



Soil Testing for Environmental Contaminants

Interpreting Your Heavy Metals Test Results

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What Are Heavy Metals?

Heavy metals are a class of elements that include lead, copper, arsenic, and cadmium, and can be toxic to humans and plants if ingested in high enough quantities. Soils have often been the landing spot for heavy metals, chemicals, and wastes as byproducts of industrial and agricultural pollutants. Many of these metals are present in soils naturally, usually in small amounts, although the natural level may vary.

If you are concerned about heavy metals on your land, you should have the soil analyzed by a laboratory for heavy metal content before using it for a vegetable garden, farm site, or children’s play area. Heavy metals are more of a concern in urban areas, especially when near sites historically used for industry. Certain contaminants, when present in high amounts, can cause detrimental effects on humans, animals, and plants. With proper care and treatment, contaminated soils can be remediated and used safely.

The UNH Cooperative Extension Soil Testing Program offers a series of analyses for certain heavy metals. Our “Environmental Package” includes analysis for total cadmium, chromium, copper, nickel, lead, and zinc. We also offer individual analyses for total arsenic, mercury, molybdenum, and selenium. These analyses are done using EPA methods.

Interactions between heavy metals and soil constituents (clay, organic matter, pH, etc.) are fairly complex; therefore *we suggest that you also request the standard fertility analysis and organic matter if you are concerned about contamination.* This will allow us to interpret the results and suggest some approaches to minimize the risk of plant uptake.

Why Should I Be Concerned and Which Metals Are of Greatest Concern?

Very low concentrations of these metals are necessary for plant nutrition and human health, and are found in plant tissue and the human body. Testing positive for these metals is common in soil, it is only in high concentrations when precautionary measures should be taken. Unlike plant nutrients, heavy metals break down very slowly; without remediation they can exist in the environment for a very long time.

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Did You Know?

Lead does not degrade and can remain in the soil for thousands of years. Lead accumulates on the top 1 to 2 inches of the soil as it binds tightly to soil particles and organic matter.



A single exposure to metals at a low concentration may not produce any lasting health effects, but repeated exposure over a long period of time can prove detrimental—especially for children who are more sensitive.

Lead poses the greatest concern because it is the most common contaminant and is most likely to exceed health based guidance values in the United States (McBride et al., 2014). Lead does not degrade and can remain in the soil for thousands of years. Lead accumulates on the top 1-2 inches of the soil as it binds tightly to soil particles and organic matter. Paint manufactured before 1978 is likely to be lead-based; therefore, vegetable gardens should be located away from these high risk areas. In addition to lead, cadmium and mercury are the most likely to pose the greatest health risk to humans.

Elevated levels of copper, nickel, and zinc can cause plant toxicity, while cadmium and arsenic can be of concern to human health. *Any metal testing positive in soils at a high rate should be of concern, but each case is unique based on characteristics of the site.*

Where Did They Come From?

There are significant correlations between soil type and land use history and heavy metal contamination. Knowing the history of the site will help explain how the contamination arrived. For example, historical use of metal-containing pesticides, industrial pollution, or dumping could be the cause of contamination. Land surrounding old houses containing lead paints commonly test high in lead. Lead pipes and motor vehicle exhaust also produce soil lead contamination. Car repair sites or garages might also be high in heavy metals. In areas where coal was burned, certain pesticides were used, or old mining sites remain in place, soils could be high in arsenic. Treated lumber can also contain arsenic, although pressure treated lumber for residential use no longer contains arsenic in the United States. Metals may be more ubiquitous in urban areas where construction, transportation, manufacturing, and fossil fuel combustion are more common.

Today, we understand the danger of such products and have created federal regulations against dumping of heavy metals and pollutants into the environment. Many materials no longer contain these toxins, and systems have been implemented to properly dispose of toxic materials. As a result, much less heavy metal contamination occurs. As an example, biosolids (or sewage sludge) applied to land previously contained heavy metals. Today, steps are taken to remove those metals before land application. Standards created by the U.S. Environmental Protection Agency limit heavy metals in all biosolids applied to land. All material is now tested before being used.

Generally, all soils will test positive for heavy metals because metals are found naturally in the earth's crusts and soil parent materials.

Routes of Exposure

Gardeners, children, and animals can be exposed in a number of ways:

- √ Eating soil (including soil attached to fruits and vegetables)
- √ Absorbing contaminants through skin
- √ Breathing volatiles and dust particles
- √ Eating fruits and vegetables that have absorbed contaminants.

