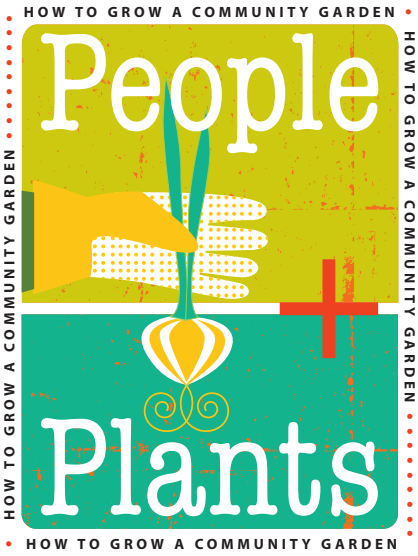

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Soil Contaminants in Community Gardens

Community gardening is becoming increasingly popular as people come to value produce grown near where they live or work. Locally grown food may be used to supply a food bank or school lunch program, to stock a farmers' market stand, or to feed a gardener's own family. Consuming food near where it is grown means that less energy is used to move or store it.

Frequently, the land available for community gardens in urban areas is either former industrial or commercial land or residential lots where old structures have been removed. These areas may contain contaminated soil. It's important to be aware of the risks posed by exposure to metals and other contaminants so that necessary precautions can be taken. Contaminants of particular concern are metals, solvents, pesticides, and petroleum hydrocarbons.

Exposure to soil contaminants can increase risk for acute and chronic health problems. Therefore, it is important to determine if soil contaminants are present, and if so, that they are below levels that pose a health risk for growing vegetables and working in the garden. Soil analysis is an effective way to evaluate the risk associated with gardening in a potentially contaminated soil.

This publication describes common soil contaminants, explains soil analysis, and offers strategies to minimize the risk of exposure in potentially contaminated gardens.

Site history

Conducting a thorough site history is critical to selecting an appropriate site for a community garden. Often, researching adjacent properties will also be necessary. You will want to find out basic information about a site, including property class, zoning information, and current and previous owners, by viewing city records. In some areas, this information may be accessible online. Libraries frequently have *Sanborn Fire Insurance Maps* that recorded detailed property use information. The Wisconsin State Historical Society also has the Wisconsin Sanborn maps available online. Talking with previous owners and neighbors about a site's history is often useful. If

the property was used for industrial or commercial purposes, it may have environmental hazards and previously been evaluated by the Wisconsin Department of Natural Resources (DNR). The DNR maintains an open database of contaminated sites (**dnr.wi.gov/topic/Brownfields/clean.html**).

Even if the property is not listed in this database, there is no guarantee that contamination will not be discovered in the future. Organizations or individuals looking to purchase or lease property in former industrial and commercial areas to establish gardens need to investigate potential liability issues before finalizing agreements. Currently Wisconsin law holds property owners responsible for environmental contamination clean up even if the pollution occurred before they took possession of the property. DNR has additional environmental liability information (**dnr.wi.gov/topic/brownfields/liability.html**).

Types and sources of contaminants

Metals, hydrocarbons, solvents, and pesticides are the most common soil contaminants of concern in community garden locations. These contaminants can be either widespread or localized. **Widespread contaminants** are of greater concern in most urban environments. Metals and polycyclic aromatic hydrocarbons (PAHs) are the most common widespread contaminants. For example, mercury levels can be high in areas downwind from coal-fired power plants. In addition, vehicle exhaust and rain runoff from asphalt parking lots can introduce PAHs into nearby soil.

Solvents, pesticides, and petroleum products are **localized contaminants** found in a small geographic area. Examples include leaking fuel storage tanks and solvents spilled from older dry cleaning operations.

