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Evaluation of pressure treated wood impact on landfill waste decomposition using a methane yield assay

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Abstract

Research was conducted to investigate the potential impact of CCA-treated wood and other arsenic-free Cu-based preservative-treated wood on microorganisms, involved in the anaerobic decomposition of waste in landfills. Wood preservatives used included alkaline copper quat (ACQ), copper citrate (CC), copper boron azole (CBA), copper dimethyldithiocarbamate (CDDC), and chromated copper arsenate (CCA). The biochemical methane potential (BMP) assay was used to estimate the possible impacts. The methane yields of mixtures of preservative-treated wood or untreated wood with cellulose (group 1) and these wood samples only (group 2) were determined. An analysis of variance (ANOVA) test found that there were no significant differences among methane yields results in either group 1 or group 2, at the 0.05 level of significance. The results indicate that under the conditions tested, none of the treated wood products evaluated were toxic to the methane-producing organisms. At the end of the assays, test bottle contents were analyzed for Cu, Cr, and As. When the fraction of each metal in the solution (relative to original metal in the wood, leachability %) was examined, As was present at the great extent. The leachability of As was in the range from 15.1% to 21.7% while relatively low leachability (1.7–7.6%) of Cu was observed.

Keywords: Treated wood; Landfill; Methane; Leaching; Solid waste

1. Introduction

The application of wood preservatives is one of the most commonly employed methods to protect wood products from decay caused by wood-deteriorating organisms. Many commercially used softwoods (e.g., Douglas Fir and Southern Yellow Pine) have little resistance to environmental decay; treatment with a wood preservative is essential when applications are outdoors in an aggressive environment (wet, warm). For the last three decades, the production of wood products treated with waterborne preservatives has increased by a factor of 10, with chromated copper arsenate (CCA) used to the greatest extent (approximately 17 million m^3 of wood products per year in US, Solo-Gabriele and Townsend, 1999). While treatment with CCA greatly increases the life span of a wood product in the environment, weathering and gradual loss of preservative requires that the treated wood product ultimately be discarded. Large amounts of discarded pressure treated wood products are, as a result, disposed of in the solid waste stream. Although the production of CCA-treated wood will be substantially reduced in the near future as a result of an industry phase-out of most residential uses (USEPA, 2002), the majority of CCA-treated wood products manufactured to date remain in service and will at some time require disposal.

As a result of the concern over arsenic and its potential impact on human health (Mandal and Suzuki, 2002), other waterborne wood preservatives have been developed as arsenic-free alternatives to CCA. The majority of the arsenic-free waterborne preservatives contain copper. Examples include alkaline copper quat (ACQ), copper citrate (CC), copper boron azole (CBA)

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and copper dimethyldithiocarbamate (CDDC). The arsenic and chromium used in CCA are replaced with larger amounts of copper along with an organic co-biocide. ACQ and CBA are poised to become the primary replacements for the phased-out uses of CCA. Wood products treated with these chemicals closely resemble products treated with CCA, and the average consumer will not likely notice a difference. The replacement of arsenic and chromium with copper offers several benefits with respect to human health and waste management issues. Copper, however, is more toxic to aquatic biota and some kinds of microorganisms (Flemming and Trevors, 1989).

The objective of the research presented in this paper was to investigate the potential impact of CCA-treated wood and Cu-based preservative-treated wood on one particular set of organisms, those involved in the anaerobic decomposition of waste in landfills. One option for disposing of discarded treated wood is co-disposal with municipal solid waste (MSW) in lined landfills. Questions that arise include: (1) will disposal of CCA-treated wood in MSW landfills have an impact on the decomposition of the landfilled waste (e.g., food waste and paper products), and (2) will the future disposal of alternative copper-based treated wood products have a similar or different effect to that of CCA-treated wood. The procedure used to estimate the possible impacts was the biochemical methane potential (BMP) assay (Owen et al., 1979). BMP assays have been used to estimate the potential methane yield of waste components (Owens and Chynoweth, 1993) and to assess the toxicity of pollutants to the methane-forming organisms (Owen et al., 1979).

