Environmental Soil Issues

Garden Use of Treated Lumber

Because it has excellent decay resistance, treated lumber is often used in situations when wood needs to be in contact with soil. In the garden, this includes use as bed borders or trim; support for raised garden beds; plant stakes; and compost bins. However, many gardeners are concerned that the chemicals used to preserve the lumber could harm garden plants and the people who eat them. This fact sheet explains the most widely used method for treating wood, examines the possible risks from gardening uses of treated lumber, and makes recommendations for reducing any such risks.

What is treated lumber?

Lumber used in contact with the ground and/or in outdoor environments can be attacked by insects, fungi, and bacteria that cause deterioration, decay, and rot of the wood. Over the centuries, various practices have been used to protect wood from such attacks. In the past 60 years, however, chemical methods of wood preservation have become increasingly popular. Chemical preservatives can be divided into two major groups: organic (or oilborne) and inorganic (or waterborne). Organic preservatives include pentachlorophenol, creosote, and coal tars, while inorganic preservatives include chromated copper arsenate (CCA), ammoniacal copper arsenate (ACA), and acid copper chromate (ACC). Wood preserved with organic chemicals is generally not available for use by the general public and will not be considered further in this fact sheet.

Virtually all treated wood available in retail outlets for use by the general public is preserved with inorganic chemicals, most commonly with CCA. (See the update on CCA-treated lumber on this page.) Copper (Cu) is an effective fungicide, arsenic (As) is an effective insecticide, and chromium (Cr) serves to bind the chemical preservative to the wood. The treatment process usually involves immersing wood in a 2–3% solution of CCA and subjecting it to high pressure, which encourages deep penetration of CCA into the wood. Up to 50 gallons of CCA solution is used per cubic yard of wood. The treated wood has concentrations of Cr, Cu, and As that range from 1000 to 5000 mg/kg (parts per million). Wood treated by this method is also known as "pressure-treated lumber" and by the trade name "Wolmanized." The CCA method of wood preservation is popular because it is effective, and because wood treated with CCA can be painted and has no objectionable odors.

Landscaping timbers are manufactured from the center cores of logs that have been peeled for plywood. Opposite sides of the cores are machined flat, leaving the other surfaces rounded. The timbers are often dipped in or coated with CCA solution, but they are generally not pressure-treated.

The U.S. Environmental Protection Agency (EPA) classifies CCA as a restricted-use pesticide, meaning the chemical may only be used by certified applicators. The EPA does not restrict the use of CCA-treated wood; however, retail stores that sell CCA-treated wood should have copies of a consumer information sheet that describes safety precautions that should be followed when working with CCA-treated wood. When you purchase CCA-treated wood, you should obtain a copy of this bulletin and read and follow the recommendations it contains. These recommendations are also available on the EPA Web site at: *http://www.epa.gov/opp00001/citizens/1file.htm#4*

Update on CCA-Treated Lumber

On February 12, 2002, the Environmental Protection Agency (EPA) announced a voluntary decision by the wood preserving industry to phase out the use of wood preservatives that contain arsenic for any wood products destined for consumer use. The phaseout is to be completed by December 31, 2003. This transition affects virtually all residential uses of wood treated with chromated copper arsenate, also known as CCA, including wood used in play structures, decks, picnic tables, landscaping timbers, residential fencing, patios, and walkways/boardwalks. By January 2004, the EPA will not allow CCA products for any of these residential uses. The EPA has not concluded that there is unreasonable risk to the public from CCA lumber, but believes that any reduction in exposure to arsenic is desirable. More information on this action can be found at the following EPA Web site: *http://www.epa.gov/pesticides/citizens/cca_transition.htm#bkmrk8.* This fact sheet focuses on risks from garden use of CCA lumber. We have decided to reprint the fact sheet because many people have questions concerning risks from CCA lumber that is already in place.

Can arsenic, chromium, and copper affect plant and human health?

