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New Orleans Soil Lead (Pb) Cleanup Using Mississippi River Alluvium: Need, Feasibility, and Cost

HOWARD W. MIELKE,*,†,‡
ERIC T. POWELL,†
CHRISTOPHER R. GONZALES,†
PAUL W. MIELKE JR.,§
ROLF TORE OTTESEN,‖ AND
MARIANNE LANGEDAL⊥

College of Pharmacy, Xavier University, New Orleans, Louisiana, Tulane/Xavier Center for Bioenvironmental Research, New Orleans, Louisiana, Department of Statistics, Colorado State University, Fort Collins, Colorado, Geological Survey of Norway, N-7491 Trondheim, Norway, and Department of Environment, City of Trondheim, N-7004 Trondheim, Norway

In New Orleans, LA prior to hurricane Katrina 20−30% of inner-city children had elevated blood Pb levels ≥10 μg/dL and 10 census tracts had a median surface soil level of Pb >1000 mg/kg (2.5 times the U.S. standard). This project tests the feasibility of transporting and grading contaminated properties ($n = 25$) with 15 cm (6 in.) of clean Mississippi River alluvium from the Bonnet Carré Spillway (BCS) (median soil Pb content 4.7 mg/kg; range 1.7−22.8). The initial median surface soil Pb was 1051 mg/kg (maximum 19 627). After 680 metric tons (750 tons) of clean soil cover was emplaced on 6424 m² (69 153 ft²), the median surface soil Pb decreased to 6 mg/kg (range 3−18). Interior entrance wipe samples were collected at 10 homes before and after soil treatment and showed a decreasing trend of Pb (p value = 0.048) from a median of 52 μg/ft² to a median of 36 μg/ft² (25th and 75th percentiles are 22 and 142 μg/ft² and 12 and 61 μg/ft², respectively). Average direct costs for properties with homes were $3,377 ($1.95 per square foot), with a range of $1,910−7,020, vs $2,-622 ($0.61 per square foot), with a range of $2,400−3,040 for vacant lots. Approximately 40% (86,000) of properties in New Orleans are in areas of >400 mg Pb/kg soil and estimated direct costs for treatment are between $225.5 and $290.4 million. Annual costs of Pb poisoning in New Orleans are estimated at ∼$76 million in health, education, and societal harm. Urban accumulation of Pb is an international problem; for example, the new Government of Norway established a policy precedence for an isolated soil cleanup program at daycare centers, school playgrounds, and parks to protect children. New Orleans requires a community-wide soil cleanup program because of the extent and quantity of accumulated soil Pb. The post-Katrina benefits of reducing soil Pb are expected to outweigh the foreseeable costs of Pb poisoning to children returning to New Orleans.

Introduction

In 1980, the late Clair Patterson presented a comprehensive view about lead (Pb) in urban areas when he stated, "Sometime in the near future it will probably be shown that all older urban areas of the United States have been rendered more or less uninhabitable by the millions of tons of poisonous industrial lead residues that have accumulated in cities during the past century (*1*)." Patterson's prediction was demonstrated by many studies reporting that Pb accumulated in urban soils from multiple sources is a major contributing factor to the overall Pb problem in numerous U.S. cities (*2*−*8*).

Early direct evidence of the urban accumulation of Pb was presented by a study of metropolitan Baltimore where high soil Pb samples were so tightly clustered toward the inner city compared to outlying areas that chance alone could not explain the results (p value $\sim10^{-23}$) (*9*). A comparative study of large cities in Minnesota and Louisiana provided additional perspective on the enormity of the soil Pb reservoir by calculating that the top 0.000984 in. (0.025 mm) of the soil contains between 558 and 2976 μg Pb/ft² (6000−32 000 μg Pb/m²) (*10*). These levels far exceed the established value of 40 μg per ft² (430.6 μg Pb/m²) set for the interior floor by the U.S. Environmental Protection Agency (EPA) (*11*).

