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Environmental Health
FACT SHEET

UNDERSTANDING WATER CONTAMINATION

By Lono Ho'ala

Contamination of the nation's water supply is a growing concern, and with good reason. The Environmental Protection Agency (EPA) reports that nearly half of all municipal water supplies have violated federal health standards. In 1993 they cataloged over 200,000 serious unsafe water violations affecting over 120 million people. People on private wells fare no better. EPA surveys of private wells show that fully two-thirds of them violate at least one Safe Drinking Water Act Standard. In the United States, a million people a year become ill from water-borne disease.

Newspapers and television news feature almost daily reports of serious water contamination problems. A 1993 Cryptosporidium outbreak in Milwaukee left tens of thousands sick. A similar outbreak in Albuquerque in May of 1994 led to television newscast warnings for people with weakened immune systems to boil their water. Early in 1994 dangerous E. Coli bacteria were found in New York City water at about the same time Washington D. C. residents were being told to boil their water for three days due to chlorine-resistant parasites that were found in their water system.

While Americans are becoming increasingly aware of how our drinking water is contaminated by the deluge of pesticides, agricultural and industrial run-off, we are just beginning to realize the extent of pollution that is caused by landfills, chemical dumps as well as buried oil and gas tanks and lines. These chemicals are slowly soaking into the earth's underground water reservoirs and are regularly showing up in tests of private well water as well as municipal water supplies.

RISK ASSESSMENT

Every day, you can be exposed to combinations of many toxic substances and these substances may interact. What is in water may represent only a small part of your overall exposure to a specific contaminant. Scientists who investigate how contaminants affect human health get information in several ways. They may study how a toxic substance has affected people in a community over time. In some cases, this can show a relationship between exposure to a contaminant and a health effect. They may also use animal studies to collect information on the acute and chronic health effects.

Research helps scientists determine toxic doses and levels below which toxic effects are not observed. For non-cancer-causing toxic substances, scientists use ``acceptable daily intake'' to estimate risk. The acceptable daily intake is the amount of a contaminant or toxic substance that humans can consume daily for a lifetime without any known ill effects. It includes a margin of safety. For a cancer-causing substance, no safe level has been set. Toxicity is estimated by calculating a risk estimate, or the concentration of a substance that presents the least acceptable risk. In the case of cancer-causing toxins, regulations are based on a level of risk that is acceptable, not a safe amount or concentration of a substance.

The sad fact is that city infrastructures are decaying while the amount and types of pollution are increasing dramatically. There isn't enough money to maintain our highways or schools, much less domestic water treatment systems. States complain that there is no money to rebuild water treatment facilities, most of which are running on archaic technology developed prior to or during World War II.

While municipalities struggle to maintain outdated technology, every year 18 billion pounds of pollutants and chemicals are released by industry into the atmosphere, soil, and ground water. Over 70,000 chemical compounds are now in use by industry, agriculture, and private citizens. 5,000 new chemical compounds are being introduced every year. At least 700 of these chemicals have been regularly found in America's drinking water, but the EPA has set safety standards for less than 100 of these chemicals.

Water contaminants can be broken down into two broad categories.

1. The first contains substances that affect water's taste or appearance, or that might cause damage or staining to plumbing and/or fixtures, but that are considered harmless to ingest.
2. The second contains substances that present proven or likely health hazards.

The "cosmetic" contaminants include such minerals as iron, copper, manganese, calcium and magnesium. The more serious health hazard contaminants include a spectrum of microorganisms called "biological" contaminants, radioactive materials called radionuclides, and an array of inorganic and organic chemical compounds, some of which are added to water to disinfect it. Disinfection also creates an array of chemicals known as disinfection by-products, some of which are known to be powerful toxins.

COSMETIC CONTAMINANTS

HARDNESS

Hardness enters a water supply when calcium and magnesium salts are dissolved by ground water. Hardness is commonly measured in grains per gallon (gpg). Soft water has 0 gpg of hardness. Ideal water has 3-5 gpg of hardness. Water is considered very hard at 10 gpg of hardness. 1 gpg is equal to 17.1 milligrams per liter (mg/l) or parts per million (ppm.)

Some hardness is desirable. That's because completely soft water tends to be acidic and an aggressive solvent, causing corrosion on the surface of pipes and plumbing fixtures. Unfortunately, many areas of the southwest have water supplies that are extremely hard, measuring from 10 to more than 60 gpg of hardness.

As levels increase above 10 gpg, hardness becomes an increasingly serious economic problem. Calcium carbonate tends to precipitate out of water as calcite thereby building an amorphous crystalline scale that builds up on the inside of pipes, hot water heaters, plumbing fixtures and appliances like clothes washers and dishwashers. At 20 gpg, this buildup can be so severe that hot water heaters may have to be replaced as often as every two years and the service life of appliances can be cut by half.

Over the life span of your water heater, very hard water will cost much more to heat than soft water. You'll use up to 30% more energy because heating the water through the scale that builds up on the inside of hot water heaters is like cooking with a ceramic tile placed between your pot and the burner. If you amortize in the cost of installing new water heaters at the rate of 2 to 4 every ten years, it becomes clear that hard water is expensive. But it doesn't end there. There are other expensive economic costs associated with very hard water.

Because things don't dissolve as well in hard water, you'll use up to one third more coffee or tea to make your favorite beverage. Some powdered or frozen drink and soup concentrates won't go as far either. On the positive side, clean hard water tastes better than distilled, de-ionized, or reverse-osmosis water.

Hardness increases your cleaning costs as well. Hardness ions combine with soap to create an insoluble curd. This curd is deposited on plumbing fixtures and anything else exposed to it including skin and clothes. When your clothes go through a dryer the heat of the dryer causes this curd to harden around each fiber and break off, thus resulting in a shorter useful life. At 10 gpg of hardness the average household can use up to ten times the amount of soap or detergents as would be required for soft water. Most household cleaning products contain numerous chemicals designed to remove hardness so the soap they contain can do its job. These chemicals are then flushed down the sewer where they can leach into ground water supplies as phosphates and nitrates, further degrading water quality for whomever lives downstream.

It used to be thought that drinking highly mineralized water was good for health because the water supposedly provided the minerals our bodies need. In 1985, scientists at Oak Ridge National Laboratories decided to test the hypothesis that the calcium and magnesium could reduce mortality from heart attacks and stroke. What they found was that chlorinated water increases the risk of heart disease because it creates abnormalities in the body's ability to metabolize fats. (This subject is discussed more fully under chlorine).

Additional studies have confirmed that to the extent that your water provides trace organic minerals it is healthier to drink. But most often, very hard water contains large amounts of inorganic minerals such as dissolved limestone (calcium carbonate) that the body cannot absorb or utilize in any way.

While no evidence exists to link extremely hard water to internal health problems, it (along with the harsh detergents and caustic water conditioning chemicals needed to bathe in it) can cause dry, itchy, skin and brittle hair when people wash in it.

If your water has over 10.0 gpg of hardness, an investment in quality water softening or conditioning equipment will quickly pay for itself. If your water has over 20.0 gpg of hardness, water softening equipment is an economic necessity as well as desirable for health.

Fortunately, a new technology for conditioning water has recently proven its worth. Conditioners employing ceramic beads upon which have been etched tiny patterns cause the calcium and magnesium ions to form inert crystals. These crystals then detach from the ceramic beads and travel through the system where they cause existing limescale to attach to them and dissolve. These microscopic crystals are invisible in water, don't cause limescale, and don't react with soap to form curd. They simply pass harmlessly through the water supply.

Because the calcium and magnesium is not actually removed from the water it is inappropriate to call the process "softening." Instead, most water treatment professionals refer to the process as "conditioning" the water. Whatever you choose to call it, it offers the important benefits of softening without the associated costs and hassle of adding salt to a brine tank and reintroducing a concentrated stream of brine back into the environment. Best of all, unlike magnets, the technology works consistently and reliably.

IRON & MANGANESE

Next to hardness, the presence of iron is probably the most common water problem faced by consumers and water treatment professionals. It often occurs alongside other contaminants, most commonly manganese. The secondary (aesthetic) maximum contaminant levels (MCL) for iron and manganese are 0.3 milligrams per liter (mg/l) and 0.05 mg/l, respectively. Iron and manganese in excess of the suggested maximum contaminant levels (MCL) usually results in discolored water, laundry, and plumbing fixtures.

Contaminant in Drinking Water

Since iron is one of the most prevalent elements in the earth's crust, most ground water supplies contain iron in some fashion. In its soluble form, ferrous iron can cause taste and odor problems, and will oxidize on exposure to air, forming insoluble, reddish-brown stain-causing rust. This rust, or ferric iron can create havoc in plumbing systems, water softeners, water filters, and other water-using devices.

The presence of certain strains of bacteria that feed on iron complicates matters further. These bacteria create a gelatinous, filamentous sludge capable of clogging valves, plumbing fittings, and water-using appliances, often rendering them useless. Even very small amounts of these bacteria can create a large problem.

Well water from the faucet or tap is usually clear and colorless. However, when water containing colorless, dissolved iron is allowed to stand in a cooking container or comes in contact with a sink or bathtub, the iron combines with oxygen from the air to form reddish-brown particles (commonly called rust). Manganese forms brownish-black particles. These impurities can give a metallic taste to water or to food.

Small amounts of iron are often found in water because of the large amount of iron present in the soil and because corrosive water will pick up iron from pipes.

Clothing washed in water containing excessive iron becomes permanently stained a brownish color. The taste of beverages, such as tea and coffee, are also be affected by iron. Manganese produces a brownish-black color in laundered clothing, leaves black particles on fixtures and as with iron, affects the taste of beverages, including coffee and tea.

The rusty or brown stains on plumbing fixtures, fabrics, dishes, and utensils cannot be removed by soaps or detergents. Bleaches and alkaline builders (often sodium phosphate) can make the stains worse. Over time, iron deposits can build up in pressure tanks, water heaters, and pipelines, reducing the quantity and pressure of the water supply.

Unluckily, iron and manganese can often be quite difficult to treat. This is due primarily to the fact that iron can be present in several forms, and each form can potentially require a different method of removal.

