Cornell University
School of Integrative Plant Sciences

Soil Health Series | Fact Sheet Number 16-14

Add-on Test: Heavy Metal Contamination

Heavy metal testing is available for situations where contamination is suspected, or as a precaution by identifying whether contamination from past human activities (such as high traffic, industrial or commercial activity, spills, or pesticide application) is affecting the site. Heavy metals such as arsenic, barium, cadmium, chromium, copper, lead, nickel, zinc as well as other elements are measured. It is important to understand that levels of metals can vary greatly across a site, and sometimes at a very small scale, so additional samples may be needed. More information is available from the Cornell Waste Management Institute's "Guide to Soil Testing and Interpreting Results" (available at cwmi.css.cornell.edu/guidetosoil.pdf).

How heavy metals relate to soil function

Soil characteristics can affect the transport and fate of heavy metals, and whether they can be readily taken up by plants or animals. Most heavy metals (e.g., barium, chromium[+3], copper, lead) are adsorbed strongly to clays and organic matter, which limits the potential for plants to take these up when soil pH is not in the acid range. A few - notably cadmium, nickel and zinc - may remain soluble enough at near-neutral pH to be taken up by plants from contaminated soils. For most heavy metals, uptake (via plant roots) into food crops may be higher if soil is acidic (pH < 5-6), high in salts, or low in organic matter. Arsenic adsorbs poorly on organic matter, but well on clays and iron oxides, and is more available to plants in non-acid (pH > 6) than acid soils. Additionally, heavy metals (e.g., copper, nickel, zinc) at elevated concentrations in soil may suppress natural microbial processes.

Managing heavy metals in soil

Soil amendments are an important technique for mitigating heavy metals in soils. For example, organic matter (composts, peat) forms strong complexes with heavy metals such as lead and cadmium, and limits availability to plant roots. Lime additions raise soil pH, reducing solubility and plant availability of most metals. Phosphate has been shown to reduce lead solubility under some circumstances, though it is generally not effective or practical for non-acid soils where lead solubility is already low. The type of crops being consumed also have varying levels of contaminants, depending on what part of the plant is being consumed.

Using plants to remove heavy metals from soil (a type of phytoremediation) is generally not effective for reducing metal levels in farm or garden soils. Many metals are not readily taken up into plant tissue when soil pH is near neutral (6.5 – 7.5).

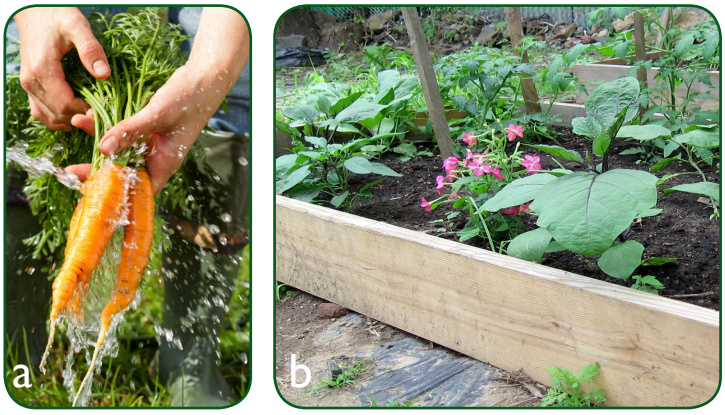


FIGURE 1 a and b. Strategies to help reduce risk of heavy metal contamination in urban soils. (a) Wash garden-grown vegetables. (b) Garden in raised beds with clean soil and landscape fabric barrier.

Plants that readily take up metals (such as cadmium, copper, nickel, and zinc) are also relatively small in stature, slow growing and will take many years to "clean up" soils. Furthermore, unlike some other contaminants, metals are chemical elements and therefore are not broken down into less toxic compounds by phytoremediation. Metals that are removed from the soil are relocated into the roots or other parts of the plants, which means the plants must be disposed of properly, and not eaten or composted.

Additional risk-minimizing strategies

- If needed, add clean soil or organic matter; adjust soil pH; promote good drainage.
- Wash hands/wear gloves when working with soil.
- Keep soil from coming indoors on shoes, pets, or clothing.
- Keep an eye on children.
- Wash produce well, using soap, (Fig. 1a) to remove soil particles from plant surfaces, and peel root crops.
- Avoid or contain contaminated areas: use raised beds where appropriate for growing edible crops (Fig. 1b); mulch, plant ground cover, or otherwise cover bare soil areas to reduce dust.
- Consider planting food crops that are least likely to have contaminants on or in them (like fruits) or grow ornamental plants.
- Avoid or limit activities that can increase soil contamination, such as the use of certain fertilizers and treated wood.

When developing a site management plan for a contaminated site, it is important to balance the many known benefits of farming, gardening, outdoor recreation, and consuming fresh fruits and vegetables with possible risks from exposure to soil contaminants.

