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**

<u>Teaching</u>

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

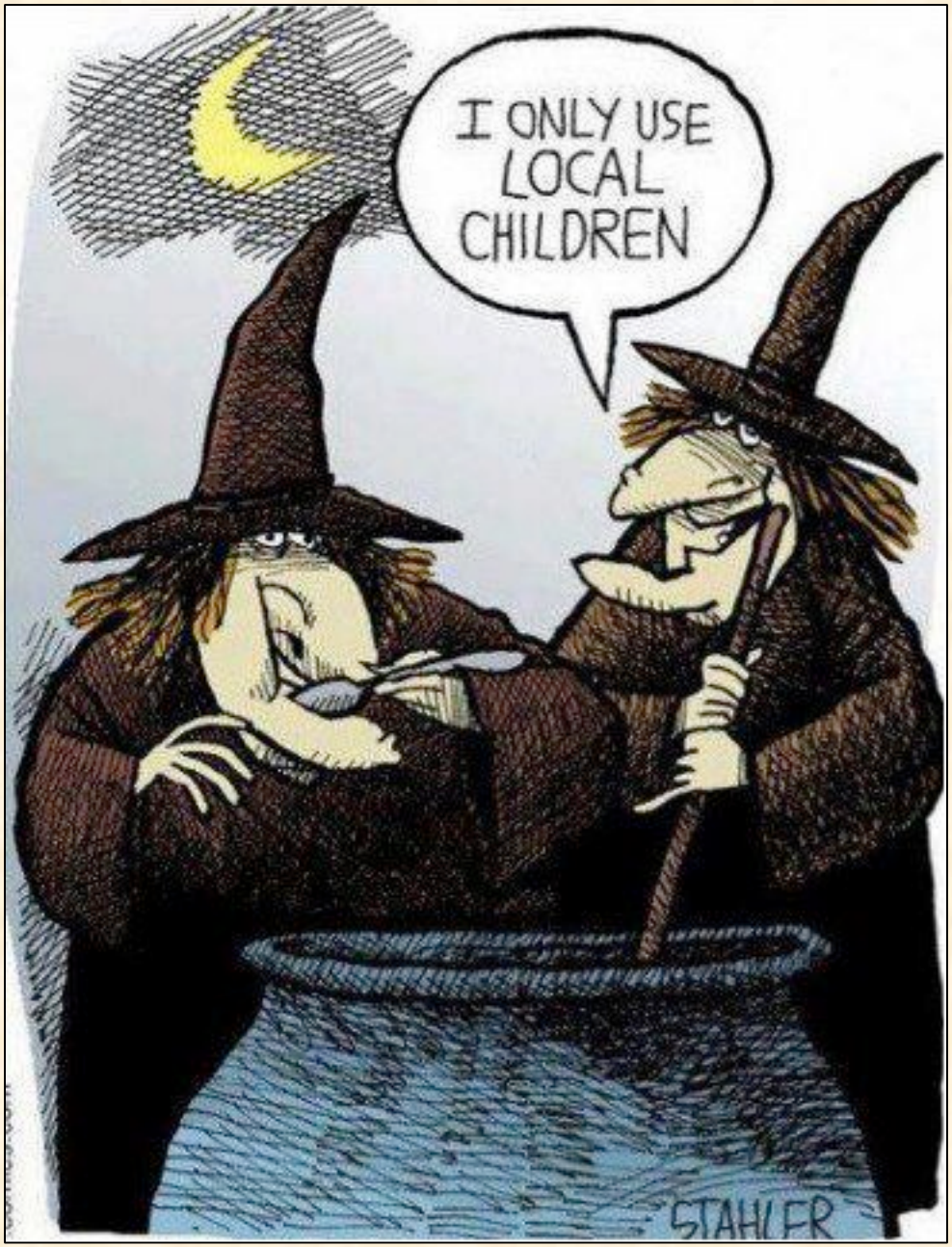
Vacant Land in Cleveland; 16,000 properties in Cuyahoga County land bank

