Evaluation of Long-Term Efficacy of Soil Remediation Efforts in an Environmental Justice Community

Madeleine Barr[1], Tyler Belanga[1], Natalia Bialkowska[1], Fiona Lockyer[1], Philip Lu[1], Tiffany Roberts[1], William Rubin[1], Emilie Schuler[1], Hanna Wellish[1], Ken Yeoh[1], Sarah Assefa[2], Matt Feinstein[2], Anita Malpani[2], James Stewart[1], Joseph Allen[1], Theodore Myatt[1], Matt Fragala[1], Laura Goldin[1]

[1]Brandeis University, Waltham, MA; [2]Worcester Roots, Worcester, MA

INTRODUCTION

According to the Center for Disease Control, approximately 250,000 U.S. children between the ages of one and five suffer from blood lead levels of over 10 mg/dL, the criterion for concern among public health officials (CDC 2009). The main paths of exposure to lead include contaminated air, soil, water, food and consumer products, and the most common and dangerous source of lead poisoning comes from contact with deteriorating lead-based paint (CDC 2009). Children are a particularly susceptible population in terms of the risks associated with lead exposure. This is because children under the age of six absorb more lead and prove additionally sensitive to the harmful effects due to their developing nervous systems (Lippman 2009). In addition, young children come into contact with lead contaminated soil more frequently, because they typically touch objects and put their hands in their mouths, thereby ingesting large doses of lead relative to their body mass. Amongst children, those who reside in older houses, come from particular racial-ethnic groups, live below the poverty line or have occupationally exposed parents are at a proportionally higher risk for lead exposure (EPA 2010).

Due to the detrimental health conditions caused by lead exposure, organizations and governments have implemented low cost, urban remediation programs to reduce the amount of lead in particular communities. One organization that engages in these various low-cost lead remediation techniques is the Worcester Roots Project in Massachusetts. The organization is built by Worcester youth who form committees known as the Toxic Soil Busters and Youth in Charge, and help organize the community to carry out lead remediation projects and create healthy living spaces. They engage in a combination of phyto-extraction, soil amendment, biostabilization with perennials, raised beds, retaining walls and bioavailability techniques. Due to Worcester's industrial history and large number of older houses, childhood lead poisoning remains a significant public health issue that the Worcester Roots Project seeks to address (Bailey 1998) (Table 1). The objective of this study is to assess the impact of Worcester Root's soil remediation efforts conducted over the past five years.

Table 1: Demographic and housing data comparing Worcester City and Massachusetts

	Worcester City	Massachusetts
Total Housing Units	73,511	2,724,787
Total Housing Units built before 1980	81.9%	76.1%
Median Family Income (2008 Inflation-Adjusted Dollars)	53,333	81,056
% Children under 5 years Living Below Poverty Level	26.7%	14.1%
% People Living Below Poverty Level	17.5%	10.0%
Median Age	34.4	38.5
Total Population	163,637	6,469,770
% Population Under 5 years	5.7%	5.9%
% Total Population White	78.5%	82.7%
% Total Population Black or African American	9.0%	6.1%

Souce: U.S. Census Bureau, 2006-2008 American Community Survey

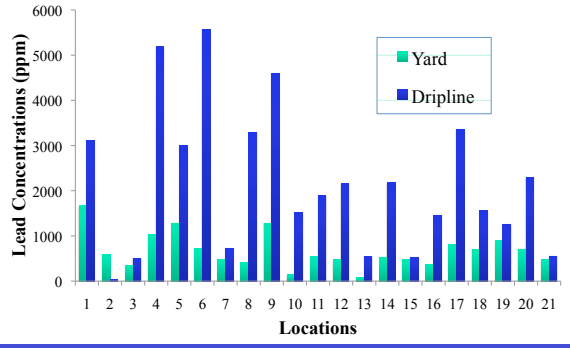
METHODS

To analyze the effectiveness of soil remediation, we re-visited homes that had been remediated and collected 3-5 new soil samples. Samples were collected from the drip line, any gardens or raised beds, and places where homeowners, in particular their children, may encounter lead exposure. The field team sketched the yard to display where the soil samples were taken. Each soil sample was placed in a separate polyethylene bag. Soil samples were homogenized and analyzed for lead content using an XRF analyzer. To estimate the impact of remediation on exposure, pre- and post-remediation soil lead concentrations (averaged by house) were entered into the US EPA Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK)

