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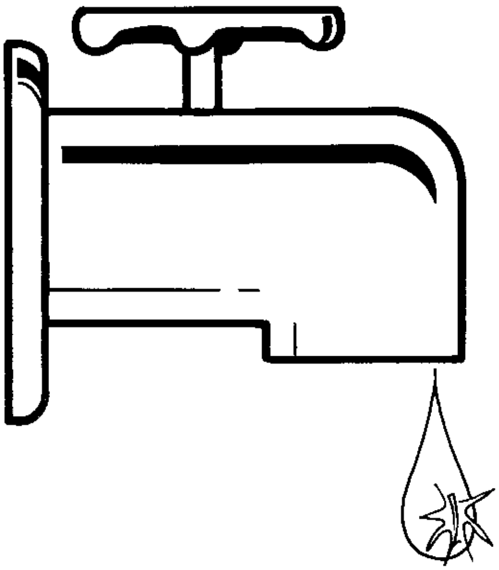

DRINKING WATER AND HEALTH

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Water - An Essential Nutrient

Water is second to oxygen as being essential for life. People can survive days, weeks or more without food, but only about four days without water.

Water regulates body temperature, participates in the chemical reactions within the body, and serves as a solvent for minerals, vitamins, amino acids, glucose and a multitude of other small molecules. Water also acts as a lubricant around joints and serves as a "shock absorber," particularly inside the eyes and spinal cord. It is the vehicle for the body's transportation system, carrying nutrients and oxygen to all parts of the body through the blood and lymph.

The average adult consumes and excretes about 2½ to 3 quarts of water a day. Some of this water is supplied through foods, but most is consumed through beverages. It is generally recommended that adults consume 6 to 8 cups of liquids daily.

Water accounts for 55 to 60 percent of a person's weight. A fluid loss causing more than 10 percent loss of body weight can be fatal in a young child. Such a loss may be caused by severe vomiting, diarrhea, high fever, burns to the body, or even excessive perspiration without replenishment. Excessive water loss, or increased need for fluids, is seen in people doing strenuous exercise, in people on high fiber or high protein diets, and in women during pregnancy.

Thirst is a good indicator that the body needs to replenish its supply. When the salt level in the blood rises, receptors in the hypothalamus trigger the thirst sensation. But some people, particularly older people, cannot rely on this and are advised to be sure they're drinking 6 to 8 8-ounce glasses of fluids a day, thirsty or not.

Some beverages, such as coffee, tea and alcohol are diuretic and increase urine excretion. An ounce of pure alcohol requires 8 ounces of water to metabolize it. These beverages, if consumed in large quantities, can upset the body water balance.

What's in your water? and what does it mean for your health?

When you turn on the tap, it's not "just" water filling your glass. Water contains dissolved solids, usually minerals. Unfortunately, it may also contain organic compounds, live organisms or heavy metals. If you are using a municipal water supply, chlorine may have been added for purification purposes and fluoride for its dental benefits.

Hard vs. Soft Water

Generally the following distinctions can be made between hard and soft water.

In **hard water** the concentration of calcium and magnesium is higher than the sodium concentration. In **soft water** the sodium concentration is higher than the calcium and magnesium concentration.

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Soft water is often preferred for household use because it makes soap lather better, gets clothes cleaner and leaves less of a ring in the bathtub. If your water source is not by nature soft and you are using a water softener, you are removing the calcium and magnesium and adding sodium through an ion-exchange process. From a nutrition standpoint, this process has drawbacks.

The average American diet often contains more than adequate sodium. Also, soft water can dissolve certain metals, such as cadmium and lead, from metal pipes. Cadmium is not an essential nutrient and has been linked to hypertension. And lead is not only toxic but is more readily absorbed by the body from soft water. Finally, for those who for health reasons need to restrict their sodium intake, their drinking water may be a significant source to consider. There is also evidence that in communities where the water is hard, there is a lower incidence of heart attacks.

The National Academy of Sciences has suggested a standard for public drinking water supplies of 100 milligrams of sodium per liter. This limit should ensure that the water supply will not add more than 10 percent to the average person's total sodium intake.

The American Heart Association has recommended a more conservative standard of 20 milligrams per liter to protect heart and kidney patients whose sodium intake must be restricted.

Considering these facts, it would seem appropriate that if you use a water softener you should have a separate faucet for unsoftened water installed in the kitchen for drinking purposes.

Fluoride

Fluoride is found naturally in water supplies in varying amounts. The dental benefits from the use of optimally fluoridated water have been well documented. At concentrations greater than 1.0 milligrams per liter, fluoride will reduce the incidence of dental caries, but at concentrations over 1.5 milligrams per liter mottling of teeth, called fluorosis, may occur. The Environmental Protection Agency has set limits for the amount of fluoride that may be found in public water supplies, either naturally or through water treatment. There are locations in North Dakota where fluoride levels exceed 1.5 milligrams per liter. If your drinking water source is a private well, an analysis of your water will reveal the fluoride level.

