO_2^-), which are used in food preservation, and decomposition of plant material, sewage, and deposition from the atmosphere.

Water from private wells can be especially susceptible to nitrate contamination because they draw from groundwater sources. The nitrogen cycle is complex, and critical for a healthy ecosystem. Elevated levels of nitrogen can lead to eutrophication in surface waters and can be detrimental to aquatic life. Nitrates are naturally found in many foods, like leafy vegetables, and are not usually a concern for healthy adults but can cause serious health problems for susceptible individuals, including infants consuming formula made with water containing nitrates.

Nitrate Sources	Health Effects	MCL, CDPHE or Applicable Regulation
• Atmosphere • Fertilizers • Sewage (leaking tanks) • Decomposition	• Methemoglobinemia (blue baby syndrome)	10 ppm MCL For Nitrites: 1 ppm MCL

Blue Baby Syndrome. Nitrate toxicity can cause a condition known as methemoglobinemia, which is most common in bottle-fed infants less than six months of age (also called blue baby syndrome). This disorder affects the ability of blood cells to transport oxygen, resulting in serious sickness or even death. Common symptoms of blue baby syndrome include blueish skin (cyanosis), rapid heartbeat, shortness of breath, lethargy, nausea, diarrhea, and loss of consciousness. Adults with pre-existing conditions, such as cardiovascular disease, anemia, lung disease, or sepsis, are at a higher risk for developing methemoglobinemia from nitrate poisoning.

Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS)

Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are a group of manufactured chemicals used in many different products to protect from stains, heat, and water. Food packaging, furniture, and non-stick cookware are all products that could contain PFAS. Certain types of fire-fighting foams contain these chemicals and are a major source of PFAS contaminated water. When firefighters spray the foam during training exercises, it can contaminate nearby water and groundwater. PFAS have the nickname ‘forever chemicals’ because they do not break down in the environment and accumulate in the soil, water, and living organisms. So far, exposure to PFAS has been associated with liver, immune, developmental, reproductive, endocrine, and kidney system effects. It may also increase the risk of developing certain kinds of cancer.

Some public water systems in Colorado have been tested for PFAS and the Colorado Department of Public Health and the Environment (CDPHE) has made these results available to the public. If you have a private well, you can order a kit to test for PFAS. Even if your water is contaminated with PFAS, it may still be considered safe to bathe, shower, and use the water around the house, since PFAS are not readily absorbed through the skin. The Environmental Protection Agency has set a health advisory of O.004 parts per trillion (ppt) for PFOA and 0.02 ppt for PFOS. Currently, this value is an interim recommended value, not an enforceable standard. To reduce exposure, use a filter certified to remove PFAS or look for a bottled water brand that uses reverse osmosis treatment. In 2021, the EPA Council on PFAS was created to streamline research opportunities to better understand PFAS and reduce the risk of exposure to these chemicals.

PFAS Sources	Health Effects	MCL, CDPHE or Applicable Regulation
• Landfills • Firefighting training sites • Industrial sites • Wastewater treatment plants • PFAS-containing products	• Increased cholesterol • Effects on immune function, thyroid hormones, and liver enzymes • Decreased infant birth weight • Higher risk of some types of cancer	Currently, the Health Advisory Value for PFOA is 0.004 parts per trillion and 0.02 ppt for PFOS but these are interim values, not enforceable standards.

