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Safe Container Gardening

by

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Introduction

This guide explores the safe use of raised beds and container gardening for agricultural or other uses. Container gardening is a method that utilizes any number of materials to contain soil, including wood, stone, concrete, rubber tires, metal, and bricks, among others. For the purposes of this report, raised bed gardens are also included within the definition of container gardening. Raised beds are a common form of gardening where the soil level in the bed is higher than the surrounding soil or ground, often with walls or a barrier to contain the soil (Lane, nd). Temporary raised beds, or "mounds," are similar to raised beds in that the soil is elevated above ground level, but they do not have walls around the perimeter to keep the soil from eroding away. They are typically formed by tilling the soil so that, when loosened, it will sit just above the surrounding ground. In some cases, additional soil, compost, or other organic matter may be added to the tilled soil to create a larger mound (Starbuck, 2003).

Container gardens and raised beds are increasingly common in a variety of settings, including community gardens, schoolyards, gardens on vacant lots in urban areas, and backyards. They can provide numerous benefits (discussed in the following section) including the potential to garden on known or suspected contaminated sites. However, container gardening and raised beds are not inherently safe, and important questions must be considered when constructing or working in these types of gardens. Careful selection of building materials, testing the soil for contamination, and knowing the history of the site can all contribute to the safety of the garden.

While numerous resources exist for the construction and design of container gardens and raised beds, there are few available resources focused specifically on *safety* as it relates to container gardening. We aim to fill this void by providing a guide to:

1) help organizations establish a policy for safe container gardening; and,

2) inform individuals who seek to build a container garden or simply learn more about safe container gardening practices.

This guide is intended for a broad audience, including anyone who is currently practicing, or interested in practicing, container gardening. We anticipate that it will be particularly useful for organizations seeking to develop guidelines or policies for safe container and raised bed gardening, including school districts that promote or require raised beds, community garden programs, or other organizations that regulate or construct container gardens.

Container Gardens and Safety

Container gardens and raised beds provide a number of advantages over more traditional methods of gardening and agriculture. Container gardens can produce higher crop yields and provide better drainage and water conservation, an expanded growing season, easier pest control, less soil erosion, and less maintenance. In addition, when the beds are elevated they provide easier access for elderly or disabled gardeners. Raised beds and container gardens are often constructed in urban areas because of their ability to maximize space and allow gardening on "difficult" sites. These are sites where more traditional methods would make gardening difficult or impossible, such as on hard surfaces (pavement, rock, etc.), hillsides, rooftops, and sites that may be contaminated or unsafe (Starbuck, 2003; Lane, nd; Harris and Mitchell, 2010). The latter reason is perhaps the most important to examine because of the potential health risks involved, primarily through exposure to toxic substances such as lead and arsenic, among others. While container gardens can provide a safe means of gardening on contaminated or unsafe sites, container gardens and raised beds are not inherently free from potential safety problems.

Being informed about the site of the garden, where the soil comes from and what materials to choose when building a garden can help minimize exposure to any potentially-harmful chemicals or substances.

Gardeners can be exposed to contaminants primarily in two ways when working in container gardens:

1) the soil and environmental contaminants in the soil; and,

2) the materials used for construction.

The soil used in the garden may be brought in from off-site or already be present on the site. Soil on-site may contain contaminants left over from a previous use of the site, contaminants transferred through the air or water from a nearby site, or chemicals that have leached into the soil from the materials used to construct the garden. Thus, in these cases, it is important to know the history of the site where the garden is located, where the soil comes from (if it is imported from off-site), what pollutants may reach the garden from off-site, and the potential risks associated with different construction materials.

We also acknowledge the abundance of "folk wisdom" that is available with regards to safe container gardening. A number of gardening books, websites, and blogs provide information that is sometimes based on scientific research, and other times based on personal experience or cultural knowledge and practices. For the purposes of this guide, only those practices and recommendations that are rooted in scientific research are included, although this does not imply that folk wisdom on this topic is invalid or incorrect. Rather, the guide provides an alternate perspective and recognizes that more empirical research is needed to clarify which gardening materials, soil, and practices are safe.