There has been controversy over the fluoridation of water. Some argue that it promotes sickle-cell anemia, cancer, cardiovascular disease and AIDS. Opponents also argue that fluoridation violates individual rights, goes against religious beliefs that ban medication and is not really effective in preventing decay.

Fluoridation is endorsed by the American Dental Association and the American Medical Association. Allegations that fluoride is a carcinogen have been refuted by the American Cancer Society and the National Cancer Institute.

Too much fluoride, like other trace elements, can be toxic. Most cases of fluoride poisoning have involved small children consuming bottles of fluoride supplements.

Bacteria and other Infectious Disease Agents

Although most microorganisms in water are harmless, some can cause problems. Bacteria from human or livestock waste can cause serious health problems such as dysentery, hepatitis and typhoid fever.

Bacteriological tests are based on the detection of coliform bacteria. Most coliform organisms may not themselves cause disease, but may be accompanied by various organisms which do.

Chlorination and filtration effectively control the level of bacteria in water supplies. Chlorination is closely regulated by the EPA. Chlorine reacts in surface water with certain organic compounds that result from decaying vegetation, and produces compounds known as trihalomethanes (THMs). THMs are the most common organic contaminant found in chlorinated water supplies, and some are known to cause cancer in laboratory animals.

In the past few years, Giardia lamblia, a tiny one-celled parasite not readily killed by chlorination, has entered water supplies. It is common in rural and mountain communities without adequate filtration systems. This is primarily a problem in surface water, not groundwater.

Bacterial contamination can cause a change in water color, taste or odor, and these may indicate a problem. But water contaminated with Giardia may look, smell and taste good.

Giardiasis is a gastrointestinal illness affecting people and animals of all ages who have ingested the Giardia cysts. The symptoms of Giardiasis include diarrhea, abdominal cramps, gas, dehydration, weakness and loss of appetite. Infected individuals can be treated with prescription medication. Some infections disappear spontaneously without any treatment. Proper hygiene, proper waste disposal and well construction are important factors in preventing infections.

Nitrate

Nitrate contamination of water supplies can come from many sources - chemical fertilizers, animal wastes, and septic systems. Because in the digestive systems of human infants and in some livestock nitrate is converted to nitrite, a very toxic substance, nitrate-contaminated water is a serious problem.

Infants are extremely susceptible to acute nitrate poisoning because of certain bacteria present in their digestive systems at birth. These bacteria change nitrate into toxic nitrite. The nitrite reacts with hemoglobin in the bloodstream to form methemoglobin. Hemoglobin carries oxygen, methemoglobin does not. As the circulating oxygen level decreases, the infant suffers from methemoglobinemia, or blue-baby disease, which is characterized by a bluish skin color, particularly around the eyes and mouth. This is a sign of suffocation and the infant should be taken to a doctor immediately for treatment. Treatment results in methemoglobin converting back to hemoglobin.

Starting at about three months of age, an increase in the amount of hydrochloric acid in the infant's stomach kills most of the bacteria that convert nitrate to nitrite, and enzyme systems affecting nitrite formations mature. By the time the baby is six months old its digestive system is fully developed and none of the nitrate-converting bacteria appear to remain in the intestine. In older children and adults nitrate is generally absorbed and excreted. Some authorities are concerned about the possible ill effects on the fetus and infant when pregnant or nursing mothers consume high-nitrate water. Little is known about the possible long-term chronic effects of drinking high-nitrate content water. A potential cancer risk for nitrate (and nitrite) in water and food has been reported. If your drinking water contains more than 10 parts per million of nitrate-nitrogen, it is advisable to use an alternate source of water for infant formula and food.

Sulfate

Sulfates that occur naturally in groundwater include calcium, magnesium and sodium salts. Normally, small amounts of sulfate salts have little public health significance. Sodium sulfate (Glaubers salt) and magnesium sulfate (Epsom salt) are both laxatives. The laxative dose is approximately 2 grams. This would equal the consumption of about two quarts of water having 300 parts per million of Glauber salt or 390 parts per million of Epsom salt. The laxative effect is noted most often by persons not accustomed to drinking water with these quantities of these chemicals. Those who consume such water on a constant basis become used to it. The EPA recommends that water containing more than 250 parts per million of sulfate, not be used if other less mineralized supplies are available, primarily because of how this water tastes.

If the water smells like rotten eggs, it has a hydrogen sulfide problem.

