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Soils in Urban Agriculture: Testing, Remediation, and Best Management Practices

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Urban agriculture, including community and school gardens and small farms in cities, has become a popular means of obtaining fresh local produce. San Francisco, San Diego, Los Angeles, and several other California municipalities have changed policies to facilitate these activities.

Fertile soil. *Photo:* G. Heilig.

Soils are an important consideration for individuals, community groups, and local governments becoming involved in urban agriculture. In many situations, urban soil has been contaminated and degraded by past uses and activity, including industry, unauthorized dumping, construction, heavy traffic, and adjacent buildings where lead-based paint has been applied. Elevated levels of lead in particular are fairly common in urban soils and pose health risks, especially to young children who can ingest soil while playing or helping in gardens. Ongoing exposure to lead can damage the nervous system, interfere with brain development, and create other health problems. Arsenic, cadmium, copper, zinc, and other naturally occurring trace elements in soils, especially heavy metals, can also be elevated to unsafe levels by past land uses.

Although soil degradation and contamination are important concerns and should be addressed, they are not always a problem with urban agriculture sites. A study conducted at several community gardens in the Los Angeles area by University of California researchers found that “in nearly all cases concentrations of trace elements were well within natural ranges” (Hodel and Chang 2002). In contrast, a study conducted in San Francisco found that “a majority of the gardens exceeded the California Human Health Screening Level for arsenic, cadmium, and lead” (Gorospe 2012).

Children playing in soil. *Photo:* UC ANR.

Debris in soil. *Photo:* L. Costello.

Even where there are elevated levels of lead or other heavy metals or contaminants in soil, relatively little is absorbed by plants that can be harmful to humans, although this depends on soil and other environmental conditions as well as on the plant's characteristics. Accidentally swallowing or inhaling contaminated soil or dust is the most likely way urban farmers will be exposed to unsafe levels of lead or other contaminants. This can happen easily, for example, when people put their fingers in their mouths without thinking.

Beyond heavy metals, other sources of soil contamination and soil hazards might include solvents found at sites with a history of manufacturing use, various petroleum-based chemicals common at former gas stations and other industrial sites, chlorinated pesticides and residual herbicides on former agricultural lands or public landscaped areas, saline soil, and sites where a contaminant may not be harmful to people but may prevent plant growth or production. Physical debris such as lumber, concrete, wire, broken glass, and discarded syringes can also create hazards for the urban farmer.

Clearly, there are no easy answers: each site and situation is unique. However, establishing reasonable policies and encouraging sustainable practices will help to ensure that urban farmers and consumers of urban agricultural products are not exposed to unsafe levels of contaminants, including lead and other heavy metals.

This publication outlines strategies for urban soil contamination assessment, testing, and remediation; explains best management practices for urban agriculture; and discusses municipal policy concerning safe soils for urban agriculture. This publication does not cover soil fertility or other important soil science topics in depth; additional resources on these topics are presented in the section "Sources of More Information."

Soils Assessment for Urban Agriculture

Site Selection

Overall soil conditions should be a consideration when selecting a site for urban agriculture. If plants, even weeds, are growing abundantly on the site, it is a good indication that the soil will be able to support crops. If the soil is reasonably easy to dig, it is a positive sign as well. The presence of plant roots and earthworms can indicate soil health. However, these indicators do not guarantee that soil is uncontaminated. When assessing potential sites, be aware that properties with considerable amounts of trash and rubble or obvious dead spots where plants do not grow may pose challenges. Heavy herbicide or pesticide use may have even sterilized the soil on a site. A simple test for evaluating soil fertility is to plant bean seeds in soil from the site, perhaps in a pot or biodegradable paper cup, and compare their germination and growth with an equal number of beans grown in purchased potting soil. It is also advisable to dig a hole 1 to 2 feet deep in several places to assess the presence of debris on the site.

Site History

Learn as much as possible about the history of a proposed site and how it has been used in the past. Walking around the site may provide some clues. Adjacent older homes with peeling paint, paint chips, or evidence of sandblasting (a pitted surface) indicate potential soil lead contamination. Any building built before 1979 that has old or peeling paint may be a hazard due to use of lead-based paint. Proximity to a freeway or a heavily trafficked road is also a source of lead. Although leaded gasoline has not been in use since the 1980s, lead particles in vehicle exhaust may have settled from the air into the soil.