TYPES OF IRON

There are three main forms of iron and manganese. Other types exist, but are so rare that they are not normally considered:

- **Ferrous** - This type of iron is often called "clear water iron" since it is not visible in poured water. It is found in water, which contains no oxygen, such as water from deep wells or groundwater. Carbon dioxide reacts with iron in the ground to form water-soluble ferrous bicarbonate, which, in the water, produces ferrous ions (Fe^{++}).
- **Ferric** - Ferric iron is also known as "red water iron". This type of iron is basically ferrous iron, which has been exposed to oxygen (oxidized) usually from the air. As carbon dioxide leave the water, oxygen combines with the iron to form ferric ions (Fe^{+++}). These oxidized particles are generally visible in poured water.
- **Bacterial Iron** - Slime depositing in toilet tanks or fouling water filters and softeners is a good indication of the presence of bacterial iron. Better described as iron biofouling, the iron bacteria problem is both complex and widespread. It attacks wells and water systems around the world in all sorts of aquifer environments, both contaminated and pristine. In some places, it causes great damage; in others, it is considered a minor nuisance.

TREATMENT METHODS

Iron Bacteria: Iron bacteria can be controlled by periodic well chlorination or it can be treated in the building. The treatment involves chlorination, retention in a tank to allow oxidation to occur, followed by filtration to remove the oxidized contaminants. Activated carbon is usually used as a part the filter material so any excess chlorine can also be removed.

Ferric Iron: In theory, the elimination of ferric iron is simple. It seems that all one has to do is use a properly sized media filter to filter it from the water. In practice, however, there may be other issues:

> Some iron may be present in colloidal form. Unlike ferric iron, which will generally stick together to form large flakes, the tiny particles of colloidal iron do the opposite. Their large surface area and charge relative to their mass causes the individual particles to repel one another. As a result they will not coagulate. Their

small size, then, makes them difficult to filter, and a coagulating agent is often required to obtain adequate filtration.

Most water containing ferric iron also contains ferrous iron. This can add complexity to the process, since some of the methods for removing ferrous iron will also remove ferric iron.

Ferrous Iron: There are a variety of ways for removing ferrous iron, each with its own strengths and limitations. These methods fall into two categories: Ion exchange and Oxidation / filtration

ION EXCHANGE (WATER SOFTENER)

The most common method of iron removal from water is the use of a common water softener. Water softeners can be applied to remove iron when the water is clear when drawn and no iron bacteria are present.

The downside is that water softener resins are easily ruined by colloidal iron, bacterial iron, levels of iron over 5 ppm, and other water contaminants that often occur alongside iron. Another problem is the need for brine regeneration, which is not only costly and a hassle, but reintroduces a concentrated stream of brine into the environment. Nevertheless, iron removal by a water softener is still one of the most common ways to deal with this nuisance contaminant. When the type or amount of iron exceeds the treatment limits of a water softener, additional treatment is usually necessary.

Water softeners use the process of ion exchange. Ion exchange should be considered only for the removal of small quantities of iron and manganese. For practical purposes in an everyday working softener, the upper limit is about 5 parts per million.

Ion exchange involves the use of synthetic resins where a pre-saturant ion on the solid phase (the "adsorbent" - usually sodium) is exchanged for the unwanted ions in the water. One of the major difficulties in using this method for controlling iron and manganese is that if any oxidation occurs during the process, the resulting precipitate can coat and foul the media. Cleaning is then required using acid or sodium bisulfate

Where the concentration of iron is above 5 or 6 parts per million, or when there is both dissolved and precipitated iron or manganese in the water, a different approach is needed.

CATALYTIC OXIDIZING FILTRATION

Catalytic oxidizing filter can remove iron. This type of filter employs a medium that has been impregnated with various oxides of manganese. As ferrous iron bearing water passes through such a filter, the iron comes in contact with the medium and oxidizes to form insoluble ferric iron. The resulting rust particles are trapped in the filter bed, which is then cleaned through a process called backwashing.

Theoretically, this process is supposed to remove 100% of the iron. Practice shows that it will remove 75 - 90 percent of the iron. Since iron can cause stains at levels as low as 0.3 mg/l, an oxidizing filter is best followed by a water softener to remove the remaining iron and any hardness that might be present in the water supply.

The choice of media and the quality of the valve that controls backwashing is very important in this type of system. There are a variety of media available, each having unique characteristics. Because this type of water can create all kinds of plumbing issues, the valve used to control backwashing must be robust and able to withstand clogging, as well as be capable of sustaining high flow rates.

Manganese Greensand - the most common chemical oxidant used, it has a relatively high capacity for iron removal and can operate at high flow rates with moderate backwash requirements. Greensand is a processed material consisting of nodular grains of the zeolite mineral glauconite. The material is coated with manganese oxide. The ion exchange properties of the glauconite, facilitates the bonding of the coating. This treatment gives the media a catalytic effect in the chemical oxidation-reduction reactions necessary for iron and manganese removal. This coating is maintained through regeneration with potassium permanganate – about 1.5 to 2 oz. per cubic foot of greensand.

Birm - acts as a catalyst to promote the reaction between the oxygen and iron dissolved in the water. Iron removal efficiency is very high. Under proper conditions it requires no regeneration but it needs a relatively high level of dissolved oxygen and works best at a pH above 6.8. Will remove manganese if pH is 8-9. The media is durable with a long life and wide temperature range.

Pyrolox - a natural ore that oxidizes and then filters the resulting insoluble iron. It does not need to regenerate, therefore, it doesn't need other chemicals. However, it needs, ideally, to backwash at 25 to 30 gallons per sq. ft.

Filox – a high performance media for iron, hydrogen sulfide, and manganese removal. No oxidizing chemicals are needed for regeneration. Filox offers the highest flow rate of any standard iron removal media, 6 gpm/cu.ft service flow; 12-15 gpm/sq.ft backwash rate and out performs traditional media such as birm (x7,500) and manganese greensand.

Important Notice: Dissolved Oxygen (DO) is critical to the performance of Filox. Water with an Oxidation Reduction Potential (ORP) of below 170 millivolts requires the use of chlorine injection, permanganate solution injection, or an air injection system upstream to boost the oxidation process. This is very important. A water service professional should measure the ORP of your water supply before you purchase a system based on this media.

OXIDATION / RETENTION/FILTRATION

When iron levels exceed 20 mg/l, or when higher amounts of bacterial iron are present, or when arsenic, methane gas, hydrogen sulfide or other contaminants are present in the water supply, a different treatment method is required.

Perhaps the best method is called oxidation/retention/filtration. The iron is held in a retention tank where an oxidizing chemical is introduced into the water supply. This creates a resulting floc that is then removed by a filter. This is usually accomplished by injecting some form of chlorine into the inlet-supply line ahead of a pressure or storage tank. The iron is oxidized and precipitated in the tank and removed by a backwashable filter that may contain several kinds of complimentary media. This may be followed by a water softener or other kinds of conditioning equipment designed to remove remaining contaminants.

OXIDATION

Before iron and manganese can be filtered, they need to be oxidized to a state in which they can form insoluble complexes. Oxidation involves the transfer of electrons from the iron, manganese, or other chemicals being treated to the oxidizing agent.

OXIDIZING AGENTS

Ozonation - An ozone generator is used to make ozone that is then fed by pump or by an air injector into the water stream to convert ferrous iron into ferric iron. Ozone has the greatest oxidizing potential of all the common oxidizers. This is followed by a contact time tank and then by a catalytic medium or an inert multilayered filter for removal of the ferric iron. The disadvantage of this method is constant maintenance. That is because ozone is extremely corrosive, even causing parts made of resistant materials to deteriorate.

Chlorination - Chlorine can be introduced into water in one of several forms: as chlorine dioxide gas; as calcium hypochlorite tablets; or commonly, as sodium hypochlorite (liquid bleach.) The treated water is then held in a retention tank where the iron precipitates out and is then removed by filtering with manganese greensand, anthracite/greensand, activated carbon, or a mixture of these and other media. If applied this way, a dosage of one part of chlorine to each part of iron is used. If manganese greensand is used as the oxidizing filter, a feed of 0.2 parts of potassium permanganate per part of iron is fed into the water downstream of the chlorine.

The potassium permanganate and any chlorine residual serve to continuously regenerate the greensand. Using potassium permanganate however, can be a very messy process.

Aeration - Air can also be used to convert dissolved iron into a form that can be filtered. This approach mimics what happens when untreated dissolved iron comes into contact with the air after leaving a faucet.

Aeration methods can be of a two-tank or a single-tank variety. In a two-tank system, air is introduced into the first tank using a pump or other injection device. The dissolved iron precipitates in the first tank and is carried into the second tank where it is filtered in a Birm or multi-media filter. One drawback to this system is that water bearing the precipitated iron goes through the head of the first unit and the piping between the units. Particularly at lower flow rates, the sticky ferrous hydroxide tends to foul the valve on the first unit and may require cleaning every 6-24 months.

A single-tank system essentially combines the two tanks of a single tank system into one. The iron is oxidized at the top of the tank before falling into the filter medium at the bottom. There is no potential fouling of the head. The iron is filtered before it goes through the outlet port of the valve.

NOTE: For very high levels of iron, or iron complexed with manganese, arsenic, hydrogen sulfide or bacterial iron, chlorination followed by backwashing with a multi-media filter is the only practical approach.

FILTRATION

When Oxidation/Retention/Filtration becomes the system of choice, the selection of media and correct sizing is critical to assure the removal of oxidized contaminants. Usually several media are carefully combined in a multi-media tank that automatically backwashes on a cycle that is programmed into a robust control valve.

NOTE: When iron bacteria are detected, shock chlorination is recommended prior to the installation of water-conditioning equipment. This is accomplished by dumping 1 gallon of bleach directly into the well and allowing faucets to run until a bleach or chlorine odor is noticeable throughout the system. After the system has been left idle overnight of for at least two hours, the water is allowed to run until the bleach odor is gone. If the well is severely contaminated, it may be necessary to repeat this procedure after 2 or 3 days and then periodically throughout the year. Since most iron bacteria are aerobic, this shock-chlorination procedure may control the bacteria and eliminate the need for continuous chlorination, especially where low levels of iron are present.

MANGANESE

Manganese is a metal that is frequently found associated with iron but is rarer than iron. Manganese causes a dark brown or black staining of porcelain plumbing fixtures and clothing. The limit for manganese in water is 0.05 mg/l. The same equipment that removes iron will remove manganese.

HYDROGEN SULFIDE

Hydrogen sulfide is a gas with a rotten egg odor. In the southwest, it often occurs in tandem with iron and manganese. It is very corrosive to plumbing and can be dangerous to health. When present it must be removed before the water is suitable for drinking purposes. This is usually accomplished with aeration and chlorination equipment. The EPA maximum level for this gas is 0.05 mg/l.