Lead

Lead has no known useful function in the body. It is a well-known toxic heavy metal. Lead can cause damage to the nervous system, the blood-forming processes, the gastrointestinal systems and the kidney. Children who accumulate high levels of lead in their blood - by drinking contaminated water, inhaling car exhaust or eating old paint chips containing lead pigment - often have learning difficulties and stunted growth. Even low levels of lead exposure can contribute to hypertension in adult males. Young children and fetuses are most at risk for damage by exposure to lead.

Lead rarely occurs naturally in drinking water sources. The major source of lead in drinking water is the corrosive action of water on the materials used in distribution and plumbing systems. Old homes may still have lead pipes, lead alloy pipes or lead solder used with copper plumbing. Lead contamination is more serious in areas with soft water that is corrosive. To minimize exposure to lead, run the tap for a few minutes each morning to flush out standing water and use only cold water for drinking and preparing foods. Once heated by the hot water heater, water comes more corrosive and tends to increase leaching of lead from plumbing.

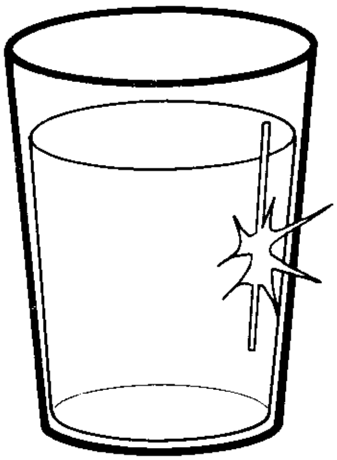
Organic Contaminants

New types of contaminants have come under investigation in recent years. They are the residues of pesticides and leakage from underground storage tanks, land fills and toxic waste dumps.

Research on these substances has been taking place for very few years. This is obviously an increasingly important research topic as indications are that many organic compounds are toxic. Several chemicals, agricultural and otherwise, have been implicated in acute and chronic diseases and in impaired function of several organ systems. Standards are currently being established and the risks of exposure to such compounds determined.

Health Advisories are nonregulatory numbers, designed to provide advice to state and local officials regarding the safety of water that has been contaminated. For select contaminants in drinking water EPA's Office of Drinking Water under the Safe Drinking Water Act, established health advisory levels at which adverse health effects would not be anticipated.

For example, based on health effects information, the EPA has established a health advisory level for nitrate and nitrite. Consuming water containing nitrate and nitrite, at or below the health advisory level, is not expected to result in adverse non-cancer health effects. The health advisory level for nitrate is 10 milligrams per liter or 10 parts per million. For nitrite, the health advisory level is 1 milligram per liter.



Drinking Water Standards

The Federal Safe Drinking Water Act (SDWA) was signed into law in 1974. The act authorizes the EPA to establish a cooperative program among local, state and federal agencies for drinking water. Under the SDWA, the primary role of the federal government is to develop national drinking water regulations that will protect public health and welfare. The states' responsibility is to implement the regulations and moniter the performance of public water systems. The local public water systems are responsible for treating and testing drinking water to ensure that its quality consistently meets the standards set by the regulations. The SDWA was amended by Congress in 1986 to require EPA to set new standards for numerous contaminants in a more timely fashion. Standards for 83 contaminants were specifically listed by Congress to be determined within three years.

National Primary Drinking Water Regulations - Maximum Contaminant Levels

Impurities in drinking water which have adverse health impact on man can be grouped into five catagories: inorganic chemical contaminants, organic chemical contaminants, microbiological contaminants, turbidity contaminants and radiological contaminants. Many of these contaminants occur naturally in small or trace amounts in ground or surface waters.

Standards set under authority of the SDWA are called Maximum Contaminant Levels (MCLs). An MCL is the highest amount of a specific contaminant allowed in the water delivered to any customer of a public water system. EPA and most states do not apply them to private water supplies.

EPA's policy has been to set the MCL goal at absolute zero for a proven carcinogen, or cancer-causing chemical, in humans, or for a probable carcinogen in animal studies. For noncarcinogens, the MCL goals is set at a level corresponding to a percentage of the reference dose.

The **reference dose** is the amount of the chemical that may be taken into the body daily with a practical certainty that injury will not result, even after a lifetime of exposure. Previously this was known as 'acceptable daily intake,' or ADI. The reference dose is derived from the lowest level at which no toxicological endpoint was observed in any test studies. This "no observable adverse effect level" (or NOAEL) is the basis for the reference dose and applies to noncarcinogens.

National Secondary Drinking Water Regulations - Secondary Maximum Contaminant Levels (SMCLS)

The contaminants covered by these regulations are those which may adversely affect the aesthetic qualities of drinking water, such as taste, color and appearance, and which may deter public acceptance of drinking water provided by public water systems.

