Guidelines at a Glance

Canadian Soil Quality Guidelines

Selenium

This fact sheet describes the Canadian Soil Quality Guidelines for selenium to protect environmental and human health. It is part of the series *Guidelines at a Glance*, which summarizes information on toxic substances and other parameters for which there are Canadian Environmental Quality Guidelines.

The National Guidelines and Standards Office of Environment Canada coordinates the development of Canadian Environmental Quality Guidelines in cooperation with the Canadian Council of Ministers of the Environment (CCME).

Where does selenium come from?

Selenium (Se) is a non-metallic element that occurs naturally in the earth's crust at concentrations of approximately one twentieth of a part per million. Se occurs in various forms, ranging from a grey metallic to a reddish glassy appearance, and is found in various rocks and minerals, coal, and oil.

Canada is among the world's largest producers of Se. The main markets for Se are electronics and photography, glass manufacturing, pigments, additives for metal processing, and agricultural/biological applications (e.g., as an additive to animal feeds and fertilizers). These, and other activities by humans, like copper refining operations and burning of coal and oil, release Se into the environment.
The major natural sources are the weathering of rocks, soils, and minerals, volcanic activity, and deposition (for example, through rainfall) of Se compounds present in the atmosphere.

What happens to selenium released into the environment?

The various forms of selenium behave differently in the environment. Heavy metal selenides, selenium sulphides, selenites, and selenates all vary in solubility (that is, their ability to dissolve in water). Selenates (salts containing one Se atom and four atoms of oxygen) are among the most mobile Se compounds due to their high solubility and inability to cling onto soil particles. Thus, they are readily taken up by microorganisms in the soil or leached through the soil. Selenites (salts containing one Se atom and three atoms of oxygen) are less soluble than selenates. Elemental Se is common in some soils, but does not dissolve much in water and therefore is not likely to be taken up by living organisms.

While both selenates and selenites are accumulated by terrestrial plants, selenates are more readily taken up from the soil because of their greater solubility. Elemental selenium, organic, and inorganic forms of selenium may be chemically transformed by soil microorganisms into a vapour that will enter the atmosphere. The transformation of Se in soils (and plants) to a vapour, its movement to the atmosphere, followed by its return to soil through precipitation and the settling of dust from the atmosphere, is the major natural process for cycling of Se in the environment.

The Canadian population is exposed to Se compounds in ambient air, drinking water, soil, and food. For most humans, the greatest Se exposure is through food; it has been estimated that more than 98% of the total daily intake of Se occurs through food consumption.

What effects can selenium have on terrestrial forms of life and humans?

Toxic effects of Se have been demonstrated in bacteria, fungi, algae, plants, and invertebrates. Indications of Se toxicity in plants include stunting, yellowing of the leaves, yield reduction, and reduced shoot weight. Effects observed in invertebrates (i.e., beetles and earthworms) include reduced survival and decreased reproduction.

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Terrestrial mammals and birds are exposed to Se primarily through the food chain. Selenium is nutritionally required by animals in small amounts, but can become toxic in slightly greater amounts. For livestock, the threat of having too little Se is considered by some scientists to be a greater threat than having too much Se. Livestock that consume feed or plants with excessive levels of Se can develop blind staggers (a disease characterized by disorientation, abnormal gait, and circling) and/or alkali disease (characterized by emaciation, lameness, hair loss, and hoof malformations). Other effects of Se toxicity in mammals include damage to the liver, inflammation of the kidneys, hyperemia (excessive amounts of blood in an organ), ulceration in the upper gastro-intestinal tract, reduced conception, and increased fetal resorption. Sheep appear to be particularly sensitive to the toxic effects of Se. In birds, Se can cause fewer eggs to hatch, a higher death rate of chicks, abnormal development, reproductive effects, and suppression of the immune system. The evaluation of Se toxicity is complicated by its occurrence in many different chemical forms that differ greatly in their toxicity.

Selenium is also an essential trace element in human nutrition. The recommended daily intake of Se is approximately 1 microgram per kilogram of body weight per day. It is a unique element in that there is a small margin of safety between levels of Se compounds that will cause dietary deficiency and those that result in toxicity. Many symptoms of Se toxicity are remarkably similar to those observed in cases of Se deficiency. In general, people exposed to very high levels of Se through their diet have reported dizziness, fatigue, irritation, collection of fluid in the lungs, and severe bronchitis. Upon contact with skin, Se compounds have caused rashes, swelling, and pain. High blood levels of Se can also result in a condition called selenosis, which produces symptoms of garlic odour breath, thickened and brittle nails, hair and nail loss, reduced hemoglobin, mottled teeth, skin lesions, and pain or numbness in the limbs. There is no human evidence of reproductive effects, developmental abnormalities, or cancer due to Se exposure.

What levels of selenium are safe for humans, and for plants and animals that live in or on Canadian soils?

The Canadian Soil Quality Guideline (CSoQG) to protect against adverse effects to environmental and human health on agricultural and residential/park lands is 1.0 milligram of selenium per kilogram of soil. The CSoQG to protect against adverse effects to environmental and human health on commercial and industrial lands is 3.9 milligrams of selenium per kilogram of soil. These guidelines are based on a number of scientific studies that examined the impacts of Se on humans and on the plants and animals that live in or on our soils.

If the level of Se measured in soil is less than the corresponding guideline, one would not expect to see adverse health effects in the plants and animals that live there. In places where the CSoQGs for Se are exceeded, adverse effects may not necessarily occur. Whether effects will occur depends on the amount by which the guideline levels are exceeded, what kinds of plants and animals live there, and on other characteristics of the soils (e.g., organic carbon content and pH). Further investigation at a particular site is needed to actually determine whether or not there is a negative impact.

How do levels of selenium in Canadian soils compare to the guidelines?

Data on levels of Se in Canadian soil are limited. In Ontario, approximately 98 percent of soil samples from rural parkland and old urban parkland contain soil concentrations of Se below the guideline values. A study of a variety of soil types from 53 sites across Canada, representing all provinces and territories except Manitoba, found naturally-occurring Se concentrations to range from 0.03 to 2 milligrams per kilogram of soil, with an average of 0.26 milligrams of Se per kilogram of soil. Natural background concentrations of Se can occur in some areas of Canada at levels greater than the CSoQGs; however, in most places where the guidelines are exceeded, it is due to human activities.

How can CSoQGs be used to make a difference?

In general, Canadian Soil Quality Guidelines can be used by Canadian federal, provincial, and territorial governments on a voluntary basis to set local guidelines and clean-up targets. CSoQGs are most commonly used in environmental assessments as benchmarks or yardsticks to which measured levels are compared. Anyone can use the guidelines to determine if the level of Se measured in a soil sample has the potential to cause adverse environmental effects.

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