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**

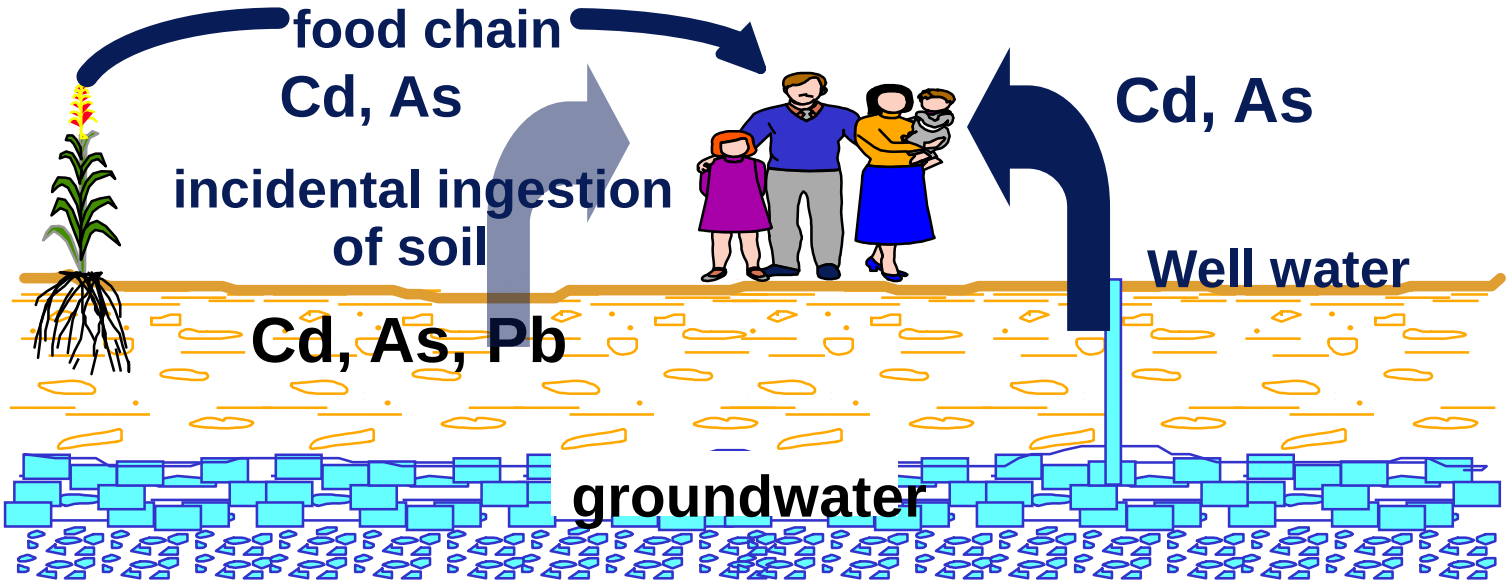
Locavore movement


I ONLY USE LOCAL CHILDREN
STAHLER

Urban Soils May Contain Contaminants

- Heavy Metals, Pb etc
- Toxic organics
- benzo(a)pyrene

Health Concerns / Chronic Exposure

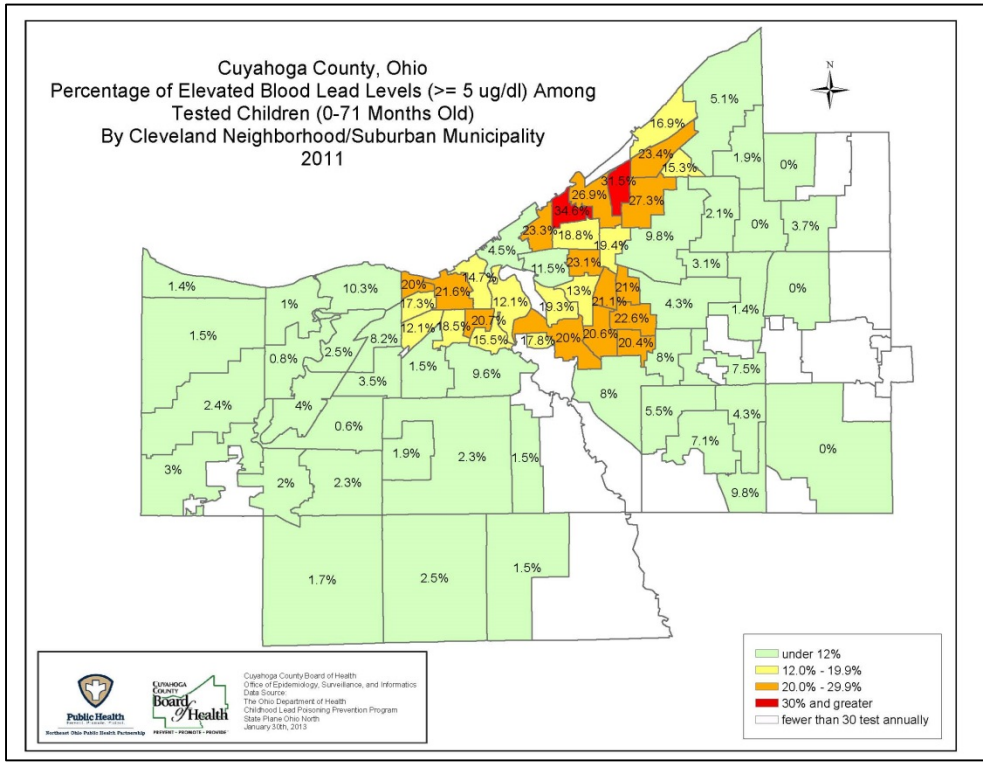


Cd - kidney disease
As - internal organ/skin cancer
Pb - impaired mental development
Zn - loss of vegetation (phytotoxicity)
increase exposure from soil erosion

Lead Exposure and Public Health

Excessive Blood Pb (EBL) in Cuyahoga County

	EBL > 5 µg/dL
Cuyahoga county	**13.1 %**
Cleveland	**17.6 %**



http://www.ccbh.net/child-elevated-blood-lead-leve/

Significant Pb exposure

-- indoor (house dust), drinking water

outdoor (soil)

Pb Toxicity

Pb encephalopathy (poisoning)

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

<u>Symptoms</u>

- **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**

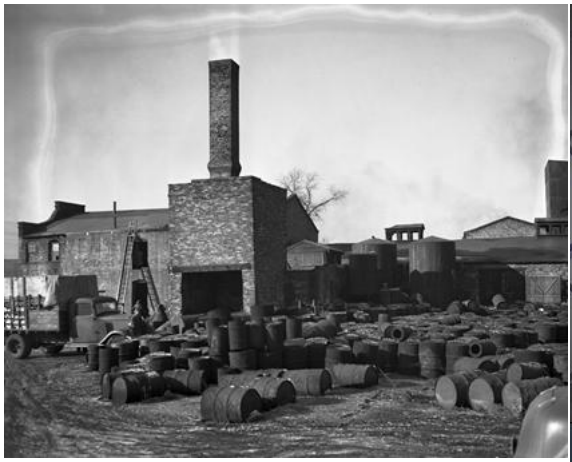
Where did the Pollution Come From?