In Los Angeles, resuspension of Pb from soil was identified as a major source in balancing the input and output of Pb in a modeling study, and thus soil will remain as a major contributor of environmental Pb for many decades into the future (*4*). Resuspension of soil Pb also appears to account for the strong correlation between soil dryness and children's peak blood Pb in cities with climates as different as Indianapolis, IN, Syracuse, NY, and New Orleans, LA (*6*). An empirical study of Pb dust accumulation in New York City showed that exterior sources of Pb dust loading are driving interior accumulations of Pb dust and that the average amount of dust accumulating on exterior surfaces in only two weeks results in Pb dust loading that exceeds the U.S. guideline of 40 μg Pb per ft² (*2*, *11*). Research on Pb contaminated residential soils (∼1000 mg/kg) at a former smelter site describes the relationship between exterior soil Pb and interior Pb dust and indicates that community-wide cleanup of soil Pb ultimately results in reducing children's blood Pb (*12*).

Meanwhile, research advances about the effects of even small exposures to Pb are being demonstrated. First, IQ deficits from Pb exposure are more severe than previously recognized. The effects of Pb on the IQ of children are curvilinear and blood lead levels less than the CDC guideline of 10 μg/dL may result in a larger decline in IQ (7.4 points per 10 μg/dL) than blood Pb over the entire range of exposures (4.6 IQ points per 10 μg/dL) (*13*). Second, children's blood Pb is much more strongly associated with soil Pb (p value $\sim10^{-24}$) than it is with age of housing (p value $\sim10^{-12}$), the common surrogate for Pb-based paint exposures (*14*). The major implication is that although children with low blood Pb are associated with census tracts with new housing, children with high blood Pb live in census tracts with both old and new housing. In contrast, the pattern for soil Pb is more straightforward; children with high blood Pb live in census tracts with high soil Pb and children with low blood Pb live in census tracts with low soil Pb (*14*). Third, when

* Corresponding author e-mail: howard.mielke@gmail.com.
† College of Pharmacy, Xavier University.
‡ Tulane/Xavier Center for Bioenvironmental Research.
§ Colorado State University.
‖ Geological Survey of Norway.
⊥ City of Trondheim.

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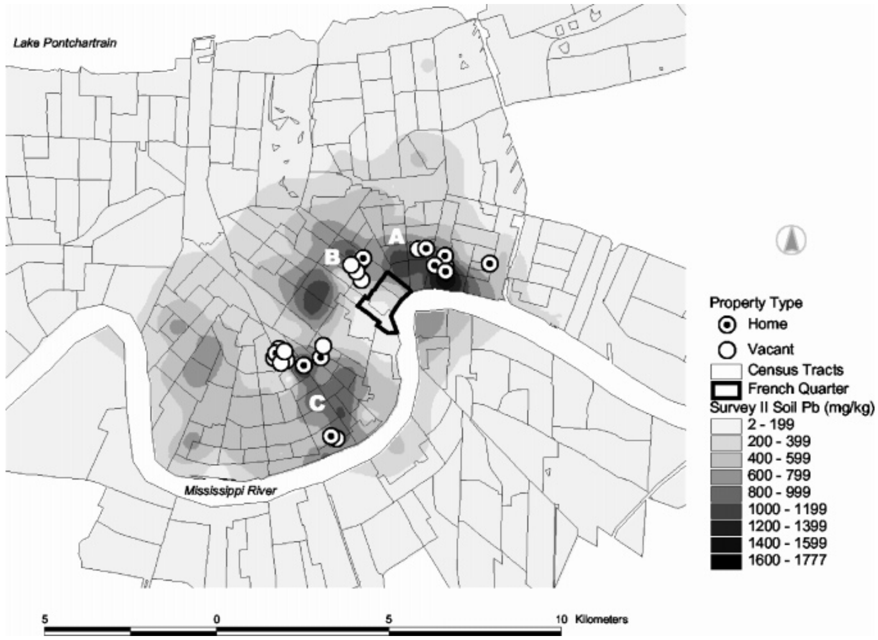

FIGURE 1. Map of New Orleans showing 10 census tracts that contain a median soil Pb content of 1000 mg/kg or more. The map was produced from a survey of 5467 soil samples stratified by 286 census tracts of New Orleans (*29*–*31*). See text for letter key.

