From the Ground Up:

Soil Testing in Ottawa's Urban Gardens

Just Food
Alimentation juste

Community Gardening
Network of Ottawa
Réseau de jardinage
communautaire d'Ottawa

Sources

Information to produce this document was collected from the "Guide for Soil Testing in Urban Gardens" produced by the Toronto Public Health Department of the City of Toronto.

To create the original "Guide for Soil Testing in Urban Gardens" Toronto Public Health collected information from literature reviews, expert and gardener consultation, a pilot study of five proposed gardens, experiences in other jurisdictions as well as information on the soils in the city of Toronto. The full original report, "From the Ground Up Guide for Testing in Urban Gardens" can be found at: https://www.toronto.ca/wp-content/uploads/2019/09/96a1-FromtheGroundUp_Guide-Soil-TestingOct2013.pdf

Disclaimer

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Contact Us

Just Food
2391 Pepin Court
Ottawa, Ontario
K1B 4Z3
613 824 7771
info@justfood.ca

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Summary

Even a city can make a great place for a garden, but certifying that your soil is safe should be of utmost importance. This Soil Testing guide tells you how to better know your soil and determine whether it is safe to use for growing produce.

There are three steps you must follow to determine whether or not your soil is safe:

1. Establish a Level of Concern
2. Sample and test the soil if necessary
3. Take risk reducing actions

Reading this guide should help to ensure you have a full understanding of the process at each step before beginning your soil analysis.

This guide is not intended for funded community garden programs. If you are looking to apply to the Community Garden Development Fund (CGDF), or work with the Community Gardening Network (CGN) to start a community garden, please contact communitygardening@justfood.ca.

Establishing a Level of Concern

The first step is to determine the activities that have taken place on the land in the past as certain activities have the potential to leave harmful contaminants in the soil. To do this, inspect the site and research its history. By completing this initial step you will establish whether your site is of a low, medium or high Level of Concern (LOC). With this information you will determine if your soil needs testing and which actions to further follow to reduce your risk of being exposed to contaminants.

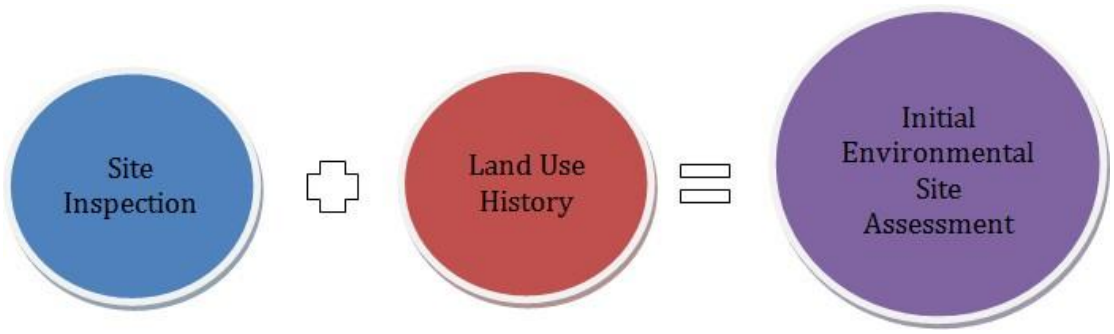

Figure 1: Components of an Initial Environmental Site Assessment

Completing ***a site inspection*** and ***land use history*** are the initial steps of an Environmental Site Assessment (ESA). Under the Environmental Protection Act Ontario Regulation 511/09 part XV.I it is necessary to complete an ESA when a property owner intends to alter the use of a site from a less sensitive site to a more sensitive site. A more sensitive site is an area where routine activities occurring at regular times would experience adverse effects from contamination. For example, creating a public playground at the site of a preexisting gas station would be dangerous as chemicals may have leached into the surrounding area. Simply put, contamination in these areas would have a greater effect than in a less sensitive site.

PART 1: Completing a Site Visit

Before completing your site visit, it is important to be informed of the indicators of potentially hazardous previous or current uses. Indicators, such as the ones listed below, can provide evidence of harmful chemicals present in the soil even after the land use has been discontinued.