For these reasons, it is important to wash all your garden produce and reduce your direct exposure if your soils are contaminated. When working in the soil you can easily breathe in soil particles or accidentally ingest soil. If your soils test high, limit this type of activity and always wear gloves when working in the soil.

Plants can also suffer from heavy metal contamination, this is called phytotoxicity. Generally, plants are affected at a much lower level than what is considered toxic to humans.

Interpreting Your Results

Soil type, pH, and how a plant grows, can have a great influence on metal uptake by plants and humans. For example, uptake of lead is generally low when pH is high because metals are locked-up (immobilized) by soils. Keeping soil pH near neutral (pH of 7.0) will help reduce exposure risks. (“Soil Screening Guidance: User’s Guide.” July 1996. EPA Document Number: EPA540/R-96/018).

The U.S. Environmental Protection Agency as well as the New York Department of Environmental Conservation and New Hampshire Department of Environmental Safety have taken many background soil tests to establish limits on heavy metals. Due to the natural variability of soils and of heavy metals and the various uses of soils, these numbers do not always match. Different soils were screened for different purposes and the recommended levels therefore vary. The U.S. EPA established conservative soil screening levels. If your soil tests above these limits, further evaluation will be needed.

The U.S. EPA levels do not define “unacceptable” levels; additionally, many states have developed more stringent screening levels. Soils from N.H. were pulled from twenty different sites in urban and rural communities.

Use Table 1 as a guide to help aid in your decision making. *Every soil has a unique history and the purpose or use of that soil may widely vary.* If your soils test at or below the average level for New Hampshire soils there should be little cause for concern. *It is best to discuss your results with your local Extension specialist or a soil scientist who can help you interpret your results.*

Remember: A soil test offers but a single guideline to assist your decision making. Correlations between soil heavy metals and vegetable heavy metal concentration are very weak. Predicting exposure from consuming contaminated crops based on soil concentration is very difficult, and therefore your best judgment should be used as to the appropriate use of potentially contaminated soil.



Did You Know?

Children have a much lower tolerance to heavy metals. They should always wash their hands after playing outside, even in low-contaminated soils.



Notes:

¹ Sanborn, Head & Associates, Inc (SHA). Background metals concentration study, New Hampshire soils, New Hampshire Department of Environmental Services, Concord, New Hampshire. 1998. File 1571.

² Schacklette, H. T., and J. G. Boerngen. (1984) Element concentrations in soils and other surficial materials of the conterminous United States. U.S. Geological Survey Professional Paper 1270.

³ Al-Wardy, M.M. 2002. Elemental Distribution in the surface and subsurface soils of central and western New York. *Doctoral Dissertation*, Cornell University, Ithaca, NY.

⁴ US Environmental Protection Agency, Office of Solid Waste and Emergency Response. Soil Screening Guidance. Publication. www.epa.gov/superfund/health/conmedia/soil/index.htm#fact July 1996.

Did You Know?

Soil type, pH, and how a plant grows can have a great influence on metal uptake by plants and humans who consume the plants.



Notes:

S-1, S-2, and S-3 represent the range of potential human exposure situations based on accessibility, frequency, and intensity of usage. The three categories of direct contact risk based soil concentrations are derived using USEPA guidelines.

¹ N.H. Department of Environmental Services, Direct Contact Risk Based Soil Concentrations. <http://des.nh.gov/organization/divisions/waste/hwrb/documents/rcmp.pdf>. Feb 2013

Table 1: Background Heavy Metal Concentrations in Soils

Metal	Average level in soil around NH ¹	Average level in soil around NY State ³	Natural level in soils around U.S. ²	US EPA Soil Screening Level ⁴
	(ppm)			
Arsenic (As)	11	5.0	5.2	0.39
Cadmium (Cd)	2	0.5	0.2	70
Chromium (Cr)	33	13.5	37	230
Copper (Cu)	31	14.2	17	
Iron (Fe)			18000	
Lead (Pb)	51	18.7	16	400
Mercury	0.31		0.06	1
Molybdenum	3.5		0.6	39
Nickel (Ni)	23	17.1	13	1600
Selenium	5			39
Zinc (Zn)	98	65.2	180	23,000

Interpreting Your Results Based Potential Use

Whether or not the heavy metal levels in your soil are a cause for concern depends on how the area is being used. If children use the area, such as in a play yard or anywhere there will be direct soil to skin contact on a regular basis, this would be deemed as “sensitive use,” and the amount of heavy metals in the soil should be relatively low. If an adult comes into contact with soil as part of their regular job or recreationally, then the “moderate exposure” risk designation applies. If you will come in heavy contact but only for a limited length of time, such as during excavation work, then “restricted access” exposure risk should be used. In this case it is assumed one would only be working in the soil for four months out of the year (the warmest months) and would not be exposed to this soil during the other eight months of the year. This also assumes exposure by adults, and not children, who are sensitive at lower levels. See Table 2.

