United States
Department of
Agriculture

Forest Service

Forest
Products
Laboratory

Research
Paper
FPL–RP–584

In cooperation
with the

United States
Department of
Transportation

Federal
Highway
Administration

Role of Construction Debris in Release of Copper, Chromium, and Arsenic From Treated Wood Structures

Stan T. Lebow
Steven A. Halverson
Jeffrey J. Morrell
John Simonsen

Abstract

Recent research on the release of wood preservatives from treated wood used in sensitive environments has not considered the potential contribution from construction residues. This study sought to develop leaching rate data for small construction debris and compare those to the release rate from treated wood itself. Western hemlock boards were pressure treated with chromated copper arsenate Type C (CCA-C), and then common construction tools were used to generate sawdust or shavings from those boards. These wood particles were then leached in deionized water, and the leaching rate was compared with that of solid wood samples cut from the same specimen. Release rate data from this study were also compared with those from end-matched samples that were leached in artificial rain in an earlier study. The release rates of copper, chromium, and arsenic from CCA-C treated chain saw sawdust, circular saw sawdust, and spade bit shavings were many times higher than from solid wood when samples were immersed in water. There was little difference in the release rates among the three types of shavings and sawdust, despite differences in their particle sizes. The rates of release from decking exposed to rainfall were many times lower than that of construction debris or solid wood continually immersed in water. These results show the importance of minimizing the amount of construction debris that is allowed to enter the aquatic environment. However, example calculations also demonstrate that if reasonable efforts are made to minimize release of construction debris, the contribution of these particles to the overall release of preservative from the structure will be minimal.

Keywords: wood preservative, chromated copper arsenate, treated wood, construction debris, leaching

June 2000

Lebow, Stan T.; Halverson, Steven A.; Morrell, Jeffrey J.; Simonsen, John. 2000. Role of construction debris in release of copper, chromium, and arsenic from treated wood structures. Res. Pap. FPL-RP-584. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 6 p.

A limited number of free copies of this publication are available to the public from the Forest Products Laboratory, One Gifford Pinchot Drive, Madison, WI 53705–2398. Laboratory publications are sent to hundreds of libraries in the United States and elsewhere.

The Forest Products Laboratory is maintained in cooperation with the University of Wisconsin.

Acknowledgment

The authors acknowledge the support of the U.S. Department of Transportation, Federal Highway Administration, for this project.

Contents

Role of Construction Debris in Release of Copper, Chromium, and Arsenic From Treated Wood Structures

Stan T. Lebow, Research Forest Products Technologist
Steven A. Halverson, Physical Science Technician
Forest Products Laboratory, Madison, Wisconsin

Jeffrey J. Morrell, Professor
John Simonsen, Associate Professor
Department of Forest Products, Oregon State University, Corvallis, Oregon

Introduction

Preservative-treated wood is widely used for construction of highway bridges and footbridges, wetland boardwalks, and other applications in or over water. Treated wood is used for these types of applications because it is economical, blends well with the environment, and is relatively easy to install. The wood is durable because the chemicals in the preservative are toxic to decay fungi and insects. However, these same chemicals are also potentially toxic to aquatic organisms. Concerns that chemicals might leach out of the wood and accumulate in the environment to harmful levels led to a recent evaluation of the leaching and biological impacts of four types of wood preservatives in a wetland boardwalk (Forest Products Laboratory 2000). Although all four wood preservatives released measurable amounts of chemicals into the environment, no detectable impact on aquatic insect populations at the sites was observed. However, because that study was designed to evaluate leaching from the treated structure, care was taken to minimize discharge of construction residues into the environment. In more routine construction projects, sawdust and shavings generated during construction might enter the water below the structure. It is important to understand the relative contribution that these construction residues might make to overall releases from the structure.

