Reducing Lead Hazard in Gardens and Play Areas

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Lead is the most common metal contaminant in urban areas. Children younger than 6 years living in older houses are at greatest risk of exposure to chips and dust from lead-based paints. Other common sources of lead exposure are from drinking water contaminated by lead pipes or lead solder that joins the pipes, or from contaminated soil or dust. Eating soil or eating unwashed produce are the most common exposure routes from soil. This publication is designed to help homeowners evaluate and manage lead hazard in their landscape or garden. We explain:

1. How soils become contaminated with lead
2. How people are exposed to lead
3. How to get your soil tested for lead
4. How to interpret soil lead test results
5. How to reduce exposure to soil lead
6. What to do if your soil is contaminated
7. Which garden produce is easier to wash

This publication does not address indoor lead hazards or provide a comprehensive lead risk assessment. See "Common questions about lead" (page 7) and the resources listed under "More information" (page 8) for additional information on lead.

Lead occurs naturally in the soil

Lead exists naturally in soils at concentrations of 10 to 50 parts per million (ppm). This range is the *background level*. Higher concentrations may indicate lead contamination. The longer humans have occupied a site, the more likely it is contaminated with lead and other metals. Urban and residential soils often have higher lead concentrations because paints contained lead until 1978 and gasoline contained lead until 1996.

If lead in your garden soil is a concern, grow plants in raised beds or containers filled with an uncontaminated planting mix.

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Areas near existing or former smelters, mine tailings, coal-fired power plants, and cement factories often have elevated soil lead concentrations.

Lead-arsenate sprays were used for pest control in fruit and nut orchards from about 1910 to the 1950s. If your home is located on an old orchard site, soil lead and arsenic concentrations may be elevated.

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How people are exposed to lead from soil

- **Play areas.** Children are at greatest risk for lead poisoning because of their behavior and physiology. Hand-to-mouth behavior is very common among infants and children. They absorb more of the lead they consume than adults do. Bare soil and dusty areas, including indoor areas, carry the greatest risk of lead exposure. The federal limit for lead in outdoor play areas is 400 ppm.
- **Property adjacent to heavily traveled streets and roadways.** Soils near older and high-traffic streets are likely to have greater lead contamination from exhaust emissions. Oregon banned leaded gasoline in 1996. Newer streets, newer subdivisions, and less-traveled roads are likely to be less contaminated by lead from exhaust.
- **Planting beds and gardens adjacent to structures.** Houses built before 1960 almost certainly have been painted with lead-based paint. The older the structure and the more coats of paint, the greater the likelihood of contaminated soils at or near the foundation as lead flakes off the structure and onto the soil. The chance of contamination is less as you move away from structures.
- **Pets in the household.** Pets often dig in soil, and can bring contaminated dust into the house. Contaminated dust can transfer onto floors or the hands of people who handle pets.
- **Lead on plants.** Eating soil or eating unwashed produce are the most common exposure routes from soil. Contaminated dust on plants is a greater concern than lead in plants.

What happens to lead in soil?

In contaminated soils, lead accumulates in the top 1 to 2 inches unless soil is disturbed by digging or tilling. Lead is held tightly on the surfaces of very fine clay and organic matter particles, which may stick to skin and clothing. Almost all of the lead in soil is in a solid form; it does not dissolve in water. Plant roots can only absorb what is dissolved in water. The function of plant roots is to take in nutrients and to exclude non-nutrients, such as lead. Read more on page 4, "Plants take up less lead when soils are well managed."

Vegetable gardening

1. The greater health risk is from lead-contaminated dust *on* plants, not *in* plants.
2. Plant roots only take up metals or any nutrient dissolved in water.
3. Most plants don't grow well in low pH, acidic soil conditions that allow metals to dissolve.
4. Garden practices that promote robust vegetable growth reduce the human exposure to lead.

Soil tests for lead

The best way to learn whether soil lead concentrations are high enough to pose a risk is to have the soil tested for lead. Accurate results come from submitting a good sample.

