Growing on previously used Sites - Best Management Practices

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Questions

- Is there contamination?
- If so, what is it and how much?
- Does the site require environmental cleanup?

- Growing in-ground or above ground?
- What crops will be grown?
- What are the general soil conditions?
- Who will work in the garden (adults, kids, ADA)?

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Most Common Contaminant in Urban Environment

Lead

- Lead based paint, automobile exhaust, waste oil
- Lead levels of 200-300mg/kg are common in urban soils

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Our Project

Work with select community–based gardening initiatives to evaluate uptake of heavy metals and other contaminants by food crops, and develop recommendations for seedbed preparation and corrective/protective actions to address contaminants.

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Process

- Establish site history
- Collect soil samples
- Best management practices (adding soil amendments, raised beds)
- Continuous monitoring, soil and produce sampling
- Training and technical assistance to participating organizations (sample collection, site eval., etc.) throughout

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Washington Wheatley

Kansas City, MO

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Washington Wheatley

Kansas City, MO

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Soil Test Results

- Detectable levels of DDT (0.04 ppm to1.3 ppm) and DDE (0.03ppm and 0.04 ppm)
  - DDE is a daughter/breakdown product of DDT
  - DDT, an insecticide, was banned in the US in 1972, but is very persistent in soils (half-life of DDT ~15 yrs., DDE ~11 yrs.)
- No detectable chlordane
- Mildly elevated lead levels (58mg/kg-305mg/kg)
- Distribution of lead was highly heterogeneous
- Laboratory results were in close agreement with in situ XRF data

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Recommendations, 2009

To minimize absorption of lead and/or DDT by plants:

- Maintain soil pH levels above 6.5 to 7.0. Lead is relatively unavailable to plants when the soil pH is above this level. The soil pH at the WW site is about 7; therefore, no action is required.

- Lead is also less available when soil phosphorus concentrations are high. Phosphorous concentrations at the WW site are very high. So phosphorus addition will not be necessary for this growing season.

- Add organic matter to soil to reduce both lead and DDT availability to plants.

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Kansas City Test Plot

Summer 2009

Experimental Design:

Completely randomized block design (RCBD) in spilt-plot arrangement

Factor	Variables
Compost	yes (28 kg/m^2), no
Plant type	tomato, sweet potato, swiss chard

Kansas City, Test Plot - 2010

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Lead Uptake in Crops

Compost	Crop Type	Total Pb in Soil (mg/kg)	Pb Uptake in Crop Tissue (mg/kg)*
YES	Swiss Chard	155	0.289
	Carrot	129	1.406
	Tomato	154	0.064
NO	Swiss Chard	221	0.704
	Carrot	224	1.369 **
	Tomato	189	0.088

*Dry weight

All concentrations are averages of four field replicates, except **. **average of three field replicates; 2010 data

Concentrations are far below the recommended maximum permissible concentration (FAO/WHO, 2009) of 5-6 mg/kg dry weight for swiss chard. The recommended MCL for carrots and tomatoes is 1.5 mg/kg.

Unpublished preliminary data which is not released for reproduction, distribution, or publication by others.