Talking to the property owner and neighbors is a good strategy, as neighbors are often familiar with past uses of the property. It may also be necessary to do some Internet or library

Flower beds at Silver Lake Farms, Los Angeles. *Photo:* S. Golden.

research. For example, at some public libraries and online sources it is possible to access Sanborn maps, which were used by insurance companies to determine the risk involved with insuring individual properties. These maps can provide information about prior uses of a proposed site. Old aerial photographs, which can also be found in local libraries or online, can help identify a site's history as well. The local city hall may have aerial photographs accessible in their archives. There is also a fee-for-service website, http://www.historicaerials.com/ that includes aerial maps of various regions of California that can be used when researching the history of a site. The county tax assessor's office and the local city hall are important sources of tax records and permits that have been obtained for the property, which can help uncover past uses. Sites can also be checked on the California Department of Toxic Substances website, www.envirostor.dtsc.ca.gov/public/, to see whether any documented issues or ongoing cleanup activities are associated with the property.

Examples of prior uses of sites that may have caused soil contamination are parking lots, junkyards, auto repair or painting, carpentry, machine shops, dry cleaners, gas stations, railroad yards, and illegal dumping. The history of a site will help to determine what kind and how much soil testing is necessary. A site that has been primarily residential or used as green space is generally lower risk. A site that has had past industrial or commercial uses should be more carefully analyzed.

Soil Testing

Laboratory soil testing is always recommended for urban agriculture projects and should be considered a basic cost of starting any project. The cost depends on the size of the proposed site, the number of soil samples needed, and the type of analysis conducted by the lab.

Soil test kits sold at hardware stores or garden centers provide basic estimates of soil fertility but are not suitable for assessing soils at a potential urban agriculture site, as they do not provide information about soil contaminants.

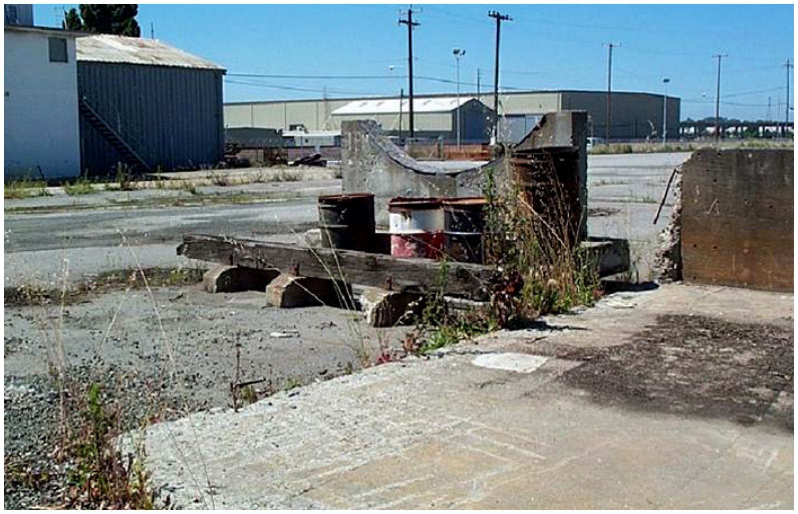
Selecting a Soil Testing Lab

Finding a university or commercial lab to conduct soil testing is not difficult; searching online for your region or state should yield several choices. Note that in many publications, the University of California Cooperative Extension is listed as a resource for testing soil. UC Cooperative Extension does not offer soil testing. However, some other state land grant universities accept out-of-state soil sample submissions by mail at very reasonable prices, including the University of Massachusetts at Amherst and Penn State University. When selecting a soil testing lab, consider asking some of the following questions.

1. Do you participate in the North American Proficiency Testing Program (NAPT)? This program assures that soil test analyses are being performed using validated testing methods.
2. Which tests do you recommend for an urban agriculture site with no site history?
3. Do you recommend any specific tests for sites with a history of industrial or commercial use?
4. Do you perform tests for elevated levels of heavy metals and other contaminants, in particular, those listed in the California Code of Regulations Title 22: Inorganic Persistent and Bioaccumulative Toxic Substances?
5. What costs are involved for testing, given the type of analyses recommended and the anticipated number of samples?
6. What is the recommended procedure for taking soil samples?
7. Is it okay to call the lab for advice and information?
8. Do you provide a narrative with the soil test results? Is there an extra charge for this?
9. Do you provide remediation recommendations with soil tests?
10. What is your turnaround time?

