



**Geoffrey Siemering and
Doug Soldat**

Lead in garden soil can pose health risks to gardeners and to those who eat the garden's produce.

Reducing exposure to lead in your garden soil

Lead in garden soil can pose health risks to gardeners and to those who eat the garden's produce.

This publication explains how to lower your potential exposure to lead from garden soil. The presence of lead in garden soil can be inferred by the garden site's history or location, or can be determined definitively through sample analysis. General information on lead in home garden soil can be found in the UW-Extension publication, *Lead in Home Garden Soil* (A4089). Information about soil sampling and analysis can be found in *Sampling Garden Soils and Lawn Areas for Analysis* (A2166).

Lead occurs naturally in all soils and in Wisconsin is not considered a gardening hazard at levels of 52 milligrams of lead (or less) per kilogram of soil (52 parts per million or less). If you analyze your garden soil and find levels higher than that, you can take action to lower the risk of lead exposure. The actions recommended in this publication are based on scientific research and professional opinion.

Recommendations for garden sites highly suspected or known to have elevated soil lead levels.

If you haven't analyzed your soil and your garden site is located in an area developed before 1979, or has been used in ways that may have resulted in soil contamination, these recommendations will lower your potential lead exposure.

- Add compost and/or fertilizer to your garden soil derived from organic sources (for example, Milorganite®). Adding organic matter will help to dilute and bind (or tie up) the lead in the soil while improving soil quality.
- Wash fruit and vegetables thoroughly. We eat more dirt on our food than we realize. By carefully scrubbing garden produce, you will remove soil-bound contaminants.
- Maintain your garden soil at a neutral to slightly alkaline pH level (pH 6.5-8). A neutral pH can help reduce the amount of metals bioavailable in soil. If your soil pH is low or acidic (pH less than 6), raise it by adding garden lime.
- Avoid planting low-growing leafy vegetables such as arugula and leaf lettuce. Low-growing plants are splattered by soil when it rains and their crinkled texture makes it difficult to thoroughly clean them. Focus instead on taller greens (kale, chard, and mustard greens) and fruits and vegetables.

Actions to take with different levels of lead in garden soil

If you have had your soil analyzed, note the total soil lead value and find which range below that it falls into.

Total lead may be listed in your lab report as: Pb (the elemental symbol for lead), XRF Lead content, or Lead (Pb).

Soil value	Recommendation	Actions
0-52 parts per million (ppm), or milligrams per kg (mg/kg)	No intervention is necessary. This amount of lead occurs naturally in Wisconsin soils. Normal exposure to soil lead at this level is unlikely to cause any adverse health effects.	<ul style="list-style-type: none"> No action is necessary
52-200 ppm (mg/kg)	This range is considered safe for gardening, based on the "blood lead level of concern" guidelines from the U.S. Centers for Disease Control. ^{3,4}	<ul style="list-style-type: none"> Limit your exposure to garden soil. Wear gloves and shoes while working in the garden. Wash gloves and shoes afterward to prevent bringing contaminated soil into the house. If children will be in the garden, make sure they wash their hands, bare feet or shoes. Do not let them put soil or dirty fingers into their mouths. Amend your garden soil with a mixture of sulfur and a fertilizer containing phosphate. This will not decrease the total amount of lead in the soil but should reduce possible lead exposure by decreasing the amount of lead that is readily available for absorption by the body. See the sidebar to calculate the amount of sulfur and fertilizer you should apply.
200-1200 ppm (mg/kg)	It is difficult to make clear recommendations how to treat soil containing lead in this range. The homeowner or a professional advisor should make the informed decision on which action to take.	<ul style="list-style-type: none"> Amend your soil by adding sulfur and fertilizer according to the directions in the following section. Install raised beds and fill them with uncontaminated soil. Or, create windrows (long mounded rows of uncontaminated soil in which to plant). Either of these methods will separate garden beds and the gardener from contaminated native soil. You may use landscape barrier cloth under the raised beds or windrows to further separate your uncontaminated garden soil from the contaminated native soil. Relocate the garden to a less contaminated area of your yard. Often this will be the simplest and most cost-effective option. Convert your produce garden to a perennial garden. Perennial plants require fewer interactions with the soil, which means you will lower your lead exposure.
Over 1200 ppm (mg/kg)	Do not garden in soil that contains this amount of lead. ⁴	<ul style="list-style-type: none"> Install raised beds and fill them with uncontaminated soil. Landscape barrier cloth should be used to further separate your garden soil from the contaminated native soil. Relocate your garden to another part of the yard where the soil contains less lead. Be sure to cover the bare soil of the old garden site with vegetation (grass, groundcover plants, etc), or with a manmade cap (concrete or paver blocks), or with landscape fabric covered by mulch. Convert your produce garden to a perennial garden. Perennial plants require fewer interactions with the soil, which will lower your lead exposure.