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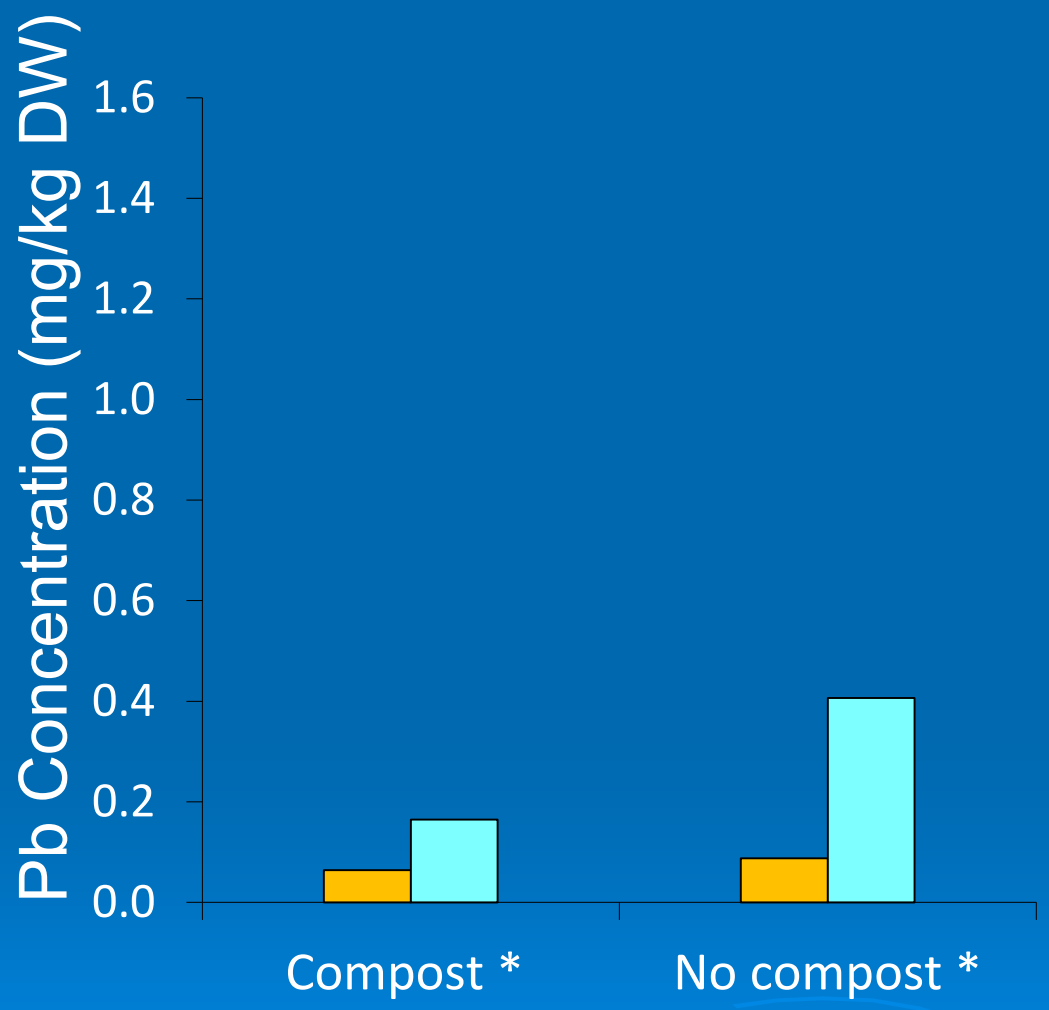
Pb Concentrations in Tomatoes