The following sections of this practice guide will address contaminants often found in soil, what materials used in container gardening may contaminate garden soil, and conclude with recommendations for organizational policy and safe practices for container gardening.

Soil

The U.S. Department of Agriculture defines *soil* as

> "a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment" (U.S. Department of Agriculture, 1999).

There are a number of elements that are naturally present in soil and do not pose a health risk to gardeners. These *trace elements* typically occur in very low concentrations that are safe for humans to ingest. In fact, some are required for healthy plant growth.

When constructing a container garden, some gardeners will use soil from the garden site. In other cases, soil may be brought from off-site, most likely purchased from a garden center or other local retailer. Regardless of where it comes from, it is important to test the soil to make sure it is safe and to determine if essential plant nutrients are present at levels needed for healthy plant growth. Thus, it is important to know the site history of where the container garden is constructed, or where the soil comes from to determine what hazardous materials may be present.

Contaminants Found in Soil

Soil contaminants are commonly deposited by water runoff (from adjacent land, nearby buildings, or groundwater beneath the surface), as air particulates settling (from nearby roadways or industrial uses), or are left from a previous use on the site as legacy contaminants or through illegal dumping (Heinegg, Maragos, Mason, Rabinowicz, Straccini, and Walsh 2002). While trace elements may be present, the concentration of these elements can increase through human activities that cause potentially-harmful accumulations of trace elements to be deposited in the soil and on plants, particularly heavy metals such as lead, cadmium, and arsenic. When these trace elements occur in elevated levels they can pose a health risk to people who eat, ingest, or inhale them. Although edible plants often absorb a certain amount of trace elements from the soil, it is often too small an amount to pose a safety risk when eaten. Of primary concern are trace elements that are deposited from the air or water as dust on leafy vegetables, or in soil where root vegetables such as carrots and beets are grown (Hodel and Chang, 2009). Thus, attention should be paid to exposure to contaminants through contact with the soil, not just to the potential risk regarding risks of exposure through eating what is grown in the soil.

One important factor in deciding what levels of contamination are safe is *bioavailability*. As defined by the U.S. Environmental Protection Agency (EPA), bioavailability is

> "the amount of a contaminant that is absorbed into the body following skin contact, ingestion, or inhalation" (U.S. Environmental Protection Agency, 2011).

Thus, the amount of a contaminant in soil is not necessarily the amount that is "available" to the person eating food grown in that soil. Determining the bioavailability of various contaminants is extremely complex since it depends on a number of factors, including the type of plant being consumed, the environment in which it was grown, and the characteristics of the person eating it. This makes it difficult to develop general standards for what level of contamination is safe for growing edible plants. For example, crops such as spinach, lettuce, carrots, and radishes grown in the same soil will absorb different amounts of contaminants, and those contaminants accumulate in different parts of the plant (e.g. roots vs. leaves) (Intawongse and Dean, 2006). In addition, children are more vulnerable to the harmful effects of contaminants because they tend to ingest more soil (through hand-to-mouth contact), eat and drink more in relation to their body size, and absorb more contaminants than adults (Shayler, McBride, and Harrison, 2009).

The following sections highlight the three contaminants that have been researched in the greatest depth: arsenic, lead, and cadmium. These three substances have received most of the attention in the research literature, perhaps because of their greater potential to be harmful to human health. Other contaminants may be present in garden soil as well and will also be discussed in this section, although the list of substances covered in this guide is certainly not exhaustive.

