Healthy Soils, Healthy Communities

Metals in Urban Garden Soils

Metals are naturally present in rock, soil, and other materials. They are also used in manufactured (*anthropogenic*) materials, and human activity can increase the levels of metals in soil. Urban soils often have higher levels of metals than rural soils because they have been affected more by human activity. Gardening in urban soils may increase your exposure to metals if you swallow or breathe in soil particles or eat food raised in or on the soil.

What metals can be found in urban gardens?

The table on this page lists several metals commonly found in urban garden soils, along with guidance values developed to protect human health, and ranges of "background" levels typically found in rural and urban soils in New York State (NYS) and New York City (NYC).

The following pages provide some basic information for gardeners about each of these metals: where they come from (both natural and anthropogenic sources), how they behave in soil, considerations for human and plant health, and what gardeners can do to help reduce exposure to metals in garden soils.

Metals commonly found in urban garden soils: Guidance values and background levels [a]

Metal	Level in soil (parts per million [ppm])		
	Guidance Value Protective of Public Health	NYS Rural Background Level	NYC Urban Background Level
Arsenic	16	< 0.2 - 12	4.1 - 26
Barium	350	4 - 170	46 - 200
Cadmium	2.5	< 0.05 - 2.4	0.27 - 1.0
Chromium	36	1 - 20	15 - 53
Copper [b]	270	2 - 32	23 - 110
Lead	400	3 - 72	48 - 690
Mercury	0.81	0.01 – 0.20	0.14 – 1.9
Nickel [b]	140	0 - 25	10 - 43
Zinc [b]	2200	10 - 140	64 - 380

[a] References, page 9

[b] Can be toxic to plants at levels below guidance values protective of public health

What levels of metals are acceptable in garden soils?

There are no standards protective of public health specifically for metals in garden soils in NYS, but there are guidance values developed for other purposes that gardeners can consider. The guidance values in the table on this page are residential soil cleanup objectives developed by the NYS Department of Environmental Conservation and the NYS Department of Health for the NYS environmental remediation programs (see References, p. 9). These values were developed to consider residential exposures, including gardening. However, they assume that you live on the property with the soil, and that you are exposed in some ways every day and over a lifetime. Exposure to metals in soils for an urban gardener may be less than this.

The guidance values also generally assume that metals are in one of the most toxic and available chemical forms, which is not always the case with metals in garden soil. Metals can be present in soil in different chemical forms. The behavior of metals in the environment, tendency to be taken up by plants, toxicity to plants and potential for health effects of human exposure to those metals depend on their chemical form. For example, some forms of metals can readily dissolve in water (soluble) and therefore can enter plants or the human body more easily than forms that cannot easily dissolve (insoluble). Human and plant toxicity depend upon the amount of metal that enters the body or plant.

Should I be concerned about exposure to metals in my garden soil?

Certain metals are essential in small amounts in the diet for good health, but eating or drinking large amounts of them can cause health effects. Other metals can cause health effects even in small amounts. Lead can pose a particular health concern, especially for young children. The likelihood that health effects will occur depends

March 2015

NEW YORK STATE Department of Health
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not only on the specific metal, but also on who is exposed, how much, how often, and for how long. In general, the higher the levels are, the greater the concern.

Most of what we know about the potential health effects of exposure to metals comes from studies in which laboratory animals were given large amounts of the metals, or from studies of people exposed by accidents or in the workplace. An urban gardener would have less exposure to these metals in soil. However, metals that cause health effects after high-level exposures may also increase the risk of health effects in people exposed to lower levels for long periods of time.

In urban garden soils, it is not uncommon to find metals at levels near or above guidance values. Health risks associated with metals in soils at levels slightly or moderately above guidance values cannot be ruled out, but these risks are likely to be low.

More information about these metals is available from the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR's frequently asked questions fact sheets for metals and other chemicals (ToxFAQs™) are available at http://www.atsdr.cdc.gov/toxfaqs/index.asp.