BIOLOGICAL CONTAMINANTS

Pathogens are disease-producing micro-organisms, which include bacteria (such as giardia lamblia), viruses, and parasites. They get into drinking water when the water source is contaminated by sewage and animal waste, or when wells are improperly constructed. They can cause gastroenteritis, dysentery, shigellosis, hepatitis, and giardiasis (a gastrointestinal infection causing diarrhea, abdominal cramps, and gas). The presence of coliform bacteria, which is generally a harmless bacteria, may indicate other contamination to the drinking water system.

The United States Environmental Protection Agency (EPA) has determined that the presence of microbiological contaminants are a health concern at certain levels of exposure. If water is inadequately treated, microbiological contaminants in that water may cause disease. Disease symptoms may include diarrhea, cramps, nausea, and possibly jaundice, and any associated headaches and fatigue. These symptoms, however, are not just associated with disease-causing organisms in drinking water, but also may be caused by a number of factors other than your drinking water.

EPA and the state have set enforceable requirements for treating drinking water to reduce the risk of these adverse health effects. Treatment such as filtering and disinfecting the water removes or destroys microbiological contaminants. Drinking water, which is treated to meet EPA requirements is associated with little to none of these risk and should be considered safe.

TOTAL COLIFORM

The United States Environmental Protection Agency (EPA) has determined that the presence of total coliforms is a possible health concern. Total coliforms are common in the environment and are generally not harmful themselves. The presence of these bacteria in drinking water, however, generally is a result of a problem with water treatment or the pipes, which distribute the water, and indicates that the water may be contaminated with organisms that can cause disease. Disease symptoms may include diarrhea, cramps, nausea, and possibly jaundice, and any associated headaches and fatigue. These symptoms, however, are not just associated with disease-causing organisms in drinking water, but also may be caused by a number of factors other than your drinking water. EPA and the state have set an enforceable drinking water standard for total coliforms to reduce the risk of these adverse health effects. Under this standard, no more than 5.0 percent of the samples collected during a month can contain these bacteria, except that systems collecting fewer than 40 samples/month that have one total coliform-positive sample per month are not violating the standard. Drinking water, which meets this standard is usually not associated with a health risk from disease-causing bacteria and should be considered safe.

FECAL COLIFORMS/E. COLI

The United States Environmental Protection Agency (EPA) has determined that the presence of fecal coliforms or E. coli are generally not harmful themselves, but their presence in drinking water is serious because they are usually associated with sewage or animal wastes. The presence of these bacteria in drinking water generally is a result of a problem with water treatment or the pipes, which distribute the water, and indicates that the water may be contaminated with organisms that can cause disease. Disease symptoms may include diarrhea, cramps, nausea, and possibly jaundice, and any associated headaches and fatigue. These symptoms, however, are not just associated with disease-causing organisms in drinking water, but also may be caused by a number of factors other than your drinking water. EPA and the state have set an enforceable drinking water standard for fecal coliforms and E. coli to reduce the risk of these adverse health effects. Under this standard all drinking water samples must be free of these bacteria. Drinking water which meets this standard is associated with little or none of this risk and should be considered safe.

STANDARDS FOR MICROBIOLOGICAL CONTAMINANTS

There are three maximum contaminant levels (MCL) for microbiological contaminants. The first is based on the presence or absence of coliform bacteria. This group of bacteria is very common and is not harmful. The presence of coliform bacteria is used as an indicator that the water system must pay closer attention to its disinfection process. Violation of this MCL is not an emergency situation.

The second MCL is based on the presence of fecal coliform or *Escherichia coli* (E. coli). Violation of this MCL is an emergency, and the State requires water systems to promptly notify the public.

In addition to the above two MCLs, a third one applies to public water systems that use surface water or ground water that is determined to be under the influence of surface water. Because these type systems are very susceptible to contamination from bacteria, viruses, and pathogens like *Giardia lamblia* and *Cryptosporidium*, they are required to filter the water and disinfect it before sending it to customers. Measures are established to ensure water from surface water plants is clean. Violation of this standard is an emergency, and the State requires water systems to promptly notify the public.

A public water system must determine its compliance with the maximum contaminant level for microbiological contaminants each month (or quarter for non-community water systems which serve 1,000 or fewer persons).

THE STANDARD

1. The maximum contaminant level for coliform bacteria is based on the presence or absence of total coliforms in a sample, rather than coliform density. For the purpose of the public notice requirements in Rule 62-560.410, F.A.C., a violation of the standards in this paragraph poses a non-acute risk to health.
    a. For a system, which collects at least 40 samples per month, if no more than 5.0 percent of the samples collected during a month are total coliform-positive, the system is in compliance with the maximum contaminant level for total coliforms.
    b. For a system, which collects fewer than 40 samples per month, no more than one sample collected during a month can be total coliform-positive, for the system is in compliance with the MCL for total coliforms.
2. Any fecal coliform-positive repeat sample or E.coli-positive repeat sample, or any total coliform-positive repeat sample following a fecal coliform-positive or E.coli-positive routine sample is a violation of the maximum contaminant level for total coliforms. For the purposes of the public notification requirements this is a violation that poses an acute risk to health.
3. For surface water systems using conventional or direct filtration, the turbidity level of representative samples of filtered water taken throughout the day must be less than or equal to 0.5 NTU in at least 95 percent of the measurements taken each month. At no time is the turbidity level of the filtered water allowed to

exceed 5.0 NTU. In addition to filtration, the water must contain a disinfectant like chlorine before it can be used by the public.

DISINFECTANTS & DISINFECTION BY-PRODUCTS

CHLORINE: Chlorine is a highly effective and inexpensive disinfecting agent used extensively in the United States to treat water for municipal and individual supplies. It has played a key role in eradicating water-borne infectious diseases such as typhoid and cholera. But while chlorination has helped save many lives, the practice of chlorination so that it leaves high levels of free residual chlorine in the water after it leaves the treatment facility to arrive at your tap is common. That is because decaying infrastructure and the potential for broken water lines makes the delivery of disinfected water uncertain. Nevertheless, a growing body of evidence indicates that the practice may be very hazardous to human health.

In the early 1950's, scientists linked chlorine with the development of atherosclerosis in chickens. Further studies demonstrated that chlorine destroys vitamin E, an essential antioxidant that prevents the formation of free radicals (highly destructive molecules that promote tissue breakdown and tumor formation) from oxidized dietary fats, from synthetic chemicals, and from various immune system activities. Vitamin E also promotes heart muscle function, strengthens capillary walls, and dilates blood vessels, thereby reducing blood pressure and the risk of heart disease.

In a June 1989 conference sponsored by the University of Missouri, scientists from the Oak Ridge National Laboratory in Oak Ridge, Tennessee reported that a study of 1,520 residents from 46 Wisconsin towns had linked the drinking of chlorinated water to the formation of high cholesterol. Women were shown to be at greater risk than men. The women drinking chlorinated municipal water had roughly an 8% greater risk of heart attack than women drinking non-chlorinated well water.

At the same conference, J. Peter Bercz of the EPA's Health Effects Research Laboratory (HERL) described various "abnormalities" in fat metabolism of mice drinking highly chlorinated water (15 ppm) and eating diets with a fat content comparable to that of the typical American diet. The chlorine caused a noticeable increase in low density lipoproteins suggesting that chlorinated water alters the way the body metabolizes fat, thus increasing the risk of heart disease.

Other evidence linking chlorinated water and health problems are equally disturbing. Studies show that chlorinated water is toxic to human intestinal bacteria that convert organic compounds in our food into necessary nutrients. It may also deplete the small intestine of bacteria that produce vitamin B12.

Of most concern is evidence that toxic chemical compounds called trihalomethanes (THMs) are formed when chlorine reacts with organic matter in water. These THMs (chloroform and trichloroethylene, for example) are known to cause kidney, liver, and nervous system damage and many of them are proven to be potent carcinogens (cancer-causing agents).

In addition to THMs, HERL scientists have found that haloacetic acids and two other potent carcinogenic substances are formed when clorine interacts with organic material formed from the decay of plants. One of these, known as MX, has shown up in every chlorinated drinking water source tested for it. According to EPA chemist H. Paul Ringhand, MX may be the single largest contributor of mutagenicity (the ability to induce genetic mutations (a rough gauge of cancer-causing potential) in municipal water supplies. Another mutagen, called DCA, is known to alter cholesterol metabolism and cause liver cancers.

In 1987, the Journal of the National Cancer Institute reported that chlorinated water was the cause of up to 27% of bladder cancers. More recently, studies also suggest that chlorine in water supplies may be responsible for as many as 30% of breast cancers in women.

Not only is free chlorine dangerous, but hot showers and baths can also release 50% of dissolved chlorine and up to 80% of THMs like chloroform and tetrachlorethylene which are then breathed into the lungs or absorbed into the body through the skin. It is now clear that at least 50% of all dangerous water pollution exposure is due to absorption through the skin and lungs via hot showers and baths. As with all toxic exposure, small children, elderly people, and those with weakened immune systems are most at risk.

Because of their experience in World War 1 with chlorine gas used as a chemical weapon, communities in Europe use ozone and ultraviolet light to disinfect water supplies. Holland uses sand filtration to deliver highly purified water to its citizens.

Clearly, other methods of disinfection of water supplies are available. They are just far more expensive than most municipalities are able to afford.

In spite of the promises made by the Clinton administration in his State of the Union address, it is likely to be decades, if ever, before non-chlorinated or non-chloraminated water is routinely available from the tap. Until that time, common sense dictates that individuals protect themselves with the purchase of bottled drinking water or point of use filtration systems that are effective at the removal of chlorine, and it should be removed not only for drinking purposes, but for bathing purposes as well.

Chlorine can be removed by granular activated carbon, reverse-osmosis, distillation, or the copper-zinc medium of KDF55®. See section entitled "Understanding the Technologies", for more information.

CHLORAMINE: Chloramines are biocides. Like Cl_2 they are oxidants and kill bacteria by penetrating their cell walls and disrupting their metabolism. Chloramines are, however, much slower to "react". Unlike chlorine they do not evaporate from water. Neither are they removed by typical water treatment techniques. As with chlorine, municipalities aim for 1 to 2 mg/l (ppm) chloramine residual in the potable water supply.