Indicators of Historical Risk

- Discoloration
- Odor
- Broken or abandoned equipment
- Proximity to major roads
- Use as an orchard
- Age of the housing
- Industrial activity
- Waterfront infill

For further information on determining the Level of Concern of your site refer to Table 1 for the Classification Factors.

Conducting a Site Visit

The purpose of completing a site visit is to help you establish the Level of Concern. As you now know, there are several features you will be looking for that act as indicators when determining the presence of soil contamination.

Equipment to Bring:

- Work boots
- Work gloves
- A shovel
- Notebook and pencil

Steps:

1. When you arrive on site create a sketch; use the Site Assessment Form on page 8. Make note of the size, location and the surroundings:
   - *Are your surroundings residential, commercial, industrial or old parks?*
   - *What is the distance to major roads or rail lines? (defined as roads with more than 20,000 vehicles/day at speeds of 50 – 60 km/h with no stop signs and used by city buses.*
2. Walk the site
   - *While you walk take note of any stained soil, unusual odors, trash, burned patches, old equipment, pipes or tanks or dead or dying plants. All of these are potential indicators that the soil may be contaminated.*
   - *Be sure to dig into the soil in a few random locations within your prospected garden spot to check for these features.*
3. Talk to the neighbors
   - *Ask what the site was used for in the past, if there was any dumping or burning. Mark the affected areas on you site diagram*

Site Assessment Form

Current Surroundings: Residential/Commercial/Industrial/Old park/Other _____

Distance to Nearest Major Road: _____

Presence of Historical Risk Indicators: Yes / No

If Yes, list them: -

_____
_____
_____
_____

Historical Use According to Neighbours:

_____
_____
_____
_____

Site Sketch:

Table 1: Determining Your Site's Level of Concern

Level of Concern	Classification Factors	Next Steps
Low	• Garden site has always been residential, parkland, farmland, child care centre or school	Action Level 1
Medium	• Garden site is or has once been a risk managed park, orchard, hydro corridor, infill area, commercial land uses (excluding gas station, dry cleaner, printing and auto body shop) • Garden site is located within: a former landfill; former lead reduction zone; or 30 m from a rail line or a major arterial road • Industrial land that has been remediated	Action Level 2
High	• Garden site is or has once been a gas station, dry cleaner, print shop, auto body shop, rail line or rail yard • Is or has once been industrial land • Garden site reveals indications of dumping or burning, smells or staining in the soil	Action Level 3

PART 2: Conduct a Site History

By searching the city archives and other city and online resources, you can determine with higher certainty the Level of Concern of your site.

To determine potential historical land uses check the City Geo Ottawa Map at http://maps.ottawa.ca/geoottawa/. This tool will help you to investigate previous potential land uses. The dropdown bars on the right top corner allow you to adjust the Base Map, Aerial Map and add layers. By selecting aerial maps from different years you will be able to see land use changes over time. If it appears a building was erected and demolished on the property you plan to use for your urban garden site, you will want to determine the type of building it was to gain an understanding of the potential threats its presence may pose.

To determine the type of materials used on the property it may be possible to use the Georeferenced Ottawa Fire Insurance Plans. These maps kept track of the building materials used through Ottawa as a way of estimating the risk of fire spread. https://library.carleton.ca/find/gis/geospatial-data/georeferenced-ottawa-fire-insurance-plans

If you have specific questions on the building permit history of a land parcel, call the zoning office at (613) 580 - 2424 ext 28333.

Visiting the Archives

Select the location you wish to visit:

Central Archive: James K. Bartleman Centre

Location	100 Tallwood Drive (Corner of Woodroffe)
Contact	*Tel.*: 613-580-2857 *Fax* :613-580-2614 *Email*: archives@ottawa.ca
Hours	*Tuesday to Friday:* 9 am to 4 pm *Saturday*: 10 am to 5 pm *The Central Archives is always closed on Mondays, Sundays, and statutory holidays.*

Gloucester Archives

Location	4550 Bank Street (at Leitrim Road)
Contact	Information: 613-580-2857 **To book an appointment: 613-822-2076 (leave a message on the answering machine, your call will be returned)**
Hours	Thursdays 10 am - 3 pm from May - October, or by appointment only.

