UConn Soil Nutrient Analysis Laboratory
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Lead in Garden Soils

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What is lead?
Lead is a soft, grayish-white, naturally occurring metal that has been mined for thousands of years. Early Egyptians, Greeks and Romans used it for water pipes and in ceramic glazes and paint pigments. In the eighteenth century, lead poisoning among Americans and the English was traced to cider vats made with lead. Early tinkers and printers were exposed to lead through their daily work activities. Lead was an ingredient in paints for many years because it created a tough, lasting film when dry. Although the dangers of lead poisoning have been know for almost 2000 years, lead still continues to be used for industrial purposes. It remains in use because it has properties that make it a versatile, durable and economical material.

Where is lead and what are considered to be normal background levels?
Lead is everywhere. It is present in water, soil, our homes, our cars, our food and even in our bodies. In fact, no other contaminant has accumulated in humans to average levels so close to those which are potentially clinically poisonous. In native, undisturbed soils, lead generally ranges from 2 to 60 parts per million. Over the years, human activity has increased the levels of lead in some soils to hazardous levels.

How did soils become contaminated with lead?
Lead contamination and health problems caused by the contamination are associated mostly with mining, smelting and other industrial activities. In New England, lead contamination is primarily due to three sources – lead paint, exhaust from leaded gasoline, and the use of lead arsenate as a pesticide, particularly in old orchards. Use of these products has been phased out, but lead is a persistent pollutant and will remain in the soil pretty much indefinitely. Because it is a mineral, it will not decompose. Lead can, however, accumulate in plant tissues.

Many homes in New England were built before 1978 when lead was banned from paints for U.S. homes. As the paint aged and peeled, it was scraped off, sanded or sand-blasted resulting in paint chips and dust falling to the ground. The older the home, the more likely this process was repeated over the years. Even rain washing down buildings covered with lead-based paints may carry some lead into the surrounding soil. Unless the soil was physically disturbed, a typical scenario results in soil lead levels being highest closest to the homes with the levels decreasing as the distance from the building increases. The U.S. Environmental Protection Agency (EPA) found that the highest soil lead levels were located within the 1- to 3- foot dripline around the home.

Lead was used in gasoline as an anti-knock ingredient. Two forms of lead were used as additives, tetraethyl lead and tetramethyl lead. These were banned in 1991 as a result of the Clean Air Act. By some estimates, hundreds of thousands of pounds of lead found their way into the air each year via vehicle exhausts. Because of the use of lead in gasoline, soils along heavily traveled roadways are often found to contain elevated levels of lead.

Sometime in the late 1800's, lead arsenate was introduced as an insecticide for fruit trees. Orchards were a common site across the New England landscape. Many are still in production today. Although use of lead arsenate was discontinued in the 1950's, lead as well as arsenic remains in the soil on these old orchard sites, some of which have been developed and sold as residential properties.

Who is affected by lead?
While lead poisoning knows no age boundaries, most at risk from exposure to lead are children between the ages of six months to six years. This is because they most commonly engage in hand-to-mouth activities through which lead can be ingested. Toys or food can be dropped on contaminated soil and picked up by children who may put this item or their dirty hands in their mouths. Children often engage in physical activities on the ground that may stir up dust, which is then breathed in. Contaminated soil inadvertently brought into homes on shoes or dust from home renovations may also be ingested by young children. Older homes may have peeling paint chips that children could ingest.

How does lead affect children and adults?

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Childhood lead poisoning is the nation's number one environmental health threat. Lead can cause serious damage to the developing brains and nervous systems of fetuses and children under 6 years of age. Even low levels of lead are associated with behavioral problems, impaired hearing, and decreased growth and intelligence. High levels of lead in the body results in acute poisoning causing blindness, deafness, kidney damage, convulsions, coma and even death.

According to the New England Lead Coordinating Committee, the health and behavioral problems caused by low to moderate levels of lead in the body remain long after childhood. When compared with children who were not exposed to lead, the ones who were exposed would be more likely to have problems with reading, vocabulary, attention, fine-motor coordination, school attendance and academic achievement. They are also more likely to become high school dropouts.