Energy production

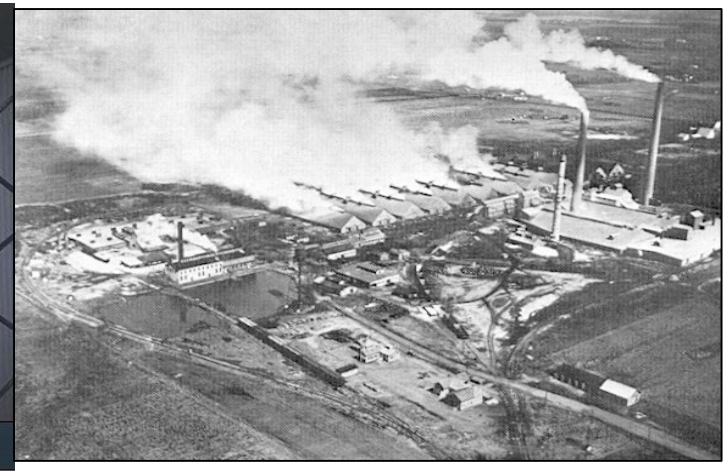
Coal burning power plants
Electric power generation

Mining and metal production

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



Neighborhood smelter



Edge of town large smelter

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

http://usatoday30.usatoday.com/news/nation/smelting-lead-contamination

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 !

