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Soil intervention as a strategy for lead exposure prevention: The New Orleans lead-safe childcare playground project

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ABSTRACT

The feasibility of reducing children's exposure to lead (Pb) polluted soil in New Orleans is tested. Childcare centers (median = 48 children) are often located in former residences. The extent of soil Pb was determined by selecting centers in both the core and outlying areas. The initial 558 mg/kg median soil Pb (range 14–3692 mg/kg) decreased to median 4.1 mg/kg (range 2.2–26.1 mg/kg) after intervention with geotextile covered by 15 cm of river alluvium. Pb loading decreased from a median of 4887 μg/m^2 (454 μg/ft^2) range 603–56650 μg/m^2 (56–5263 μg/ft^2) to a median of 398 μg/m^2 (37 μg/ft^2) range 86–980 μg/m^2 (8–91 μg/ft^2). Multi-Response Permutation Procedures indicate similar (*P*-values = 0.160–0.231) soil Pb at childcare centers compared to soil Pb of nearby residential communities. At ~$100 per child, soil Pb and surface loading were reduced within hours, advancing an upstream intervention conceptualization about Pb exposure prevention.

1. Introduction

Children, because of their physiological requirements for essential minerals, rapidly developing nervous systems, and their age-specific hand-to-mouth behaviors, are especially vulnerable to Pb exposure. Recent reviews indicate that blood Pb (BPb) as low as 2 μg/dL has adverse health effects to multiple organ systems including cardiovascular (Navas-Acien et al., 2007), renal (Fadrowski et al., 2010), and the neurological (Jusko et al., 2008).

The usual practice for determining environmental contamination is through children's BPb. The U.S. Centers for Disease Control and Prevention (CDC) guideline for elevated BPb is currently ≥10 μg/dL (U.S. CDC, 2005). A child's elevated BPb triggers an environmental investigation to find the source of Pb exposure; the approach is consistent with thinking downstream or a reactionary secondary prevention approach that responds only after poisoning and health damage has occurred (Butterfield, 2006; Steingraber, 1998). An alternative and proactive approach is what Butterfield (2006) considers upstream thinking; a focus on primary prevention and protection of children from ever being exposed. The possibility for primary prevention in metropolitan New Orleans exists because the environmental hazard, soil Pb, has been identified, surveyed and mapped using a relatively high median density of 19 samples per km^2 that are stratified by Census Tract (Mielke et al., 2005). The associations between soil Pb, age of housing, and BPb have been evaluated, and overall the strongest association is found between soil Pb and BPb (Mielke et al., 1997, 1999; 2007a). Additional supporting evidence concerning the strength of the association between soil Pb and BPb occurred after the devastating storms Hurricanes Katrina and Rita which washed Pb-safe sediments into New Orleans, variously covering the soils during the flooding of the city; as expected, the decrease of soil Pb was accompanied by a reduction of BPb (Zahran et al., 2010).

Numerous (n = 155) childcare centers including Head Start programs have opened in post-Hurricane Katrina/Rita New Orleans (Agenda for Children). Childcare centers are often created within established buildings that were previously used as residential properties. Because childcare centers are places with large numbers

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of children (median = 48) they are ideal intervention settings to lessen the impact of Pb pollution. For this project we build on experience regarding soil Pb surveys in New Orleans and Pb loading of soil surfaces (Mielke, 2005; Mielke et al., 2006, 2007b).

The purpose of this study is to test the feasibility of creating Pb-safe playgrounds at childcare centers as a starting point for primary Pb exposure prevention in New Orleans. The objectives were to determine the magnitude and extent of soil Pb on exterior play areas at childcare centers, to review the relationship between soil Pb and soil surface Pb loading at childcare centers throughout the city, and to compare the soil Pb results obtained from this project with the results of the New Orleans Survey II soil Pb map completed in 2001.

2. Methods

2.1. Project protocol

To determine the extent and magnitude of soil Pb within play areas of childcare centers of New Orleans, communities in both the core and outlying areas of New Orleans were selected for the project. Childcare center proprietors were contacted in the different communities and offered the opportunity for Pb-safe soil emplacement on their outdoor play areas. The location of 10 childcare centers and one community center selected for this project are shown Fig. 1 in the context of the 2001 Survey II residential soil Pb map (Mielke et al., 2005). Note that some residential communities within the inner city of New Orleans have excessive soil Pb where over half of the soil samples contain several times higher amounts of Pb than the U.S. EPA guideline of 400 mg/kg for areas where children may play.

Once a childcare center proprietor consented to be part of the project, our contractor was contacted to initiate the soil project. In order to shield childcare centers from liability, the soil emplacement was done prior to laboratory analysis of the soil and Pb loading samples. Using protocols established for the soil mapping projects, soil samples were collected from the 2.5 cm (1 inch) depth of the soil (Mielke et al., 2005), and wipe samples were collected to measure the *potential lead on play surfaces* (PLOPS) (Mielke et al., 2007b). Thus, on the day of the project, initial (i.e., before intervention) soil and PLOPS samples were collected and stored for subsequent chemical analysis.

The soil emplacement was conducted by first spreading out a bright orange, water pervious geotextile material to cover the original soil of the play area. The geotextile layer prevents Pb-safe soil from mixing with the underlying original soil and acts as a warning layer to anyone digging into soil. Soil was not removed from the play areas in this project.