Arsenic

Arsenic occurs naturally in the earth's crust, generally at low levels. However, there are areas where naturally occurring arsenic levels are higher due to underlying geology as well as areas where non-ferrous metal processing has generated arsenic as a byproduct. (http://minerals.usgs.gov/minerals/pubs/commodity/arsenic/mcs-2011-arsen.pdf)

Arsenic has long been used in agriculture as an herbicide, pesticide, plant dessicant, and animal feed. Agricultural use of arsenic peaked in the 1940's when it comprised over 90% of U.S. use, although this dropped to roughly 15% by 1991 (Loebenstein, 1994). Arsenic can be found in container gardens primarily through its use in pressure-treated lumber, which provides rot-resistance. During the pressure-treating process lumber is stored in a tank where chromium, copper, and arsenic (CCA) are added, seep into the wood, and serve to arrest rot and decay. All three of these chemicals are toxic, but arsenic is the only one not recommended for human consumption in any amount (De Koff, Lee, and Schwab, 2007). In 2002, the EPA announced a voluntary decision by the lumber industry to shift the consumer use of treated lumber products away from those that contain arsenic. By 2004, lumber treated with CCA was withdrawn from the residential market, but some of this lumber is still in use today. It may be found in existing container gardens or it may be used to construct new gardens when lumber is recycled from another use. Wood is now commonly treated with alkaline copper quaternary (ACQ), which is higher in copper than CCA but contains no arsenic, making it a safer alternative to CCA (Relf, 2009).

Because some lumber treated with CCA is still in use, it is important to understand its potential effects on the soil, plants, and ultimately those coming into contact with both. Several studies have examined the arsenic content of vegetables grown in arsenic-enhanced soils. While soil that is heavily contaminated with arsenic will often not support plant life, growing vegetables in soil that is less-heavily contaminated can still produce crops with unsafe levels of arsenic (Grant and Dobbs, 1977). Both the types of plants being grown (Woolson, 1973) and the soil's properties, such as the amounts of phosphorus, iron oxide, and organic matter, can also affect the extent to which arsenic is absorbed into plants (Stilwell, 2002). Studies have generally concluded that little arsenic and chromium is absorbed into the seeds and fruits of plants and that the greatest amounts are found in the roots. Most studies have also found that arsenic is not particularly mobile in soil, and plants that are located at least 6 inches (30 centimeters) away from pressure-treated wood are unlikely to be contaminated at levels dangerous to human health (Rahman, Allan, Rosen, and Sadowsky, 2004).

Lead

Lead is one of the most common contaminants found in soil and has been extensively researched. It is not naturally present in the human body and high levels of lead have been linked to mental retardation and learning disabilities in children under the age of seven. Lead most often reaches humans through inhalation of airborne lead particles, consumption of contaminated water or food, and ingestion of soil or dust contaminated by lead. Young children are at greater risk for health problems associated with exposure to lead because 1) they are more likely to place soil or other objects in their mouths, and 2) their bodies are smaller and less developed, thus the contamination has a greater impact on them than an adult (EPA, 2002). Lead is most often deposited in soil around older buildings in the form of lead paint chips or dust. Lead is mostly immobile in soil (Pattee and Pain, 2003), thus contamination is most often confined to within several feet of the structures. However, particles can travel into other areas of the property (or nearby properties) through the air, groundwater, or remain in the soil from previous demolition of structures on the site. Thus, it is always important to research the site history to determine where lead particles may be present in soil or materials that will be used in a container garden, and to always test the soil for lead before gardening. Since lead also reaches soil and plants from highway traffic and air pollution, it is important to locate container gardens away from roadways that experience high traffic volumes.

Cadmium

Cadmium is a by-product of zinc production and is used in a variety of industrial and commercial applications. It can be deposited at a site through water-runoff or the air. For the general population, most cadmium exposure comes from food. If you are a smoker your exposure is greater, as the leaves on tobacco plants naturally accumulate high concentrations of cadmium (Friberg, Elinder, and Kjellstrom, 1992). Cadmium is absorbed into the roots, leaves, and sometimes fruits of leafy vegetables such as lettuce, cabbage, and spinach. Cadmium is mobile in soil and more readily absorbed by plants than most elements (Mench, Vangronsveld, Didier, and Clijsters, 1994). The concentration of cadmium in the soil is determined primarily by the soil pH. Cadmium is more readily absorbed in neutral or alkaline soils than in acidic soils: cadmium decreases as the soil pH increases (Friberg, Elinder, and Kjellstrom, 1992).