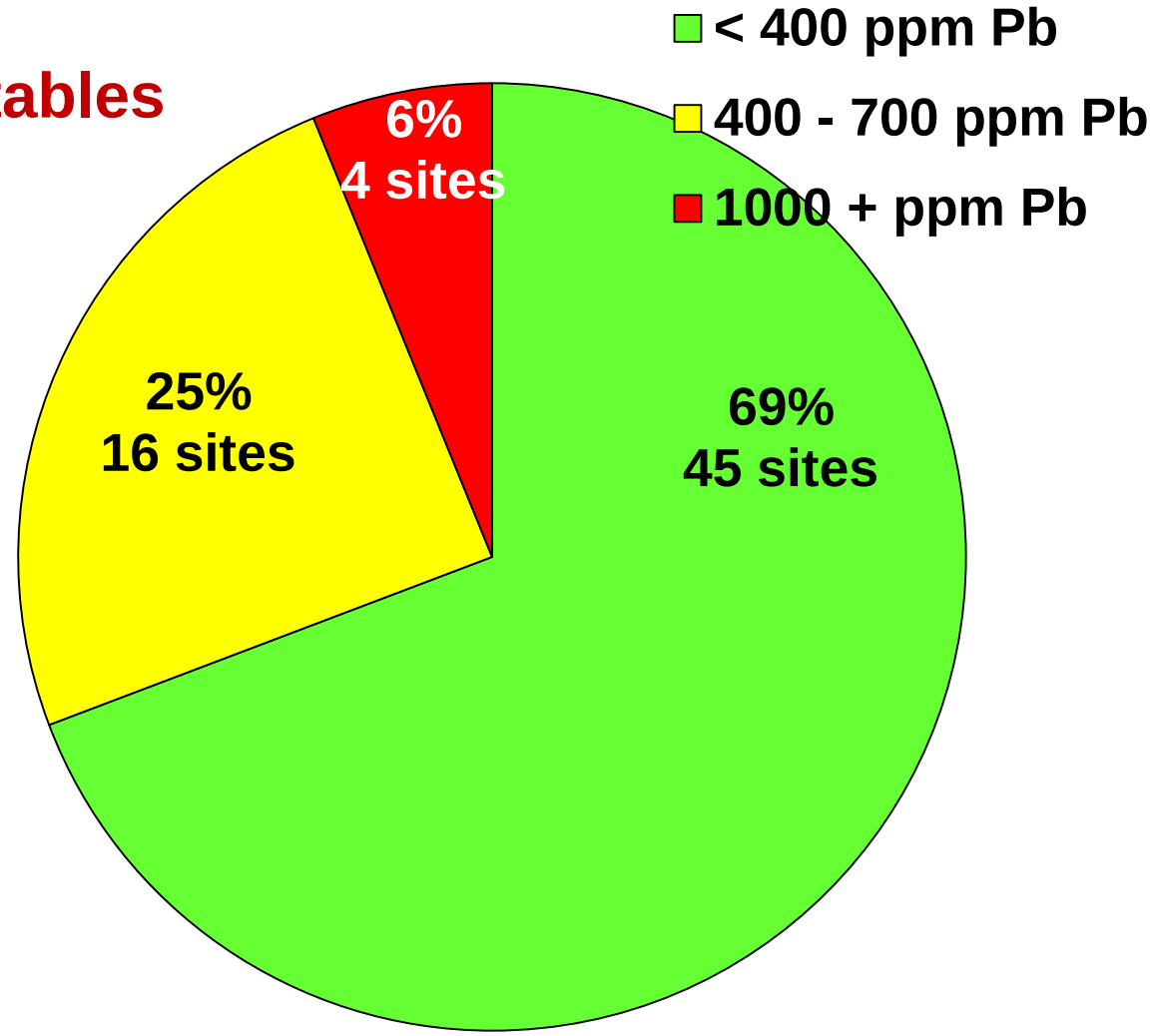
Most Urban Soil are not Contaminated

65 urban lot soils from OSU extension from urban residential sites in Cleveland

Don’t grow vegetables

Manage / treat

fine to use



How do Address Contaminated Soil?

Soil Excavation/Landfilling

Excavate top 6”

Fill with new soil
“borrowed soil”

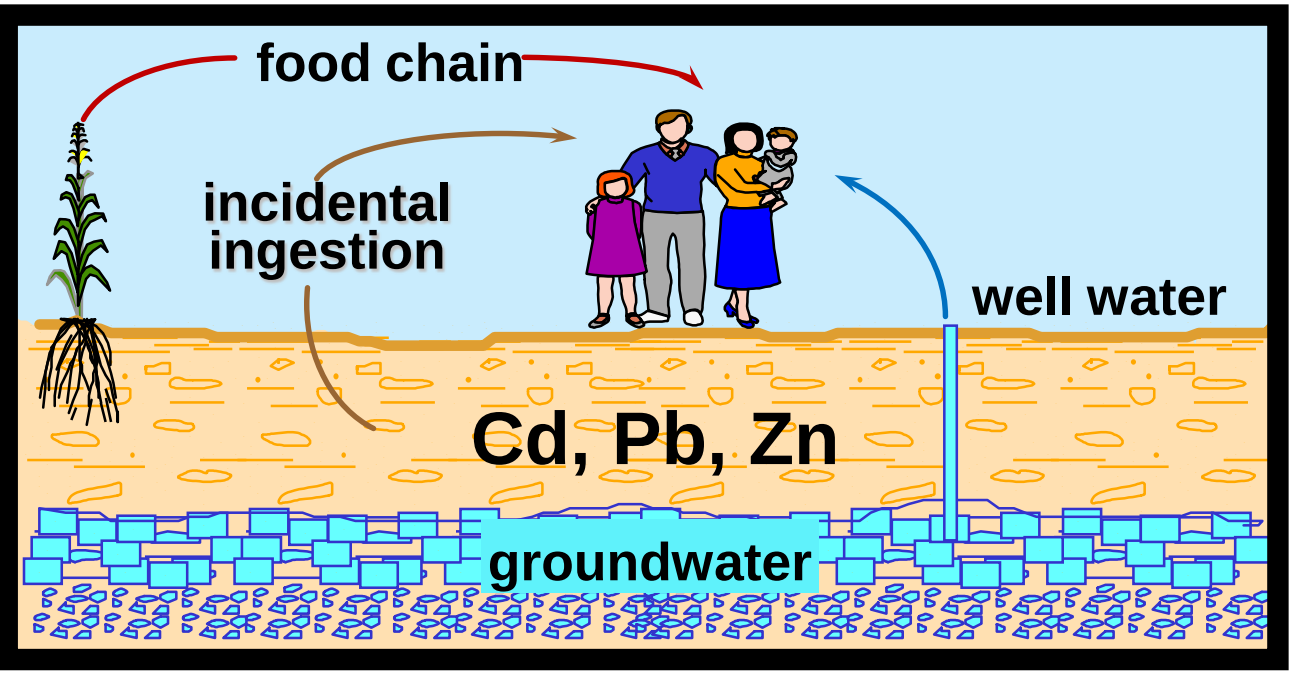
Soil Pb, 800 mg/kg

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

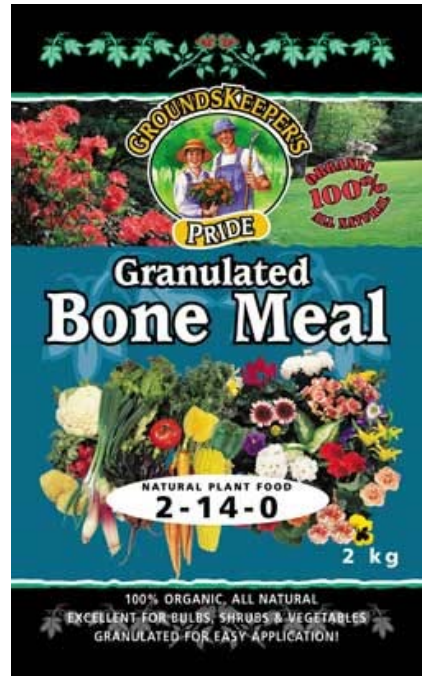
Bone Phosphate

$$Ca_{10}(PO_4)_6(OH)_2 + xPb^{2+} \rightarrow Ca_{10-x}Pb_x(PO_4)_6(OH)_2 + xCa^{2+}$$

