



Lead in Air, Soil, and Blood

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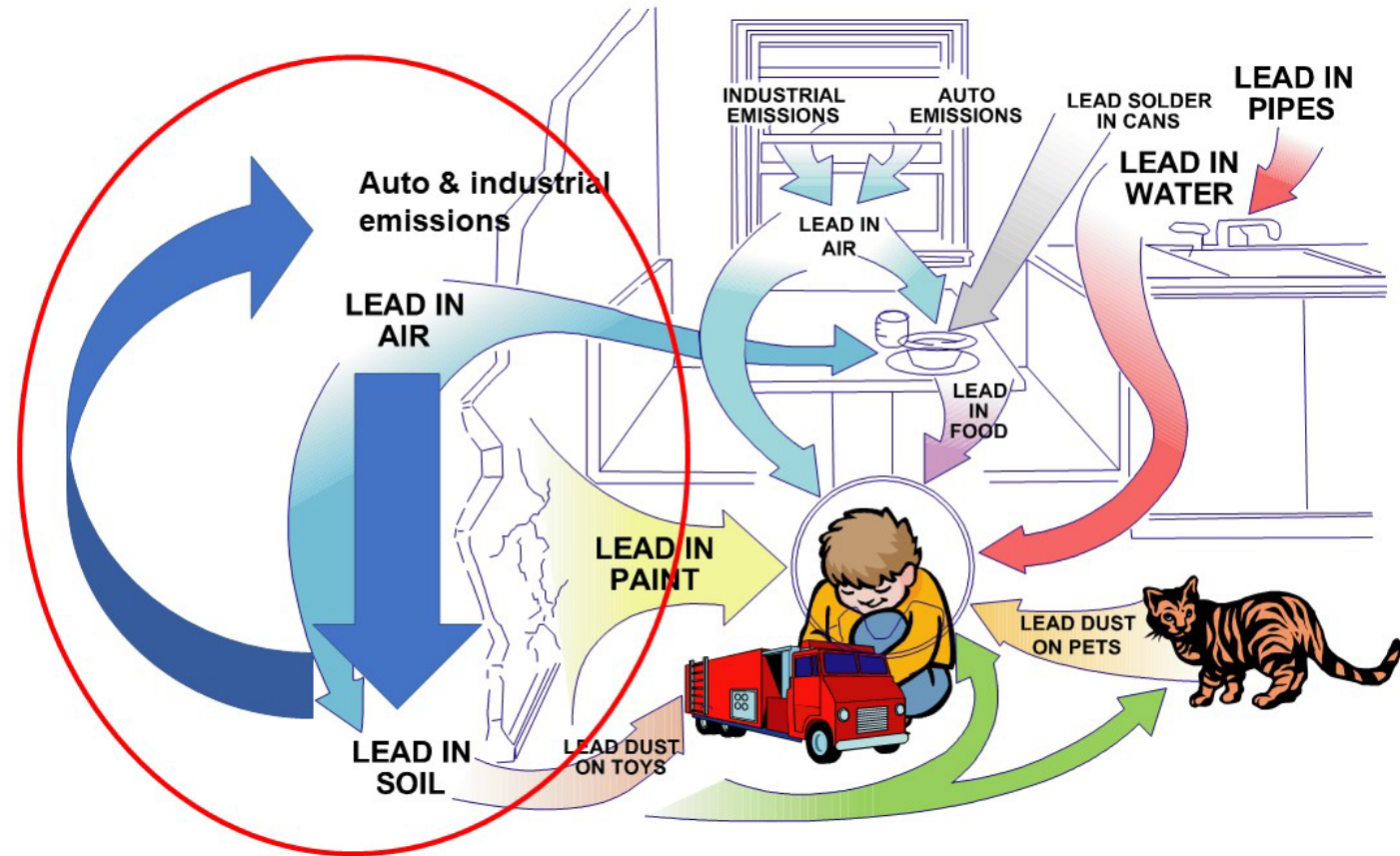
Invited by the American Chemical Society to fill a position as a member of the Lead Exposure Prevention Committee (LEPAC)

Presentation to LEPAC, May 12, 2022

Environmental Signaling Sources of Childhood Lead Exposure

Primary Prevention requires finding and eliminating Pb before children do.

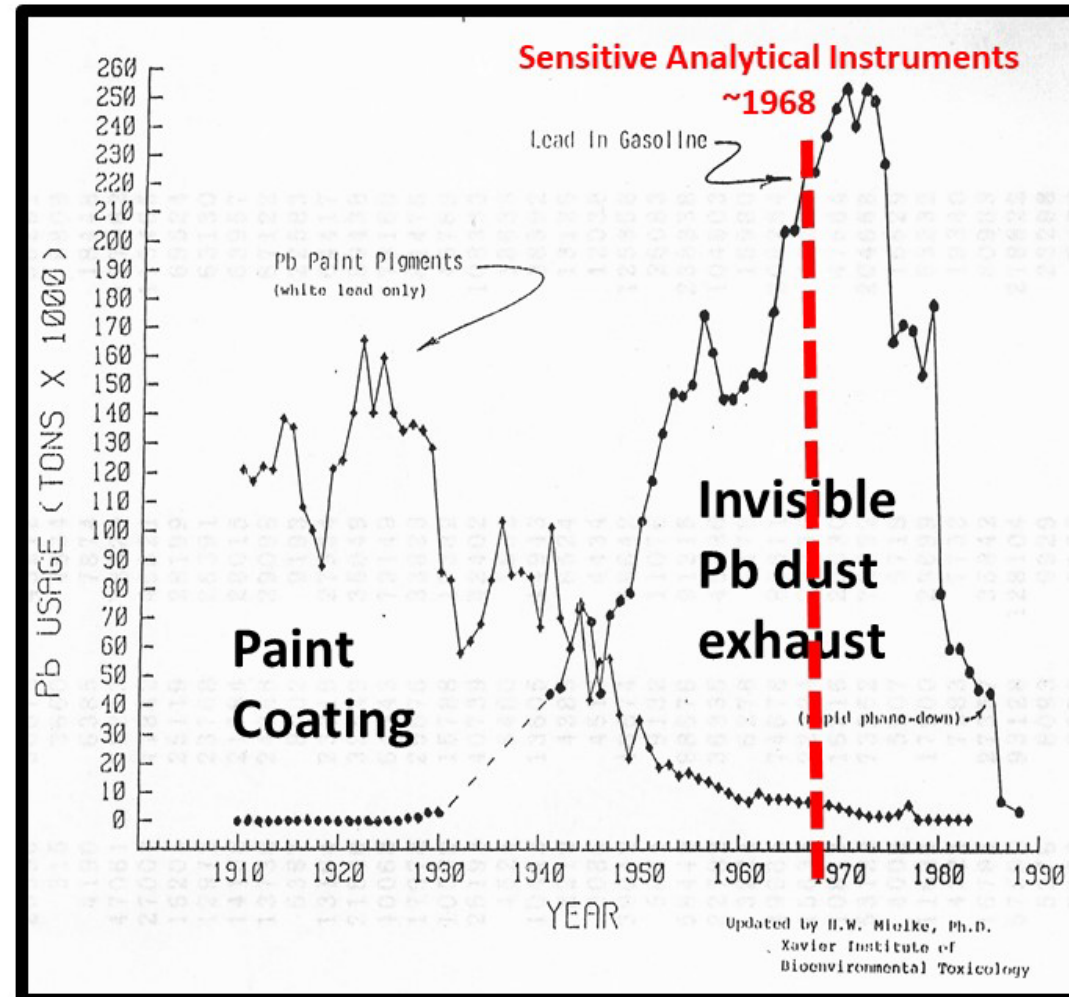
- **Objective:** To inform LEPAC about the facts of the continuing impact of lead in air and soil on Pb exposure. This topic has not received the attention it warrants.



Source: CDC Recommendations for Lead Poisoning Prevention in Newly Arrived Refugee Children Medical Provider Module

The paint industry and Ethyl Corporation reported at least 6 million metric tons of Pb in their respective products.

- **Goal:** To demonstrate why dust from the use of leaded gasoline must be addressed to advance lead exposure prevention.



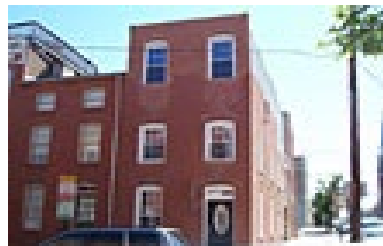
Statements about lead in soil and lead dust in cities, 1969-1980

- **1969 LIA-Lead Industries Association influenced public policy (board minutes on April 13, 1969)**
 - “It should be a primary objective of any LIA program...aimed at resolving the childhood lead poisoning problem to keep attention focused on old, leaded paint as its primary source and to make clear that other sources of lead are not significantly involved.”
- **1974 EHP article on soil Pb by Ethyl Corporation employees echoed LIA objective.**
 - “...lead in dirt around houses is due to paint from the houses. Lead antiknock additives [TEL] are therefore not a significant contributor to the lead content of dirt around houses where children usually play.”
- **1974 Dr. Sayer M.D. et al. Rochester, N.Y.**
 - Questioned Pb paint chips as the main source of Pb exposure because he found larger amounts of Pb dust in inner-city homes and on children’s hands than in suburban homes and children’s hands.
- **1980 Clair Patterson. Lead in the Human Environment. National Academy of Sciences.**
 - “Sometime in the near future it probably will be shown that the older urban areas of the US have been rendered more or less uninhabitable by the millions of tons of poisonous industrial [including auto] lead residues....”
- **Were Sayer’s and Patterson’s concerns warranted about the consequences of urban Pb dust?**

1976-79 Baltimore Urban Garden soil—Pb, metals etc. Inner city vs. outer city garden soils

