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Determination of lead dust fall rates during deconstruction of wood frame buildings in an urban region in the Northeastern United States.

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ABSTRACT

Title: Lead dust fall deposition rates during deconstruction of wood frame buildings in an urban region in the Northeastern United States.

Objectives: Determine the lead dust fall deposition rate due to hybrid deconstruction (separation and removal of building components) of wood-frame structures, and compare that to the lead dust fall deposition rate from demolition (compression and collapse of building components).

Scope: A city block with a total of 11 wood-frame structures was selected as the location for the deconstruction leadfall testing. Testing was done during the deconstruction of 7 of the 11 pre-1950 homes (mean construction year 1928, mean floor area 283 square meter).

Method: During deconstruction, the lead deposition rate was measured by using the modified APHA 502 method (Mucha et al. 2009).

Findings: The geometric mean deposition rate for the lead dust fall at the property perimeter from the houses using deconstruction was 61.3 ug/sg m/hr. Published values for deposition rates from demolition in Chicago (Jacobs, et al. 2013) are 59.0 and 152 ug/sq m/hr for homes with and without the use of dust suppression. The deposition rate during hybrid deconstruction is similar to the deposition rate during demolition when dust suppression is employed.

Implications: Many older urban areas have abandoned buildings containing lead-based paint. Governments in these regions invest in removing these buildings, using a variety of methods. To avoid further lead contamination in the soil surrounding these buildings, methods which minimize the total lead dust fall must be employed. The proper quantification and evaluation of these methods will help policy makers with their decisions.

KEYWORDS

Environmental lead, soil contamination, lead deposition rate, deconstruction, demolition

INTRODUCTION

During the late 20th century major urban areas in US manufacturing regions experienced population loss, and an increase in abandoned homes. For cities in the Northeast and Midwest of the United States, this has become an acute problem. These homes create problems on many fronts, including the impact on investment in the community, use for illicit activities, danger due to arson, and loss of tax base. In many of these urban areas, these abandoned buildings were built before the 1978 ban on lead paint, and as a result lead can be found on both exterior and interior surfaces.

The removal by demolition and landfilling of these homes can also create significant problems. First, the volume of landfill waste created is significant. Based on a 2014 EPA study, the waste from construction and demolition activities constitutes more than two-thirds of all landfill waste (by weight). Of this construction and demolition waste, more than 90% is from demolition (EPA, 2014). Another problem is that during the demolition of these homes the possibility exists for significant soil lead contamination from lead dust dispersion (Farfel, 2003).

However, many communities are looking for alternatives that will decrease the amount of material going to a landfill, return salvageable materials for new construction, help to provide employment for community members, and reduce the transportation impacts and greenhouse gas releases from materials transported and then left to decay in landfills. One way to do this is through deconstruction instead of demolition (Bell, 2012).

The disassembly and separation of building elements with the intent for reuse or recycling is known as “Deconstruction”. Traditional deconstruction involves an increased amount of labor and expense compared to demolition. However, depending on the costs of disposal, the value of the reclaimed materials, and the relative amount of labor in the process, under certain conditions deconstruction can be a lower cost solution (Pun, 2006). In an attempt to optimize these conditions, an adaptation of deconstruction known as “hybrid” deconstruction has been developed. In this process, the building’s planar surfaces are mechanically separated and then lowered to the ground where workers harvest the most easily separated materials, and avoid expending additional time for small amounts of reclaimed material. The goal of this method is to maximize the amount of materials salvaged per unit of labor invested.

Regardless of the method chosen, the presence of hazardous materials in the structure to be removed must be managed. During traditional demolition, the impact and crushing of the building materials creates a plume of dust that settles around the site. Some demolition contractors use a water stream sprayed at the materials to try to reduce this plume. Nevertheless, researchers have found that lead dust deposition measured around demolition sites represent a significant source of soil contamination. (Farfel, 2003)

The deleterious effects of exposure to environmental lead during childhood are well documented. In their 2015 report on Educational Interventions for Children Affected by Lead, the expert panel compiling the report cites 83 separate studies on the negative neurodevelopmental consequences of lead exposure (Educational Services for Children Affected by Lead Expert Panel, 2015). Results of such elevated childhood lead blood levels can range from anti-social and behavioural problems (Dietrich, 2001) to violent crime (Reyes, 2007). While guidelines from 1960 set safe lead blood levels at 60 µg/dL, recent studies show levels as low as 5 µg/dL, can have impacts on brain development in children (CDC, 2012).