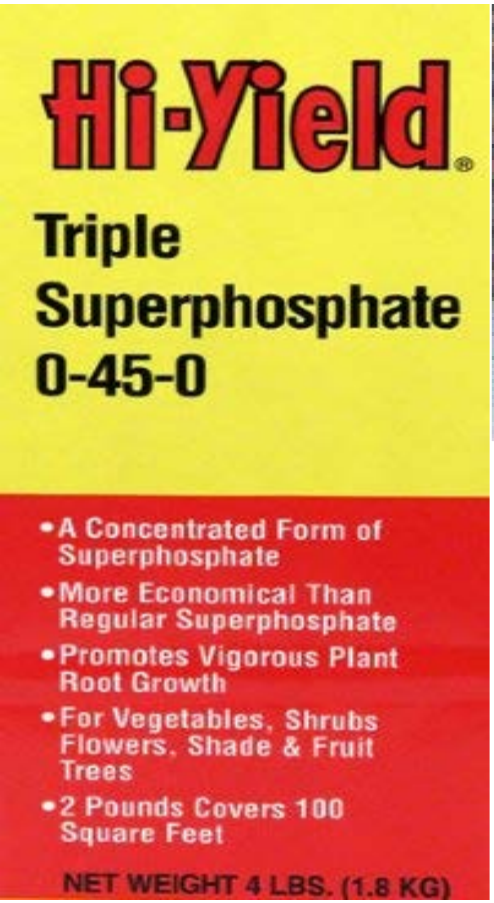
Hydroxyapatite + available Pb → Unavailable Pb

bone

Lead pyromorphite



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

$CaCO_3$ + Pb^{2+} → $PbCO_3$

Pb^{2+}: available

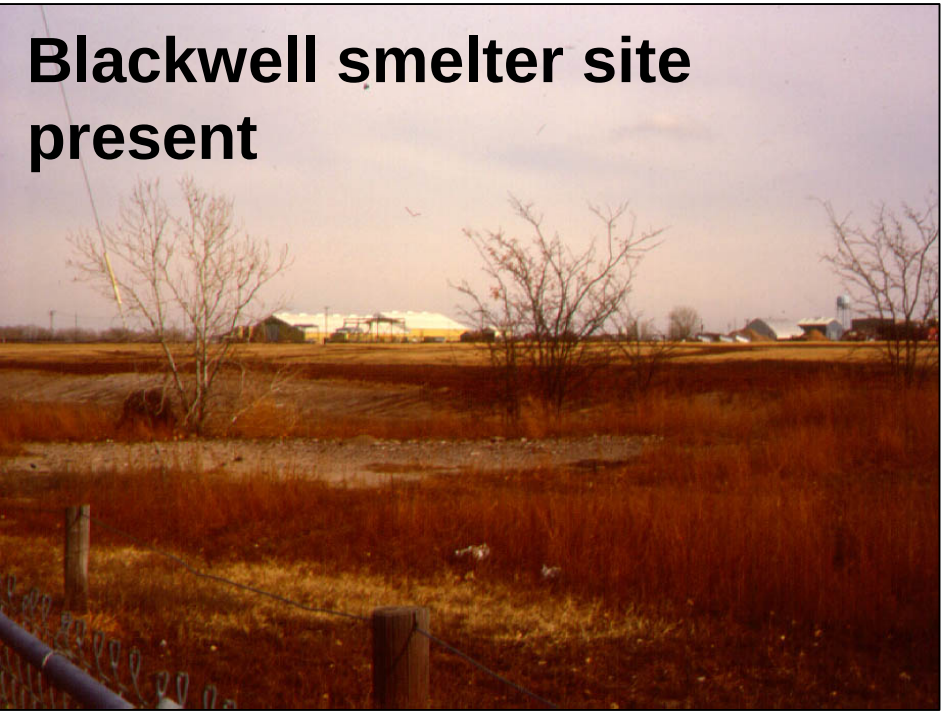
$PbCO_3$: unavailable to plants
available if ingested
Carbonate dissolves in stomach