Several disinfectants ranked by their "biocidal efficiency" and "stability" are noted below. (Biocidal efficiency was considered as the effectiveness of the disinfectant against a-number of viruses and bacteria in the pH range of 6 to 9. Stability reflects a lack of reactivity with constituents other than microorganisms and is a measure of persistence in the treated system)

Biocidal Efficiency (best to worst)

ozone > chlorine dioxide > free chlorine > chloramines

Stability (best to worst)

chloramines > chlorine dioxide > free chlorine > ozone

Water Treatment Concerns

Like any other molecule, chloramines contribute to the overall total dissolved solids content of the water and like chlorine, are selectively reactive, thus may have deleterious effects on downstream processes. In equilibrium with chloramines are trace amounts of ammonia and/or hypochlorite ions. Their (NH_3 and HOCl) presence must also be recognized when one is designing an ultrapure treatment system to remove chloramines.

HEALTH ISSUES

By far the biggest health concern is that no long term, and very few short-term studies have been performed that can clarify the effect of chloramines on human metabolism. What we know for sure about chloramines demonstrates that they are both reactive and persistent — not only in water, but also in human tissue. One study demonstrated that after 5 days, over 95% of a single dose of chloramine administered to laboratory rats was still concentrated in tissues including plasma, blood, skin, packed cells, kidney, nerves, testes, thymus gland, spleen, liver, muscle tissue, bone marrow, etc. Notwithstanding this information, public water suppliers around the country routinely misinform their customers, telling them that chloramines are effectively neutralized by stomach acids before they can reach the blood.

It is also known that chloramines cause DNA damage and are potential carcinogens. They are extremely dangerous to all forms of fresh and salt-water fish because they are absorbed directly from the gills and transported directly into the blood causing death in a short period of time.

In one study, doses at the levels used by municipalities to treat water resulted in a significant reduction of water consumption by rats vs. controls, along with significant decreases in blood glutathione levels in rats. Other studies demonstrated changes in the organ weights of rat spleens, livers, and kidneys. Other studies show that chloramine ingestion may be toxic to the organs that comprise the immune system.

The EPA admits that in their review of studies available, not much has been done to research the effect of oxidant stress on blood or tissues, nor is the long term effect of chloromine ingestion on plasma cholesterol metabolism.

Clinical reports of the effects of chloramines on humans show that some people suffer allergic contact dermatitis when exposed. Chloramines are also irritants to mucous membranes including those that line the nose, throat, and gut.

Remarkably, based on very few poorly designed studies, and virtually no long term studies, public utility companies routinely declare that the EPA has determined that the addition of chloramine to drinking water is absolutely safe!

METHODS OF TREATMENT

Distillation or evaporation does not effectively remove chloramines. During distillation the chloramines would be volatilized and carried over to the product water (distillate). This is especially important to keep in mind in the pharmaceutical, power and laboratory markets due to their heavy use of distillation technology (boilers in the power industry produce steam via evaporation). The effects of reactive chlorinated materials on their products are of special concern.

Neither is chloramine removal by reverse osmosis particularly effective. Cellulose Acetate (CA) membranes will not reject significant percentages of the monochloramine form. Much like chlorine, it passes through to the permeate side and becomes concentrated in the product water. Due to tighter pore structure, TFC membranes would be expected to reject a higher percentage of chloramines than cellulosic membranes but the effect is not substantial.

Catalytic Activated Carbon (CAC) is proven to reduce chloramine presence from 1 to 2 ppm to less than 0.1 ppm (a USP WFI requirement). While CAC is a viable method to reduce chloramines, careful consideration must be given to system design to ensure appropriate empty bed contact times.

While the effect on public health by not disinfecting drinking water supplies would be far worse than the alternative, advising the public that either chlorination or chloramination are completely non-toxic methods is ill-advised. We now know that chlorination has contributed greatly to heart disease, cancer, and other serious health issues in our human population. There is no reason to believe that chloramination will prove to be less troublesome. In fact, just the opposite is likely.

Consumers interested in home appliances capable of solving this problem will be disappointed to learn that most popular treatment technologies are completely unable to handle chloramines without modification. These include most cartridge-based systems using ceramic or carbon media, reverse-osmosis systems, and distillation.

For systems designed to accept post-filters, Catalytic Activated Carbon filters can replace typical carbon filters in RO and distillation systems. Those interested in purchasing new systems are well-advised to consider purchasing a 6-stage LivingWaters™ Water Treatment System that is capable of removing not only chloramine, but also chlorine, their disinfection by-products, fluoride, heavy metals, organic compounds that cause tastes and odors, as well as render product water completely sterile, all without the need for power or high water pressure.

INORGANIC CHEMICALS

There are many sources of inorganic contamination. Some of it is man-made and some of it occurs naturally.

Contaminant	**Maximum Contaminant Level**
Antimony	0.006 mg/L
Arsenic	0.05 mg/L
Asbestos	7 Million fibers per Liter
Barium	2 mg/L
Beryllium	0.004 mg/L
Cadmium	0.005 mg/L
Chromium	0.1 mg/L
Cyanide	0.2 mg/L
Fluoride	4.0 mg/L
Lead	0.015 mg/L
Mercury	0.002 mg/L
Nickel	0.1 mg/L
Nitrate	10 mg/L as Nitrogen
Nitrite	1 mg/L as Nitrogen
Total Nitrate and Nitrite	10 mg/L as Nitrogen
Selenium	0.05 mg/L
Sodium	160 mg/L
Thallium	0.002 mg/L

ANTIMONY

This inorganic chemical occurs naturally in the ground and is often used in the flame retardant industry. It is also used in ceramics, glass, batteries, fireworks and explosives. It may get into drinking water through natural weathering of rock, industrial production, municipal waste disposal or manufacturing processes. This chemical has been shown to decrease longevity, and alter blood levels of cholesterol and glucose in laboratory animals such as rats exposed to high levels during their lifetimes. EPA has set the drinking water standard for antimony at 0.006 parts per million (ppm) to protect against the risk of these adverse health effects. Drinking water, which meets the standard is associated with little to none of this risk and should be considered safe with respect to antimony.

ARSENIC

Arsenic is the 52nd most abundant element on the earth, averaging 2 parts per million (ppm) of the earth's crust. Arsenic is classified as a metal by the periodic table of elements. Elemental arsenic is a steel-gray colored mineral with a metallic luster that tarnishes in air to a black oxide. The free elemental form of arsenic is very rare. Arsenic is usually bound up in rocks with other minerals and leaches into water as arsenate (+5 oxidation state) or arsenite (+3) oxidation state. Arsenite is more difficult to remove from water because it has no charge in pH neutral water. Both are known to be potent carcinogens in humans.

Early civilizations in China, Greece and Egypt were familiar with arsenic-containing minerals that were mined along with co- existing native metal ores of lead, gold and copper. The arsenic minerals were used as pigments: yellow (orpiment) and red (realgar). The early Greeks identified metals with gender and called yellow orpiment "arsenikon" to associate it with "arenikos" meaning male. Between 2,000 and 600 BC during the Bronze Age, the Greeks used arsenic compounds to harden copper-tin alloy implements.

Arsenic is widely distributed in drinking water throughout the world. In the United States, it is a problem contaminant in the vast majority of drinking water supples, both in municipal water as well as private wells. The NRDC analyzed data compiled by the U.S. Environmental Protection Agency on arsenic in drinking water in 25 states. Their most conservative estimates based on the data indicate that more than 34 million Americans drink tap water supplied by systems containing average levels of arsenic that pose unacceptable cancer risks. It is likely that as many as 56 million people in those 25 states have been drinking water with arsenic at unsafe levels -- and that's just the 25 states that reported arsenic information to the EPA.

HEALTH EFFECTS OF ARSENIC IN DRINKING WATER

According to a 1999 study by the National Academy of Sciences, arsenic in drinking water causes kidney, bladder, lung and skin cancer, and may cause prostate and liver cancer. It also appears to make certain cancers more aggressive. The study also found that arsenic harms the central and peripheral nervous systems, as well as heart and blood vessels, and causes serious skin problems. It also may cause birth defects and reproductive problems.

Arsenic is considered an "accumulative enabler" because it makes people more likely to become ill from various cancers, diabetes, and high blood pressure. It may cause diseases related to the cardiovascular, pulmonary, immunological, neurological and endocrine systems within the body.

The table below shows the lifetime risks of dying of cancer from arsenic in tap water, based on the National Academy of Sciences' 1999 risk estimates (see our report for details on how we calculated total cancer risk).

Arsenic Level in Tap Water (in parts per billion, or ppb)	**Approximate Total Cancer Risk (assuming 2 liters consumed/day)**
0.5 ppb	1 in 10,000
1 ppb	1 in 5,000
3 ppb	1 in 1,667
4 ppb	1 in 1,250
5 ppb	1 in 1,000
10 ppb	1 in 500
20 ppb	1 in 250
25 ppb	1 in 200
50 ppb	1 in 100

Arsenic is dangerous only when consumed. That means you don't have to treat water in which you bathe or shower. Your concern relates to water that is used for drinking and cooking.

Unfortunately, arsenic is one of those contaminants that you can't rely on municipal treatment or bottle water to eliminate because it is a contaminant that is very difficult, and very expensive to remove. Your best bet is to rely on a point-of-use (POU) water treatment system designed to do the job effectively and reliably.

Distillers do a good job on arsenic. The problem is that they require power to operate so if you lose power, you lose your supply of safe water. Distillers also concentrate certain dangerous contaminants like chloramine in your drinking water.

Most reverse-osmosis (RO) systems can effectively reduce arsenic if they have good thin-film composite membranes and are operated with high enough water pressure. The problem with most RO systems is that they can concentrate chloramine in drinking water when these are present.

If you have a cartridge based water treatment system like certain LIVINGWATERS® systems, you can use a media called activated alumina that is specially designed to remove both fluoride and arsenic from water. The key is to make sure that the media has enough contact time with the water being treated. This means you will need one entire standard-sized cartridge (2-1/2" x 9-3/4") that is completely filled with high quality media, processing no more than 3/4 of a gallon per minute. The LW10FRC is an example of this kind of cartridge. Just make sure you change it at least once per year or if your water usage is high, once every six months.

If you are on a well and there is iron present in your water, the hands-down best way to remove it is to install a chlorine feeder either on the well, or on an open air tank with a repressurization pump. Either of these kinds of units require a special multi-media backwashing tank after the chlorine treatment. Systems that use dry chlorine pellets are more reliable and require far less maintenance than the types that use chlorine bleach.

