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Sources and Impacts of Contaminants in Soils

Soils Overview

Soils are formed by the decomposition of rock and organic matter over many years. Soil properties vary from place to place with differences in bedrock composition, climate, and other factors. At times, the amounts of some soil elements and other substances may exceed levels recommended for the health of humans, animals, or plants. Certain chemical elements occur naturally in soils as components of minerals, yet may be toxic at some concentrations. Other potentially harmful substances may end up in soils through human activities.

In some regions of the United States, naturally occurring concentrations of certain chemicals may be higher than those in other areas. For example, typical levels of arsenic in the soils of some regions of New York State can exceed recommended values. At times this results in groundwater arsenic concentrations above US Environmental Protection Agency (USEPA) limits for drinking water, requiring treatment to ensure a safe water supply. In New York State, the naturally occurring concentrations of potentially toxic elements in soils are otherwise generally not a problem.

Soil properties are affected by past land use, current activities on the site, and nearness to pollution sources. Human activities have intentionally added substances such as pesticides, fertilizers and other amendments to soils. Accidental spills and leaks of chemicals used for commercial or industrial purposes have also been sources of contamination. Some contaminants are moved through the air and deposited as dust or by precipitation.

CWMI Resources for Healthy Soils

http://cwmi.css.cornell.edu/soilquality.htm

- **Sources and Impacts of Contaminants in Soils**
- **Guide to Soil Testing and Interpreting Results**
- **Best Practices for Healthy Gardens**
- **More Information about Arsenic and Lead**

This document provides background information about soil contaminants and their impacts on human health and the environment. It is part of a series of CWMI resources intended to help people who are interested in soil testing, interpreting test results, and best practices for healthy soils.

What Happens to Contaminants in Soils?

Once contaminants are in soils, where they go and how quickly they travel depends on many factors. Some organic (carbon-based) contaminants can undergo chemical changes or degrade into products that may be more or less toxic than the original compound. Note that chemical elements (such as metals) cannot break down, but their characteristics may change so that they can be more or less easily taken up by plants or animals. Different contaminants vary in their tendency to:

- End up in water held in the soil or in the underlying groundwater (by leaching through the soil);
- Volatilize (evaporate) into the air; or
- Bind tightly to the soil.

The characteristics of the soil also affect the fate of contaminants and whether they can be readily taken up by plants or animals. Site management and land use (such as gardening practices) can affect some soil characteristics. Important soil characteristics that may affect the behavior of contaminants include:

- Soil mineralogy and clay content (soil texture);
- pH (acidity) of the soil;
- Amount of organic matter in the soil;
- Moisture levels;
- Temperature; and
- Presence of other chemicals.

Are Contaminants Biologically Available?

The bioavailable portion is the amount of a substance that can cause direct effects on plants, animals or humans because it can be taken up by their bodies. Usually, not all of a contaminant found in soil is biologically available. The bioavailability of a contaminant depends on many characteristics of the soil and of the site. Site conditions affect how tightly the contaminant is held by soil particles and its solubility (how much of it will dissolve in water). Greater solubility usually means that more of the contaminant is bioavailable, but this also means that the contaminant is more likely to leach out of the soil. Certain chemicals show an "aging effect" and can become less bioavailable the longer they remain in soils.

Most commonly available soil tests measure a large part of the total amount of a particular contaminant in the sample, not just the bioavailable portion. The bioavailable portion may be only a small fraction of the total amount. Changes in site conditions, such as soil acidity or organic matter content, can change the bioavailability of a contaminant. There is no easy way to know what portion may be bioavailable. Using bioassay tests to measure uptake of contaminants by plants or soil organisms is the most direct way to estimate bioavailability. Unfortunately, bioassay tests are slow and expensive and are not generally available. For this reason, only the total levels or chemically extractable amounts (commonly used to approximate the total amount) of a particular contaminant are usually measured.

How are Contaminants Distributed in Soils?

The distribution of contaminants released to soils by human activities is related to how and where they are added. For instance, the amount of contaminants in the soils of an industrially-contaminated site may vary depending on the activities conducted on the site. The movement of air and water will also affect how soil contaminants move throughout a site. Chemicals may be carried by winds and deposited on the surface of soils; tilling can then mix these surface deposits into the soil. The movement of groundwater or surface water may also affect how contaminants spread from the source.

Many pesticides and soil amendments used for agricultural, industrial, or commercial activities may be found in residential soils. This could happen if former industrial or agricultural lands are later used for residential properties, and contaminants remain in the soil. Spills, runoff , or aerial deposition of chemicals used for agriculture or industry can also result in contamination of the soils of residential sites.