The U.S. Environmental Protection Agency (U.S. EPA) recommends that for urban areas, "at a minimum, the soil test should include pH, percent organic matter, nutrients, micronutrients, and metals, including lead" (U.S. EPA 2011b). This level of testing is adequate for a site that has been residential or green space. Most commercial soil labs can test for the most important heavy metals, including lead, arsenic, cadmium, chromium, and nickel.

More testing may be appropriate for a site with a history of industrial or commercial use, which might include CAM-17 testing. ("CAM-17" refers to the list of seventeen metals specified in the California Administrative Manual: antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc.) An EPA-recognized laboratory is the best choice for this level of testing.



Brownfield. *Photo:* California Water Boards.

It is possible that other types of tests may be necessary, such as testing for PAHs (polynuclear, or polycyclic, aromatic hydrocarbons), a class of potentially toxic byproducts of incompletely burned garbage, oil, wood, coal and other organic materials. They can accumulate in soils and become a concern on a site that has been used previously as a car wash, parking lot, road and maintenance depot, or vehicle service station.

Staff members at soils labs can be great sources of information. They are generally willing to talk on the phone about appropriate testing based on site history. However, there are instances where additional support may be necessary.

Resources for Brownfield Soil Assessment

According to the California Department of Toxic Substance Control (DTSC), "brownfields are properties that are contaminated, or thought to be contaminated, and are under-utilized due to perceived remediation costs and liability concerns" (DTSC 2015). In cases involving brownfields that were formerly industrial or manufacturing sites, old gas station sites, and other situations, expert assistance may be necessary: these sites may have cleanup

Composite soil sample.
Photo: S. Paisley.

issues beyond what a community project can accomplish without technical expertise and a significant budget. These sites may be too expensive to test and remediate; help may be available, though, through state and local brownfield programs. California DTSC oversees a voluntary cleanup program for brownfield sites. Some cities have brownfield programs that may be able to provide guidance, resources, and perhaps even help in securing funding for cleanup. Although urban agriculture is not yet a common reuse for brownfield sites, it is an area for further exploration. Local offices of the USDA Natural Resources Conservation Service (NRCS) may also be able to provide technical assistance and guidance on a case-by-case basis.

Taking Soil Samples

Laboratories generally provide an online instruction sheet on how to sample the soils, prepare the samples, and mail them to the lab. Once you have selected a lab, review its website for instructions or speak to a staff member by phone. Detailed instructions on collecting soil samples are also available in several of the resources listed in the section "Sources of More Information." Review these instructions carefully, since poorly collected or unrepresentative soil samples may not provide accurate information.

Generally, it is essential to approach soil testing with a plan in mind. Making a simple map of a proposed site and noting areas with different characteristics helps you decide how many samples to collect.

