One in four US Households likely in violation of new US soil lead standard

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Abstract

Lead exposure has blighted communities across the United States (and the globe), with much of the burden resting on lower income and communities of color. On January 17, 2024, the US Environmental Protection Agency (USEPA) has, after more than 30 years, lowered the allowable level of lead in residential soils. Our analysis of tens of thousands of citizen-science collected soil samples from cities and communities around the US reveals the scale of the soil lead problem, and the challenge that the USEPA will face in implementing its new soil standard. Under this standard, we find that nearly one quarter of households may contain a soil lead hazard. Extrapolating across the nation, that equates to nearly 30 million households needing to mitigate potential soil lead hazards, at a potential total cost of 290 billion to - $1.2 trillion. We do not think this type of mitigation is feasible at the massive scale required and we have instead focused on a more immediate, far cheaper strategy: capping current soils with clean soils and/or mulch. At a fraction of the cost and labor of disruptive conventional soil mitigation, it yields immediate and potentially life-changing benefits for those living in these environments.

Keywords
Lead, soil, contamination, lead poisoning, USEPA

Synopsis
The USEPA recently reduced its soil lead standard. We find that nearly one in four households may now contain a soil lead hazard, challenging the current expensive approach to mitigation.

Introduction

Lead exposure has blighted communities across the United States, with much of the burden resting on lower income and communities of color. The reasons behind this disproportionate exposure are myriad, including Redlining and other societal shifts during the 20th century, but the results are manifest in lower educational outcomes and lower economic potential for exposed communities. Despite immense current federal efforts to “get the lead out,” our national lead problem is nowhere near over.

With the Clean Air and Clean Water Acts, US policy began severely limiting the production and use of lead in infrastructure and consumer products, including water pipes, paint, and gasoline that have been historical sources of lead entry into the environment. The results have been stunningly successful and quite positive overall—with a decline in the percentage of children affected by lead (by modern standards) from nearly 100% of the population in the 1970s to about 1% today. However, these improvements in health outcomes are not shared equally, and many urban children are still exposed to lead at unsafe levels. Notably, this continuing toxic exposure does not primarily come from the pipes, paint, and gasoline targeted by the Clean Air and Water Acts. Degradation of aging lead-based paint on pre-1980s housing, and past deposition from leaded gasoline and industrial emissions, means that urban lead is now in the soils and dust upon which neighborhoods are built, children play, and food is grown. In other words, our modern lead problem is a legacy of historical contamination: the lead is still largely "out there" and posing continued risks to communities.

In recognition of this continued exposure from soil, and the dust generated from those contaminated soils (e.g., Laidlaw et al., 2012), on January 17, 2024, the US Environmental Protection Agency (USEPA) has, after more than 30 years, lowered the allowable level of lead in residential soils. The original allowable level, below 400 parts per million (ppm, or mg/kg) of lead in soil, was based on the science of the time, linking contaminated soils to average blood lead levels of children living in these locations. While the Centers for Disease Control and Prevention has continuously ratcheted down the blood lead standard for children's health, from 10 micrograms per deciliter in the 1990s to the current 3.5 micrograms per deciliter health safety standard, the soil standard has remained unchanged, until now. In recognition of this public health prevention mismatch, several states, including California and Minnesota, instituted lower more protective soil lead standards. Why then has the USEPA soil lead standard lagged behind? We propose that it is simply the immensity and ubiquity of the problem.

Results and Discussion

Our analyses of tens of thousands of citizen-science collected soil samples from cities and communities around the US (MapMyEnvironment, 2024) and supplemented by similar sample sets from colleagues around the country reveal the scale of the soil lead problem. These samples don't come from Superfund clean-up sites, but rather from the soil around real residential properties nationwide that people live in a call home.