Lab cleaned

Kitchen cleaned

Treatment	Soil Pb (mg/kg)
No compost	143-271
Compost	122-193

MCL: 1.5 mg/kg DW

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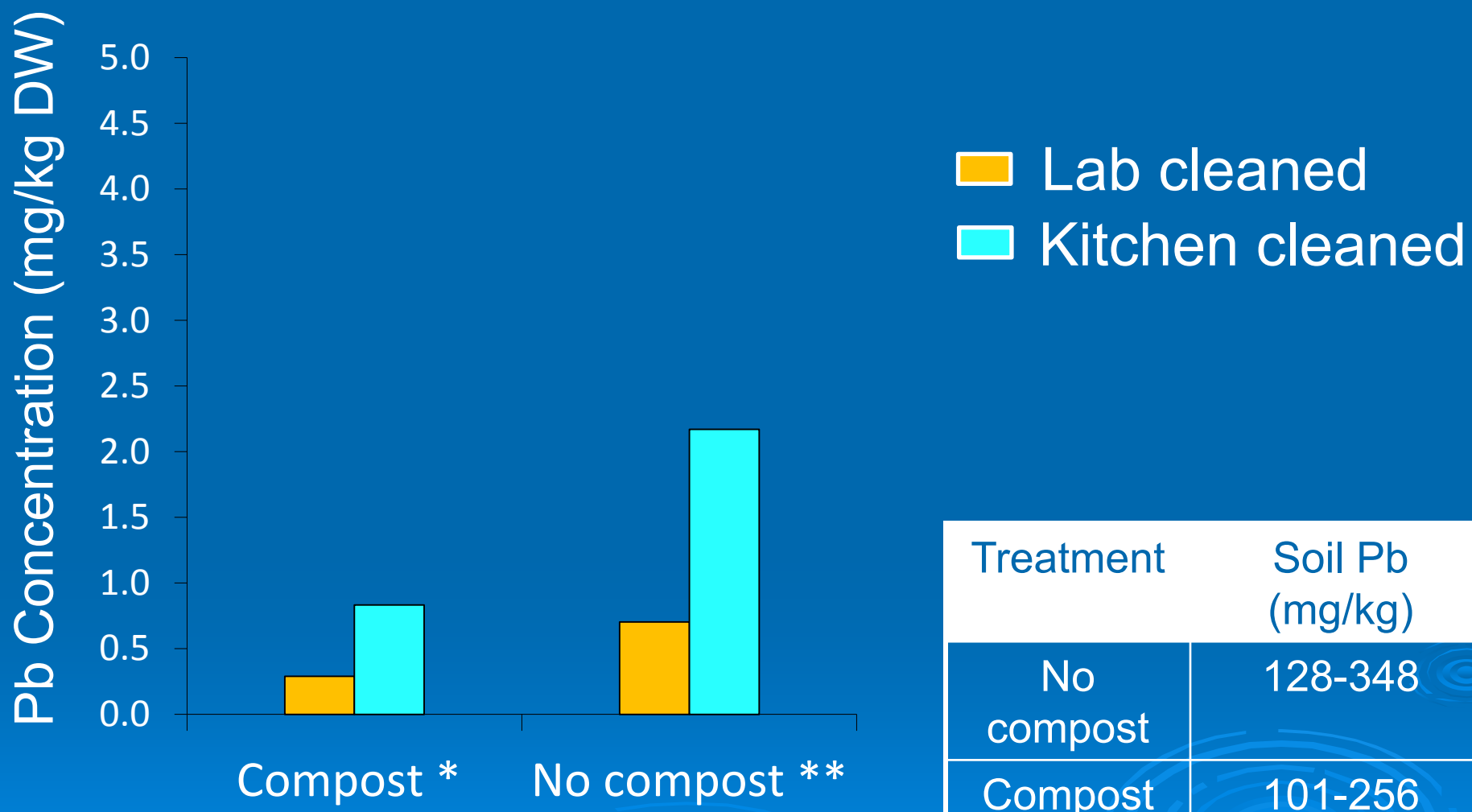
Pb Concentrations in Swiss Chard



