Minnesota Pollution Control Agency

Environmental Outcomes Division

Ground Water Monitoring & Assessment Program

Selenium, Molybdenum, Vanadium and Antimony in Minnesota's Ground Water

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What are selenium, molybdenum, vanadium, and antimony?

Selenium, molybdenum, vanadium and antimony are chemicals found in small quantities in soils and rocks. Molybdenum and vanadium are classified as transition metals, while selenium and antimony are not metals. However, all of these chemicals can be relatively mobile in soils and therefore impact ground water.

What are sources of selenium, molybdenum, vanadium and antimony in ground water?

Selenium, molybdenum, vanadium and antimony are found in rocks at concentrations less than 10 mg/kg (parts per million). Their concentrations in soil is usually greater their concentrations in rocks. Selenium and vanadium occur at high concentrations in some shales. Antimony and molybdenum occur in a variety of anthropogenic wastes, including fossil fuel combustion products, sewage sludge and mining waste. Antimony is used in fertilizers, pigments, flame retardants and explosives. Molybdenum is used in fertilizers and alloys. Uses for selenium include pigments, rubber, steel and phosphate fertilizers. Vanadium has minor application in industry. Although these chemicals do not have wide use in commercial applications, their mobility in soil makes them chemicals of potential concern when they are released to the environment.

What are considered safe levels of selenium, molybdenum, vanadium and antimony in ground water?

The Minnesota Department of Health (MDH) established health risk limits (HRLs) of 30, 50 and 6 ug/L (parts per billion) for selenium, vanadium and antimony, respectively. A HRL is the concentration of a contaminant in ground water that is safe to ingest daily over a lifetime. The HRL was established based on observed effects in animal studies, although specific endpoints (for example, the kidneys or cancer) have not been identified. A health-based value (HBV) of 30 µg/L has been established for molybdenum. HBVs are similar to HRLs except that they have not been promulgated into law.

How are selenium, molybdenum, vanadium and antimony distributed in Minnesota ground water?

The drinking water standards for selenium, molybdenum, vanadium and antimony were exceeded in seven, one, two and one sample, respectively, in

wells sampled from the Ground Water Monitoring and Assessment Program (GWMAP) statewide baseline network of 954 wells. Median concentrations of these chemicals were 2.0, less than 4.2, 4.8 and 0.016 µg/L, respectively. Although median concentrations were low (less than 10 percent of the drinking water standards), the chemicals were not distributed uniformly across aquifers. Concentrations of selenium were highest in the Quaternary aquifers and lowest in the Paleozoic bedrock aquifers, such as the Jordan and Prairie du Chien aquifers. Concentrations increased to the west and south as well as in oxygenated waters. This suggests that selenium leaches through the soil to ground water. Concentrations of antimony were highest in the Cretaceous, Precambrian and Prairie du Chien aquifers, and lowest in the Jordan and St. Peter aquifers. Antimony concentrations were not related to any other measured parameter. Differences in concentrations of geologic materials comprising the aquifer account for differences between aquifers. Concentrations of vanadium were highest in the Cretaceous, Galena, Precambrian and surficial Quaternary aquifers, and lowest in the buried Quaternary, Franconia and Jordan aquifers. Concentrations of vanadium were most strongly related to concentrations of other metals, such as nickel and cobalt. Elevated concentrations of vanadium appear to be primarily related to geology, although the high concentration in surficial aquifers suggests that soil leaching can also be important. Molybdenum was not detected in 71 percent of the samples, making it difficult to determine the factors that affect its distribution in ground water. Molybdenum concentrations were related to concentrations of arsenic and boron, suggesting a geologic source.

Which aquifers are most sensitive to contamination with selenium, molybdenum, vanadium and antimony?

Aquifers do not appear to be sensitive to naturally occurring concentrations of antimony, molybdenum and vanadium. Selenium occurs at higher concentrations in surficial Quaternary aquifers. For each of these chemicals, shallow ground water is potentially at risk because these chemicals are relatively mobile in soil. Nonpoint, anthropogenic sources, such as combustion of fossil fuels, do not appear to be important. Point sources, such as a landfill, represent a much greater threat to shallow ground water.

Why is it important to measure selenium, molybdenum, vanadium and antimony concentrations in ground water?

Selenium should be sampled in surficial aquifers of western Minnesota. Molybdenum and antimony are occasionally found at high concentrations near point sources. Vanadium is rarely found at high concentrations. It is therefore important to sample for these chemicals only when a potential source has been identified.

What are some management strategies for reducing risks from selenium, molybdenum, vanadium and antimony?

Considering results of this study, there are no management strategies necessary for naturally occurring concentrations of selenium, molybdenum, vanadium and antimony. Sewage sludge or other wastes with high concentrations of these chemicals should not be disposed of on permeable soils overlying shallow aquifers.

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***.