Salinity

Sodium chloride (table salt) is vital to human health. It allows nerves and muscles to function and is essential for regulating hydration. Unfortunately, too much salt can increase blood pressure and cause irreversible damage to the cardiovascular system. Most of the salt in our bodies comes from the food we eat, but some saline consumption comes from the water we drink. Although we generally think of salty water in the ocean, fresh water has salt content, too. The salt that makes water salty is made of one atom of sodium and one atom of chlorine. So, how does “fresh” water become salty? A major source of salt in fresh water is from mining, oil, and gas extraction. These industries often disturb rock that contains sodium chloride and can release underground depositions of salty water. Drilling and extraction can expose previously contained salt that can contact nearby rivers and streams, thus making fresh water saltier. Another surprising source of sodium in freshwater sources is treatment chemicals, like sodium hydroxide. Sometimes, salts are added to water to remove harmful toxic metals from drinking water. These chemicals can also be added as a buffer at water treatment facilities to help control the pH. Overall, our exposure to salt from water may be changing. A nationwide study reported that up to one-third of freshwater bodies in the United States have gotten significantly saltier in the last 25 years. Increasing salt content can also significantly affect agricultural product quality and yield. Salt impacts osmosis and can divert water from the plant, resulting in dehydration of crops and reduced yields. It has been reported that higher levels of salt in fresh water affects the growth rate of several keystone aquatic species, including trout, and insects, like the water flea. These populations may also have decreased reproduction and survival rates. The EPA does not have a drinking water standard for sodium chloride but recommends a sodium limit in drinking water of 20 milligrams per liter based on the recommended level for those following sodium-restricted diets.

Salinity Sources	Health Effects	MCL, CDPHE or Applicable Regulation
• Natural deposits • Wastewater treatment plants	• Elevated blood pressure	N/A

Sulfates

Sulfates occur naturally in the groundwater and exist in the form of sulfate salts. These form when an element with a positive charge forms a bond with sulfate, which has a negative charge, resulting in a neutral compound. Calcium, magnesium, and sodium all have a positive charge, and often bind with sulfate to form a salt. While sulfates are not acutely toxic, a concentration exceeding 250 ppm may give the water a bitter taste and have a laxative effect.

Some bacteria in water use sulfate for anaerobic respiration in place of oxygen. Anaerobic respiration is the process by which organisms produce energy by breaking down glucose without oxygen. The end-product of this process is hydrogen sulfide, a toxic gas with a characteristic rotten egg smell. If you notice this unusual odor, it is essential that you contact the county health department or a commercial testing laboratory to test for bacterial contamination.

Sulfate Sources	Health Effects	MCL, CDPHE or Applicable Regulation
• Natural deposits • Bacteria • Decomposition	• Unpleasant taste • Mild laxative effect	250 ppm Secondary MCL (not an enforceable standard

Radon

Radon is a colorless, tasteless, and odorless radioactive gas formed as a decay product of uranium. As uranium ages, it emits energetic particles into the environment and becomes a new element. When radon is inhaled over a prolonged period of time, it increases the risk of developing lung cancer. Radon causes damage by releasing radioactive particles inside the lungs. The main source of exposure is via inhalation from seepage through cracks and holes in housing foundations. However, you can also be exposed to radon if your groundwater is contaminated by natural deposits. Typical household activities, including showering, washing dishes, and laundering, can release dissolved radon gas into the home. The risk of drinking water containing radon is considered low compared with the increased risk of lung cancer when radon is released into the air in the home. Before testing your water for radon, test the indoor air. If the indoor air level is high in your home and you use groundwater, have your water tested. Smaller community systems and private wells are more likely to be affected by radon contamination. Larger municipalities typically treat the water in such a way that radon gas is dispersed before reaching home taps.

Radon Sources	Health Effects	MCL, CDPHE or Applicable Regulation
• Cigarette smoke • Private wells drilled into bedrock containing radon gas	• Increased risk of lung cancer	N/A

Hard vs. Soft Water

The concentration of calcium, magnesium, and iron in the water determines its ‘hardness.’ The more minerals present, the ‘harder’ the water. Conversely, soft water contains little calcium, magnesium, or iron. You cannot tell whether water is hard or soft based on how it looks. Even if water is extremely hard and contains elevated levels of minerals, it may appear clear. However, you may be able to tell if water is soft because it has a different feel during use. For example, soft water makes soap lather better, gets clothes cleaner, and leaves less of a ring around the tub. You may find spots on your dishware or less water pressure in your home if you use hard water. A common treatment for hard water includes using an ion-exchange water softener. When the similarly charged magnesium and calcium ions bind to the ion exchange resin, sodium ions are released, softening the water. Although effective for managing the physical effects of hard water, removing calcium and magnesium has drawbacks from a nutritional standpoint since these are both essential dietary nutrients. Elevated sodium intake increases the risk of hypertension, whereas calcium intake may have a protective effect. However, consuming excess calcium could negatively impact health.

