

Garden and Soil Contaminant Factsheet Collection

1. arsenic
2. cadmium
3. chromium
4. diesel-range organics
5. lead
6. mercury
7. nickel
8. PCE & TCE



SUPERFUND
Research Center

early life exposures, later life consequences



National Institute of
Environmental Health Sciences
Superfund Research Program

ARSENIC in the garden

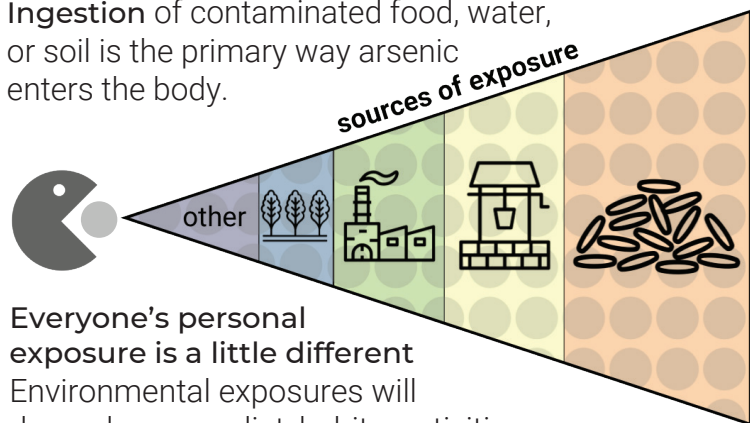
Arsenic is a heavy metal which has both natural and human-related sources. Some regions of North Carolina may have naturally high levels of arsenic in soils or well water. Other sources of arsenic include industrial manufacturing, historical pesticide use, mining, and coal-fired power plants.

Summary for Gardeners

- » Garden-related arsenic exposure is generally low. To limit exposure, rinse produce before consuming, remove any chromated copper arsenate (CCA) treated wood from your garden, and avoid using soil amendments from large-scale poultry farms.
- » Unless you have unusually high levels of arsenic in your soils, the majority of your arsenic exposure likely comes from non-garden sources like store-bought foods.





Sources of arsenic exposure

Ingestion of contaminated food, water, or soil is the primary way arsenic enters the body.



Everyone's personal exposure is a little different

Environmental exposures will depend on your diet, habits, activities, lifestyle, and many other factors. Research tells us that, in general, purchased foods and well water likely make up the biggest portion of a person's total arsenic exposure, followed by arsenic from nearby industry and finally sources in the garden.

-  **purchased foods** Store-bought rice, cereals, and fruit juices may contain higher levels of arsenic
-  **well water** In some areas, there may be high levels of naturally-occurring arsenic in drinking or irrigation water from wells
-  **nearby industry** Past or current industrial activities can release arsenic into air, water, and soil
-  **in-garden sources** Arsenic in soils or garden produce is likely a minor source of a person's total arsenic exposure

Exposure to arsenic in the garden

How am I exposed? Gardeners and children can be exposed to arsenic by ingesting soil particles, eating vegetables grown in contaminated soil, handling contaminated soil, touching CCA treated wood, or breathing in contaminated soil particles.

Are my garden plants safe to eat? In general, very small amounts of arsenic move from the soil into most fruits and seeds (e.g. tomato, pepper, squash). Rice, however, is the exception and is known to take up higher amounts of arsenic.

Should I be worried? Garden-related arsenic is likely to be a small portion of a person's arsenic exposure. However, reducing or limiting exposure to arsenic in the garden is still a good idea, especially for children.

Limit children's exposure

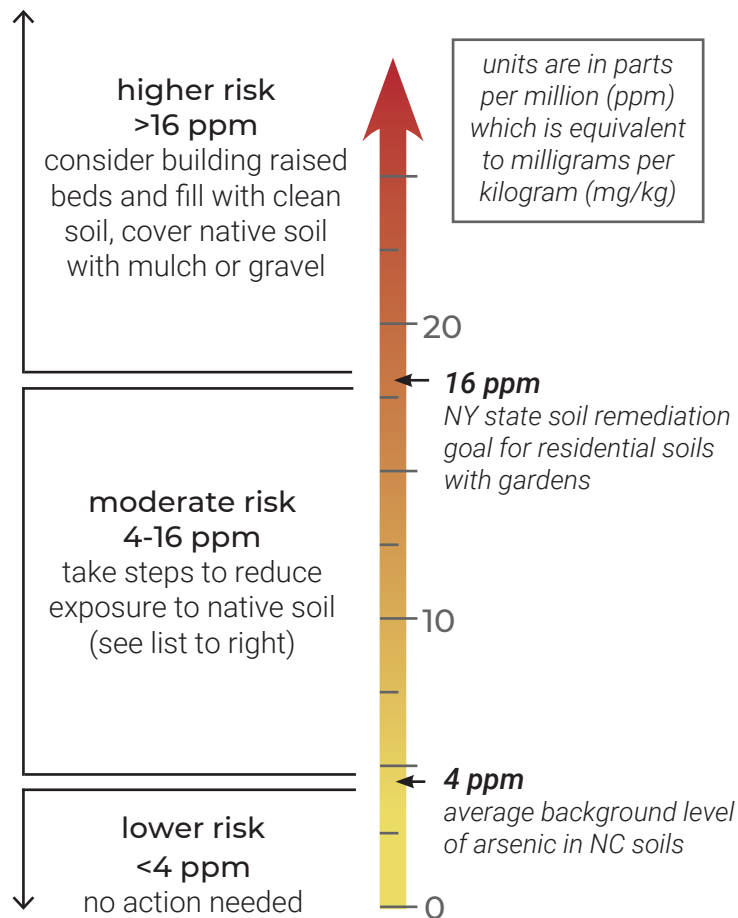
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- Their bodies and brains are still developing
- Children spend more time on the ground and often put things (like dirt) into their mouths
- They have more skin surface area than adults, so skin exposure also matters



ARSENIC in the garden

Making sense of regulatory standards

No official standards have been established in North Carolina for acceptable levels of arsenic in garden soils. The guidelines below can help you determine whether arsenic levels in your garden are above or below the average levels.



Testing resources



Well water testing for arsenic: <https://epi.dph.ncdhhs.gov/oe/wellwater/howtotest.html>



How to test your soil and interpret the results: <https://sites.nicholas.duke.edu/superfundcec/gardens/soil-testing/>



Still have questions about arsenic soil testing? Email us at superfund@duke.edu

Health impacts of arsenic

There is no official “safe” level of arsenic exposure from soil or food for the general population. Increasing your exposure to arsenic can incrementally increase your risk of adverse health effects. However, the increased risk due to exposure to arsenic in garden soils is likely to be very small compared to other sources of exposure.