Metals

Arsenic, barium, cadmium, chromium, mercury, lead, and selenium are the most common widespread metal contaminants. These metals are all naturally occurring and will be present at detectable levels in almost all soils; therefore mere detection does not constitute a threat to health. Metal contamination is an issue only when the metal concentration is above a value that has been shown to be hazardous to human health (i.e., a risk threshold). Once discharged into the environment, metals remain in the soil typically near where they were first deposited so historical contamination of a site must be taken into account. Common metal contaminant sources are listed below:

Arsenic

- Treated lumber (until 2004)
- Herbicides to treat lawns, golf courses, and agricultural fields (until 2009)
- Naturally at harmful levels in limited locations outside of Wisconsin
- Fruit orchard insecticides from the early 1800s through 1960

Barium

- Paint, brick, glass, and tile production
- Medical diagnostic imaging

Chromium

- Treated lumber (until 2004)
- Stainless steel manufacture
- Chrome plating operations

Mercury

- Batteries (most until 1996, currently only used in button cell batteries)
- Exhaust from coal-fired power plants
- Paint fungicide (until 1991)
- Older heating and cooling thermostats

Lead

- Gasoline (until 1995)
- Paint (until 1978)
- Plumbing and electronics solder
- Improper car battery recycling
- Fruit orchard insecticides from the early 1800s through 1960

Selenium

- Exhaust from coal-fired power plants
- Copper smelting and refining
- Some semiconductor manufacture

Hydrocarbons

Hydrocarbons can be divided into two groups: petroleum products and polycyclic aromatic hydrocarbons (PAHs). Petroleum hydrocarbon products include hundreds of individual chemicals and mixtures. Benzene, ethylbenzene, toluene, and xylene are petroleum compounds found near commercial and industrial areas such as gas stations. Because they degrade rapidly near the soil surface or migrate deep into the ground, levels of concern for gardening would be associated with noticeable gasoline-like odors and would generally indicate new spills, possibly a result of leaking underground petroleum storage tanks.

PAHs are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances. While some of these are known carcinogens, most either rapidly evaporate into the air or bind tightly to soil particles and are not likely to be an issue for community gardens. PAHs can accumulate in lake and stream sediment where they can cause health problems in fish and bivalves.

PAHs sources

- Byproduct of coal coaking process/ production of coal tar
- Asphalt and roofing tar (from use of coal tar)
- Municipal trash incinerators
- Vehicle exhaust
- Cigarette smoke and grilled foods

Solvents

Solvents typically consist of industrial or commercial chemicals that may have been spilled or disposed of improperly. Former dry cleaning sites and machine shops are frequently the source of solvent soil contamination. The most common solvents are highly volatile in surface soils or will migrate to subsurface soil areas. While solvent contamination may be identified, it generally will not affect the soil within the root zone of plants.

Trichloroethylene (TCE)

- Commonly used to remove grease from metal in industrial settings
- Paint removers
- A building-block chemical used to make other chemicals

Tetrachloroethylene (PCE or PERC)

- Commonly used as a dry-cleaning product
- Used in the production of other synthetic chemicals

Pesticides

Atrazine and carbaryl (often sold as Sevin®) are commonly used in lawn and garden areas. These pesticides might be considered local contaminants on land previously used for growing crops, and in some industrial and commercial areas where they were stored or mixed. The amount of time these pesticides remain in the soil depends largely on environmental and soil conditions, but is generally short. Carbaryl has a half-life (the time until 50% has broken down into other compounds) of 7 to 28 days and atrazine has a half-life of 60 to 100 days. You can expect that these products will be at one thousandth of their original

Tips for healthy gardening

- Wash all produce well to remove dirt and dust.
- Remove outer leaves of leafy vegetables to avoid consuming soil.
- Wash your hands well after working in the garden.
- Wear gloves to avoid contact with soil.
- Remove shoes outside to avoid tracking soil into the house.
- Watch children carefully when they are playing in soil. Some children will try to eat it, and most will stick dirty fingers in their mouths.

concentration after ten half-lives, or about 280 days and 1,000 days (2.7 years), respectively.

Insecticides and fungicides no longer being manufactured sometimes contained lead and arsenic. Contamination from this source is common in areas that were formerly fruit orchards.

