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Leaching of chromated copper arsenate (CCA)-treated wood in a simulated monofill and its potential impacts to landfill leachate

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Abstract

The proper end-of-life management of chromated copper arsenate (CCA)-treated wood, which contains arsenic, copper, and chromium, is a concern to the solid waste management community. Landfills are often the final repository of this waste stream, and the impacts of CCA preservative metals on leachate quality are not well understood. Monofills are a type of landfill designed and operated to dispose a single waste type, such as ash, tires, mining waste, or wood. The feasibility of managing CCA-treated wood in monofills was examined using a simulated landfill (a leaching lysimeter) that contained a mix of new and weathered CCA-treated wood. The liquid to solid ratio (LS) reached in the experiment was 0.63:1. Arsenic, chromium, and copper leached from the lysimeter at average concentrations of 42 mg/L for arsenic, 9.4 mg/L for chromium, and 2.4 mg/L for copper. Complementary batch leaching studies using deionized water were performed on similar CCA-treated wood samples at LS of 5:1 and 10:1. When results from the lysimeter were compared to the batch test results, copper and chromium leachability appeared to be reduced in the lysimeter disposal environment. Of the three metals, arsenic leached to the greatest extent and was found to have the best correlation between the batch and the lysimeter experiments.

Keywords: CCA-treated wood; Disposal; Leaching; Arsenic; Lysimeter

1. Introduction

Once chromated copper arsenate (CCA)-treated wood is removed from service, the risk of direct exposure to humans and the environment is minimized, but management as a solid waste begins. Discarded CCA-treated wood is exempt from characterization as a hazardous waste in the U.S., even though it often leaches arsenic at concentrations greater than the U.S. Environmental Protection Agency (EPA) toxicity characteristic concentration for hazardous wastes [1]. When CCA-treated wood is commingled with untreated wood as part of recycling operations, the mulch product produced often becomes contaminated to such an extent that it cannot be land applied [2,3]. When CCA-treated wood is incinerated, resulting arsenic emissions demand the use of proper air pollution control equipment; in addition, arsenic, copper, and chromium become concentrated in the ash, limiting ash management options [4,5]. In some countries (e.g., Germany), discarded CCA-treated wood is banned from landfill disposal, and after all reuse options have been exhausted, the material must be incinerated [6]. In the U.S. (including Florida) and some other countries (e.g., Canada and Australia), CCA-treated wood is typically disposed of in landfills without any processing or pretreatment. A natural concern of landfill disposal of discarded CCA-treated wood is the possibility of preservative elements leaching at levels that result in harm to the environment or that make it difficult for the landfill operator to manage collected landfill leachate.

The leaching of arsenic, copper, and chromium from the in-service use of CCA-treated wood has been examined extensively [7–10], including the development of predictive models [11]. In the past several years, more attention has been placed on the leaching of CCA-treated wood in disposal environments such as landfills. The leaching of arsenic, copper, and chromium from CCA-treated wood using a variety of regulatory batch leaching tests has been completed, along with experiments to investigate the impact of factors such as particle size, pH, contact time, and leaching fluid [1,12]. Batch leaching studies provide

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some indication of which metals are prone to leaching in a disposal scenario, and the research referenced above demonstrated that arsenic, copper, and chromium do leach from CCA-treated wood. The utility of batch tests may be limited, however, since they cannot incorporate all of the factors that impact pollutant leaching and mobility in various landfill environments. The type of landfill can be very important because of differences in oxidation–reduction potential and chemistry resulting from biological reactions in the waste mass.

Several different types of landfills may be used for the disposal of CCA-treated wood. Since CCA-treated wood is a construction material, in some locations it is often managed as part of the construction and demolition (C&D) debris stream. In the U.S., C&D debris is often considered inert; in 27 states, C&D debris landfills are not required to have a liner [13]; in these circumstances, contamination of groundwater is a concern. The disposal of CCA-treated wood as part of C&D debris has been shown to increase leachate concentrations of arsenic and chromium [14,15]. When CCA-treated wood is disposed in lined landfills, where it would normally be disposed with municipal wastes, elevation of preservative elements in leachate becomes a potential issue. An additional disposal scenario, one not currently practiced for CCA-treated wood but practiced for other special wastes, is disposal as a separate material in a lined landfill. In such a monofill, preservative leaching would be concentrated, making it easier to contain and possibly recover the preservative elements.