2. Materials and methods

The collection and characterization of the treated wood samples were performed as part of a larger project (Townsend et al., 2003) in which the relative leaching and toxicity of CCA-treated wood and wood treated with arsenic-free preservatives were evaluated.

Approximately 30 cm (1-ft) lengths of untreated Southern Yellow Pine (SYP) dimensional lumber were sent to several chemical manufacturers and wood treatment facilities for treatment with ACQ, CBA, CDDC, CC and CCA. Information on different types of treatment chemicals and other details can be found elsewhere (Stook et al., 2005). Two different CCA samples were created, one each at a different facility. Retention values for arsenic and chromium were analyzed by Timber Product Inspections (TPI), Conyers, GA. Retention value analysis for copper was measured by five separate laboratories (TPI; Southern Pine Inspection Bureau of Pensacola, FL; Spectrum Laboratories Inc. in Ft. Lauderdale, FL; the University of Florida Environmental Engineering Lab in Gainesville, FL; and the University of Miami Environmental Engineering Lab in Coral Gables, FL). Retention value is a term used by wood preservation industry and represents the amount of preservative contained in a unit volume of wood (e.g., kg CCA per m^3 of wood). Table 1 presents the measured retention values of the wood preservatives. The copper results presented in Table 1 correspond to the average of the five laboratories.

Table 1
Actual retention values (kg/m^3) for treated and untreated wood

	Untreated	CCA-1	CCA-2	ACQ	CBA	CC	CDDC
Cu					1.46		2.26
CuO	0.13	0.66	0.80	2.55	1.83	3.00	2.82
CrO_3		1.70	2.07				
As_2O_5	0.02	1.43	1.59				

Treated wood samples were size reduced to less than 3 mm by first cutting the boards into small blocks and then using a Pulverisette 19 mill (Fritsch, Columbus, OH). To evaluate the environmental impact on waste decomposition and to estimate the methane yield of each wood type, two different experimental groups were assigned. In one group, 0.2 g (as volatile solids (VS)) of each wood type and 0.2 g (as VS) of cellulose powder (Aldrich, Milwaukee, USA) were weighed and placed into a 270-ml capacity serum bottle for the first group. In the second group, 0.2 g (as VS) of ground wood samples were added.

A synthetic media containing buffers, nutrients and trace metals was prepared following ASTM method E1196-92 (ASTM, 1992). Anaerobically digested sludge obtained from a laboratory-scale anaerobic reactor was added as an inoculum to the prepared media while flushing with nitrogen gas. Six serum bottles were used for each wood type. Three of the bottles contained the wood sample only, while the remaining three contained the wood sample plus cellulose powder. A 100-ml portion of inoculated media was then transferred into the prepared serum bottles along with the wood and/or wood-cellulose samples under anaerobic conditions. Pure cellulose and ground newspaper were utilized as primary and secondary positive controls, respectively. Sludge without wood or cellulose was employed as a negative control.

A gas sample was collected from each serum bottle once per week over a 50-day period. At each sampling, a 50-ml capacity syringe was used to measure the biogas volumes. The collected biogas was analyzed for methane and carbon dioxide using a gas chromatograph (Model 5890, Hewlett–Packard, USA) equipped with a thermal conductivity detector and GS-Carbon PLOT capillary column (30 m × 0.32 mm ID, 3.0 μm, Agilent Technology, Palo Alto, CA, USA).

At the end of the experiment, the soluble concentrations of copper, chromium and arsenic were measured. The contents of the three triplicate serum bottles were first combined and then filtered prior to digestion. The digested samples were analyzed using inductively coupled plasma atomic emission spectrometry (ICPAES, Thermo Jarrell Ash Corp. Model 95970, USEPA Method 6010B). The leachability of arsenic, chromium and copper was determined by dividing the mass of the chemical in the leachate