Soil analysis

A site history can give you an idea of whether contaminants may be present, and soil analysis can help you understand the extent of possible contamination in your soil. If the site history suggests possible contamination or if the property is in an older developed area, there is likely lead, PAHs and maybe other contaminants present.

Sites that are near past or present dry cleaners, landfills, junkyards, gas stations, manufacturing or industrial sites are especially at risk of containing high levels of metals or chemicals. Past demolition of lead paint-coated buildings are a concern for almost all sites. However, it is not absolutely necessary to sample. If you follow the recommended safe gardening practices outlined in this publication you can limit potential exposure and use the garden safely.

If you decide that soil analysis would help evaluate the risk for your garden site, this section provides guidance on the best ways to sample and interpret the results.

The cost of soil testing ranges widely. Generally, for each sample, testing for metals will cost $20 to $50 per metal, while testing for solvents, pesticides, and hydrocarbons can cost several hundred or even thousands of dollars. However, depending on the size of your garden or whether you or your organization will need to assume liability for the food you grow and distribute, these tests can be worth the money. There are several labs in Wisconsin that can test for soil constituents (see sidebar). Outside of Wisconsin, contact your state extension office for a list of labs. Contact a specific lab to find out which constituents they test for and the cost of testing. Most labs also provide information about handling and collecting soil samples.

Interpreting results

If you have had your soil tested, the next step is to make sense of the results. Most labs report the amount of a given constituent in the soil as parts per million (ppm). One ppm means that for every one million parts of soil, there is one part of the constituent. A lab may also report the results in milligrams of contaminant per kilogram of soil (mg/kg) or micrograms per gram of soil (µg/g), which are both equivalent to ppm.

Soil analysis labs in Wisconsin and services offered

Marshfield
UW Soil and Forage Analysis Laboratory
2611 Yellowstone Dr.
Marshfield, WI 54449
(715) 387-2523
uwlab.soils.wisc.edu/madison
Tests for: Metals, soil nutrients

Madison
Wisconsin State Laboratory of Hygiene
465 Henry Mall
Madison, WI 53706
(608) 442-4618
www.slh.wisc.edu/environmental
Tests for: Metals, volatile organic compounds, PAHs, petroleum products, pesticides

Milwaukee
Milwaukee Health Department Laboratory
841 N. Broadway, Room 205
Milwaukee, WI 53202-3653
(414) 286-3526
milwaukee.gov/healthlab
Tests for: Lead, soil nutrients

Compare your soil test results to the accepted gardening risk thresholds summarized in table 1. If the concentrations in your soil fall below the gardening toxicity risk values, then gardening poses very low risk. If the levels in your soil exceed the gardening toxicity risk values, then you may need to take precautions to ensure that accumulation of contaminants in edible crops and time spent working in the soil does not lead to exposures that may cause health effects.

For more specific information on soil lead contamination refer to *Lead in Home Garden Soil* (A4089) and *Reducing Exposure to Lead in Your Soil* (A4088).

Soil test results

Please be aware that interpreting soil test results is not for beginners. There are experienced environmental professionals at state agencies, universities, and extension offices that can help you interpret your results at no cost.

Table 1. Cleanup levels and risk values of select soil contaminants

Soil contaminant	Wisconsin soil background levels (ppm)[a]	Gardening toxicity risk values (ppm)[b]
Metals		
Arsenic	8	0.613[c]
Barium	364	15300
Chromium	44 (total Cr)	0.293 (CrVI)[c]
Copper	35	3130
Lead	52	200[d]
Mercury	NA	3.13
Solvents		
Tetrachloro-ethylene (PCE)	NA	30.7
Trichloroethylene (TCE)	NA	1.26
Pesticides		
Atrazine	NA	2.11
Sevin® (Carbaryl)	NA	6110
Polyaromatic Hydrocarbons (PAH)		
Benzo(a)pyrene	NA	0.015

NA (not available).