This fact sheet concerns possible exposure to As, Cr, and Cu from gardening uses of CCA-treated lumber. It does not consider possible exposure from other uses of or from working with CCA-treated lumber. In a gardening situation, exposure to these elements can only occur if they move from the treated wood into soil or compost that is in contact with the wood, then are taken up by plants, and finally are ingested by humans who eat those plants. This is known as an "exposure pathway," and the possible effects of As, Cr, and Cu will be discussed here in the context of this pathway.

Low concentrations of arsenic, chromium, and copper occur naturally in water, soil, plants, and the human body (Table 1). Copper and possibly chromium is essential for plant nutrition, and all three of these metals are essential for human and animal nutrition. That means humans must always have small amounts of these elements present in their diets. Although there are rare instances of dietary deficiencies of these elements, most normal diets supply adequate levels of each. Intake of excessive amounts, however, can have adverse effects on plants and humans.

When trace elements such as these three are added to soil, most of what is added is not available for plant uptake. Chromium and copper are bound very strongly by soil particles, especially by soil clays and organic matter. They are most strongly bound in near-neutral soils (pH 6–8) and become more soluble in acidic soils (pH less than 5). As a result, Cr and Cu tend not to move in soil, and only a small fraction of what is added to the soil can be taken up by plants. Arsenic is also bound to soil particles, but in general it is not held as tightly as Cr or Cu. Consequently, As tends to be somewhat more mobile in soil, and more of what is added to soil can be taken up by plants. Because soils vary greatly in the amounts of As, Cr, and Cu they can bind, it is difficult to predict how much can be added before the soil becomes toxic to plants.

Plant species also vary widely in their uptake and tolerance of these metals. Different types of plants growing in the same soil may take up different amounts of trace metals. Furthermore, tissue concentrations that are toxic (i.e., causing observable adverse effects on growth) for some types of plants will have no effect whatsoever on others. Toxic tissue concentrations for most plants are in the ranges 5–20, 1–20, and 20–100 mg/kg for As, Cr, and Cu respectively.

If a person were to consume a very large dose of As, Cr, or Cu in a very short period of time (days), "acute toxicity"—an immediate adverse effect on health, or even death, caused by chemical poisoning—could result. For example, arsenic at extremely large doses is a systemic poison and can be lethal to humans. It is virtually impossible, however, for a person to eat enough vegetables to contract acute toxicity from any of these metals. A more realistic human health concern relating to eating garden vegetables grown in contaminated soil is the long-term or "chronic effects" of daily consumption of vegetables with elevated levels of As, Cr, or Cu over a period of many years (10–15).

Table 1. Normal amounts of arsenic, chromium, and copper in soils, plants, and humans. (All values are based on dry weight.)

Element	Normal concentration range of element in: Soils (mg/kg^{-1})	Plants (mg/kg^{-1})	Humans[1] (mg/kg^{-1})
Arsenic	6–10	0.01–1.5	0.01–1.6
Chromium	10–80	0.1–0.5	0.002–33
Copper	17–65	5–30	10–26

[1]First value is low range for muscle tissue; second value is high range for bone tissue.

In the case of Cr and Cu, even chronic health effects of eating vegetables grown near CCA-treated wood are extremely unlikely, if not impossible. This is because the human body can tolerate relatively large intakes of Cr and Cu and is also able to excrete excess amounts of these metals. Furthermore, plants are less tolerant of Cr and Cu than humans are. This means that Cr and Cu would kill plants before plant tissue concentrations could get high enough to cause a chronic toxic effect in humans from eating the plants. Finally, most Cr or Cu released by CCA-treated wood is bound by the soil and never gets into the plants in the first place.

