

Release of Arsenic to the Environment from CCA-Treated Wood. 2. Leaching and Speciation during Disposal

BERNINE I. KHAN,^{†,||} JENNA JAMBECK,[‡]
HELENA M. SOLO-GABRIELE,^{*,†}
TIMOTHY G. TOWNSEND,[‡] AND
YONG CAI[§]

Department of Civil, Architectural, and Environmental Engineering, University of Miami, P.O. Box, 248294, Coral Gables, Florida 33124-0630, Department of Environmental Engineering Sciences, University of Florida, Gainesville, Florida 32611-6450, and Department of Chemistry & Biochemistry and Southeast Environmental Research Center (SERC), Florida International University, Miami, Florida 33199

Wood treated with chromated copper arsenate (CCA) is primarily disposed within construction and demolition (C&D) debris landfills, with wood monofills and municipal solid waste (MSW) landfills as alternative disposal options. This study evaluated the extent and speciation of arsenic leaching from landfills containing CCA-treated wood. In control lysimeters where untreated wood was used, dimethylarsinic acid (DMAA) represented the major arsenic species. The dominant arsenic species differed in the lysimeters containing CCA-treated wood, with As(V) greatest in the monofill and C&D lysimeters and As(III) greatest in the MSW lysimeters. In CCA-containing lysimeters, the organoarsenic species monomethylarsonic acid (MMAA) and DMAA were virtually absent in the monofill lysimeter and observed in the C&D and MSW lysimeters. Overall arsenic leaching rate varied for the wood monofill (0.69% per meter of water added), C&D (0.36% per m), and MSW (0.84% per m) lysimeters. Utilizing these rates with annual disposal data, a mathematical model was developed to quantify arsenic leaching from CCA-treated wood disposed to Florida landfills. Model findings showed between 20 and 50 t of arsenic (depending on lysimeter type) had leached prior to 2000 with an expected increase between 350 and 830 t by 2040. Groundwater analysis from 21 Florida C&D landfills suspected of accepting CCA-treated wood showed that groundwater at 3 landfills was characterized by elevated arsenic concentrations with only 1 showing impacts from the C&D waste. The slow release of arsenic from disposed treated wood may account for the lack of significant impact to groundwater near most C&D facilities at this time. However, greater impacts are anticipated in

the future given that the maximum releases of arsenic are expected by the year 2100.

Introduction

Traditional disposal pathways for CCA-treated wood are through construction and demolition (C&D) debris facilities, but in some cases the wood may be inadvertently recycled as mulch or wood fuel (1–3). Nonrecycled treated wood may be disposed in C&D landfills, which in some states, such as Florida (4), are not required to be lined. Another disposal alternative is municipal solid waste (MSW) landfills, which are required to be lined. The U.S. Federal government has set in place several regulatory procedures, such as the toxicity characteristic leaching procedure (TCLP), to evaluate the hazardous nature of wastes and determine whether more elaborate containment is necessary upon disposal. The TCLP is a standardized leaching test designed to simulate the acid phase conditions that occur as part of the decomposition process within a MSW landfill. A solid waste subjected to the TCLP is considered hazardous if the TCLP leachate contains particular constituents above set threshold levels. For example, unless otherwise excluded, a solid waste containing arsenic is considered hazardous waste if the TCLP results exceed 5 mg/L. Although CCA-treated wood has been shown by the TCLP to leach arsenic above 5 mg/L (5–7), it is exempted at the federal level from being classified as a hazardous waste and can be disposed of as regular solid waste (8). Consistent with this policy, efforts are currently underway to divert CCA-treated wood products directly to lined landfills and limit quantities from being recycled as mulch or wood fuel or disposed within unlined C&D landfills.

Studies to evaluate the extent of arsenic releases after CCA-treated wood is disposed to landfills are few and focus primarily on measuring total arsenic. Leachate generated from experimental field test cells and lysimeters show arsenic concentrations between 45 and 96 $\mu\text{g/L}$ (9, 10). Gifford et al. (11) found that when CCA-treated wood was co-disposed with soil, the arsenic concentration in the leachate was reduced by 96% from 980 to 39 $\mu\text{g/L}$. Furthermore, additional information about the total arsenic concentrations in leachate, and additional metals from the lysimeters used in the current study can be found in Jambeck (12).

As mentioned in the previous paper (13), speciation of arsenic from CCA-treated wood is rarely evaluated during in-service use and in particular during disposal. Speciation is of importance as it defines toxicity, which dictates mobility and hence bioavailability. Although arsenic in the CCA formulation is in the form of inorganic As(V), both inorganic As(V) and the more toxic reduced inorganic As(III) species have been observed leaching from new and weathered CCA-treated wood (7). The less toxic organoarsenic species, dimethylarsinic acid (DMAA) and monomethylarsonic acid (MMAA), formed from the biotransformation of inorganic arsenic species (14, 15), can also play a role in arsenic leaching rates from disposed CCA-treated wood.

The objectives of the current study were to evaluate the speciation of arsenic leachate generated from disposed CCA-treated wood under different landfill conditions, to utilize the leaching rates to forecast arsenic releases during disposal, and to evaluate the speciation of arsenic from groundwater in the vicinity of C&D landfills, with the intent of documenting to date the current impacts of disposed CCA-treated wood. Landfill conditions were evaluated through a series of field-scale lysimeters (columns) designed to simulate wood

* Corresponding author tel: 305-284-3489; fax: 305-284-3492; e-mail: hmsolo@miami.edu.

[†] University of Miami.

[‡] University of Florida.

[§] Florida International University.

^{||} Present address: U.S. Environmental Protection Agency, Office of Water/Office of Science and Technology Health and Ecological Criteria Division, Washington DC 20460.