[a] Wisconsin DNR, dnr.wi.gov/topic/Brownfields/documents/tech/RCLs0115.xlsm

[b] Calculated for from USEPA direct contact recommended contaminant levels (RCLs) at epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search

[c] Chromium (VI) and certain forms of arsenic are known to cause cancer at levels well below the total concentrations normally found in uncontaminated soil. However toxicity is highly dependent on chemical form and binding to soil constituents.[1,2]

[d] The current U.S. Centers for Disease Control "blood level of concern" is 5 micrograms lead/deciliter of blood. This correlates to 200ppm soil lead.[3]

Recommended safe gardening practices

If your site has soil contamination from historical uses, soil test results show unsafe contaminant levels, or the property is in an older developed area, you can take these precautions to reduce exposure to soil contaminants and limit uptake in crops:

- **Compost**. Add compost and/or fertilizer derived from organic sources (Milorganite for example) to your garden soil. Adding organic matter will help to dilute and bind the contaminants in the soil while improving soil quality.
- **Clean soil**. Bring in clean soil from an outside source and place it on top of contaminated soil. Laying landscape fabric before adding the clean soil can prevent plant roots from growing into the contaminated soil.
- **Location of garden**. Move the garden to a different spot in the same plot of land. If the contaminants are localized, the most cost effective solution would be to move the garden to another part of the property where there is less or no contamination.
- **Garden in raised beds**. They can be built in any size and shape. Fill beds with uncontaminated soil. Don't use railroad ties or treated lumber to make raised beds because of the chemicals used to treat these wood products.

- **Wash produce**. Wash your fruit and vegetables really well. We eat more dirt on our food than we realize. By very carefully scrubbing produce grown in the garden, soil-bound contaminants are also removed.
- **Older buildings**. Avoid growing edible plants directly adjacent to older painted buildings. The soil is likely to have elevated lead levels due to past use of lead-based paint.
- **Neutral pH**. Maintain a neutral to slightly alkaline pH level (pH ≥7) in your garden soil. A neutral pH can help reduce the amount of metals bioavailable in soil. If your soil pH is too low (or acidic), raise it by adding lime.

Resources

For more information on community gardening, vegetable gardening, soil contaminants, and soil sampling, consult the following:

American Community Gardening Association. **communitygarden.org**/.

Guide to Soil Testing and Interpreting Results, H. Shayler, M. McBride, & E. Harrison. Ithaca, NY: Cornell University, 2009. **cwmi.css.cornell.edu/guidetosoil.pdf**.

Lead and Arsenic in Soil at Old Fruit Orchards, **datcp.wi.gov/uploads/Environment/pdf/ArmPub99.pdf**

Reusing Potentially Contaminated Landscapes: Growing Gardens in Urban Soils. USEPA 542/F-10/011. Spring 2011.

Soil Contaminants and Best Practices for Healthy Gardens, H. Shayler, M. McBride, & E. Harrison. Ithaca, NY: Cornell University, 2009. **cwmi.css.cornell.edu/Soil_Contaminants.pdf**.

Sources and Impacts of Contaminants in Soils, H. Shayler, M. McBride, & E. Harrison. Ithaca, NY: Cornell University, 2009. **cwmi.css.cornell.edu/sourcesandimpacts.pdf**.

Urban Gardening: Managing the Risks of Contaminated Soil, R. Kessler. Environmental Health Perspectives. Vol. 121:11-12, 2013. **ehp.niehs.nih.gov/121-a326/**

Wisconsin Historical Society **www.wisconsinhistory.org** (Sanborn Fire Insurance Maps)

Find your county office at: **yourcountyextensionoffice.org**

References

[1] Toxic Substances Portal: Arsenic, Agency for Toxic Substances and Disease Control. **www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=3**

[2] Toxic Substances Portal: Chromium, Agency for Toxic Substances and Disease Control. **www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=17**

[3] Zahran, S. et al (2011). Nonlinear associations between blood lead in children, age of child, and quantity of soil lead in metropolitan New Orleans. *Science of Total Environment*, 409(7), 1211-1218.

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