Rideau Archives

Location	6581 Fourth Line Road (Main Street)
Contact	*Tel*.: 613-489-2926
	Email: rideauarchives@ottawa.ca
Hours	*Tuesday*: 9:30 am to 4:30 pm

The Archives hold civic government records and community records. Their data dates back to land surveys and civic government documents from the late 18th century and community records from the 17th century.

When Accessing Information from the Archives:

For specific questions about Ottawa call 613-580-2857 or email archives@ottawa.ca reference staff. For more complex question visit the archives.

If you plan to visit the archives, call ahead of time to ensure the documents you wish to view will be on location. You should be prepared to spend several hours at the archives to complete your search, order and or reading of the records. If the records you wish to view are being stored off site you will need to order them and delivery can take roughly two business days.

If you wish to view your documents at the Rideau Archives location in North Gower please note that it will take additional time for the documents to be sent there.

Requested documents will only be kept on site for one week.

If you wish to access restricted information you will need to submit a request through Reference Services. An Archivist will review the records to determine whether you may have access. This process can take up to 20 business days. Some government records may be subject to Municipal Freedom of Information and Privacy Act (MFIPPA) and you will be required to submit a request through the City of Ottawa's ATIP request. Access to restricted information may require the completion of a research access agreement form and supervision by an archivist.

Some of the collections can be viewed online at:
http://ottawa.minisisinc.com/ottawa/scripts/mwimain.dll?logon&application=UNION_SEARCH&language=144&file=[ottawa_web]NewOPAC\index.html .

To learn more about the history of a specific property contact the archivist at erchives@ottawa.ca for their researching guide, "Tracing the History of your Ottawa Property".

If you would like building plans, the archives may have them or you may have to contact the Building Records Department. To access these records fill out the Access to Building and Permit Records Application Form.

Putting it All Together

If you find High Risk indicators you may stop your search as you will consider this site a High Risk site. If your site visit or site history indicate the presence of a COC not on the streamlined list, the site should be considered a High Concern Site as it is likely that other **chemical levels will also be present and elevated**.

> ***To consider for all sites:*** Though site inspections and site histories can provide excellent insight into the potential contaminants soil may hold, soil testing is the only way to know for sure the safety of exposing yourself to your soil. Alternatively it is possible to use raised beds or container gardens.

Raised Beds

A raised bed, also known as a garden box, is a contained method of gardening. A box of any length and width is created and filled with soil with a depth of 8 – 24 inches deep depending on what you plan to grow.

Though there are benefits to gardening in raised beds, there are also drawbacks. Your soil will warm more quickly in the spring, you can maintain a barrier between your crop and contaminated soil and its easier to maintain high nutrients in your soil. All this considered, the Community Garden Network (CGN) of Ottawa does not encourage the use of raised beds.

There are several risks associated with growing produce in raised beds, to mitigate a contaminated site. There is the risk that with time the liner separating your clean soil from the contaminated soil may become ripped or frayed. Frequent replacement of the soil will be necessary to maintain soil fertility. Studies have shown that recontamination of the raised soil is also possible by way of wind transfer from adjacent soil beds (Clark, H., Hausladen, D. & Brabander, D., 2008). It is also important to note that regardless of the level of contamination in the soil the plants are grown in, the risk of ingestion of contaminants is significant. Though the plant itself may not have accumulated that much of the contaminant, tiny contaminated particles transported by wind will become lodged on the produce. Produce contaminated in this manner would require thorough cleaning otherwise it would pose a health threat.

Container Gardens

Container gardens are gardens comprised of a series of plant pots of any sizes. The benefits and shortcomings of container gardens are similar to those of raised beds. Though they can provide growing space in an otherwise contaminated site, contaminated soil can still become airborne and contaminate produce.