Can metals affect the health of my plants?

Yes. Some metals, such as copper and zinc, are taken up by plants and can be toxic to plants (*phytotoxic*) at levels below guidance values protective of public health. Levels of phytotoxic metals that may be of concern to gardeners are discussed in the sections below. Other metals may not harm the health or growth of the plant, even though they may be a concern for human health. Additionally, some metals are not easily taken up by plants under conditions commonly found in gardens.

Glossary:

Adsorb: adhere, become attached (for instance, become attached to a soil particle).

Anthropogenic: caused by human activity.

Carcinogen: a substance that can cause cancer.

CCA: a preservative containing copper, chromium, and arsenic that was used in treated lumber. CCA-treated lumber is no longer commercially available.

Exposure: contact (touching, breathing, eating or drinking a substance).

Hyperaccumulator: a plant that concentrates metals from the environment.

Insoluble: generally incapable of dissolving in water.

Organic matter: material made of compounds formed from the decay of living things; for example, compost.

pH: a measure of acidity (low pH) or basicity (high pH). Urban garden soils typically fall within a pH range between 5 (high acidity) and 8 (low acidity). A pH between 6.5 and 7.5 is considered to be in the neutral range.

ppm: parts per million, the units used to measure metals levels in soil. A level of 1 ppm means there is one particle of the metal in one million particles of soil. This equals about one teaspoonful in 10,000 pounds of soil.

Soluble: readily able to dissolve in water.

Phosphate: an essential nutrient for plant growth, present in many fertilizers.

Phytoremediation: using plants to reduce soil environmental contamination.

Phytotoxic: harmful to plants.

Saline: containing extra salts (which may affect plant growth).

Serpentinitic: soils containing certain characteristic minerals from serpentinite rock, common in certain areas.

Are there crops I can plant to remove metals from my garden soil?

Using plants to remove metals from soil (a type of *phytoremediation)* is generally not effective for reducing metals levels in urban garden soils. Many metals are not readily taken up into plant tissue when soil pH is near neutral (6.5 – 7.5), as it typically is in urban gardens. For those metals that are more easily taken up by plants (such as cadmium, copper, nickel, and zinc), the plants that take them up most readily are also relatively small in stature and slow growing, and they will take many years to "clean up" soils with metals levels even moderately above guidance values. Also, unlike some contaminants, metals are not broken down into less toxic compounds by phytoremediation. Metals that are removed from the soil go into the roots or other parts of the plants, which means the plants must be disposed of properly, and not eaten or composted.

How can I reduce exposure to metals in my garden soil?

The following sections describe steps gardeners can take to help reduce exposure to specific metals found in urban garden soils. For many metals, adjusting soil pH and adding organic matter (such as compost) can help keep metals in the soil from being taken up by plants. In addition, healthy gardening practices such as growing in raised beds filled with clean soil and compost, washing vegetables thoroughly, and being careful not to track soil indoors can help reduce exposure to all metals, as well as other contaminants that may be present in garden soils. You can find more information about healthy gardening practices on the *Healthy Soils, Healthy Communities* web page at *http://cwmi.css.cornell.edu/healthysoils.htm*.

Arsenic

Sources: *Natural* – Trace levels are normally associated with rock minerals and clays in all soils. Higher levels are present in ores of copper and lead, sulfide ores (pyrites) mined for metals, and in black shales and coal. *Anthropogenic* – Arsenic was historically used in pressure-treated lumber (the older "CCA" type) and some pesticides. It can also be found in coal ash.

Form and behavior in garden soil: Arsenic usually exists as the arsenate form, which behaves chemically like phosphate and is therefore fairly easily taken up by plants. It adsorbs poorly on organic matter but well on clays and iron oxides. It is more available to plants in non-acid (pH greater than 6.0) than acid (pH less than 6.0) soils. Uptake into food crops may be significant if levels of soil arsenic are unusually high. Leafy green vegetables are the strongest accumulators of arsenic.