Higher levels of exposure to arsenic are associated with several types of skin lesions and cancers as well as impacts on nervous system, respiratory, and heart health. Exposure in early life has been associated with altered brain development and increased risk of lung disease later in life.

Reduce arsenic exposure in the garden

- If applicable, test well water sources for arsenic
- Remove any CCA treated wood from the garden and choose untreated woods like cedar, black cherry, or oak or other non-leaching materials
- Add compost or other organic matter from a contaminant-free source. Check the [NC Composting Council](#) website to find STA or OMRI certified compost
- Avoid using fertilizer (i.e. poultry litter) from commercial poultry farms. Arsenic is often used as a growth additive in poultry feed
- Aim for a neutral soil pH (around 7) to limit the bioavailability of arsenic in the soil
- Conduct a soil safety training to teach exposure reduction strategies to all garden users
- Visit our website below for our factsheet on [10 Healthy Garden Habits](#)

For more information visit:

<https://sites.nicholas.duke.edu/superfundcec/gardens/>



CADMIUM in the garden

Cadmium is a heavy metal that has both natural and man-made sources. Cadmium is often a byproduct from mining other metals like zinc and copper, and is also found in fossil fuel emissions and fertilizers. It is used in a variety of products including batteries, metal coatings, and pigments.

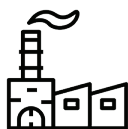
Summary for Gardeners

- » Plants take up more cadmium if soils are acidic (pH below 6) or have a high amount of salts.
- » Adding organic matter or agricultural lime (to raise soil pH) can limit how much cadmium is taken up by plants.
- » Cadmium levels are often higher in leafy greens than other produce.
- » Only long-term, sustained exposure at low or moderate levels poses a health risk.

Sources of cadmium exposure

Cadmium exposure can occur in and outside the garden. Cadmium is usually found at very low levels in soils, but hotspots from man-made sources may also exist. Below are some of the main sources that release cadmium into the environment.

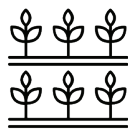
Once in the environment, we can be exposed in a few different ways (see exposure section to the right).



nearby industry Power plant emissions and other industries that use cadmium can release the metal into air, water, and soil.



traffic Emissions from nearby busy roads may increase cadmium in soil. The closer these roads are, the more likely high cadmium levels may be found.



in-garden sources Old tires and galvanized steel may be cadmium sources. Try to use other materials in the garden, especially for edible crops



housing One study found that older neighborhoods tended to have higher levels of cadmium in soils.



fertilizer Cadmium occurs naturally in phosphate rock, which is used for fertilizer. Past use of phosphate fertilizer may be a source of cadmium in soils.

Exposure to cadmium in the garden

How am I exposed? Eating, breathing, or direct skin contact with contaminated soil particles, or eating contaminated produce, can all be routes of exposure.

Are my garden plants safe to eat? Leafy greens tend to have higher concentrations of cadmium, followed by herbs and roots. Fruits have low cadmium levels. Overall, garden and supermarket produce tend to have similar levels of cadmium.

Should I be worried? Exposure to moderate levels of cadmium in soils or produce poses no immediate health risk, but limiting exposure (especially for children) is still a good idea. It is important to remember that there are many health benefits to home and community gardening.

Limit children's exposure

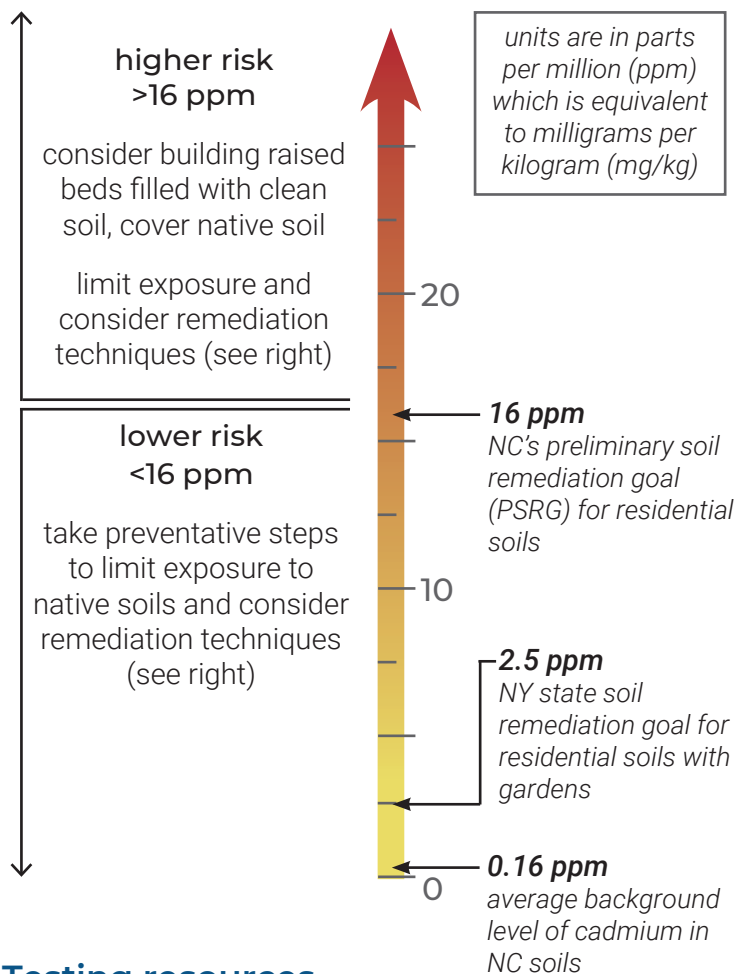
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- They have more skin surface area than adults, so skin exposure also matters



CADMIUM in the garden

Making sense of regulatory standards

No official standards have been established in North Carolina for acceptable levels of cadmium *in garden soils*. The guidelines and background values below can help you determine whether cadmium levels in your garden soil might require further attention.



Testing resources



How to test your soil and interpret the results: <https://sites.nicholas.duke.edu/superfundcec/gardens/soil-testing/>



Well water testing for cadmium: <https://epi.dph.ncdhhs.gov/oe/wellwater/howtotest.html>



Still have questions about cadmium soil testing? Email us at superfund@duke.edu

Health impacts of cadmium

Cadmium is a known human carcinogen (it can cause cancer). Low or moderate levels of cadmium in soil do not pose any immediate risk, but consistent exposures over long periods of time can increase cancer risks.