Because of their greater surface area to volume ratio, small wood particles such as sawdust might contribute proportionally greater amounts to chemical release than the treated wood itself. In fact, the toxicity characteristic leaching procedure (TCLP) that is sometimes used to evaluate the potential toxicity of treated wood is designed to magnify leaching by requiring that solids be reduced to a size that will pass through a 9.5-mm (0.375-in.) screen (EPA 1996). Haloui and Vergnaud (1997) noted this effect on a larger scale, reporting that the rate of leaching of the wood preservative pentachlorophenol was much greater for samples with dimensions of 20 by 20 by 20 mm (0.8 by 0.8 by 0.8 in.) than for samples with dimensions of 40 by 20 by 20 mm (1.6 by 0.8 by 0.8 in.). In general, previous leaching studies using small samples have reported higher leaching rates (Lebow 1996). However, the effects of smaller waste particles generated during construction are not known. This study sought to develop leaching rate data for smaller construction debris for comparison with release rates from wood treated with chromated copper arsenate type C (CCA-C).

Materials and Methods

The general approach used in this study was to treat boards with preservative and then use common construction tools to generate sawdust or shavings from those boards. These wood fragments were then leached in deionized water, and the leaching rate was compared, on a weight basis, to that of solid wood cut from the same specimen.

CCA-C Treatment of Western Hemlock Boards

Four No. 1 grade, western hemlock boards (*Tsuga heterophylla* (Raf.) Sarg.), 38 by 140 mm (1.5 by 5.5 in.) and 2.44 m (8 ft) long were obtained from a mill in western Washington state. No attempt was made to select for sapwood or a specific grain orientation. A 406-mm- (16-in.-) long specimen and an end-matched 587-mm (23.1-in.) specimen were cut from each board and conditioned to constant weight at 23ºC (74ºF) and 65% relative humidity. Prior to treatment, both ends of each section were sealed with two coats of a neoprene rubber sealant to prevent end-grain penetration of preservative. The specimens were pressure treated with a 1.3% CCA-C solution (actives ratio of 17.4% CuO, 46.9% CrO_3, 35.7% As_2O_5) using an initial vacuum that reduced pressure to 17 kPa (5 inHg) for 30 min followed by a pressure period of 1,034 kPa (150 lb/in^2) for 2 h. Following treatment, the specimens were reweighed to determine the amount of solution uptake, and then each specimen was placed into a plastic bag and stored for 10 days at 23ºC

(74ºF) to allow for fixation of the CCA-C. The specimens were then stickered and air-dried in a room maintained at 23ºC (74ºF) and 65% relative humidity. Only the 406-mm- (16-in.-) long specimens were used in this study. The 587-mm- (23.1-in.-) long specimens were used in a previous study that assessed leaching in artificial rainfall (Lebow and Evans 1999).

Preservative retention was determined by weight gain and by removing samples of the wood for chemical analysis. Samples for chemical analysis were removed by drilling a minimum of 20 holes, each 15 mm (0.6 in.) deep, in each specimen using a 6-mm- (0.25-in.-) diameter bit. The resulting shavings were collected and analyzed as specified in AWPA Standard Method A11–83 (AWPA 1998). The retention varied from 5.92 to 8.64 kg/m^3 (0.37 to 0.54 lb/ft^3) as determined by weight gain and from 6.08 to 12.64 kg/m^3 (0.38 to 0.79 lb/ft^3) as determined by chemical analysis.

Preparing Sawdust, Shavings, and Blocks

Wood particles were generated using three common construction tools: a circular saw, a chain saw, and a drill bit. In each case, an effort was made to collect a representative sample of the cross section of the specimen. First, one pass was made through each specimen with a chain saw that cut a 6-mm- (0.25-in.-) wide kerf. The specimen and chain saw were placed inside a large plastic bag during cutting to capture all the sawdust generated. A new chain was used, and the chain was run without oil to prevent contamination of the sawdust. This technique produced between 12.4 and 15.7 g of sawdust from each specimen. Circular saw cutting was done inside a large plastic bag to collect all the sawdust. The circular saw was equipped with a new, 184-mm- (7.25-in.-) diameter, 24 tooth construction-and-framing carbide-tipped blade with a 2.5-mm (0.1-in.) kerf. The sawdust from three passes was combined, producing between 12.7 and 19.7 g of sawdust per specimen. Each specimen was then bored through the wide face in two locations using a 25-mm- (1-in.-) diameter wood boring spade bit. One hole was placed in the center of the board, and the other hole was placed at the edge of the board. Again, a plastic bag was used to collect all the shavings. This technique produced between 15.2 and 18.6 g of sawdust per specimen. Finally, a 40-mm- (1.6-in.-) long by 38-mm- (1.5-in.-) thick by 140-mm- (5.5-in.-) wide block was cut from each specimen. The weight of these blocks ranged from 78.5 to 101.2 g. The blocks were then end-coated with neoprene rubber sealant to prevent leaching through the end-grain.