Mapping the Sampling Area

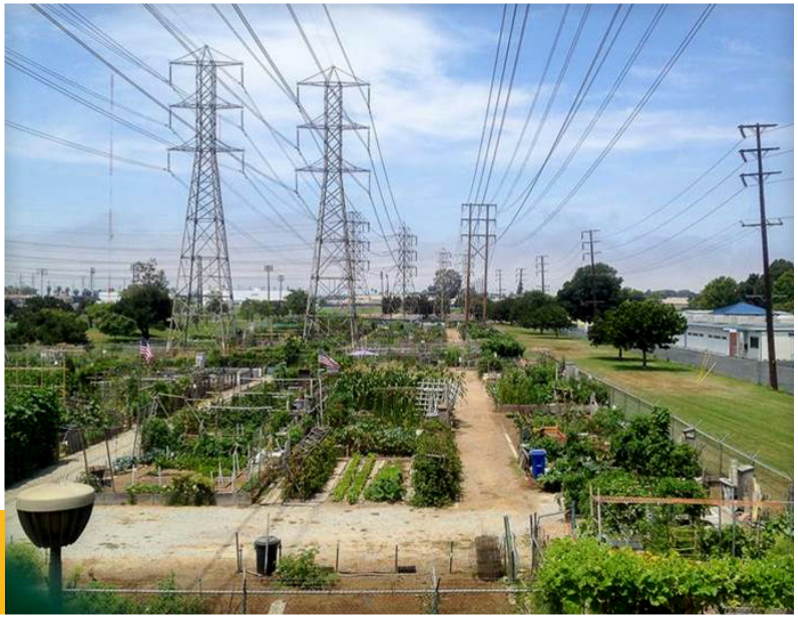
1. Areas where plants are not growing or the soil is discolored should be sampled separately.
2. An area adjacent to a building with peeling paint should be sampled separately due to the possibility of lead contamination.
3. For each area to be sampled, it is usually appropriate to take five to seven subsamples, then mix them together to create a composite sample.
4. Take samples from the top 4 to 6 inches of soil.
5. Remove litter, leaves, grass, or anything else covering the soil before sampling. The subsamples can be mixed together thoroughly in a clean bucket to form a composite sample after breaking up any clumps and removing roots, stones, or other materials.
6. Repeat this process for each distinct area of the site.
7. Keep track of the location of each sample. Once results come back, you will need to refer to records that clearly show where on the site samples were taken.

Transporting Samples

1. Use a resealable, clean plastic bag that holds approximately 2 cups (1 to $1^1/_2$ lb) of soil to transport the sample.
2. Remove most of the air from a double-bagged sample to prevent spillage.
3. Some labs supply sample jars, which may be free with testing.
4. The soil sample does not need to be refrigerated, but keeping it in the shade or a cool, dry place until it is shipped or delivered to the lab can help achieve accurate test results.
5. Wet samples should not be shipped, as inaccurate testing may result.
6. Soil samples can be dried prior to shipment by keeping the bag open in a dry and well-ventilated place or by spreading the soil in a thin layer on clean butcher or waxed paper and allowing it to dry at room temperature.

Interpreting Soil Test Results

Some soil labs provide a narrative report with recommendations. Most labs are receptive to questions regarding interpretation of test results. Soil testing will indicate whether plant nutrients are low and need to be raised for best plant growth and whether the soil pH needs to be adjusted. The soil test can also indicate whether there are higher than acceptable levels of heavy metals or other contaminants, depending on what tests were requested.



Farming under the wires. *Photo:* J. Gerber.

Table 1. Advisory levels to guide interpretation of soil test results for heavy metals in parts per million (ppm)*

Inorganic chemicals	California residential HHSLs	U.S. EPA SSLs
arsenic†	0.07	0.4
cadmium and compounds	1.7	70
chromium III	100,000	120,000
chromium VI	17	230
lead and lead compounds	80	400
nickel and compounds	1,600	1,600
zinc	23,000	23,000

Notes:
*These state and federal soil screening level standards are for advisory purposes only. Please refer to the section "Interpreting Soil Test Results" for details.
†The screening numbers for arsenic are for contamination resulting from human activity. Concentrations of naturally occurring arsenic may be far above the screening number. When levels of arsenic at a site are a concern, consult the agency with authority over remediation decisions.

Heavy metals are the contaminants most commonly tested for, and there is more guidance available about heavy metals, especially lead, than for many other contaminants. Even so, there is no one standard as to what constitutes safe levels of heavy metals in urban agriculture. Most guidelines that exist are created for residential use scenarios and contact with soil through skin exposure or accidental ingestion, rather than being formulated for gardening or farming. Still, they provide some guidance about what is acceptable.

One standard to consider is the California Human Health Screening Level (HHSL), which is used by the City and County of San Francisco and the City of San Jose in their guidance on lead hazard assessment for urban gardens and farms. For lead, the HHSL is 80 parts per million (ppm). Anything lower is considered below the level of concern for human health. Another standard is U.S. EPA's Soil Screening Levels (SSLs) for residential use, which consider lead to be a hazard at levels of 400 ppm or more. In 2013, the U.S. EPA Technical Review Workgroup (TRW) for Lead provided a bit of clarification specifically for gardening and deemed soil lead at less than 100 ppm to be low risk for home-grown produce.