For example, arsenic and lead were once used as pesticides on a number of crops, including orchards, throughout the United States. Sodium arsenate was also commonly used on potato crops in eastern Long Island. Therefore, old orchards, farms, and adjacent areas are places where testing for arsenic and lead might be advisable. Within an orchard, the distribution of these contaminants may be very spotty since individual trees may have been treated, resulting in higher residues under each tree. Collecting multiple soil samples from such an area would help to determine the pattern of contamination.

What are Some Common Sources of Soil Contaminants?

Due to the wide array of contaminants, soils and site conditions, the levels of possible contaminants will depend on the specific conditions of a particular property. If the answer to any of the following questions is "yes," soil testing can help provide more information about the levels of a particular contaminant (or contaminants).

♦ **Lead Paint:** *Has lead paint been used on the outside of homes or other buildings on or near the property?*

Some paints manufactured before 1978 are likely to contain lead. As lead paint ages and peels off or is intentionally removed through activities such as stripping, scraping or sandblasting, lead can make its way into the soil surrounding homes or other buildings. The concentrations of lead in soil are usually highest right near a building, and tend to decrease with distance away from the contamination source. See more information from the Cornell Waste Management Institute (CWMI) at: *http://cwmi.css.cornell.edu/soilquality.htm.*

♦ **Pesticides:** *Are pesticide chemicals currently used on the property? Were pesticides used in the past, such as for old orchards or farms?*

Pesticides include chemicals used as insecticides, herbicides, fungicides, rodent poisons and some other kinds of poisons. When testing for pesticides in soil, there is no single test to see if there are pesticide residues. It is necessary to test for specific chemicals, and unfortunately, there are hundreds of pesticides from which to choose. The best way to proceed is to consider if and how pesticides might have been used on your property, and to try to get information on what might have been used and where. For example, chlordane, a persistent chemical, was often used for termite control around foundations in the past. Pesticide mixing areas are often "hot spots" of contamination. Fact sheets providing more information about specific pesticide chemicals and their uses are available from the National Pesticide Information Center at: *http://npic.orst.edu/npicfact.htm*.

♦ **Industrial / Commercial Site Use:** *Is the property near an industrial or commercial site that may be using chemicals or might have used chemicals in the past? Was the property formerly the site of industrial or commercial activity?*

The particular chemicals that may be present due to industrial or commercial activities will depend on the type of industry and the specific procedures used on site. If commercial or industrial activities are currently occurring on or near the property, or may have occurred in the past, it may be helpful to research what chemicals might have been used for a specific activity. The level of contamination will depend on many factors, such as how close to the property a particular activity occurred, and how long it has been since chemicals were used. The USEPA (*http://www.epa.gov/*) and the Agency for Toxic Substances and Disease Registry (ATSDR, *http://www.atsdr.cdc.gov/*) may have more information about specific chemicals and contaminated sites.

♦ **High Traffic Areas:** *Is the property located near a roadway with frequent traffic?*

A property's distance from roadways and traffic can affect the amounts of certain chemicals in the soil, especially lead. Lead compounds were used in gasoline until the late 1970s; after this time their use was phased out. Even though the use of leaded gasoline has now been discontinued, the highest concentrations of lead in soils are still generally found adjacent to busy roadways. Polyaromatic hydrocarbons (PAHs) are chemicals associated with the incomplete combustion of fossil fuels and with coal tars and asphalt. The levels of PAHs and some other chemicals may also be higher in high traffic areas as compared to other areas. The lowest levels of contamination would be expected in the areas of the property farthest away from traffic.

♦ **Treated Lumber:** *Were decks, swing sets, playscapes, or other structures on the property built from pressure treated wood?*

Arsenic, in the form of chromated copper arsenate or CCA, has been used in wood preservatives to make pressure-treated lumber. CCA-treated lumber is no longer available in the US for residential uses, but it can still be used for industrial purposes. Some of the arsenic in CCA-treated wood can move from the wood to nearby soil, although it does not travel far from the wood structure. The ATSDR provides more information to answer common questions about CCA and arsenic (*http://www.atsdr.cdc.gov/cabs/arsenic/*), while Pennsylvania State University offers additional information about garden use of treated lumber (*http://pubs.cas.psu.edu/freepubs/pdfs/uc173.pdf*). Also see more information from CWMI at: *http://cwmi.css.cornell.edu/soilquality.htm*.

♦ **Petroleum Spills:** *Is there a history of spills or leaks of fuel oil, gasoline or other petroleum products on or near the property?*

Petroleum leaks or spills from gas stations, fuel tanks, or other activities can result in elevated levels of contaminants such as benzene, toluene, and xylene in the soil. Some of these chemicals (especially volatiles) are unlikely to remain in the surface soil where they would be taken up by plants or be in direct contact with humans, unless the spill was very recent or large. However, this is not true for all contaminants or all spills, especially for some underground spills that may result in vapors that make their way to the surface soil. If the source is a leaking underground heating oil tank, it is unlikely that the surface soil would be contaminated with these chemicals. However, these spills should be reported to the NYS Department of Environmental Conservation (NYS Spill Hotline: 1-800-457-7362)

It is particularly important to find out if contaminants are a problem in areas where children play or in gardens where fruits or vegetables are grown for food.