Eating food or drinking water with very high levels of cadmium can severely irritate the stomach, leading to vomiting and diarrhea (this is uncommon).

Other health effects are still being researched. Animal studies have shown that cadmium can harm development and reproduction, lung function (if inhaled), and lead to kidney disease.

Reduce cadmium exposure in the garden

- Adding compost or other organic matter from a contaminant-free source may help limit cadmium uptake by plants. Check the [NC Composting Council](#) website to find STA or OMRI certified compost
- Adding agricultural lime (to raise soil pH) can also limit plant uptake
- Thoroughly wash produce grown in cadmium-contaminated soil, to remove any soil or dust
- If your soil cadmium levels are high, consider **not** planting leafy greens such as lettuce, spinach, and swiss chard (which take up more cadmium)
- Conduct a soil safety training to teach exposure reduction strategies to all garden users
- Visit our website below for our factsheet on [10 Healthy Garden Habits](#)

For more information visit:

<https://sites.nicholas.duke.edu/superfundcec/gardens/>



CHROMIUM in the garden

Chromium is metal that occurs naturally in the environment, but can also exist at higher levels due to human activity. Chromium comes in different forms, the most common is the low-toxicity trivalent chromium (Cr^{+3}). Hexavalent chromium (Cr^{+6}) is less common but far more toxic at low levels.

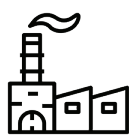
Summary for Gardeners

- » Cr^{+6} dissolves more easily in water than Cr^{+3} , and so is more likely to be found in well water than garden soils. Chromium often shifts between these two forms, so there may be very small amounts of Cr^{+6} in soil.
- » Historical chromium inputs are less likely to be a cause for concern than current sources of chromium pollution.
- » Adding more organic matter (e.g. compost) can help convert chromium into the less-harmful Cr^{+3} form.

Sources of chromium exposure

Chromium is not easily taken up by plants, so direct contact with contaminated soil is the most common exposure pathway in the garden. This can include breathing in or eating soil particles directly or from soil covered-produce, and tracking soil inside the home and breathing or eating the soil at a later time.

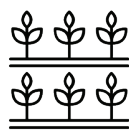
Chromium exposure can occur in and outside the garden.



nearby industry Industries producing steel, wood preservatives, paints, and more can release chromium (Cr^{+6} specifically) into air, water, and soil.



well water In some areas, well water is the most common source of Cr^{+6} exposure. Direct exposure can occur if a well is used for drinking water.



in-garden sources Well water or nearby industry can contaminate garden soils, but exposure via soils or garden produce is a minor source, particularly for Cr^{+6} .

Chromium comes in different forms

Cr^{+3}

- » common in soils
- » essential nutrient
- » not harmful except at very high levels

total chromium

Cr^{+5}

Cr^{+1}

Cr^{+2}

Cr^{+4}

Cr^{+6}

- » uncommon in soils
- » main source is human activity
- » harmful at very low levels

Exposure to chromium in the garden

How am I exposed? Ingestion, inhalation, or direct skin contact with contaminated soil particles can all be routes of exposure

Are my garden plants safe to eat? Most garden plants do not take up large amounts of chromium, so washed produce is unlikely to be a major source of chromium exposure. Root crops like carrots, onion, and beets can contain slightly higher concentrations of chromium.

Should I be worried? Exposure to chromium from garden soil is unlikely to be a major health concern for healthy adults unless there is a continuous addition of Cr^{+6} to the soil from a current pollution source.

Limit children's exposure

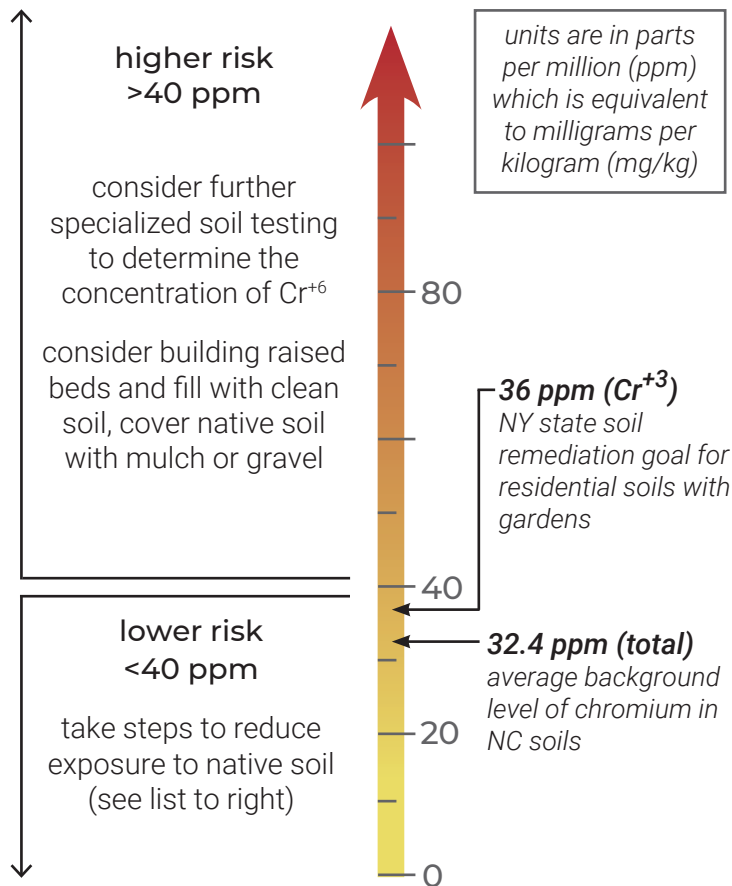
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CHROMIUM in the garden

Making sense of regulatory standards

No official standards have been established in North Carolina for acceptable levels of chromium in garden soils. For remediating soil at industrial sites, NC uses EPA's guideline of **24,000 ppm for Cr⁺³**, and **0.3 ppm for Cr⁺⁶**. The guidelines below can help you contextualize the chromium levels in your garden soil.



Health impacts of chromium

Cr⁺³, the more common form, is a beneficial nutrient in small doses and is not easily absorbed into the body. Cr⁺⁶, however, is a known carcinogen when inhaled and therefore has no "safe" level of exposure.