The three main targets of lead in the human body are the bones, the kidneys and the brain. Lead accumulates in the bone marrow where red blood cells are produced. Because lead interferes with the incorporation of iron into hemoglobin, this produces anemia. As the body tries to rid itself of excess lead, it is either deposited into bone tissue or excreted by the kidneys in the form of urine. Once lead enters the kidneys, it can damage them. Lead that makes its way into the brain can cause irreversible brain damage. Because a child's brain is still developing, children often experience more brain damage from lead poisoning than adults. For more information on human health problems associated with lead poisoning, visit newenglandlead.org/about-lead/new-england-states/

Lead in soil – Distribution and sampling
Lead may be unevenly distributed throughout a particular area due to the nature of the contamination process. In general, one would expect lead in the soil to be elevated near older painted buildings, along heavily traveled roadways, and under the dripline of old fruit trees.

Depth of sampling should reflect the intended use of the site. If the soil was not previously disturbed or mixed, lead tends to remain in the top inch or two of the soil surface. If lead is a concern for children's play areas, collect samples from the top one to two inches of soil. Take 6 to 12 small, random samples from the designated play areas and mix them together to create a sample for testing.

To see where the lead levels drop off around an older home take a series of samples around the perimeter at varying distances from the building. The EPA suggests sampling at 1 to 3 feet, 4 to 7 feet, 8 to 15 feet and greater than 15 feet from the house. If the intent is only to check for lead contamination, a one to two inch sampling depth would suffice. Collect 3 to 4 small, subsamples from each side of the house at one of the recommended distances and mix them together for your sample. Repeat this procedure for the other distances. Label samples 1 – 3 feet, 4 – 7, etc. so results can be easily interpreted.

Lead is a problem in garden soils for several reasons. Plants take up lead from the soil and if vegetables or herbs are grown in contaminated soil and consumed, so is the lead. Contaminated soil particles can be breathed in or deposited on plant parts and subsequently ingested, and contaminated soil can be brought into the house on clothing or footware, and children can breathe in or ingest the contaminated soil.

When sampling for lead on garden sites, collect subsamples from the rooting zone which would be the top 6 to 8 inches of soil. The number of subsamples depends on the size of the garden, but for a 10-foot by 20-foot site, 6 to 10 subsamples are recommended. Mix the subsamples thoroughly in a clean container and remove about one cup for testing. If the lead level is elevated and the garden plot is large, it can be divided into smaller subplots and the testing repeated to evaluate whether the contamination is limited to one area or is widespread.

When is a Soil Considered Contaminated With Lead?
Recently the U.S. EPA has set levels of concern for lead in soils. Soils that contain 400 parts per million total lead are considered a cause for concern in children's play areas and those containing 1200 parts per million total lead are considered a concern for all users.

Suggestions for Managing Soils With Elevated Lead Levels
Management techniques for soils with elevated lead levels depend on factors such as the level of contamination, the intended land use, the costs associated with removal or remediation, and regulatory

requirements. Presently, options for dealing with lead contaminated soils are:

1) Removal and replacement with non-contaminated soil
2) Physically covering the soil with temporary or permanent barriers
3) Diluting the contaminated soil with lead-free soil
4) Using the site for low maintenance tree and shrub plantings
5) Building raised beds
6) Changing the soil chemistry to facilitate lead immobilization in situ
7) Phytoremediation whereby plants that accumulate lead from the soil are grown and periodically harvested.

While removal of contaminated soil would be an ideal solution, in many cases this is not financially or logistically possible. Interest and research in phytoremediation, which is the removal of lead from soil by plants that accumulate large amounts of lead, has been growing in recent years, but more work is needed to determine if this technique would be appropriate for small scale users. Also, the contaminated plant material would have to be disposed of properly.

The appropriate use of a site should be determined by the total lead level. **The University of Connecticut Soil Nutrient Analysis Laboratory recommends that areas testing higher than 400 parts per million total lead should not be used for growing vegetables or herbs.** Children should not be allowed to play in these areas and it is strongly recommended that their blood lead levels be tested. Contact the child's pediatrician for information on blood lead testing. If the contaminated soil cannot be removed, install barriers over the contaminated area to prevent direct contact with the soil. Barriers could be a vigorous turf grass, several inches of mulch, dense plantings of ground covers or shrubs, patio pavers or black top. Plant vegetables in raised beds lined with landscape fabric and filled with new soil, or grow them in containers.

Areas with total lead levels greater than 100 but less than 400 can be used for growing vegetables if certain precautions are taken. If children are playing in these areas, install a physical barrier to prevent them from coming in contact with the bare soil. Suggested barriers include dense turf, several inches of mulch or landscape fabric covered with mulch, sand or uncontaminated soil. Sandboxes in these areas should be lined with landscape fabric or have solid bottoms of wood or plastic. If mulch or sand is placed under swing sets or in other play areas, be prepared to renew these barriers occasionally if bare soil becomes apparent.