Human health: Arsenic is a known human carcinogen (a substance that can cause cancer). Arsenic in soil at levels slightly or moderately above the guidance value poses no immediate risk, but there may be some increased risk if you are exposed a lot over a long time.

Plant health: Arsenic phytotoxicity is typically not a practical concern for gardeners. The growth and health of plants are unlikely to be significantly affected until levels in soil exceed those of concern for human health.

What gardeners can do: Unlike most metals, arsenic is not immobilized by organic matter additions or liming, and these measures may actually increase arsenic availability to crops. Soluble iron (ferrous) salts or iron oxide additions have helped to reduce arsenic availability in experimental situations. Phytoremediation has been demonstrated using certain subtropical fern species, which act as "hyperaccumulator" crops that take up large amounts of arsenic.

Barium

Sources: *Natural* – Barium is associated with common rock minerals such as feldspars and micas in soils. It is also found in some foods, such as Brazil nuts, seaweed, fish, and certain plants. *Anthropogenic* – Barium is used in oil and gas drilling muds (as a lubricant for drill bits), in the production of paints, bricks, tiles, and ceramics, as an additive for jet fuels, and as a contrast agent in X-ray diagnostic work. It can also be found in automotive brake linings.

Form and behavior in garden soil: Barium generally occurs as relatively insoluble sulfates and carbonates, or bound strongly to clays and organic matter, which limits the potential for plant uptake. Uptake into fruits and vegetable fruits is typically quite low. Some uptake into roots and leafy greens does occur. Lower soil pH increases barium solubility in the soil, and uptake into food crops may be more significant if soil is acidic (pH less than 6.0).

Human health: The most sensitive effect in laboratory animals of long-term exposure to barium (in drinking water) is kidney toxicity. Barium found in soils is usually in a very insoluble form, which is likely to be less toxic. The soil guidance value for barium was developed to consider soluble forms of barium.

Plant health: Barium phytotoxicity is typically not a practical concern for gardeners. Although barium can be considered weakly phytotoxic (by competing with calcium needed for plant growth), the growth and health of plants are unlikely to be affected until levels in soil greatly exceed guidelines protective of public health.

What gardeners can do: Organic matter additions and, for acidic soils (pH less than 6.0), liming, may reduce barium uptake by crops. Little is known about the potential effectiveness of phytoremediation for barium.

Cadmium

Sources: *Natural* – Cadmium can be found in black shales, which in some parts of the northeastern US are the parent materials of soils. It also occurs in rock phosphate deposits around the world, which are mined to produce commercial phosphate fertilizers. It is present in uncontaminated soils worldwide at trace levels. Many zinc ores contain low levels of cadmium. *Anthropogenic* – Cadmium usually occurs as an impurity in zinc metal, which is used in galvanized steel. Cadmium can also be found in electroplating waste, batteries, coal burning and incinerator emissions, and some fertilizers.

Form and behavior in garden soil: Cadmium is generally adsorbed more strongly on clays and organic matter as soil pH increases, but it is relatively easily released to the soluble and plant-available form compared to other metals. High levels of salts in soils can make cadmium more soluble. Uptake into food crops, especially leafy greens, may be a concern if soil has high levels of salts or if soil is acidic (pH below 6.0), but most urban garden soils have a pH near neutral (6.5-7.5).

Human health: Cadmium is a known human carcinogen (a substance that can cause cancer). Cadmium in soil at levels slightly or moderately above the guidance value poses no immediate risk, but there may be some increased risk if you are exposed a lot over a long time.

Plant health: Cadmium phytotoxicity is typically not a practical concern for gardeners. The growth and health of plants are unlikely to be significantly affected until levels in soil greatly exceed those of concern for human health.