Exposure to Cr⁺⁶ can increase your risk of developing breathing difficulty, asthma or allergy-like symptoms, stomach ulcers or irritation, anemia, lung cancer, and more. Long-term exposure to Cr⁺⁶ may affect the male reproductive system.

It is unknown whether children are more vulnerable to the effects of Cr⁺⁶ specifically, but it is still important to limit their contact with chromium.

Reduce chromium exposure in the garden

- Adding compost or other organic matter from a contaminant-free source may help convert Cr⁺⁶ into Cr⁺³. Check the [NC Composting Council](#) website to find STA or OMRI certified compost
- Thoroughly wash produce grown in chromium-contaminated soil
- Avoid growing root vegetables in soils with high levels of chromium, and peel root vegetables before eating to further minimize risk
- If applicable, test well water sources for chromium, specifically Cr⁺⁶
- Conduct a soil safety training to teach exposure reduction strategies to all garden users
- Visit our website below for our factsheet on [10 Healthy Garden Habits](#)

Testing resources



Well water testing for chromium:
<https://epi.dph.ncdhhs.gov/oe/wellwater/howtotest.html>



How to test your soil and interpret the results: <https://sites.nicholas.duke.edu/superfundcec/gardens/soil-testing/>



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LEAD in the garden

Lead is a metal that can be found naturally in the environment, but also exists at higher levels due to human activity. Lead is still mined, but in the U.S., most lead is recovered from lead acid batteries. Paint and gasoline no longer contain lead, but these past uses are major sources in urban settings.

Summary for Gardeners

- » Garden-related lead exposure is generally low and there are simple steps you can take to limit exposure.
- » Unless you have unusually high levels of lead in your soil, most of your lead exposure likely comes from non-garden sources like lead paint and drinking water.
- » No amount of lead exposure is considered safe, but it is important to remember that there are many health benefits to home and community gardening.

Sources of lead exposure

Lead exposure can occur in the garden, but non-garden sources including lead paint and drinking water are likely bigger concerns. Still, urban soils in particular may contain hotspots of lead contamination.

Once lead is in the environment, we can be exposed in a few different ways (see exposure section to the right). Below are some of the main sources that release lead into the environment.



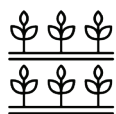
housing Houses built before 1978, especially those built before 1960, may contain lead-based paint. When paint weathers, particles of lead end up in house dust. Outdoor paint and home demolition can contaminate nearby soils.



drinking water Some metal pipes may contain lead solder. Under certain conditions, this lead can enter drinking water. Older cities with aging infrastructure are more likely to have issues with lead in drinking water.



traffic Past car emissions from busy roads may mean higher lead levels in undisturbed soil nearby. In 1976, leaded-gasoline began to be phased out.



agriculture Up until the 1960s, some pesticides used in orchards, vineyards, and gardens contained lead.

Exposure to lead in the garden

How might I be exposed? Gardeners and children can be exposed to lead by eating contaminated soil particles or produce, and by handling or breathing in contaminated soil particles.

Are my garden plants safe to eat? In general, plants do not take up much lead from contaminated soil, so washed produce is probably not a major source of exposure. One study found that herbs tends to have the highest lead levels, followed by root vegetables, leafy greens, and finally fruits.

Should I be worried? Garden-related lead is likely a small portion of a person's overall lead exposure. However, reducing or limiting exposure to lead in the garden is still important, especially for children.

Limit children's exposure

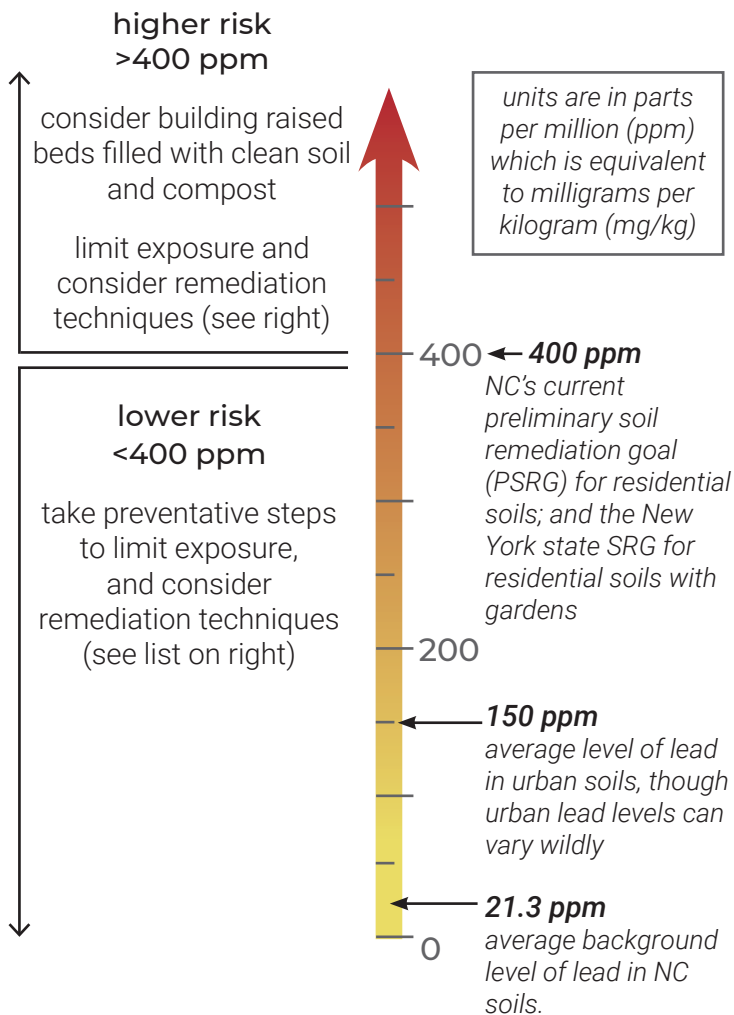
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LEAD in the garden

Making sense of regulatory standards

There is no accepted safe level of lead exposure. There are standards for soil lead levels in residential and play areas, but no specific limits for garden soils. The guidelines below can help you contextualize the lead levels in your garden soil.



