Cleaning up Lead and Other Dirty Issues in Soil for Community Health on a Budget

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Soil Environmental Science / Chemistry Program

Research program

- Soil/Environmental contaminant chemistry
  emphasis on environmental media (soil, dust, water, food)
  and human and ecosystem exposure

- Development and evaluation of soil remediation technologies

- Beneficial use of industrial and agric. byproducts via land application

Teaching

Environmental Fate and Impact of Pollutants in Soil and Water

Soil Chemical Processes and Environmental Quality

Urban Soils and Ecosystem Services: Assessment and Restoration
Reuse of Vacant Land Soil in Metropolitan Areas

Vacant Land in Cleveland;
16,000 properties in Cuyahoga County

Land bank

Rural Detroit
Vacant Land Reuse Opportunities

- **Urban agriculture/gardening**
  improve the availability of healthy, fresh foods,
  improve nutrition and health of residents
Community gardens improve the quality of life and social fabric of city neighborhoods

- **Creation of parks, playgrounds and other commons**
Locavore movement

Cleveland Urban Ag

RID-ALL
GREEN PARTNERSHIP

COME SEE WHAT'S GROWING ON AT RID-ALL

DAILY FARM TOURS AVAILABLE
- SCHOOLS
- FIELD TRIPS
- COMMUNITY GROUPS
- GARDEN CLUBS
- CHURCHES
- VETERANS
- VOLUNTEERS

SCHEDULE YOUR TOUR TODAY

INFO@RIDALL.ORG
216.999.7004
I only use local children
Urban Soils May Contain Contaminants

- Heavy Metals, Pb etc
- Toxic organics
- benzo(a)pyrene
Health Concerns / Chronic Exposure

- **Cd, As**
  - Cd - kidney disease
  - As - internal organ/skin cancer
- **Pb** - impaired mental development
- **Zn** - loss of vegetation (phytotoxicity)

- Incidental ingestion of soil containing Cd, As, Pb
- Increase exposure from soil erosion
- Cd, As in food chain
- Well water exposure
- Groundwater contamination
Lead Exposure and Public Health
Excessive Blood Pb (EBL) in Cuyahoga County

<table>
<thead>
<tr>
<th></th>
<th>EBL</th>
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<tbody>
<tr>
<td></td>
<td>&gt; 5 μg/dL</td>
</tr>
<tr>
<td>Cuyahoga county</td>
<td>13.1 %</td>
</tr>
<tr>
<td>Cleveland</td>
<td>17.6 %</td>
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</table>

Significant Pb exposure
-- indoor (house dust), drinking water outdoor (soil)

http://www.ccbh.net/child-elevated-blood-lead-level/
Pb Toxicity

Pb encephalopathy (poisoning)
high exposure to Pb; blood Pb level (BLL) ≈ 70 ug/dL

Symptoms
- vomiting
- headaches
- muscle and joint weakness or pain
- excessive tiredness or lethargy
- behavioral problems or irritability
- difficulty concentrating
- Coma, death

- Neurological outcomes
  2 to 4 point IQ deficit for each ug/dL Pb in range 5 to 35 ug/dL

- Many other effects, renal toxicity, blood pressure, bone, immunotoxicity
Where did the Pollution Come From?

Energy production
Coal burning power plants
Electric power generation

Mining and metal production
Soil Pb/heavy metal contamination risk from historical (legacy) contamination from smelter sites in old industrial cities

USA Today Investigative Report, Apr 19, 2012
Ghost Factories “poisons in the ground”
Long-gone lead factories leave poisons in nearby yards

Pb Contamination from Paint and Gasoline

Pb in paint until 1978

Leaded gasoline

Phased out in 1970s

50% deposited within 100 m of road

other 50% dispersed
Restoration of Degraded/Contaminated Soil

Call in the Soil Doctor

Soil Assessment (Testing / Diagnosis)
Is the soil contaminated?
Does it need treatment?

