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# Influences of wood preservation, lumber size, and weather on field leaching of red pine lumber

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## HIGHLIGHTS

- Less leachate is generated by rain with small lumber and ACQ-treated lumber.
- Leachate volume is correlated to rainfall depth and temperature before rainfall.
- Leachate quality was similar between two sizes of lumber.
- ACQ treatment increased copper, arsenic, and total dissolved solids in wood leachate.
- Leachate copper content is correlated to weather conditions and rain properties

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## ABSTRACT

Alkaline copper quaternary (ACQ) is a widely used wood preservative. This study evaluated leachate volume generation and contaminant leaching from ACQ-treated lumber during rainfall events in comparison to untreated lumber. The influences of wood preservation with ACQ, lumber size, and weather on leachate generation ratio and contaminant concentrations in wood leachate were investigated with four red pine lumber piles exposed to natural weather conditions. The average volumetric ratio of leachate to rainfall was significantly higher for the large-lumber piles (0.62) compared with the small-lumber piles (0.35). Less leachate was generated in the ACQ-treated lumber piles (0.42) than the untreated lumber piles (0.55). Leachate volume could be predicted with rainfall depth, air temperature, and wetted lumber surface area. Lumber size did not make a statistically significant difference in leachate quality except for zinc concentration. The average copper concentrations were 4034 μg/L in the leachate from the ACQ-treated lumber piles and 87 μg/L in the leachate from the untreated lumber piles. Moreover, ACQ treatment significantly increased leaching of arsenic and total dissolved solids. Copper concentration in leachate from ACQ-treated lumber can be predicted with rainfall intensity, the time interval between two consecutive leachate-generating events, rain copper concentration, and rain pH



## 1. Introduction

Except for naturally durable species such as redwood and cedar, wood in outdoor applications is usually pressure treated with preservatives. Preservatives are forced into the cellular structure of wood to deter wood decay. Alkaline copper quaternary (ACQ) is one of the wood preservatives used worldwide for both commercial and residential wood products. The most common formula of ACQ (type D) contains 66.7% copper oxide and 33.3% quat as didecyldimethylammonium chloride [1]. Its primary biocide, copper (Cu), can leach out of wood in outdoor storages and uses by rainfall [2]. Wood leachate generated intermittently by rainfall at various storage sites of freshly treated lumber and decommissioned wood may percolate to groundwater, be discharged to surface waters, or infiltrate through soil. The leached Cu can be toxic to aquatic organisms and pose human health risks at trace levels [1,3].

Environmental authorities are increasingly concerned with environmental impacts of wood preservation [1]. In New York State, for example, Multi-Sector General Permit for Stormwater Discharges Associated with Industrial Activity covers log storage and handling facilities, general sawmills and planing mills, and wood preserving facilities [4]. This general permit sets the benchmark monitoring cutoff of wood leachate and contaminated stormwater at 0.012 mg/L total recoverable Cu for the timber products sector.

Metal leaching from pressure treated wood has been investigated with laboratory tests, such as continuous leaching with synthetic precipitation or an extraction solution [5–9]. However,

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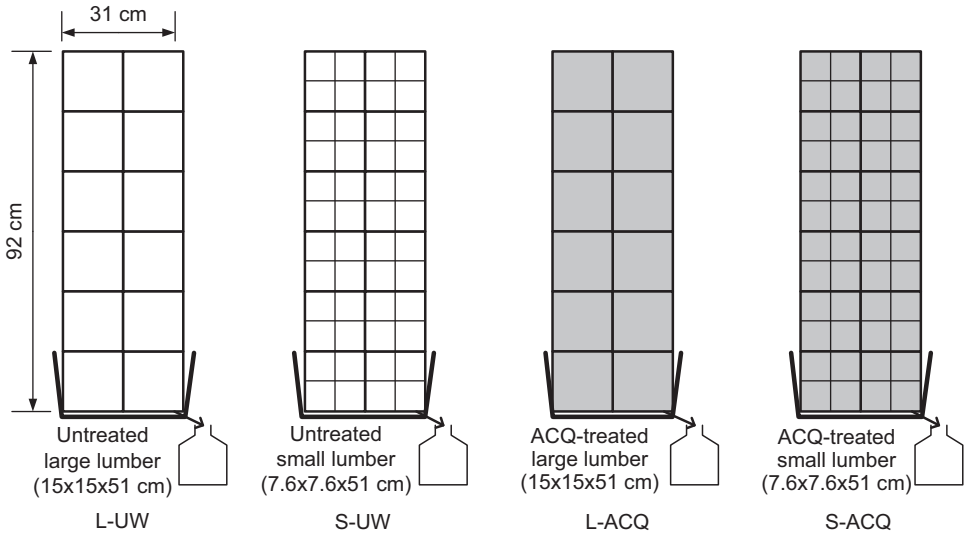