There are no direct adverse health effects from hard or soft water. However, whether your water is hard or soft may affect other aspects of your water quality. First, soft water is more likely to corrode toxic metals from outdated piping. This could potentially introduce metals like cadmium and lead into the drinking water. Second, adding sodium to the water supply may be a significant source of sodium for those on a sodium-restricted diet. As stated in the sodium section, the EPA has not set a mandatory upper limit for sodium in drinking water but recommends no more than 20 milligrams per liter to protect individuals on a sodium-restricted diet.

Chlorination of Municipal Water

Public water treatment facilities often add chlorine as a disinfectant. It is favored over other forms of disinfection such as ultraviolet light or ozonation because it prevents the regrowth of pathogens. Most pathogens do not survive treatment with chlorine; it effectively kills the pathogens that cause typhoid fever, dysentery, cholera, and Legionnaire's disease. Due to its wide success and application, chlorination of municipal drinking water has been accepted as the common treatment to prevent waterborne disease outbreaks in the United States. Chlorine is used by more than 98% of all water utilities in the U.S. that disinfect drinking water for their communities. Why doesn't this potent treatment harm humans? The gastrointestinal tract neutralizes the chlorinated water when it is ingested. The concentration of chlorine is monitored closely and regular testing is performed to measure 'chlorine residual,' or the amount of chlorine remaining in the water when it reaches the tap (see: Disinfection By-Products). Water with chlorine levels less than 4 parts per million is unlikely to cause harmful human health effects.

Reptiles, fish, amphibians, and other aquatic pets should not be contained in or offered chlorinated water. These species absorb water directly into their bloodstream and may experience toxicity from chlorinated water. Use water purchased at a local pet store or let chlorinated water sit out for a few days to allow the chlorine to dissipate.

Disinfection By-Products

One drawback of using chlorine as a disinfectant is that it introduces the potential for the formation of disinfection by-products, or "DBPs." Chlorine is a reactive chemical and can react with many other chemicals in the water, forming hundreds of DBPs. Scientists and regulators do not yet have a clear understanding of how DBPs affect us and the environment, but it is thought that chronic exposure to DBPs may lead to liver, kidney or central nervous system problems and increased risk for cancer and reproductive effects. To err on the side of caution, the EPA has chosen to monitor commonly detected DBPs as a sum of the highest contributing constituents. This measurement is referred to as "TTHM" or "Total Trihalomethanes." The DBPs in this family are chloroform, bromodichloromethane, dibromochloromethane, and bromoform.

Fluoride

Fluoride is a naturally occurring mineral. There are trace amounts of fluoride in soil, water, plants, and food. Having some fluoride in your diet is important to prevent dental cavities and tooth decay. Many municipalities add fluoride to their drinking water so the public has less risk of developing tooth decay. Children can receive fluoride treatment at the dentist if they are drinking water that does not contain the optimal level of fluoride. It is estimated that intervention with fluoride reduces the risk of tooth decay by 30 percent. Evidence suggests that fluoridated drinking water is safe and effective at preventing tooth decay and saves healthcare costs. In the United States, adverse health effects due to excessive fluoride are unlikely but exposure over many years may cause bone pain, tenderness, and disease. Overall, fluoride treatment has improved the dental health of millions of Americans but children who drink water with excess fluoride may experience tooth staining or pitting.