♦ **Automobile or Machine Repair / Junk Vehicle Storage:** *Has automobile or other machine repair work been done that may have resulted in chemical spills or dumping on or near the property? Are junk vehicles stored on or near the property?*

Automobile or machine repair activities may result in accidental spills or intentional dumping of chemicals into residential or community soils. Many possible contaminants could be associated with these activities, including petroleum products, PAHs (particularly from motor oil), solvents like trichloroethylene (TCE), used tires and rubber products, metals (used engine oil may contain chromium, lead, molybdenum, or nickel from engine wear), or used batteries (which may release lead or mercury). Junk vehicles may also be a source of these chemicals or other contaminants, depending on their condition and how and where they are stored.

♦ **Furniture Refinishing:** *Has furniture been refinished on or near the property?*

Some chemical strippers used in furniture refinishing contain methylene chloride and other solvents, including toluene and methanol. These substances can contaminate the soil and groundwater if handled improperly during commercial operations or projects by a home hobbyist. Note that a variety of chemical strippers are available commercially, some of which do not contain these toxic substances.

♦ **Landfills / Garbage Dumps:** *Is the property near a landfill or garbage dump? Was it formerly the site of a landfill or garbage dump?*

Many different soil contaminants can leach from landfills or other garbage disposal sites, including petroleum products, solvents, pesticides, lead and other heavy metals. The chemicals that may be present in soils near locations used for waste disposal (currently or in the past) will depend on the specific conditions of a particular site, and on what types of materials were disposed of at that site.

♦ **Fires:** *Have materials been burned on or near the property? Has there been an accidental fire?*

The intentional or accidental burning of materials can produce and release PAHs, dioxins or other chemicals into soils, depending on what was burned and how long ago. Burning yard wastes, such as tree branches, is much less likely to release harmful contaminants than intentional or accidental fires that burn garbage, buildings or their contents, or other synthetic substances.

♦ **Fertilizers:** *Are fertilizers used for lawns or gardens on the property? Is the property near farmland or was it formerly used for agriculture?*

The use of some fertilizers based on waste materials, particularly sewage biosolids or fly ash, may result in the addition of heavy metals (such as copper, zinc, cadmium and lead) and PBTs (persistent, bioaccumulative, toxic chemicals) to soils. Products made from cement kiln dust may also contain heavy metals and dioxins. The use of animal manure or chemical fertilizers may result in higher levels of some soil contaminants. Phosphate fertilizers are known to contain some cadmium (from the rock phosphate), and manures are sometimes relatively high in copper or zinc.

How are People Exposed to Soil Contaminants?

Generally, people can be exposed to contaminants in soil through ingestion (eating or drinking), dermal exposure (skin contact) or inhalation (breathing). The route of human exposure to a soil contaminant will vary with the contaminant and with the conditions and activities at a particular site.

Many people, especially children, accidentally ingest small amounts of soil as part of their normal activities, such as performing yard work, gardening or playing. Young children usually ingest more soil than older children and adults because of their frequent hand-to-mouth behavior. Children and adults may also ingest soil while indoors if soil is transported into homes or other buildings, such as on shoes, clothing, or pets. Some contaminants, such as many pesticides, can pass through the skin and enter the body. People may also inhale contaminants bound to soil particles that become airborne (such as in windblown dust), or contaminants that vaporize from soil.

People can be exposed to contaminants in soil particles that stick to edible parts of garden produce or get taken up into garden plants from the soil. Animals raised for food may also take in contaminants from soil, and people may be exposed to these contaminants by eating animal products such as meat, eggs and milk. Drinking water may contain contaminants that were directly discharged into the water source or entered the surface water through runoff, or had leached from the soil into groundwater. In some situations, a contaminant may vaporize from the underlying groundwater and become part of the air that people breathe.

What are the Possible Health Effects of Exposure?

For any exposure to a contaminant, the likelihood that health effects will occur depends on the toxicity of the contaminant (how harmful it is to humans), how much of the contaminant is in contact with humans, and how long and how often the exposure occurs. Other potentially important factors include how healthy the person is, and his or her age, diet, gender, family traits and lifestyle. Differences in these factors may affect how people will respond to a given level of exposure to a particular contaminant. Children are generally more vulnerable because they ingest more soil, absorb more of the ingested contaminants, and eat, drink and breathe more in relation to their body size than adults. The bodies of unborn babies, infants, and children are also still developing and are more vulnerable to contaminants.