To take a soil sample, collect 15 to 20 subsamples from the area of concern. For garden soils, sample from the surface to a depth of 6 inches. For play areas, sample the top 2 inches of soil. See OSU Extension publication *Soil Sampling for Home Gardens and Small Acreages* (EC 628) for detailed sampling instructions. Mix the subsamples thoroughly in a plastic container, place about 1 cup of the mixed soil in a clean, sealable plastic bag, and submit it to a laboratory. Laboratory soil lead concentrations (ppm) are expressed on a dry weight basis. This is the same as the EPA guidance.

Soil test interpretation for garden and bare soils

Lead concentrations in soil are expressed as parts per million. This means parts of lead per million parts of dry soil. State and U.S. Environmental Protection Agency (EPA) regulations limit lead concentrations in soils for play areas for children, high-contact areas for children, and bare-soil areas in the landscape. The United States does not have specific guidelines for garden soils or for lead concentrations in foods. The guidelines shown in Table 1 (page 3) are based on state and federal rules and apply only to soils. *They do not apply to plant tissues or to water.*

The EPA has established the following maximum lead concentrations in bare soil at residences:

- Building perimeter and yard: 2,000 ppm
- Bare soil play areas and high-contact areas for children: 400 ppm
- The rest of the yard: 1,200 ppm on average for bare soil
- If the lead concentration is 5,000 ppm or above, paving over the soil or otherwise eliminating the lead is required.

Oregon Administrative Rules (OAR) Chapter 333 regulates the certification of individuals and firms engaged in lead abatement activities. This state regulation is slightly more restrictive than the federal standards set by the EPA. Under OAR 333-069-0015(68), soil lead hazard is defined as "bare soil on residential real property or on the property of a child-occupied facility that contains total lead equal to or exceeding 400 parts per million in a play area or average of 1,200 parts per million of bare soil in the rest of the yard based on soil samples."

Table 1. Recommended gardening practices based on results of soil test for lead

Total soil lead test (ppm)	**Recommendations**
Less than 50	Little or no lead contamination in soil. No special precautions needed.
50 to 400	Some lead present from human activities. Grow any vegetable crops. Choose gardening practices that limit dust exposure or soil consumption by children.
400 to 1,200	Do not grow leafy vegetables or root crops. These crops carry the highest risk of lead contamination. Choose gardening practices that limit dust exposure or soil consumption by children.
Greater than 1,200	Not recommended for vegetable gardening. Plant perennial shrubs, groundcover, or grass, and cover any bare soil with mulch. Grow vegetables in uncontaminated soil in raised beds or containers.

Figure 1. When metals in soil are a concern, grow leafy and root vegetables in raised beds filled with an uncontaminated soil or growing medium.

Figure 2. Covering bare soil with a thick layer of mulch will reduce exposure to contaminated soil.

Photo: Linda Brewer, © Oregon State University

Note that the concentrations in Table 1 are *total* soil lead. If your soil is tested by dissolving the soil sample in strong acid, you can interpret your test results according to Table 1. This test measures all the lead in the soil, including lead that is very tightly bound to other minerals.

Figure 3. Reduce your exposure to contaminated soil by wearing shoes and gloves. Reduce contamination inside the house by leaving dirty or dusty clothes outside the living space.

Photo: Linda Brewer, © Oregon State University

It is *not* appropriate to interpret results from tests measuring *available or dissolvable* lead using Table 1. Table 1 cannot be used to interpret results from drinking water or plant lead testing. See the section "Soil tests for lead" (page 2) and the sidebar "Which soil test? It makes a difference" (page 5) for details on choosing a soil test. See section "Soil test interpretation for garden and bare soils" (page 2) to understand the results of a soil test.

Follow good gardening practices

If you don't know the history of your garden site, have the soil tested before you establish a vegetable garden. If lead or other metals are a concern, grow root crops and leafy greens in raised beds or containers filled with an uncontaminated planting mix (Figure 1, page 3). Cover bare soil with mulch; mulch garden paths, perennial beds, and other bare soil areas in the landscape (Figure 2, page 3).