Water Testing

According to the Centers for Disease Control and Prevention (CDC), the U.S. boasts some of the safest water supplies in the world. Due in part to enforceable water standards and public education, waterborne illness outbreaks are rare.

Small to Large Water Treatment Facilities

If you live in a city or town, your water comes from a public water system. All public water treatment systems are required by local and federal law to perform mandatory testing, make public advisories (when applicable) and implement interventions in the case of any maximum contaminant level violations. Water in this supply often comes from surface water, and then is pumped and treated at a treatment facility prior to reaching your tap. People served by a public water supplier should pay attention to public advisories and can consult their community's annual 'Consumer Confidence Report' to learn more about the quality of their water. Testing is not required, but owners of homes with older piping systems may want to test to verify their systems are free of corrosion.

Private Wells Rural homes are more likely to be supplied by private wells that access groundwater. These private water wells are not required to meet federal drinking water regulations. Although water from a well can be a reliable, safe source of drinking water, it is up to the owner of the well to request testing to ensure the water is appropriate for consumption. It is recommended to have well water tested annually for bacteria, nitrate, and nitrite, and possibly tested for other contaminants if there are concerns.

Environmental Impacts on Water

Algal Blooms

Algal blooms occur when populations of cyanobacteria rapidly increase. Cyanobacteria are naturally occurring in all types of surface water sources. When the water is warm and nutrient-rich, cyanobacteria can grow quickly. This event is called an algal bloom, cyanobacteria bloom, or a blue-green algae bloom. Another way to describe this occurrence is eutrophication. You may also see algal blooms abbreviated as HABs or 'harmful algal blooms.' Sometimes an algal bloom may create a visible scum, film, or foam. At other times, the water may smell musty but you may not be able to detect an algal bloom just by looking at or smelling the water. Algal blooms are harmful for a few reasons. First, algal blooms can block sunlight and hoard oxygen and nutrients from other living species. Second, some cyanobacteria can produce toxins that can make humans and animals sick. The symptoms of cyanotoxin poisoning in humans can range from fever, headaches, and vomiting to more serious conditions, including liver failure, and respiratory arrest. It is impossible to know if the algae can produce toxins just by visual inspection. Exposure to blue-green algae can occur through drinking contaminated water, swimming, or other forms of recreation in areas where a cyanobacteria bloom is present.

It is important to keep dogs away from areas where you think there may be an algae bloom, as canines are likely to drink water even if it tastes or smells bad. The CDC recommends keeping out of the water if you are unsure about an algae bloom.

Drought

Many states depend on water from Colorado's Rocky Mountains to support their consumption needs. In response to historic droughts and water shortages in the west, the Colorado Water Basin States have worked together to develop plans to conserve and protect this limited resource. The goal of these plans is to decrease the economic, social, and physical impacts water shortages have on the western United States. This water issue is unique because its impacts are widespread and require multiple governments to collaborate and agree to manage risks associated with water shortages. Even though it seems like there is enough water to go around, some communities will face major shortages in the coming years. We can reduce the burden of water shortages for Colorado residents by monitoring our water use and actively taking steps to reduce the amount used.

Wildfires

Wildfires are a natural occurrence across the western biomes of the U.S. However, in recent years, the intensity and frequency of wildfires have become a major concern for human health and the environment. The impact of wildfires reaches beyond the immediate destruction to land, infrastructure, and forests. Burned material, ash, sediments, and debris end up in nearby surface waters, changing the water bodies' physical and chemical makeup. The loss of vegetation increases the erosion rate, leading to flooding and more sediment runoff. Although most wildfires occur in remote areas, the changes in water quality ripple downstream to municipal water systems. Regular water testing and monitoring is vital to help Colorado recover from wildfire damage.

According to the Colorado State Forest Service, more than three million Coloradans live in the wildland-urban interface, or WUI. This area, which has expanded in recent years, is more susceptible to uncontrolled wildfires. Due to the increasing population and activity in the WUI, wildland firefighters have taken more invasive measures to decrease the regularity of fires and contain active flames. Although these measures have been crucial to preserving property and structures, the impact on the surrounding environment has been significant.