**Fig. 1.** Sketch of leaching piles with ACQ-treated and untreated red pine at two lumber sizes.

laboratory tests with wood subjected to continuous leaching ignore the influence of weather conditions, water absorption by wood, and weathering on leachate volume generation and metal leaching under field conditions [2,10,11]. Leachate is generated when the volume of rain that falls on a pile of wood is in excess of the volume that the wood can absorb. Laboratory test results do not reflect metal leaching dynamics and intensity in the field and provide no information about the amount of leachate that could actually be generated. Field studies [10,11] have reported influences of rainfall intensity and duration on metal leaching from wood treated with chromated copper arsenate preservatives. Nevertheless, only one recent study [2] investigated metal leaching from ACQ-treated wood under field conditions. Moreover, Hasan et al. [2] only monitored wood leachate weekly, rather than tracking metal leaching across rainfall events. Leachate volume generation and metal leaching from treated wood could vary with weather conditions, wood species, lumber size, and preservative type. No study has yet quantified leachate volume generation and Cu leaching from ACQ-treated wood on a rainfall event basis under field conditions. Investigation into event-based Cu leaching will provide a more realistic evaluation of environmental impacts of Cu leached from ACQ-treated wood.

Trees assimilate various metals, many of which are macro- and micro-nutrients. The inorganic content of wood can be up to 1% of wood dry mass, varying with wood species, soil chemistry and climatic conditions [12]. Metals could leach out of untreated wood as well [13–17]. Moreover, leachate from untreated wood has high concentrations of organic substances [12,18]. Some of the organic substances such as tannins and phenols are toxic to aquatic organisms, though the greatest concern is oxygen demand of the organic substances [12,18]. Pressure treatment deters wood decay, but erosion of wood fiber from lumber surfaces still occurs [7]. The effects of pressure treatment with ACQ on leaching of oxygen-demanding substances and non-biocide metals are unknown. Furthermore, different sizes of lumber have different surface areas exposed to precipitation when stored outdoors, which affects initial water retention and could result in different leachate characteristics [6,11]. To the authors' knowledge, there are no side-by-side comparisons of organic matter and non-biocide metals leaching from untreated and treated wood in the literature.

The objectives of this study were 1) to evaluate the intensity and dynamics of leachate volume generation and contaminant leaching from newly ACQ-treated red pine lumber in comparison to those from untreated lumber during rainfall events; 2) to examine the effects of lumber size on wood leaching; and 3) to develop regression models to predict leachate volume generation and contaminant leaching with meteorological parameters.

## 2. Materials and methods

### 2.1. Wood leaching piles

Four wood leaching piles were set up on March 6, 2010 in an open area located in Syracuse, New York, USA. The dimensions and configuration of the piles were selected to simulate wood leaching by rainfall in outdoor storage situations. Each pile was stacked with new red pine lumber (51 cm long) to 92 cm tall in a rectangular polypropylene tank with interior floor dimensions of 32 cm by 53 cm. The lumber pieces in each tank were tied with a plastic string to keep the piles straight and stable. The four piles were differentiated by lumber size (15 cm × 15 cm vs. 7.6 cm × 7.6 cm) and ACQ treatment as shown in Fig. 1. The ACQ-treated red pine lumber was produced for above ground use, which had a preservative retention level of 2.4 kg Cu/$m^3$ as specified by AWPA [19]. Each pile had a total lumber volume of 0.14 $m^3$ and a top surface area of 0.16 $m^2$. Each tank holding a lumber pile had top dimensions of 34 cm by 54 cm. The slightly larger top dimensions relative to the floor dimensions were chosen to minimize direct rainfall to the open space of the tanks and prevent rainfall on the piles from significant loss due to splashes. When leachate was generated during rainfall events it was drained freely by gravity into acid-washed polypropylene bottles. A sheet of 1-cm polystyrene foam was laid on the bottom of each tank to avoid submersion of wood in leachate. A Taylor 1″ analog rain gauge was set up beside the wood piles to record rainfall depth and collect rain samples for individual rainfall events.

Syracuse has a humid continental climate, with cold, snowy winters and relatively cool summers. Mean annual precipitation is 1017 mm. Precipitation is well distributed throughout the year, while snow falls mostly in the period from December to March. Daily average temperatures recorded at the nearby SUNY ESF Weather Station [20] were collected for the study period. The average daily temperature during the study period from March 6 to November 18, 2010 was 15.8 °C, with a maximum temperature of 31.2 °C and a minimum temperature of −7.2 °C.