Inner city

Brick and stone



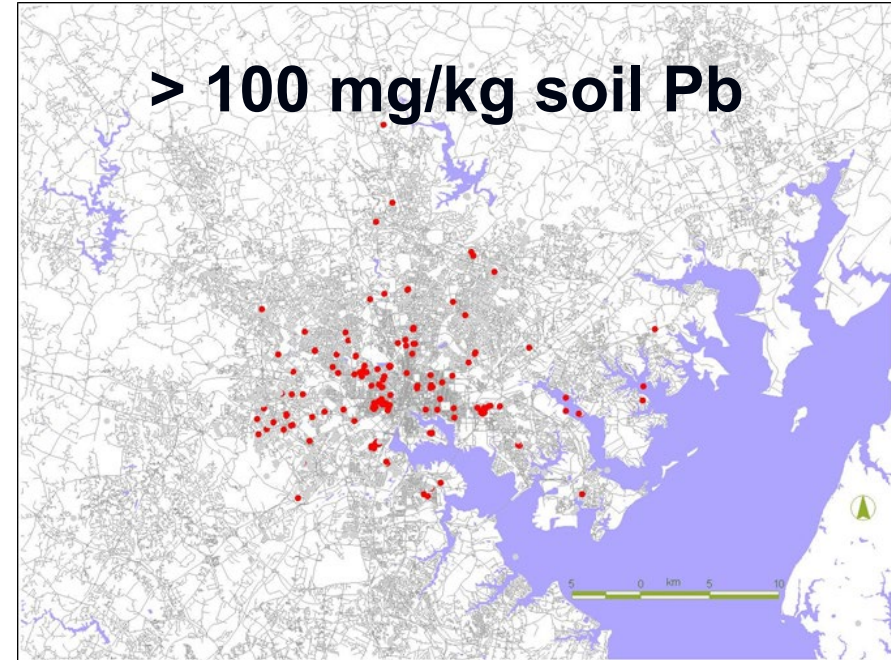
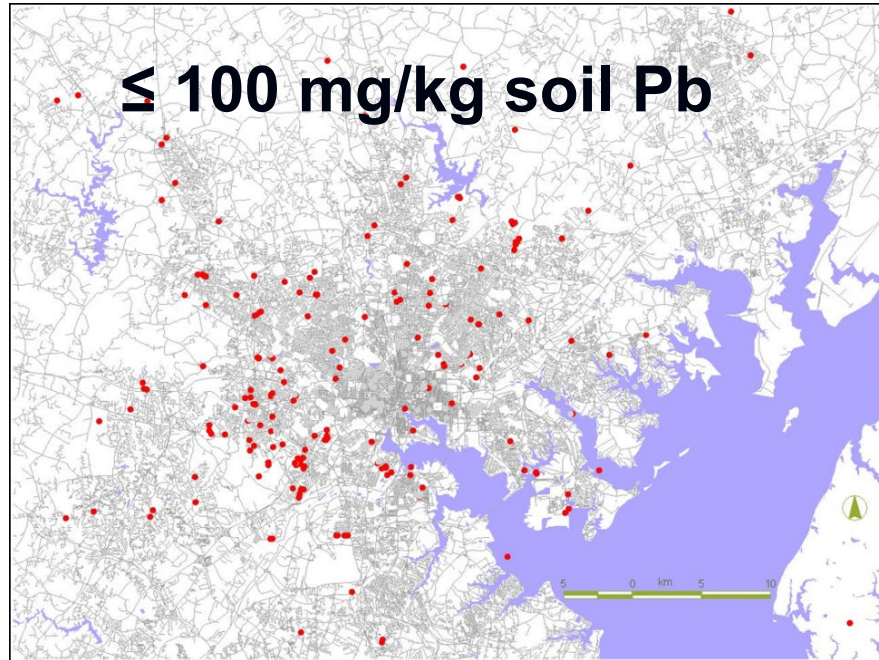
Outer city

Pb painted wood



Comparison of high vs. low Pb garden soils in Baltimore

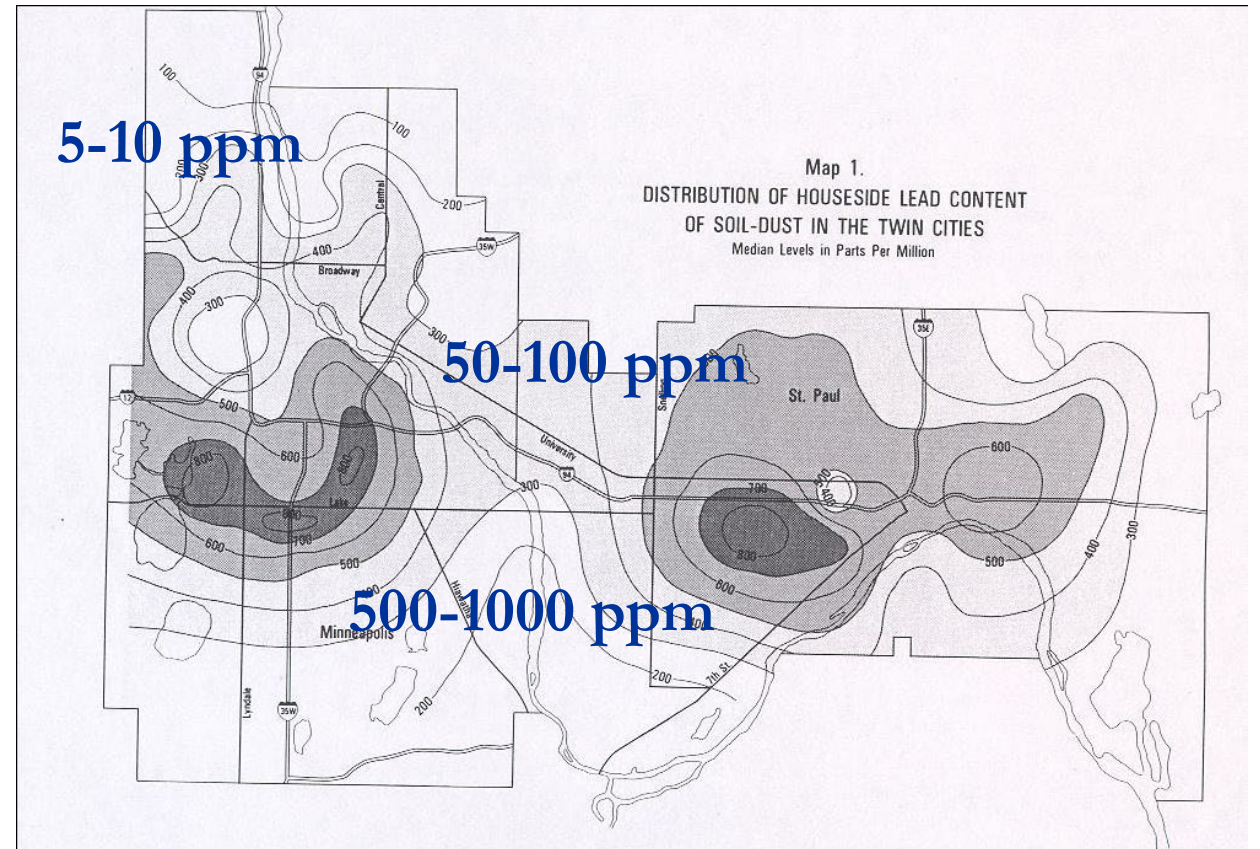
- Astonishing spatial disparity of soil Pb (P-value $<10^{-23}$)



- “...expect the soil Pb pattern in **all large cities** to be similar to Baltimore”
- Mielke et al. 1983, Am J Public Health 1983, 73(12): 1366–1369

Test of the “all large cities” expectation.

- Soil Pb in Twin Cities communities of Minneapolis and St. Paul Minnesota
- Are there differences between larger vs. smaller cities?



Soil Pb in various sized MN cities 1984/85

- Why are foundation samples so Pb contaminated?