Determining Particle-Size Distribution

The samples were placed on a series of screens with successively smaller openings (Fig. 1) and mechanically agitated for 3 min. The particles retained on each screen were weighed, and the percentage of particles failing to pass through each mesh size was calculated (Fig. 1).

Determining Release Rates

The samples of sawdust or shavings generated from each specimen were sewed into polyester bags. Each bag was then placed into a 500-mL flask and submerged in 200 mL of deionized water. Blocks cut from the specimens were placed into glass jars and submerged in 300 mL of deionized water. The filled flasks and jars were subjected to a vacuum that reduced pressure to 17 kPa (5 inHg) for 15 min and then placed on a mechanical agitator. The leaching samples were continuously agitated for 50 days, with frequent collection of the leachate for analysis (Table 1). At each collection, the available water was drained off the specimens and again replaced with 200 mL (sawdust and shavings) or 300 mL (blocks) of deionized water. Concentrations of copper, chromium, and arsenic in the leachate were determined by atomic absorption analysis, using either furnace or flame atomization, as appropriate. The results were expressed as weight of chemical lost per gram of wood.

Results and Discussion

Particle-Size Distribution

As might be expected, the shavings generated by the spade bit contained a higher proportion of large particles than did the sawdust generated by the chain saw or circular saw (Fig. 1). More than 50% of the spade bit shavings failed to pass through the screen with the 2,000-µm (0.08-in.) openings. The chain saw produced intermediate-sized particles, with the majority passing through the 2,000-µm (0.08-in.) openings but failing to pass through the 840-µm (0.03-in.) openings. Particle sizes generated by the circular saw were both smaller and more widely distributed than those generated by the other two tools. This suggests that the rate of release from the circular saw particles would be higher than from particles generated by the chain saw or spade bit.

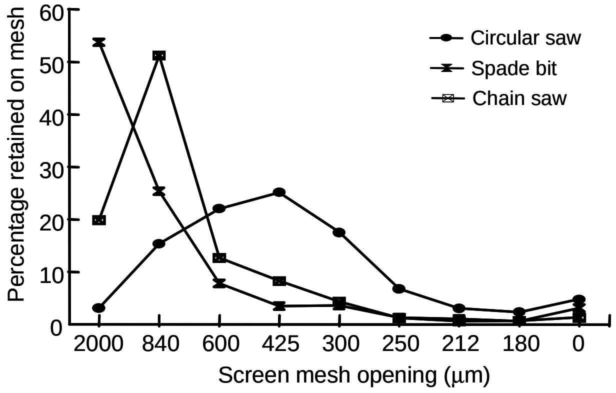

Figure 1—Distribution of particle sizes generated by the three types of construction tools.

Table 1—Average copper, chromium, and arsenic release rates from construction particles and solid wood[a]