Research was conducted to study the effects of CCA-treated wood disposal on leachate quality in various landfill scenarios [16]. This paper reports the results of one of these scenarios, one where CCA-treated wood was segregated and separated for management in a monofill. A CCA-treated wood monofill restricts the wood from contaminating other disposal scenarios, thereby more efficiently concentrating and controlling the metals released. The monofill could also be used as a resource if recycling and/or recovery options for CCA-treated wood were developed and became economically feasible. The primary objective of the research was to quantify the release of arsenic, copper, and chromium from a CCA-treated wood monofill by constructing a leaching column (lysimeter) and measuring the concentrations of preservative elements in the leachate over time. An added benefit to the observation of leachate from a lysimeter is that the leaching behavior of CCA-treated wood can be examined and evaluated at very low liquid to solid ratios, those much lower than can be achieved in batch leaching studies. Batch leaching studies were conducted on the same wood used in the monofill simulation in order to compare the results. With the lysimeter representing more realistic conditions, results were compared to the laboratory batch leaching studies conducted on the CCA-treated wood.

2. Experimental

2.1. Leaching column (lysimeter)

A 6.7-m high and 0.3-m (1-ft) diameter leaching column, also called a lysimeter, was constructed at the Alachua County Solid Waste Landfill, located in North Central Florida, U.S. Fig. 1 presents a diagram of the lysimeter. The lysimeter was constructed (from the bottom to the top) with: 15.2 cm of washed gravel, a stainless steel screen, 15.2 cm of washed gravel, 6.1 m of simulated waste, a cap with a water distribution system, and a catchment basin for rainwater. Natural precipitation was allowed to infiltrate the lysimeter (1 cm of precipitation applied to the lysimeter is equal to 0.73 L of water addition). Natural precipitation was supplemented by the addition of deionized water during the dry season (September 2002–January 2003) to produce required quantities of leachate for the analysis of general water quality parameters in the field and analysis of other parameters, including arsenic, copper, and chromium in the laboratory. Natural precipitation contributed 207 cm of the total 230 cm of water input throughout the 755 days of the experiment. The lysimeter was located outdoors and exposed to ambient temperature variations. Thermocouple wires (type T) were placed at three separate depths (6.1 m, 4.6 m, and 1.5 m) within the lysimeters to obtain temperature readings.

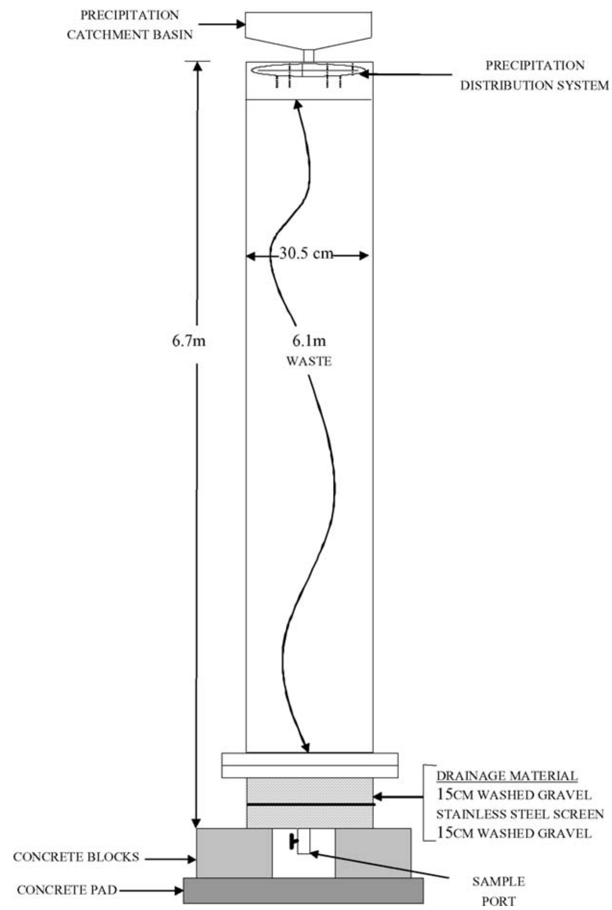

Fig. 1. Diagram of the lysimeter.

2.2. Simulated wood waste

The experimental lysimeter contained 100% CCA-treated Southern Yellow Pine (Type C). Southern Yellow Pine is commonly used for treated wood since it contains a large proportion of sapwood (the highly penetrable portion of wood); however,