Add-on Test: Heavy Metal Contamination

Add-on tests

The suite of soil analyses in the Cornell Assessment of Soil Health packages are all available as individual tests. Certain analyses, such as Heavy Metal Contamination, are not part of the Basic or Standard packages but are available as add-ons or as individual tests. A complete list of the packages we offer in addition to the add-on tests is available on our website at bit.ly/CSHLPackages.

Basic protocol

- A dried soil sample is digested in concentrated acid at high temperature.
- Particulates in the digestate are removed by filtration, centrifugation, or by allowing the sample to settle.
- The sample is analyzed by an inductively coupled plasma (ICP) instrument that identifies and quantifies individual elements accurately and precisely (Fig. 2).

Interpreting heavy metals results

Laboratories report concentrations of measured elements in mg/kg or ppm. Results can inform decisions about how to manage a site, farm, or garden, and other activities to promote healthy soils, high quality crops, and efforts to protect human health by reducing exposure to contaminants. Yet, understanding heavy metal results is not always an easy task. There is no single standard for acceptable concentrations in the soils of farms, gardens, or residential yards. Some guidance can be found by comparing soil test results to soil background levels or state guidance values, where these are available.

Guidance values are given outside of the CASH report. This guidance was developed by the NYSDEC and the NYS DOH for environmental remediation programs (Table 1).

TABLE 1. Guidance values and background levels of metals commonly found in garden soils*. See Healthy Soils, Healthy Communities resource *Metals in Urban Garden Soils*** for more information.

Metal	Level in soil (parts per million [ppm])		
	Guidance Value Protective of Public Health	NYS Rural Background Level	NYC Urban Background Level
Arsenic	16	< 0.2 - 12	4.1 - 26
Barium	350	4 - 170	46 - 200
Cadmium	2.5	< 0.05 - 2.4	0.27 - 1.0
Chromium	36	1 - 20	15 - 53
Copper***	270	2 - 32	23 - 110
Lead	400	3 - 72	48 - 690
Mercury	0.81	0.01 – 0.20	0.14 – 1.9
Nickel***	140	0 - 25	10 - 43
Zinc***	2200	10 - 140	64 - 380

* See NYSDEC 2006, NYSDEC and NYSDOH 2005, Retec Group, Inc. 2007

** http://cwmi.css.cornell.edu/Metals_Urban_Garden_Soils.pdf

*** Can be toxic to plants below health-based guidance values

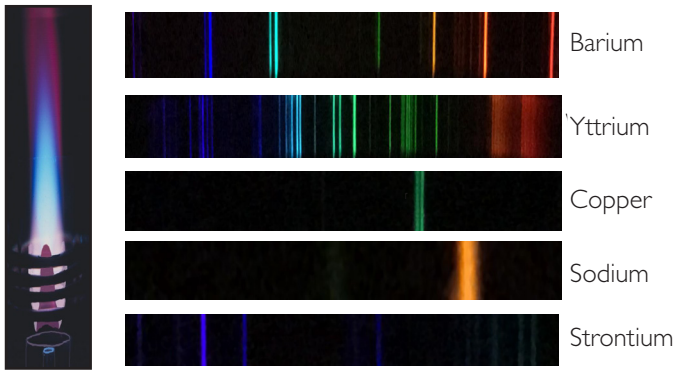


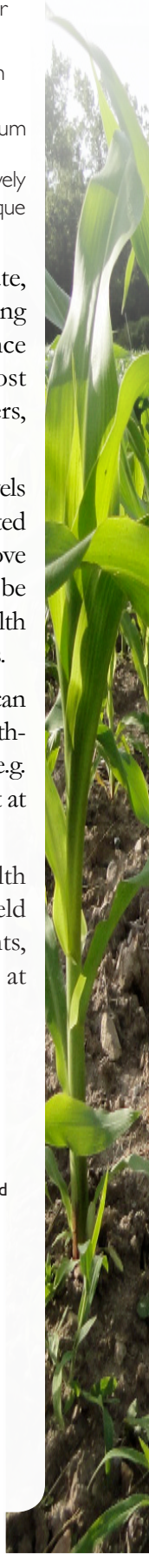
FIGURE 2. (Left) Heavy metal samples are analyzed by an inductively coupled plasma (ICP) instrument. (Right) Every element has a unique spectrum that can be identified and quantified.

Although the values were developed by New York State, they can be used elsewhere as a guide when considering human health and the environment. The guidance values for residential scenarios are typically the most appropriate reference point for farmers, gardeners, homeowners, and others.

It is not uncommon to find heavy metals in soil at levels near or above guidance values. Health risks associated with metals in soils at levels slightly or moderately above guidance values cannot be ruled out, but are likely to be low. High levels of exposure can be associated with health effects, and the higher the levels are, the greater the risks.

Regarding plant health, some heavy metals (such as Zn) can be toxic to plants (phytotoxic) at levels below human health-based guidance values. In contrast, some heavy metals (e.g. Cd or Pb) do not adversely affect the health of the plant at levels that would be a concern for human health.

For a more comprehensive overview of soil health concepts including a guide on conducting in-field qualitative and quantitative soil health assessments, please download the Cornell Soil Health Manual at bit.ly/SoilHealthTrainingManual.



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