The HHSL levels for heavy metals and other potential contaminants are listed in the chart at the California Environmental Protection Agency's (CalEPA) Office of Environmental Health Hazard Assessment (OEHHA) website, oehha.ca.gov/risk/chhsltable.html; some of the most common are listed in table 1 along with the corresponding SSLs. The U.S. EPA TRW chart with specific, tiered soil lead recommendations for gardening is available in table 2. These standards are advisory only; check with local municipalities (or school districts for school-based projects) to find out whether more specific requirements have been established.

Table 2. EPA TRW Lead Committee recommended best management practices for gardening in lead-contaminated areas

Soil-lead concentration (ppm)	Category	Recommendations	
		Gardening practices	Choosing plants*
<100	low risk	No specific remedial action needed. Wash hands, produce, and clothes (good gardening and housekeeping practices).	No restrictions of crop types.
>100–400[†] 400–1,200	potential risk	Increasing use of good gardening and housekeeping practices as described in the section "Best Management Practices."[§] Relocate garden to lower-risk garden areas. Increasing use of soil amendments (e.g., compost, clean fill), barriers (e.g., mulch), and other remedial measures up to and including raised beds and containers. Ensure that gardeners wear gloves and use tools to reduce soil contact and ingestion.	Decrease planting of root vegetables or relocate root crop planting to lower-risk areas. Increase use of soil amendments and barriers to reduce soil deposition onto leafy vegetables. Increase planting of fruiting vegetables, vegetables that grow on vines, and fruit trees.
>1,200	high risk	All of the above good gardening and housekeeping practices. Raised beds, soil containers, soil replacement (i.e., excavate contaminated soil and replace with soil containing low lead concentrations) are strongly recommended.[‡] Consider finding other locations for garden. Restrict child access to only established safe areas. Restrict all gardening by or for children in contaminated soils.	Select plants with shallow roots for raised beds or areas with replacement soil to ensure that roots do not reach contaminated soil that is left in place (if any); otherwise, no restrictions.

Source: U.S. EPA 2014.

Notes:

*Sources: See U.S. EPA 2014, pp. 20–21.

[†]While 400 ppm lead in soil is considered an appropriate screening level for residential soil-lead, the TRW recommends that 100 ppm be used as the low end of the range of soil lead concentrations to mitigate exposure to lead in soil when gardening is an important exposure pathway. Lacking the information to support a quantitative approach for estimating risk for gardening scenario to support establishing acceptable concentration of lead in garden areas, best professional judgment was used to establish the low end of the range. This soil concentration is below the 400 ppm soil screening level for lead because the gardening exposure pathway includes other sources of lead exposure not sufficiently accounted for in the soil screening level. The basis for the Soil Screening Level (SSL) is children playing in lead contaminated soil and some other exposures, with the predominant source of exposure from direct soil ingestion or ingestion of soil manifested as house dust. Scientific limitations when it was developed did not allow the SSL for lead to adequately account for consuming home-grown produce. In developing an acceptable concentration of lead in soil for home garden exposures, the same child receptor would be exposed if accompanying the adult in the garden and also exposed through consumption of lead in and on the produce grown in the soil. Hence, the garden-based level is lower than the SSL and reasonable steps to mitigate exposure to lead while gardening in soil lead concentrations between 100–400 ppm would be appropriate. The TRW acknowledges that background soil lead concentrations in some communities may exceed the guidance values recommended for garden areas. Mitigation may be necessary for those communities.

[§]See U.S. EPA 2014, p. 10.

[‡]Twenty-four (24) inches of clean soil cover is generally considered adequate for gardening; however, site specific conditions should also be considered. A 24-inch barrier normally is necessary to prevent contact of contaminated soil at depth with plant roots, root vegetables, and clean soil that is mixed via deep rototilling. Raised garden beds could cost effectively add 24 inches of clean soil (U.S. EPA 2003).

Remediating Soils

If soil testing indicates that levels of lead or other heavy metals are higher than acceptable, consider the following strategies to mitigate the problem.

