While lead, zinc, and other metals can be hazardous, there are simple steps you can take to minimize your risk of exposure.

G4173

MANAGING MINE-SCARRED LANDS in Southwestern Wisconsin

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Southwestern Wisconsin is well-known for its rich history in mining. Unfortunately, poor waste rock handling during mine operation, inadequate remediation after mine closure, and recent disturbance of ore or tailings continue to negatively affect human and environmental health throughout the region.

Where do the metals come from?

Approximately 4,000 square miles of hilly, unglaciated terrain in southwestern Wisconsin (Iowa, Grant, Green, and Lafayette Counties), northwestern Illinois (Jo Daviess County) and northeastern Iowa (Dubuque and Clayton Counties) make up the historic lead and zinc mining district of the Upper Mississippi River Valley (figure 1). Large-scale mining in the area began in the early 1800s and the region was the principal source of lead in the United States until the Civil War. As lead mining declined in the 1840s, production shifted to zinc extraction, which peaked during World Wars I and II. Zinc production declined after World War II, and the last operating zinc mine in the region, located near Shullsburg, WI, closed in 1979.

From this region, an estimated 814,000 tons of lead and 1,000,000 tons of zinc were extracted from 40,000,000 tons of ore mined from an estimated 2,000 operations (Heyl et al. 1959)—mostly before rudimentary human or environmental health and safety practices were followed. Ore for lead extraction was primarily close to the surface while ore for zinc was mined deeper underground. Although metallic lead was not extracted from the zinc ore, it nonetheless contains high levels of lead.

At individual mine sites, rock was typically crushed into medium gravel-sized particles and sorted by flowing water into heavier lead or zinc ore and lighter waste rock called **tailings**. The ore was typically transported to larger facilities (for example, in Shullsburg and Mineral Point) for additional sorting and processing. In some cases, small-scale processing took place off-site on railcar-mounted ore roasters.

Tailings not worth further processing were left where the sorting was done. These tailing piles existed at virtually every mine site and were typically left behind once mine operations ceased. Some tailing piles were very large and often this material was scavenged for local building projects where crushed rock was needed (for example, road beds and building foundations). From these piles, small rock pieces and rock dust were washed downslope by rain and remained in place unless subsequently excavated or washed into local streams and creeks (Cashell 1980).

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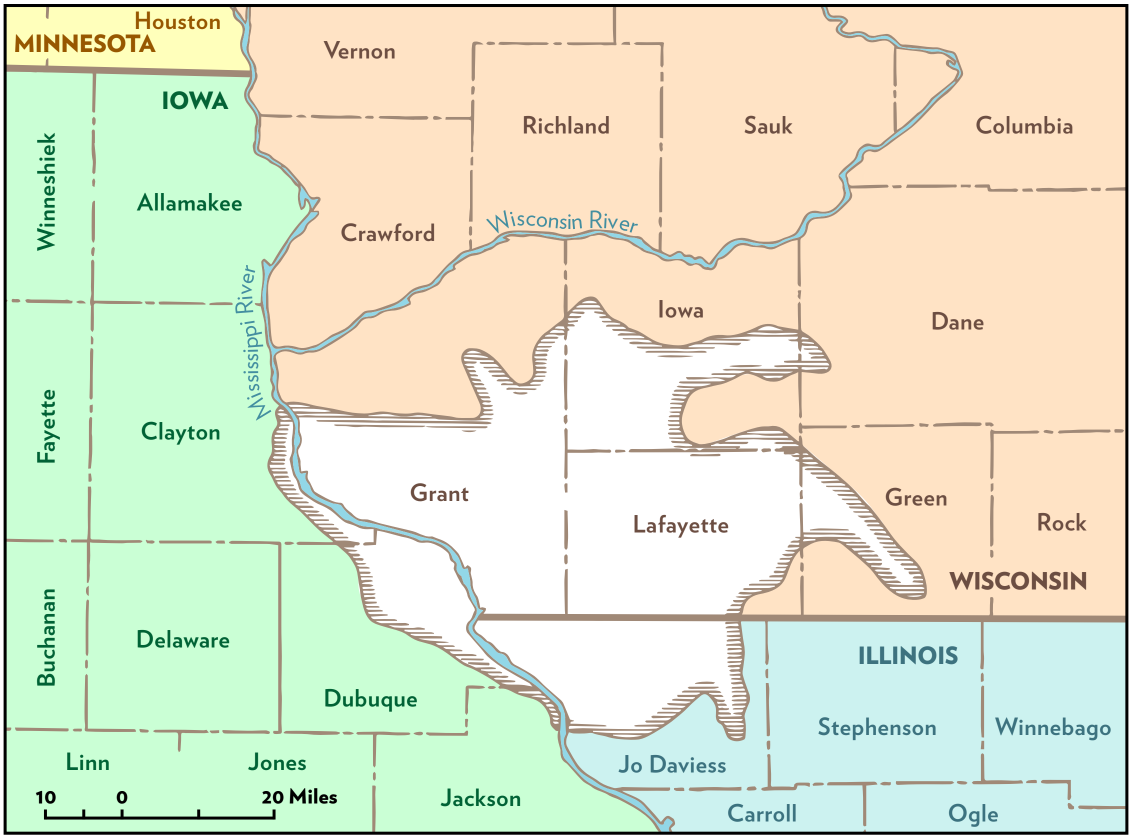