Managing wildfires requires collaboration between landowners and managers to determine how to preserve the natural cycle of wildfires, while also protecting human health. It is the responsibility of visitors and residents to educate one another about how to prevent human-caused forest fires, and to take fire restrictions seriously. The future of Colorado's natural lands and water depend on responsible use and active prevention of forest fires.

Conservation

In the U.S., most households have the convenience of being able to turn on a tap to access clean, running water. Consumers may not always consider how much water they are using, or how their water use may be affecting the environment. According to the EPA, the average American household uses more than 300 gallons of water per day, which can be costly, and is becoming costlier as water access becomes more limited. Limiting the amount of water we use for household activities can save gallons of water per day. Solutions to saving water begin with an awareness of where there is opportunity to conserve.

- Taking shorter showers, and using less water for cooking, washing, and cleaning is a good place to start.
- Choosing to use a refillable water bottle, rather than purchasing bottled water, can save money and reduce packaging waste.
- Another way to conserve water around the house is by fixing leaky taps and pipes. Older fixtures are more susceptible to damage so renovating and replacing older equipment can prevent water loss through leakage.
- Typically, newer appliances are more efficient and may have built-in meters or systems to use less water as they function.
- Learning about what fixtures are affordable for your household, such as low-flow faucets, may be another way to cut down on water use.
- Paying attention to unexpected changes in your water bill can help you identify when your water system may have developed a leak. Overall, an awareness of how much water you are using daily and where you are choosing to use your water may indicate the best measures to cut back.

Several organizations in Colorado are committed to educating residents about water conservation. For more information and resources about actions you can take to reduce your water use, visit: Colorado Water Conservation Board (Colorado Water Plan), Water for Colorado, Colorado WaterWise.

Water for Yards

Our yards can be a source of comfort and pride, but some landscaping choices come with higher water requirements. It's important to consider the environmental impacts that could result from creating a high water-use landscape or using pesticides. Check with CSU Extension to learn more about sustainable landscaping and lawn care. Homeowners can create an environmentally friendly yard by using various alternatives that require less water.

Rain Barrels

Rainwater collection, also called rainwater 'harvesting,' is the process of capturing, storing and using rainwater runoff. Place rain barrels strategically to collect precipitation and runoff from roofs for later use. In Colorado, residents are allowed to collect up to 110 gallons in two rain barrels if a municipal supply serves their home.* Barrels help collect water that would otherwise run freely across property so that it can be used where it is needed most. Barrels can be purchased or easily fashioned with materials commonly found at a home improvement store. It is an effective measure to create a more sustainable household. There are many opportunities to use the collected water. The water can be applied safely to ornamental landscapes, used to irrigate the lawn, or to wash your car. While it may be tempting to use the rainwater for vegetable gardens, it is not advised to apply the collected water directly on edible plants. Runoff is sometimes contaminated with biological or chemical sources, which originate from encountering bird feces or chemicals on the surface of the roof. If the barrel is not properly maintained, there is potential for bacteria to grow. The amount of water a rain barrel will collect depends on rainfall and the roof area, but estimates suggest that a single rain barrel can conserve up to 1,200 gallons of water per year!

NOTE: Well owners need to check with the Colorado Division of Water Resources to determine what rain barrel use is allowed.

