Ohio Department of Natural Resources
Division of Soil and Water Resources
Fact Sheet

Fact Sheet 97–47

Ground Water Quality

Introduction

Water is the most important natural resources on our planet. Water for consumptive use is divided into surface and ground water sources. According to the USEA, 48% of the United States population now utilizes ground water for their residential supply. That number is expected to continue to grow in the future. As a ground water user, it is important to understanding the issues of ground water quality.

Water quality is the composition of water as affected by natural processes and human activities. Water quality is the constituents dissolved or contained within the water. It is often thought that the chemical composition is the only factor involved. However, other conditions, such as biological, physical, and radiological factors should be considered when mentioning water quality.

Background

Ground water comes from the small percentage of precipitation that falls, infiltrates the ground, traveling downward, and fills the available pore spaces within rock, sand, gravel, and clay. This forms a large subsurface storage area of water that interacts with various rocks, minerals, microorganisms, and any man-made or natural materials that may seep from the surface. Any substance that comes in contact with the ground water can affect water quality.

Numerous tests can be run to analyze ground water for its major and trace constituents. These tests are available at many laboratories for a moderate costs. Upon receiving results of sample analyses the homeowner can then decide what measures to take to eliminate any unwanted components within the ground water. The following sections briefly list a variety of common ground water constituents, their effects on human health, and ways in which to correct the water quality problem.

Chemical Effects

Hardness

Probably the most common problem identified with ground water quality is that of hardness. Hardness is defined as water that is rich in calcium (Ca^{+2}) and/or magnesium (Mg^{+2}). Hard water generally causes the formation of soap curd in pipes, sinks, and bathtubs. Calcium may precipitate as calcium carbonate within the plumbing and clog pipes. Detergents and soaps do not readily dissolve in hard water, which limits the formation of lather and soap suds.

Calcium and Magnesium are primarily found in ground water due to the dissolving of limestone (primarily composed of calcium carbonates). The dissolving of limestone occurs when the limestone reacts with rainwater which has become slightly acidic through a reaction with carbon dioxide. Calcium and Magnesium ions are also released when the water reacts with naturally occurring gypsum.

Although it is commonplace and has no ill effects on human health, hard water can be an annoyance. The primary preventive measure is to install a water softener. The results are that the water has a slight soda taste and the formation of soap curd and mineral deposits are eliminated.

Total Dissolved Solids

Total dissolved solids (TDS), is defined as the concentration of all dissolved minerals in the water. TDS are a direct measurement of the interaction between ground water and subsurface minerals. High TDS, greater than 1000 mg/L, is commonly objectionable or offensive to taste. TDS levels over 2000 mg/L are generally considered undrinkable due to strongly offensive taste. A higher concentration of TDS usually serves as no health threat to humans until the values exceed 10,000 mg/L. At this level the water is considered a brine and defined as undrinkable. A high TDS (levels above 1,000 mg/L) may cause corrosion of pipes and plumbing systems. To remove TDS to acceptable levels, a water softener with a reverse osmosis (R/O) system is usually effective.

Iron

Iron (Fe^{+2}, Fe^{+3}) in ground water provides the typical well water "rust" taste. Not only is the taste unpleasant, iron can also stain plumbing fixtures, clothes, and dishes. Most ground water has at least trace amounts of iron because its presence in nature is so common. The Environmental Protection Agency (EPA) recommends that domestic water not exceed 0.3 mg/L. Iron concentrations exceeding this level may cause the characteristic reddish staining.

Iron is generally derived from minerals contained within the underlying bedrock. Limestone, shale, and coal which often contain the iron-rich mineral pyrite, are large contributors of iron. Acidic rainwater releases iron ions into solution.

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Treatment for the reduction of iron can be done by several methods depending upon the concentration and the pH of the water. Initially, a water softener can be used to eliminate iron to tolerable levels. Secondly, potassium permangnate or "green sand" filters are highly successful. Finally, aeration, the addition of oxygen to the water, can aid in the precipitation of iron, thus removing it from the water.

Nitrogen

Nitrogen typically is present in ground water in three forms: ammonia (NH_3), nitrate (NO_3-), and nitrite (NO_2^{-2}). Of the three, nitrite is the most toxic, yet usually occurs in the lowest concentrations.

Most nitrogen compounds found in the ground water are partially derived from the atmosphere. Specific plants can "fix" nitrogen from the atmosphere onto their roots. Nitrogen not used by the plant is released into the soil. In the soil, free reactions with water, minerals, and bacteria takes place. Secondary sources of nitrogen compounds include fertilizers, manure and urine from feedlots and pastures, sewage, and landfills.

Nitrates are especially toxic to children less than six months of age. Children who ingest nitrate may not have developed an immune system that can ward off the compound. A condition known as "blue-baby syndrome" may occur.

A variety of methods can be employed to remove nitrogen compounds from water. A reverse osmosis (R/O) system with a water softener can remove as much as 95% of nitrate and nitrite; however, ammonia may pass through. A negative ion-exchange method may also be used. This method is similar to the softening process and is also very effective in reducing nitrates and nitrites. Finally, if the origin is known, elimination of the source of nitrogen contamination may be the best corrective measure.

Silica

Silica (SiO_2), is a mineral commonly found in ground water. Not easily dissolvable in water, but held in suspension, silica is often found in concentrations as high as 100 mg/L. Concentrations lower than this are usually considered normal.