Working with Existing Soil

Many urban farmers automatically plan for raised beds to avoid potential soil problems. However, raised beds do have drawbacks, including the cost of materials, obtaining quality "clean" soil to fill them, and the fact that plant roots dry out faster in raised beds than in soil, potentially increasing irrigation needs. When possible, it is most economical to plant in the existing soil. If the site has been residential or green space, without a history of industrial use, and soil test results are borderline, it may be possible to work with existing soil by following these best management practices:

1. Turn over the soil deeply and thoroughly. Contaminants are often concentrated in the top 2 inches of soil and can be diluted through digging and mixing.
2. Maintain the soil pH at or close to neutral, 6.5 to 7.0. Soil nutrients are most available to plants at this pH, while lead and some other heavy metals are less available.
3. Add organic matter to the soil and continue to do so with each successive planting. By adding soil amendments and compost, the soil holds water and nutrients more effectively, and heavy metals bind to organic matter and become less available to plants. Organic matter improves soil structure, infiltration, and water-holding capacity, and it also creates a better environment for plant roots that slowly releases plant nutrients.

Two related products can be considered for use in improving existing garden soil. Biochar is a charcoal product that when mixed with soil adsorbs heavy metals and binds them tightly, making them less available in the soil. It has other potential benefits, including holding water and releasing plant nutrients. The second product, activated charcoal, is sometimes mixed with soil to adsorb contaminants including certain pesticides, herbicides, and petroleum products. Both can raise soil pH, which could pose a problem if soil is already alkaline. See the section "Sources of More Information" to learn more about these materials before applying them.

Organic lettuce. *Photo:* UC ANR.

Soil Removal

The most cautious strategy, perhaps most likely to be considered when dealing with a brownfield site, is to remove existing soil from the growing area and replace it with soil that is certified safe. However, this expensive procedure is out of the range of what most community groups or individuals can afford. Contaminated soil must be disposed of according to law, which can be expensive, in addition to the costs involved with soil excavation, removal, and replacement.

Raised Beds

A more common approach is to build raised beds and fill them with clean soil. A study of backyard, school, and community garden soils in San Francisco showed that raised bed gardens had significantly lower levels of arsenic, cadmium, and lead than in-ground gardens (Gorospe 2012). Another study, conducted in Chicago, measured significantly less lead in raised bed gardens than in-ground gardens (Witzling et al. 2010).

Raised beds at Treasure Island Job Corps Farm, San Francisco. *Photo:* A. Baameur.

To create raised beds, urban farmers can build frames of redwood or other lumber, brick, concrete, rocks, or any other sturdy material that won't leach contaminants into the soil. Treated lumber should be avoided since lumber treatments may cause copper or other metals to leach into the soil.

Water-permeable fabrics can be applied as a barrier between the on-site soil and the imported soil used to fill raised beds. Landscape fabric is permeable to liquids and air, unlike black plastic. Landscape fabrics are made from various materials, including nonwoven polypropylene, woven fabric, biodegradable paper mulch, or flexible geotextile fabric.

Once the frame has been lined with landscape fabric it should be filled with "clean" soil. One way of ensuring that soil is clean is to purchase topsoil or planting mix certified by the Organic Materials Review Institute (OMRI). OMRI performs an independent review of products intended for use in certified organic production, handling, and processing. OMRI reviews producer-submitted products against the National Organic Standards and generates a list of acceptable products. See the OMRI Crop Products list at their website, www.omri.org/sites/default/files/opl_pdf/crops_category.pdf. Some products that are not OMRI listed may still meet USDA organic rules; the producer may have decided against the expense of being reviewed by OMRI. Local urban farmers or gardeners may have recommendations on potential sources of quality soil. Some vendors may be able to provide documentation that soil has been tested, and if not, a sample of the soil could be sent to a lab for testing to be sure that it is not contaminated.

Other Containers

Other types of containers besides raised beds can be used in urban agriculture. For example, some commercially available growing systems are self-watering, for smaller-scale projects. Others are mesh "socks" that are filled with growing medium and placed on top of the soil. These types of "instant gardens" may be especially appropriate for short-term projects. Although tires are sometimes used as planters, this practice is not recommended, since tires can contaminate soil with leached metals as they degrade over time.