Other Contaminants

Other contaminants that may be present in soil include zinc, copper, and manganese. Each of these can be dangerous at high exposure levels (Intawongse and Dean, 2006; Hodel and Chang, 2009). When plants are grown in soil where these metals are present, each metal is absorbed into different parts of the plants and at different rates. While these all exist as trace elements throughout the environment, a standard soil test that includes heavy metals will reveal if unsafe levels of these elements are present in your soil.

Petroleum, heating oil, or other fuels, as well as asbestos, solvents, and more complex environmental contaminants could also be potential contaminants. If this and a broader range of contaminants are suspected, you may wish to consult with your local, state, or tribal brownfields program for additional information or technical assistance.

Soil Testing and Remediation

Before constructing a container garden it is essential to insure that the soil in the container is safe for growing food. In order to determine whether the soil is safe it is important to determine where the soil came from, test the soil, and then proceed to remediate the soil if necessary.

Where did the soil come from?

Soil for container gardens either comes from the site where the garden is located or is brought in from off-site. If soil from the garden site is being used, researching the past uses of the site can be important in determining the probability and type of soil contamination, as well as determining what types of soil tests are most appropriate. Sanborn (fire insurance) maps and deeds are particularly useful places to start when determining the past uses of a site, which can be accessed through local libraries and universities. In addition, neighbors or previous owners may also have information about site history. If the soil is brought in from off-site (such as bags of soil from a garden center), and its safety and origin are unknown, it important to test the soil for contamination. Just because soil is sold by a retailer does not mean it is safe. While contaminated soil is typically associated with urban soils from vacant lots or former industrial areas, soil that is sourced from suburban or rural areas may also be contaminated. Suburban and rural areas may have soil contamination from pesticides and fertilizers, and those areas near highways may have lead or other heavy metal contamination from automobile traffic (left from the days of leaded gasoline).

Soil testing

Many gardeners turn to their extension agents for testing services. Generally, soil testing involves a process of selecting and mapping soil sampling sites, collecting and packaging the soil samples, and sending them to a laboratory for testing. The cost of soil testing varies and is dependent on the number of samples and what contaminants are being tested for. Local branches of your state's cooperative agricultural extension service typically provide nutrient soil testing services at little or no cost, although they do not always offer testing for heavy metals. If your local extension service branch does not provide testing for contaminants, the University of Massachusetts Extension Service is a respected and affordable testing resource, offering a standard soil test for $10.[1] Testing services typically provide easy-to-follow, detailed instructions on how to collect and transport the soil samples, as well as help with interpreting the test results. If testing reveals unsafe levels of contamination, the soil can be removed, properly disposed of, and replaced with clean soil, or it can be remediated.

Soil remediation

If soil testing reveals levels of contamination that are considered unsafe, there are a number of remediation options depending on how the site will be used and whether the soil is on-site or brought in from another source. While there is no single measure for what levels of contamination are considered safe, many institutions and states, as well as the EPA, have their own guidelines for determining what levels are acceptable. The options for remediation include:

Capping: If the contaminant is not mobile and will not travel with water, then installing a barrier with an appropriate layer of new soil can provide protection from exposure.

Soil Mending: This technique allows for the removal of contaminants from the soil, essentially cleaning or "mending" it. Soil is typically removed from the site and "washed" off-site or at a plant. Once the soil is clean it is returned to the site. This process can be expensive and requires the appropriate disposal of the chemical residue following washing.