Silica is derived from the weathering of silicate minerals. Its abundance in ground water depends upon the amount of silicate minerals contained within the bedrock. Excess silica in ground water causes no harmful health effects. In extreme cases, silica can precipitate from solution and cause scaling within pipes and impede the flow of water.

Sulfur

Sulfur appears in two species, that of sulfide (S^{-2}) and sulfate (SO_4^{-2}). Sulfide is generally in the form of dissolved hydrogen sulfide gas (H_2S). Sulfides originate from areas such as marshes, oil wells, mines, and manure pits. Sulfates are principally derived from the dissolving of minerals such as gypsum ($CaSO_4*2H_2O$) and anhydrite ($CaSO_4$). Secondary sources of sulfates are from the weathering of pyrite and the dissolving of ammonium sulfate fertilizers.

Hydrogen sulfide gives the characteristic rotten egg smell that many people associate with sulfur. Sulfides can cause corrosion to plumbing, darken water, and create a foul odor and taste. Sulfates, at high levels, taint the taste of water and may create a laxative effect.

Treatment for the removal of sulfur in water can be done through many methods. Aeration is very effective in removing H_2S gas. Chlorination may be used to eliminate bacteria and the gas. Removal of sulfates may be conducted by an R/O system or a negative ion-exchanger.

Pesticides

A pesticide is a general term used to identify any substance applied to destroy or inhibit the growth of unwanted animals or plants. Pesticides include insecticides, herbicides, repellents, and fumigants. Most pesticides are toxic, at some level, to humans.

In Ohio, the two most widely used pesticides are atrazine and alachlor. Atrazine is the most common pesticide found in ground water. Although concentrations are usually in the part per billion range or less, continued consumption of these toxic compounds over a lifetime may be carcinogenic (cancer-causing). Studies throughout Ohio have shown that in most sites little or no amounts of pesticides are present in ground water.

Biological Effects

Microorganisms, more specifically bacteria, can be found virtually in any water sample. Most microorganisms contained within normal well water supplies do not pose a threat to human health. Bacteria are generally introduced into a well by foreign means. Foreign methods can range from contaminated drilling tools to an improperly sealed well casing.

Bacteria thrive in environments which contain iron, nitrogen, or sulfur compounds. Sources of these compounds may be derived from sewage, animal manure, and leaky septic systems. Well water serves as excellent living environments for bacteria. For example, iron-rich water encourages growth of iron bacteria. Proliferation of the bacteria can be so rapid that clogging of pipes may occur due to the formation of bacterial mounds. Dark brown slimy masses within toilet holding tanks are diagnostic of the presence of iron bacteria in water. No health hazards exist for the presence of iron in water, however, a high concentration of iron bacteria may cause health risks.

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Wells high in nitrate (>10 mg/L) and sulfate levels should be bacteriologically tested. Bacteria can convert nitrate in water to the more dangerous nitrite. Water rich in sulfur could contain bacteria which may convert sulfate ions to potentially toxic sulfide ions.

If it is determined that excessive amounts of bacteria are present in well water, a few corrections exist. Probably the least expensive method is that of chlorination. Chlorination is highly effective in destroying pathogenic (disease causing) organisms. Other more expensive methods include ultraviolet light radiation and physical filtration.

Physical Effects

Turbidity

Turbidity refers to any solid or organic material that does not settle out of water. This means that the material is not dissolved but is in suspension. Such material includes dust particles and colloidal organic matter.

Suspended solids are rarely harmful, yet elimination of turbidity is important. Initially, it increases the aesthetic quality of the water. Clear water is more appealing to drink. Secondly, toxic contaminants can cling to suspended particles, which in turn may be ingested by humans and cause health problems. It is important to look for causes of the turbidity when trying to treat the water. Turbidity in a well is often caused by improperly installed well casing, damaged well casing or a missing well cap. One treatment method is a filtration system.

pH

Another common problem is that of low pH. Low pH water is acidic. The primary causes of low pH are the addition of acidic rain water or local mining activities. Other ions found in ground water such as nitrates and sulfates may result in lower pH.

The negative effects of acidic water are many. Highly acidic water may result in pipe corrosion, causing the possible release of iron, lead, or copper into the tap water. A low pH may discolor the water and give it a bitter taste.

The best method in which to reduce the acidity of ground water is to increase the pH by filtering the water through a neutralizer such as calcite chips. Running the water through the calcite raises the pH to a neutral level, thus reducing release of metals through pipe corrosion.

Radiological Effects

Radon and radium have recently received much publicity regarding possible health risks to humans. Radium is a radioactive solid produced from the decay of uranium. Radon is a radioactive gas produced from the decay of radium.

Naturally occurring radioactive material typically appears in trace amounts throughout Ohio. Radioactive material is found within the shale, as well as glacially deposited granitic and metamorphic rocks. Ohio has substantial reserves of shale that produces natural radioactivity.

Ground water rarely contains radioactive matter. If radon or radium are discovered, treatment is simple. Dissolved radon gas can be released through aeration of the water. Radium is easily removed through a water softener or R/O system.

Summary

Because our reliance on ground water is continuously increasing, the knowledge of our water quality is important. This knowledge is important because it affects our lives daily. Understanding the constituents contained within ground water and more important, how they affect us, is invaluable information.

If you wish to obtain more information about water quality, or have any specific questions about this fact sheet, please feel free to give us a call or stop by, our phone number and address are:

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