Mulching with organic matter increases the soil's capacity to store water and reduces dust formation. It also provides a barrier between the gardener and any lead-contaminated dust that may have been deposited.

For intensive gardening with bare soil and frequent tillage on sites with high soil lead concentrations, reduce lead hazard by:

- Filling raised beds with uncontaminated soil mix or use a soil-free planting mix (Figure 1, page 3). Before buying any compost or planting mix, ask whether it's been tested for metals. Avoid using topsoil, planting mix, or compost of unknown quality or origin.
- Placing solid plastic or geotextile covers between uncontaminated and contaminated soils to reduce mixing.
- Growing plants in containers using uncontaminated potting soil. Ask the supplier for test results for metals before buying these products. Compost and planting mixes that bear the OMRI (Organic Materials Review Institute) logo or the U.S. Composting Council Seal of Testing Assurance have been tested for metals.

Practice good gardening hygiene

Wear work gloves and shoes, don't track soil into the house, wash your hands, and change clothes if they are dusty or dirty (Figure 3). Monitor children while they are in the garden. Supervise hand washing after they play outdoors or work in the garden.

Plants take up less lead when soils are well-managed

Lime and phosphorus change the soil environment so that lead and other metals such as zinc, copper, cadmium, and nickel are less soluble. Plants can only take up minerals that are dissolved in soil water. When soil lead is greater than 400 ppm, maintain soil pH near 7.0 by applying lime. Before adding amendments, including lime, have the soil tested for the basics: phosphorus (P), potassium (K), pH, and lime requirement. Adding lime and phosphorus to soil will not reduce total lead, but may reduce the bioavailabity of lead in soil. Applying compost or other organic matter will reduce exposure to lead-contaminated dust. Meeting basic plant needs will

ensure robust growth and reduce the concentration of any lead that might be taken up by plants. See "Soil tests for lead" (page 2) for more information.

Add lime and phosphorus when a soil test indicates a need for them.

- ***Lime.*** Soil pH is a measure of how acidic or alkaline a soil is; 5 is acid, 7 is neutral, and 8 is alkaline. Soil pH near 7 is ideal for most garden crops. Lead forms rock-like minerals in neutral soils. The lime requirement test indicates how much lime is required to increase soil pH to neutral. Lime is most effective when tilled or spaded into soils. Because it usually takes 3 to 6 months for the lime to increase soil pH, adding it in the fall is a common practice. Plants such as blueberry, rhododendron, and azalea require a lower pH—closer to 5.5. Do not lime the soil around these plants. Reduce lead hazard near them by covering bare soil with a thick layer of woody mulch or bark.
- ***Phosphorus.*** Phosphorus reacts with lead to form minerals that don't readily dissolve. Add phosphorous when the Bray P1 soil test is less than 50 ppm or the Olsen test is less than 25 ppm. Manure, compost, and phosphorus fertilizers are good sources of phosphorus. Composted municipal biosolids can be used to supply organic matter and phosphorus.
- ***Compost.*** Add 1 to 2 inches of composted yard debris to your garden beds or mulch with leaves in the fall every year to reduce dust. Be selective in the materials you use. Most organic matter is good at covering bare soil; some sources provide too many nutrients if added at the rate of 2 inches per year. As a general rule, manures that are high in nitrogen are also high in potassium and other soluble salts. In this case, we define "high in nitrogen" as containing more than 2 percent nitrogen on a dry weight basis. While these have nutrient value, they can be over-applied and kill or injure plants. This is part of the reason why chicken manure "burns" plants.