Composting: Compost can be added to the soil, which is a quick and inexpensive fix but generally does not remove the contaminants. For some contaminants this is appropriate because it reduces the *bioavailability* of the contaminant by diluting its presence in the soil. This technique is sometimes used in container gardens, where plants can grow in the compost without the roots entering into the contaminated soil below.

Phytoremediation: This is a process where plants are used to extract or transform contaminants in the soil. It must be done carefully with consideration for what will be done with the plants used in the process (disposal).

Ground Cover: Ground covers can be applied to areas around a container garden to serve as a physical barrier to the soil on a site, reducing gardeners' exposure to contaminated soil. This is particularly important for reducing children's exposure to contaminants, as they are

[1] University of Massachusetts, Soil and Plant Tissue Testing Laboratory. http://www.umass.edu/soiltest/

more likely to ingest soil. Examples of ground covers include thick plantings, stone pavers, or mulch.

Any soil remediation should be performed by, or in partnership with, trained professionals. The knowledge, materials, techniques that are necessary for successful and safe remediation require professional expertise.

In addition, it is important to note that the current state of research about uptake in plants and bioavailability of contaminants in general is not conclusive. Despite this uncertainty in the research community, it remains important to continue to ask questions about the soil safety and quality of each site and not to take safety for granted (Turner, 2009).

For more information about soil contamination, testing, and remediation please refer to the Center for Environmental Policy and Management Practice Guide #25, *Urban Agriculture and Soil Contamination: An Introduction to Urban* Gardening at
http://cepm.louisville.edu/Pubs_WPapers/practiceguides/PG25.pdf

Materials

A wide variety of materials are used in the construction of container gardens. Some of these materials may contain hazardous chemicals that can leach into the soil and become absorbed by the plants. Although there is a generally lack of empirical research available on the safety of certain materials used in container gardening, some common construction materials do contain potentially hazardous chemicals.

Wood

One of the most commonly used materials in container gardening is wood. Wood materials used for container gardens include railroad ties, plywood, pressure treated lumber, barrels, fallen limbs, and recycled lumber. Raised-bed walls are often constructed using pressure-treated lumber because of its ability to resist rotting. Until 2004, lumber was treated with chromium, copper, and arsenic (CCA), of which arsenic is potentially harmful to human health in high quantities. CCA has since been replaced by alkaline copper quaternary (ACQ), which contains no arsenic. Manufacturers of CCA maintained that the chemicals, though toxic, were safely absorbed into the wood and resulted in minimal leaching from the wood into the soil or air. However, studies on the effects of CCA on container gardens have produced mixed results. While studies indicate that wood treated with CCA is somewhat resistant to leaching, arsenic can be deposited in high concentrations in soil within six inches of the wood (Rahman, Allan, Rosen, and Sadowsky, 2004).

Other common wood materials that used to construct raised beds contain toxic substances, as well. Railroad ties contain the wood preservatives creosote and pentachlorophenol, both of which are hazardous to human health in large quantities (EPA, 2011b; EPA, 2001c). Plywood and other pressed-wood boards contain formaldehyde, which causes cancer in animals and may be a carcinogen for humans, as well (EPA, 2011d). In addition, while using recycled building lumber promotes sustainability through the reuse of materials, some lumber may have been exposed to lead paint, asbestos, or other chemicals during a previous use or storage. Overall, there is a lack of research concerning the potential of these and other chemical substances to be absorbed into the soil or into edible plants. Thus, without fully knowing the risks involved, it is advisable not to use any lumber that has been treated with creosote or pentachlorophenol, and to know the source of recycled lumber or fallen limbs in order to determine what substances it may have been exposed to.