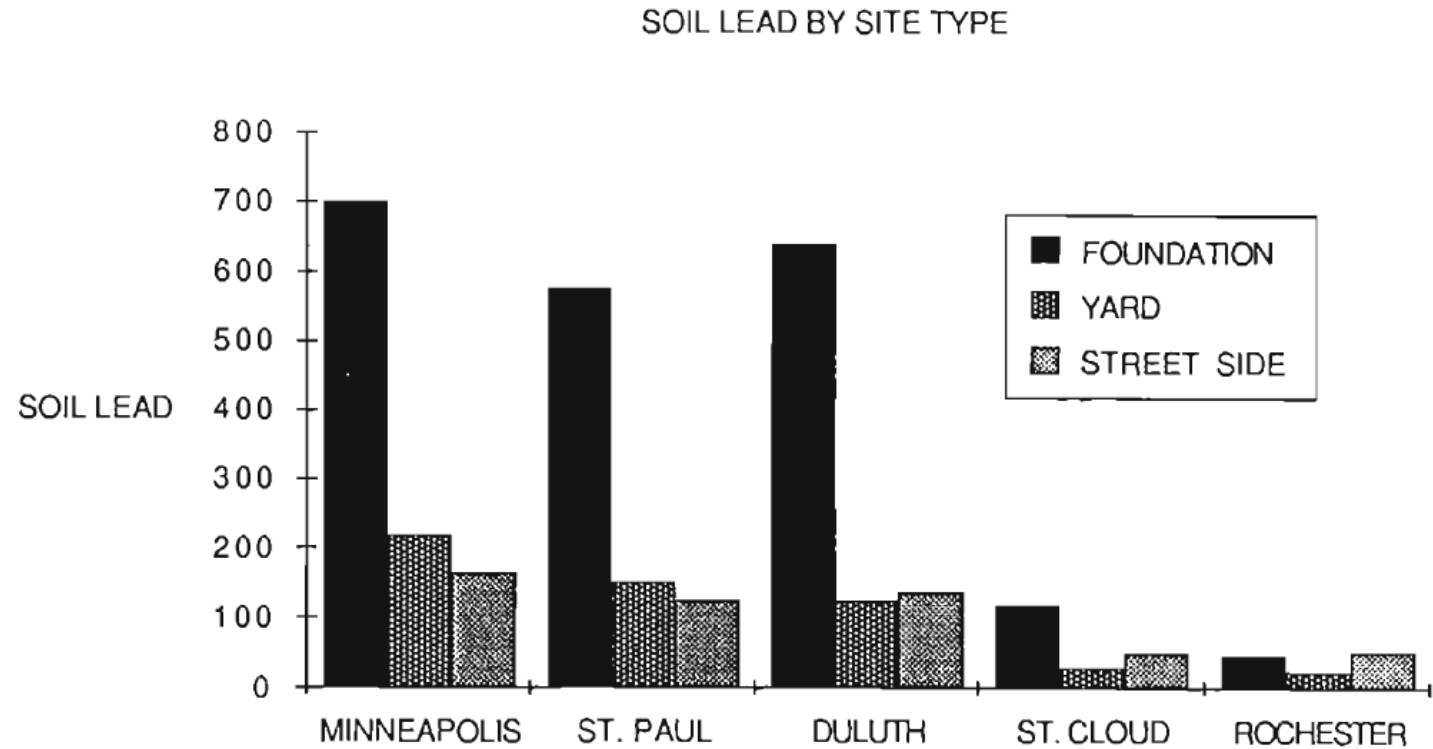
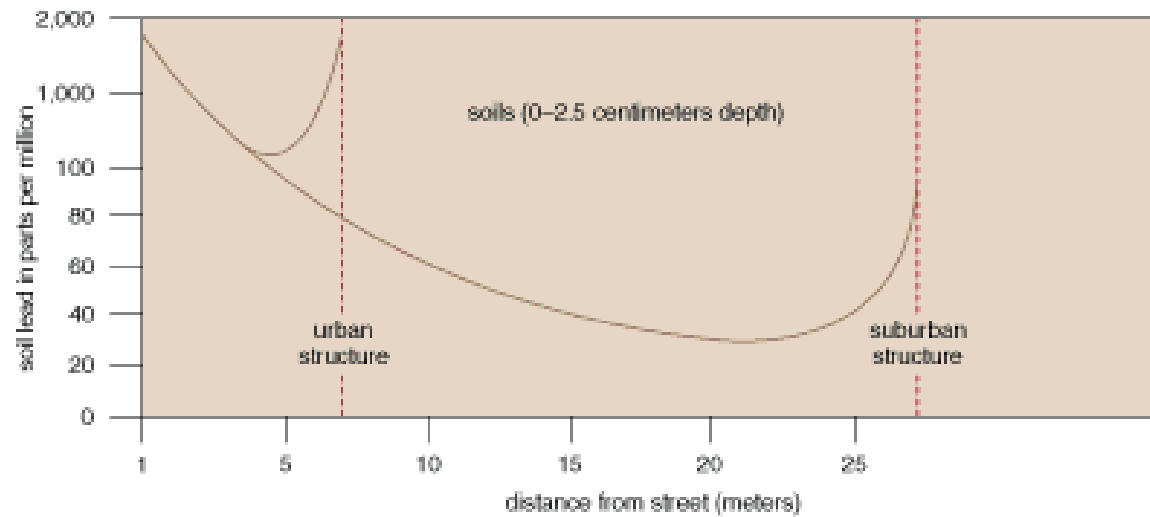
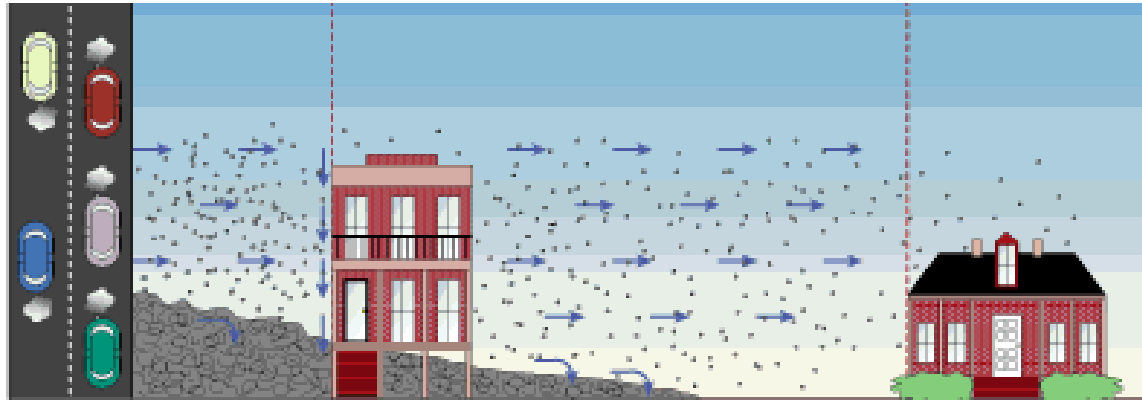


Figure 3. Median soil lead level by collection type for each city sampled.

Pb particles collect on building siding and wash into soil



- High risk area near foundations.

1983-84. Children convey important information. Citizens' science and actions to ban leaded gas.

- In the 1980s blood Pb ~ 15 $\mu\text{g}/\text{dL}$ was common. My daughter's Pb exposure motivated me to understand why her lead exposure was so high?
- A small group of thoughtful, committed people worked together to study, understand, and act to prevent Pb exposure.
- Are all children being Pb poisoned? Highlights of findings.