The Pb-safe soil was from the Bonnet Carré Spillway, located up-river from New Orleans (U.S. ACE or Army Corps of Engineers). The alluvial soil, derived from the sediments of the Mississippi River at the Bonnet Carré Spillway, has a median Pb content of 5 mg/kg (Mielke et al., 2000). The Bonnet Carré soil was transported to the childcare center and emplaced on top of the geotextile layer to a depth of at least 15 cm (6 inches). This alluvial soil was deposited by the Mississippi River through the Bonnet Carré Spillway during April 2008, the most recent opening of the spillway gates (U.S. ACE). After the Bonnet Carré alluvial soil was emplaced on the childcare center properties, a second collection (i.e., after intervention) of soil samples and PLOPS were obtained.

2.2. Chemical analysis

After interventions on the exterior play areas were completed, all of the stored soil samples and PLOPS were prepared for Pb quantification according to our revised Survey II Chaney–Mielke room temperature (~22 °C) extraction protocols (Mielke et al., 2005, 2007b).

First the soil samples were dried and sieved (USGS # 10 sieve-2 mm). The extraction method involved weighing out 0.4 g soil portions into 50 ml polypropylene centrifuge tubes, adding 20 mL of 1 mol/L HNO_3acid to the soil, shaking the samples for 2 h, centrifuging the tubes, and filtering through Fisher brand P4 paper into 20 mL HDPE scintillation vials. An Inductively Coupled Plasma-Atomic Emissions Spectrometer (ICP-AES) was used for measuring Pb in the filtrate. The ICP-AES was calibrated with U.S. Department of Commerce, Technology Administration National Institute of Standards and Technology traceable standards (SPEX). Internal laboratory references included one low metal soil sample and one high metal sample collected from different parts of the city. Laboratory references were included in each run at a rate of 1 per 15 samples. Duplicate extractions were introduced every 15 samples.

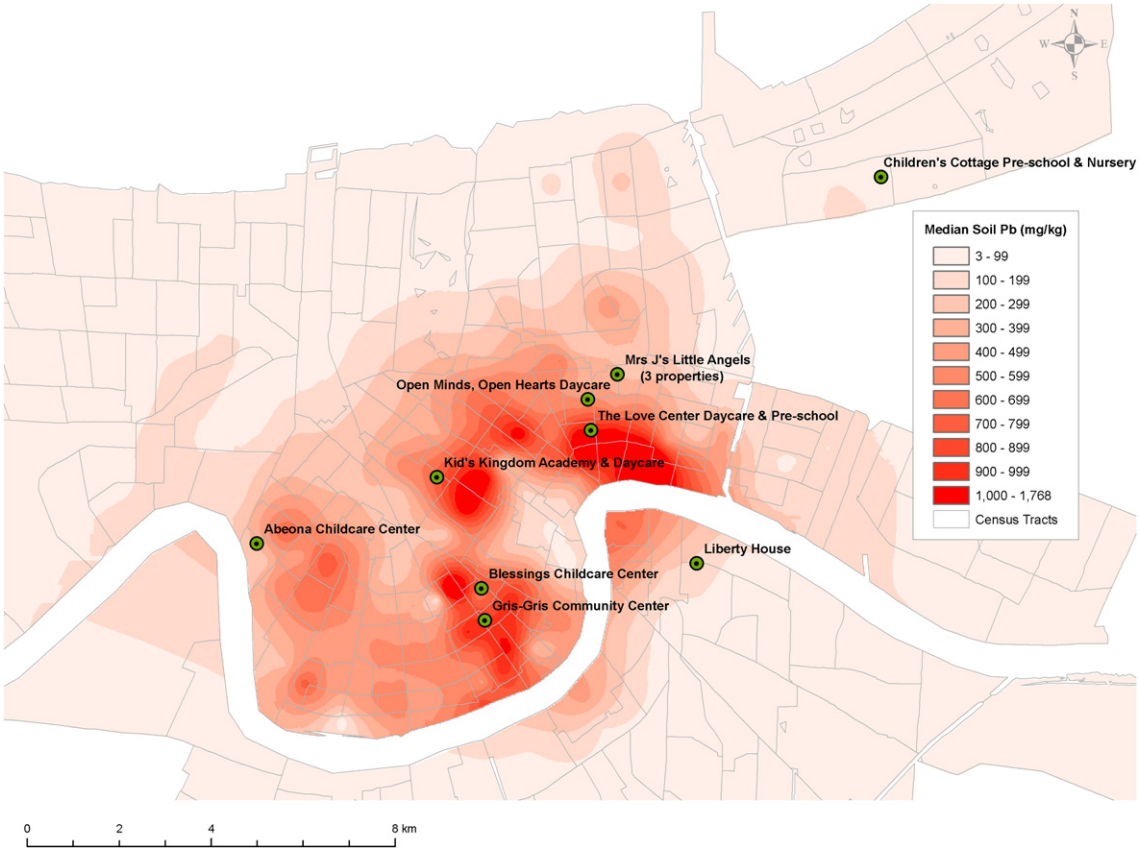

Fig. 1. Ten childcare centers and one community center in the context of the New Orleans soil Pb map (Mielke et al., 2005).