data are stratified by census tract, the association between soil Pb and blood Pb is curvilinear and extremely strong (p value $\sim10^{-23}$) (*15*). The slope of the curve of blood Pb is steeper when soil Pb is below 100 mg/kg (i.e., ppm) whereas above 100 ppm the blood Pb response flattens out, and this relationship was also identified in Syracuse, NY (*5*). In accord with the curvilinear relationship between IQ and blood Pb, children are far more sensitive to lower amounts of Pb in soils than is generally recognized (*8*). Fourth, in New Orleans, achievement scores of 4th grade students are directly associated with the amount of metals (including Pb) accumulated in the soils of the communities that correspond with each school. The results for Pb for all 4 achievement scores, English Language Arts (ELA), Social Studies (SOC), Mathematics (MAT), and Science (SCI), were strong (p value $< 10^{-5}$) and indicated a strong connection between student achievement, as measured by the tests, and amount of soil metal in the community of each school (*16*). Many metals and organics have accrued in the urban environment and they are all strongly associated with Pb and with each other (*16*, *17*). The above studies in New Orleans strongly suggest that the accumulated amount of Pb is so large it is hazardous to children's health and welfare. These studies support Patterson's statement about the Pb accumulation and habitability for families, especially children, living in all old (and larger) urban areas (*1*).

Exterior soil and interior dust are recognized as sources of Pb exposure to children especially because of their play and hand-to-mouth behaviors. Studies incorporating measurements of Pb dust on hands before and after outdoor play indicated that in inner-city communities children's hands became Pb-contaminated after playing outside (*18*–*20*). In a Danish study of children's hand Pb, a significant reduction was noted when soil containing 100–200 mg Pb/kg (several times higher than the 40 mg/kg Danish soil Pb standard) was replaced with soils containing ≤10 mg Pb/kg (*21*). Studies have also noted that when soil Pb is specifically targeted for corrective action, blood Pb of children also decreased over time (*12*, *22*–*25*).

In pre-Katrina New Orleans, around 20–30% of the children of inner city New Orleans had elevated blood Pb levels (*26*, *27*); the range is due to the climate-related influence of dry soil on blood Pb levels (*6*). For the entire city, the rate of elevated blood Pb of children was 14% (*26*).

The purpose of this paper is to describe the effects of emplacing clean soil (<10 mg Pb/kg) on residential properties within extremely Pb contaminated communities (soil >1000 mg/kg) based on exterior soil and interior dust samples. The study was completed the week before the August 29, 2005 catastrophic flooding of 80% of New Orleans that occurred in conjunction with Hurricane Katrina. Measurements of the environment, and not of the children, were used to determine research outcomes (*28*). Costs of emplacing clean soil were carefully recorded for each part of the project. We hypothesize the following: (1) the soil surface Pb will be substantially reduced after clean soil emplacement; (2) there will be a concurrent decrease in Pb dust at interior entrance floors of homes; and, (3) the median amounts of surface soil Pb measured on the residential properties will be similar to the median amounts predicted by the most recent soil Pb map of New Orleans (*29*–*31*). Finally, we expect that the children living on the treated properties will benefit with a decrease of their blood Pb as a result of the reduction of Pb from exterior soils and home interior dust.

Materials and Methods

To study the effect of emplacement of clean soil on Pb contaminated residential properties the following tasks were completed: (1) selection of 25 properties as test sites,; (2) conduct of soil sampling and interior floor wipe sampling to measure the interior Pb dust on each property before corrective action; and, (3) follow-up soil sampling and interior floor wipe sampling to measure the amount of Pb after the emplacement of clean soil at the test sites.

Property Sites. Inclusion in the study was based on properties with homes and vacant lots having a predicted soil lead concentration of >1000 mg/kg as determined by our previous metals mapping project (*29*–*31*) (see Figure 1). The selected census tracts were located in three groups of communities: (A) Bywater/St. Roch/St. Claude; (B) Tremé/Lafitte; and (C) Central City and Irish Channel.

The participating property or lot owners voluntarily signed consent forms to permit Pb testing and soil emplacement on their properties. All activities and forms were reviewed by the Xavier Institutional Review Board and given an expedited approval because human subjects were not a component of the soil emplacement study. The presence of children and/or blood Pb results were not a criterion for participation in the project.

Of the 25 properties, two types were included in the study: home sites and vacant lots. Fifteen of the sites were residential lots with existing homes. All of the homes were old, wood-sided structures. Ten vacant properties were selected for treatment prior to new home construction. In New Orleans, many blighted buildings have been condemned and razed and the lots are scheduled for redevelopment. The purpose of including vacant properties was to evaluate the impact of home construction on the surface soil Pb of treated lots.