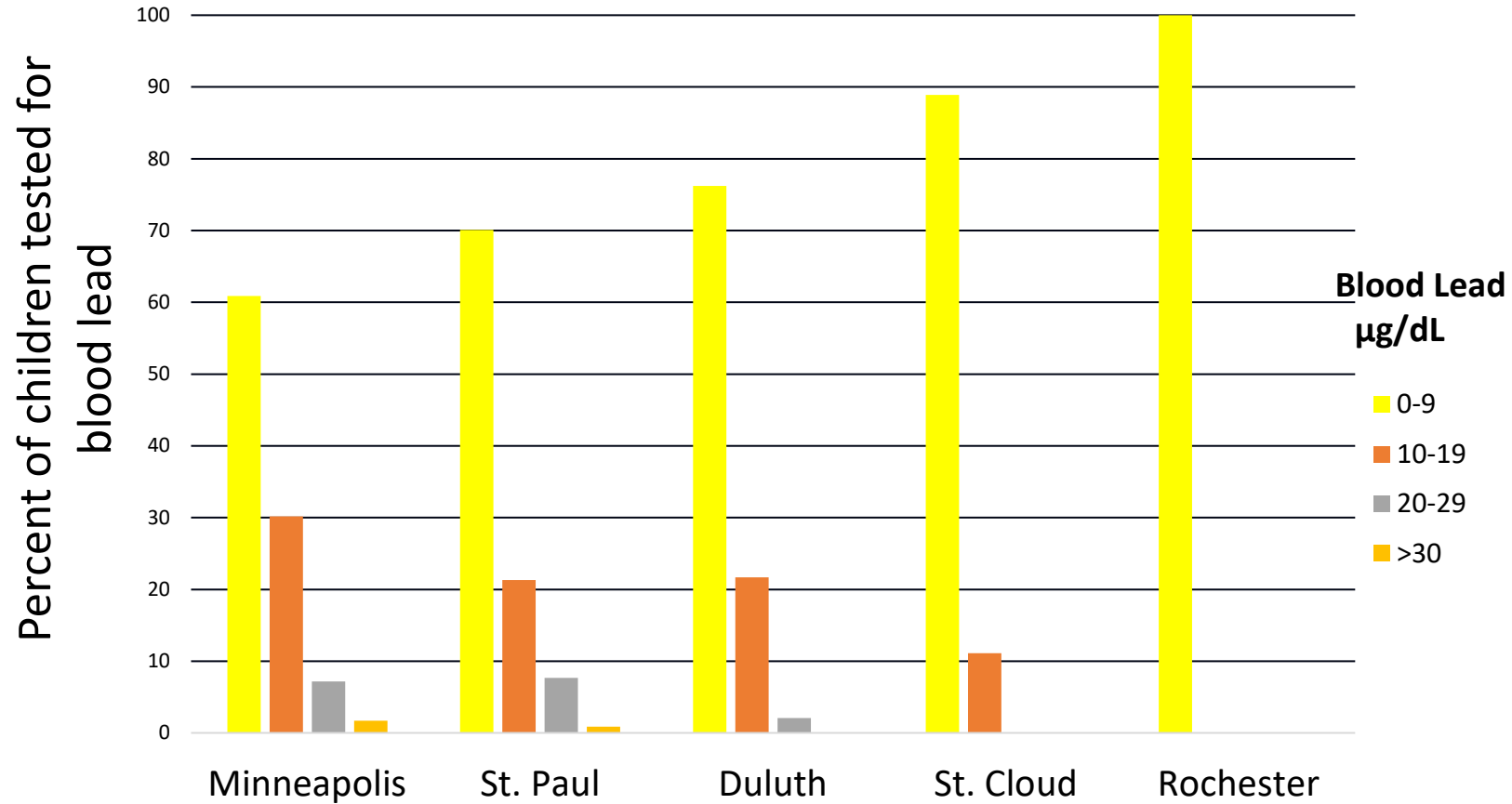


*The Lead
Coalition*

144 Melbourne Ave. S.E. Mpls. MN 55414



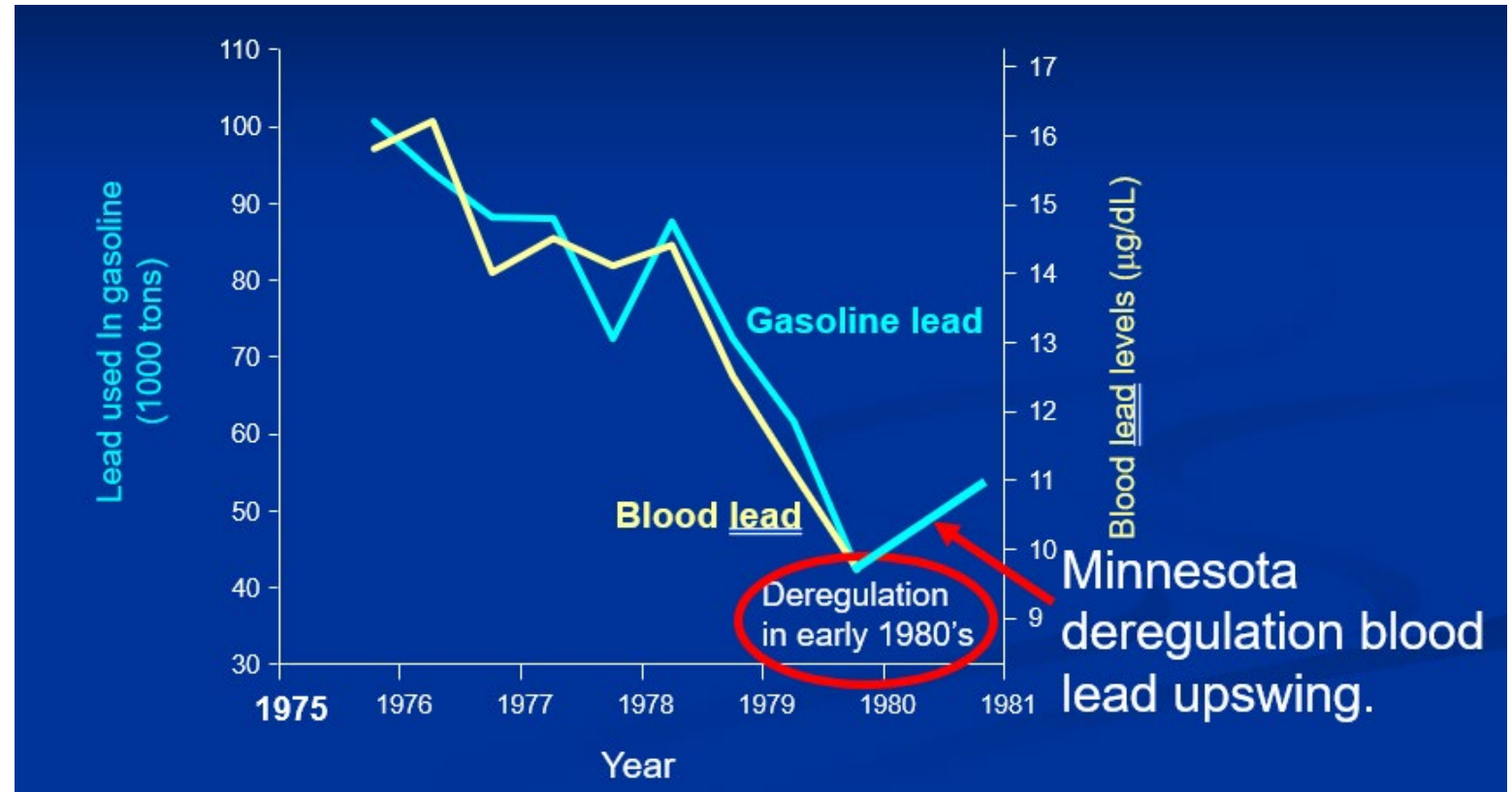
Children's blood Pb results by MN city size-1983



Minnesota Department of Public Health findings

1983 Trends of lead in petrol and in blood lead. NHANES II, 1976-1980.

- Catalytic converter – 1975
- **Source:** Annest, Pirkle, Makuc, et al., Chronological trend in blood lead levels between 1976 and 1980. NEJM 1983; 308:1373-7.

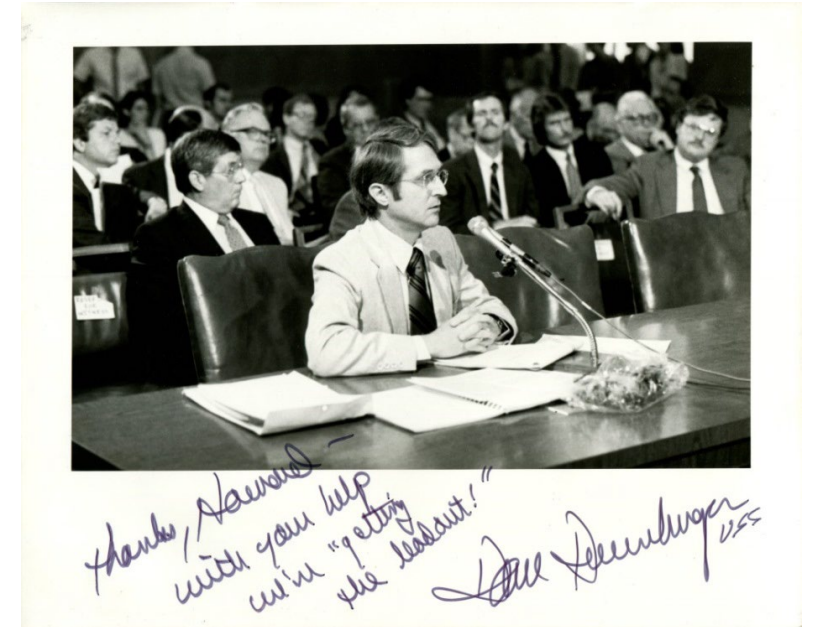


Minnesota Legislature blood Pb & soil Pb findings

- Minneapolis and Saint Paul inner-city vs. outer-city soil Pb results were like Baltimore.
- Quantities of soil lead were associated with city size.
- Children's blood lead was associated with city size & soil lead (Minnesota Department of Health finding).
- High school dropout rates were associated with city size & soil lead (Legislature finding).
- Minnesota Legislature attempt to ban leaded gasoline was prohibited by federal law (Legal finding).
- The Minnesota Legislature petitioned Congress to ban lead additives in gasoline.
- **How was the petition acted on?**

June 22, 1984-Hearing of the Environment & Public Works Committee, 89th Congress, S.2609.

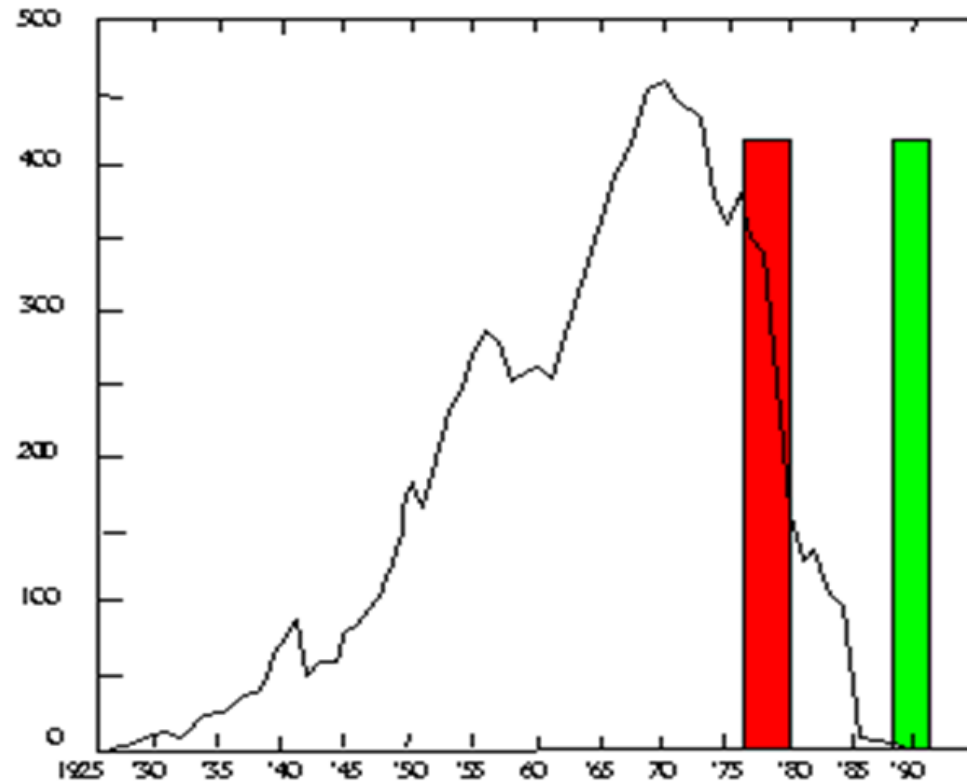
- Senator David Durenberger MN, chaired the Hearing.
- The petition required action by the EPA to revise the schedule for banning leaded gasoline by 10 years.
- Patrick Reagan and I wrote the comments for Regulation of Fuel and Fuel Additives: Docket No. EN-84-05 Lead phase Down~ Proposed Rule (49 FR 31032-31050).
- The regulations were applied to highway gasoline, not avgas.
- What was the effect of the Jan.1,1986 rapid phase-down?



National childhood blood Pb—ten years after the Jan. 1986 rapid phase-down of leaded gasoline.