SMCLs are established for chloride, color, copper, corrosivity, foaming agents, iron, manganese, odor, pH, sulfates, total dissolved solids and zinc. These secondary levels represent reasonable goals for drinking water quality, but are not enforceable. States may establish higher or lower levels, depending on local conditions such as unavailability of alternate water sources.

For the large number of North Dakotans who rely on private water systems, it is important to note that state laws do not require testing of private, domestic water supplies, nor do regulatory agencies regularly moniter the quality of private supplies. Water testing is up to the user.

To ensure that a private water supply is safe to drink, it should be tested for bacteria and nitrate annually and whenever situations occur that could result in contamination, such as leaking underground storage tanks, mine drainage, septic system leakage, pollution from livestock facilities and in wells less than 50 feet deep.

The North Dakota State Department of Health and Consolidated Laboratories in Bismarck and several local health department laboratories perform bacterial analysis of water samples. The State Lab and private laboratories in the state perform mineral analysis.

Refer to NDSU Extension Service circular AE-937, "Interpreting Your Water Test Report" for further information.

Health Guidance Levels for Agricultural Chemicals in Groundwater

Several pesticides have been detected in groundwater samples across the country and in North Dakota. According to current scientific thought, the mere presence of a pesticide does not necessarily mean there is a health or environmental risk. Once a significant contamination incident does occur, the groundwater can remain unusable as potable, or drinkable, water for decades if treatment is not feasible.

Health guidance levels (HGL's) for agricultural chemicals in groundwater are determined by using data that chemical manufacturers must give EPA in order to register a pesticide. From that registration data, which usually results from studies in which the chemical is fed to animals, EPA establishes human acceptable daily intake values (reference doses) for chemical residues on foods. The toxicological data base and methodology which EPA, Office of Pesticide Programs, currently uses to establish tolerances for pesticide residues in food provides a way to evaluate the risk posed by chemicals in groundwater where there is a potential for human consumption.

Once the reference dose, or daily acceptable intake, is established for a given chemical, a calculation is made to determine the HGL, or health guidance level for that chemical. The HGL is the concentration level that the EPA determines may be safe in drinking water. The calculation of the HGL is based on an infant who weighs 10 kilograms and drinks 1 liter of water per day, or on an adult who weight 70 kilograms and drinks 2 liters of water per day.

When lifetime HGLs are determined, the safe concentration levels are based on a 70-kilogram adult who consumes 2 liters of water per day, and the assumption is made that only 20 percent of a person's intake of the chemical is from drinking water. Eighty percent is assumed to come from direct contact, food residues or other sources. An additional uncertainty factor (safety factor) of 10 is applied in the calculation of a lifetime HGL.

Because much of the available data comes from high-dosage, short-term studies done with animals, scientists are generally very conservative in setting health guidelines for chemicals. Also, before scientific findings become policy, they are debated publicly so that economic, social and public health considerations are taken into account. This process generally results in conservative standards.

The following example shows how the safe level for one chemical, atrazine, is determined. The NOAEL (no observable adverse effect level) for atrazine, based on animal studies, is 0.35 milligrams/kilogram/day (milligrams of atrazine ingested per kilogram of body weight per day). The reference dose (RFD) is calculated by dividing this amount by an uncertainty factor of 100 - which comes to 0.0035 milligrams/kilogram/day.

$$\text{RFD} = \frac{(0.35 \text{ mg/kg/day})}{(100)} = 0.0035 \text{ mg/kg/day}$$

Where:
0.35 mg/kg/day = NOAEL based on the absence of adverse health effects in dogs
100 = uncertainty factor

From this reference dose the drinking water equivalent level, or DWEL, is determined, based on a 70 kilogram adult who consumes 2 liters of water per day. The reference dose of 0.0035 milligrams/kilogram/day is multiplied by 70 kilograms and divided by 2 liters/day to give a DWEL of 0.123 milligrams/liter. The 2 liters/day is the assumed daily water consumption of an adult.

$$\text{DWEL} = \frac{(0.0035 \text{ mg/kg/day})\ (70 \text{ kg})}{(2 \text{ l/day})} = 0.123 \text{ mg/1}$$

Where:
0.0035 mg/kg/day = RFD
70 kg = assumed body weight of an adult
2 l/day = assumed daily water consumption of an adult

At this point, the lifetime HGL (health guidance level) can be determined. It equals 20 percent of the drinking water equivalent level, divided by another uncertainty factor of 10.

$$\text{lifetime HGL} = \frac{(0.123 \text{ mg/l})\ (20\%)}{(10)} = 0.0025 \text{ mg/l}$$

Where:
0.123 mg/l = DWEL
20% = assumed relative source contribution of drinking water to the total atrazine intake
10 = additional uncertainty factor

Since 0.0025 milligrams/liter equals 3 micrograms/liter (ug/l) or 3 parts per billion, the