When to Test your Soil

Toronto Public Health recommends testing your soil if it ranks as a Medium Concern site AND the garden is larger then $16m^2$.

To test your soil you will take a sample, send it to be analyzed, and then interpret the results you receive. As soil testing for a small garden is not cost effective see Action Level 3, page 23, if you have a small or medium concern garden and do not wish to test your soil.

Toronto Public Health has developed Urban Garden Soil Screening Values (SSVs) that can be used to determine whether your soil contains unsafe levels of contaminants for growing garden produce. TPH considered several important factors while deriving the SSVs including children's exposure, public health, and other sources of exposure and background levels of soil contaminants.

Remember, the purpose of collecting a soil sample is to retrieve a sample that is representative of the site to be used. To do this collect a composite sample, a sample comprised of two or more combined subsamples to represent the site.

Having Your Soil Tested

1. Select a laboratory to test your soil

Some Examples of Soil Testing Labs in Ottawa:
Caduceon Environmental Laboratories: www.caduceonlabs.com
Paracel Laboratories Ltd.: www.paracellabs.com
Eurofins: https://www.eurofins.ca

2. Contact the Laboratory
    a. Before you collect your sample contact the lab to determine
        i. The price and turnaround time
        Each laboratory is different, but prices are roughly $150 to $300 for each composite sample.
        ii. Obtain a chain of custody form
        iii. Inform the lab when you expect to deliver the samples
        iv. Get instructions for handling and delivering the samples
3. Fill out the chain of custody form
    a. Indicate what you want your soil to be tested for (heavy metals, PAHs, pH values, etc)
    b. Soil interpretation: ask the lab to interpret the soil samples according to the SSVs – in mg/kg
4. Collect your soil sample
5. Deliver the samples to the lab
    a. Ensure the samples are refrigerated from the time they are sampled to the time they are sent/delivered to the lab

If your site visit and site history indicate a Medium Level of Concern and you decide to proceed with soil testing after obtaining cost estimates, proceed to the following steps. To prepare for your soil sampling collection, acquire the following items.

Sample Collection Checklist:

- Work boots
- Work gloves
- Measuring tape
- Trowel
- Shovel
- Two clean plastic buckets (9L each)
- Resealable bags (3.7 L)
- Cooler and Ice pack
- Notebook and pencils
- Permanent marker
- Tape, pylons or rope to indicate proposed boundary line of garden

Steps to Sample

1. Start by sketching the planned garden location and sample collection site
2. Note the address and date of the sample collection
3. Using your rope, tape or pylons mark off the perimeter of your garden site.
   ***Note**: a community garden will need roughly one or two soil samples. A composite sample should be taken every 10 x 10 x 15m area*
   For gardens larger than half an acre call 311 for help
4. Indicate the locations of your subsamples on your diagram
5. Collect the nine subsamples of soil:
   a. Remove the turf/vegetation from the subsample spot
   b. Scoop down 40 cm and place sample into Bucket 1 for all nine sites
   c. Break up and mix subsamples in Bucket 1
   d. Remove all stones and visible debris (note their presence)
   e. Transfer a trowel full of the mixed sample into Bucket 2
6. Refill the hole with the remaining soil in Bucket 1 and replace turf
7. Repeat steps 5 and 6 for the remaining eight subsample sites
8. Label a resealable sample bag
   a. Site name
   b. Sample number
   c. Sample date
   d. Name(s) of sampler(s)
9. Thoroughly combine the nine soil subsamples added to Bucket 2
10. Add soil from Bucket 2 to the labeled composite sample bag
    ***Note**: Check with your lab of choice how much soil they require you to submit for testing*
11. Seal bag and place in a cooler with ice packs