Use “Agricultural” Limestone
Very fine grind

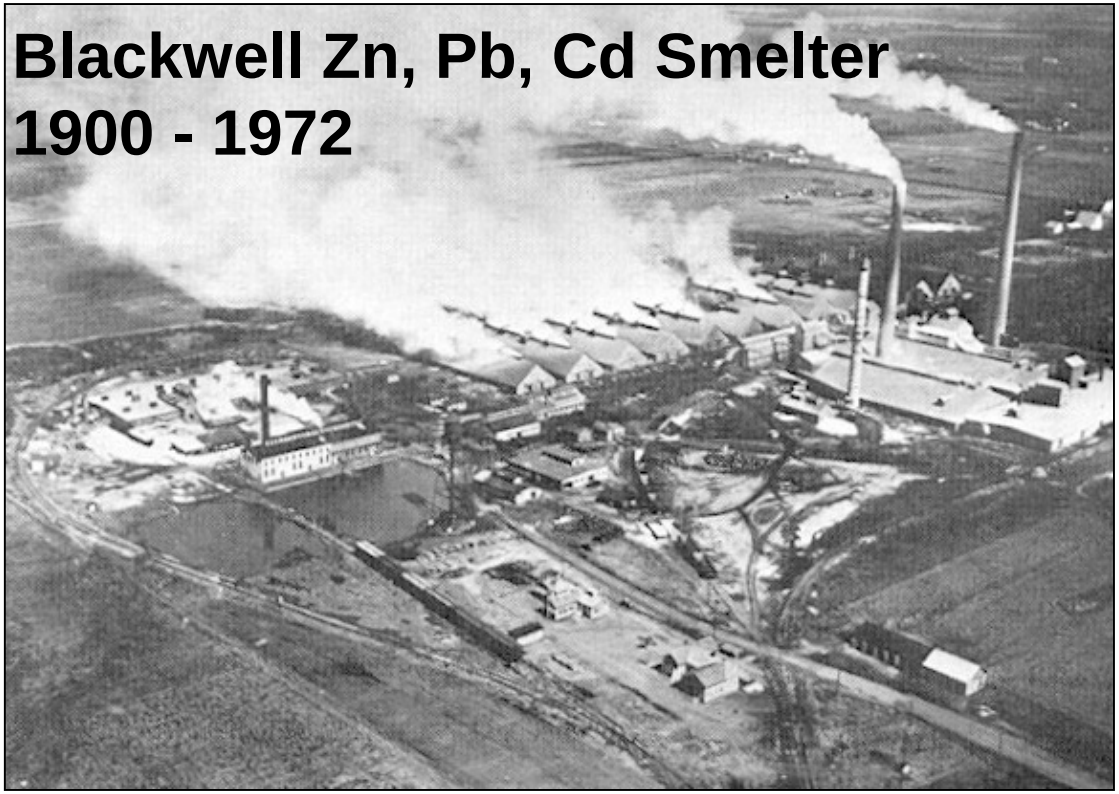
Case Study

Remediation of Smelter Contaminated Soil

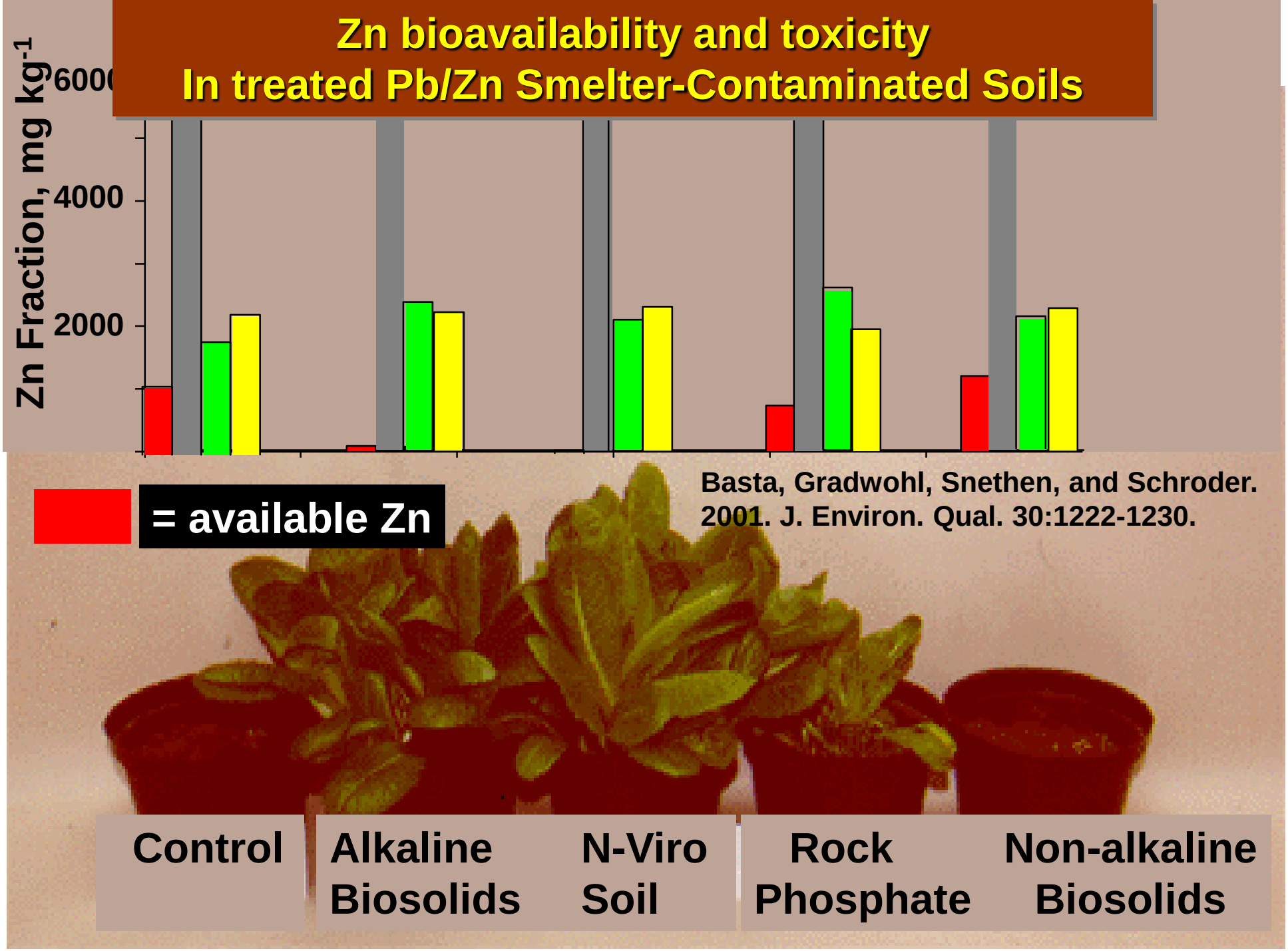
Blackwell, Oklahoma



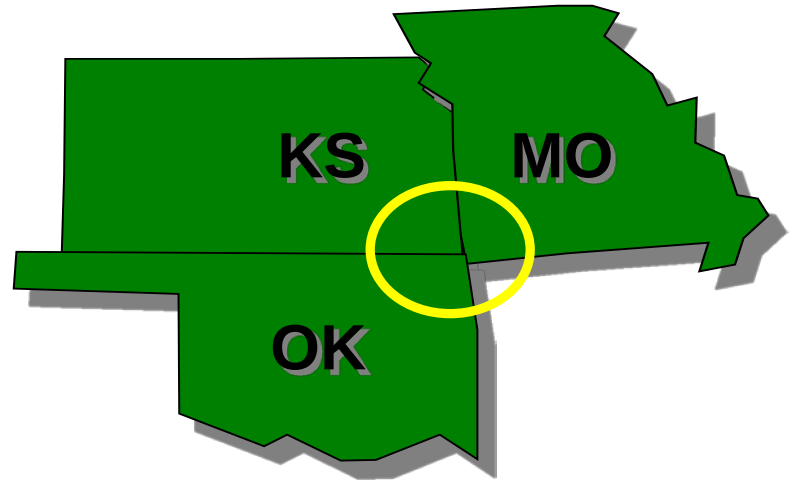
69,000 mg/kg Zn
5,150 mg/kg Pb
1,090 mg/kg Cd
152 mg/kg As



Zn bioavailability and toxicity
In treated Pb/Zn Smelter-Contaminated Soils



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**

Phosphate Soil Amendment Reduced Blood Pb (Bioavailability) to Humans

Joplin Soil Results