What gardeners can do: Organic matter additions and liming (for acid soils) should reduce cadmium uptake by crops. Phytoremediation (by plants such as willows or "hyperaccumulator" plants that take up large amounts of cadmium) is possible because of the relatively high ability of cadmium to be taken up by crops. However, this strategy is unlikely to be practical for gardeners, as it would require several decades or more to reduce cadmium levels in even a moderately contaminated soil to levels more suitable for gardening.

Chromium

Sources: *Natural* – Chromium is found at high levels in serpentinitic rocks, which in some areas (including Staten Island in New York City) may form the parent material of soils. More commonly, it is found as a trace element bound in the structure of many soil minerals. *Anthropogenic* – Chromium is used for electroplating, in the manufacture of steel and in the textile, tanning and leather industries, and as a component of some paints and pigments. It is present in wastes from mining and processing of chromite ores. Chromium was historically used in pressure-treated lumber (the older "CCA" type).

Form and behavior in garden soil: Chromium in urban garden soils is very likely to be in a form called "trivalent" chromium rather than the more soluble and toxic "hexavalent" form (also known as "chromate"). This more toxic form is unlikely to be present unless pollution has increased soil chromium to high levels (for example, by spills or other pollution), pH is above 6.0, and organic matter content of the soil is low. The trivalent form adsorbs extremely strongly on clays and organic matter over a wide range of soil pH (5 to 8). Exposure through crop consumption is highly unlikely due to very little transfer of chromium from soils to above-ground plant parts. An exception is some plant species growing on serpentinitic soils that can accumulate high concentrations of chromium, possibly because they are taking up the soluble chromate form (chromate, if present, can be taken up by crops or leach to groundwater). Note that soil tests commonly available to gardeners do not typically specify the form of chromium present.

Human health: A small amount of trivalent chromium in the diet is essential for good health. In contrast, hexavalent chromium has caused cancer in people who worked with it and inhaled it (breathed it in) for a long time. Hexavalent chromium also caused cancer in animals that ingested (ate or drank) it daily over their lifetimes. Whether ingested hexavalent chromium causes cancer in humans in unknown. Hexavalent chromium in soil at levels slightly or moderately above the guidance value poses no immediate risk, but there may be some increased risk if you are exposed a lot over a long time.

Plant health: In its stable form in soil (trivalent chromium), chromium is quite insoluble and phytotoxicity is not a concern. However, soluble hexavalent chromium (chromate) is phytotoxic, but is unlikely to be encountered in garden soils.

What gardeners can do: If hexavalent chromium is present, adding fresh organic material can help convert the toxic hexavalent form to the much less soluble trivalent form, which is much less likely to be taken up by plants. Although some plants are able to take up chromium that is dissolved in water (particularly hexavalent chromium), phytoremediation has not been shown to be a practical solution for chromium-contaminated soils.

Copper

Sources: *Natural* – Copper is found in many types of rock, with higher levels found in black shales and some basalts. *Anthropogenic* – Copper was historically used in pressure-treated lumber (the older "CCA" type) and is found in some newer treated lumber products as well. It is used in fungicides in orchards, vineyards and gardens. Copper can also be found in dairy manure and sewage sludge composts.

Form and behavior in soil: Copper adsorbs very strongly on organic matter when soil pH is greater than 5.5, but also on clay minerals at near-neutral pH (6.5 – 7.5). The solubility of copper is generally quite low in soil unless pH is unusually low (less than 5.5) or high (greater than 7.5). Copper is an essential micronutrient for human health that is found in many foods. Excessive copper in food crops is unlikely because this metal is strongly retained in fine roots with relatively little transferred to aboveground portions of plants.

Human health: Small amounts of copper in the diet are essential for good health. Too little copper can cause a wide variety of serious adverse effects; too much copper may damage the liver.

Plant health: Copper in soil may be toxic to plants (*phytotoxic*) at levels below those that are a concern for human health. At levels above 75-100 ppm in soil, copper can cause toxicity and stunted growth in some crops. This is more likely to be a concern if pH is low.