Can Vegetables Be Grown In Soils With Elevated Lead Levels?

Many vegetable and herb plants accumulate lead in their leaves and stems so avoid growing green leafy vegetables or herbs even in moderately contaminated sites (100 – 400 ppm total lead). Lead can also accumulate in the roots of plants. It is not advised to grow root crops like potatoes, carrots or beets. However, if these are grown, peeling the skin before eating will remove much of the lead. Best choices for moderately contaminated sites are fruiting plants like tomatoes, peppers, eggplants, beans, peas, corn and squash. Lead does not readily accumulate in the fruiting parts of the plant.

Suggestions for Reducing Lead Availability in Vegetable Gardens

Soils can be amended to lessen the amount of lead available for plant uptake. Generally this is accomplished by maintaining the soil pH around 6.5, maintaining adequate phosphorus in the soil, and increasing organic matter levels

The soil pH is a measurement of the acidity of a soil. A pH of 7.0 is neutral, a pH below 7.0 indicates acidity, and a pH above 7.0 indicates alkalinity. Most soils in Connecticut are acidic. If non-native vegetables and herbs are to be grown, the soil pH would be raised to the pH level these plants prefer, typically in the mid 6's. Limestone is commonly used to raise the soil pH. The soil pH is important because it affects the solubility, and thus, the availability of both plant nutrients and contaminants in the soil. Lead is less available for plant uptake in near neutral soils. Recommended amounts of ground limestone to apply will be listed on your soil test results.

Strive to maintain Modified-Morgan extractable soil phosphorus at optimum (13 to 20 lbs/acre) or slightly above optimum (21 to 60 lbs/acre) levels. Maintaining optimum soil phosphorus assists in reducing lead availability to plants because phosphorus forms insoluble lead phosphate in soils. The soil pH also affects the solubility of phosphorus. Phosphorus is most available to

garden plants when the pH is between 6.0 and 7.0. A major drawback to using phosphorus solely to reduce lead availability to plants is that quantities in excess of plant requirements are needed. Excess phosphorus in soils can leach through the soil profile or be carried away by surface runoff, and this can lead to surface and groundwater pollution causing environmental degradation.

Adding organic matter to the soil will reduce the lead available for plant uptake because some organic compounds in the organic matter will chemically react with the lead and make it insoluble. Some sources of organic matter include organic fertilizers, compost, leaf mold, manure, reed-sedge Michigan peats, and organic mulches. Keep in mind that some composts and most manures contain significant amounts of nutrients and excess amounts of nutrients should not be applied. If the organic matter in the soil is low and the nutrients are already at optimum levels, select low nutrient leaf-based composts, leaf mold and reed-sedge Michigan peats. If the more acidic sphagnum peat moss is used, plan on adding limestone to counteract the acidity. Aim to increase your soil organic matter content 1 to 2 %, for example, from 3 % to 4 % or from 5 % to 7%. Greater increases require careful monitoring of soil phosphorus.

Have your soil retested every 2 to 3 years to monitor nutrient and pH levels. If you are applying manure or compost to increase soil organic matter content, test your soil annually. Do not increase Modified-Morgan extractable phosphorus above 60 lbs/acre because above 60 lbs/acre you increase the chance of phosphorus contamination of water bodies. The standard nutrient analysis offered by the UConn Soil Nutrient Analysis Laboratory measures soil pH, available macro- and micro-nutrients using Modified-Morgan as the extractant, and screens for lead contamination. The laboratory can also determine the organic matter content of soils.

While the above guidelines are important, good hygiene practices are also essential:

1) Do not bring food or drink into the garden.
2) Wash your hands and tools if gardening in contaminated soil.
4) All produce should be washed thoroughly to remove any soil particles before consumption.
5) Wipe your shoes on a utility mat or remove them before entering a home.
6) Clean your pet's feet as well if they are muddy to avoid transporting soil into the house.

For most gardeners and landowners, it makes sense to minimize human exposure to lead contaminated soil by selecting an appropriate use for the site, follow good hygiene procedures after coming into contact with contaminated soil, install barriers to minimize contact, and create soil conditions that reduce lead uptake by food plants.

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