These systems are not cheap (the open-air tank and its associated multi-media backwashing tank) run about $5,000 installed, but they are a bargain when you consider that they are the most effective way to remove not only both forms of arsenic, but also iron, manganese, hydrogen sulfide, radon and methane gas, sulfate, tannins, iron and sulfur bacteria as well as pathogenic microbiological organisms, algae, mold, low pH and more. Best of all, they can perform the removal of these particularly difficult contaminants on low producing wells because they don't require extensive amounts of backwashing.

ASBESTOS

Asbestos is a naturally occurring mineral. Most asbestos fibers in drinking water are less than 10 micrometers in length and occur in drinking water from natural sources and from corroded asbestos-cement pipes in the distribution system. The major uses of asbestos were in the production of cements, floor tiles, paper products, paint, and caulking; in transportation-related applications; and in the production of textiles and plastics. Asbestos was once a popular insulating and fire retardant material. Inhalation studies have shown that various forms of asbestos have produced lung tumors in laboratory animals. The available information on the risk of developing gastrointestinal tract cancer associated with the ingestion of asbestos from drinking water is limited. Ingestion of intermediate-range chrysotile asbestos fibers greater than 10 micrometers in length is associated with causing benign tumors in male rats. EPA has set the drinking water standard for asbestos at 7 million long fibers per liter to reduce the potential risk of cancer or other adverse health effects which have been observed in laboratory animals. Drinking water, which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to asbestos.

BARIUM

This inorganic chemical occurs naturally in some aquifers that serve as sources of ground water. It is also used in oil and gas drilling muds, automotive paints, bricks, tiles and jet fuels. It generally gets into drinking water after dissolving from naturally occurring minerals in the ground. This chemical may damage the heart and cardiovascular system, and is associated with high blood pressure in laboratory animals such as rats exposed to high levels during their lifetimes. In humans, EPA believes that effects from barium on blood pressure should not occur below 2 ppm in drinking water. EPA has set the drinking water standard for barium at 2 parts per million (ppm) to protect against the risk of these adverse health effects. Drinking water that meets the EPA standard is associated with little to none of this risk and is considered safe with respect to barium.

BERYLLIUM

This inorganic metal occurs naturally in the ground and is often used in electrical equipment and electrical components. It generally gets into water from run-off from mining operations, discharge from processing plants and improper waste disposal. Beryllium compounds have been associated with damage to the bones and lungs and induction of cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods of time. EPA has set the drinking water standard for beryllium at 0.004 part per million (ppm) to protect against the risk of these adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to beryllium.

CADMIUM

Food and the smoking of tobacco are common sources of general exposure. This inorganic metal is a contaminant in the metals used to galvanize pipe. It generally gets into water by corrosion of galvanized pipes or by improper waste disposal. This chemical has been shown to damage the kidneys in animals such as rats and mice when the animals are exposed at high levels over their lifetimes. Some industrial workers who were exposed to relatively large amounts of this chemical during working careers also suffered damage to the kidneys. EPA has set the drinking water standard for cadmium at 0.005 part per million (ppm) to protect against the risk of these adverse health effects. Drinking water that meets the EPA standard is associated with little to none of this risk and is considered safe with respect to cadmium.

CHROMIUM

This inorganic metal occurs naturally in the ground and is often used in the electroplating of metals. It generally gets into water from run-off from old mining operations and improper waste disposal from plating operations. This chemical has been shown to damage the kidneys, nervous system, and the circulatory system of laboratory animals such as rats and mice when the animals are exposed at high levels. Some humans who were exposed to high levels of this chemical suffered liver and kidney damage, dermatitis and respiratory problems. EPA has set the drinking water standard for chromium at 0.1 part per million (ppm) to protect against the risk of these adverse health effects. Drinking water that meets the EPA standard is associated with little to none of this risk and is considered safe with respect to chromium.

CYANIDE

This inorganic chemical is used in electroplating, steel processing, plastics, synthetic fabrics and fertilizer products. It usually gets into water as a result of improper waste disposal. This chemical has been shown to damage the spleen, brain and liver of humans fatally poisoned with cyanide. EPA has set the drinking water standard for cyanide at 0.2 parts per million (ppm) to protect against the risk of these adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to cyanide.

FLUORIDE

For 55 years, fluoride has been added to the water supply in many communities to help prevent tooth decay. But after all this time, surprising new research is raising such serious doubts about its safety that entire communities are abandoning the practice and many of the world's best scientists are urgently calling for change. As one doctor aptly stated: *"No physician in his right mind would prescribe for a person he has never met, whose medical history he does not know, a substance known to be extremely toxic in low doses, with the intention of creating bodily change, with the advice: 'Take as much as you like for the rest of your life because some children suffer from tooth decay.' It is a preposterous notion."*

The latest research reveals fluoride to be a neurotoxin. Consuming fluoride in drinking water contributes to learning disabilities in children including hyperactivity and attention deficit disorder. It also contributes to lower IQ, because the compounds used to fluoridate water cause the body to increase its uptake of lead through the gut. The amount of fluoride consumed by the average person in their drinking water has also been shown to be capable of causing Alzheimer's disease when consumed over an extended period of time. Add these newest revelations to previous research that shows that fluoride ingestion can cause skeletal fluorosis, bone cancer, and hypothyroidism (under-active thyroid and its symptoms including weight gain, muscle and joint pain, fatigue, depression, high cholesterol and heart disease), along with a host of other serious health related issues, and any reasonable person has cause for concern.

State regulations require that fluoride, which occurs naturally in some water supplies, not exceed a concentration of 4.0 mg/L in drinking water.

State regulations also require a water system to notify the public when monitoring indicates that the fluoride in drinking water exceeds 2.0 mg/L This is intended to alert families about dental problems that might affect children under nine years of age.

Fluoride in children's drinking water at levels of approximately 1 mg/L reduces the number of dental cavities. However, some children exposed to levels of fluoride greater than about 2.0 mg/L may develop dental fluorosis. Dental fluorosis, in its moderate and severe forms, is a brown staining and/or pitting of the permanent teeth.

Removal of fluoride can be accomplished by distillation, reverse-osmosis, and cartridge-based water treatment systems that employ a full cartridge of activated alumina.

MERCURY

This inorganic metal is used in electrical equipment and some water pumps. It usually gets into water as a result of improper waste disposal. This chemical has been shown to damage the kidneys of laboratory animals such as rats when the animals are exposed at high levels over their lifetimes. EPA has set the drinking water standard for mercury at 0.002 part per million (ppm) to protect against the risk of these adverse health effects. Drinking water that meets the EPA standard is associated with little to none of this risk and is considered safe with respect to mercury.

NICKEL

This inorganic metal occurs naturally in the ground and is often used in electroplating, stainless steel and alloy products. It generally gets into water from mining and refining operations. This chemical has been shown to damage the heart and liver in laboratory animals when the animals are exposed to high levels over their lifetimes. EPA has set the drinking water standard for nickel at 0.1 part per million (ppm) to protect against the risk of these adverse effects. Drinking water which meets the EPA standard is associated with little to none of his risk and should be considered safe with respect to nickel.

SELENIUM

Selenium is an essential nutrient at low levels of exposure. This inorganic chemical is found naturally in food and soils and is used in electronics, photocopy operations, the manufacture of glass, chemicals, drugs, and as a fungicide and a feed additive. In humans, exposure to high levels of selenium over a long period of time has resulted in a number of adverse health effects, including a loss of feeling and control in the arms and legs. EPA has set the drinking water standard for selenium at 0.05 part per million (ppm) to protect against the risk of these adverse health effects. Drinking water that meets the EPA standard is associated with little to none of this risk and is considered safe with respect to selenium.

SODIUM

The State of Florida Department of Environmental Protection (DEP) has set the drinking water standard for sodium at 160.0 parts per million (ppm) to protect individuals that are susceptible to sodium sensitive hypertension or diseases that cause difficulty in regulating body fluid volume. Sodium is monitored so that individuals who have been placed on sodium (salt) restricted diets may take the sodium in their water into account.

Sodium naturally occurs in food and drinking water. Food is the common source of sodium. Drinking water contributes only a small fraction (less than 10 percent) to the overall sodium intake. Sodium levels in drinking water can be increased by ion-exchange softeners at water treatment facilities or some point-of-use treatment devices.

THALLIUM

This inorganic metal is found naturally in soils and is used in electronics, pharmaceuticals, the manufacture of glass and alloys. This chemical has been shown to damage the kidneys, liver, brain and intestines of laboratory animals when the animals are exposed at high levels over their lifetimes. EPA has set the drinking water standard for thallium at 0.002 parts per million (ppm) to protect against the risk of these adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to thallium.

NITRATE

Nitrate is used in fertilizer and is found in sewage and wastes from human and/or farm animals and generally gets into drinking water from those activities. Concentrations as low as 10 mg/liter can cause death of infants. It reduces the ability of the blood to carry oxygen resulting in a condition called methemoglobinemia (blue baby syndrome.) The serious illness in infants is caused because nitrate is converted to nitrite in the body. Nitrite interferes with the oxygen carrying capacity of the child's blood. This is an acute disease in that symptoms can develop rapidly in infants. In most cases, health deteriorates over a period of days. The most common symptom of the illness is blueness of the skin called cyanosis and shortness of breath. Clearly, expert medical advice should be sought immediately if these symptoms occur. While adults can tolerate more nitrate, elderly people, people with respiratory dysfunction of any kind, and families with children do well to avoid all nitrate in their water.

EPA has set the drinking water standard at 10 parts per million (ppm) for nitrate to protect against the risk of these adverse effects. EPA has also set a drinking water standard for nitrite at 1 ppm. To allow for the fact that the toxicity of nitrate and nitrite are additive, EPA has also established a standard for the sum of nitrate and nitrite at 10 ppm. Drinking water that meets the EPA standard is associated with little to none of this risk and is considered safe with respect to nitrate.

Nitrate nitrogen enters the water supply by seeping through soil containing nitrate bearing minerals, fertilizers, plant debris, or the products of bacterial decomposition. Its presence indicates that the source may also be contaminated with human and/or animal wastes such as effluent from septic systems or cesspools. Surveys conducted by the EPA indicate that nearly one million households on private wells use water that exceeds the EPA nitrate standard of 10 parts per million (ppm.)