Since the phase out of lead from gasoline beginning in the 1970s, to the elimination of lead from gasoline in 1996, lead blood levels in children have been shown to be correlated to soil lead levels (Johnson and Bretsch, 2002)(Mielke et al, 1997). The deposition of lead on soils from demolition activities has been identified as an important soil contamination pathway. Farfel (2003) found that lead dust fall rates during demolition increased by more than 40 fold from the background levels. In a study from St. Loius, MO., Rabito et al found a significant correlation between multiple demolitions in a census block, and elevated blood lead levels in children (2007). Gulson and Taylor (2017) found that children's blood lead levels were found to be correlated both to leadfall on interior surfaces (100 µg/m2/30d rate corresponds to an increased in children's blood lead levels of about 1.5 µg/dL) and soil increases (0 to 1000 mg Pb/kg soil increase results in an increase of 1.7 µg/dL of blood lead levels). Results from this study were suggested to be used for "action levels" to monitor activities such as housing demolition.

A study by Ayodle (2014) tracked aerosol lead concentrations and soil deposited lead from five homes in Detroit: One home was demolished, one home was fully deconstructed (ten days), and the remaining three homes were partially deconstructed (over one to five days), and then demolished. This study analysed the dust that was collected using a high volume air sampler. These particles were then analyzed using elemental ratios, and classified. Ayodle found that airborne dust concentration during demolition frequently exceeded National Ambient Air Quality Standards, and recommended dust suppression. The study recommended that the impacts of Deconstruction be measured by measuring lead depositional flux (dustfall rates) using buckets with liquid, rather than by determining the lead dustfall concentration in the soil. Due to the method of the study, the authors were unable to say if the total lead dustfall due to deconstruction was more or less than that during demolition.

Work to reduce pathways for blood lead contamination have shown that significant societal and economic benefits can be accrued from the investment to reduce lead hazards from indoor and outdoor paint using partial to full abatement. Protecting children from lead in buildings by remediating the building has shown to have significant economic benefits, with each dollar invested in lead paint hazard control resulting in a return of $17–$221 (Gould, 2009).

The present study proposed to measure the lead dustfall rate during the hybrid deconstruction of seven multi-family homes in an urban area in the Northeastern United States, and compare this to other methods of removal.

METHODS

A city block (85 m x 85 m) in the city of Syracuse, NY was chosen for the study. Eleven multi-family houses were located on this block and sequentially removed using hybrid deconstruction. During this process, lead dustfall rates were recorded for seven of the homes. The average size of the sampled homes was 283 sq. m., the average year of construction of the homes was 1928, and each of the homes had an interior lead survey performed before the deconstruction was done. The lead survey was performed on interior surfaces using an X-ray fluorescence (XRF) analyser by an accredited testing agency. HUD guidelines (1.0 milligram per square centimeter or greater) were used for the definition of lead paint, and all but one of the homes was found to contain interior lead paint. No testing was done for the presence of lead paint on the exterior. Detailed house information is shown in Table 1

Table 1. Housing characteristics for sampled multi-family homes

Home location	Year Built	Living Area (sq. m.)	Presence of interior lead paint
700 Raynor St.	1950	396	Yes
704 Raynor St.	1920	272	Yes
708 Raynor St.	1924	284	Yes
117 Standart St.	1940	164	No
119-21 Standart St	1922	283	Yes

125 Standart St.	1920	385	Yes
131-33 Standart St.	1922	**283**	Yes
Average	**1928**		

The houses were deconstructed over the course of two months, November and December of 2012. The approach selected for this work was a hybrid of demolition and deconstruction. Hybrid deconstruction entailed the planar building surfaces being separated into 2.5 m by 5m panel sections, and these sections being lowered to the ground for disassembly by hand or disposal. In this case, the larger wood members from the floor and roof assemblies were salvaged, while the smaller wood members (studs, plates, lath) located in the wall assemblies were not separated. The result of this approach was that the building could be broken down into these assemblies in one-two days, as opposed to the two-three weeks required for traditional on-site deconstruction.