Asphalt Removal

At some sites, such as schools, open ground is not available, and gardens are constructed over asphalt. In other cases, the asphalt is removed, a process known as depaving, which converts an unused paved area into a garden space. This is a sizeable project to undertake, especially if done manually with the help of volunteers. If a professional company is hired to do the job, though, depaving can be a major expense.

Soil from West Oakland Woods (WOW) Urban Farm in West Oakland, California.
Photo: A. Baameur.

Many sites have created successful urban agriculture projects through depaving. For example, in 2006, volunteers removed 5,000 square feet of asphalt from the grounds of Carthay Center Elementary School in Los Angeles and created a thriving garden for the entire community. To improve the hardened clay soil, tons of soil, mulch, and compost were donated and tilled into the soil by volunteers. The garden consists of raised beds and in-ground beds, as well as a stone fruit orchard, citrus orchard, tropical garden, butterfly garden, and poetry garden.

If a site plan calls for depaving, test for heavy metals and other contaminants prior to asphalt removal. To test soil beneath asphalt, cut triangular holes in the asphalt with a hand-held concrete saw to expose the soil. Then remove the asphalt triangles, along with any subgrade debris or stones, and obtain the samples. Replace the pavement triangles and add sand or pea gravel afterward to eliminate a tripping hazard. If soil tests show heavy metals above recommended levels, consider raised beds or large containers rather than removing the asphalt.

Choosing Ornamentals over Food Crops

Some sites not appropriate for growing food might still be perfect for ornamental trees and shrubs or a wildflower meadow. Not every site needs to be for food production; sites can serve other purposes in the community, such as green space and beautification.

Best Management Practices

Several gardening practices make sense in many urban agriculture settings, whether gardening in the soil, raised beds, or other containers, even where soil testing does not indicate problems.

1. Remove any debris from the site, such as trash, metal, wood, and tires. Use care in removal and disposal of these materials, being aware of and following any pertinent regulations.
2. Cover the soil wherever possible. Do not leave soil in open areas uncovered, especially if the soil is known to be contaminated. Plant open areas with a ground cover or mulch them. Mulch paths and walkways between planting beds. Mulch not only keeps weeds in check and conserves water, it also helps prevent dust that may contain lead or other contaminants from getting on crops or other surfaces participants may touch. Install landscape fabric under mulch to prevent erosion, evaporation, airborne dust, and weeds.
3. Wear gloves while working on the site.
4. Facilitate hand washing. Incorporate a hand washing station into the urban farm and train participants to use it frequently. Washing hands immediately after working in the urban farm is an important practice to prevent exposure to harmful materials that may be in the soil. Hand washing is even more important for children, who tend to put their fingers in their mouths and are more vulnerable to relatively smaller amounts of harmful materials.
5. Thoroughly wash produce from the site before storing, cooking, and eating. If desired, rinsing in a vinegar solution (1 part vinegar to 100 parts water) can help ensure that tiny particles of soil are washed off. Remove older, outer leaves of lettuce or leafy greens before eating. Peel root vegetables before eating.
6. Wear closed-toe footwear while working on the urban farm. If possible, remove shoes worn while at the farm before entering the home. Consider rinsing gardening items that may also have soil on them.

Students working at WOW farm in West Oakland. *Photo:* A. Baameur.

Municipal Policies for Soil Testing and Urban Agriculture

As urban farming in all its forms becomes more popular, municipalities are beginning to consider a variety of policies related to land use for this purpose, including requirements for soil testing and remediation. Generally, the decision faced by municipalities is whether to require soil testing and a remediation plan where appropriate, or to make recommendations and provide educational materials on best practices. Requiring soil testing can create challenges for municipalities if they do not have staff available and qualified to review and evaluate soil test results and remediation plans. Some municipalities require soil testing for contaminants (and sometimes other soil properties) for community gardens. Anyone contemplating establishment of such a garden or farm should check with the local city or county environmental health department, parks and recreation department, or other appropriate agency.

Municipal decision makers should ensure that policies do not create insurmountable barriers for urban agriculture. Many community groups pursuing community gardens or other urban agriculture projects have limited funds to conduct extensive site analysis for contaminants and perform any needed remediation.