Testing resources



How to test your soil and interpret the results: <https://sites.nicholas.duke.edu/superfundcec/gardens/soil-testing/>



Well water testing for lead: <https://epi.dph.ncdhhs.gov/oe/wellwater/howtotest.html>



Still have questions about lead soil testing? Email us at superfund@duke.edu

Health impacts of lead

Children are most at risk from lead exposure because it is a developmental neurotoxin and it can harm developing brains. Lead exposure is linked to many health problems such as impacts on learning and behavior, lower IQ, hyperactivity, slowed growth, and anemia. At high levels, lead can damage the heart and kidneys, and may cause miscarriages.

Our bodies use lead in the same way they use calcium, so it tends to be stored in bones and teeth. This stored lead may be released later in life, causing secondary lead exposure. Lead can also be released during pregnancy, where it can expose the fetus.

Reduce lead exposure in the garden

- Adding compost or other organic matter from a contaminant-free source may help limit lead uptake by plants. Check the [NC Composting Council](#) website to find STA or OMRI certified compost
- Aim for soil pH between 5.0 and 7.5 to reduce bioavailable lead (the form of lead absorbed by the body) in soil
- To reduce lead particles in air from dust, cover bare soil with mulch and keep the soil moist
- Thoroughly wash and/or peel produce grown in lead-contaminated soil
- If your soil lead levels are high, consider installing raised garden beds and replacing the top 1-2 inches of soil each year with compost
- Conduct a soil safety training for all garden users on exposure reduction strategies
- Visit our website below for our factsheet on [10 Healthy Garden Habits](#)

For more information visit:

<https://sites.nicholas.duke.edu/superfundcec/gardens/>



DIESEL RANGE ORGANICS in the garden

Diesel range organics, or DROs, are a group of compounds commonly found in diesel fuel. All DROs are made of carbon and hydrogen, along with some other compounds, and all are thick and oily. DROs can vary greatly in their associated health risks due to their different chemical structures.

Summary for Gardeners

- » Children should avoid playing in or unintentionally eating DRO-contaminated soil.
- » Carefully rinse produce, wear garden gloves, and use mulch to reduce dust to help reduce exposure to DRO-contaminated soil in the garden.
- » DROs bind strongly to soil particles and so are not easily taken up by plants. Produce grown in DRO contaminated soil is generally safe to eat.

Sources of exposure to DROs

Because DROs are not easily taken up by plants, direct contact with contaminated soil is the most common exposure pathway in the garden. This can include breathing in or eating soil particles, or tracking soil inside the home and breathing or eating the soil at a later time.

DROs can stay in soils for a long time. This means that a past land use may be a potential source. Regular, low-level contamination can also build up over time, like with rain runoff from roadways.

Where DROs in soil might come from



gas stations Underground fuel storage tanks, like those at gas stations, may leak over time. As a result, DROs can move into nearby native garden soils



traffic Water runoff from heavily trafficked areas and parking lots can contain fuels, motor oil, and other petroleum compounds. like DROs



nearby industry Past or current industrial sites, including car- and truck-related industry, can release petroleum compounds into the soil, water, and air



roofing shingles If you collect rain water from your roof for gardening, it may contain petroleum compounds if your shingles are made with asphalt

Exposure to DROs in the garden

How am I exposed? Gardeners can be exposed to DROs by eating or touching DRO-contaminated soil and by breathing in soil dust. Ingesting DROs is the main way exposure occurs.

Are my garden plants safe to eat? DROs are unlikely to accumulate in garden produce, but can remain in soil for a long time due to their thick, oily nature, so be sure to remove all soil from produce.

Should I be worried? Short-term, infrequent exposure to DROs are less likely to cause significant health effects when compared to long-term, daily exposures to these contaminants. However, reducing or limiting exposure is still a good idea.

Limit children's exposure

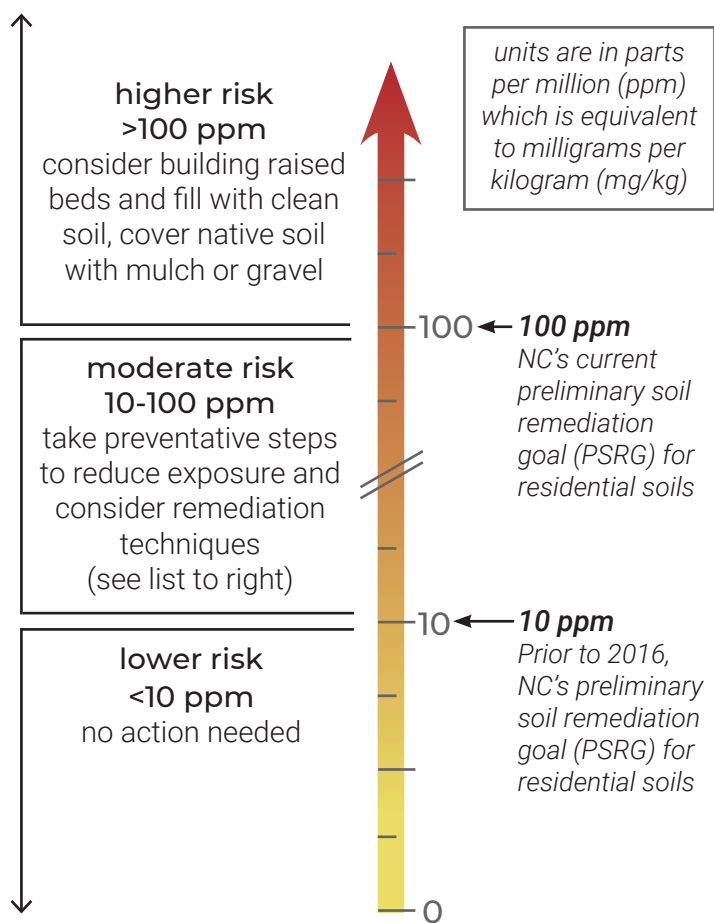
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DIESEL RANGE ORGANICS in the garden

Making sense of regulatory standards

No official standards have been established in North Carolina for an acceptable level of DROs in garden soils, specifically. The NC guidelines below (used to clean up old industrial sites) can help you determine whether DRO levels in your garden might need more attention.



Through testing, you may find DRO levels greater than 10 ppm. This does not mean that *all* of your garden soil is contaminated. Contamination "hotspots" can occur, and there are actions you can take. →

Testing resources



How to test your soil and interpret the results: <https://sites.nicholas.duke.edu/superfundcec/gardens/soil-testing/>



Still have questions about testing soil for DROs? Email us at superfund@duke.edu

Health impacts of DROs

Continuous or frequent exposure to DROs or other petroleum-based compounds can increase your risk of health problems. Effects from exposure to DROs depends on their concentration in the soil, the frequency and duration of exposure, as well as the specific types of DROs that are present in the soil.