Tires and Rubber

Rubber is used for container gardening primarily in two ways: 1) used tires as container borders, and 2) shredded rubber mulch, which is most often made from recycled tires. While recycling old tires for gardening uses is often hailed as a safe and sustainable solution to the difficult problem of used tire disposal, there are safety risks involved. The mineral content of tires includes aluminum, cadmium, chromium, manganese, and zinc, among others (Chalker-Scott, nd). In particular, tires contain high levels of zinc, which is used in the vulcanization process during their manufacture. As the tires wear they give off small particles containing cadmium that can settle in soil and on plants (Hodel and Chang, 2009). Used tires serving as a container or border for a garden may contain contaminants that can leach into the soil over time, posing a potential health risk for gardeners or those consuming the plants. In addition, rubber mulch may also contain small pieces of wire missed in the final shredding process (P. Long, personal communication, *June 5*, 2011).

Metal

Galvanized steel tubs or pots are sometimes used as containers for gardening. The primary component of galvanizing is zinc, which is applied to steel to prevent corrosion (American Galvanizers Association, 2008). Many manufactured products with zinc-plating or galvanized metal containers are potential sources of cadmium (Hodel and Chang, 2009), and both zinc and cadmium are potentially-harmful contaminants at high levels of exposure (Intawongse and Dean, 2006). Tomato cages or other support structures may also be made of galvanized steel. The amount of zinc and cadmium that transfer from galvanized steel into the soil has not been adequately researched, and thus the safety of using it in container gardening is not known. A safer alternative is to use regular (non-galvanized) steel or steel wire, which will eventually rust but should last approximately 10 years (Chaney, Sterrett, and Mielke, 1984).

Other Materials

A number of other materials are used in container gardens, including rocks, plastic bags, burlap, straw bales, concrete blocks, and bricks. There is not enough research available on these materials to determine their safety for use in gardens where food is grown. However, simply determining where the material comes from can help reduce the potential health risk: where a material comes from is just as important as what the material is made of. If you are considering using concrete blocks, bricks, or rocks, ask "were they salvaged from a structure that may have been located on a contaminated site (such as a gas station, industrial site, etc.) or are they from an older building that may have been painted with lead paint or insulated with asbestos at one time?" While common, the use of plastic bags, containers, and liners has not been adequately studied and their safety also likely depends on what chemicals are present in the plastic being used.

The Sustainable Sites Initiative (SSI) is working with landscape architects and environmental professionals to identify and promote the use of more environmentally-benign materials and provides information about materials used in hardscapes and softscapes that can be helpful for container and raised bed gardening at http://www.sustainablesites.org/materials/.

Organizational Policies

As container gardening becomes more common, organizations are beginning to develop policies and standards for soil content and safety for their construction and use. School systems, churches, community garden programs, greening and gardening organizations, and park systems, among others, can develop policies that insure the soil and materials are both safe and productive for growing and consumption.

Even though all the risks are not known, organizations can develop guidelines for "*what the soil should look like*" both in terms of composition and safety. Once those guidelines are established, the soil can be tested against those standards. There are no standards for either soil makeup or soil safety for retailers, so organizations must be proactive in testing any soil they purchase for use in container gardens. The purpose of the testing should be for the nutrients, pH, and soil composition (to determine soil productivity), as well as for heavy metals (to determine soil safety). Manufacturers of soil typically test for debris, but not for soil safety or composition.

There are two primary ways for organizations to insure the soil they are purchasing is safe. One is to request a certificate from, or enter into a legal agreement with, the soil supplier. However, some suppliers may be unwilling to enter into a legally-binding agreement over soil safety, and if they did an additional cost would likely be passed on to the consumer. A second option involves early testing and developing a monitoring program, which may be a more reasonable alternative to contracts between organizations and suppliers. For organizations that buy soil in bulk, they can approach a retailer and request permission to test the soil before purchase to determine whether the soil meets the organization's guidelines. Once the soil is in the container garden, develop a monitoring program by performing random soil samples to insure its continued productivity and safety. State and local agricultural extension services can help organizations with soil testing and interpreting the results (P. Long, personal communication, *May 19*, 2011).