The study data collection began by sampling the lead deposition rate during the deconstruction process. Previous studies (Mucha, 2009) placed their containers at an average distance of 5 m from the deconstruction activity. Containers for this study were placed just inside the perimeter at distances of 2-5 m from the deconstruction activity. Sampling was done just inside the property perimeter using the method described by Mucha et al. (2009) based on APHA 502. Four polyethylene sampling containers of 0.073 square meters surface area with 1 liter of water were located on portable stands that positioned them at approximately 2 m elevation above grade at the corners of the property. In some cases one or more of the corners of the site was inaccessible, or obstructed by machinery moving on the site. The containers were left open for dust fall for a period of 8 hours each day. At the end of the sampling period, the liquid in each container was transferred to a sterile bottle and transported to the laboratory. In the laboratory the liquid was filtered, and then the filter was dried and digested following EPA SW3050B. The remaining material was analyzed using inductively coupled mass spectrometry following EPA method SW6020. 30 total samples were taken from 7 different properties. Testing of samples included one control and processing included duplicate processing. The IC mass spectrometry measured weight of the lead was divided by the water surface area, and the hours left exposed, and the resulting value is reported as the deposition rate in ug/sq m/hr.

RESULTS

The geometric mean deposition rates were compared to two other studies, both from Chicago (Mucha, 2009)(Jacobs, 2013). One of these studies sampled lead dust fall at the perimeter of the work site, and the other study sampled the dustfall at an average distance of 5 m from the perimeter. .

Table 2. Comparison of results from studies of lead deposition rate during demolition and deconstruction

Location	Condition	Dust suppression	$N_{samples}$	$N_{address}$	Geometric mean (µg $Pb/m^2/h$)	Sampler location	Year
Chicago	Background		18	6	12.9		2009
Chicago	Demolition	Hose	25	5	48	5 m outside perimeter	2009
Chicago	Demolition	None	22	6	74.6	5 m outside perimeter	2009
Syracuse	**Deconstruction**	**None**	**29**	**7**	**61.3**	**Perimeter**	**2012**

Chicago	Demolition	Hose	84	NR	59	Perimeter	2013
Chicago	Demolition	None	13	NR	152.6	Perimeter	2013

NR = Not Reported

Based on an assumed demolition (without dust suppression) time of 8 hours for a single structure, and an assumed hybrid deconstruction time for primary separation and lowering of materials of 8 hours, the cumulative geometric mean leadfall deposition at the site perimeter would be 1220 µg Pb/m^2 for demolition and 490 µg Pb/m^2 for deconstruction. Based on the work of Gilson (2017), if these lead levels were left exposed on a surface (e.g. inside an adjacent home) for 30 days, this difference in lead levels would correspond to an additional increase in blood lead level of 10.95 µg/dL for the occupants next to the demolition site. The value of 10.95 µg/dL is well above the 5 µg/dL level of action recommended by the CDC (2012). The corresponding lead deposition due to deconstruction under a similar scenario, would cause a 4.40 µg/dL increase, below the 5 µg/dL level of action recommended by the CDC.

DISCUSSIONS

The lead deposition rate found in this study falls between the results for demolition with and without dust suppression found by Mucha (2009). The lead deposition rate found in this study is within 4% of the demolition with dust suppression found by Jacobs (2013).

Based on the comparison to both of the previous studies, the use of hybrid deconstruction reduces the lead fall deposition rate compared to demolition without dust suppression. Even in the case of demolition with dust suppression, deconstruction eliminates the water contamination and runoff resulting from dust suppression with a hose.

One difficulty with this study was that it was performed on buildings that were all deconstructed by the same firm. Measurements from hybrid deconstruction done by a variety of companies would provide a more representative sample.

A further difficulty is that location of the collection containers at the site perimeter does not accurately predict the impact on structures at a greater distance from the site.

CONCLUSIONS

While the result of the work clearly showed a reduction in leadfall deposition during the hybrid deconstruction process, there a number of considerations to note.

First, the deposition rate measured occurred over the eight-hour period of large panel separation and lowering to the ground. However, once on the ground, hand disassembly occurred over a number of days, and the possibility of continued elevated lead deposition exists. Ayodle (2014) found that during the full deconstruction process, aerosol lead increased during the third day when wall plaster and window frames were removed during the separation of wall elements, and the other days of deconstruction showed markedly less airborne dust. Comparison of total lead dustfall during the duration of the work could improve the direct comparison to demolition.

Second, the work that was done in this study set the measurement containers within the project perimeter. Because of this the comparison to other studies where the containers were located outside the worksite fencing is confounded. Jacobs (2013) study included sampling at distances up to 400 ft from the perimeter, and they found elevated levels at that distance.

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