



Benzene

This fact sheet describes the Canadian Soil Quality Guidelines for benzene 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 benzene come from?

Benzene is a colourless, flammable liquid that occurs naturally and is also produced by humans. Natural sources of benzene are petroleum seeps, forest fires, volcanic eruptions, and volatile emissions from vegetation. Natural emissions of benzene are small compared to human emissions. Most benzene production in Canada is from petroleum refining and processing. Natural gas and coal processing also release benzene to the environment.

Benzene is used during the manufacturing of some chemicals and pharmaceuticals. Benzene is also an ingredient in solvents and paints, although other compounds are beginning to replace benzene in these products. Benzene exists naturally in petroleum, and therefore it is found in gasoline. Benzene is typically 1 to 4% of gasoline. Since 1995, reductions in the benzene content of gasoline, increases in the use of fuel-efficient vehicles, and changes to chemical manufacturing and various industrial processes have contributed to declining benzene emissions to the Canadian environment. The Canadian Council of Ministers of the Environment reported a 39% decrease in benzene emissions from 1995 to 1999.

What happens to benzene released into the environment?

Benzene can be very mobile when released into the environment. There are four main routes that benzene takes: (i) Benzene easily evaporates into the atmosphere from surface soils (top 1.5 metres). One study found that more benzene evaporated from sandy surface soil than from clay-rich surface soil. (ii) If benzene is spilled as a liquid, it flows into the ground, filling the spaces between soil particles. There, benzene binds to soil, particularly to organic matter such as decaying plants. (iii) When plenty of oxygen is available, soil microbes degrade benzene. (iv) Benzene is fairly soluble in water, so rainwater leaching through the ground can carry benzene into groundwater aquifers.

What effects can benzene have on terrestrial forms of life?

Benzene toxicity has been found in a limited number of studies of soil microbes, invertebrates, plants, and mammals. Respiration rates of soil microbes declined when microbes were first exposed to benzene, but after several days the effects were minimal. The growth and survival of earthworms and an insect species were reduced at high benzene concentrations. Barley, carrot, and tomato plants sprayed with benzene showed cell damage, and lettuce and radish seeds exposed to benzene in the soil were less likely to emerge as seedlings.

In mammals, benzene slows down nerve transmission, depresses the central nervous system, lowers the capacity of blood hemoglobin to hold oxygen, and reduces the ability of cells to bind molecules involved in the hormone system. Laboratory rats and mice exposed to benzene have developed cancer. A study examining the effects of benzene exposure on survival found different responses between species (rats died, rabbits lived) and between sexes (more male rats died than female rats). There are no studies of the effects of benzene on livestock, wildlife, or birds.



Guidelines at a Glance

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

The Canadian Soil Quality Guidelines (CSoQG) depend on the type of land and its use. The four land uses considered are agricultural, residential and parkland, commercial, and industrial. The guidelines also distinguish soil textures (coarse and fine) and soil depths (surface soil: ≤ 1.5 metres deep, and subsoil: > 1.5 metres deep). The guidelines are based on a number of toxicity studies that examined the effects of soil contact on plants and animals that live in or on our soils. In the case of agricultural land, the effects of soil and food ingestion are also considered. Guidelines for human health are based on a lifetime incremental cancer risk from benzene of either one in one million people, or one in one-hundred-thousand people. Individual jurisdictions in Canada have different policies on which of these incremental cancer risks to use.

For fine-textured soils with all land uses and either incremental cancer risk level, the CSoQG to protect environmental and human health is 0.0068 milligrams of benzene per kilogram of soil for both surface soils and subsoils.

For coarse-textured soils on agricultural land and residential/parkland, at an incremental cancer risk of one in one million, the CSoQG to protect environmental and human health is 0.0095 milligrams of benzene per kilogram of soil for surface soils and 0.011 milligrams of benzene per kilogram of soil for subsoils.

For coarse-textured soils on industrial and commercial lands at an incremental cancer risk of one in one million, and for all land uses at an incremental cancer risk of one in one-hundred-thousand, the CSoQG to protect environmental and human health is 0.030 milligrams of benzene per kilogram of soil for both surface soils and subsoils.

If the level of benzene measured in soil is less than the respective guideline, one would not expect to see adverse effects. In places where the CSoQG for benzene is exceeded, adverse effects will not necessarily occur. Whether effects will occur depends on the amount by which the guideline level is exceeded and on the plants and animals that live there. Further investigation is needed at a particular site to determine whether or not there is a negative impact.

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

Very little information is available on the levels of benzene in Canadian soils. A study in Ontario examined soil samples collected near a petroleum plant in Port Credit and a refinery in Oakville. The study found that two-thirds of the samples had benzene levels below 0.002 milligrams per kilogram of soil, which is within all of the guidelines. The other one-third of samples had benzene levels ranging from 0.002 to 0.16 milligrams per kilogram of soil. The upper end of this range exceeds the CSoQGs listed above.

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 benzene measured in a soil sample has the potential to cause adverse environmental or health effects.

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