The new USEPA soil screening level has been set at 200 ppm for residential properties. At residential properties with multiple sources of lead exposure, the USEPA will generally use 100 ppm as the screening level. This is heading closer to the standard adopted by California (80 ppm) and those of many other countries. The change is welcomed by environmental health professionals around the country, as it reflects our knowledge of today's major lead exposure sources being largely soil-based. But our analysis of the on-the-ground reality suggests why it has taken the USEPA awhile to lower this protective standard—namely, once the threshold for lead in soils is lowered, the agency needs to consider providing guidance and resources to every household whose soils exceed the new threshold. The scale is astounding, and the nation's lead remediation efforts just became substantially more complicated.

Our nationwide analysis of our citizen science database of 15,595 residential soil samples reveals that in the US, just over 12% of residentially collected soils (including from yards, gardens, driplines, alleys, etc.) exceed the previous standard of 400 ppm (Table 1; Fig. 1). This alone is a startling finding, but when the standard is decreased to the new 200 ppm screening level, nearly one quarter of households contain a lead hazard. Extrapolating across the nation, that equates to roughly 29 million households (out of 123.6 million total based on the 2020 census) needing to mitigate potential soil lead hazards. As that level drops to the screening level of 100 ppm for residences with multiple lead exposure sources, which just over 40% of household soil samples exceed, the number goes up to nearly 50 million households.

The integrated dataset upon which these analyses were conducted does include some differences in sampling protocols, sampling dates, and sampling dates for various municipalities. For example, the cities of Chicago, Indianapolis, and New Orleans utilized similar citizen-science approaches for collecting large numbers of samples that represent community-scale lead distribution, which we feel is highly representative of household exposure potential. One outcome of this approach is that these municipalities have a much higher percentage of household soils that have high lead values, including Chicago with 53% of household soils above the new 200 ppm standard (Table 1). Meanwhile, other municipalities have soil samples that are either collected by researchers to identify hotspots and backgrounds (i.e., South Bend) or were specifically focused on urban background locations (Table 1). Samples were collected at various times over the past 15 years, and lead concentrations might have changed due to land use practices, disturbance, and/or new additions of lead (e.g., from deteriorating lead-based paints). It is thus difficult to fully assess city-specific soil lead burdens, both because of the limitations of the citizen science dataset upon which this analysis is based (i.e., uneven sampling throughout a city) and because there is no other systematic, comprehensive measurement of residential soil lead values across the US.

Our citizen science initiatives are intended to empower people with knowledge about lead exposure risks at their homes and in their neighborhoods. While these initiatives have provided us with far more data points than we could have collected ourselves, the voluntary nature of citizen science means that the distribution of data points is not homogenous. In metro areas with high levels of participation (New Orleans, LA; South Bend, IN; Indianapolis, IN; Chicago, IL), we can be more confident in our assessment of the overall soil lead burden than in metros where data is scarce. Likewise, our extrapolations of the numbers across the US are subject to the limitations of the dataset and should therefore be considered preliminary. We anticipate that the new USEPA soil lead screening level of 200 ppm will raise awareness of the ongoing lead problem and increase participation in our citizen science initiatives. This, in turn, will grow our dataset and improve projections. In the meantime, these preliminary results are nevertheless illustrative of the massive scale of the task ahead in light of the new USEPA soil standard.

These results indicate that soil lead in residential neighborhoods can be an issue, and we don't really know which particular households, besides older homes being a general risk factor (e.g., Dietrich et al., 2023a), have the greatest risk potential This is due both to the paucity of publicly available data for lead and to the very small spatial scale at which lead hotspots occur—even within a household itself (Dietrich et al., 2023b). Thus, the real cost of mitigating this soil lead problem is unknown. At a typical per household rate of $10,000 - $30,000 for a soil lead remediation (which involves removal of contaminated soil and replacement with clean soil; e.g., Abreu Environmental, 2024), the projected price tag for mitigating all households in the country estimated to have soil above the new USEPA standard is a staggering $290 billion to - $1.2 trillion. Additionally, removing and bringing in soil mined from other places for so many millions of households seems infeasible, economics aside. Lastly, soil remediation is extremely disruptive, and if done poorly, can scatter lead contaminated soils and dust to adjacent properties and homes.