NITRITE

This inorganic chemical is used in fertilizers and is found in sewage and wastes from humans and/or farm animals and generally gets into drinking water as a result of those activities. While excessive levels of nitrite in drinking water have not been observed, other sources of nitrite have caused serious illness and sometimes death in infants under six months of age. The serious illness in infants is caused because nitrite interferes with the oxygen carrying capacity of the child's blood. This is an acute disease in that symptoms can develop rapidly. However, in most cases, health deteriorates over a period of days. Symptoms include shortness of breath and blueness of the skin. Clearly, expert medical advice should be sought immediately if these symptoms occur. EPA has set the drinking water standard for nitrite at 1 part per million (ppm) to protect against the risk of these adverse effects. EPA has also set a drinking water standard for nitrate (converted to nitrite in humans) at 10 ppm and for the sum of nitrate and nitrite at 10 ppm. Drinking water that meets the EPA standard is associated with little to none of this risk and is considered safe with respect to nitrite.

LEAD

Lead is one of the most dangerous pollutants found in drinking water. It is dangerous not only because of its effects, but because of the widespread nature of its distribution. Health care researchers estimate that as many as 20% of Americans are exposed to dangerously high levels of lead in their drinking water.

Lead is responsible for kidney, brain, and central nervous system disorders. In adults it can cause miscarriages, hypertension, multiple sclerosis, impotency, numerous nervous system disorders and even death. Young children and fetuses are even more vulnerable. For them, consuming even very small amounts of lead can lead to irreversible brain damage, intellectual, emotional, and developmental problems, numerous nervous system impairments, and stunted growth.

High levels of lead have been found in children suffering from lethargy, personality aberrations, and mental retardation. Studies of prison populations show an increased tendency for cocaine abuse among people who have high levels of lead in their systems.

Lead gives a sweet taste to water, causing people to mistakenly believe that their water is particularly "good". Since lead is cumulative in the human body (builds up over a lifetime), particular care must be taken to insure that lead does not enter your water supply.

Lead leaches into drinking water in a variety of ways. Many older communities use lead water mains to supply water to their communities. Over 90% of all U. S. homes have lead in their plumbing in some form, either as lead service pipes, lead-soldered connections, or brass faucets (brass is an alloy of copper and zinc which contains a small amount of lead).

Although a federal ban against the use of lead in plumbing systems took affect in June of 1988, it is sometimes ignored by plumbers who continue to use lead solder and certain manufacturers of water delivery equipment like well pumps, water fountains, and water faucets who use metal alloys that contain lead.

As recently as April 18, 1994 the EPA issued a warning to hundreds of thousands of people who drink from private wells to switch to bottled water and test for lead contamination from submersible pumps.

In 2005 a well-known manufacturer of faucets commonly used in home drinking water filers including both many brand-name reverse osmosis systems and cartridge based filter systems was put out of business in California when the State of California discovered that its "lead-free" faucets contained high amounts of lead.

WARNING! Certain myths circulate around the water industry among people who are better salesmen of equipment than they are educated to water quality issues. One of these myths is that lead in wells can be removed by the pouring of bleach down the well. THIS IS NOT TRUE! Bleach acidifies the water and actually causes MORE lead to leach into the system instead of less. This myth probably originated because bleach poured down the well is used to treat systems for iron causing bacteria that damage house plumbing. (For more information, see heading of iron in this section).

The maximum amount of lead permitted by the EPA is 0.05 mg/l. Municipalities do test for lead, but they draw their samples at the source and lead is a contaminant that is most likely to show up after it has left the treatment plant, passed through city piping, your home piping, and arrives at your tap.

Until you are certain that your water does not contain lead, switch to bottled drinking water and have your water supply tested before drinking any more of it. It is also a good idea not to regularly drink water from water fountains or other tap water sources in schools, government, and commercial buildings especially if they were built prior to 1988 unless you know they have been tested and are certified to be free of lead contamination.

ORGANIC CHEMICALS

People worry the most about potentially toxic chemicals and metals in water. Only a few of the toxic organic chemicals that occur drinking water are regulated by drinking water standards. This group of contaminants includes:

1. **Trihalomthanes** (THMs), which are formed when chlorine in treated drinking water combines with naturally occurring organic matter.
2. **Pesticides**, including herbicides, insecticides, and fungicides.
3. **Volatile organic chemicals** (VOCs), which include solvents, degreasers, adhesives, gasoline additives, and fuels additives. Some of the common VOCs are: benzene, trichloroethylene (TCE), styrene, toluene, and vinyl chloride. Possible chronic health effects include cancer, central nervous

system disorders, liver and kidney damage, reproductive disorders, and birth defects.

4. **Synthetic Organic Contaminants**, which includes pesticides, PCB, and dioxin.

TABLE OF VOLATILE ORGANIC CHEMICALS

This group of contaminants includes solvents, cleaning agents, degreasers, gasoline additives, and a variety of compounds that give water tastes and odors.

Contaminant	Maximum Contaminant Level
1,1-Dichloroethylene	0.007 mg/L
1,1,1-Trichloroethane	0.2 mg/L
1,1,2-Tricholoroethane	0.005 mg/L
1,2-Dichloroethane	0.003 mg/L
1,2-Dichloropropane	0.005 mg/L
1,2,4-Trichlorobenzene	0.07 mg/L
Benzene	0.001 mg/L
Carbon tetrachloride	0.003 mg/L
cis-1,2-Dichloroethylene	0.07 mg/L
Dichloromethane	0.005 mg/L
Ethylbenzene	0.7 mg/L
Monochlorobenzene	0.1 mg/L
o-Dichlorobenzene	0.6 mg/L
para-Dichlorobenzene	0.075 mg/L
Styrene	0.1 mg/L
Tetrachloroethylene	0.003 mg/L
Toluene	1 mg/L
trans-1,2-Dichloroethylene	0.1 mg/L
Trichloroethylene	0.003 mg/L
Vinyl chloride	0.001 mg/L
Xylenes (total)	10 mg/L

BENZENE

This chemical is used as a solvent and degreaser of metals. It is also a major component of gasoline. Drinking water contamination generally results from leaking underground gasoline and petroleum tanks or improper waste disposal. This chemical has been associated with significantly increased risks of leukemia among certain industrial workers who were exposed to relatively large amounts of this chemical during their working careers. This chemical has also been shown to cause cancer in laboratory animals when the animals are exposed at high levels over their lifetimes. Chemicals that cause increased risk of cancer among exposed industrial workers and in laboratory animals also may increase the risk of cancer in humans who are exposed at lower levels over long periods of time. The enforceable drinking water standard for benzene has been set by DEP at 0.001 part per million (ppm) to reduce the risk of cancer or other adverse health effects which have been observed in humans and laboratory animals.

CARBON TETRACHLORIDE (TETRACHLOROMETHANE)

This chemical was once a popular household cleaning fluid. It generally gets into drinking water by improper waste disposal. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. The enforceable drinking water standard for carbon tetrachloride has been set by DEP at 0.003 part per million (ppm) to reduce the risk of cancer or other adverse health effects which have been observed in laboratory animals. Drinking water, which meets this standard is associated with little to none of this risk and should be considered safe.

DICHLOROMETHANE

This organic chemical is a widely used solvent. It is used in the manufacture of paint remover, as a metal degreaser and as an aerosol propellant. It generally gets into drinking water after improper discharge of waste disposal. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods of time. EPA has set the drinking water standard for dichloromethane at 0.005 part per million (ppm) to reduce the risk of cancer or other adverse health effects which have been observed in laboratory animals.

ORTHO-DICHLOROBENZENE

This organic chemical is used as a solvent in the production of pesticides and dyes. It generally gets into water by improper waste disposal. This has been shown to damage the liver, kidneys and the blood cells of laboratory animals such as rats and mice exposed to high levels during their lifetimes. Some industrial workers who were exposed to relatively large amounts of this chemical during working careers also suffered damage to the liver, nervous system, and circulatory system. EPA has set the drinking water standard for o-dichlorobenzene at 0.6 part per million (ppm) to protect against the risk of these adverse health effects.

PARA-DICHLOROBENZENE

This chemical is a component of deodorizers, mothballs and pesticides. It generally gets into drinking water by improper waste disposal. This chemical has been shown to cause liver and kidney damage in laboratory animals such as rats and mice when the animals are exposed to high levels over their lifetimes. EPA has set the enforceable drinking water standard for para-dichlorobenzene at 0.075 part per million (ppm.)

1,2-DICHLOROETHANE

This chemical is used as a cleaning fluid for fats, oils, waxes, and resins. It generally gets into drinking water from improper waste disposal. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. The enforceable drinking water standard for l,2-dichloroethane has been set by DEP at 0.003 part per million (ppm) to reduce the risk of cancer or other adverse health effects which have been observed in laboratory animals.

1,1-DICHLOROETHYLENE (L,L-DICHLOROETHENE)

This chemical is used in industry and is found in drinking water as a result of the breakdown of related solvents. The solvents are used as cleaners and degreasers of metals and generally get into drinking water by improper waste disposal. This chemical has been shown to cause liver and kidney damage in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. EPA has set the enforceable drinking water standard for l,l-dichloroethene at 0.007 part per million (ppm.)

CIS-1,2-DICHLOROETHYLENE

This organic chemical is used as a solvent and intermediate in chemical production. It generally gets into water by improper waste disposal. This chemical has been shown to damage the liver, nervous system, and circulatory system of laboratory animals such as rats and mice when exposed at high levels over their lifetimes. Some humans who were exposed to relatively large amounts of this chemical also suffered damage to the nervous system. EPA has set the drinking water standard for cis-1,2-dichloroethylene at 0.07 part per million (ppm.)

TRANS-1,2-DICHLOROETHYLENE

This organic chemical is used as a solvent and intermediate in chemical production. It generally gets into water by improper waste disposal. This chemical has been shown to damage the liver, nervous system, and the circulatory system of laboratory animals such as rats and mice when exposed at high levels over their lifetimes. Some humans who were exposed to relatively large amounts of this chemical also suffered damage to the nervous system. EPA has set drinking water standard for trans-1,2-dichloroethylene at 0.1 part per million (ppm.)

1,2-DICHLOROPROPANE

This organic chemical is used as a solvent and pesticide. When soil and climatic conditions are favorable, 1,2-dichloropropane may get into drinking water by run-off into surface water or by leaching into ground water. It may also get into drinking water through improper waste disposal. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. EPA has set the drinking water standard for 1,2-dichloropropane at 0.005 part per million (ppm.)

ETHYLBENZENE

This organic chemical is a major component of gasoline. It generally gets into water by improper waste disposal or leaking gasoline tanks. This chemical has been shown to damage the kidneys, liver, and nervous system of laboratory animals such as rats exposed to high levels during their lifetimes. EPA has set the drinking water standard for ethylbenzene at 0.7 part per million (ppm) to protect against the risk of these adverse health effects.