“Management /Revitalization" (Treatment) remove or detoxify the contaminant

Don’t want this!
Most Urban Soil are not Contaminated
65 urban lot soils from OSU extension from urban residential sites in Cleveland

- 69% (< 400 ppm Pb)
- 25% (400 - 700 ppm Pb)
- 6% (1000 + ppm Pb)

Don’t grow vegetables
Manage / treat
fine to use

45 sites
16 sites
4 sites
How do Address Contaminated Soil?

Soil Excavation/Landfilling

- Excavate top 6”
- Fill with new soil “borrowed soil”

Soil Pb, 800 mg/kg

Very Expensive but Contaminant “Gone”
--at least gone from earth surface

$100 to $300/ton
$20,000 to $60,000 / property

Thousands of properties in one city? $200M?
Soil Remediation by Soil Amendment on a Budget

Tie up the contaminant
Detoxify and keep it from moving from the soil

Soil Amendments must be locally available (eliminate transportation $$)
Easy to use / apply to soil by local producers / public
Bioavailability-Based Soil Remediation
by Soil Amendment

Add organic amendment to reduce Pb bioavailability

Akron Composted Biosolids

Many cities provide Composted biosolids
Bone Phosphate

\[ \text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2 + x\text{Pb}^{2+} \rightarrow \text{Ca}_{10-x}\text{Pb}_x(\text{PO}_4)_6(\text{OH})_2 + x\text{Ca}^{2+} \]

Hydroxyapatite + available Pb \rightarrow Unavailable Pb
bone

Lead pyromorphite

Granulated Bone Meal

100% Organic, All Natural

2-14-0

2 kg
Soluble P Fertilizer Amendments

Agricultural phosphate fertilizer
Calcium phosphate (TSP)

Soluble P Fertilizer reaction with Pb is much faster than Insoluble Phosphates (hydroxyapatite, bone meal)
Poultry Litter
organic material with soluble calcium phosphate

Ca phosphate is added to Chicken grain / feed as a Mineral P supplements

Our research in Cleveland Reported we were able to remediate soil Pb contaminated soil
Agricultural Limestone

Pb Precipitation: raising soil pH with limestone

\[ \text{CaCO}_3 + \text{Pb}^{2+} \rightarrow \text{PbCO}_3 \]

available \quad \ quad
Case Study
Remediation of Smelter Contaminated Soil
Blackwell, Oklahoma

Blackwell smelter site present

Blackwell Zn, Pb, Cd Smelter 1900 - 1972

69,000 mg/kg Zn
5,150 mg/kg Pb
1,090 mg/kg Cd
152 mg/kg As
Zn bioavailability and toxicity in treated Pb/Zn Smelter-Contaminated Soils


Control | Alkaline Biosolids | N-Viro Soil | Rock Phosphate | Non-alkaline Biosolids

= available Zn
Tri-state Mining District
Joplin, Missouri Case Study

Tri-State Mining Region
Extensive Pb, Zn Mining Smelting / Processing
Tri-State Mining District
Mining processed waste
Environmental / health impacts
Residential population

Epidemiological studies

Increased incidence of chronic kidney disease, heart disease, skin cancer, and anemia to nearby control areas

10 to 20% of children (6 to 72 months old) have > 10 ug/dL blood Pb
Excessive exposure to Cd
Remediation of Soil Pb at Joplin, Missouri

USEPA, USDA, industry, universities

Add soil amendments to Pb-contaminated soils to reduce Pb bioavailability
Joplin Soil Feeding Test
Clinical Protocol
Professor J. Graziano
Mailman School of Public Health
Columbia University

• Human volunteers with Pb isotope ratio different from that of the test soils.
• Screening and physical exam.
• Obtain informed consent.
• Three day clinic admission.
• Subject dosed at 250 µg Pb/70 kg BW using soil <250 µm in gelatin capsules.
• Collect blood and urine samples
### Joplin Soil Results