Group	Age	Weight	Pb Dose	Soil Dose	Bioavailability
	yr	kg	µg	mg	%, Absolute
Untreated	29.6	62.2	238	45.7	42.2 (26.3-51.7)
P-Treated	34.5	72.2	261	61.5	13.1 (10.5-15.8)

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

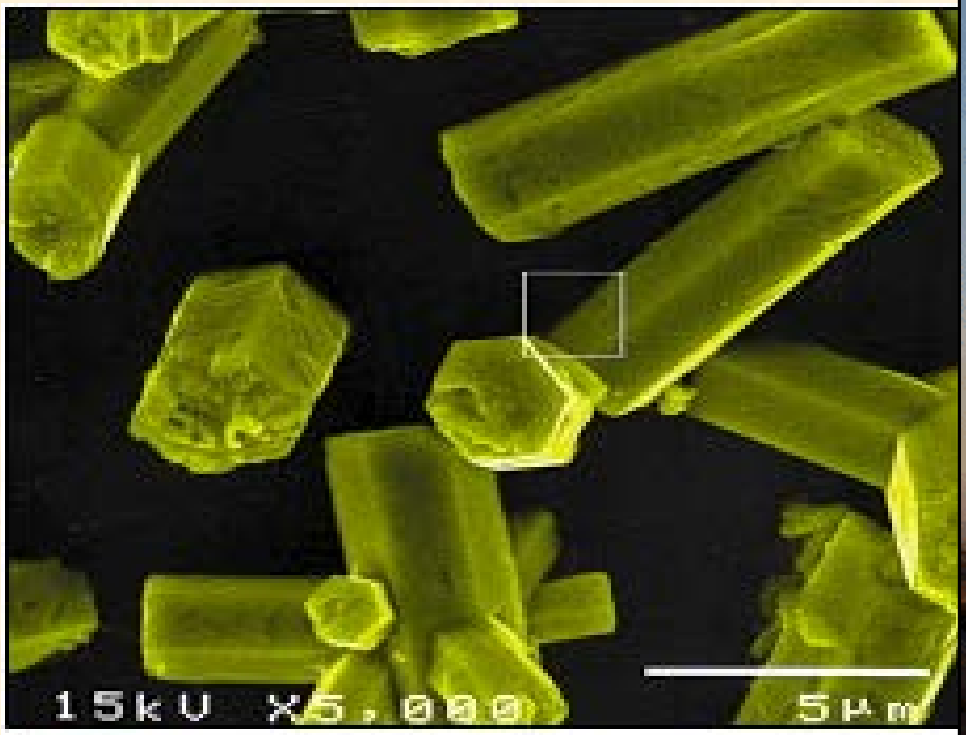


Figure 3. Pyromorphite crystals. Phosphorus from a hydroxyapatite additive can immobilize soil-based lead into this stable compound and make it less bioavailable.

Soil Remediation using Soil Amendments To Revegetate Superfund Contaminated Land

Univ. of Washington, USEPA ERT, Okla. State Univ.