If sampling more than one composite sample wash equipment thoroughly

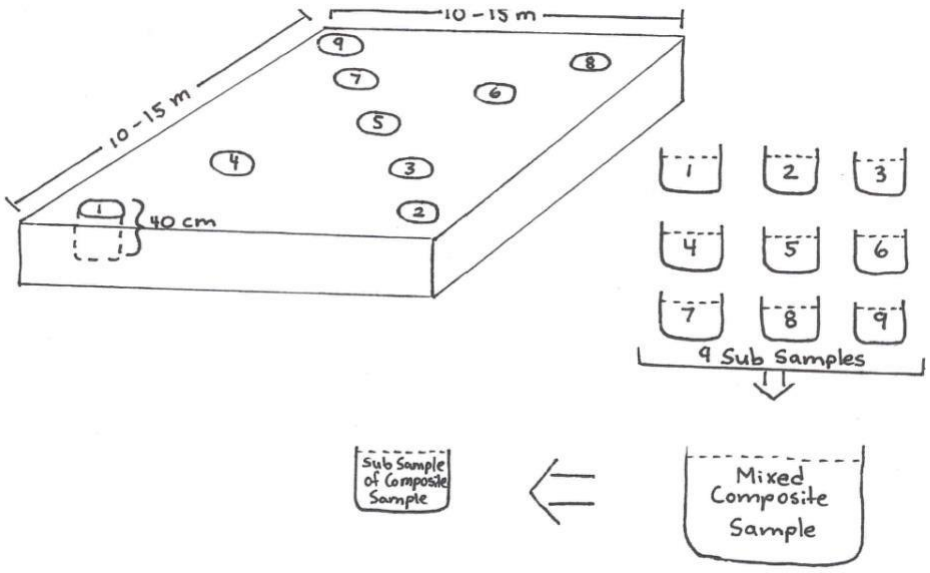

Figure 2: How to Take a Representative Composite Subsample

What to Test for and Why?

pH

One of the most important factors to test in your soil is pH as it will affect many other properties of your soil. The pH can impact your soil's fertility as well as it's ability to make metals and PAHs bioavailable. As the pH increases and your soil becomes more basic, the bioavailability of contaminants decreases. Therefore, soil with a lower pH, acidic soil, has a higher risk of contaminating your garden produce.

Conductivity

A measure of the conductivity of your soil will provide an indication of the salts present in your soil.

Chloride

Though chloride is an essential micronutrient in low concentrations, in high concentrations it can be toxic accumulating in the plant's leaves causing leaf and subsequent plant death. Chloride does not absorb into soil particles and therefore travels easily through water and into plants (White and Broadley, 2001).

Sodium Absorption Ratio (SAR):

The SAR is the ratio of sodium molecules to calcium and magnesium molecules. When the sodium levels are high compared to calcium and magnesium levels the soil becomes sticky and slippery when wet and hard and crusty when dry. When the SAR is high, above 13, plant growth will be challenging (Agriculture Soil Fertility Guide, Manitoba).

It is important to note that a high salt concentration is bad for seed germination and will inhibit growth. Note: 0.5 to 1.0 μδ/cm3 is considered high.

Factors Affecting Bioavailability

- Soil type (organic, clay, loam, sand)
- Rate of material uptake of plant
- Solubility type of a metal (less soluble means a lower uptake)
- Age of the metal (older metals will be less bioavailable)

Contaminants of Concern (COC)

In the process of creating the *Assessing Urban Impacted Soil for Urban Gardening: Decision Support Tool*, Toronto researchers developed a streamlined list of COCs for both metals and PAHs. The metals and PAHs were added to the COC list under the following rationales:

- Commonly found in urban soils
- Cheap and easy to test for
- Present in Toronto soils
- Common industrial pollutants
- Metals that accumulate in garden produce
- Metals found in literature to be of risk to gardens
- PAHs only persistent in soil
- PAH related to incomplete combustion

Contaminants were excluded from the streamlined COC list if they were determined to have a low level of likelihood persisting in the soil or posing a threat to human health. For example, PAHs with a fast breakdown time or inability to be taken up by plants (not bioavailable) were not included in the COC list as they are very unlikely to pose a health threat through urban garden produce consumption.

Pesticides were not included in the list of COCs as modern pesticides degrade rapidly and bind strongly to soil (they are not bioavailable). Additionally, in 2010 there was a province wide ban of pesticides. However, it is important to be aware of the historical use of land as pesticides such as organochlorine were used up until they were banned in the 1970s. Organochlorine is dangerous to human health and degrades slowly.