Some DRO compounds are suspected to cause cancer. Other health effects include respiratory system effects such as lung inflammation or difficulty breathing, decreased liver and kidney function, neurological system effects, and eye damage. DRO-contaminated soil may also irritate skin.

Reduce DRO exposure in the garden

- Take steps to prevent or limit stormwater from running off into your garden
- Tilling the ground can help to limit DRO hotspots
- Add compost or other organic matter from a contaminant-free source. Check the [NC Composting Council](#) website to find STA or OMRI certified compost
- If you decide to build raised beds in your garden, make sure to place landscape fabric between the ground and the new soil in order to strengthen the separation barrier
- Conduct a soil safety training to teach exposure reduction strategies to all garden users
- Visit our website below for our factsheet on [10 Healthy Garden Habits](#)

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MERCURY in the garden

Mercury is a metal that has both natural and man-made sources. Depending on the type of mercury, it can be found as a solid, liquid, or gas. Mercury is a byproduct of coal burning and mining, and was historically used in thermometers, barometers, and some electronics.

Summary for Gardeners

- » Plants do not readily take up mercury from the soil, so you can reduce exposure by controlling dust and limiting the soil children ingest.
- » Mercury comes in different forms, but the most toxic form is not usually found in soils.
- » Children and pregnant women are at greatest from exposure, but mercury in garden soil is much less of a concern than other sources like contaminated fish.

Sources of mercury exposure

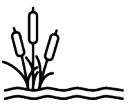
Sources outside the garden are typically greater health risks. Mercury is usually found at very low levels in soils, but hotspots from man-made sources may also exist. Below are some of the main sources of mercury exposure, both in and outside the garden.



nearby industry Coal power plants, mining operations, and other industries can release the metal into air, water, and soil.



fish Highly toxic methylmercury can build up in the food chain, as one fish eats a smaller fish.



aquatic environments Peaty and waterlogged soils have the highest concentration of naturally occurring mercury.

Mercury comes in different forms

Methylmercury

- » not usually in soils
- » exposure from eating some types of fish
- » harmful at very low levels

Total Mercury

Metallic

- » not usually in soils
- » "pure" form
- » previously used in thermometers, barometers, etc.

Inorganic

- » low levels common in soils
- » not as harmful, but still has health effects

Exposure to mercury in the garden

How am I exposed? You can be exposed by eating or breathing contaminated soil particles, or by eating contaminated garden produce.

Are my garden plants safe to eat? Soils tend to contain inorganic mercury. Plants (and people) are not good at absorbing mercury in this form. Garden produce is not a major source of mercury exposure.

Should I be worried? It is important to remember that there are many health benefits associated with gardening. Mercury exposure is a serious concern in mining communities and among communities that eat certain types of fish. However, garden exposure at high levels is uncommon. Even so, limiting exposure, especially for children, is always a good idea.

Limit children's exposure

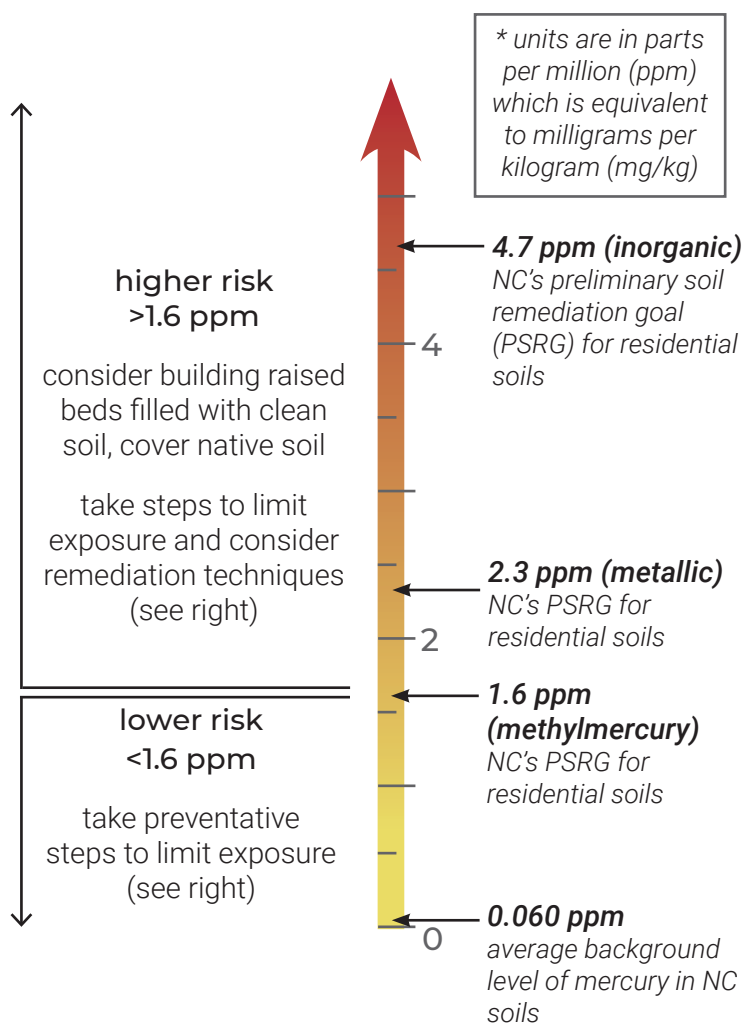
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MERCURY in the garden

Making sense of regulatory standards

No official standards have been established in North Carolina for acceptable levels of mercury *in garden soils*. For remediating residential soil, NC uses EPA's guidelines for different forms of mercury. New York State's guideline (0.81 ppm*), considers exposures like gardening and assumes mercury is in its most toxic form, so it is a conservative value that represents an abundance of caution.



Health impacts of mercury

Exposure to inorganic mercury at high levels can damage kidneys, stomach, and intestines. Impacts to the nervous system can cause mood swings, memory loss, and behavioral changes. Skin exposure can cause rashes and dermatitis.

Children and pregnant women are at greatest risk from mercury exposure. The developing fetus is vulnerable to the toxic effects of maternal mercury exposure.

Methylmercury is particularly toxic and can accumulate up the food chain, but it is not usually found in garden soils.