<table>
<thead>
<tr>
<th>Group</th>
<th>Age</th>
<th>Weight</th>
<th>Pb Dose</th>
<th>Soil Dose</th>
<th>Bioavailability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>29.6</td>
<td>62.2</td>
<td>238</td>
<td>45.7</td>
<td>42.2 (26.3-51.7)</td>
</tr>
<tr>
<td>P-Treated</td>
<td>34.5</td>
<td>72.2</td>
<td>261</td>
<td>61.5</td>
<td>13.1 (10.5-15.8)</td>
</tr>
</tbody>
</table>

70% reduction in Pb bioavailability!
How Long will the Soil Treatment Last?

Research has shown Pb Pyromorphite is Stable Remediation Treatment Will Last

Other treatments that degrade (e.g. biosolids, compost) will require repeat treatments

Figure 3. Pyromorphite crystals. Phosphorus from a hydroxyapatite additive can immobilize soil-based lead into this stable compound and make it less bioavailable.
Soil Remediation using Soil Amendments To Revegetate Superfund Contaminated Land
Univ. of Washington, USEPA ERT, Okla. State Univ.

72 plots on Pb, Zn, Cd contaminated land
Alkaline Biosolids
Biosolids Compost
Commercial phosphorus fertilizer
Al-Drinking water residuals
Fe-Drinking water residuals

Seeded with Bermudagrass
Restoration of Urban Degraded Land
Pb / Zn Smelter Contaminated Land
Bare ground and contaminant transport

Palmerton, PA. 1980; Dead Ecosystem on Blue Mountain
Restoration of Blue Mountain in Palmerton Using Soil-Biosolids Blends

Organic Amendments are excellent choices for soil restoration

Palmerton, PA.
Looking down revegetated Blue Mountain
Revitalization of Degraded (Unhealthy) Soils

Many urban soils and brownfields have lost their soil health. These soils have lost their essential “ecosystem services, to support vegetation, support the food chain (earthworms for birds, etc), and recycle waste materials (dead vegetation, excess nutrients).
Soil Organic Treatments

Biosolids

Vegetative Compost

Poultry Litter

Biochar
Historical Contamination of Soil from Pb paint, Gasoline, smelters
Old Historical Industrial Cities: Cleveland, Ohio

Community Garden (AG)
Cleveland, OH
soil Pb 910 mg/kg

Urban City Lot
Cleveland, OH
soil Pb (mean) 807 mg/kg
Management Options that Produce Food, Protect Public Health and Improve Soil Health

Cleveland Dredge (Sediment) Blend
Site Soil: Compost: Sediment 1:1:1 (v/v/v)
2 Composts:
City of Columbus ComTil compost
composted biosolids/ yard waste/ wood chips
Price Farms Organics (manure/yard waste)

Incorporation of sediment blend + compost into site soil
improved soil health (aggregate stability, active C, respiration, nutrients) and
removed public health constraints due to contaminants

reduced lead from 500 to 150 ppm
reduced benzo(a)pyrene from 4.27 ppm to 0.99 ppm

How do I get my soil tested for metals?

Commercial lab, $50 to $125/sample
University Lab “estimates”: start at $17 for just Pb

Field XRF gun, $35,000 +
X Ray only penetrates 5 mm

Benchtop X Ray Fluorescence (XRF)
OSU Soil, Water, Environment Lab (SWEL, $10/soil)
Many metals not just Pb!

https://swel.osu.edu/
We Offer Comprehensive Testing and Interpretation of Soil Remediation using Soil Amendments
Damaged Soil Investigation, Restorations and Treatment
https://dirt.osu.edu/

Internationally known for Soil Ingestion Soil Tests (inexpensive) research since 1994
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The New Frontier

Live Long and Prosper
Soil Amendments for Soil Restoration
Making the Good Earth Better

Aaron Mali and Oulu Coquie
rototill in the Soil Treatments
Thank you for listening

For more information
Ohio State Univ. Damaged Soil Investigation, Restorations and Treatment
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