Plant uptake of soil lead

The most common way that lead travels from garden soil to the human bloodstream is through direct ingestion of soil. Breathing garden dust is another way, but far less common. Although considerably less hazardous even than dust inhalation, eating produce grown in lead-contaminated soil may not be completely hazard-free.

Lead uptake by garden plants depends on many factors, including soil lead concentration, soil organic matter content, phosphorus levels, and pH. The amount of lead taken up by plants is small, but minimizing all sources of lead exposure is important. Fortunately, the techniques you use to improve your garden (such as adding compost, using fertilizer containing phosphate, maintaining correct soil pH) also help to lower the amount of lead being taken up by plants. Roots tend to take up and retain the most lead, leaves retain less, and fruits still less.

While it is most important to thoroughly wash all garden produce to reduce your exposure to lead, growing the right plants can also help decrease your exposure. In general, tall leafy plants (mustard, cabbage, Swiss chard, collard greens) and fruiting plants (tomatoes, eggplant, cucumber and zucchini) pose less risk than other plants grown in lead-contaminated soil. Root crops (particularly carrots) are more likely to contain lead above recommended levels.^{1,2} The amount of lead ingested from eating root vegetables can be greatly decreased by peeling and washing them to remove all garden dirt.

Phytoremediation—the technique of using plants to remove contaminants from soil—is not a good option for home gardeners because plants normally won't take up enough lead to lower the amount of lead found in garden soil. Lead phytoremediation works only under certain soil conditions, often requires special chemicals, and often requires a license for disposal of the harvested plant material.

Amending soil with sulfur and phosphate-containing fertilizer

Adding sulfur and a fertilizer that contains phosphate to your garden soil can reduce your exposure to lead. A triple super phosphate (TSP) or fish bone meal fertilizer is recommended. At the right soil pH, phosphate combines with lead to form a stable mineral (pyromorphite) that, even if ingested, cannot be absorbed by the body. The sulfur will lower the soil pH to the range where this mineral formation occurs best. The amount of sulfur and fertilizer needed depends on your garden size and amount of lead in the soil.



First, you must have your garden soil analyzed to determine the exact amount of lead it contains and the soil pH. If you attempt to amend your soil without first having a laboratory soil analysis done, you will be wasting your time and effort, and you will likely cause harm to local streams, ponds, and lakes. Use the information from your laboratory report and the formulas and tables here to calculate the amount of fertilizer and sulfur needed. **Note:** If you know or suspect that your property is on former fruit orchard land, do not use this amendment technique without first testing to be sure that your soil is not contaminated with arsenic (see Resources).

After you have calculated the amount of fertilizer and sulfur required for your garden, you are ready to spread the amendment materials over the garden surface. The sulfur and phosphate-containing fertilizer should be added to the soil at the same time but do not need to be mixed together before application. Once both have been applied, mix them into your garden soil. Any phosphorus in the soil from past applications will aid in converting the lead to the stable mineral (pyromorphite) form. Lead conversion will occur over several months. **Repeat applications of fertilizer and sulfur are not necessary.**

This method of amending your soil will not make it hazard-free but should reduce human exposure to soil lead if any soil is accidentally ingested or inhaled. Recommended gardening precautions should still be followed. Use this method only for your garden, not for your entire yard. Applying this amount of phosphorus to your yard may contribute to water quality problems and is prohibited by Wisconsin Department of Natural Resources regulations.

How to calculate the amount of fertilizer needed to treat lead in garden soil

For triple super phosphate (TSP) fertilizer (45% or 46% phosphate):

1. Find the estimated total lead (Pb) concentration in your soil (in ppm or mg/kg) from your soil analysis report.
2. Multiply that number by 0.0015. This will give you the pounds of phosphate fertilizer to apply to each 100 square feet of garden.

Lead value x 0.0015 = pounds TSP fertilizer for each 100 square feet of garden

For fish bone meal (FBM) fertilizer (16% to 20% phosphate)

1. Find the estimated total lead (Pb) concentration in your soil (in ppm or mg/kg) from your soil analysis report.
2. Multiply that number by 0.0038. This will give you the pounds of fish bone meal you should apply to each 100 square feet of garden.

Lead value x 0.0038 = pounds FBM fertilizer for each 100 square feet of garden

Recommendations for garden sites where lead may be present at elevated levels.

The two primary ways gardeners are exposed to soil lead are through ingestion (eating) and inhalation (breathing) of soil. Minimizing these will lower potential lead exposure. Follow these suggestions to help lower your risk.

- Wash all produce well to remove dirt and dust. Peel root vegetables to remove all surface dirt.
- Don't plant low-growing leafy greens. Remove outer leaves of tall leafy vegetables to avoid consuming soil.
- Cover all bare soil with vegetation, mulch, or hard surfaces.
- Wash 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.