			Release rate (µg/day/gram of sample[b])					
			Copper		Chromium		Arsenic	
Type of sample	Total days leached	Days in leaching interval	Mean	SD	Mean	SD	Mean	SD
Block	0.08	0.08	10.55	4.19	12.53	4.42	24.64	12.15
Chain saw	0.08	0.08	417.51	91.16	303.42	39.27	208.99	1.72
Spade bit	0.08	0.08	288.65	77.66	352.26	47.95	179.80	0.42
Circular saw	0.08	0.08	345.39	76.55	381.99	39.16	208.39	21.13
Block	0.25	0.17	4.00	1.65	4.79	1.71	13.74	6.49
Chain saw	0.25	0.17	140.17	35.92	99.46	9.48	105.37	1.48
Spade bit	0.25	0.17	96.91	32.50	111.58	9.37	89.24	0.69
Circular saw	0.25	0.17	116.18	23.07	118.61	6.58	97.61	1.38
Block	1	0.75	2.36	1.48	1.48	0.54	4.42	1.49
Chain saw	1	0.75	39.54	9.59	19.14	1.14	22.69	0.23
Spade bit	1	0.75	23.02	7.87	19.38	2.13	19.40	0.34
Circular saw	1	0.75	28.23	6.28	20.30	2.53	21.40	0.17
Block	2	1	2.46	0.57	0.72	0.14	3.51	0.24
Chain saw	2	1	20.55	4.52	7.49	0.23	13.12	0.30
Spade bit	2	1	11.69	4.16	7.07	0.57	10.94	0.21
Circular saw	2	1	14.02	3.50	7.47	0.49	12.23	0.10
Block	4	2	1.35	0.58	0.39	0.09	2.04	0.18
Chain saw	4	2	10.39	2.08	3.28	0.19	6.41	0.06
Spade bit	4	2	5.82	2.05	2.87	0.34	5.52	0.17
Circular saw	4	2	6.88	1.60	2.95	0.28	5.78	0.58
Block	7	3	0.90	0.27	0.30	0.12	0.46	0.35
Chain saw	7	3	6.81	2.00	2.51	0.17	3.83	0.08
Spade bit	7	3	4.20	1.29	2.39	0.23	3.69	0.41
Circular saw	7	3	4.40	0.86	2.85	0.21	4.28	0.25
Block	9	2	0.82	0.28	0.34	0.17	0.33	0.17
Chain saw	9	2	8.80	2.50	3.13	0.27	6.60	0.23
Spade bit	9	2	4.90	1.49	3.07	0.14	5.90	0.23
Circular saw	9	2	5.37	0.99	3.55	0.39	6.57	0.74
Block	11	2	0.63	0.20	0.25	0.08	0.28	0.11
Chain saw	11	2	6.80	1.73	3.06	0.29	7.03	0.14
Spade bit	11	2	3.97	1.34	2.83	0.23	5.75	0.55
Circular saw	11	2	4.47	0.75	3.24	0.47	5.32	1.15
Block	14	3	0.59	0.11	0.21	0.10	0.32	0.15
Chain saw	14	3	4.38	0.89	2.02	0.29	4.71	0.22
Spade bit	14	3	2.56	0.90	1.83	0.23	3.99	0.46
Circular saw	14	3	2.91	0.55	2.32	0.24	4.13	0.78
Block	17	3	0.54	0.15	0.22	0.06	0.26	0.08
Chain saw	17	3	3.67	0.78	1.88	0.27	4.29	0.25
Spade bit	17	3	2.11	0.85	1.49	0.24	3.63	0.59
Circular saw	17	3	2.38	0.46	2.22	0.30	3.73	0.64
Block	22	5	0.36	0.08	0.04	0.05	0.09	0.00
Chain saw	22	5	2.43	0.36	0.53	0.07	1.88	0.10
Spade bit	22	5	1.27	0.43	0.16	0.07	1.38	0.07
Circular saw	22	5	1.76	0.43	0.41	0.24	1.50	0.07
Block	28	6	0.34	0.14	0.07	0.04	0.07	0.00
Chain saw	28	6	2.11	0.35	0.53	0.06	1.49	0.10
Spade bit	28	6	1.16	0.43	0.20	0.09	1.22	0.05
Circular saw	28	6	1.57	0.33	0.42	0.17	1.28	0.10
Block	36	8	0.19	0.09	0.07	0.03	0.16	0.02
Chain saw	36	8	1.46	0.38	0.40	0.05	0.71	0.02
Spade bit	36	8	0.89	0.35	0.21	0.04	0.54	0.07
Circular saw	36	8	1.22	0.28	0.36	0.13	0.59	0.06
Block	50	14	0.27	0.09	0.03	0.04	0.10	0.02
Chain saw	50	14	1.09	0.17	0.26	0.06	0.37	0.03
Spade bit	50	14	0.58	0.29	0.09	0.04	0.27	0.04
Circular saw	50	14	0.77	0.24	0.22	0.10	0.31	0.05

[a] Mean and standard deviation (SD) are for four replicates.
[b] Rate is calculated using the number of days since the previous water replacement (days in leaching interval).