Emplacement Soils from the Bonnet Carré Spillway. New Orleans is protected from Mississippi River flooding by a water diversion channel, the Bonnet Carré Spillway (BCS), from the river directly through Lake Pontchartrain to the Gulf of Mexico. The spillway gates were last opened during the 1997 spring flood event of the Mississippi River, and therefore, the BCS soils are relatively fresh sediments deposited as alluvium (*30*). Previous research reported that the BCS alluvium contains a median of 4.7 mg/kg Pb with a range of 1.7−22.8 mg/kg Pb or approximately one hundredth the amount of Pb allowed by the U.S. 400 mg/kg standard (*11*, *30*); also, the BCS alluvium contains only traces of organic toxicants (*32*, *33*). On an average basis ∼272 metric tons (300 U.S. tons) of sediment per minute are transported by the Mississippi River past New Orleans. BCS soil samples were collected for Pb analysis after they were deposited on the properties.

Soil Samples and Emplacement Actions. Soil sample collection was done using a stainless steel trowel from a depth of 2.5 cm (1 in.). Three samples were taken before and after soil emplacement on each property. To determine the variation of Pb that occurred on each property the collected samples were not composited and mixed. The individual soil samples were placed into labeled polyethylene bags and taken to the laboratory for drying, extraction, and analysis according to protocols described previously (*14*, *15*, *29*).

Emplacement action involved two hired contractors: one with trucks and the other with experience in measuring and grading soils on properties. Emplacement involved transporting BCS soil to a property and then landscaping it on the surface to a depth of 15 cm (6 in). Landscape grading was done in accordance with the New Orleans runoff standards; i.e., the surface had to slope toward the street and the landscaping had to be designed to prevent pooling of water on either the treated or neighboring lots.

Floor Wipe Samples. Baby wipes (Huggies Natural Care) were used for collection of samples to test the amount of Pb in floor dust at home interior entrances using HUD collection protocols (*34*). [The median for the wipe sample blanks was 8.2 μg Pb/ft^2 (10% = 5.8, 90% = 12.7, $n = 66$). The maximum result, 13.8 μg/ft^2, was subtracted from the analytical results for each wipe sample. The detection limit for the wipe samples was 5.8 μg/ft^2 for our ICP.] The wipe samples were collected from an area of 1 ft^2 on bare floor of the home entrance. The results are expressed in the units of μg/ft^2 (1 ft^2 = 0.0929 m^2) in accord with the HUD/EPA interior uncarpeted floor standard of 40 μg Pb/ft^2 (*11*). All 15 homes were sampled for entrance dust wipes before soil emplacement. Floor wipe samples were collected, where possible, at the front, side, or back entrances of the 15 study homes. In two homes, single sampling was conducted due to only one entrance. After soil emplacement, entrance floor wipe sampling in 5 homes was not completed because of the Hurricane Katrina flooding of New Orleans (August 29, 2005); all 25 properties were flooded with varying depths of water. Therefore, data for only 10 homes were measured for wipe samples collected both before and after soil emplacement ($n = 18$ paired wipe samples). Most of the homes were not reoccupied as of February 2006.

Serendipitous Blood Pb Measurements. Any serendipitous blood Pb measurements that happened to be available for children living at these properties were collected by the New Orleans Childhood Lead Prevention Program. The property owners participating in the study voluntarily released these results.

TABLE 1. All Before and After Soil Samples Compared with Soil Samples of Census Tracts Stratified by Community Groups A, B and C[a]

	all soil samples		community A		community B		community C	
percentile	before	after	before	after	before	after	before	after
min	5	3.0	93	3.4	43	3.0	5	3.1
25%	438	4.8	560	5.4	284	3.4	217	5.2
median	*1051*	*6.3*	*1168*	*6.8*	*1279*	*4.1*	*1047*	*6.8*
75%	1977	8.7	2606	11.7	3492	5.2	1627	8.6
max	19627	17.9	19627	16.7	6804	10.6	5931	17.9
N	75	77	32	30	8	13	35	34

[a] All results are listed as soil Pb in mg/kg.