Graywater

Finding creative uses to apply graywater in and around the home is another way you can reduce the impact of your water consumption. Graywater is any water that has been previously used for washing, bathing, or cleaning. According to the Colorado Department of Public Health and Environment (Water Quality Control Commission Regulation 86): "Sources of graywater are limited to discharges from bathroom and laundry room sinks, bathtubs, showers, and laundry machines. Graywater does not include the wastewater from toilets, urinals, kitchen sinks, dishwashers, or nonlaundry utility sinks." Although it is not clean enough to drink, there are many ways you can reuse graywater. When used safely, it is a great option to reduce the burden of demand for fresh, clean water. Graywater can contain detergents, chemicals, and small amounts of biological material depending on its original use, so it is important to consider where you will be using it. Graywater should only be used for non-potable purposes. It is safe for consumers to use graywater as irrigation water for lawns, trees, shrubbery, and flowers. In fact, it may contain higher levels of phosphorus and nitrogen that may nourish your flower garden! However, it is not advised to use on root crops, or other edible plants where the water will be in direct contact with the parts you will consume.

If your water supply is from a well, outdoor use of gray water may not be allowed as a result of restrictions imposed by your well permit, which is intended to prevent conflicts with water rights of others. This does not apply if your water is from a municipal supply. Resources are available that provide suggestions on how to set up a gray water system that diverts collected water directly to your lawn or garden.

In Colorado, modification of plumbing systems for indoor graywater use must comply with applicable plumbing codes. Graywater plumbing codes and programs have not been established in all Colorado jurisdictions. You need to check with your local health or building department to determine if it will be possible for you to install a graywater collection and reuse system.

Home Water Treatment

Depending on the source of water to your home, it may be necessary to choose a water treatment system to improve the quality of the supply. Municipal systems are typically monitored regularly so water from this source does not require additional intervention. As a consumer, you should pay attention to public advisories that may be applicable to you in instances of contamination or malfunction. To understand what type of treatment system you need at home, it may be helpful to submit samples for testing. Well water accesses groundwater aquifers, the quality of which can be altered by a multitude of factors. Having some idea of your water's quality prior to installing a system may help inform your choice. Companies that sell water treatment systems are not required to prove their efficacy. Independent organizations, such as NSF International, test products to document and certify their performance. The results follow voluntary national standards. This information is available at Consumer Resources | NSF International.

Backcountry Water Sources

While camping, hiking, fishing, or biking in Colorado's great outdoors, you may need to use drinking water from streams, lakes, or rivers. In the backcountry, water always needs to be treated before consuming. Using water that comes from a natural source without treating it first can lead to serious waterborne illness. Even if it looks clean, there is no way to guarantee safety. Microorganisms that cause acute illness are the greatest threat associated with water in the backcountry. While there are certainly other influences on the water's quality, microbes are the most immediate threat. Other components, such as toxic metals, salts, sediments, and chemicals are more likely to cause harm if consumed over a longer period of time.

To decrease the risk of illness, it is important to follow guidelines and treat the water appropriately. There are many affordable water treatment methods that can be used in the backcountry You should read all instructions carefully and follow them to ensure that the water is safe. If you do not have a filter system, UV light, or tablets, you should boil your water to disinfect it. Bringing the water to a rolling boil for one minute is the only method that inactivates all pathogens. At altitudes greater than 6,562 feet (2000 m), boil the water for at least three minutes.

Filtration

The effectiveness of using filtration as a water treatment method depends on the size and quality of the filter's pores, and the size and electrical charge of the contaminants.

Public Advisory

In the case of emergency, public water authorities may request that you boil your water before using it, avoid drinking your water, or not use the water for any purpose. This may occur in the case of suspected contamination of a municipal supply, such as a leak or contamination with harmful microorganisms, chemicals, or radioactive materials. When an advisory is implemented, it will give you an idea of how many households are affected, instructions on what to do, and a description of the water emergency.

Boil Water Advisory

This type of notice occurs when a water supply has been or is thought to be contaminated with microorganisms. Should you be affected by this type of advisory, use bottled water for anything that will be used for drinking, cooking, or brushing teeth. Alternatively, boiling the water can be used to disinfect it. Bring tap water to a rolling boil for 60 seconds. Locations at elevations greater than 6500 feet should boil for a minimum of three minutes. Allow the water to cool completely before offering it to children or pets. Use disposable dishware and flatware if possible. You can still use the dishwasher if the wash cycle reaches temperatures greater than 150°F, and if there is a sanitizing option. A boil water advisory usually means that you can still use water for most other purposes, but you should take care in ensuring that you do not swallow the water in the case of bathing or showering.

