

ARSENIC in Garden Soils

Should I Be Concerned?

What is arsenic?

Arsenic (As) is an element that occurs naturally in the earth's crust. Arsenic can be classified as inorganic or organic, based on its chemical form, and is found in many kinds of rock.¹

Where does arsenic in the soil come from?

Arsenic exists naturally in soil in many areas, but it can also occur above natural "background" levels due to human activities. Important drivers of arsenic levels in urban soils include:

- 1 Naturally occurring arsenic in soil
- 2 Industrial sources of arsenic nearby, and
- 3 The use of garden materials made of treated wood

Nationwide, there is a range of naturally occurring arsenic levels in soils, mostly due to variations in rock formations that contain arsenic. The average soil concentration of arsenic in undisturbed areas in the U.S. ranges from 0.1 to 97 parts per million (ppm) with an average of 7.2 ppm.² A study of 3,286 soil samples in North Carolina by the North Carolina Department of Agriculture found average North Carolina arsenic background levels of 4.5 ppm³ and a US Geological Survey study of 83 samples from across North Carolina found an average concentration of 3.7 ppm of total arsenic.⁴

Arsenic has many historic and current uses in industry and agriculture, though several uses have been phased out in recent years. Inorganic arsenic was used as a pesticide in the early 20th century, although that use is no longer allowed. Organic arsenic (a compound containing arsenic and carbon) is used in agricultural products⁵ and pesticides.⁶ Arsenic is also produced from industrial processes like pyrotechnics and bronzing.³

Inorganic arsenic was also used in chromated copper arsenate (CCA) treated wood to prevent wood rotting and decay but CCA is no longer used in decks and playgrounds.⁷ Cultivated soils lined with arsenic treated wood show slightly elevated arsenic concentrations compared to soils lined with non-treated wood, but the difference is small.⁸



How might I be exposed to arsenic in the garden?

Overall, the potential exposure through soil in your garden is likely to be much lower than the exposure to naturally occurring arsenic from food we buy or from water sources that contain high levels of arsenic.⁶ Arsenic is widely distributed in U.S. soils, so most people are exposed to very small amounts of arsenic. This low level exposure generally does not pose risks to human health, but exposures may be higher where soil is high in arsenic.⁶ Any health risks from arsenic are based on what type of arsenic you are being exposed to: inorganic arsenic can pose harm to health, while studies have shown that organic arsenic compounds are relatively nontoxic to people.⁵

People can be exposed to arsenic in the garden by touching soil directly, breathing in dust, or by eating vegetables that are grown in arsenic contaminated soil. In garden produce, very low amounts of arsenic are transported to the fruit (e.g., tomato, pepper, squash) or seeds of the crop, and root vegetables such as carrots and onions may carry arsenic dirt residues.³ Two crop varieties that are known to take up relatively higher concentrations of arsenic are carrots (roots)⁶ and rice (seeds).⁷ One recent study indicated that plants like broccoli and kale tended to accumulate higher amounts of arsenic.⁹ However, even in contaminated soils, the uptake of arsenic into most crops occurs at such low levels that it is generally not detected. As such, the likelihood of exceeding safe levels of arsenic through eating vegetables grown in the garden is low.⁶

Human exposure to arsenic from eating soil directly is also low, due to the generally low bioavailability of arsenic in soil. Breathing contaminated soil is a minor pathway for arsenic exposure,¹⁰ and exposure to arsenic in air is less than 1% of the total exposure from other sources such as water and food.⁶ Arsenic is not easily absorbed through the skin after contact with the soil.¹¹ Direct skin contact with treated wood is of more concern than contact with soil.¹¹

Arsenic exposure beyond the garden

The food we eat is a significant source of arsenic exposure for the average U.S. citizen. Other significant sources of exposure include drinking contaminated well water, smoking, or living near mining or other industrial or hazardous waste sites.¹² Arsenic in the diet comes from many sources, including water, grains, fish, and produce² but rice and other cereals are a significant source of inorganic arsenic in food.¹³

Are there regulations for arsenic in soil?

The state of North Carolina has adopted the U.S. EPA's residential health-based Preliminary Soil Remediation Goals (PSRG) for soil contaminants in North Carolina. For arsenic, the PSRG is 0.68 ppm for inorganic arsenic in soil, which is lower than most commonly detected average background concentrations of arsenic in soil.^{3,4} The U.S. EPA uses conservative, health-protective guidelines when they are assessing risk, and because North Carolina has fairly high levels of naturally occurring arsenic, it is possible that your soil sample showed levels above the PSRG. Risk assessors in North Carolina take into account natural background levels when they are determining human health risks at an individual site. Recall that there are also different species (forms) of arsenic, with inorganic arsenic being toxic and organic arsenic being relatively nontoxic. Unfortunately, we do not currently know the type of arsenic in your soil sample.

There is no official arsenic "safe" reference level of arsenic exposure for the general population in the United States. For context, however, the U.S. FDA has an action level of 100 ppb (parts per billion) of inorganic arsenic in infant rice cereal.¹⁴

How can arsenic affect health?

It is important to know that the level of exposure to arsenic that would likely lead to health effects is typically much larger than the level a typical gardener will experience from exposure to garden soils.

The health effects of arsenic depend on a few different factors including:

- The type or species of arsenic (inorganic vs. organic)
- How bioavailable the arsenic is (how readily your body absorbs and processes it)
- How much you are exposed to and for how long
- Other individual factors like age, genetics, height and weight, etc.
- How much total arsenic you are receiving from other sources

Historical concerns about arsenic contamination and exposure come from studies of exposure to contaminated drinking water, particularly in natural, shallow, or untested wells. Arsenic in water is the more toxic, inorganic form. High concentrations of inorganic arsenic in drinking water are linked to various cancer and non-cancer adverse health effects.⁶ Breathing inorganic arsenic from soil dust can cause gastrointestinal effects along with central and peripheral nervous system disorders, but this exposure pathway is expected to be of limited impact in gardens. Oral exposure can also cause cardiovascular effects along with liver, kidney, and blood disease.¹⁵

What can I do to reduce my arsenic exposure in the garden?

There are several steps you can take to reduce exposure to arsenic at your garden. Studies have shown that the addition of organic matter, such as compost, and lime (which lowers acidity) can reduce the uptake of arsenic by crops.^{16,10} This strategy has been used in heavily contaminated areas in order to significantly reduce the arsenic uptake into vegetables. The addition of compost or phosphorous have also been shown to decrease the bioavailability of arsenic.¹⁰ If there is wood treated with CCA in the garden it should be removed along with the surrounding soil, in order to reduce potential arsenic exposure.¹⁷

Some general best practices for urban and community gardens include the following (adapted from U.S. EPA)¹⁷:

- Maximize the distance of your garden from large roadways and industrial factories, or if needed create a physical barrier such as a fence, in order to reduce windblown or mobile sources of contaminants.
- Cover soil with mulch, stones, or fabric to reduce erosion and movement of soil particles.
- Build raised beds or container gardens using non-treated wood such as cedar.
- Line the bottom of the garden plot with a water permeable fabric in order to reduce contamination or exposure to soils of concern.
- Wear gloves while in the garden and wash hands after working.
- Avoid bringing dirt into the house by taking off dirty shoes and other gear outside.
- Thoroughly wash all garden produce before eating or storing, along with peeling all root crops and removing the outmost leaves of leafy vegetables.

It is also important to remember that there are many health benefits to home and community gardening that may far outweigh the possible negative effects of soil contamination.¹⁸



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