At the same time, contamination of urban soil is an important environmental health consideration, yet it is possible to have urban agriculture that is both safe and cost-effective. Soil testing is extremely important and should be facilitated and encouraged by municipalities. Ideally, this would include subsidizing the cost of soil testing and providing assistance with interpretation of soil tests and development of simple remediation plans. Minimally, it would involve having a list of best practices that urban farmers would agree to implement at their site.

Education is important in every case. Many best management practices, such as adding organic matter and managing soil pH, are important strategies for ensuring safe soils but are not practical to handle via policy. Cities and counties should explore forming partnerships with the local UC Cooperative Extension office to provide educational resources and training on soil management for urban agriculture. UC Cooperative Extension has trained Master Gardener volunteers available who may be able to help provide education at the local level.

Cities should also foster a connection between their own brownfield program, if one exists, and urban farmers. Municipal brownfield programs should be encouraged to work with urban farmers to identify potential sites and support testing and remediation for urban agriculture projects. This strategy is being used successfully in several U.S. cities, including Milwaukee, Wisconsin, and Kansas City, Missouri.

WOW farm in West Oakland below BART commuter line. *Photo:* A. Baameur.

Sources of More Information

Basic Soil Science. The University of California's Master Gardener Program has a "Garden Web" that offers a helpful list of common questions and answers on basic soil science, including soil texture, structure, pH, salinity, nutrients, and fertilizers, ucanr.org/sites/gardenweb/Vegetables/?uid=26&ds=462.

UC Davis Soil Web. The UC Davis Soil Web is a useful online tool that can give clues to past disturbances, soil removal, fill dirt additions, etc., in many areas of California, casoilresource.lawr.ucdavis.edu/soilweb/.

Brownfields Reuse

Although urban agriculture is not yet a common reuse, the California Department of Toxic Substances Control (DTSC) offers helpful information about brownfields and California's voluntary cleanup program, dtsc.ca.gov/SiteCleanup/Brownfields/index.cfm#CP_JUMP_13298.

"Re-Use: Creating Community-Based Brownfield Redevelopment Strategies," planning.org/research/brownfields/, is a website and downloadable guidebook that provides details on the reuse of brownfield sites, including agricultural use of remediated brownfields, and is also a helpful guide to community engagement, funding, site assessment, and cleanup of contaminated sites. The guidebook includes a case study of a brownfield site converted to a successful urban farm.

Soil Quality/Soil Health. The USDA Natural Resources Conservation Service has a very useful website with a variety of resources, including assessment cards to use to evaluate soil, www.nrcs.usda.gov/wps/portal/nrcs/site/soils/home/.

Soil Testing and Remediation for Urban Agriculture

Cornell University's Waste Management Institute has extensive information on soil testing and remediation, cwmi.css.cornell.edu/soilquality.htm.

"Heavy Metals and Gardens" offers multilingual resources for urban California residents on soil testing, interpreting results, and remediation, google.com/site/healthygardeners/home.

The Organic Materials Review Institute (OMRI) provides lists of certified organic soil and soil amendment sources that can help identify possible sources of certified clean soils and amendments http://www.omri.org/omri-lists.

"Biochar: A Home Gardener's Primer" is a Washington State University Extension fact sheet that provides a quick overview of what biochar is, the science behind its manufacture and use, and how it affects soil, plants, and the environment, cru.cahe.wsu.edu/CEPublications/FS147E/FS147E.pdf.

"Activated Charcoal" is a University of Florida Extension web page that includes information on the various uses of activated charcoal in soil remediation, solutionsforyourlife.ufl.edu/hot_topics/sustainable_living/activated_charcoal.shtml.

Policy-Related Resources on Urban Agriculture and Soil

"Seeding the City: Land Use Policies to Promote Urban Agriculture" is a downloadable toolkit that focuses on best practices for urban agriculture, with helpful model comprehensive plan language on various aspects of farming in cities, including soil testing, changelabsolutions.org/sites/default/files/Urban_Ag_SeedingTheCity_FINAL_%28CLS_20120530%29_20111021_0.pdf.

"Dig, Eat, and Be Healthy: A Guide to Growing Food on Public Property" is a guidebook that offers strategies for negotiating the use of public land for growing food, including types of agreements and specific suggestions on how to handle the issue of soil testing in such agreements, and includes a helpful section on school gar-dens, see http://www.changelabsolutions.org.

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