FIGURE 1. Approximately 4,000 square miles of hilly, unglaciated terrain spanning Illinois, Iowa, and Wisconsin make up the historic lead and zinc mining district of the Upper Mississippi River Valley.

Although the tailings did not contain enough metal to be worth further processing, they still contain relatively high levels of lead and zinc. Additionally, arsenic and chromium were occasionally found in the rock of this region.

Miners and their families founded most towns in the lead and zinc mining region. This means that most towns grew up very close to the mines and that current residents of many cities, towns, and villages live in close proximity to former mine sites and the potential hazards they left behind. Since lead and other metals do not degrade or move much from where they enter the soil, activities like developing, excavating, and farming these lands can inadvertently expose people to metals mined long ago.

Why are lead and zinc in soil a problem?

Once metals contaminate soil, that soil will remain contaminated. Exposure to lead-contaminated soil can increase lead levels in blood, which can result in severe and long-lasting health problems, especially in children. Effects can include lower IQ, hyperactivity, and behavioral and learning problems. A surprising amount of soil is accidentally ingested or inhaled by people playing on bare soil, working in a garden or farm field, eating or smoking with hands dirtied from farm or garden work, tracking dirt into the home or farm, or eating produce that has not been thoroughly washed.

Exposure to zinc-contaminated soil is not particularly problematic as humans need some dietary zinc. Plants also need some zinc, but at high levels it is **phytotoxic** (toxic to plants). However, in this region, where elevated zinc is found it is safe to assume that high levels of lead are also present. UW–Madison Division of Extension researchers have observed that zinc is commonly found at three to four times the amount of lead in mine-contaminated soil. For example, 800 milligrams per kilogram (mg/kg) of zinc would indicate 200 to 260 mg/kg of lead may be present.

If you are concerned about the possibility of lead exposure, a blood test is available through local health departments (see Additional resources) or your primary healthcare provider. Clients of the Women, Infants, and Children (WIC) program can be tested through WIC clinics.

Guidelines for screening crop, garden, and yard soil

Screening is recommended if:	Screening is encouraged if:
• Poor plant growth is observed year after year in specific areas • Soil or plant micronutrient tests indicate unusually high zinc levels • Agricultural advisors have identified soils as low-productivity • Plants show signs of chlorosis year after year • The **USDA Web Soil Survey** identifies an area as mine spoils	• There is a localized area with a large amount of crushed rock and gravel present in the soil. • You are excavating, landscaping, or recontouring fields in any areas identified as potentially impacted in **Extension publication G4177, *Digital Atlas of Historic Mining Features and Potential Impacts in Southwestern Wisconsin***. • You have a field, garden, or yard that may have fill or soil added from an unknown source.