How to calculate the amount of sulfur to treat lead in garden soil.

Find the pH of your garden soil from the soil analysis report. Use the table below to determine how much sulfur to add to your soil to facilitate conversion of lead to a more stable form (to a depth of 6 inches).

Soil pH	Elemental sulfur (lbs) per 100 square feet
8.0-7.5	4.0
7.5-7.0	3.5
7.0-6.5	2.0
6.5-6.0	1.0
Below 6.0	none



Installation of raised beds

Constructing hard-sided raised beds and filling them with clean soil, or constructing windrows of mounded clean soil, will allow you to separate your garden plants from contaminated native soil. Be sure that the soil used in the raised beds or windrows is free of contaminants. Both raised beds and windrows can be placed on top of geotextile fabric to prevent clean soil from mingling with the contaminated soil, and to prevent plant roots from reaching the contaminated native soil.

Raised bed walls can be constructed of masonry, rock, or wood. Cedar or white (not red) oak lumber is recommended. Pine and red oak lumber will decay rapidly and will need to be replaced every three to four years. Treated wood and railroad ties should not be used because of the chemicals and metals they contain. Windrows (commonly used in commercial vegetable farms) are simply rows of mounded soil with plants grown on the top of the mounds. Both raised beds and windrows should be 8 to 10 inches deep to allow for adequate root depth.

Relocating your garden

If the soil of your produce garden is found to have unacceptably high levels of lead, you may decide to relocate the garden to an area where lead levels are lower. Frequently gardens are constructed next to houses or other buildings where soil lead levels can be high due to lead-based paint that has weathered, flaked, or been scraped or sanded from those buildings. Areas located at least 20 feet from painted structures—and 20 feet from other sources of lead, such as demolished building sites or burn pits—are more likely to have low lead levels since lead does not migrate very far from where it first reaches soil. Cover the bare soil of the old garden with grass or with landscape fabric plus mulch. Doing this will help prevent dust exposure and will reduce the temptation to garden in that spot in the future.

Converting your garden

If you decide to convert your produce garden to a perennial garden, the produce garden's soil will be perfect for growing flowers or other ornamental plants. The new flower garden will require you to have only minimal contact with the lead-tainted soil. After installing new plants, cover any remaining bare soil with mulch.



Raised beds (above) and windrow garden (below)



References

1. Attanayake, Chammi P., et al. "Potential Bioavailability of Lead, Arsenic, and Polycyclic Aromatic Hydrocarbons in Compost-Amended Urban Soils." *Journal of Environmental Quality* 44.3 (2015): 930-944.
2. United States Centers for Disease Control and Prevention. "Lead" Accessed June 26, 2015. www.cdc.gov/nceh/lead
3. Zharan, S., et al. "Nonlinear association between blood lead in children, age of child, and quantity of soil lead in metropolitan New Orleans." *Science of the Total Environment* 409 (2011): 1211-1218.
4. United States Environmental Protection Agency. "Brownfields and Urban Agriculture: Interim Guidelines for Safe Gardening Practices" Accessed June 29, 2015. www.epa.gov/brownfields/urbanag/pdf/bf_urban_ag.pdf

Resources

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

Lead Arsenate Soil Sampling Guidance for Homeowners
datcp.wi.gov/uploads/Environment/pdf/ArmPub219.pdf



Copyright © 2015 by the Board of Regents of the University of Wisconsin System doing business as the division of Cooperative Extension of the University of Wisconsin-Extension. All rights reserved.

Authors: Doug Soldat, associate professor; Geoff Siemering, outreach specialist; with the Department of Soil Science, College of Agriculture and Life Sciences, University of Wisconsin–Madison. Soldat holds a joint appointment with University of Wisconsin-Extension, Cooperative Extension. Cooperative Extension publications are subject to peer review.

University of Wisconsin-Extension, Cooperative Extension, in cooperation with the U.S. Department of Agriculture and Wisconsin counties, publishes this information to further the purpose of the May 8 and June 30, 1914, Acts of Congress. An EEO/AA employer, the University of Wisconsin-Extension, Cooperative Extension provides equal opportunities in employment and programming, including Title IX and ADA requirements. If you have a disability and require this information in an alternative format, or if you would like to submit a copyright request, please contact Cooperative Extension Publishing at 432 N. Lake St., Rm. 227, Madison, WI 53706; pubs@uwex.edu; or (608) 263-2770 (711 for Relay).

This publication is available from your county UW-Extension office (yourcountyextensionoffice.org) or from Cooperative Extension Publishing. To order, call toll-free 1-877-947-7827 or visit our website at learningstore.uwex.edu.

Reducing Exposure to Lead in Your Garden Soil (A4088)

I-08-2015