Information about the health effects of a particular contaminant may be available through the ATSDR (*http://www.atsdr.cdc.gov*), the USEPA (*http://www.epa.gov*), or other sources.

What are the Possible Effects on Ecosystem Health?

In addition to possible effects on human health, elevated levels of soil contaminants can negatively affect plant vigor, animal health, microbial processes, and overall soil health. Some contaminants may change plants' metabolic processes and reduce yields or cause visible damage to crops. Even relatively low concentrations of certain contaminants can alter soil chemistry and impact organisms that depend on the soil or plants for their nutrition and habitat. The effects on plants, animals, microbes, and soils within a given system will depend on the properties of the soil, the levels of contamination, the specific contaminants present, and the sensitivity of a particular organism to existing contamination.

For example, legume plants are able to fix nitrogen in the soil through a symbiotic relationship with *Rhizobium* bacteria in their root nodules. Such crops (including beans, lentils, peas, and peanuts) are often used to replenish nitrogen levels in depleted soils. However, these bacteria are sensitive to zinc contamination, which can disrupt the nitrogen fixation process. Nitrogen, a key nutrient for plant growth, may then no longer be available to the plant or to the rest of the system.

What Resources are Available to Help Locate Site History Information?

Finding site history information may be easier for some properties than others. Any information will help to address questions about the past and present uses of a site, and how the site history may have affected the current soil quality or the levels of contamination. Local libraries, historical societies, or map archives are good places to begin to track down site history information. Searchable Internet resources, such as *http://www.propertyshark.com*, may provide additional information.

Gathering information about soil conditions and past and present uses of a property can clarify whether soil testing is needed.

To assess whether contamination problems are likely at a particular site, try to find out:

- *What activities took place on this site?*
- *What chemicals were used?*
- *Where, and how much, were chemicals applied?*

What if a Property is Bought or Sold?

New York State Property Law requires a seller to disclose the results of any environmental testing (including soil and water tests) when a property is sold in the Property Condition Disclosure Statement. Property laws may differ in different states.

If a property is being bought or sold and there are questions or concerns about soil contaminants, soil testing may provide information to help identify if and where problems occur, and to what degree contamination may be present.

Where Can I Get More Information?

Cornell Waste Management Institute Resources for Healthy Soils: ***http://cwmi.css.cornell.edu/soilquality.htm***

♦ Sources and Impacts of Contaminants in Soils ♦ Guide to Soil Testing and Interpreting Results

♦ Soil Contaminants and Best Practices for Healthy Gardens ♦ More Information about Arsenic and Lead

Other Resources

Agency for Toxic Substances and Disease Registry, Department of Health and Human Services, Atlanta. Provides information to prevent harmful exposures and diseases related to toxic substances. Accessible at: *http://www.atsdr.cdc.gov/*

California Office of Environmental Health Hazard Assessment. A database with toxicity information on many chemicals. Accessible at: *http://www.oehha.ca.gov/risk/ChemicalDB/index.asp*

Cleanup Levels for hazardous waste sites. Links to many federal, state and international websites that address soil clean up levels. Accessible at: *http://cleanuplevels.com/*

National Pesticide Information Center. Provides information about pesticides and related topics. Accessible at: *http://npic.orst.edu/*

New York State Department of Environmental Conservation. Brownfield and Superfund Regulation, 6 NYCRR Part 375 - Environmental Remediation Programs. Accessible at: *http://www.dec.ny.gov/chemical/34189.html*

Penn State University. Agronomy Fact Sheets: Environmental Soil Issues. Information about lead in residential soils, garden use of treated lumber, and other issues. Accessible at: *http://cropsoil.psu.edu/extension/esi.cfm*

US Environmental Protection Agency. Office of Solid Waste and Emergency Response. Soil Screening Guidance: Quick Reference Fact Sheet, EPA/540/F-95/041. Accessible at: *http://www.epa.gov/superfund/health/conmedia/soil/pdfs/fact_sht.pdf*

US Environmental Protection Agency. US Office of Solid Waste and Emergency Response. Superfund Soil Screening Guidance: Technical Background Document, EPA/540/R95/128. Accessible at: *http://www.epa.gov/oerrpage/superfund/health/conmedia/soil/introtbd.htm*

US Environmental Protection Agency. Integrated Risk Information System (IRIS). Searchable database with information on the toxicity of numerous chemicals. Accessible at: *http://cfpub.epa.gov/ncea/iris/index.cfm*

Washington State University Cooperative Extension. Gardening on Lead- and Arsenic-Contaminated Soils. Additional information about arsenic and lead in garden soils. Accessible at: *http://cru.cahe.wsu.edu/CEPublications/eb1884/eb1884.pdf*

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