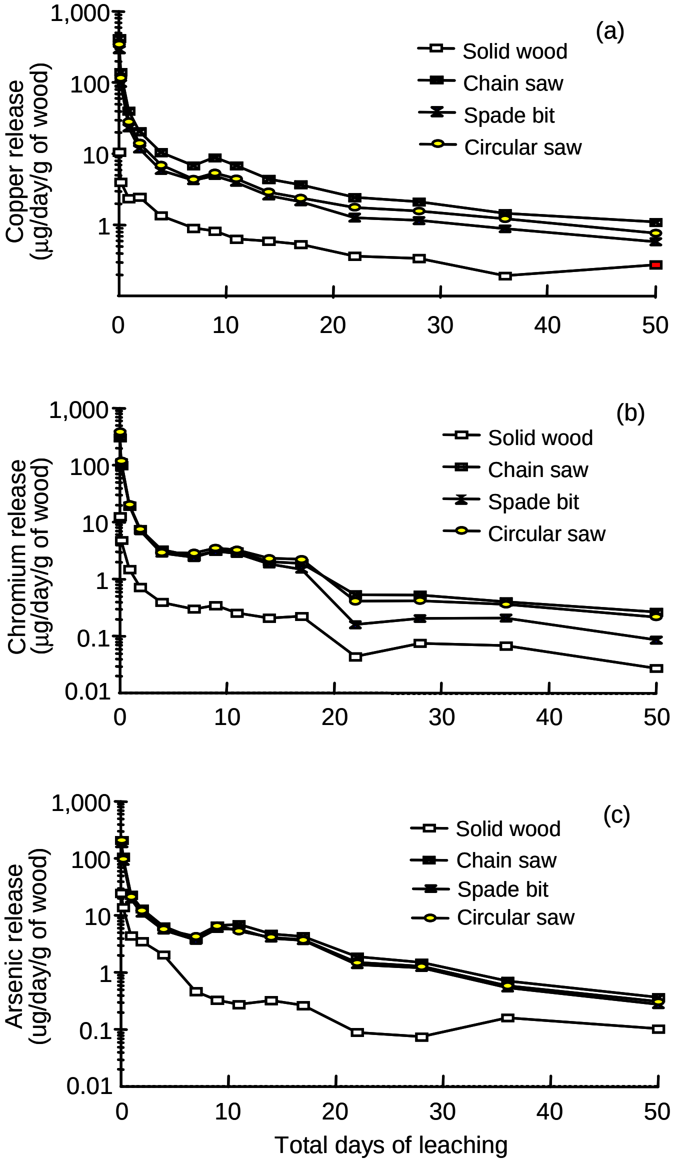

Figure 2—Rate of release of (a) copper, (b) chromium, and (c) arsenic from solid wood and the three types of construction debris during 50 days of water immersion.

As discussed below, this premise was only partially supported by the release rate data. The particle sizes evaluated in this study are meant only to serve as examples. It is readily apparent that different types of tools, different drill bits, and different saw blades could all greatly affect the particle size and size distribution of construction debris.

Release Rates From Construction Debris

The amounts of copper, chromium, and arsenic released from the solid wood sample were many times lower than those from sawdust or drill shavings (Fig. 2). The effect was greatest for copper, where the average release was initially more than 20 times greater from the particles than from the solid wood (Table 1). This gap between the solid wood and particulate leaching rates narrowed with time, although the release rate from the particles remained several times higher after 50 days. Eventually, one might expect that the reservoir of available CCA-C within the particles would become so depleted that their release rate would drop below that of solid wood.

Little difference in release rates was noted among the three types of sawdust or shavings. This is somewhat surprising given the differences in particle-size distribution between the three groups (Fig. 1). As might be expected based on their larger particle size, release from the spade-bit shavings did tend to be slightly lower than from either type of sawdust. This trend was especially evident for the later stages of chromium release. However, releases from the chain saw sawdust were at least as high as those from the circular saw sawdust, despite the differences in particle-size distribution. In addition to size differences, it is likely that these tools produce particles with different surface topographies that might affect leaching. In general, release rates from sawdust and shavings generated during construction were much greater than from solid wood.