Results and Discussion

The data were evaluated for changes before and after BCS soil emplacement. All results are strictly based on empirical distributions, and appropriate data-dependent statistical methods were used in the evaluations (*35*). Direct costs of soil emplacement were also determined.

Soils Stratified by Community Group. Table 1 presents descriptive statistics for lead in soil before and after emplacement and descriptive statistics stratified by community.

As can be seen in Table 1, there were statistically significant reductions of soil Pb for all 3 community groups. Prior to soil emplacement, the median soil Pb for the overall results was 1051 mg/kg, and the medians for communities A, B, and C were 1168, 1047, and 1279 mg/kg, respectively. These results validate the soil Pb map results which predicted that the median soil Pb for these three communities would be ≥1000 mg/kg (*29*−*31*). As expected, covering properties with clean BCS alluvial soil reduced the median surface soil Pb to 6.3 mg/kg (range 3.0−17.9). The results of the emplaced soils were not significantly different from the median Pb content of 4.7 mg/kg (range 1.7−22.8) previously reported for the alluvium of the Bonnet Carré Spillway (*30*). Comparisons among all soil samples and the soil samples stratified by individual communities were made with the Mann−Whitney Rank Sum Test and indicated no significant differences in the soil Pb results among communities.

Pb Results Stratified by Properties with Homes and Vacant Lots. Table 2 is an overview of the Pb percentiles both before and after soil emplacement results for properties with existing homes and vacant lots.

As shown in Table 2, before soil emplacement, soil Pb on properties with homes measured a median of 1430 mg/kg (range 5−19 627 mg/kg) and for vacant lots measured a median of 797 mg/kg (range 37−5931 mg/kg). This finding is similar to previous research that has also shown that soil samples from open spaces away from buildings generally contain less Pb than soil samples collected next to structures (*10*, *36*, *37*). There are several explanations for this observation. First, housing structures were often painted with Pb-based paints and when these coatings deteriorate or are deliberately removed by such procedures as power sanding, the Pb accumulates in the soil next to the structure (*7*, *36*, *37*). Second, tiny particles of Pb (from airborne sources) are extremely dense and impact on vertical surfaces where they

TABLE 2. Before and After Samples Stratified by Homes (Including Entrance Wipes) and Vacant Properties

	homes				vacant lots	
	soil[a]		entrance wipes[b]		soil[a]	
percentile	before	after	before	after	before	after
min	5	3	10	5	37	4
25%	509	4	22	12	111	7
median	*1430*	*6*	*52*	*36*	*797*	*8*
75%	2111	8	142	61	1174	9
max	19627	18	201	239	5931	18
N	53	55	18	18	22	22

[a] Units for the soil samples are mg Pb/kg. [b] Units for the entrance wipes are μg Pb per ft^2 of bare floor surface.

are then washed by rain down those surfaces and accumulate in the soil next to the building (*38*−*40*). Resuspended soil Pb would also be captured by buildings' vertical surfaces and end up accumulating in the soils along the sides of buildings by the same process (*4*, *38*, *39*). Finally, the process of razing houses generates Pb dust on properties, but razing is also accompanied by the addition of new fill to level the land and this action may reduce the amount of Pb in the open space of the vacant lot.

The median Pb of the before and after soil samples (Table 2) is reduced by a factor of 238 for properties with homes and reduced by a factor of 100 on vacant lots. The small amount of soil Pb on the New Orleans properties and lots after emplacement is the amount expected on the Delta of the Mississippi River if the human-caused accumulation of Pb contamination had not occurred (*30*, 40).

Wipe Results. The interior entrance wipe results are presented in columns 4 and 5 in Table 2. Before new soil was emplaced on the properties, interior wipe samples were collected from home entrances and these measured a median of 52 μg Pb/ft^2 and exhibited a range of 22 and 142 μg Pb/ft^2, respectively, between the 25th and 75th percentiles. After clean soil was emplaced on these same properties, the median entrance wipe sample decreased to 36 μg Pb/ft^2 and exhibited a range of 12 and 61 μg Pb/ft^2, respectively, between the 25th and 75th percentiles. The time between emplacement and soil wipe measurements ranged from 1 to 3 weeks. An exact one-sided Fisher−Pitman *t*-test result for these 18 before and after matched-pair samples is significant (p value 0.048). This result supports the hypothesis that covering Pb contaminated exterior soils with clean soil significantly reduces Pb dust being transferred into the home interior entrances and supports other study findings of the same phenomenon (*12*, *24*, *25*).