Arsenic, however, can have chronic toxic effects on humans at much lower intake levels than Cr or Cu. The EPA estimates that the safe daily intake level for arsenic is about 0.05 mg for an average adult, with lower levels for children. Consistent intake of As substantially above this level over a period of several years could cause disruption of protein function and energy production and may also cause certain cancers. Plants grown in soil to which arsenic has been added can accumulate arsenic in their tissues at much higher than normal concentrations. If a person were to eat enough of such vegetables, he/she could possibly exceed the threshold for safe dietary intake of arsenic. This leads to the question of whether or not plants grown near CCA-treated wood could accumulate levels of arsenic that would exceed safe dietary intake for people who eat the plants.

WHAT IS THE SCIENTIFIC EVIDENCE?

Several studies have clearly shown that As, Cr, and Cu can leach from (be removed from) CCA-treated lumber when it comes in contact with water, soil, and/or compost. The amounts of these elements that are leached from the wood depend on several factors. Among these are:

Surface area. The amount of wood surface area that is in contact with water, soil, or compost affects the rate at which metals will leach from the wood. Large pieces of wood with only one side in contact with soil or compost will lose a small percentage of the CCA elements they contain. The percentage lost will increase if more than one surface of the wood is in contact with soil or compost. Therefore, smaller pieces of wood will lose greater percentages of CCA elements. When CCA-treated wood is reduced to sawdust-sized pieces, virtually all of the As, Cr, and Cu will be released from the wood.

Acidity. As the water, soil, or compost in contact with the CCA-treated wood becomes more acidic (lower pH), the amounts of As, Cr, and Cu leached from the wood will increase. A very small percentage of the metals in CCA-treated wood is lost to near-neutral water or soil (pH 6–8). In slightly acidic environments (pH 5–6) the amount of loss increases (10–40%), while in very acidic environments (pH 3–4) losses can be very high (50–100%).

Organic matter. Loss of CCA metals is increased when CCA-treated wood is in contact with certain materials, such as silage or compost, that are high in organic matter and have an abundance of organic acids. Such organic acids are formed during production of silage and compost. Because organic matter strongly binds CCA metals, little of what is released into these materials can be taken up by plants.

Studies have been conducted in which soil or compost in contact with CCA-treated wood was analyzed for As, Cr, and Cu; these studies have produced conflicting results. A study of soil in raised garden beds found no increase in arsenic in soil 1–12 inches away from CCA-treated wood.[1] By contrast, analysis of soil adjacent to CCA-treated posts that had been in the ground for 30 years showed increases in As, Cr, and Cu within 6 inches of the posts, but no change in soil further away.[2] Analysis of soil below decks and retaining walls constructed with CCA-treated wood found increased soil concentrations of all three metals, indicating that there was significant leaching from the wood.[3] In some cases, soil As levels were above regulatory standards. Soil below decks that were coated with a waterproof sealant had much lower concentrations of As, Cr, and Cu. Concentrations of all three metals were greatest at the soil surface and decreased with depth, with no increased concentrations found at depths greater than 6 inches.

Scientific studies of trace element uptake in plants have shown that plant species differ greatly in the amounts of metals they take up from the same soil. Plant species also behave very differently with regard to movement of metals from roots to stems, leaves, and fruits. In general, most metals remain in the roots, with limited movement to edible portions above the ground. There are exceptions, of course: leafy green vegetables such as lettuce, spinach, and mustard greens tend to move As from roots to leaves. In general, however, the greatest human consumption of metals results from eating root crops such as beets, turnips, carrots, and potatoes. In these crops, most of the metals remain in the surface skin and can be removed by peeling.

Very few studies have analyzed plants grown in close proximity to CCA-treated wood. The Hickson Corporation, a manufacturer of CCA-treated wood, analyzed carrots, okra, peppers, cucumbers, and tomatoes grown in raised beds made with CCA-treated wood. They found that As, Cr, and Cu contents were in the same range as those of vegetables purchased at a grocery store or grown in raised beds made with untreated wood. Analysis of grapes grown adjacent to CCA-treated stakes showed no increase in As, Cr, or Cu.[4] Romaine lettuce grown in pots with soil that contained small (approx. 1 inch) cubes of CCA-treated wood showed increased uptake of As such that a normal serving (50 g) would contain 0.004 mg of As.[5] This compares to the normal dietary intake of 0.004–0.01 mg of inorganic As and the estimated safe intake level of 0.05 mg of inorganic As. The average adult would have to eat over 1.3 pounds of this romaine lettuce every day to exceed the estimated safe intake level of As.