Is it safe to eat plants grown or animals raised in lead and zinc contaminated fields?

Plants generally absorb only very small quantities of lead, even in soils that have high lead concentrations. Lead uptake by plants depends on many factors, including the type of lead mineral present, soil organic matter content, phosphorus levels, and soil pH. Even though lead is not a nutrient required by plants and the amount taken up is small, it is important to minimize all sources of lead exposure.

While local garden produce is safe to eat, dust or soil particles stuck to the outside of the produce could contain dangerous lead levels if grown in contaminated soil. The most common way that lead travels from contaminated soil to the human bloodstream is by unintentionally ingesting soil. Commodity grain crops will not be affected by soil lead contamination due to post-harvest processing.

Animals can be exposed to lead through forage crops or grazing. Lead that has adhered to leaves and stalks pre-harvest could be ingested, and harvesting practices that put the crop in direct contact with soil (for example, dry hay production) could cause greater contamination. Livestock grazing pastures containing contaminated soils may also expose the animals to elevated lead through ingestion. Animals can also transport contaminated soils back to the barn on hides and hooves.

Unlike lead, zinc is a required micronutrient for plants and can be taken up in relatively large quantities. Zinc is also a necessary part of the human diet. At high enough concentrations, zinc can be phytotoxic, however, the amount of zinc taken up by plants is not a hazard to humans or animals.

How can I tell if there are areas of lead and zinc contamination on my property?

Naturally formed, uncontaminated surface soils in this region are dark brown or black and typically have very little rock near the surface. Areas of rocky soils or soils that differ in color may indicate mine waste is present. Soils containing high concentrations of zinc can result in poor plant growth or sickly looking plants, which could be zinc phytotoxicity or limited access to other essential plant nutrients, such as phosphorus or iron. Symptoms of zinc phytotoxicity may be misdiagnosed as other micronutrient deficiencies, so it is important to verify elevated zinc levels through soil or plant tissue tests. For example, chlorosis in corn due to elevated zinc levels may be misdiagnosed as low zinc or another micronutrient deficiency, but low zinc is uncommon in this region. Elevated zinc concentrations in soil or plant tissues strongly indicates that high levels of other metals such as lead are also present.

Some visual clues of zinc phytotoxicity include:

- Stunted growth or sickly looking plants that occur in the same area year after year (figure 2)
- Overall yellow color or yellow-to-white striping of corn leaves (chlorosis), particularly on the newer leaves (figure 3)
- Purple or reddish coloration in corn leaves, indicating phosphorus deficiency even though soil or plant analysis may indicate otherwise (figure 4)
- Yellow, or yellow with brown spots and vertically oriented leaves on soybean (figure 5)
- Yellow sections of lawns
- Bare spots in lawns

Common signs of soil contaminated with waste rock include:

- Patches of soil with a higher percentage of gravel or small rocks in the soil
- Patches of soil with a lighter color than surrounding soil

The **USDA Web Soil Survey** provides mine-impacted soil maps for Lafayette County (soil type Mp) and Iowa County (soil type 2019), however, similar maps are unavailable for Grant and Green Counties. **Extension publication G4177, *Digital Atlas of Historic Mining Features and Potential Impacts in Southwestern Wisconsin***, contains maps of the entire region that detail all known mine features and indicate whether historic mine activity might have led to soil contamination on your property. **SnapMaps**, online maps for nutrient management planning in Wisconsin, includes all surface historic mine features from publication G4177 for Grant, Green, Iowa, and Lafayette Counties.

FIGURE 2. Area of zinc toxicity with stunted corn plants.

What should I do if I think I have metal-contaminated soil on my property?

If you observe the symptoms previously described in farm fields, it is recommended that soil and plant samples be sent to a certified soil testing laboratory for analysis. **Your county Extension agriculture agent** or a certified crop advisor can assist you with this. The **University of Wisconsin Soil and Forage Laboratory** frequently works with homeowners and individuals who need fewer samples analyzed.

