Lead in Residential Soils: Sources, Testing, and Reducing Exposure

INTRODUCTION

Lead occurs naturally in soils, typically at concentrations that range from 10 to 50 mg/kg (milligrams of lead per kilogram of soil, equivalent to parts of lead per million parts of soil, or ppm). Because of the widespread use of leaded paint before the mid-1970s and leaded gasoline before the mid-1980s, as well as contamination from various industrial sources, urban soils often have lead concentrations much greater than normal background levels. These concentrations frequently range from 150 mg/kg to as high as 10,000 mg/kg at the base of a home painted with lead-based paint. Lead does not biodegrade, or disappear over time, but remains in soils for thousands of years.

Serious human health risks, particularly for children under 6 years of age, are associated with lead poisoning. It is estimated that between 5.9 and 11.7 million children nationwide potentially are exposed to lead in soil or dust. Low-level, chronic exposure to lead in contaminated residential soil can cause several developmental and behavioral problems in children. Among these are reduced IQ and attention span, hyperactivity, impaired growth, learning disabilities, hearing loss, and insomnia. Once absorbed by the human body, lead is extremely difficult, if not impossible to remove. Therefore, not only is prevention of lead poisoning the best cure, but it may be the only cure.

This fact sheet provides some background information about how lead behaves in soil. It explains how soils become contaminated with lead and how people are exposed to lead in soils. Information also is provided about how to test soils for lead contamination and how to interpret the results of such testing. Finally, several measures are outlined that can reduce exposure to soil lead and prevent lead poisoning and its associated health risks.

LEAD IN SOIL

Soil lead is held tightly on the surfaces of very fine clay and organic matter particles. Therefore, when lead is added to the soil surface, it tends to accumulate in the upper 1 to 2 inches of soil unless the soil has been disturbed by activities such as excavation for building or tillage for landscaping and gardening. Added lead also will become most concentrated in very fine soil particles, which tend to stick to skin and clothing and form airborne soil dust.

Not all of the lead in soil is available to plants (or to the human body, should the soil be eaten). The availability of soil lead depends on how tightly it is held by soil particles and on its solubility (how much of it will dissolve in water). At low soil pH (pH<5, acidic conditions) lead is held less tightly and is more soluble. At near neutral or higher pH (pH>6.5, neutral to basic conditions) soil lead is held more strongly, and its solubility is very low. Lead is held very tightly by soil organic matter, so as organic matter increases, lead availability decreases.

Some lead added to soil may combine with other soil elements to form lead-containing minerals. One such mineral that has extremely low solubility is lead phosphate (pyromorphite). Formation of this mineral is favored by high soil pH and high levels of lead and phosphate, conditions that would occur with the application of ground agricultural limestone and large amounts of phosphate fertilizer to a lead-contaminated soil.

MAJOR SOURCES OF LEAD IN SOILS

Lead compounds were used as antiknock agents in gasoline until 1989. It is estimated that 4.5 to 5.5 million tons of lead used in gasoline remain in soil and dust. Soils adjacent to heavy traffic volume areas in cities and busy roadways have the highest concentrations of lead. The other major source of lead in residential soils is leaded paint. It is estimated that leaded paint was used on about 75% of houses built before 1978, when it was banned. Chalking, leaching, flaking, weathering, scraping, and sandblasting of leaded paint result in lead deposits in the soil near the base of these houses, creating a “halo” of lead contamination. Although less widespread, airborne lead from industrial sources also may have contaminated some nearby residential soils.

Exposure to soil lead

People are exposed to soil lead either from direct contact with contaminated soil or from contact with very fine soil particles carried into houses as airborne dust or on shoes, clothing, or pets. Lead is taken into the body by either ingestion (eating) or inhalation (breathing). Children 2–3 years of age are at high risk for ingesting lead because they are apt to mouth dirty items such as toys and pacifiers and to suck dirty fingers and hands. (It is estimated that young children consume around 200 mg of soil per day, about the volume of an aspirin tablet.) Some young children exhibit *pica,* the desire to eat soil, and consume much larger quantities. Exposure also may result from eating garden produce grown in or near contaminated soil. Lead can be taken up from the soil into plant tissues, or contaminated dust may settle on edible leaves and fruits.

Testing residential soil for lead

Soils can be tested to determine if they are contaminated with lead and, if so, what measures should be taken to reduce exposure to the lead. Soils around older houses or near roadways may be contaminated and should be tested. Several laboratories in Pennsylvania, including Penn State's Agricultural Analytical Services Laboratory, have the facilities to conduct these tests. Contact your county extension agent or look in the yellow pages under "Laboratories" to obtain information about testing laboratories that offer this service to your area.

Before collecting any soil samples, contact the laboratory for any specific instructions, sampling kits, or forms that might be required. The steps described below typically are followed when collecting soil samples for lead analysis.