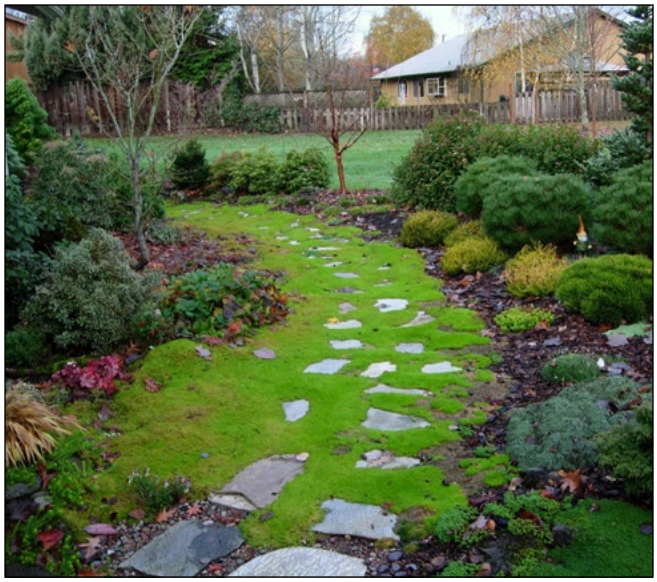

Figure 4. Groundcovers can reduce exposure to lead in soil and dust.

Photo: Dan Sullivan, © Oregon State University

See Oregon State University Extension publication *Improving Garden Soils with Organic Matter* (EC 1561) for more on mulching and organic matter. See Washington State University (WSU)

Which soil test? It makes a difference

When choosing a lab to analyze soil for metals, it's important to know which test method the lab uses. The test method makes a difference in how the results are interpreted.

An environmental lab would test for *total* metals. An agricultural lab is more likely to run a routine soil nutrient test. A few labs offer both types of tests. Request a total metal digest using a strong acid; the results will be equivalent to the EPA 3050 B soil test method. You can then compare the results to the established EPA limits for metal concentrations around homes, play areas, and child care facilities, and follow established recommendations shown in Table 2. A routine soil test for soil nutrients, for example zinc, is not useful for comparison with soil metal concentrations published by the EPA (Table 1, page 3) or the U.S. Geological Survey.

Contact the lab in advance and ask whether your sample will be tested for total metals. Tell the lab representative about the purpose for the test and the intended use of the results: you want screening for soil metal contamination, especially lead, and you want to determine the soil's suitability for gardening or for a play area. This will ensure that you get useful information from the results. Confirm instructions for sample preparation, packing, labeling, and mailing.

Extension publication *Using Biosolids in Gardens and Landscapes* for more on using biosolids in home landscapes.

Do fruits and vegetables accumulate lead?

Plants grown in well-managed soils do not absorb much lead through their roots. Dust on the outside of the edible portion of vegetables is the main route of exposure to lead. In soils that are high in lead, crops that are difficult to wash present the highest lead hazard to humans. Table 2 lists plants that will supply more lead to the diet, because they are more difficult to wash.

Follow good food-preparation practices

Eat only well-washed vegetables and fruits; discourage eating produce straight from the garden. Lead-contaminated dust on any unwashed vegetable is a concern.

Figure 5. Add compost to soil. It will help bind lead to the soil, reducing dust and lead solubility. Drip irrigation reduces splashing of contaminated soil onto the edible parts of plants.

Photo: Linda Brewer, © Oregon State University

- Vegetables with large, complex surfaces such as lettuce, Swiss chard, broccoli, and cauliflower can trap a lot of dust. Remove the outer leaves of leafy crops and thoroughly wash with cold, running water just before eating, cutting, or cooking. The Food and Drug Administration does not recommend soaking produce or using soaps, detergents, or commercial produce washes.
- Thoroughly scrub root vegetables with a clean produce brush and peel them before eating. Even if you discard the peel, it is important to wash produce first so that soil and bacteria are not transferred on the knife from the peel to the edible portion.

Table 2: Which garden produce is easiest to wash?