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[1] Finch, C., and F. Dainello. "Arsenic leaching from lumber treated with chromated copper arsenate." *American Nurseryman* 177 (1993): 105–106.

[2] DeGroot, R. C., T. W. Popham, L. R. Gjovik, and T. Forehand. "Distribution gradients of arsenic, copper, and chromium around preservative-treated wooden stakes." *Journal of Environmental Quality* 8 (1979): 39–41.

[3] Stillwell, D. E., and K. D. Gorny. 1996. "Contamination of soil with copper, chromium, and arsenic under decks built from pressure-treated wood." *Bulletin of Environmental Contamination and Toxicology* 58 (1996): 22–29.

[4] Levi, M. P., D. Huisingh, and W. B. Nesbitt. "Uptake by grapes of preservatives from pressure treated posts not detected." *Forest Products Journal* 24(9) (1974): 97–98.

[5] Personal communication from Dr. David Stillwell, Department of Analytical Chemistry, The Connecticut Agricultural Experiment Station.

What can be done to reduce the risks of garden uses of CCA-treated wood?

Although the plant and human health risks from garden uses of CCA-treated lumber appear to be extremely small, there are steps gardeners can take to further reduce any such risks.

1. Use alternative materials. Any possible risks from exposure of plants or humans to CCA metals can be eliminated by not using CCA-treated wood in vegetable garden applications. Alternative materials include:

- Naturally decay-resistant wood such as eastern or western red cedar, northern white cedar, Osage orange, white oak, locust, or redwood (none of these will last as long as CCA-treated wood, however).
- Plastic lumber, concrete blocks, brick, or stone; wire mesh for compost bins.
- Wood treated with ACQ (alkaline copper quaternary ammonium). This is an alternative wood-treatment chemical that contains no arsenic, chromium, or any other chemical considered toxic by the EPA. However, ACQ contains more copper than CCA, and some copper will leach from ACQ-treated lumber as it does from CCA-treated lumber.

2. If you choose to use CCA-treated wood for gardening purposes, do not allow sawdust or wood scraps to fall onto garden beds and do not put CCA sawdust in your compost pile.

3. Cover CCA-treated wood used for raised garden beds or borders with heavy plastic to prevent contact with garden soil.

4. Manage your garden soil to reduce plant availability of As, Cr, and Cu.

- Maintain soil pH in the near-neutral range (pH 6–7). Solubility of Cr and Cu is greatly reduced in neutral soils.
- Maintain adequate phosphorus fertility levels. Plant uptake of As is reduced by the presence of phosphorus.
- Maintain high soil organic matter levels by adding compost or manure. Organic matter strongly binds As, Cr, and Cu and thus reduces their availability to plants.

5. Plant vegetables, especially root crops, at least 12 inches from CCA-treated wood. Concentrations of CCA metals will be highest in soil immediately adjacent to the wood. If plants are some distance from the CCA-treated wood, most of the root systems will be in soil with normal As, Cr, or Cu levels.

6. Thoroughly wash all soil from vegetables grown in close proximity to CCA-treated wood. In general, soil will have much larger concentrations of CCA metals than will plant tissues. Thus, human intake of CCA metals can be reduced by removing all soil from vegetables immediately after harvest.

7. Peel root crops grown in close proximity to CCA-treated wood. Plant tissue concentrations of CCA metals will be highest in roots, especially at the root surface. Thus, peeling root crops such as carrots, potatoes, and turnips will remove much of any As, Cr, or Cu that the plant may have taken up.

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