MONOCHLOROBENZENE

This organic chemical is used as a solvent. It generally gets into water by improper waste disposal. This chemical has been shown to damage the liver, kidneys and nervous system of laboratory animals such as rats and mice exposed to high levels during their lifetimes. EPA has set the drinking water standard for monochlorobenzene at 0.1 part per million (ppm.)

STYRENE

This organic chemical is commonly used to make plastics and is sometimes a component of resins used for drinking water treatment. Styrene may get into drinking water from improper waste disposal. This chemical has been shown to damage the liver and nervous system in laboratory animals when exposed at high levels during their lifetimes. EPA has set the drinking water standard for styrene at 0.1 part per million (ppm.)

TETRACHLOROETHYLENE

This organic chemical has been a popular solvent, particularly for dry cleaning. It generally gets into drinking water by improper waste disposal. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods of time. DEP has set the drinking water standard for tetrachloroethylene at 0.003 part per million (ppm.)

TOLUENE

This organic chemical is used as a solvent and in the manufacture of gasoline for airplanes. It generally gets into water by improper waste disposal or leaking underground storage tanks. This chemical has been shown to damage the kidneys, nervous system, and circulatory system of laboratory animals such as rats and mice exposed to high levels during their lifetimes. Some industrial workers who were exposed to relatively large amounts of this chemical during working careers also suffered damage to the liver, kidneys and nervous system. EPA has set the drinking water standard for toluene at 1 part per million (ppm) to protect against the risk of adverse health effects.

1,2,4-TRICHLOROBENZENE

This organic chemical is used as a dye carrier and as a precursor in herbicide manufacture. It generally gets into drinking water by discharges from industrial activities. This chemical has been shown to cause damage to several organs, including the adrenal glands. EPA has set the drinking water standard for 1,2,4-trichlorobenzene at 0.07 part per million (ppm.)

1,1,1-TRICHLOROETHANE

This chemical is used as a cleaner and degreaser of metals. It generally gets into drinking water by improper waste disposal. This chemical has been shown to damage the liver, nervous system and circulatory system of laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. Some industrial workers who were exposed to relatively large amounts of this chemical during their working careers also suffered damage to the liver, nervous system and circulatory system. EPA has set the enforceable drinking water standard for l,l,l-trichloroethane has been set at 0.2 part per million (ppm.)

1,1,2-TRICHLOROETHANE

This organic chemical is an intermediate in the production of 1,1,-dichloroethylene. It generally gets into water by industrial discharge of wastes. This chemical has been shown to damage the kidneys and liver of laboratory animals such as rats exposed to high levels during their lifetimes. EPA has set the drinking water standard for 1,1,2-trichloroethane at 0.005 part per million (ppm) to protect against the risk of these adverse health effects.

TRICHLOROETHYLENE (TRICHLOROETHENE)

This chemical is a common metal cleaning and dry cleaning fluid. It generally gets into drinking water by improper waste disposal. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed at lower levels over long periods of time. The enforceable drinking water standard for trichloroethene has been set by DEP at 0.003 part per million (ppm) to reduce the risk of cancer or other adverse health effects which have been observed in laboratory animals.

VINYL CHLORIDE

This chemical is used in industry and is found in drinking water as a result of the breakdown of related solvents. The solvents are used as cleaners and degreasers of metals and generally get into drinking water by improper waste disposal. This chemical has been associated with significantly increased risks of cancer among certain industrial workers who were exposed to relatively large amounts of this chemical during their working careers. This chemical has also been shown to cause cancer in laboratory animals when the animals are exposed at high levels over their lifetimes. Chemicals that cause increased risk of cancer among exposed industrial workers and in laboratory animals also may increase the risk of cancer in humans who are exposed at lower levels over long periods of time. The enforceable drinking water standard for vinyl chloride has been set by DEP at 0.001 part per million (ppm) to reduce the risk of cancer or other adverse health effects which have been observed in humans and laboratory animals. Drinking water that meets this standard is associated with little to none of this risk and should be considered safe.

XYLENES

These organic chemicals are used in the manufacture of gasoline for airplanes and as solvents for pesticides, and as cleaners and degreasers of metals. They usually get into water by improper waste disposal. These chemicals have been shown to damage the liver, kidneys and nervous system of laboratory animals such as rats and dogs exposed to high levels during their lifetimes. Some humans who were exposed to relatively large amounts of these chemicals also suffered damage to the nervous system. EPA has set the drinking water standard for xylenes at 10 parts per million (ppm) to protect against the risk of these adverse health effects. Drinking water that meets the EPA standard is associated with little to none of this risk and is considered safe with respect to xylenes.

TABLE OF SYNTHETIC ORGANIC CONTAMINANTS

This group of contaminants includes pesticides, PCB, and dioxin.

Contaminant	Maximum Contaminant Level
2,3,7,8-TCDD (Dioxin)	3 X 10E-8 mg/L
2,4-D	0.07 mg/L
2,4,5-TP (Silvex)	0.05 mg/L
Alachlor	0.002 mg/L
Atrazine	0.003 mg/L
Benzo(a)pyrene	0.0002 mg/L
Carbofuran	0.04 mg/L
Chlordane	0.002 mg/L
Dalapon	0.2 mg/L
Di(2-ethylhexyl)adipate	0.4 mg/L
Di(2-ethylhexyl)phthalate	0.006 mg/L
Dibromochloropropane (DBCP)	0.0002 mg/L
Dinoseb	0.007mg/L
Diquat	0.02mg/L
Endothall	0.1 mg/L
Endrin	0.002 mg/L
Ethylene dibromide (EDB)	0.00002 mg/L
Glyphosate	0.7 mg/L
Heptachlor	0.0004 mg/L
Heptachlor epoxide	0.0002 mg/L
Hexachlorobenzene	0.001 mg/L

Hexachlorocyclopentadiene	0.05 mg/L
Lindane	0.0002 mg/L
Methoxychlor	0.04 mg/L
oxamyl (vydate)	0.2 mg/L
Pentachlorophenol	0.001 mg/L
Picloram	0.5 mg/L
Polychlorinated byphenyl (PCB)	0.0005 mg/L
Simazine	0.004 mg/L
Toxaphene	0.003 mg/L

ALACHLOR

This organic chemical is a widely used pesticide. When soil and climatic conditions are favorable, alachlor may get into drinking water by run-off into surface water or by leaching into ground water. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods of time. EPA has set the drinking water standard for alachlor at 0.002 part per million (ppm) to reduce the risk of cancer or other adverse health effects which have been observed in laboratory animals.

ATRAZINE

This organic chemical is a herbicide. When soil and climatic conditions are favorable, atrazine may get into drinking water by run-off into surface water or by leaching into ground water. This chemical has been shown to affect offspring of rats and the heart of dogs. EPA has set the drinking water standard for atrazine at 0.003 part per million (ppm) to protect against the risk of these adverse health effects. Drinking water that meets the EPA standard is associated with little to none of this risk and is considered safe with respect to atrazine.

BENZO(A)PYRENE

Cigarette smoke and charbroiled meats are common sources of general exposure. The major source of benzo(a)pyrene in drinking water is the leaching from coal tar lining and sealants in water storage tanks. This chemical has been shown to cause cancer in animals such as rats and mice when the animals are exposed at high levels. EPA has set the drinking water standard for benzo(a)pyrene at 0.0002 part per million (ppm) to protect against the risk of cancer. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to benzo(a)pyrene.

CARBOFURAN

This organic chemical is a pesticide. When soil and climatic conditions are favorable, carbofuran may get into drinking water by run-off into surface water or by leaching into ground water. This chemical has been shown to damage the nervous and reproductive systems of laboratory animals such as rats and mice exposed at high levels over their lifetimes. Some humans who were exposed to relatively large amounts of this chemical during their working careers also suffered damage to the nervous system. Effects on the nervous system are generally rapidly reversible. EPA has set the drinking water standard for carbofuran at 0.04 part per million (ppm) to protect against the risk of these adverse health effects. Drinking water that meets the EPA standard is associated with little to none of this risk [pg. 3591] and is considered safe with respect to carbofuran.

CHLORDANE

This organic chemical is a pesticide used to control termites. Chlordane is not very mobile in soils. It usually gets into drinking water after application near water supply intakes or wells. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods of time. EPA has set the drinking water standard for chlordane at 0.002 part per million (ppm) to reduce the risk of cancer or other adverse health effects which have been observed in laboratory animals. Drinking water that meets the EPA standard is associated with little to none of this risk and is considered safe with respect to chlordane.

DALAPON

This organic chemical is a widely used herbicide. It may get into drinking water after application to control grasses in crops, drainage ditches and along railroads. This chemical has been shown to cause damage to the kidneys and liver in laboratory animals when the animals are exposed to high levels over their lifetimes. EPA has set the drinking water standard for dalapon at 0.2 part per million (ppm.)

DI(2-ETHYLHEXYL)ADIPATE

Di(2-ethylhexyl)adipate is a widely used plasticizer in a variety of products, including synthetic rubber, food packaging materials and cosmetics. It may get into drinking water after improper waste disposal. This chemical has been shown to damage liver and testes in laboratory animals such as rats and mice exposed to high levels. EPA has set the drinking water standard for di(2-ethylhexyl)adipate at 0.4 part per million (ppm.)

DI(2-ETHYLHEXYL)PHTHALATE

Di(2-ethylhexyl)phthalate is a widely used plasticizer, which is primarily used in the production of polyvinyl chloride (PVC) resins. It may get into drinking water after improper waste disposal. This chemical has been shown to cause cancer in laboratory animals such as rats and mice exposed to high levels over their lifetimes. EPA has set the drinking water standard for di(2-ethylhexyl)phthalate at 0.006 part per million (ppm) to reduce the risk of cancer or other adverse health effects which have been observed in laboratory animals.

DIBROMOCHLOROPROPANE (DBCP)

This organic chemical was once a popular pesticide. When soil and climatic conditions are favorable, dibromochloropropane may get into drinking water by run-off into surface water or by leaching into ground water. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods of time. EPA has set the drinking water standard for DBCP at 0.0002 part per million (ppm) to reduce the risk of cancer or other adverse health effects which have been observed in laboratory animals.

DINOSEB

Dinoseb is a widely used pesticide and generally gets into drinking water after application on orchards, vineyards and other crops. This chemical has been shown to damage the thyroid and reproductive organs in laboratory animals such as rats exposed to high levels. EPA has set the drinking water standard fordinoseb at 0.007 part per million (ppm) to protect against the risk of adverse health effects.