Comparison With Release From Decking

The vast majority of treated wood used in construction is not immersed in water; it is used above the ground or above the water. Treated wood used over standing water would be subjected to leaching only intermittently, during periods of precipitation, whereas construction residues would fall into the water. Thus, it may be more meaningful to compare the rate of release from treated wood subjected to rainfall to that of construction residue immersed in water.

In a previous study, end-matched 587-mm- (23.1-in.-) long specimens cut from the same boards used in this study were subjected to leaching by artificial rainfall (Lebow and Evans 1999). Because they are end-matched specimens and treated in the same charge as the specimens used in this study, they have very similar CCA-C retention and penetration. The release rates from the construction debris and from the rainwater specimens can be most directly compared after 28 days, when leachate samples were collected from both types of samples. At the 28-day sampling point, the decking specimens had been subjected to an average of 198 mm (7.8 in.) of artificial rainfall, which corresponds to a yearly rainfall amount of approximately 2.54 m (100 in.). The high amount of rainfall represents a fairly severe aboveground leaching exposure. However, as can be seen from Figure 3, the total amount of CCA-C released from the decking specimens was much lower than from any of the types of samples in the construction debris study, including the solid wood samples. It is apparent that constant immersion of treated

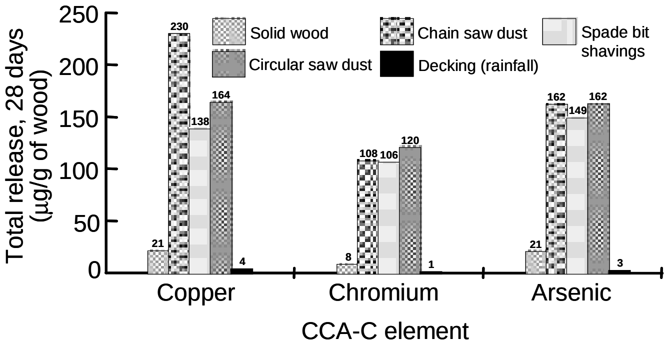

Figure 3—Total release of copper, chromium, and arsenic from solid wood and construction debris immersed in water and from decking exposed to artificial rainfall.

wood or treated wood particles causes a higher rate of leaching than does exposure to rainfall. Discharge of construction debris into standing water increases leaching in two ways. First, the smaller size of the particles increases the leaching rate and second, immersion in water causes more rapid leaching than does exposure to precipitation only.

Proportion of Total Leaching Caused by Construction Debris

Particulate construction debris clearly releases CCA-C components much more rapidly than does the solid treated wood within the structure itself. However, in most cases, the volume of treated wood used in a structure will be many times greater than that of the debris generated during construction. To put the relative amounts of CCA-C released from the treated structure and construction debris in perspective, it is useful to estimate releases from a hypothetical construction project.

Consider CCA-C treated decking on a wetland boardwalk 30.5 m (100 ft) long and 1.2 m (4 ft) wide. The construction crew might purchase standard 38- by 140-mm (nominal 2- by 6-in.) boards in 2.4-m (8-ft) lengths and cut them in half to create the 1.2-m- (4-ft-) long deck boards. The boardwalk would require approximately 214 deck boards, or 107 of the 2.4-m- (8-ft-) long boards, necessitating 107 saw cuts to create the decking. If we assume that the 107 saw cuts are made with a circular saw blade similar to that used in this study and that 100% of the sawdust was discharged into the standing water, we can estimate the amount of CCA-C components released by the sawdust relative to that released by the decking, which is exposed to leaching by rainfall only. To make the comparison, we must assume that the CCA-C retention in the boards is similar to that of this study and base the releases from the sawdust and deck boards on the 28-day release data discussed earlier (Fig. 3). Given those assumptions, approximately 562 g of sawdust would be generated, and after 28 days, that sawdust would have released 91 mg of copper, 67 mg of chromium, and 90 mg of arsenic into the water. Similarly, if we assume that each of the 214 1.2-m- (4-ft-) long deck boards weighs 2.912 kg, we can calculate that approximately 2.493 g of copper, 533 mg of chromium, and 1.870 g of arsenic would be released by rainfall runoff from the decking. In other words, the sawdust would have contributed approximately 4% of the copper, 11% of the chromium, and 5% of the arsenic released by the construction project during the first 28 days. Thus, although the rate of release from construction debris is much greater than from the wood used in the structure, the greater volume of wood used in the structure will cause the structure itself to contribute the bulk of the preservative released. And, as noted earlier, a previous boardwalk study reported that although four types of treated wood release measurable amounts of chemicals into the environment, no detectable impact on aquatic insect populations was observed (Forest Products Laboratory 2000).