Treatment	Soil Pb (mg/kg)
No compost	128-348
Compost	101-256

MCL: 6.0 mg/kg DW

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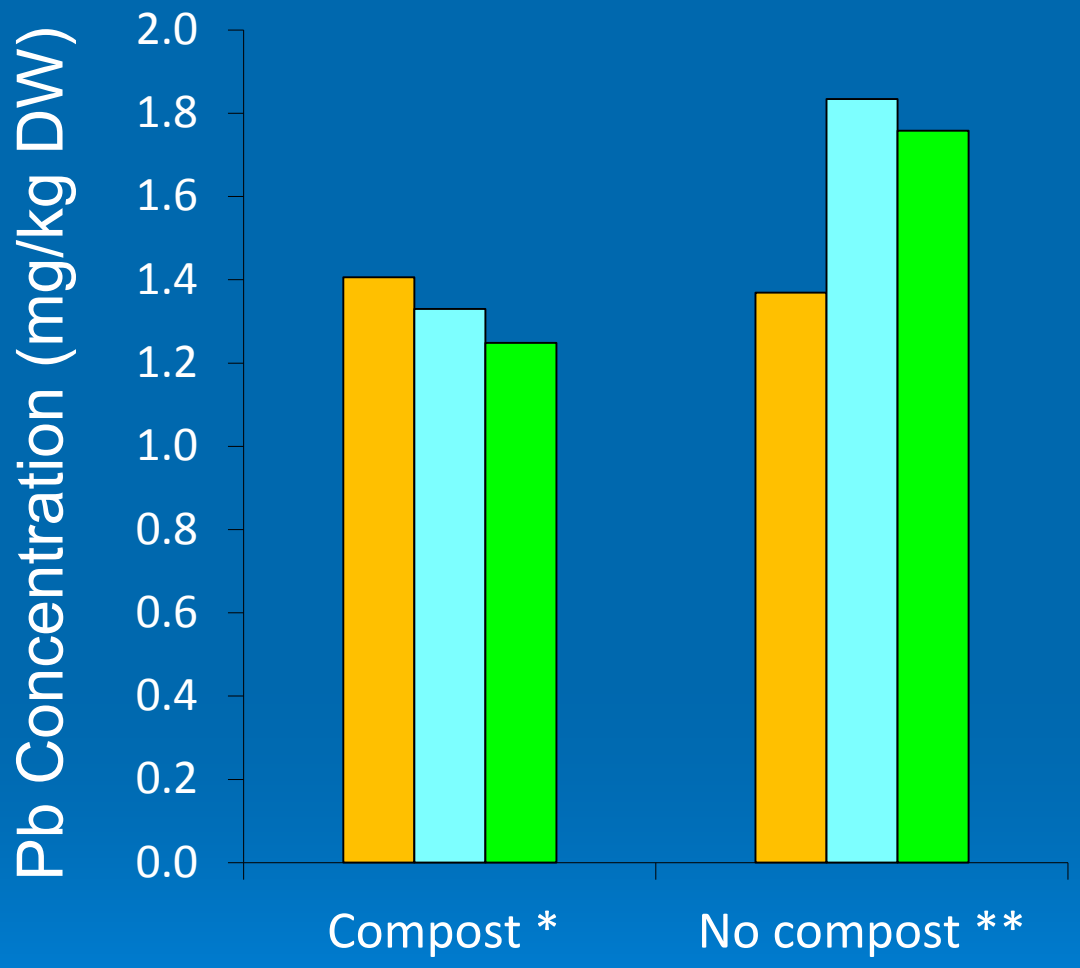
Pb Concentrations in Carrots