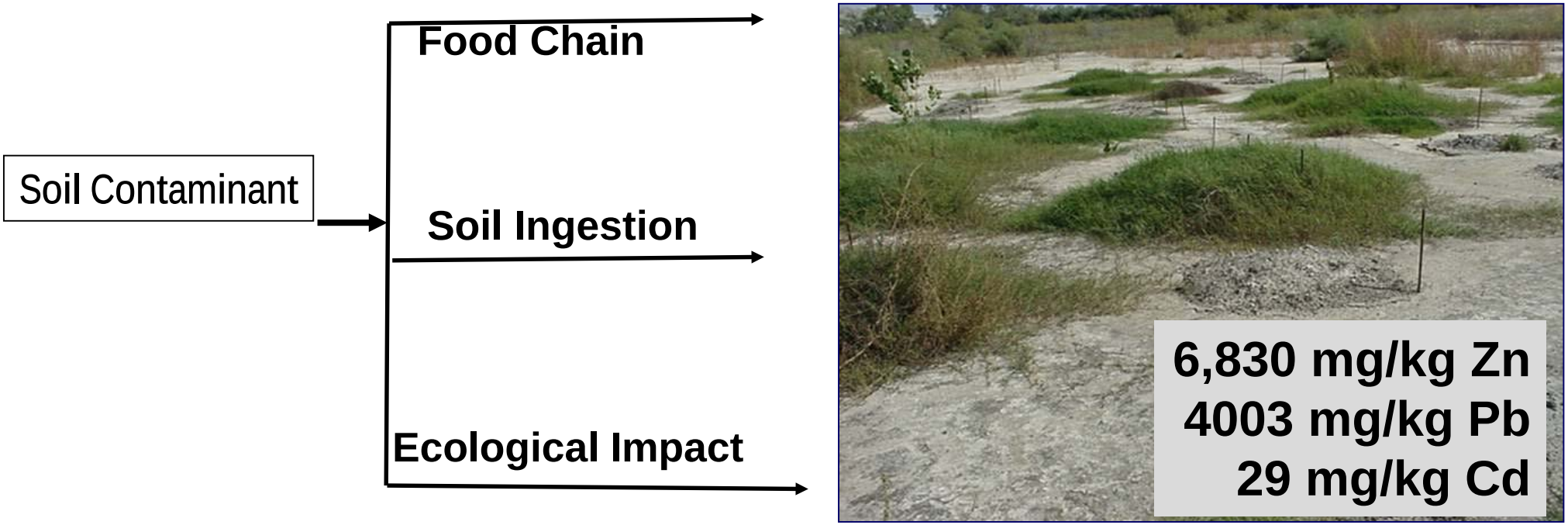
<u>72 plots on Pb, Zn, Cd contaminated land</u>

Alkaline Biosolids
Biosolids Compost
Commercial phosphorus fertilizer
Al-Drinking water residuals
Fe-Drinking water residuals

Seeded with Bermudagrass

Best Soil Amendment

Biosolids + Phosphorus Combination



Brown, S.L., H. Compton, and N.T. Basta. 2007.
Field Test of *In Situ* Soil Amendments at the Tar Creek National Priorities List Superfund Site
J. Environ. Qual. 36:1627-1634.

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

Palmerton, PA.
Looking down revegetated Blue Mountain

Organic Amendments are excellent choices for soil restoration

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).

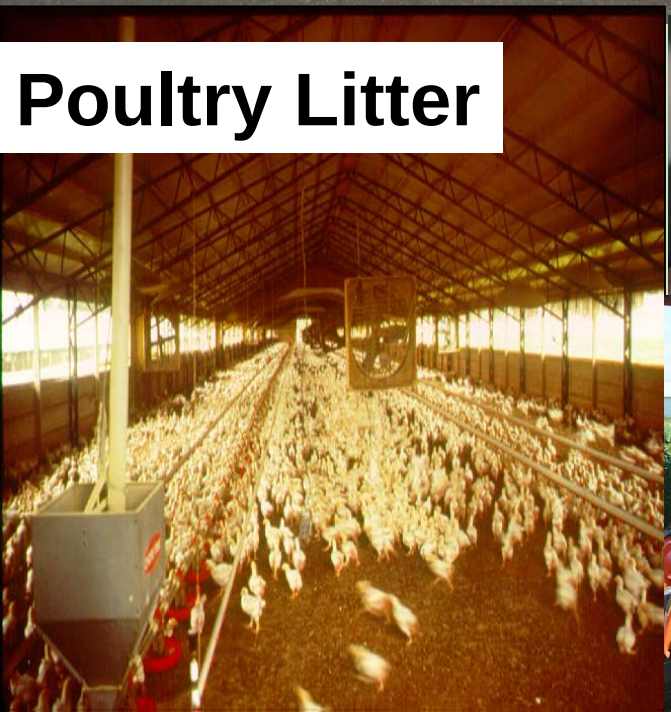
Degraded soils in Calumet, IL

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)
<u>2 Composts:</u>
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

Obrycki, John F., Nicholas T. Basta, Steven W. Culman. Management Options for Contaminated Urban Soils to Reduce Public Exposure and Maintain Soil Health. J. Environ. Qual. doi.2134/jeq2016.07.0275

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

1997

2007

Unable to obtain photo

2017

Soil Remediation by Soil Amendment

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
https://dirt.osu.edu/

OSU Soil, Water, and Environment Lab
https://swel.osu.edu/

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