Reduce mercury exposure in the garden

- Uptake of mercury by plants is low, so focus on controlling dust and limiting soil ingestion
- Remove boots or shoes after gardening to reduce the amount of contaminated soil you track into your home
- To reduce mercury particles in air from dust, cover bare soil with mulch and keep the soil moist
- Flooded soils may help convert mercury to its more toxic form, but this can take many months
- Adding compost or other organic matter from a contaminant-free source may help dilute mercury concentration in soil. Check the [NC Composting Council](#) website to find STA or OMRI certified compost
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Testing resources



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NICKEL in the garden

Nickel is a metal that has both natural and man-made sources. Nickel is used to produce stainless steel, cast iron, coins, rechargeable batteries, and more. Mining, coal power plants, and trash incinerators can all introduce nickel into the environment. Nickel comes in many different forms, some of which are more toxic than others.

Summary for Gardeners

- » People need very low levels of nickel, but high exposure levels can cause health problems.
- » The forms of nickel that do not dissolve in water are more often found in the environment, and are less toxic than forms of nickel that do dissolve in water.
- » Nickel is not easily taken up by plants, and so your garden produce is not likely to be a major source of exposure.

Sources of nickel exposure

Nickel is not easily taken up by plants, so direct contact with contaminated soil is the most likely route of exposure in the garden. Low level exposure from soil or water are not major concerns, but hotspots from man-made sources may also exist. Below are some of the main sources that release nickel into the environment or directly expose people.



nearby industry Power plant emissions and other industries that use nickel can release the metal into air, water, and soil.



incinerators Trash incinerators, like other power plants, emit nickel into the air. The metal attaches to small particles and stays in the air for many days.



on the job Occupational exposure by breathing in high levels of nickel can occur in some industries.



smoking Cigarette smoke typically contains nickel and can contribute to lung cancer.



foods Food contains low levels of nickel, but is still the main source for most people. Foods with the highest levels of nickel include chocolate, soybeans, oatmeal, and nuts.

Exposure to nickel in the garden

How am I exposed? Eating or direct skin contact with contaminated soil particles, or eating contaminated produce can cause exposure, but mainly at very low levels.

Are my garden plants safe to eat? Nickel binds very tightly to soil, and is not easily taken up by most plants. Some plants like Indian Mustard and sunflowers take up more nickel than other plants, but most of the metal will stay in the roots.

Should I be worried? When we consume nickel, only about 1% is absorbed by our bodies, which is then quickly excreted. The low levels we may be exposed to from produce is not a major concern, and there are many health benefits from gardening.

Limit children's exposure

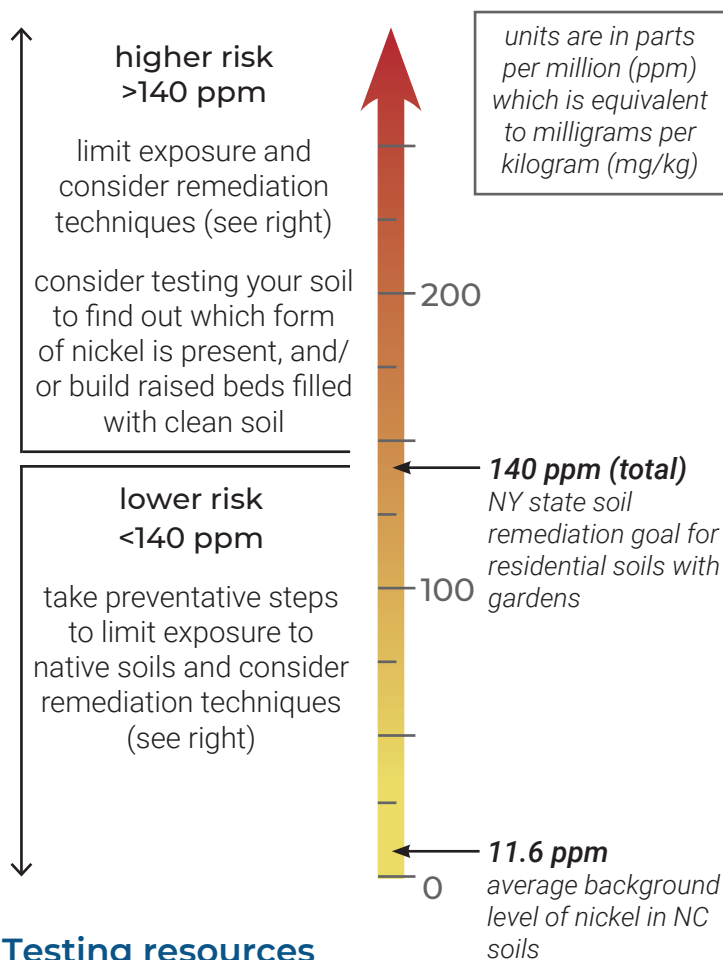
- Small doses matter. Children breathe, eat, and drink more relative to their size than adults
- Their bodies and brains are still developing
- Children spend more time on the ground and often put things (like dirt) into their mouths
- They have more skin surface area than adults, so skin exposure also matters



NICKEL in the garden

Making sense of regulatory standards

No official standards have been established in North Carolina for acceptable levels of nickel in *garden soils*. For eight different nickel compounds, the preliminary soil remediation goal (PSRG) for residential soils in NC ranges between **140 and 310 ppm**. A ninth compound, nickel subsulfide, is considered more toxic and has a PSRG of **0.41 ppm**.



Testing resources



How to test your soil and interpret the results: <https://sites.nicholas.duke.edu/superfundcec/gardens/soil-testing/>



Well water testing for nickel: <https://epi.dph.ncdhhs.gov/oe/wellwater/howtotest.html>



Still have questions about nickel soil testing? Email us at superfund@duke.edu

Health impacts of nickel

People need very low levels of nickel in their bodies, which we get from food, but high levels of exposure can cause health problems.

Occupational exposure to high levels of airborne nickel can lead to chronic bronchitis, reduced lung function, lung and sinus cancers, and more. Nickel in cigarette smoke has also been linked to lung cancer.

Skin contact with nickel, usually from jewelry, can lead to skin irritation. This can occur in 10 to 20 percent of people after prolonged contact. In some people, eating or breathing nickel can lead to similar reactions or asthma attacks, but this is uncommon.