1. Select sites—Take samples from areas you suspect may have lead contamination such as near roadways or the base of an older home. Also collect samples from high-exposure areas such as garden sites and play areas. It is a good idea to sample each area separately and to make a map showing where each sample was collected.

2. Collect sample—In undisturbed areas, collect soil from the upper 1–2 inches of the soil. In areas where the soil has been disturbed, and in flower beds and vegetable gardens, collect 6-inch-deep samples. If a soil auger or corer is not available, use a shovel to dig a 6-inch-deep hole such that one side exposes a smooth vertical area of soil. Shave a 1-inch-thick slice of soil from this face, keeping it on the shovel. Then collect a 1-inch-wide sample from the center of this slice that reaches from the soil surface to a depth of 6 inches. Take 8–12 samples from a given area, put them together in a clean plastic bucket, and mix well. Take a small subsample (about a cup) and allow it to air dry. Do not heat in an oven or over a register. Put the air-dried sample in a clean plastic bag and seal and label it.

3. Send sample—Send the sample to a soil testing lab. You should request analysis for total sorbed lead (using EPA method 3050 or 3051 or its equivalent). You also should request analysis of pH, lime requirement, and soil phosphorus. If you need assistance interpreting the report you receive from the testing lab, contact your local extension office.

Interpreting soil test results

Laboratory test results normally will report soil lead concentrations in terms of µg/g (micrograms per gram), mg/kg, or ppm (parts per million). These are all equivalent units of measurement. The table below indicates the degree of lead contamination indicated by various soil lead concentrations. The following section provides information on measures that should be taken to reduce exposure at each level of contamination.

Soil Lead Level (Total Sorbed Lead Test)	Level of Lead Contamination mg/kg or ppm
Less than 150	None to very low
From 150 to 400	Low
From 400 to 1,000	Medium
From 1,000 to 2,000	High
Greater than 2,000	Very high

How to reduce exposure to soil lead

None to very low lead contamination (less than 150 mg/kg). There is no need to be concerned about lead exposure from these soils. Recognize, however, that other possible sources of lead exposure exist such as home interiors or school or daycare playgrounds.

Low lead contamination (150 to 400 mg/kg). Consider the following measures to reduce exposure to lead in these soils:

- Enforce a clean hands policy. Children should wash their hands when they come in from playing outside. Teach your children not to put their fingers in their mouths.