We do not think this type of mitigation is feasible at the massive scale required and we have instead focused on a more immediate, far cheaper strategy: capping current soils with clean soils and/or mulch. At a fraction of the cost and labor of disruptive conventional soil mitigation, this approach has long been advocated by one of us (Mielke) and, although imperfect, it yields immediate and potentially life-changing benefits for those living in these environments.

Covering contaminated soils rather than removing them is not a permanent solution, since the clean soil or mulch can be disturbed, exposing the lead-contaminated soil underneath. However, even the act of covering polluted soil with clean soils will permanently dilute the lead concentration of the total soil profile if soil perturbation occurs. Given that nearly all the anthropogenic lead is captured in the upper 10 inches of soils (e.g., Filippelli and Laidlaw, 2010) adding another 10 inches of clean soil (i.e., geogenic or naturally occurring lead levels of 18-22 ppm) on top will cut the total soil lead concentration by half. Here, the adage rings true: the solution to pollution is dilution. This simple, affordable, scalable approach provides immediate results, making it a powerful solution in this new phase of our ongoing mission to "get the lead out."

While the general idea of capping lead polluted soils with uncontaminated soil is viable, there are locations where readily available uncontaminated soil is more difficult to come by than other areas. Thus, while effective and cheaper than entire lead remediation efforts of both soil removal and capping, a concerted effort does have to be made on a case-by-case basis as to the most effective means for bringing in uncontaminated capping material. In some areas, such as the Mississippi River Delta, where fresh, uncontaminated alluvium is readily available, that may be a cheap and accessible capping material. Other locations, such as New York City (NYC Office of Environmental Remediation, 2024), have invested in urban soil banks which also have the potential to mitigate soil lead exposure (Egendorf et al., 2018). However, in other areas, such as arid mining towns in the western US, other capping material like biochar, mulch, or crushed limestone may be cheaper and more readily available. Regardless of where the capping material comes from, it should undergo quick, yet effective screening to ensure it is not contaminated with lead or other heavy metals, which a handheld X-Ray fluorescence device can easily provide within minutes.

Conclusions

Given the scale of the urban soil lead contamination issues and the disproportionate exposure potential faced by environmental justice communities, this issue finally needs to be fully grappled with. The USEPA has taken a critical first step by developing and implementing new soil lead screening standards—it is now up to the network of people concerned about soil lead exposure to consider reasonable, feasible, and equitable ways to reduce exposure and to regain the vitality, health, and fertility of this critical resource of the commons.

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Table 1

		Soil Lead (mg/kg)							
		≥ 400		200 to < 400		100 to < 200		< 100	
	n	%	n	%	n	%	n	%	n
United States	15595	12.3	1933	11.4	1789	15.7	2475	59.8	9398
New Orleans, LA	5434	14.8	805	10.4	566	13.2	718	61.6	3345
South Bend, IN[a]	4905	4.3	216	5.0	249	12.0	604	76.4	3836
Indianapolis, IN	2641	20.1	530	17.0	448	20.1	531	42.8	1132
Chicago, IL	1187	20.2	240	32.6	387	29.5	350	17.7	210
Burlington, VT	523	17.8	94	5.9	31	11.8	62	63.8	336
Springfield, MA	166	3.6	6	11.9	20	26.8	45	56.5	95
Lowell, MA	152	3.9	6	12.5	19	38.8	59	44.7	68
Hartford, CT	139	10.7	15	21.4	30	32.9	46	34.3	48
Winston-Salem, NC[b]	53	15.1	8	20.8	11	26.4	14	37.7	20
Chattanooga, TN[b]	53	5.7	3	5.7	3	15.1	8	73.6	39
Louisville, KY[b]	53	5.7	3	22.6	12	20.8	11	50.9	27
Memphis, TN[b]	53	5.7	3	9.4	5	11.3	6	73.6	39
Lexington, KY[b]	53	3.8	2	7.5	4	17.0	9	71.7	38
Columbia, SC[b]	53	0.0	0	1.9	1	5.7	3	92.5	49
Raleigh, NC[b]	53	0.0	0	0.0	0	5.7	3	94.3	50
Gainesville, FL[b]	53	0.0	0	0.0	0	1.9	1	98.1	52