A soil micronutrient test can analyze for zinc and is less costly than a lead-specific analysis. Elevated zinc can be assumed to indicate elevated lead at a ratio of approximately four parts zinc to one part lead. Soil lead analysis is also available from the University of Wisconsin Soil and Forage Laboratory and other certified laboratories.

Your county Extension agriculture agent will be able to advise you on proper sampling techniques and interpretation of the analysis results. Agents have specialized training and access to specialists within the University of Wisconsin system to help you correctly diagnose the problem and advise you on what to do next. Most agronomists and certified crop advisors do not receive specific training to manage metal-contaminated soils.

FIGURE 3. Chlorosis in corn grown in rocky mine-impacted soil.

FIGURE 4. **Stunted and purple coloration along leaf edges in corn indicate zinc-induced phosphorus deficiency.**

FIGURE 5. **Characteristic symptoms of zinc phytotoxicity in soybean.**

How do I manage metal-contaminated soils on my property?

Remediation of metal-contaminated soils involves either excavation and off-site disposal of the contaminated materials or burying the contaminated soil under a 4-foot layer of clean, uncontaminated soil. Both of these options are expensive, require special equipment, and must be approved by the Wisconsin Department of Natural Resources. Incorrectly performed remediation almost always leads to contamination of new areas. Using contaminated soil to fill low areas, gullies, or old quarries may endanger local water supplies and fishing resources.

The metal amount found in tailings is almost always very high from an environmental perspective and there are no easy ways to make contaminated soil not hazardous. If you have a farm field with contaminated soil that causes poor crop productivity, the best option is to stop working that portion of the field, particularly if the area is close to a residence that might be affected by dust or runoff generated from the site. Leaving the area fallow and under permanent vegetation minimizes the risk of spreading the contaminated soil to other fields and limits exposure to livestock and people. Consider enrolling the contaminated area in a set-aside program or establish a conservation easement as a long-term solution. Extension or local conservation staff can assist you with this.

If the area absolutely must be worked, avoid doing so when the soils are very dry to limit the amount of dust that is generated. This will prevent you from inhaling contaminated dust and from spreading the dust onto nearby fields and properties. Planting perennial species and using no-till practices lowers the risk of dust generation from exposed soil and decreases runoff. In some cases the zinc levels may be low enough to not cause significant yield loss under proper management, and the area may be at low risk for off-site transport of metal-contaminated soil. These areas may be suitable for producing crops that are not for human consumption. Your local Extension agent can recommend soil amendments and cropping practices to maintain productivity of these soils while minimizing exposure to metals.

If forage crops are being produced or livestock are grazing in areas of contaminated soil, keep livestock soil contact to a minimum. When cutting forages, flatten ant or mole hills prior to cutting and calibrate cutters to maintain adequate crop height and minimize contact with soil. Providing salt licks and mineral supplements, avoiding overgrazing, and fencing off bare areas will limit grazing livestock’s consumption of soil.

How to minimize your exposure to lead and other metals in the soil

- Avoid contact with contaminated soils and minimize their disturbance.
- If contaminated soil is located near your home, you should not garden or place playground equipment in that area.
- If a farm field is contaminated, do not farm that area; if a contaminated field absolutely must be worked, practice no-till techniques.
- If performing tillage operations or other soil-disturbing activities when soils are dry enough to generate dust, use a dust mask rated N, P, or R-100.
- If you must disturb contaminated soil, remove as much soil as possible from tools and equipment while on-site and wash them thoroughly as soon as you are finished.
- Do not eat, drink, or smoke while working in contaminated areas as these activities increase the risk of ingesting contaminated soil.
- Wash your hands and shower to remove lead-contaminated dust from your skin.
- Store and wash clothing exposed to contaminated soil separately from other clothes so that other clothes are not contaminated.