- **Were similar Blood Pb decreases observed in other places?**
- **Source:** Pirkle J.L. et al. 1994. The decline in blood lead levels in the United States. The National Health and Nutrition Examination Surveys (NHANES). JAMA 272, 284–291

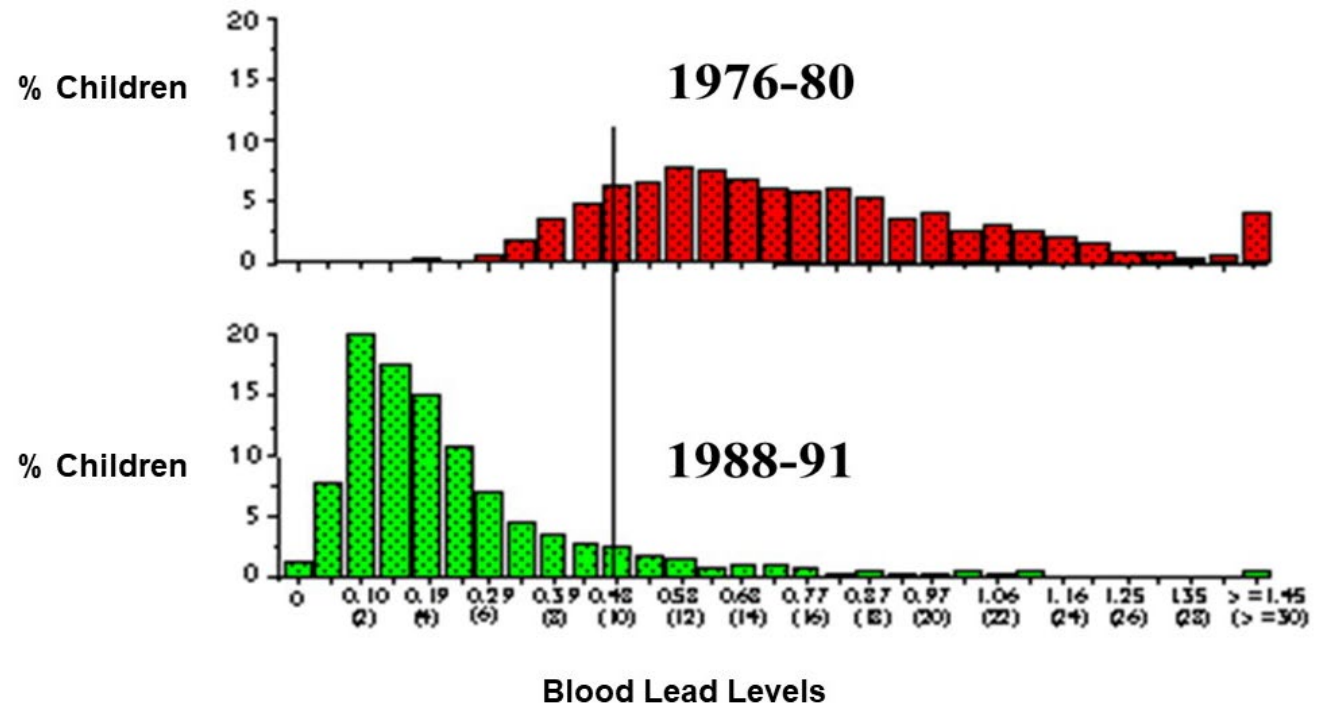
U.S. children's Pb exposure
1976-80 vs. 1988-91.



National childhood blood Pb—ten years after the Jan. 1986 rapid phase-down of leaded gasoline (continued).

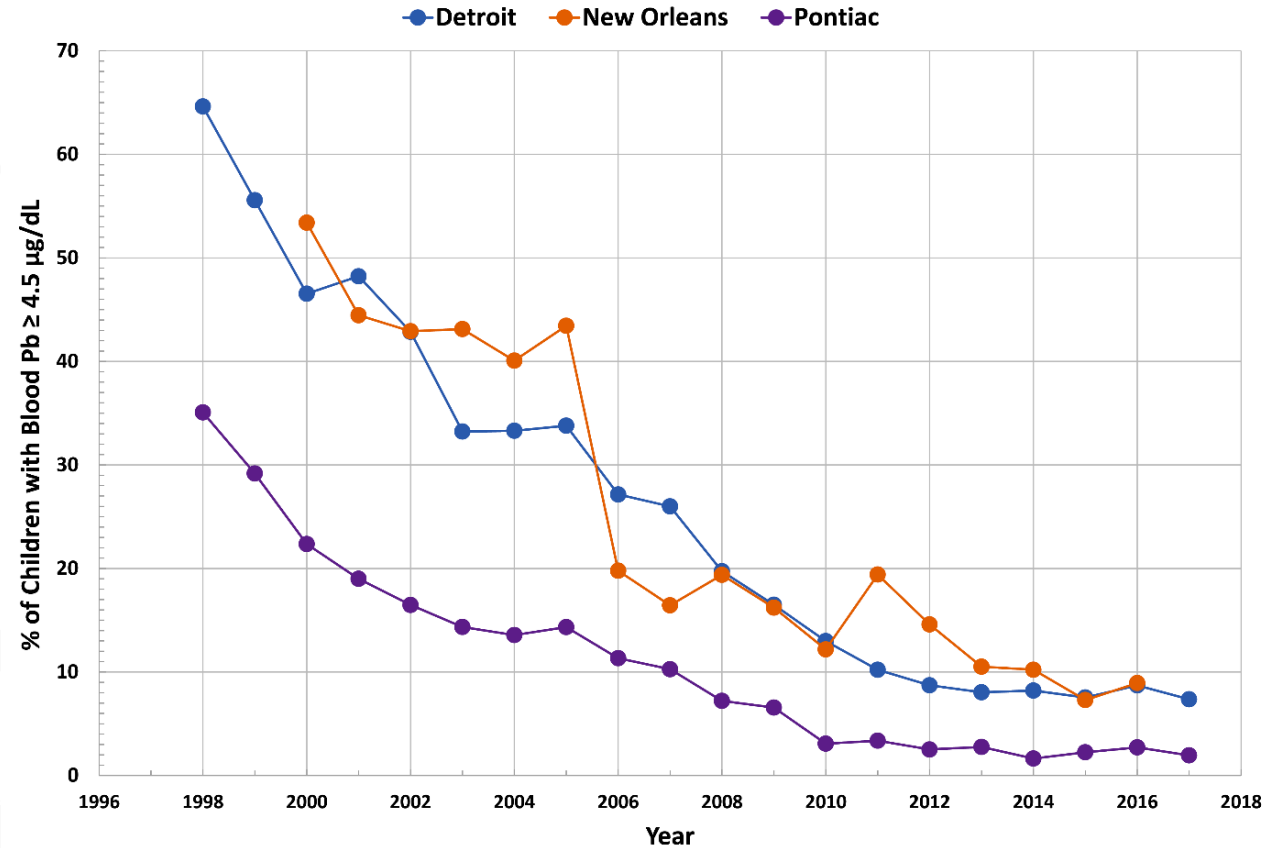
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NHANES surveys of childhood blood Pb



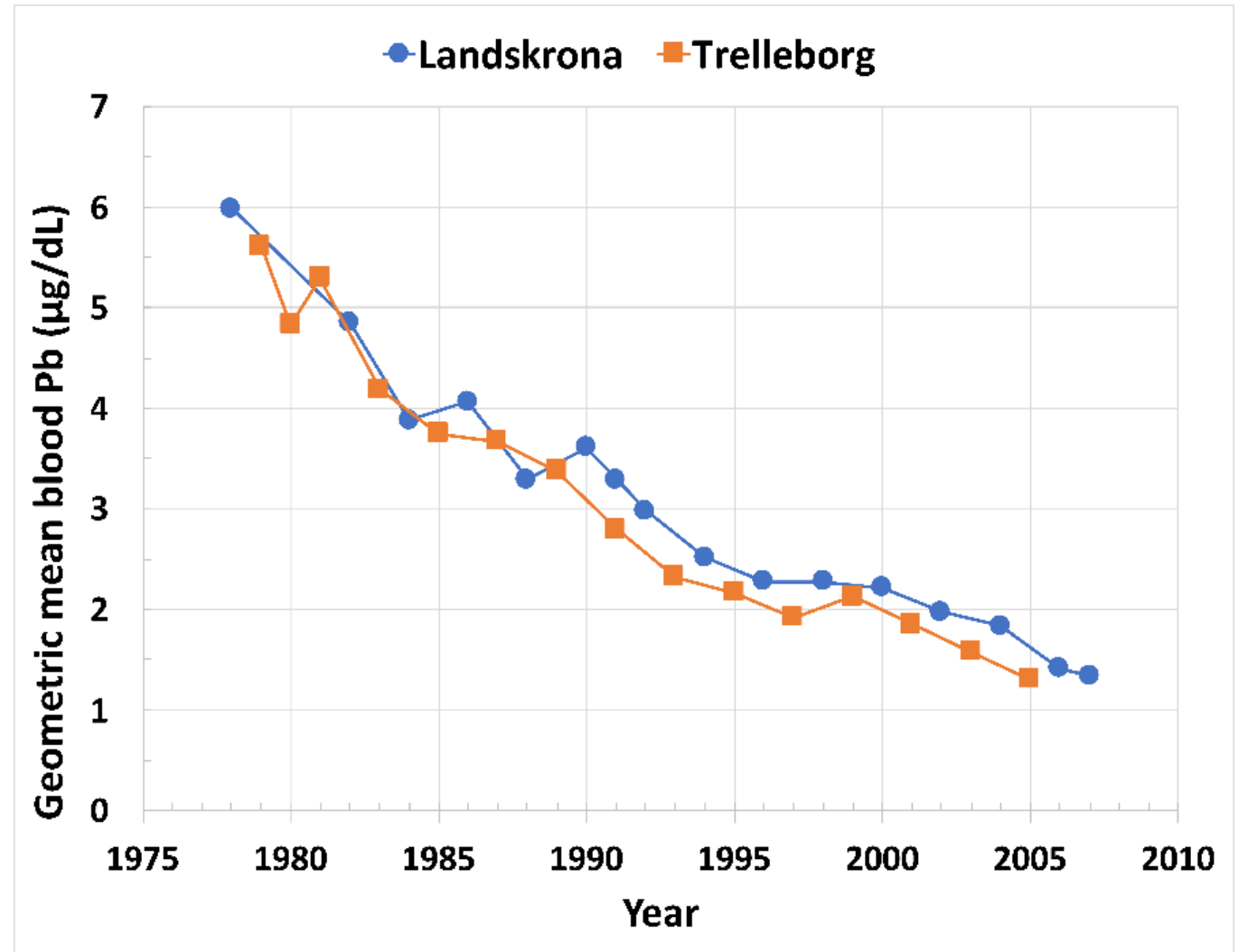
Decreasing blood Pb in Detroit and Pontiac, Michigan, and New Orleans, Louisiana

- Decrease of blood Pb in Detroit MI, New Orleans LA, and Pontiac MI.
- Blood Pb stabilized at $< 8 \mu\text{g/dL}$ in larger cities and $< 2 \mu\text{g/dL}$ in smaller urban areas.