RESULTS

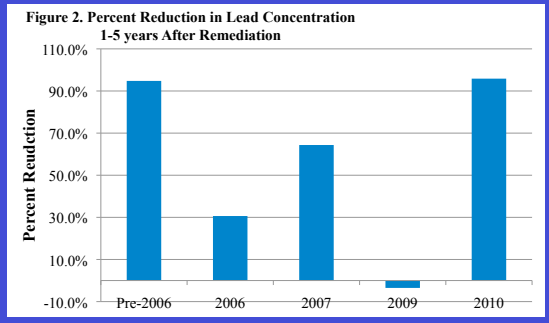
Post-remediation soil lead concentrations were significantly lower than pre-remediation concentrations (1947 ppm v. 945 ppm; p=0.02 (Wilcoxon Signed Rank Sum test)). Within a yard, lead concentrations were significantly higher at the dripline compared to samples collected elsewhere in the yard (p<0.0001)

Figure 1. Lead concentrations in soil at the dripline vs yard



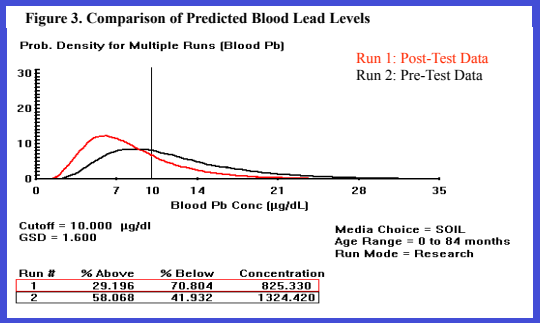
Soil lead concentrations from samples collected prior to remediation in 2005-2010 were compared to post-remediation concentrations as measured in 2010. The percent reduction in average soil lead concentrations is depicted in Figure 2. The most recently remediated yards (2010) had the greatest reduction in average soil lead concentration . A downward trend is observed over time; the benefit of remediation on lead concentrations was reduced over time, likely due to recontamination of remediated soil. The 'Pre-2006' data do not conform to this downward trend. This may be explained by the fact that before 2006, most of the areas remediated were community farms that are consistently replenished with fresh compost and plants (ie, continually remediated). This may explain why the pre-2006 data is the closest to the data from 2010 ; the yards that are consistently maintained are the yards least likely to see a relapse in high soil lead content.

Figure 2. Percent Reduction in Lead Concentration
1-5 years After Remediation



Using the median total lead concentrations of pre-test and post-test soil data, the IEUBK model predicts that approximately 58% of children aged between 0 to 84 months would have blood lead levels greater than 10 mg/dL before remediation. After remediation, it is estimated that only 29% of the same children had higher blood lead levels than 10 mg/dL (Figure 3).

Figure 3. Comparison of Predicted Blood Lead Levels



CONCLUSIONS

- Lead concentrations in multiple soil samples taken in a yard were only moderately correlated (Spearman r = 0.5, p<0.001).
- Lead concentrations were significantly elevated in samples taken at the dripline compared to samples from elsewhere in the yard (p<0.001)
- Low cost remediation did prove to lower the soil lead concentrations at remediated houses, on average, with the greatest effect seen in the first year post-remediation.
- The public health impact of the reduced soil lead concentrations is significant; the percentage of children estimated to have blood lead levels >10 mg/dL was reduced from 58% to 29%.
- Although remediated areas have a decreased lead content, partially remediated yards still present a risk of exposure due to non-remediated areas.