Decrease in Blood Lead of Children. Serendipitously, three children enrolled in the New Orleans Childhood Lead Prevention Program happened to live in two of the 15 contaminated home properties included in this study. Six months after the completion of the soil emplacement action the blood Pb levels of the children decreased from ~15−20+ μg Pb/dL to ~8 μg/dL. The decrease took place during an extended dry period when blood lead was expected to increase as indicated by Laidlaw et al. (*6*). The decreases of blood Pb are consistent with those of a controlled study of the effect of exterior soil Pb reduction in contaminated communities of Minneapolis and St. Paul, MN that demonstrated the benefits of containment of soil Pb on blood Pb of children (*24*). When the soil Pb was reduced by a factor of 3−4, the target group of children ($n = 23$) experienced a significant downward trend (p value = 0.0061) of blood Pb, with 52% of children exhibiting decreases, 44% remaining the same, and only 4% exhibiting increases. During the same time period, a control group ($n = 17$), where no actions were taken on soil Pb, 29% of the children exhibited decreases of their blood Pb, 18% remained the same, and 53% exhibited increases of blood Pb (*24*). Although the cohort is extremely small, the New Orleans children responded to clean soil in the same positive way as the children of Minnesota.

Costs of Covering Soil. The direct costs included only soil hauling and landscaping because the soil was available at no cost. Contractors were hired to haul and landscape soil. Properties with homes were planted with grass seed mixed with water and fertilizer (i.e., hydroseeded) by a garden center contractor. One hundred truck loads of clean BCS soil were hauled to the project sites. The total area of property covered with clean soil was 6424 m^2 (69 153 ft^2). The total mass of soil hauled and graded was 1307 m^3 (1710 yards^3) weighing around 680 metric tons (750 U.S. short tons). This is about the average amount of sediment transported by the Mississippi through New Orleans every 2.5 min, and, thus, the clean soil resource is virtually unlimited (*31*).

The costs of emplacing soils on properties with homes averaged \$1.95 (range \$0.93−5.63) per square foot and were higher per square foot than the costs of covering vacant lots, average \$0.61 (range \$0.45−0.97) per square foot. See Supporting Information, SI 1, for a full accounting of the costs for hauling, landscaping, and hydroseeding soil on the 25 test sites in this study. The ease of doing the work on vacant lots kept the costs down per area; properties with existing homes required more manual labor, thereby increasing the cost. Hydroseeding clean soils on properties with homes added about 10% to the expenses. Clean soils at two homes were not hydroseeded because the home owners chose to use sod instead of hydroseeding to establish the lawn and this was not paid for by the project.

Other Processes that Increase Pb Availability. Covering Pb contaminated soil on isolated properties will not alone solve the Pb exposure problem for the children of New Orleans. The main issues are old Pb-based paint and Pb resuspension from Pb contaminated soils. New Orleans is an old city with large sections of pre-1950s housing coated with Pb-based paint (*41*). The costs associated with cleanup after unsafe Pb-based paint removal is many times the cost of lead-safe paint removal practices (*42*). The New Orleans City Council enacted city legislation in September 2001 to ban the power sanding of Pb-based paint. Unfortunately, the ban is not entirely successful. One issue is that the U.S. legal definition of old Pb-based paint on the surface of a structure is 5000 ppm or 1 mg/cm^2 as measured with X-ray fluorescence (XRF) (*11*). If painting contractors submit paint samples that contain less than 5000 ppm Pb, they are free to handle painted surfaces in any way they choose. This usually results in power sanding and the environmental release of enormous quantities of Pb dust. Unsafe painting practices continue, and as a result, Pb exposure continues to be a hazard to the painters, their families, the inhabitants of the building, and the surrounding environment. A total ban on any method that pulverizes and disperses Pb from old paint to the environment would help prevent Pb poisoning of children of New Orleans. Alternative safe Pb-based paint removal methods are available that curtail the release of Pb into the environment (*41*, *42*).