Many factors could affect the proportion of release contributed by the construction debris. For example, lesser amounts of rainfall would reduce the proportion released from the decking, while longer periods of time would tend to further diminish the contribution of construction debris. Because small particles release preservative at a higher rate and have a smaller reservoir of unleached preservative than does solid wood, construction debris would be expected to make a much greater contribution to overall leaching in the first few months after construction, and much less of a contribution in the following years.

This comparison also assumes that both the construction debris and the decking release preservative uniformly into the surrounding environment. In practice, construction debris would be more likely to create localized pockets of contamination in the area immediately surrounding the site of their deposition. Release is also not uniform below decking, as runoff from precipitation tends to be channeled into specific flow paths. Lebow and others (2000) noted the high spatial variability of contamination in soil below boardwalk decking.

Despite the less substantial contributions of construction debris to the overall leaching rates, these releases are clearly preventable. Potential release from debris could be most effectively reduced through conscientious construction practices. One desirable practice is to specify that as much material as possible be cut to size, or fabricated, prior to treatment. This practice not only minimizes the generation of construction debris but also lessens the exposure of untreated wood in the center of the treated members. Where field fabrication is necessary, it should be conducted over tarps or plastic and away from sensitive environments. In most construction projects, however, some field fabrication occurs within the structure itself, and over standing water. If possible, this material should also be contained and collected.

Conclusions

The release rate of copper, chromium, and arsenic from CCA-C treated chain saw sawdust, circular saw sawdust, and spade bit shavings was found to be many times higher, per unit weight of wood, than from solid wood when samples were immersed in water. However, there was relatively little difference in the release rates among the three types of shavings and sawdust, despite differences in their particle sizes. Through comparison with a previous study, it was calculated that the rate of release from decking exposed to leaching only by rainfall is many times lower than that of construction debris or solid wood continually immersed in water. However, the release from debris was estimated to be only a small fraction of the total release in a hypothetical construction project. Chemical releases from construction debris could be minimized if reasonable efforts were made to fabricate the lumber prior to treatment and to collect and contain debris generated during construction.

Literature Cited

AWPA. 1998. Book of standards. A11–93. Standard method for analysis of treated wood and treating solutions by atomic absorption spectroscopy. Granbury, TX: American Wood Preservers' Association.

EPA. 1996. Method 1311, Toxicity characteristic leaching procedure. In: Test methods for evaluating solid waste, physical/chemical methods. Publication SW–846. Washington, DC: U.S. Environmental Protection Agency.

Forest Products Laboratory. 2000. Environmental impact of preservative treated wood in a wetland boardwalk. Res. Paper FPL–RP–582. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory.

Haloui, A.; Vergnaud, J.M. 1997. Study of the release in water of chemicals used for wood preservation. Effect of wood dimensions. Wood Science and Technology. 31:51–62.

Lebow, S.T. 1996. Leaching of wood preservative components and their mobility in the environment—Summary of pertinent literature. Gen. Tech. Rep. FPL–GTR–93. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 36 p.

Lebow, S.T.; Evans, J.W. 1999. Effect of prestain on the release rate of copper, chromium, and arsenic from western hemlock. Res. Note FPL–RN–0271. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 6 p.

Lebow, S.T.; Lebow, P.K.; Foster, D.O. 2000. Leaching and environmental accumulation of preservative elements. Part I. In: Environmental impact of preservative treated wood in a wetland boardwalk. Res. Paper FPL–RP–582. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory.