

Leachable & Dislodgeable Arsenic & Chromium from In-Service CCA-Treated Wood

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ABSTRACT

Leachable and dislodgeable arsenic and chromium from CCA (chromated copper arsenate)-treated wood were studied to evaluate the fate of these CCA-chemicals and possible human exposures when the chemicals have been released to the environment. To evaluate the leachable component, two full sized decks were constructed. One was made of CCA-treated wood, and the other was made of untreated wood. Rainfall, runoff water from the top surface of the deck, and infiltrated water through 70 cm of soil below the deck had been monitored for 408 days. Soil below the decks was collected 6 months and 13 months after deck installation. The results of the deck monitoring showed that a significant portion of arsenic could be leached to environment during the service life of the CCA-treated wood product when exposed to rainfall. During the monitoring period, the average concentration in the runoff water from the CCA-treated deck was 1,000 µg/L for arsenic and 99 µg/L for chromium. Release of these metals to the surface soil was also observed. The surface arsenic concentrations increased from 4.5 mg/kg for the 6 month soil sample to 11.5 mg/kg for the 13 month sample. The impacts of the releases were also observed in the infiltrated water samples collected from below the experimental decks. The arsenic concentrations below the CCA-treated deck increased from a background level of 2 µg/L to 20 µg/L during the 408 day monitoring period; the chromium concentrations were more consistent at concentrations typically between 3 to 4 µg/L. The dislodgeable components from CCA-treated wood were quantified through wipe tests, which were designed to evaluate the effects of different wood retention levels, sapwood versus heartwood, repetitive wipes, and long-term weathering. This part of the study demonstrated that significantly larger amounts of dislodged arsenic and chromium could be removed from higher retention CCA-treated wood. The average mass of dislodged arsenic from the 40 kg/m² CCA-treated wood sample was 1200 µg/wipe, and 74 µg/wipe for the 4 kg/m² CCA-treated wood sample. The amount of dislodged arsenic and chromium from the sapwood side of CCA-treated wood was larger than from the heartwood side, and these differences were significant for the first repetition of wipe samples collected. Furthermore, the amount of dislodged arsenic and chromium significantly decreased as the number of consecutive sets of wipes increased on the same area. The average quantities of dislodged arsenic and chromium decreased from 6 months to the 12 month study period, however these averages were not statistically different.

Overall, this study confirmed that CCA-chemicals are released from the wood products through both leaching and dislodging. These releases result in environmental contamination, and may serve as a source of arsenic and chromium exposure for humans.

Keywords: leachable CCA, dislodgeable CCA, arsenic, chromium, and CCA-treated wood

MATERIALS & METHODS

Sample Collection



Figure 1: Deck used to evaluate leachable metals



Figure 2: Outdoor wipe stations to evaluate dislodgeable metals

Leachable Arsenic & Chromium: Two decks (with a 3 m² top surface area of deck sitting on a 6 m² surface area of sand base) were installed to monitor leachable arsenic and chromium during in-service use of wood (Figure 1). One deck was constructed of CCA-treated wood retention level of 4 kg/m² (= 0.25 pcf) as indicated upon purchase of the wood. The other served as a control, and was constructed of untreated wood. The total bulk volume of soil below each deck was 4.2 m³ soil, resulting in a depth of 0.7 m of soil.

Water Samples (rainfall, runoff water, and infiltrated water): The two decks had been monitored for a 13-month period since September 7, 2002 through October 20, 2003 for a total of 408 days.

Soil Samples: Sand samples from below each deck were collected using a 28.6 mm diameter unslotted stainless probe fitted with a pre-acid washed plastic liner. Samples were collected after six months and one year from the installation date of the decks. The collected sand samples were divided into 2.5 cm depth intervals.

Dislodgeable Arsenic & Chromium: In order to study dislodgeable arsenic and chromium, wipe samples were collected from CCA-treated wood including wood kept in the laboratory, decks and wipe station (Figure 2). Wipe samples were collected using the U.S. CPSC 2003 procedure which requires the use of an 8 cm diameter's sampling device fitted with a polyester cloth (Figure 3). The area wiped was 400 cm².

Wipe Samples: Wipe samples were collected to evaluate 4 different factors including Retention effects, Sapwood vs. Heartwood, Repetition effects, Long weathering effects.

Sample Analysis

Preparation

- Accidification:** All water samples from decks
- U.S. EPA Method 3050B:** Sawdust, soil, wipe
- U.S. CPSC Procedure:** Wipe

Metal Analysis

- Atomic Absorption Spectrometer (AA 800 PerkinElmer)**
 - Flame atomization analysis:** high concentration samples (range of mg/L)
 - Graphite furnace atomization analysis:** low concentration samples (range of µg/L)



Figure 3: Wiping device

RESULTS

Leachable Arsenic & Chromium

Table 1: Summary of water samples from the deck monitoring

		Rainfall		Runoff		Infiltrated Water	
		untreated deck	treated deck	untreated deck	treated deck	untreated deck	treated deck
Depth/Volume	Mean	13 mm	13 mm	581 ml	584 ml	42 L	48 L
	Stdev.	23 mm	23 mm	1174 ml	1174 ml	73 L	73 L
pH	Mean	4.78	4.83	6.18	6.25	7.91	8.1
	Stdev.	0.81	0.81	0.65	0.65	0.89	0.89
ORP (mV)	Mean	121	117.6	42	37.9	-70	-74.8
	Stdev.	55	55	32	32	30	30
As (µg/L)	Mean	< 1	< 1	< 1	1,001	< 1	6
	Stdev.	< 1	< 1	< 1	770	< 1	6
Cr (µg/L)	Mean	< 1	< 1	< 1	99	< 1	3
	Stdev.	< 1	< 1	< 1	79	< 1	2

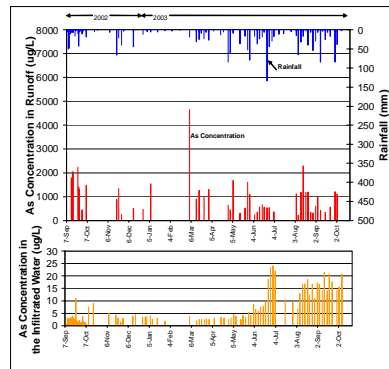


Figure 4: Rainfall and arsenic concentrations in runoff and infiltrated water from the CCA-treated wood

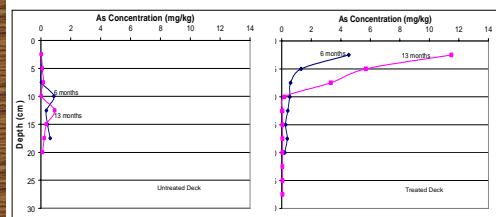


Figure 5: Arsenic in soil under the decks after 6 and 13 months

Dislodgeable Arsenic & Chromium

Table 2: Retention Level Effect

Sample ID ^a	Retention Level (kg/m ²)	Arsenic (µg/wipe)	Sample ID	Retention Level (kg/m ²)	Arsenic (µg/wipe)	Sample ID	Retention Level (kg/m ²)	Arsenic (µg/wipe)
WA-OS	0	<0.5	WA-4S	4	46	WA-40S	40	970
WB-OS	0	<0.5	WB-4S	4	52	WB-40S	40	1,152
WC-OS	0	<0.5	WC-4S	4	42	WC-40S	40	1,606
WD-OH	0	<0.5	WD-4S	4	112	WD-40S	40	1,112
WE-OH	0	<0.5	WE-4S	4	90	WE-40S	40	1,307
WF-OH	0	<0.5	WF-4S	4	105	WF-40S	40	949
Mean					74			1183
Stdev.					32			245

Table 3: Table Sapwood vs. Heartwood

Sapwood Side				Heartwood Side					
Sample ID	Retention Level (kg/m ²)	Repetition Number	As (µg/wipe)	Cr (µg/wipe)	Sample ID	Retention Level (kg/m ²)	Repetition Number	As (µg/wipe)	Cr (µg/wipe)
LB-4S ^a	4	1	174	132	LA-4H ^b	4	1	109	11
		2	31	56			2	27	15
		3	21	31			3	11	12
LD-4S ^a	4	1	254	12	LC-4H ^b	4	1	169	10
		2	50	17			2	32	8
		3	11	12			3	3	4
LF-4S ^a	4	1	303	3	LE-4H ^b	4	1	169	4
		2	32	2			2	69	2
		3	16	3			3	26	3
DB6-4S	3.2	1	123	162	DA6-4H	3.2	1	130	175
		2	34	48			2	47	59
		3	23	29			3	30	43
DB12-4S	3.2	1	100	94	DA12-4H	3.2	1	52	105
		2	44	59			2	39	52
		3	39	49			3	32	40
DC6-4H	3.2	1	41	83	DC12-4H	3.2	1	37	46
		2	23	39			2	13	21
		3	15	26			3	13	19
Mean			84	58				53	43
Stdev.			91	48				49	45

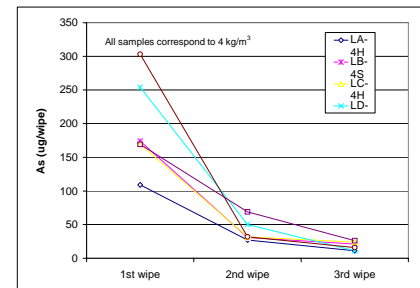


Figure 6: Effects of repetitive sets of wipes on dislodged arsenic

Table 3: Dislodged arsenic and chromium after log-term weathering

Sample ID ^a	Repetition Number	Arsenic, µg/wipe ^b		Chromium, µg/wipe ^b	
		6 months	12 months	6 months	12 months
DA-4H	1	130	52	175	105
	2	47	39	69	52
	3	30	32	43	40
DB-4S	1	123	100	162	94
	2	34	44	48	59
	3	23	39	29	49
DC-4H	1	41	37	83	46
	2	23	13	39	21
	3	15	13	26	19
Mean		52	41	75	54
Stdev		43	26	56	29

CONCLUSION & DISCUSSION

Metals are leached out from CCA-treated wood by rainfall

The average arsenic concentration of 1.0 mg/L in the runoff water from the CCA-treated deck were significantly higher than the U.S. EPA drinking water standards (MCLG of 0 mg/L and MCL of 0.050 mg/L) and Florida Criteria for Surface Water Quality Classifications (a maximum permissible concentration of 0.050 mg/L for all water classes [I to V]).

The average chromium concentration of 0.1 mg/L in the runoff water from the CCA-treated deck was near the U.S. EPA drinking water standard of 0.1 mg/L (MCL and MCLG) and higher than the Florida Criteria for Surface Water Quality Classifications of 0.05 mg/L for Class II, III (fresh), and V (predominantly marine) and 0.011 mg/L for Class I, III (marine), IV, and V (predominantly fresh).

Arsenic concentrations in the surface soil below the CCA-treated deck after 6 and 13 months of leaching were 4.5 mg/kg and 11.5 mg/kg, respectively. These concentrations are higher than the U.S. EPA soil screen level (SSL) of 0.4 mg/kg (U.S. EPA 1996) and Florida's Soil Cleanup Target Levels (SCTLs) (FDEP 1999) of 0.8 mg/kg for residential areas and 3.7 mg/kg for industrial areas.

The arsenic concentration in the soil did not exceed the Florida SCTLs of 29 mg/kg for leaching to groundwater. It should be noted that in this study, the soil was sandy and had been receiving runoff from the CCA-treated deck for only 1 year.

Arsenic (7 µg/L on average) and chromium (6 µg/L on average) were also detected in the infiltrated water located below the CCA-treated deck. Overall the concentrations increased from detection limits at the beginning of the study to upwards of 20 µg/L. Although the majority of the arsenic introduced from the CCA-treated deck was sorbed by the sand, "break-through" of the metals was still observed through the 0.7 m sand layer, resulting in concentrations that could present a threat to groundwater drinking water supplies.

Metals are dislodged by contacting on CCA-treated wood surface

This study supported earlier studies that showed that arsenic and chromium could be dislodged by wiping the surface of CCA-treated wood (U.S. CPSC 1990; Stilwell et al. 2003). The average mass of dislodged arsenic from the rated 4 kg/m² wood was 72 µg/wipe. This value was larger than the 39 µg/wipe measured by the U.S. CPSC (2003).

The current study also showed that the amount of dislodgeable arsenic decreased with repeated rubbing for wood that had been weathered up to 1 year. It would be of interest to evaluate whether repeated wipes result in reduced dislodgeable arsenic levels for wood that has been weathered for longer periods of time.

Overall

This study provides important information that could be used in the development of risk assessments for possible human exposure to leachable and dislodgeable metals from CCA-treated wood. The results of this study may be helpful in identifying feasible recommendations concerning mitigation efforts aimed at existing playgrounds and other CCA-treated structures.

Additional work should concentrate on documenting the potential impacts of CCA-treated wood leachates to ground water as an additional environmental and human risk.

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