

Impact of Surface Water Conditions on Preservative Leaching and Aquatic Toxicity from Treated Wood Products

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New alternative wood preservatives contain higher levels of copper (Cu) which can promote aquatic toxicity in natural water systems. Earlier work focused on evaluating toxicity using laboratory generated leaching solutions. In this study, the impact on preservative leaching and aquatic toxicity from treated wood products was evaluated using natural surface waters including waters from two rivers, three lakes, two wetlands, and one seawater, in addition to synthetic moderate hard water and deionized water. Blocks of wood treated with Cu based alternatives such as alkaline copper quaternary (ACQ) and copper boron azole (CBA), along with chromated copper arsenate (CCA)-treated wood, were leached under quiescent conditions, and total Cu, labile Cu, and heavy metal toxicity were measured. Results show that ACQ- and CBA-treated wood leach approximately 10 and 20 times more total Cu relative to CCA-treated wood and that the presence of organic and inorganic ligands in natural waters lowered the labile fraction of Cu relative to that from laboratory generated leaching solutions. Aquatic toxicity was found to correlate with the labile Cu fraction, and hence, the aquatic toxicity of the treated wood leachates was lower in natural waters in comparison to laboratory leaching solutions. The results of the present study suggest that studies designed to evaluate the impacts of treated wood should therefore consider the role of complexation in reducing the labile Cu fraction and its potential role in decreasing toxicity.

Introduction

As of January 2004, wood treated with chromated copper arsenate (CCA) was no longer manufactured for most residential uses. This phase out was prompted by risk assessments which indicated an elevated human health risk from arsenic (As) which could be ingested during direct contact with the wood (1–4). The primary active ingredients in most of the As-free alternatives formulations include

copper (Cu) and an organic co-biocide, among which alkaline copper quaternary (ACQ) and copper boron azole (CBA) are the most popular wood preservatives in current use for the residential market. These Cu-based alternatives have been reported to leach several times more Cu (greater concentrations as well as higher percent leaching) than CCA-treated wood, and the aquatic toxicity measured was found to correlate with total Cu concentrations (5–6). In addition to the greater quantities of Cu in Cu-based alternatives relative to CCA, the enhanced leaching of Cu from these alternatives may also be due to the absence of Cr, which partly oxidizes the lignocelluloses material to provide binding sites for Cu in CCA-treated wood (7).

Although Cu can adversely impact aquatic organisms (8), several physical and chemical phenomena limit its toxicity. Free (hydrated) Cu²⁺ ions present in natural waters tend to complex with inorganic and organic ligands such as CO₃²⁻, OH⁻, and humic and fulvic acids (9–11) rendering Cu much less bioavailable to aquatic organisms and, as a result, less toxic (8, 12–13). The chemical characteristics of the solution in contact with treated wood can thus significantly impact the bioavailability and aquatic toxicity of the copper leached (8, 14).

Although free Cu²⁺ is considered the most toxic form of Cu (15), several studies have reported that other forms of Cu such as CuOH⁺, CuCO₃⁰, and CuCO₃⁰OH⁻ (the relative abundance of these forms depends largely on solution pH) are also likely to contribute to Cu toxicity (13, 16–19). Labile Cu (the loosely bound Cu, which includes complexes such as CuOH⁺, CuCO₃⁰, and CuCO₃⁰OH⁻) converts in solution to free Cu²⁺ when a water sample is slightly acidified. Labile Cu, which can be measured by lowering solution pH and measuring Cu²⁺ with an ion selective electrode (ISE), has been shown in a few studies to correlate with aquatic toxicity (13, 20).

In the present study, the impact of surface water conditions on preservative leaching and aquatic toxicity from treated wood products was evaluated. This work differs from earlier studies in that labile forms of Cu were measured in addition to measurements of total Cu. Also of significance, the current study utilized natural waters collected in the field, whereas earlier studies only utilized aqueous solutions generated in the laboratory. Heavy metal aquatic toxicity of leachate samples was assessed using the MetPLATE assay, and the toxicity was compared with the total and labile Cu concentration measured in these samples.

Materials and Methods

Collection of Wood Samples. Samples of southern yellow pine (SYP) treated with CCA, ACQ, and CBA were prepared using treated lumber purchased from home improvement stores in Gainesville, Florida. Untreated SYP wood samples were also included in the study as controls. Blocks of approximately 80 g (with dimensions as 7–8 cm length, 3.5–4.5 cm width, and 3.8 cm height with average surface area 140–150 cm²) were obtained by cutting pieces of treated dimensional lumber (several 2.5 m lengths of 8.8 cm width by 3.8 cm height) using a power saw. For each wood type, a separate blade was used to cut the wood sample. Sawdust samples were collected for each treated wood type for subsequent total Cu measurements.

Collection and Preparation of Leaching Fluid. Ten different leaching solutions were used in this study. These leaching solutions were collected from eight natural waters in Florida (Figure A-1, online supplemental section) and included two rivers (R1 and R2), three lakes (L1, L2 and L3),

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