What gardeners can do: Organic matter additions and liming (for acid soils [pH less than 6.0]) should reduce copper uptake and toxicity to crops. Phytoremediation (by "hyperaccumulator" crops that take up large amounts of copper) is possible. However, this strategy is unlikely to be practical for gardeners, as it would require several decades or more for these generally small, slow-growing crops to reduce copper levels in even a moderately contaminated soil to levels more suitable for gardening.

Lead

Sources: *Natural* – Lead is present in rocks including black shales, where it is associated with organic matter and sulfides. Lead sulfide (galena) ore deposits have been mined for this metal for centuries in the northeastern US and other areas. *Anthropogenic* – Historically, lead compounds were used as additives in paint and gasoline, resulting in widespread contamination of soil, particularly in developed areas. Other sources include incinerator emissions, mining and smelting activities, battery disposal and recycling, plumbing and roofing. Lead was commonly used until the 1960's in pesticides applied to orchards, vineyards, and gardens.

Form and behavior in soil: Lead adsorbs strongly on organic matter in particular if pH is higher than 5.0, but also adsorbs on clays at higher pH. In highly contaminated soils, lead may also be in the form of insoluble minerals such as carbonates, hydroxides or phosphates. Lead is not very soluble in soil unless pH is extremely low (less than 5.0) or high (greater than 7.5). Lead is generally not transferred easily into food crops because of its low solubility in soils and the tendency to bind in roots where it is prevented from migrating into leaves or fruits. However, if soil pH and organic matter are low, transfer into crops may be greater. Under certain conditions (soil with low pH, low organic matter content, or high levels of lead) lead can be taken up by plant roots into edible fruits or vegetables. These exposures may add to lead exposures from other sources. Physical contamination of vegetable crops (particularly leafy greens) with lead-contaminated soil particles that end up on plant surfaces can be a significant source of dietary exposure to lead.

Human health: Lead in soil can pose a particular health concern, especially for young children. Lead can harm a young child's growth, behavior, and ability to learn. Lead in soil can pose some risks even if test results are below guidance values, and the higher the level of lead in soil, the greater the concern.

Plant health: Lead phytotoxicity is typically not a practical concern for gardeners, as most garden plants take up very little lead compared to levels in soil.

What gardeners can do: To help limit children's exposure to lead in soil, it is important to watch children carefully while they are in the garden, remind them often to avoid touching their mouths after touching the soil, and make sure they wash their hands well after touching the soil. Organic matter additions and liming (for acid soils [pH less than 6]) may reduce lead uptake by crops, and mulching and other practices to control dust are likely to reduce physical contamination of crops with soil particles. Large additions of phosphate fertilizer have been shown to reduce lead solubility in some severely contaminated soils, but this may not be practical or effective for gardeners. Phytoremediation (removal of lead by plants) is not generally effective because there are no known lead-accumulating crops ("hyperaccumulators").

Mercury

Sources: *Natural* – Mercury is found in several forms in the environment. The highest naturally occurring mercury concentrations have been found in peaty and waterlogged soils. *Anthropogenic* – Mercury may be found in emissions from incinerators and coal-burning power plants, and is also used in certain commercial products and industrial processes.

Form and behavior in soil: Mercury is generally non-mobile, not leachable, and strongly bound in soils. Soil pH is less of an influence on mercury's behavior in soils than it is for many other metals. Mercury does not transfer readily to crops; therefore, consumption of garden crops is unlikely to be an exposure pathway of concern for human health. In soil, mercury is likely to exist mainly in a form known as "divalent" mercury, which bonds strongly to organic matter. There is some potential in flooded soils for mercury to form a more toxic compound called methylmercury, but it is likely that soils would have to remain flooded for many months for this process to occur.

Human health: Eating or drinking small amounts of divalent mercury does not cause health effects. Eating or drinking large amounts of divalent mercury can damage the kidneys and nervous system. Children and unborn babies are particularly sensitive to the effects of mercury because their nervous systems are still developing.

Plant health: Mercury phytotoxicity is not typically a practical concern for gardeners, because mercury binds so strongly to soil organic matter and minerals and is not readily taken up by plants.

What gardeners can do: Plants take up very little mercury under most conditions, which means soil amendments (such as organic matter additions and liming) are likely to have little effect on the amount of mercury found in plants. It also means that phytoremediation is unlikely to be effective. Healthy gardening practices that control dust and minimize direct soil ingestion would help reduce the potential for human exposure to mercury in garden soil.

Nickel

Sources: *Natural* – Nickel is found in serpentinitic rocks, which in some areas (including Staten Island in New York City) may form the parent material of soils. More commonly, it is found as a trace element bound in the structure of many soil minerals. *Anthropogenic* – Nickel is used in the manufacture of steel and other metal alloys, as well as in electroplating and in some kinds of batteries. Emissions from incinerators and fossil-fuel combustion can also contain nickel.

Form and behavior in soil: Nickel adsorbs fairly strongly (though not as strongly as copper) on organic matter when soil pH is greater than 5.5, but also on clay minerals at near-neutral pH (6.5 – 7.5). The solubility of nickel is generally low in soil unless pH is unusually low (less than 5.5) or high (greater than 7.5). Nickel is taken up more readily into plants than some other metals (such as copper), but relatively little nickel can be expected in the edible portions of food crops.

Human health: Small amounts of nickel in the diet are essential for good health. Too little nickel can cause a wide variety of serious adverse effects in humans. Too much nickel exposure in animals can cause a wide variety of adverse effects, but the most sensitive effects appear to be decreased body and organ weights.

Plant health: Nickel in soil may be toxic to plants at levels below those that are a concern for human health. At levels above 40-60 ppm in soil, nickel can cause toxicity and stunted growth in some crops.

What gardeners can do: Organic matter additions and liming (for acid soils [pH less than 6.0]) should reduce nickel uptake and toxicity to crops. Phytoremediation (by "hyperaccumulator" crops that take up large amounts of nickel) is possible. However, this strategy is unlikely to be practical for gardeners, as it would require several decades or more for these generally small, slow-growing crops to reduce nickel levels in even a moderately contaminated soil to levels more suitable for gardening.

Zinc

Sources: *Natural* – Zinc is present in low concentrations in many types of rock. It is concentrated in sulfide ore minerals such as sphalerite, which are mined for this metal. *Anthropogenic* – Zinc is used in galvanized steel (used in roofing, pipes, and gutters), wire fences and rubber (tires). It is used in some metal alloys, batteries, and pigments. Other sources include electroplating waste, mine spoils, emissions from coal burning, smelting and incinerators, some fertilizers, manure and sewage sludge composts.

Form and behavior in soil: Zinc is generally adsorbed on clays and organic matter above pH 6.0 but is relatively easily released to the soluble and plant-available form. It is quite soluble and plant-available if soil pH is low (less than 5.5).

Human health: Small amounts of zinc in the diet are essential for good health. Too little zinc can cause a wide variety of serious adverse effects; too much zinc can alter the copper content of red blood cells and reduce the level of an important enzyme in red blood cells.

Plant health: Zinc is an essential micronutrient for plants, but it can be toxic to plants at higher soil levels, even below those that are a concern for human health. Zinc levels above 150-200 ppm may cause toxicity and stunted growth in some crops. Nevertheless, because of the near-neutral pH (6.5 - 7.5) of most urban garden soils, zinc is usually not soluble enough to be toxic to plants.