Easier to wash well	More difficult to wash well
Fruits	
Tomato, pepper, tomatillo, eggplant, beans	Strawberry
Blueberry, kiwi, raspberry, blackberry	
Cucumber, squash, pumpkin, zucchini	
Apple, pear, peach, plum	
Leaves	
Kale, kohlrabi, onion, garlic	Lettuce, mustard, spinach, chard, Chinese cabbage
Annual herbs: basil, cilantro, parsley	
Perennial herbs: rosemary, sage, lavender, thyme	
Roots	
Potato, Jerusalem artichokes	Carrot, parsnip, turnip, rutabaga, radish, celeriac
Buds, flowers, shoots	
Corn	Cauliflower, broccoli, asparagus

Reduce dust to reduce lead exposure

In addition to washing garden produce, these techniques will limit exposure to lead-contaminated dust:

Cover bare ground. Plant perennials or shrubs in areas with greatest metals contamination, and mulch beneath them. Cover bare soil under perennial flowers, fruits, vegetables, and ornamentals with a perennial groundcover, dense grass, or heavy organic mulch (Figure 2, page 3, and Figure 4, page 5). Vegetable gardens are annual plantings that require routine digging or tilling. Minimize bare soil there by planting transplants and mulching immediately afterward.

Avoid digging or tilling to control weeds. Forking is less likely to raise dust than rototilling. Consider using an appropriate herbicide (glyphosate) for weed control. Always read and follow label instructions when using any herbicide or pesticide.

Garden location. Place annual flower and vegetable gardens as far as possible from busy traffic ways and older structures.

Add compost to vegetable and flower gardens to reduce the likelihood of dust. The individual particles of soils amended with compost are held together more strongly. Compost-amended soils also store more water and promote more robust plant growth (Figure 5, page 6).

Reduce soil splash. Overhead watering can cause soil to splash onto edible plant parts. If possible, use drip irrigation. When watering with a hose or watering can, hold the water source close to the soil surface to reduce splashing (Figure 5, page 6).

Common questions about lead

What is lead and why is it dangerous?

Lead is a metal found in minerals, rocks, and soil. It is used in paints, lead-acid batteries, solder, pewter, bullets, and fusible alloys.

Lead poisoning usually causes long-term effects rather than acute toxicity in humans. For this reason, poisoning may occur over a long period of exposure without obvious symptoms.

Nerve and brain damage are possible, as well as harm to the heart, kidneys, blood, reproductive system, and nervous system. Children from 6 months to 6 years are more often exposed in the home than outdoors. Adult lead poisoning normally occurs in the workplace or during hobbies or recreational activities. Lead dust may be brought into the home on clothing, shoes, and the skin.

If you have reason to suspect lead-related health problems, contact your physician. Your local health department and the Oregon Health Authority can also assist you in evaluating lead hazards and remedying them.

What does soil contaminated with lead look like?

Lead-contaminated soil does not look or smell different than other soils. Lead does not break down in the soil, so the soil must be made "lead safe."

What about lead in water?

Although lead does not dissolve readily in water, water that has a low pH can dissolve lead from pipes, solder, or fixtures. "Hard" water has a high mineral content. If mineral buildup on the inside of pipes prevents contact between the water and the pipes or solder, it may offer some protection by reducing contact between water and the lead.

The EPA has established an "action concentration" of *15 parts per billion* for lead in tap water.

The amount of lead added to soil through irrigation usually is quite small compared to the amount of lead present in soils. Remember that the background concentration of lead in non-contaminated soil is usually 10 to 50 parts per *million*. The action concentration for lead in tap water is 1,000 times lower than the concentration of lead in soil. If you are concerned about lead in water, use drip irrigation to keep water off edible plant parts.

Should I be concerned about lead concentrations in soil amendments?

Fertilizers sold in Oregon must meet standards specified by OAR 603-059. This requirement is enforced by the Oregon Department of Agriculture. Oregon is one of the few states that regulates metal concentrations in fertilizer products.

A well-mulched garden bed.

Photo: Linda Brewer, © Oregon State University

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Use pesticides safely!

- Wear protective clothing and safety devices as recommended on the label. Bathe or shower after each use.
- Read the pesticide label—even if you've used the pesticide before. Follow closely the instructions on the label (and any other directions you have).
- Be cautious when you apply pesticides. Know your legal responsibility as a pesticide applicator. You may be liable for injury or damage resulting from pesticide use.

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