Blood Pb and air Pb in small cities of Sweden.

- Lead-based paint was banned in the 1920s.
- Decrease of leaded gasoline from 1978-1994.
- Lead free in 1995.
- Stable at $< 2 \mu\text{g/dL}$ in smaller cities
- **Why, after leaded gasoline is banned, does urban blood Pb stabilize at 2-8 $\mu\text{g/dL}$?**



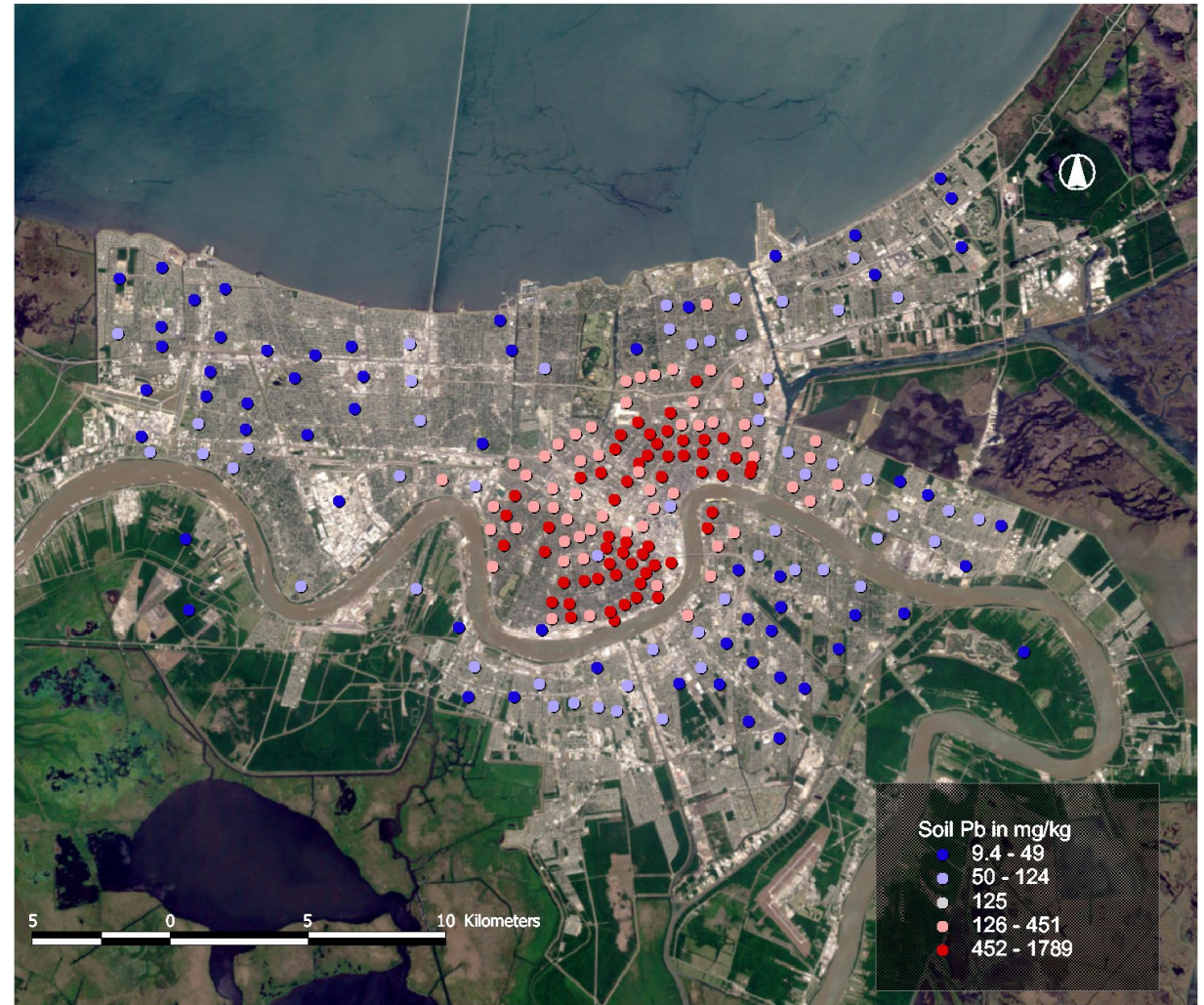
20th century Pb deposition—21st century Pb remobilization to air

- Britain banned leaded petrol in 1999.
- Pb exhaust particles settled along roads and on topsoils, etc.
- Pb isotopic composition of airborne particles match road dust and topsoil isotope composition of leaded petrol used in the 20th century.
- The results have important implications on the persistence of Pb in urban environments because **atmospheric Pb reached a baseline** in London.
- Policy measures in London are insufficient to decrease the air Pb baseline.
- **Are air and legacy soil Pb related to the blood Pb baseline?**

Reference: Resongles et al. (2021). Strong evidence for the continued contribution of lead deposited during the 20th century to the atmospheric environment in London of today. PNAS <https://doi.org/10.1073/pnas.2102791118>

1998 – 2001 New Orleans soil lead

- 1998-2001 New Orleans Soil Pb
- ATSDR grant to Xavier University of Louisiana



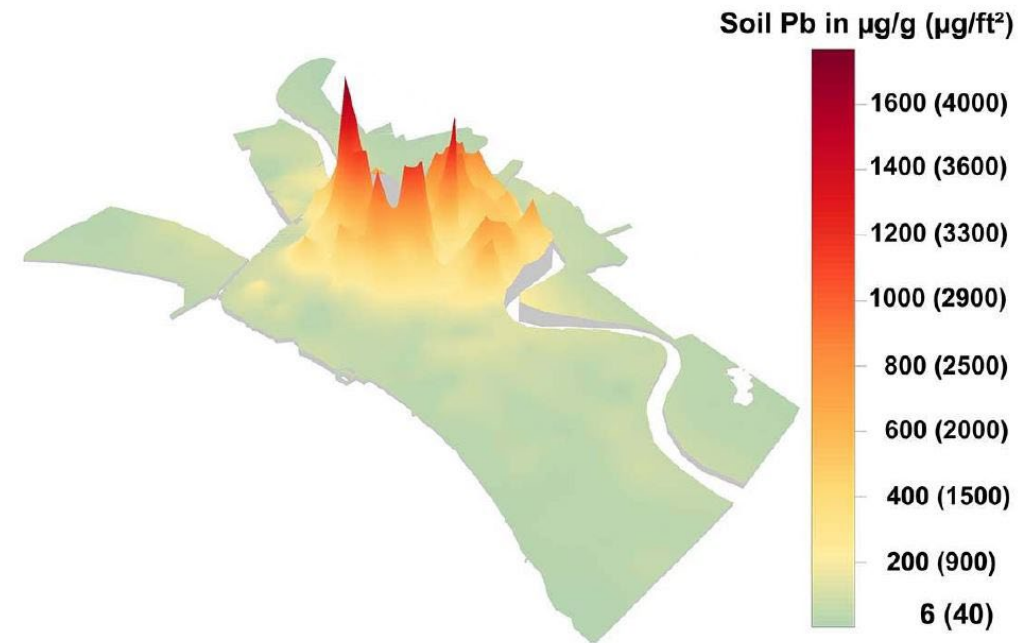
2000 – 2005 New Orleans children's blood lead levels

- 2000-2005 New Orleans Children's Blood Pb
- Louisiana Department of Health
- Why is soil Pb so potent as a source of exposure?



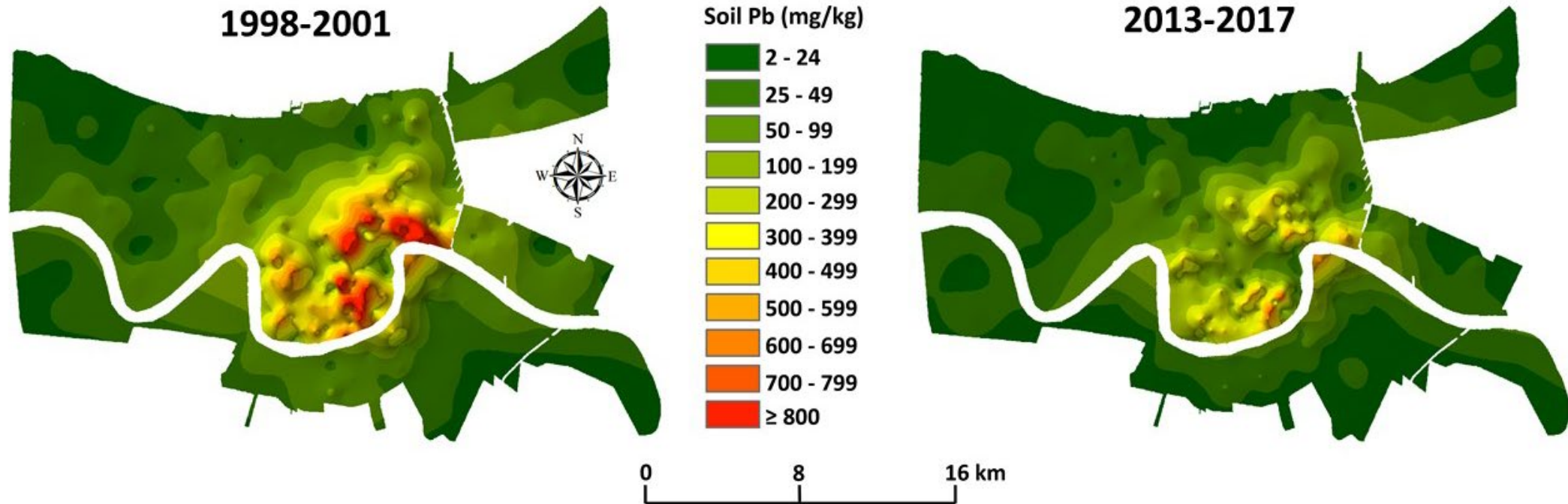
Soil lead comprises multiple routes of lead exposure

- PLOPS Sampler. HUD grant to Xavier Univ. of LA
- Exposure prevention, U.S. interior Pb dust loading guideline = $10 \mu\text{g}/\text{ft}^2$



Is a soil Pb map also a Pb dust loading and a blood Pb map?

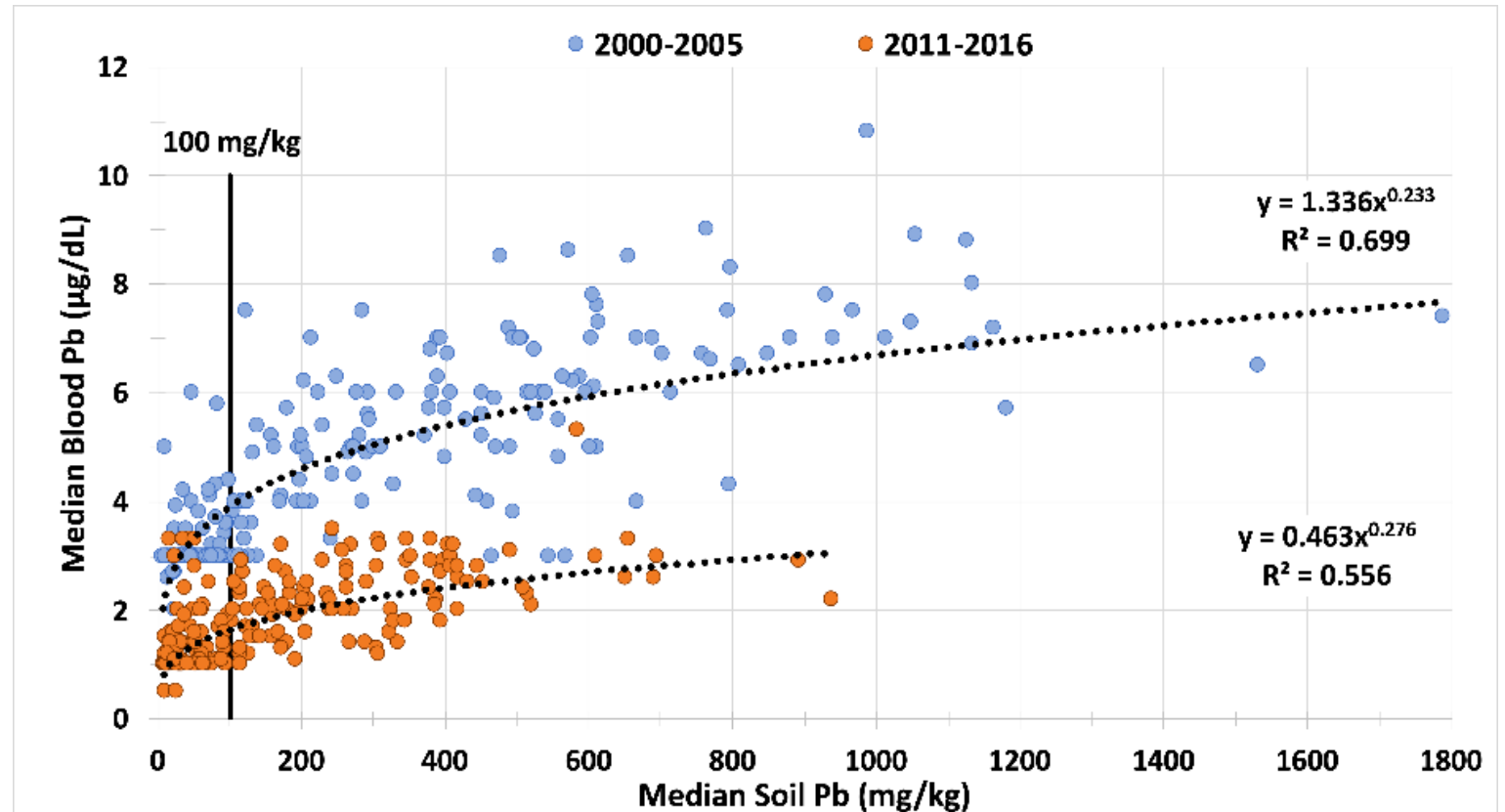
New Orleans long-term urban soil Pb and blood Pb maps: 1998-2001 and 2013-2017



- What is a safe level of soil Pb?
- Mielke HW et al. (2019). The concurrent decline of soil lead and children's blood lead in New Orleans.
 - Proceedings of the National Academy of Science.
www.pnas.org/cgi/doi/10.1073/pnas.1906092116

Children's blood Pb paired with soil Pb (N=274 communities) for two surveys.

- Non-linear slope < 200 ppm. The 2021 reference value is 3.5 $\mu\text{g}/\text{dL}$.
- Soil Pb of 50 ppm provides a margin of safety for most New Orleans children.
- At low ranges of soil Pb, red blood cells become Pb saturated.
- The associations between soil Pb and blood Pb are extreme (P-values < 1.6×10^{-26}). A strong link in cities is expected.



Consequences of soil Pb in metropolitan New Orleans

- The near-far medians of soil Pb, children's blood Pb, socioeconomic, etc.
- There is no known clinically safe level of lead exposure.
- LOD (level of detection)
- Is the observed disparity acceptable?

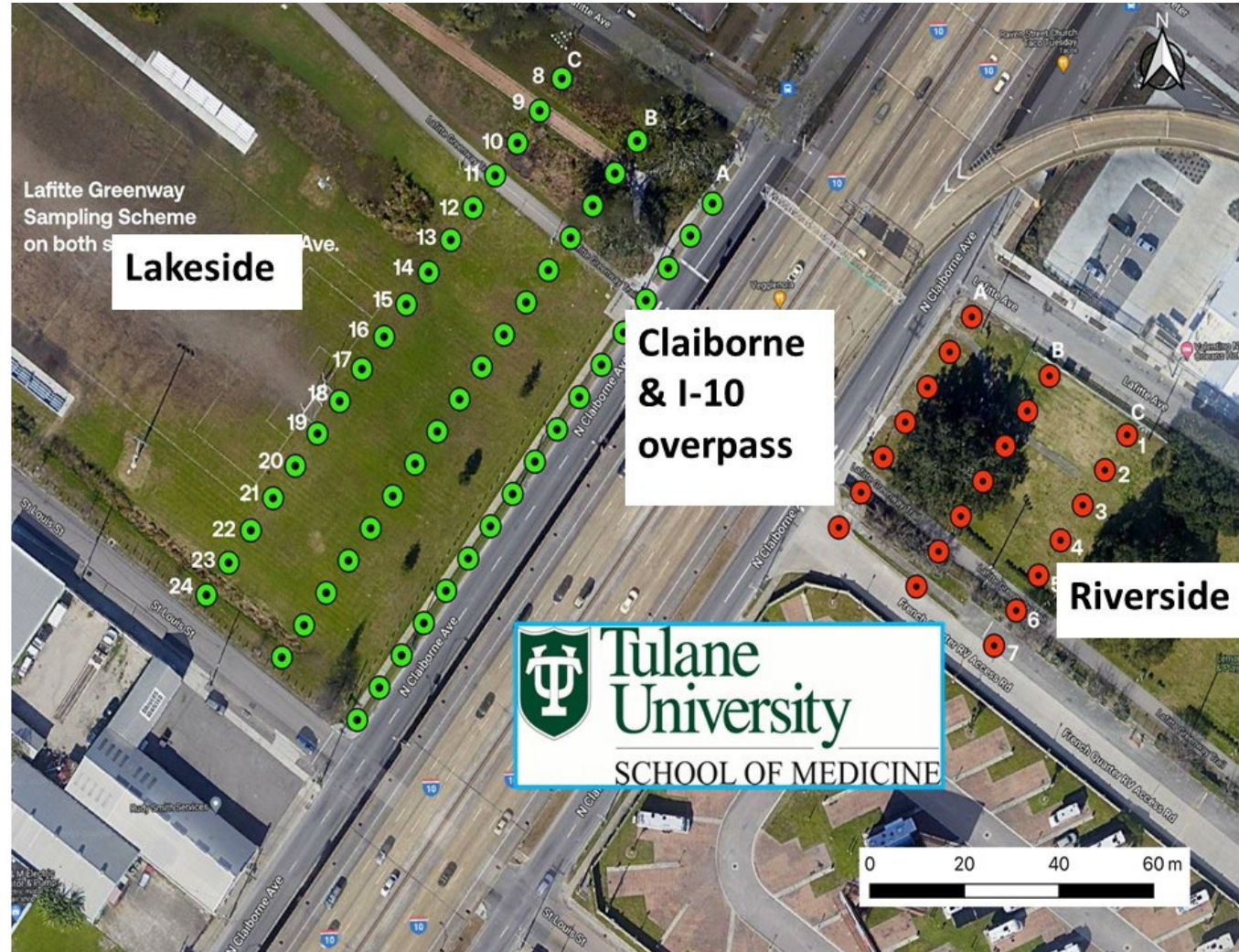
2000	Dist. MPO	% Other	% White	% Black	SPb (ppm)	BPb (µg/dL)	Household
NEAR	(km)				(interp.)	(interp.)	Med. Income
Census Tracts N=147							
Medians	3.76	3.06	23.0	72.7	410	5.7	\$21,981
FAR							
Census Tracts N=147						LOD	
Medians	10.24	4.15	78.1	12.7	44	3.0	\$37,919