[a]Samples taken in a gridded pattern throughout St. Joseph County, and thus represent a mix of urban, suburban, and rural sampling locations.

[b]Samples specifically collected to represent “urban background” locations, and thus not near typical urban lead sources (USEPA 2023).

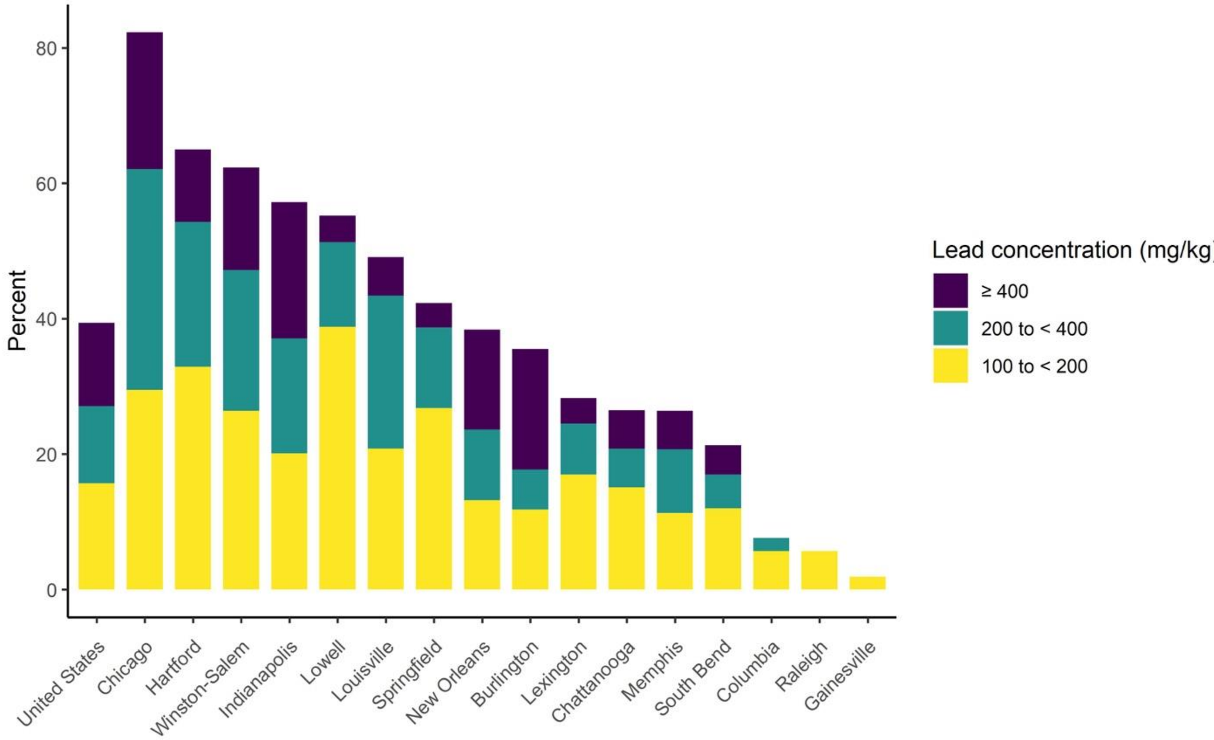

Fig. 1: Percentage of samples within each city and the United States from Table 1 that exceeded 100 mg/kg lead, binned by concentration category.