A New Orleans Clean Soil Program. The pre-Katrina prevalence of elevated blood Pb of children in the entire city was 14% and up to 30% for inner-city New Orleans (*26*, *27*). To meet the U.S. Centers for Disease Control (CDC) Healthy People 2010 goal of "no children with an elevated blood lead level (10 μg/dL or higher) (*43*)" will require monumental primary prevention for making New Orleans safe for children and must include a clean soil program.

Precedence for a clean soil program was announced by the National Government of Norway which stated that in

2006 they will produce a national plan for investigating local and isolated soil pollution at all daycare centers, kindergartens, and schoolyards, and, if necessary, soil cleanup. Research on soil pollution supporting the policy was carried out by the Geological Survey of Norway in cooperation with the local health and pollution authorities (*44*) and is further elaborated in SI 2. The National Public Health Authorities of Norway provide the abatement levels of 100−150 mg/kg for Pb, much lower than the 400−1200 mg Pb/kg action level in the United States. (*11*). The clean soil will come from local soil sources, usually with <20 mg Pb/kg (*45*). The soil hazard control policies of Norway are also supported by other studies that have included soil abatements or landscape covering to reduce soil Pb hazards (*21*, *24*, *25*, *46*).

Resuspension of Pb from soil was described in the Introduction as a major contributor to the ongoing dispersal of Pb (*2*, *4*, *6*). New Orleans soils became so contaminated with Pb that covering isolated properties with clean soil will not significantly prevent continuing exposure of urban inhabitants, especially children under age 6. The Pb from contaminated soils will be resuspended and dispersed into neighboring properties in the same manner as described for a community surrounding a former Pb smelter (*12*, *25*). Thus, to protect the children from the more severe Pb problem in New Orleans there must be a more extensive, community-wide clean soil program than that for isolated properties announced by Norway.

From the Pb map we estimate that 40% of properites, or 86 000 properties, contain at least 400 mg/kg or more soil Pb. Given the direct costs obtained for the 25 properties in this project, the estimated direct cost of covering the most contaminated properties of New Orleans in 2005 would be between $225.5 and $290.4 million. Post-Katrina New Orleans, with large sections of the city currently vacated, provides an ideal situation to undertake such a project.

To place the cost of soil cleanup in New Orleans into proper environmental health perspective, consider that the annual U.S. costs of lead poisoning (including costs of direct treatment plus other costs such as special education and reduced lifetime learning ability) is estimated at 2.2% of the total U.S. healthcare costs or $43.4 billion (*47*). If the costs for the pre-Katrina New Orleans childhood Pb poisoning were proportional to the national costs, then the costs to New Orleans would have been ∼$76 million annually (*47*). There are other large Pb related societal costs that ripple beyond IQ deficits into the arena of violent crime, diabetes, and unwed pregnancy, all of which have implications to an array of social, medical, and psychological outcomes (*48*−*50*). A post-Katrina clean soil project would improve New Orleans by reducing the amount of Pb easily available from the soil surface and thereby help prevent recurrence of the pre-Katrina prevalence of childhood Pb poisoning. The benefits to New Orleans are expected to outweigh the costs associated with Pb poisoning of the children of New Orleans. Given the number of cities where a similar pattern of Pb is identified as predicted by Patterson (*1*), we expect that large cities in the United States and abroad may require a soil cleanup program to create Pb safe environments for children.

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Note Added after ASAP Publication

The first author's name in ref 2 was misspelled in the version published ASAP March 10, 2006. The corrected version was published March 10, 2006.

Supporting Information Available

SI1, Table 3 (direct costs for emplacing clean soil on contaminated properties with homes or vacant lots, including the costs of hauling soil, grading soils to meet landscape standards, and hydroseeding of properties with homes; if clean soils were emplaced on a community-wide basis to areas where map surveys indicate excessive quantities of soil Pb then administrative and indirect costs would be relatively low); SI2, Norwegian policy (new Norwegian Government policy requiring that soil at all daycare centers, school properties, and playgrounds (generally isolated and localized) be tested for lead and other toxic substances and remedied if they exceed the guidelines set by the National Public Health Authorities of Norway; references used to advance Norway's policy toward safe play areas for children). This material is available free of charge via the Internet at http://pubs.acs.org.

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