Soil-Plant Barriers

1. *The soil matrix binding to the contaminant.* Based on the chemical make up of the soil there may be more materials in the soil that will bind to contaminants, rendering them inert
2. *Uptake of most metals to the shoots from the roots is limited by the absorption and precipitation of metals in the soils or roots.* The metals bind to the soil or roots and are rendered inert
3. *Phytotoxicity of some contaminants limits their uptake.* Toxic metals will kill the plant before they can contaminate the rest of the plant.

It is generally accepted that the underground portion of a plant is the more contaminated portion of the plant (Spittler, T., & Feder, W., 1979).

Soil Testing in Ontario

The Ministry of the Environment (MOE) tested soils across Ontario to determine background soil contaminant concentration data. From this study THP assumed that the background level of old urban parkland is roughly equal to uncontaminated soil in the city of Toronto. This guide carries over this assumption to the urban soils of Ottawa.

Understanding the Soil Screening Values (SSVs)

It is important to be aware that the SSVs are different than the soil standards developed by the provincial government. TPH developed the SSVs to account for your additional consumption of produce grown in potentially contaminated soil.

Interpreting Your Results

Compare your test results in mg/kg to the SSVs in Table 2 to determine the Level of Concern and the applicable Action Level to your garden site.

Plants do uptake metals and PAH naturally, however, they are limited by the plant's uptake methods. Metals, both good and bad, can be absorbed, taken up, by plants growing in contaminated soils. However, because of soil-plant barrier properties, the concentration of the metals in the soil to the plant will remain greater. With respect to PAHs both Health Canada and Environment Canada indicate that uptake of PAHs through consumption of produce grown in contaminated soils is not an important exposure pathway. This is because once the PAH has been taken up by the plant, it will not penetrate further than the peel, therefore, peeling produce can reduce the contaminant concentration (Zohair, A., Salim A., Soyibo, A. & Beck, A., 2006).

Table 2: Urban Gardening Soil Screening Values (SSVs) (mg/kg)

Metals	**SSV1**	**SSV2**
Arsenic (As)	11	110
Cadmium (Cd)	1.0	10
Cobalt (Co)	23	170
Chromium, total (Cr)	390	630
Chromium, VI (CrVI)	5.0	5.0
Copper (Cu)	180	660
Mercury (Hg)	2.7	2.7
Molybdenum (Mo)	13	13
Nickel (Ni)	34	340
Lead (Pb)	34	340
Selenium (Se)	10	11
Zinc (Zn)	500	1800
PAHs		
Acenaphthene	0.050	0.32
Acenaphthylene	0.093	0.47
Anthracene	0.58	0.58
Benz(a)anthracene	0.23	2.3
Benzo(a)pyrene	2.3	3
Benzo(b)fluoranthene	0.23	2.3
Benzo(g,h,i)perylene	0.10	1.0
Benzo(k)fluoranthene	0.23	2.3
Chrysene	0.099	0.99
Dibenz(a,h)anthracene	0.77	0.77
Fluoranthene	0.14	1.4
Fluorene	0.39	0.39
Indeno(1,2,3-c,d)pyrene	0.23	2.3
Phenanthrene	3.1	3.1
Pyrene	0.11	1.1

NOTE: some of the SSV1 and SSV2 values are the same this is because anything higher than the SSV1 is an indication of soil contamination and Tier 2 Actions are recommended.

Units can be expressed in mg/kg, μg/g, parts per million (ppm).

Take Action to Reduce Risks

Depending on the level of contamination and subsequent Level of Concern for your site, there are three levels of recommended actions you can take to reduce your exposure to soil contaminants. Refer to Table 3.

If you conclude that many of your garden sites classify as High Concern sites, it may not be economically feasible to test all sites. If this is the case, it is recommended that gardeners pursue raised bed or container gardens. It is also recommended to plant fruit or nut trees as the fruits or nuts receive the least amount of contaminants from the soil. Contamination in plants grown in contaminated soil will be highest in the roots, lower in the stalk and leaves and lowest in the fruits and nuts.