DIQUAT

This organic chemical is a herbicide used to control terrestrial and aquatic weeds. It may get into drinking water by run-off into surface water. This chemical has been shown to damage the liver, kidneys and gastrointestinal tract and causes cataract formation in laboratory animals such as dogs and rats exposed at high levels over their lifetimes. EPA has set the drinking water standard for diquat at 0.02 part per million (ppm) to protect against the risk of these adverse health effects.

2,4-D

This organic chemical is used as a herbicide and to control algae in reservoirs. When soil and climatic conditions are favorable, 2,4-D may get into drinking water by run-off into surface water or by leaching into ground water. This chemical has been shown to damage the liver and kidneys of laboratory animals such as rats exposed at high levels during their lifetimes. Some humans who were exposed to relatively large amounts of this chemical also suffered damage to the nervous system. EPA has set the drinking water standard for 2,4-D at 0.07 part per million (ppm) to protect against the risk of these adverse health effects.

ENDOTHALL

This organic chemical is a herbicide used to control terrestrial and aquatic weeds. It may get into water by run-off into surface water. This chemical has been shown to damage the liver, kidneys, gastrointestinal tract and reproductive system of laboratory animals such as rats and mice exposed at high levels over their lifetimes. EPA has set the drinking water standard for endothall at 0.1 part per million (ppm) to protect against the risk of these adverse health effects.

ENDRIN

This organic chemical is a pesticide no longer registered for use in the United States. However, this chemical is persistent in treated soils and accumulates in sediments and aquatic and terrestrial biota. This chemical has been shown to cause damage to the liver, kidneys and heart in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. EPA has set the drinking water standard for endrin at 0.002 part per million (ppm.)

ETHYLENE DIBROMIDE (EDB)

This organic chemical was once a popular pesticide. When soil and climatic conditions are favorable, EDB may get into drinking water by run-off into surface water or by leaching into ground water. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods of time. DEP has set the drinking water standard for EDB at 0.00002 parts per million (ppm.)

GLYPHOSATE

This organic chemical is a herbicide used to control grasses and weeds. It may get into drinking water by run-off into surface water. This chemical has been shown to cause damage to the liver and kidneys in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. EPA has set the drinking water standard for glyphosate at 0.7 part per million (ppm.)

HEPTACHLOR

This organic chemical was once a popular pesticide. When soil and climatic conditions are favorable, heptachlor may get into drinking water by run-off into surface water or by leaching into ground water. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. EPA has set the drinking water standards for heptachlor at 0.0004 part per million (ppm) to reduce the risk of cancer or other adverse health effects which have been observed in laboratory animals.

HEPTACHLOR EPOXIDE

This organic chemical was once a popular pesticide. When soil and climatic conditions are favorable, heptachlor epoxide may get into drinking water by run-off into surface water or by leaching into ground water. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods of time. EPA has set the drinking water standards for heptachlor epoxide at 0.0002 part per million (ppm) to reduce the risk of cancer or other adverse health effects which have been observed in laboratory animals. Drinking water that meets this standard is associated with little to none of this risk and is considered safe with respect to heptachlor epoxide.

HEXACHLOROBENZENE

This organic chemical is produced as an impurity in the manufacture of certain solvents and pesticides. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed to high levels during their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods of time. EPA has set the drinking water standard for hexachlorobenzene at 0.001 part per million (ppm) to protect against the risk of cancer and other adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to hexachlorobenzene.

HEXACHLOROCYCLOPENTADIENE

This organic chemical is used as an intermediate in the manufacture of pesticides and flame retardants. It may get into water by discharge from production facilities. This chemical has been shown to damage the kidneys and the stomach of laboratory animals when exposed at high levels over their lifetimes. EPA has set the drinking water standard for hexachlorocyclopentadiene at 0.05 part per million (ppm) to protect against the risk of these adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to hexachlorocyclopentadiene.

LINDANE

This organic chemical is used as a pesticide. When soil and climatic conditions are favorable, lindane may get into drinking water by run-off into surface water or by leaching into ground water. This chemical has been shown to damage the liver, kidneys, nervous system, and immune system of laboratory animals such as rats, mice and dogs exposed at high levels during their lifetimes. Some humans who were exposed to relatively large amounts of this chemical also suffered damage to the nervous system and circulatory system. EPA has established the drinking water standard for lindane at 0.0002 part per million (ppm) to protect against the risk of these adverse health effects. Drinking water that meets the EPA standard is associated with little to none of this risk and is considered safe with respect to lindane.

METHOXYCHLOR

This organic chemical is used as a pesticide. When soil and climatic conditions are favorable, methoxychlor may get into drinking water by run-off into surface water or by leaching into ground water. This chemical has been shown to damage the liver, kidneys, nervous system, and reproductive system of laboratory animals such as rats exposed at high levels during their lifetimes. It has also been shown to produce growth retardation in rats. EPA has set the drinking water standard for methoxychlor at 0.04 part per million (ppm) to protect against the risk of these adverse health effects. Drinking water that meets the EPA standard is associated with little to none of this risk and is considered safe with respect to methoxychlor.

OXAMYL

This organic chemical is used as a pesticide for the control of insects and other pests. It may get into drinking water by run-off into surface water or leaching into ground water. This chemical has been shown to damage the kidneys of laboratory animals such as rats when exposed at high levels over their lifetimes. EPA has set the drinking water standard for oxamyl at 0.2 part per million (ppm) to protect against the risk of these adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to oxamyl.

PICLORAM

This organic chemical is used as a herbicide for broadleaf weed control. It may get into drinking water by run-off into surface water as a result of herbicide application and improper waste disposal. This chemical has been shown to cause damage to the kidneys and liver in laboratory animals such as rats when the animals are exposed at high levels over their lifetimes. EPA has set the drinking water standard for picloram at 0.5 part per million (ppm) to protect against the risk of these adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to picloram.

POLYCHLORINATED BIPHENYLS (PCBS)

These organic chemicals were once widely used in electrical transformers and other industrial equipment. They generally get into drinking water by improper waste disposal or leaking electrical industrial equipment. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods of time. EPA has set the drinking water standard for PCBs at 0.0005 part per million (ppm) to reduce the risk of cancer or other adverse health effects which have been observed in laboratory animals. Drinking water that meets this standard is associated with little to none of this risk and is considered safe with respect to PCBs.

PENTACHLOROPHENOL

This organic chemical is used as a wood preservative, herbicide, disinfectant, and defoliant. It generally gets into drinking water by runoff into surface water or leaching into ground water. This chemical has been shown to produce adverse reproductive effects and to damage the liver and kidneys of laboratory animals such as rats exposed to high levels during their lifetimes. Some humans who were exposed to relatively large amounts of this chemical also suffered damage to the liver and kidneys. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed to high levels over their lifetimes. EPA has set the drinking water standard for pentachlorophenol at 0.001 part per million (ppm) to protect against the risk of these adverse health effects. Drinking water that meets the EPA standard is associated with little to none of this risk and is considered safe with respect to pentachlorophenol.

SIMAZINE

This organic chemical is a herbicide used to control annual grasses and broadleaf weeds. It may leach into ground water or run-off into surface water after application. This chemical may cause cancer in laboratory animals such as rats and mice exposed at high levels during their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods of time. EPA has set the drinking water standard for simazine at 0.004 part per million (ppm) to reduce the risk of cancer or other adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to simazine.

TOXAPHENE

This organic chemical was once a pesticide widely used on cotton, corn, soybeans, pineapples and other crops. When soil and climatic conditions are favorable, toxaphene may get into drinking water by run-off into surface water or by leaching into ground water. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods of time. EPA has set the drinking water standard for toxaphene at 0.003 part per million (ppm) to reduce the risk of cancer or other adverse health effects which have been observed in laboratory animals. Drinking water that meets this standard is associated with little to none of this risk and is considered safe with respect to toxaphene.

2,3,7,8-TCDD (DIOXIN)

This organic chemical is an impurity in the production of some pesticides. It may get into drinking water by industrial discharge of wastes. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods of time. EPA has set the drinking water standard for dioxin at 0.00000003 parts per million (ppm) to reduce the risk of cancer or other adverse health effects which have been observed in laboratory animals. Drinking water which meets this standard is associated with little to none of this risk and should be considered safe with respect to dioxin.

2,4,5-TP

This organic chemical is used as a herbicide. When soil and climatic conditions are favorable, 2,4,5-TP may get into drinking water by run-off into surface water or by leaching into ground water. This chemical has been shown to damage the liver and kidneys of laboratory animals such as rats and dogs exposed to high levels during their lifetimes. Some industrial workers who were exposed to relatively large amounts of this chemical during working careers also suffered damage to the nervous system. EPA has set the drinking water standard for 2,4,5-TP at 0.05 part per million (ppm) to protect against the risk of these adverse health effects. Drinking water that meets the EPA standard is associated with little to none of this risk and is considered safe with respect to 2,4,5-TP.

RADIOLOGICAL CONTAMINANTS

Radionuclides found in drinking water are members of three radioactive series, uranium, thorium, and actinium and include the naturally occurring elements radium, uranium, and the radioactive gas radon. These contaminants may cause different types of biological damage. Radium concentrates in the bones and can cause cancers. Uranium can cause cancers in the bones and can have a toxic effect on kidneys.

There are two sources of radioactive contamination in drinking water. The first is naturally occurring radionuclides that are contained in the soil that water moves through. The second source of radioactive contamination comes from man-made sources.

THE STANDARD

1. Naturally occurring radionuclides:
    a. Combined radium-226 and radium-228: The Maximum Contaminant Level is 5 picocurries per Liter
    b. Gross alpha particle activity including radium-226 but excluding radon and uranium: The Maximum Contaminant Level is 15 picocuries per liter.

2. Man-made radionuclides:

    a. The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce a total annual exposure greater than 4 millirem/year.

    b. Except for those radionuclides listed below, the concentration of radionuclides in paragraph (a) above shall be calculated on the basis of a 2 liter per day drinking water intake using the 168-hour data listed in "Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air or Water for Occupational Exposure," NBS Handbook 69 as amended August 1963, U.S. Department of Commerce.

Average Annual Concentration Assumed to Produce an Exposure of 4 millirem/year:

- Tritium in the total body - 20,000 pCi/L
- Strontium-90 in the bone marrow 8 pCi/L

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