2015	Dist. MPO	% Other	% White	% Black	SPb (ppm)	BPb (µg/dL)	Household
NEAR	(km)				(interp.)	(interp.)	Med. Income
Census Tracts N=143							
Medians	3.95	4.37	40.8	51.5	187	2.1	\$30,917
FAR							
Census Tracts N=143						LOD	
Medians	10.64	5.49	71.5	17.0	25	1.0	\$44,357

Reference: Egendorf SP, Mielke HW, Castorena-Gonzalez JA, Powell ET, Gonzales CR. Lead (Pb) in New Orleans: A spatiotemporal and racial analysis.

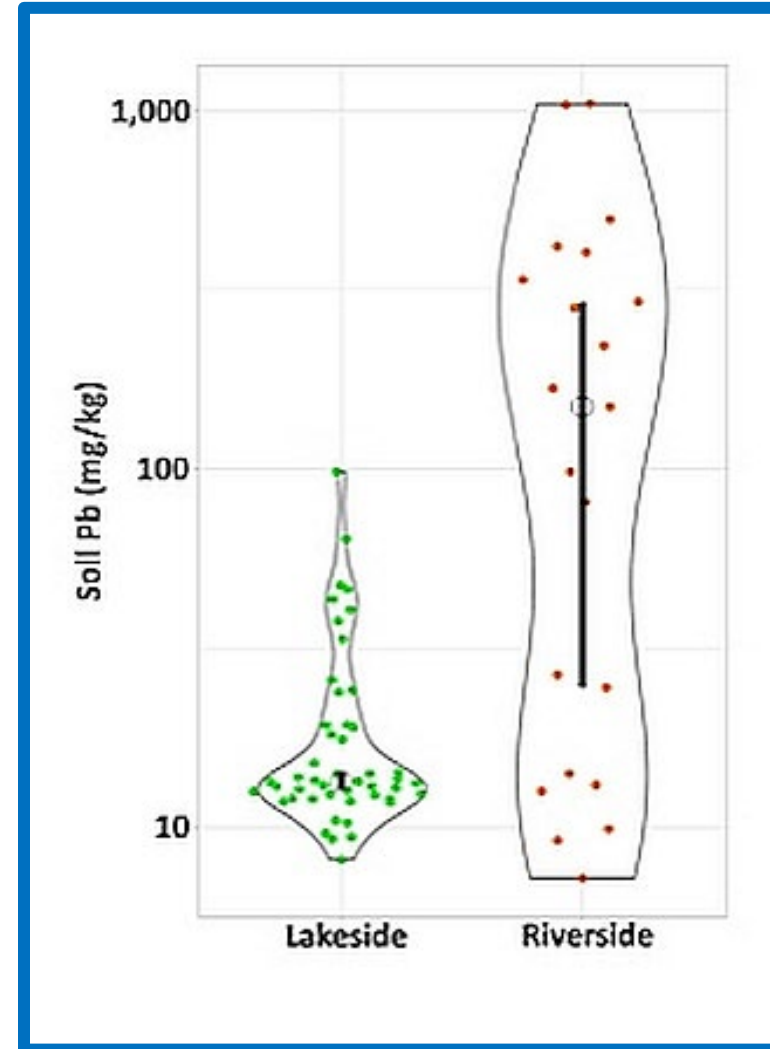
No, but we can change what is unacceptable!

- New Orleans Lafitte Greenway playground community service project.
- The Lakeside playground was landscaped with low Pb soil. The treatment on the Riverside area of I-10 was unknown.
- Does soil Pb differ between the two playgrounds?



Overview of all Pb data from the soil samples of playgrounds on the Lakeside and Riverside of Claiborne Avenue (N = 69)

- According to responses by New Orleans's children, soil Pb 50 ppm is a relatively safe community Pb level
- CDC- There is no known clinically safe level of lead exposure.
- Changing the soil Pb is a matter of applying the same landscaping techniques on the Riverside area as applied to the Lakeside area of the I-10 corridor.



Conclusions

- 50 + years of leaded gasoline dispersed millions of tons of Pb into cities.
- Air Pb particles are inhalable, a response captured by blood Pb.
- Air Pb particles accumulated in proportion to vehicle Pb emissions.
- Banning of leaded gasoline curtailed the accumulation of Pb dust.
- Previous Pb deposits remobilizes from soil to air, and drifts or is tracked into homes.
- Children are exquisitely sensitive to many pathways of exposure posed by soil lead.
- In New Orleans with low Pb soil < 50 ppm has a margin of safety for most children.
- Landscaping urban public lands with clean soil is feasible and cost effective.
- **Current policies do not address legacy soil Pb, especially in Pb contaminated cities.**

Acknowledgements

- **Blood Pb surveys.** Trina Williams and Ngoc Huynh, LHHCLPPP, provided the blood lead data for metropolitan New Orleans for both surveys. Blood Pb funding was from the CDC.
- **Soil Survey 2001** conducted at the College of Pharmacy; Xavier University of Louisiana:
 - Agency for Toxic Substances and Disease Registry (ATSDR)
 - US Department of Housing and Urban Development (HUD).
- **Soil Survey 2017** was funded privately by:
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 - Jack Eichenbaum,
 - Gabriel Filippelli,
 - Members of the Community Church Unitarian Universalist,
 - Tulane University Department of Pharmacology,



**Chris Gonzales and Eric Powell,
Laboratory & field researchers.**

References: Soil Lead and Novel Policies

- Mielke HW, Gonzales CR, Ottesen RT, Langedal M, Jartun M, et al. (2019) **Primary Health Care Consequences of Cultural Differences between New Orleans, Louisiana, USA and Oslo, Norway: Lead Contamination at Children’s Play Areas.** *J Family Med Prim Care Open Acc* 3: 140. <http://lead.tulane.edu/PDFs/Oslo-and-NOLA-playgrounds.pdf>
- Markowitz, G. and Rosner, D. **Deceit and Denial: The deadly politics of industrial pollution.** 2002. University of California Press, Berkeley and Los Angeles, California. Pp 408. Quote on p. 117.
- Kim Cecil et al. (2008). **Decreased Brain Volume in Adults with Childhood Lead Exposure.** *PLOS Medicine.* <https://doi.org/10.1371/journal.pmed.0050112>
- Bruce P Lanphear, Stephen Rauch, Peggy Auinger, Ryan W Allen, Richard W Hornung (2018). **Low-level lead exposure and mortality in US adults: a population-based cohort study.** *Lancet Public Health* 2018; 3: e177–84, [http://dx.doi.org/10.1016/S2468-2667\(18\)30025-2](http://dx.doi.org/10.1016/S2468-2667(18)30025-2).
- Mielke HW and Reagan PL. (1998) **Soil Is an Important Pathway of Human Lead Exposure** *EHP* <https://doi.org/10.1289/ehp.98106s1217>
- Mielke HW et al. (2019). **The concurrent decline of soil lead and children’s blood lead in New Orleans.** *PNAS* www.pnas.org/cgi/doi/10.1073/pnas.1906092116
<https://doi.org/10.1073/pnas.1906092116>
[Correction in: Proc. Natl. Acad. Sci. U.S.A. 118, e2119517118 \(2021\).](https://doi.org/10.1073/pnas.1906092116)
- Resongles et al. (2021). **Strong evidence for the continued contribution of lead deposited during the 20th century to the atmospheric environment in London of today.** *PNAS* <https://doi.org/10.1073/pnas.2102791118>
- Reagan PL and Mielke HW. (1984). **Comments to EPA from the Minnesota Lead Coalition**– ResearchGate https://www.researchgate.net/publication/329071466_1984_Reagan-Mielke_EPA_comments
- Christopher R. Gonzales, Anna A. Paltseva, Trevor Bell, Eric T. Powell, and Howard W. Mielke **Agreement R of Four Analytical Methods Applied to Pb in Soils from the Small City of St. John’s, Newfoundland, Canada.** *Int. J. Environ. Res. Public Health.* <https://doi.org/10.3390/ijerph18189863>
- Mielke, Howard W, Mark AS Laidlaw, Chris Gonzales. Characterization of lead (Pb) from traffic in 90 U.S.A. urbanized areas: 2011 Review of urban lead dust and health. *Environ. Int.* 37:248-257. DOI: 10.1016/j.envint.2010.08.006
- Egendorf SP, Mielke HW, Castorena-Gonzalez JA, Powell ET, Gonzales CR. **Lead (Pb) in New Orleans: A spatiotemporal and racial analysis.** *Int. J. Environ. Res. Public Health* 2021, 18, 1314. <https://doi.org/10.3390/ijerph18031314>
- hmielke@tulane.edu. <https://www.youtube.com/user/Leadsafeplay>