Table 3: Interpreting Your Results and Tacking Action

SSV1		SSV2
Action Level 1	**Action Level 2**	**Action Level 3**
Use good gardening practices • Wash your hands after gardening and always before eating • Wash produce with soap and water	Use good gardening practices AND: • Lower the concentrations of contaminants by adding clean soil and organic matter (compost and manure) to the existing soil. Adding organic matter will also improve the pH level of the soil • Reduce dust by covering bare soil with ground cover or mulch. Peel root vegetables before you eat or cook them • Avoid growing the types of produce that accumulate soil contaminants (See list on next page)	Use good gardening practices AND: • Reduce dust by covering bare soil with ground cover or mulch • Build raised bed gardens (add a minimum of 40 cm/16 in. of clean soil on top of garden fabric), or grow food in containers • Add clean soil and organic matter annually (compost and manure) to the raised bed or containers **OR** • Grow only nut and fruit trees (not any other types of produce)

Take Action to Reduce Risks

For Medium Concern Sites: avoid plants that accumulate soil contaminants

Optimal Plants for Medium Concern Sites

Grow produce where only the fruit, seed or grain is to be eaten, NOT the leaves, root or shoot.

The following plants are optimal:

- Tomato
- Corn
- Barley
- Oats
- Rice
- Rye
- Sunflower
- Wheat
- Soybean

Using Action Level 2 measures will reduce the concentration of contaminants over time. After two years of implementing Action Level 2 measures, consider testing the soil again.

Optimal Plants for High Concern Sites

Where the contaminant levels indicate the tested soil is unsafe to grow produce in; raised bed or container gardens are recommended.

There are several plants that are optimal for growth in raised beds or container gardens:

- Alfalfa
- Amaranth
- Beets
- Carrots
- Chicory
- Dandelion
- Endive
- Garden pea
- Lettuce
- Mushrooms
- Radish
- Wild rice
- Sorghum
- Sorrel
- Spinach
- Brassicas (broccoli, brussel sprouts, cabbage, cauliflower, kale, kohlrabi, mustard greens, canola, turnip)

About the SSVs

TPH developed the SSVs after reviewing national and international guidance on urban gardening soil assessment. They determined that the values were not appropriate as they did not account for:

1. Consumption of produce
2. Enhanced soil exposure
3. Originally included exposure paths irrelevant to urban gardening

To derive the SSVs, THP gathered research from a combination of sources. They took a method for qualitatively accounting for produce consumption derived by the New York Department of Environmental Conservation and combined it with the Ontario Ministry of the Environment's 2009 formulae for calculating Site Condition Standards and exposure assumptions appropriate for urban gardening.

The SSVs were designed with the knowledge that people are exposed to contaminants daily through a variety of pathways.

Furthermore, THP wanted the SSVs to include several additional criteria. It was mandatory that the SSVs are to be protective of human health and that they consider the greater susceptibility of babies and children to increased contaminant consumption. Ingestion of contaminated produce was not the only pathway of exposure accounted for. THP included exposure by ingestion of the soil remaining on the produce when consumed, soil ingested and inhaled while gardening and dermal contact with the soil while gardening into the SSVs. The values were developed to be specific to Toronto. Research and information was used from areas with comparable soils, absorption factors, temperature, weather and length of gardening season (six months).

Based on the criteria used by THP and the comparable regions soil data was selected from, these SSVs can reasonably be considered transferrable to Ottawa soils.

The base values to develop the SSVs are Toxicological Reference Values (TRV).

> "TRVs are prescribed by a variety of national and international agencies for the purpose of characterizing risks associated with exposure to environmental contaminants" (Health Canada, 2010).

It is standard practice of the MOE to allocate one fifth of each TRV to a major exposure route; ambient air, drinking water, consumer produce, grocery store foods or urban gardening. To ensure protection of human health, SSVs are equal to one tenth of a TRV.

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