When choosing materials for container gardens, organizational policies should prohibit the use of railroad ties, CCA pressure-treated wood, tires, and galvanized steel to avoid potential health risks to gardeners and consumers of foods grown in the garden. As an alternative, use ACQ pressure-treated wood, woods with natural rot-resistance, or other non-treated woods. Materials such as bricks, stone, concrete, or other recycled materials may be safe, but develop standards for determining the source and previous use of these materials to insure they were not exposed to lead paint, asbestos, or other chemicals during a previous use or storage. Garden "mounds" are an attractive option, as they do not require materials to frame the soil, reducing both the cost and potential contamination from materials.

Conclusion

The safety concerns raised in this report are not intended to deter organizations or individuals from gardening in containers. Rather, the purpose is to present information so that communities, organizations, individual gardeners can begin to ask the right questions and make informed decisions within their specific contexts. While the likelihood of encountering dangerous levels of contamination or chemicals is relatively low, gardeners can reduce the potential for harm or health risks by simply making informed choices. Many of these choices require little or no additional effort, but simply choosing to use types of materials that do not have contain potentially harmful chemicals, or soil with potentially harmful levels of contaminates. A standard, inexpensive soil test will either provide assurance that the garden's soil is free of unsafe levels of contaminants, or reveal that the soil must be remediated or replaced, which would then mitigate any harmful effects.

Safe Materials and Practices

Safety, as it pertains to container gardening, should be considered in terms of both immediate and broader effects. In an immediate sense, safe gardening practices are those that reduces risk to the gardener, those who come into contact with the garden, and those who eat the plants grown in the garden. However, broader environmental and health issues must also be considered. Using safe materials also means considering the long-term effects of the available choices. For example, while it may be relatively safe to use lumber treated with CCA if the plants are greater than six inches from the wood, there are still heavy metals leaching into the soil. That contaminated soil is now part of the ecosystem and may have resonating environmental and health effects for years to come. In addition, using a rot-resistant wood such as redwood may be safer than CCA-treated wood, but most redwood comes from old-growth forests, the destruction of which can damage watersheds and natural ecosystems (Lemley, 2000). Determining the best option is often dependant on your particular context or location.

In general, we recommend the following practices for safe container gardening:

- Avoid the use of CCA pressure-treated wood, railroad ties, and recycled wood that has been exposed to lead paint, asbestos, or other potentially-harmful chemicals or substances. As an alternative, use ACQ pressure-treated wood, wood with a natural rot-resistance, or recycled wood that has not been exposed to unsafe chemicals. Naturally rot-resistant woods include cedar, cypress, redwood, mahogany, and some exotic hardwoods, although they are relatively expensive in comparison (EPA, 2011e).
- Avoid growing food crops within 6 inches of CCA-treated wood.
- If you are gardening near CCA-treated wood, take precautions such as removing shoes before entering your home, washing your hands, and discouraging children from putting hands in their mouths. Apply a sealant to the wood every year to create a barrier between you and the CCA; painting the wood is discouraged by the EPA because it can flake or create dust (De Koff, Lee, and Schwab, 2007).
- Locate garden sites at least 50-100 feet away from roadways or older structures to reduce exposure to lead deposits in the soil (Chaney, Sterrett, and Mielke, 1984).
- Avoid the use of galvanized steel, plastics, and rubber, as their effects on soil safety have not been adequately studied.
- Always test soil for heavy metal contamination. If the soil is from a suspected or known contaminated site, test for any other harmful substances that may be present in the soil.
- Work with your local cooperative extension service for expert advice, testing, and context-specific knowledge about safe and productive gardening practices.
- Use a ground cover between container gardens to reduce gardeners' and children's exposure to contaminated soil. This can be achieved by applying 10-15 centimeters of mulch on top of heavy-duty porous landscape fabric (Stilwell, Rathier, Musante, and Ranciato, 2008).
- Explore the use of garden "mounds" which provide the benefits of raised beds without the additional cost or risk of exposure to unsafe materials.

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