Reduce nickel exposure in the garden

- Adding compost or other organic matter from a contaminant-free source may help limit nickel uptake by plants. Check the [NC Composting Council](#) website to find STA or OMRI certified compost
- Adding agricultural lime (to raise soil pH above 6.0) can also limit plant uptake
- Thoroughly wash produce grown in nickel-contaminated soil to remove any soil or dust
- To reduce nickel particles in air from dust, cover bare soil with mulch and keep the soil moist, but not water-logged.
- If your soil nickel levels are high, consider **not** planting root vegetables, since nickel tends to stay in plant roots
- Conduct a soil safety training for all garden users on exposure reduction strategies
- Visit our website below for our factsheet on [10 Healthy Garden Habits](#)

For more information visit:

<https://sites.nicholas.duke.edu/superfundcec/gardens/>



PCE & TCE in the garden

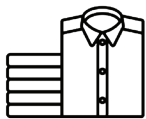
Tetrachloroethylene (PCE) and trichloroethylene (TCE) are chlorinated solvents, compounds used in a wide variety of products including as degreasers, paint thinners, and more. These solvents are part of a broader group of chemicals called volatile organic compounds (VOCs), which can easily evaporate from soils and water into the air. Dry-cleaners are a potential source of PCE in particular.

Summary for Gardeners

- » PCE and TCE are not easily taken up by plants, so without elevated levels in soil, exposure from eating produce is probably not an issue.
- » Breathing in these compounds as they evaporate from soil is only a concern if there are elevated levels in soil.
- » Taking steps to limit exposure is always a good idea. Wash hands or wear gloves, wash and peel produce, and leave dirty tools outside to help prevent exposure.

Sources of PCE & TCE exposure

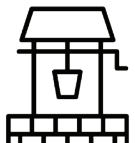
PCE and TCE exposure can occur in the garden, but non-garden sources including dry-cleaners are likely bigger concerns. Fumes from contaminated soil may enter homes, other indoor spaces, and even enclosed garden spaces like greenhouses and lead to health concerns. Urban soils in particular may contain hotspots of contamination. Groundwater may also be contaminated.



dry-cleaners PCE is used as a dry cleaning agent. Many dry-cleaners have released PCE into surrounding soil where it can either evaporate or leach into groundwater.



vapor intrusion PCE and TCE easily evaporate from soils. These vapors can build up in homes where people inhale these chemicals.



well water PCE and TCE can contaminate groundwater formations that supply drinking water via wells, and could also contaminate garden soil via watering.



nearby industry Some industries use PCE and TCE as degreasers, in glues, paint removers, etc. PCE and TCE can be released in air, water, and soil.

Exposure to PCE & TCE in the garden

How might I be exposed? Exposure can occur through skin contact with contaminated soils, eating soil particles, or breathing in soil dust or evaporated PCE and TCE.

Are my garden plants safe to eat? In general, plants do not take up much PCE or TCE from contaminated soil, so they should be safe. Washing them is still not a bad idea.

Should I be worried? Garden-related PCE and TCE exposure is likely not a concern for most people, but limiting exposure (especially for children) is still a good idea. It is important to remember that there are many health benefits to home and community gardening.

Limit children's exposure

- Small doses matter. Children breathe, eat, and drink more relative to their size than adults
- Their bodies and brains are still developing
- Children spend more time on the ground and often put things (like dirt) into their mouths
- They have more skin surface area than adults, so skin exposure also matters



PCE & TCE in the garden

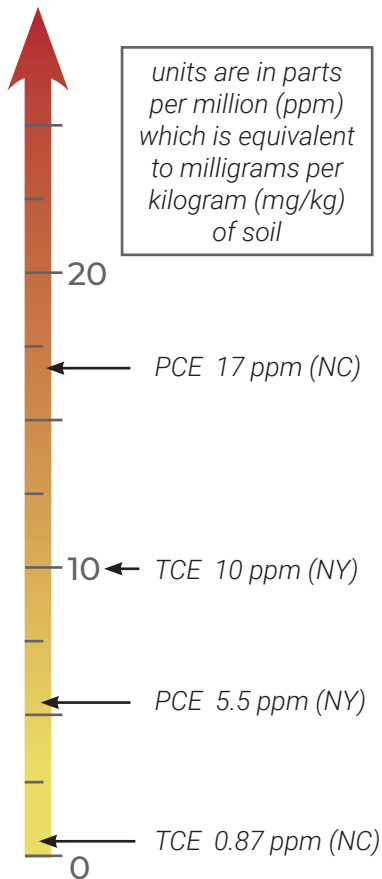
Making sense of regulatory standards

No official standards have been established in North Carolina for levels of PCE or TCE in garden soils. Below are North Carolina preliminary soil remediation goals to clean up residential soils (NC) and similar goals from New York state (NY). The New York guidelines take into account home gardening as an exposure pathway.

Assessing risk

If there are potential sources nearby and/or a history of contamination or spills, you may want to test your soil for a general group of chlorinated solvents. PCE can break down into other solvents like TCE and vinyl chloride, so the presence of these other chlorinated solvents may indicate past spills.

If levels are elevated, you should attempt to limit exposure as best you can (see right).



Testing resources



How to test your soil and interpret the results: <https://sites.nicholas.duke.edu/superfundcec/gardens/soil-testing/>



Well water testing for PCE, TCE, and other VOCs: <https://epi.dph.ncdhhs.gov/oe/wellwater/howtotest.html>



Still have questions about lead soil testing? Email us at superfund@duke.edu

Health impacts of PCE and TCE

TCE is a known human carcinogen – it has been linked to kidney cancer and potentially blood and liver cancers. PCE has been linked to bladder cancer, cancer of certain cells in bone marrow, and blood cancers, but the evidence is more limited than with TCE.

Short term exposure to PCE or TCE at high enough levels can lead to various health problems including dizziness, headaches, and the malfunction of various organs.

Exposure to PCE during pregnancy may lead to miscarriage, birth defects and slowed growth of the baby. TCE is linked to developmental health effects.

Reduce PCE and TCE exposure in the garden

- If PCE, TCE, or other chlorinated solvents are at high concentrations in your soil or groundwater, there may be a source nearby
- Uptake of PCE and TCE by plants is low, so focus on controlling dust and limiting soil ingestion
- Consider installing raised garden beds and make sure to place landscape fabric between the ground and new soil
- Remove boots or shoes after gardening to reduce the amount of contaminated soil you track into your home
- To reduce PCE and TCE particles in air from dust, cover bare soil with mulch and keep the soil moist
- Conduct a soil safety training for all garden users on exposure reduction strategies
- Visit our website below for our factsheet on [10 Healthy Garden Habits](#)

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