Around homes, maintain a healthy lawn and plant deep-rooted shrubs in problem areas. A healthy lawn will greatly reduce contact with contaminated soil. Added fertilizer, compost, or topsoil may be needed. Shrubs can be planted in areas of metal contamination to block direct contact with soil and minimize soil disturbance. Red fescue is a type of grass that is tolerant to metal. Native prairie plants that have demonstrated tolerance to high metal levels are partridge pea and bush clover. Deep-rooted shrubs such as leadplant, red twig dogwood, common ninebark, and highbush cranberry would likely also thrive as their root systems would grow into uncontaminated soil.

Where can I have my soil tested?

The University of Wisconsin Soil and Forage Laboratory (**uwlab.soils.wisc.edu**; 715-387-2523) can perform zinc, lead, and soil nutrient analyses. County Extension offices can provide contact information for private soil testing laboratories.

What do the results mean and what resources are available?

Lead and zinc naturally occur in all soils, and in Wisconsin is not considered a gardening or farming hazard at levels less than 52 milligrams of lead per kilogram of soil (52 parts per million or less) or 25,400 milligrams of zinc per kilogram of soil. Based on "blood lead level of concern" guidelines from the U.S. Centers for Disease Control and Prevention, exposure to any soil containing 200 parts per million of lead is potentially hazardous. The U.S. Environmental Protection Agency recommends that soil with more than 200 parts per million of lead be gardened with caution, and at 1200 parts per million of lead, not be used for gardening at all.

The results of your soil analysis may indicate no need for corrective action, a need for minor modifications, or a need for extensive interventions to reduce risk. University or county Extension staff, as well as public health department staff, can help you interpret the results of your soil analysis and plan any future steps.

Additional resources

UW–Madison Division of Extension county offices

Extension Grant County
https://grant.extension.wisc.edu
(608) 723-2125

Extension Lafayette County
https://lafayette.extension.wisc.edu
(608) 776-4820

Extension Iowa County
https://iowa.extension.wisc.edu
(608) 930-9850

Public health departments

Wisconsin

Iowa County
https://www.iowacounty.org/departments/HealthDepartment/environmental-health

Grant County
http://www.co.grant.wi.gov/localgov_departments_details.asp?deptid=414&locid=147

Lafayette County
https://www.lafayettecountywi.org/healthdepartment/page/environmental-health

Green County
https://gcpublichealth.org/enviromental-health/#Lead%20Poisoning

Illinois

http://dph.illinois.gov/illinoislead

Iowa

https://idph.iowa.gov/Environmental-Health-Services/Childhood-Lead-Poisoning-Prevention

City of Dubuque
https://www.cityofdubuque.org/815/Children-Lead-Poisoning

Clayton County
https://www.claytoncountyia.gov/213/Health-Zoning

UW–Madison Division of Extension publications

- A2100, ***Sampling Soils for Testing***
- A2166, ***Sampling Lawn and Garden Soils for Analysis****
- A3588, ***Management of Wisconsin Soils***
- A3905-03, ***Soil Contaminants in Community Gardens****
- A4088, ***Reducing Exposure to Lead in Your Garden Soil****
- A4089, ***Lead in Home Garden Soil****
- G4177, ***Digital Atlas of Historic Mining Features and Potential Impacts in Southwestern Wisconsin***

*Available in Spanish

References

Heyl Jr, Allen V., Allen F. Agnew, Erwin J. Lyons, Charles H. Behre Jr, and Arthur E. Flint. *The geology of the Upper Mississippi Valley zinc-lead district*. No. 309. US Government Printing Office, 1959.

Cashell, Margaret Marie. *Chemical and morphogenetic characteristics of Zn-Pb mine tailing soils in southwest Wisconsin*. University of Wisconsin–Madison, 1980.

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Images: Figure 1 adapted from Heyl et al. 1959 (**https://pubs.er.usgs.gov/publication/pp309**). Figures 2 and 5 courtesy of Chris Baxter. Figures 3 and 4 courtesy of Geoffrey Siemering.

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