Minnesota Pollution Control Agency

Environmental Outcomes Division

Ground Water Monitoring & Assessment Program

Iron in Minnesota's Ground Water

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What is iron?

Iron is a chemical element that is widely distributed in geologic materials. Iron is slowly released from soil and rocks to ground water.

The fate of iron in ground water depends on the form of iron present. Under reducing conditions, ferrous iron (FeII or Fe^{+2}) occurs. Under oxidizing conditions, ferric iron (FeIII or Fe^{3+}) dominates. Concentrations of ferrous iron in ground or surface water may be more than 1 mg/L (part per million). Ferric iron, although relatively insoluble, forms complexes with other chemicals or with suspended material.

What are sources of iron in ground water?

Most iron in Minnesota's ground water occurs naturally. Iron exists at high concentrations in many types of rocks. Concentrations may be as high as 40,000 mg/kg (parts per million) in igneous rocks, but less than 8,000 mg/kg in limestone and dolomite.

There are many industrial applications for iron, including use in machinery and structural materials. Consequently, iron concentrations in soil impacted by these materials can be very high. An example is soil beneath metal recyclers. However, despite these high concentrations, only small quantities of iron are likely to leach to the ground water.

What is considered a safe level of iron in ground water?

The Secondary Maximum Contaminant Level (SMCL) for iron is 0.30 mg/L. This standard is not based on human health effects. Iron stains plumbing fixtures and clothing. The SMCL is based on the concentration of dissolved iron in ground water.

How is iron distributed in Minnesota ground water?

Iron exceeded the SMCL of 0.30 mg/L in about 70 percent of the wells sampled in the Ground Water Monitoring and Assessment Program (GWMAP) statewide baseline network of 954 wells. The concentration of dissolved iron will be smaller since samples were not filtered. Nevertheless, dissolved concentrations are likely to be high in many samples, since iron concentrations were strongly correlated with oxidation-reduction conditions in ground water. This means that as more reducing conditions occur, more iron enters into solution, as would be expected. The median concentration of iron in all aquifers was 0.95 mg/L. Concentrations tended to be lowest in Precambrian and Paleozoic bedrock aquifers (approximately 0.30 and 0.70 mg/L, respectively) and highest in Cretaceous and buried Quaternary aquifers (more than 1.1 mg/L).

Which aquifers are most sensitive to contamination with iron?

More iron enters into solution as the age of ground water increases. This is because iron is released slowly from geologic materials. Concentrations of iron exceed 1 mg/L in aquifers occurring in geologic materials that contain large amounts of iron, such as Cretaceous and some Precambrian deposits. Concentrations are also high in aquifers with reducing conditions, such as many of the buried Quaternary aquifers. Aquifers with reducing conditions are characterized by low concentrations of oxygen and nitrate and Eh values less than about 250 mV. Under these conditions, microbes utilize ferric iron during food consumption. Conversion of ferric iron to ferrous iron results in dissolved iron concentrations that exceed the SMCL. Aquifers occurring in low-iron rocks, such as some of the Precambrian deposits, and aquifers containing oxygen, will have iron concentrations less than 0.10 mg/L.

Why is it important to measure iron concentrations in ground water?

Iron is an important chemical to measure. Many processes that occur in ground water are affected by iron. Iron concentrations also provide an indication of chemical conditions occurring in ground water. For example, trace inorganic chemicals that pose a potential health concern, such as arsenic, boron and lead, are associated with iron in ground water. Presence of high concentrations of ferrous iron also reflects reducing conditions in ground water. Under these conditions, chemicals such as nitrate and possibly some chlorinated solvents are degraded, while some chemicals associated with gasoline and fuel oils persist.

What are some management strategies for reducing risks from iron?

Ferric iron can be filtered from water, since it will be associated with organic matter and other chemicals. Distillation may also be effective in reducing iron concentrations.

Additional information, including reports and distribution maps, can be found on the Minnesota Pollution Control Agency's Web site at ***http://www.pca.state.mn.us/water/groundwater/gwmap/index.html***.