Do Not Drink Water Advisory

A “do not drink water” advisory may be issued if there is suspected or known contamination with chemicals, toxins, or microbes that will not be sufficiently removed by boiling. In this case, contact with the water in any capacity could be dangerous to your health or safety. You should use bottled water for all household activities, including brushing teeth, making ice, cooking, and drinking.

Do Not Use Water Advisory

This type of water advisory is rare, but the most serious. It occurs if there has been, or thought to be, contamination with bacteria, chemicals, or radioactive material that is a serious threat to public health. In this case, contact with the lungs, eyes, throat, or skin could harm you, so you should not use your tap water for any purpose.

Giardia; trophozoite form

Parasitic/Microbial Infection

Parasites are tiny organisms that are so small, they can only be seen with a microscope. There are a wide range of microorganisms that can contaminate drinking water. If consumed, many of these creatures cause disease in humans and can result in more serious infection in children and those with compromised immunity. Usually, a person with a healthy immune system can recover from parasitic infection on their own, or with prescribed medication. Transmission of this type of infection generally occurs via fecal-oral transfer. Containing the spread of parasitic diseases by avoiding contaminated foods and water is essential to protecting yourself from sickness.

Giardia

Giardia lamblia is a single-celled organism that deserves special discussion because is not readily inactivated by chlorination and therefore requires an adequate filtration system. These parasites are mostly found in surface waters such as mountain streams and lakes, not groundwater. Giardia can be transmitted through contaminated food and water. It has become a common problem and it is advised to treat water from mountain streams or lakes before consuming.

It is special type of parasite, known as a sporozoan, that produces the trophozoite form, which can attach to the intestines of the host. When a host is infected with Giardia, they shed microscopic cysts during excretion. The cysts can live outside of the body for weeks at a time. If you contract Giardia from contaminated drinking water, symptoms may not appear for seven to ten days and may persist for up to six weeks. Symptoms of infection include diarrhea with cramping and gas, dehydration, and loss of appetite. Often, individuals can recover at home within a few weeks or months, so it is difficult to know how many people are infected with Giardia each year. Serious cases of infection sometimes require hospitalization, usually due to dehydration. This is more common in children. Giardia can be treated with prescribed medication. Treatment also can help prevent spread of the disease between people and between pets and people. Prevention is the best solution.

Cryptosporidium

Cryptosporidium is another parasite that can be lurking in untreated water. Like Giardia, it is resistant to treatment with chlorination, and is best removed by boiling or filtration. Cryptosporidium is spread through the feces of infected animals, so surface waters are more easily contaminated than groundwater. This parasite causes bouts of diarrhea, fatigue, and nausea that can lead to dehydration. Symptoms typically resolve within a few weeks but can be treated with prescribed medication to hasten recovery.

Cyclospora

Cyclosporiasis is the intestinal illness caused by the parasite Cyclospora cayetanensis. Like other waterborne illnesses, Cyclospora causes diarrhea, vomiting, and nausea in those who become infected. If left untreated, symptoms can last from days to months with periods of relapse. Interestingly, not all who are infected with Cyclospora show symptoms.

Preventing Parasitic Infection

Practicing cleanliness and good hygiene techniques are the best ways to prevent suffering from a parasitic disease. For example, always remember to wash your hands after changing diapers and thoroughly clean change surfaces after diapering. When camping or backpacking, it is best practice to carry your own drinking water from a treated source. If this is not feasible, water obtained from the backcountry should always be treated prior to consumption. For more tips on treating water in the backcountry, see the Guide to Treating Water in the Backcountry. A treatment method should be carefully selected to make sure that it is certified to kill or remove 99.999% of the Giardia cysts.