What gardeners can do: Organic matter/compost additions and liming (for acid soils) can reduce zinc uptake and prevent toxicity to crops. Phytoremediation (e.g., by willows or hyperaccumulator crops) is possible because of the relatively high extent to which zinc can be taken up by crops. However, this strategy is unlikely to be practical for gardeners, as it would require several decades or more to reduce zinc levels in even a moderately contaminated soil to levels more suitable for gardening.

Healthy Gardening Practices

Please see our related resource “"What Gardeners Can Do: 10 Best Practices for Healthy Gardening", available at http://cwmi.css.cornell.edu/healthysoils.htm, which describes these steps gardeners can take to minimize contact with soil contaminants:

1. Use clean soil and compost.
2. Use raised beds.
3. Avoid using treated wood.
4. Maintain soil nutrients and pH.
5. Cover (or mulch) soil.
6. Keep an eye on children.
7. Don't track soil into your home.
8. Wash your hands.
9. Wash and/or peel produce.
10. Put a barrier under play areas.

Additional Resources

- Resources from *Healthy Soils, Healthy Communities* project (http://cwmi.css.cornell.edu/healthysoils.htm):
    - "What Gardeners Can Do: 10 Best Practices for Healthy Gardening" http://cwmi.css.cornell.edu/WhatGardenersCanDoEnglish.pdf
    - "What Gardeners Can Do: Tips for Urban Chicken Keepers" http://cwmi.css.cornell.edu/WhatGardenersCanDoChickens.pdf
- Agency for Toxic Substances and Disease Registry ToxFAQs™ - Information about contaminants: http://www.atsdr.cdc.gov/toxfaqs/index.asp
- Cornell Waste Management Institute fact sheets and other *Resources for Healthy Soils*: http://cwmi.css.cornell.edu/soilquality.htm
- NYSDOH brochure *Healthy Gardening: Tips for New and Experienced Gardeners*: http://www.health.ny.gov/publications/1301/index.htm
- NYSDOH Environmental Laboratory Approval Program (ELAP) list of certified laboratories: http://www.wadsworth.org/labcert/elap/elap.html
- NYSDOH Lead Poisoning Prevention website: http://www.health.ny.gov/environmental/lead
- U. S. Environmental Protection Agency information about Brownfields and Urban Agriculture: http://www.epa.gov/brownfields/urbanag/
- Agro-One Services - Testing for soil pH and fertility: http://www.dairyone.com/AgroOne/Form_H_Lawn_Garden_Landscape

References

Guidance values protective of public health are based on residential soil cleanup objectives developed for the NYS Environmental Remediation Programs. The regulation governing these programs (6 NYCRR Part 375) is available on NYSDEC's website at http://www.dec.ny.gov/chemical/34189.html. More information about soil cleanup objectives is presented in the technical support document for the regulations (click "Technical Support Document" on that page, or go directly to http://www.dec.ny.gov/docs/remediation_hudson_pdf/techsuppdoc.pdf.

NYS rural background ranges are the minimum to 95th percentile of levels in "source-distant" rural soils in NYS reported in the NYSDOH/ NYSDEC Rural Soil Background Survey. Source-distant samples came from areas that were reasonable points of human contact with soil, such as yards and trails, but at least five meters distant from potential pollution sources such as trash, roads, driveways or structures. A report on the survey is available at http://www.dec.ny.gov/docs/remediation_hudson_pdf/appendixde.pdf (or go to http://www.dec.ny.gov/chemical/34189.html and click "Technical Support Document – Appendices D and E").

NYC urban background ranges are the minimum to 95th percentile of concentrations measured in 27 samples from ornamental gardens, cemetery lawns, grass-covered vacant lots, and grass-covered courtyards in Manhattan. They were reported to NYSDEC by Consolidated Edison in a report authored by The Retec Group, Inc. entitled *Characterization of Soil Background PAH and Metal Concentrations in Manhattan, NY* (March 30, 2007).

Acknowledgments

This publication was prepared with the assistance of *Healthy Soils, Healthy Communities* project partners, Advisory Committee, and other reviewers.