Table 2: Heavy metal human exposure risks based on situations of accessibility and frequency of usage

Metal	Sensitive use NH S-1 (ppm) ¹	Moderate exposure NH S-2 (ppm) ¹	Restricted access NH S-3 (ppm) ¹
Arsenic (As)	11	11	47
Cadmium (Cd)	33	280	280
Chromium (Cr)	130	130	130
Copper (Cu)			
Iron (Fe)			
Lead (Pb)	400	400	400
Mercury	7	52	52
Molybdenum			
Nickel (Ni)	400	2,500	3,100
Selenium	180	1600	1600
Zinc (Zn)	1,000	2,500	5,000

What Can You Do to Minimize Risk?

- ✓ **Start with a Soil Test.** Include the standard fertility analysis and organic matter test along with your heavy metals results to help Extension give you our best recommendation.

If your soil has an elevated level of heavy metals, you can take several approaches that minimize your exposure risk.
- ✓ **Adjusting your soil pH** can have a direct effect on the availability of some metals to plant uptake. For example, at or near a pH of 7.0 lead binds tightly to soil particles, and its solubility is very low. Similar relationships exist for arsenic, chromium, and copper. The chemicals barium, cadmium, lead, and zinc have less plant uptake at high pH (>6.5). Periodic liming of soils can help reduce exposure risk.
- ✓ **Add Organic Matter.** Heavy metals bond more tightly to organic matter than soil particles. Incorporating any type of compost, peat moss, or mulch will bind the contaminants, helping to reduce your exposure.
- ✓ **Practice raised bed gardening.** If you are at all concerned, the safest bet for a vegetable garden is the use of a raised bed, with soil imported from off-site.
- ✓ **Maintain sod cover.** Keeping the soil covered with a crop like grass will limit dust from forming and reduce direct exposure to heavy metals.
- ✓ **Mulch walkways in garden.** Maintaining a cover will reduce dust and soil splash during rain events.
- ✓ **Consider crop type.** Avoid growing any root vegetables like beets, carrots, or potatoes as these have some of the highest risks when grown in contaminated soils. It is very difficult to remove all the soil particles and aerosols from root vegetables. Growing fruit or a vegetable that does not sit on the soil surface will also reduce your risk. Leafy greens should also be avoided as metals can readily accumulate.
- ✓ **Always wash produce.** Produce should always be washed before eating or storage, whether growing on the ground or above ground like a tomato or broccoli. During rainfall events soil can splash and contaminate produce.
- ✓ **Wear protective clothing.** Because heavy metals can be absorbed through the skin (dermally), it's best to wear gloves and long sleeves when working in contaminated soil. Make sure to wash hands thoroughly after working in the soil, especially before using the bathroom or preparing food.
- ✓ **Protect children.** Children have a much lower tolerance to heavy metals. They should always wash their hands after playing outside, even in low-contaminated soils.

Minimizing Risk Checklist

- ✓ **Start with a Soil Test.**

If your soil has an elevated level of heavy metals, consider taking one of these steps:
- ✓ **Adjust your soil pH.**
- ✓ **Add Organic Matter.**
- ✓ **Practice raised bed gardening.**
- ✓ **Maintain sod cover.**
- ✓ **Mulch walkways in garden.**
- ✓ **Consider crop type.**
- ✓ **Always wash produce.**
- ✓ **Wear protective clothing.**
- ✓ **Protect children.**
- ✓ **Avoid perennial herbs.**
- ✓ **In severe cases, contact NHDES.**



- ✓ **Avoid perennial herbs.** Due to the perennial nature of most herbs we recommend that you refrain from growing these in contaminated soils as the heavy metal concentration in the plant tissue might be high. Instead, try growing these in pots with clean soil.
- ✓ **In severe cases** the N.H. Department of Environmental Services (NHDES) can provide regulatory oversight in contaminated sites. In a case where the soil levels of one or more of these metals is very high, the soil should be excavated and replaced, and no gardening or crop production should occur. Ingestion of soil or dust particles could pose a health risk. Children should be kept out of this area. Keep the area covered, and contact the N.H. Department of Environmental Services.

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For More Information

See the US EPA Soil Screening Guidance. Fact Sheet at: www.epa.gov/superfund/health/conmedia/soil/pdfs/fact_sht.pdf.

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