Microplastics

Plastic that is not properly discarded eventually degrades into smaller and smaller pieces. When the fragments become smaller than 5 millimeters in diameter, they are classified as microplastics. Microplastics have become widespread across the Earth's surface waters. They can accumulate in living organisms and, because of their small size, are extremely difficult to remove. The total impact of microplastics on living beings is not yet well understood, but many research efforts have indicated that microplastics may cause behavioral, morphological, and physiological effects on the organism's life cycle. Additionally, some pollutants are capable of adsorbing to the small particles, making it more difficult to treat the water. Microplastics have been linked with causing inflammation, oxidative stress, neurotoxicity, and increased risk of cancer, but these outcomes in humans are not yet well documented.

Understanding water quality is vitally important for protecting our health and the health of all ecosystems.

Glossary

- **Alpha particle emission:** the decay of a radioactive element into a new element via release of alpha particles; a form of energy consisting of two protons and two neutrons.
- **Buffer:** a solution often added to avoid changes in pH
- **Cyanobacteria**: microscopic organisms, also known as blue-green algae that are naturally found in water. Cyanobacteria make their own food using sunlight.
- **Erosion:** degradation of rock by wind or water
- **Eutrophication**: rapid and uncontrolled growth of algae populations due to conditions including increased nutrients (such as nitrates and phosphates) and warm temperatures.
- **Groundwater:** water that exists naturally beneath the Earth's surface. Occurs in pores, fractures, and empty spaces between ground material such as rock, sand, and gravel. This is the water that typically supplies wells and natural springs.
- **Half-life:** the time it takes for half of a radioactive element to decay. Decay products are often also radioactive.
- **Maximum Contaminant Level (MCL): a**n enforceable chemical limit based on cost-benefit analysis defined by the U.S. Environmental Protection Agency. Regulated water must be at or below this value to minimize adverse health effects caused by exposure to the chemical. According to the EPA, meeting this requirement ensures an "adequate margin of safety" for consumers.
- **Osmosis:** the process by which water flows from areas of high concentration to areas of low concentration
- **Ozonation:** a disinfection technique in which ozone is dissolved in water to kill microorganisms and inactivate organic compounds via oxidation and production of reactive oxygen species. While efficient, the process is costly and requires considerable amounts of energy. In addition, there is potential for the reaction to produce harmful disinfection by-products if certain compounds are present in the water.
- **Pesticide:** a chemical used to control undesirable insects, weeds, fungi or microbes. They are regulated under the Federal Insecticide, Fungicide and Rodenticide Act that requires testing for safety and effectiveness.
- **pH:** a measure of the acidity or alkalinity of water. Pure water has a pH of 7, a lower value is considered acidic while a higher value is alkaline. Unpolluted natural waters are slightly alkaline. Drainage or runoff from old mines can make water acidic.
- **Potable water:** water that is safe for drink and use in food preparation.
- **ppm**: parts per million; a measure of the concentration of a chemical in water.
- **ppb**: parts per billion; a measure of the concentration of a chemical in water.
- **Secondary standard**: non-enforceable guidelines regulating contaminants that cause cosmetic effects (skin or tooth discoloration) or aesthetic effects (taste, odor, or color) in drinking water.

Glossary (continued)

- **Surface Water:** water that collects on Earth's surface and is accessible to users. Some of examples of surface waters include ponds, rivers, streams, and lakes.
- **Trophozoite:** the active, feeding stage of some sporozoan parasites that causes infection in the host.
- **Water Basin:** a geographic feature where water from the surrounding water bodies drains. A water basin is a large area shaped like a large bowl. Runoff from snow melt, precipitation also collects here.
- **Watershed:** water in a defined area, including the surface, runoff, and groundwater, that supplies water to a particular region.
- **Wildland-Urban Interface:** any geographical area where dwellings are built within or near naturally vegetated areas, putting the inhabitants at risk of exposure to uncontrolled wildland fire.

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