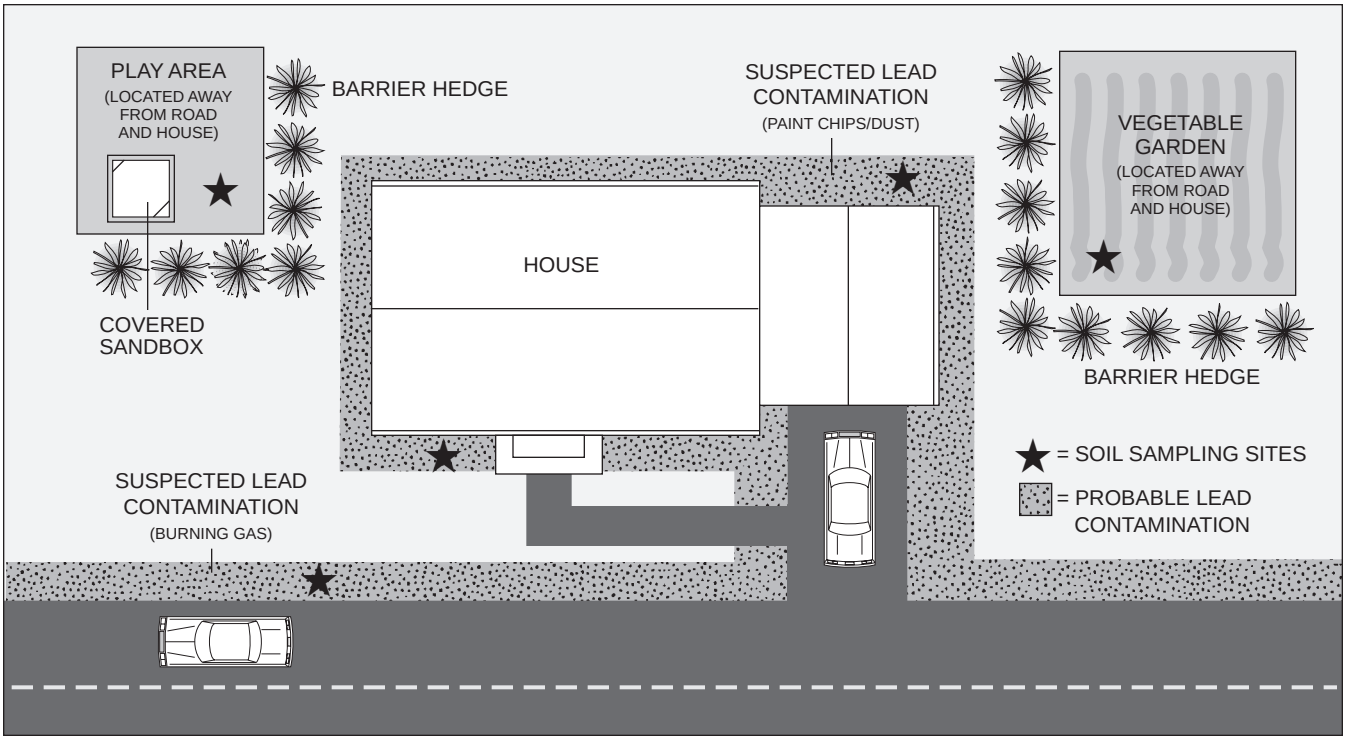

Figure 1. Suspected areas of lead contamination and suggested soil sampling sites in residential areas.

- Provide children with a covered sandbox, located away from areas where lead levels are highest. Discourage them from playing in areas of known or suspected lead contamination. Maintain a healthy grass sod on play areas, and cover bare soil with mulch. Place rubber mats or carpets over the soil in high wear areas such as under swings and at the bottoms of slides.

- Use the following gardening practices:

  Locate vegetable gardens as far as possible from roads, driveways, and old painted structures. Lay out gardens to keep leafy green vegetables and other hard-to-wash vegetables far from areas of suspected or known lead contamination.

  Incorporate one-third by volume organic material such as peat moss, compost, and manure into garden beds. For example, add three to four 4-cubic-foot bales of peat moss to 100 square feet of garden bed area.

  Apply ground limestone (available at most lawn and garden stores) to the soil, as recommended by the soil test, to obtain a pH of 6.5 to 7.

  Protect the garden area from airborne dust from contaminated soil areas (fine dust has the highest lead concentration). Erect a fence or plant a hedge between the garden and known or suspected areas of contaminated soil. Lay down a mulch in the garden to cover bare soil.

  Wash all vegetables carefully with a 1% vinegar solution or soapy water. Rinse thoroughly after washing. Peel root crops and discard the outer and older leaves of leafy vegetables. Do not compost the peelings or leaves.

Medium lead contamination (400 to 1,000 mg/kg).
Take the following measures in addition to the practices described above:

- Apply 11 lb. of triple super phosphate or concentrated super phosphate fertilizer (available at most lawn and garden stores) per 100 square feet of soil, and mix thoroughly to a depth of 6 inches. Phosphate fertilizer may lower soil pH as it reacts with the soil. One year after adding the fertilizer, test the soil again for pH and lime requirement. Apply ground agricultural limestone, as recommended by the soil test, to achieve a pH of 6.5 to 7.

- Cover the areas with mulch and restrict access of children or pets to these soil areas by erecting a fence or planting a dense evergreen ground cover.

- By following the gardening practices and phosphate fertilizer addition described above, this soil may be used safely

to grow fruiting vegetable crops (tomatoes, peppers, squash, cucumbers, peas, beans, corn).

- Do not grow leafy vegetables (lettuce, spinach, kale, cabbage) or root crops (carrots, radishes, turnips, beets) in this soil. Grow these crops in raised beds filled with noncontaminated soil and organic materials.

High lead contamination (greater than 1,000 mg/kg). Do not garden in this soil and do not allow children or pets to come into contact with it. Follow the steps described above to reduce lead availability and to keep the soil covered. If the highly contaminated soil is widespread and it is difficult to restrict access to the area, or if the soil lead concentration is greater than 2,000 mg/kg, contact your local health department, cooperative extension office, or regional DEP office for specific advice on lead abatement measures that should be taken.

FURTHER INFORMATION

More information on this subject is available from the following agencies:

Environmental Protection Agency (EPA)
401 M Street, SW
Washington, DC 20460-0003
http://www.epa.gov/lead/nlic.htm
(800) 424-LEAD

Centers for Disease Control (CDC)
Lead Poisoning Prevention Program
1600 Clifton Rd., NE
Atlanta, GA 30333
http://www.cdc.gov/nceh/programs/lead/lead.htm
(404) 488-7330

Alliance to End Childhood Lead Poisoning
227 Massachusetts Avenue, NE, Suite 200
Washington, DC 20002
(202) 543-1147
http://www.aeclp.org

United States Dept. of Housing and Urban Development (HUD)
Office of Lead Hazard Control
451 7th Street, SW, Rm. B-133
Washington, DC 20410-0000
(202) 755-1805
http://www.hud.gov/lea/

National Lead Information Center
1019 19th Street, NW, Suite 401
Washington, DC 20036-5105
(800) LEAD-FYI
http://www.nsc.org/ehc/lead.htm

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