Lab cleaned
Kitchen cleaned
Peeled

Treatment	Soil Pb (mg/kg)
No compost	154-388
Compost	119-161

MCL: 1.5 mg/kg DW

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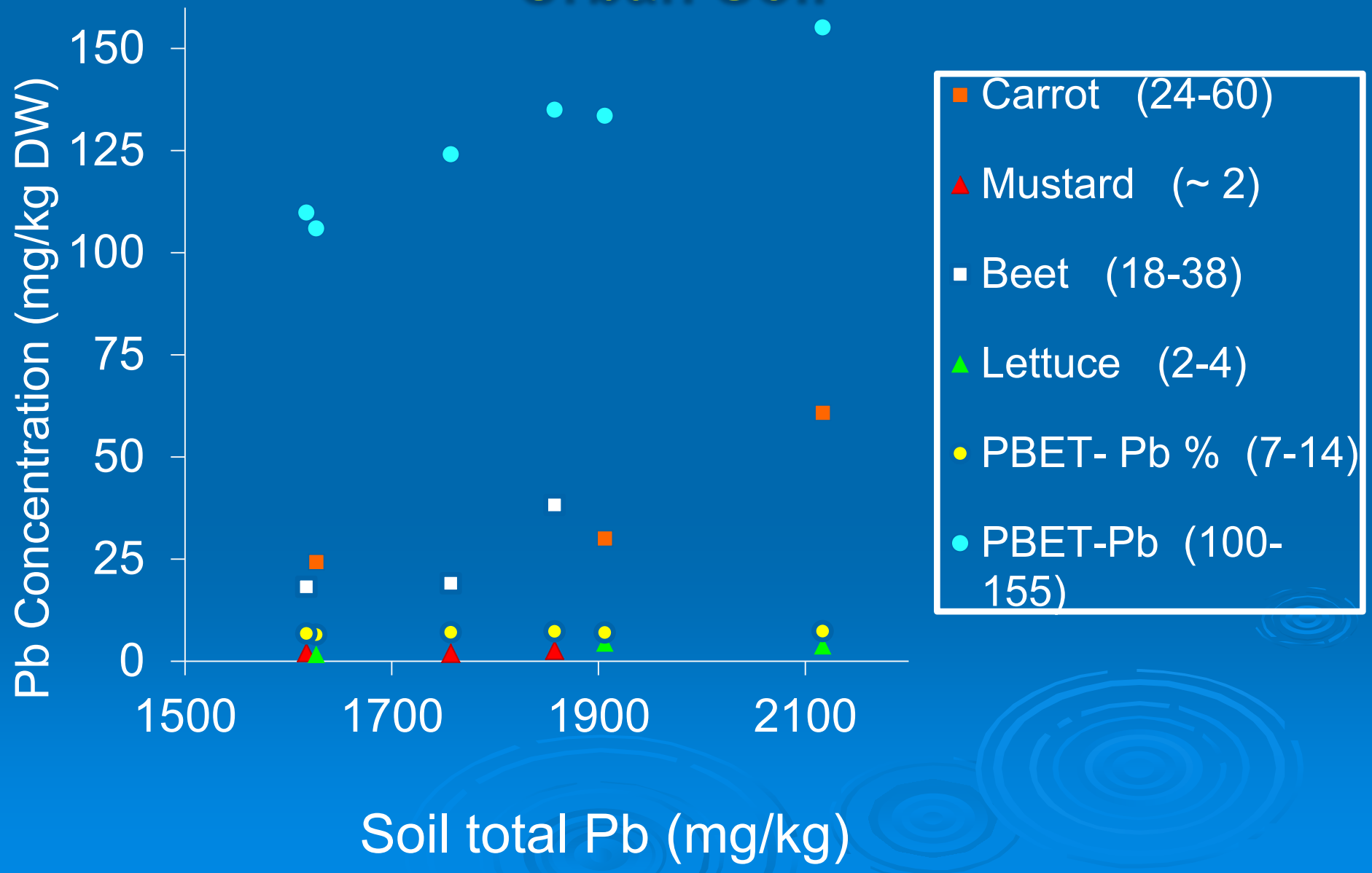
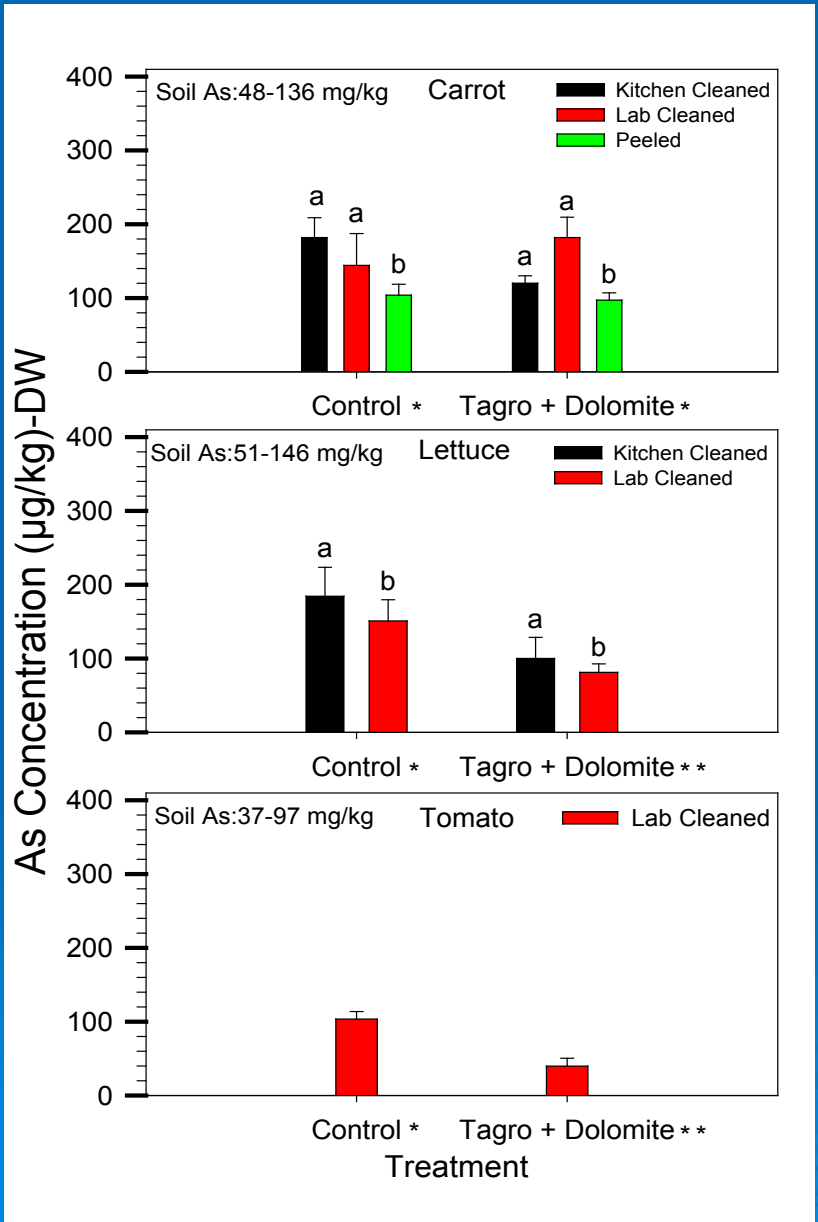
Bioavailability: High Pb-Philadelphia Urban Soil



As Uptake in Vegetables -Tacoma (2010)



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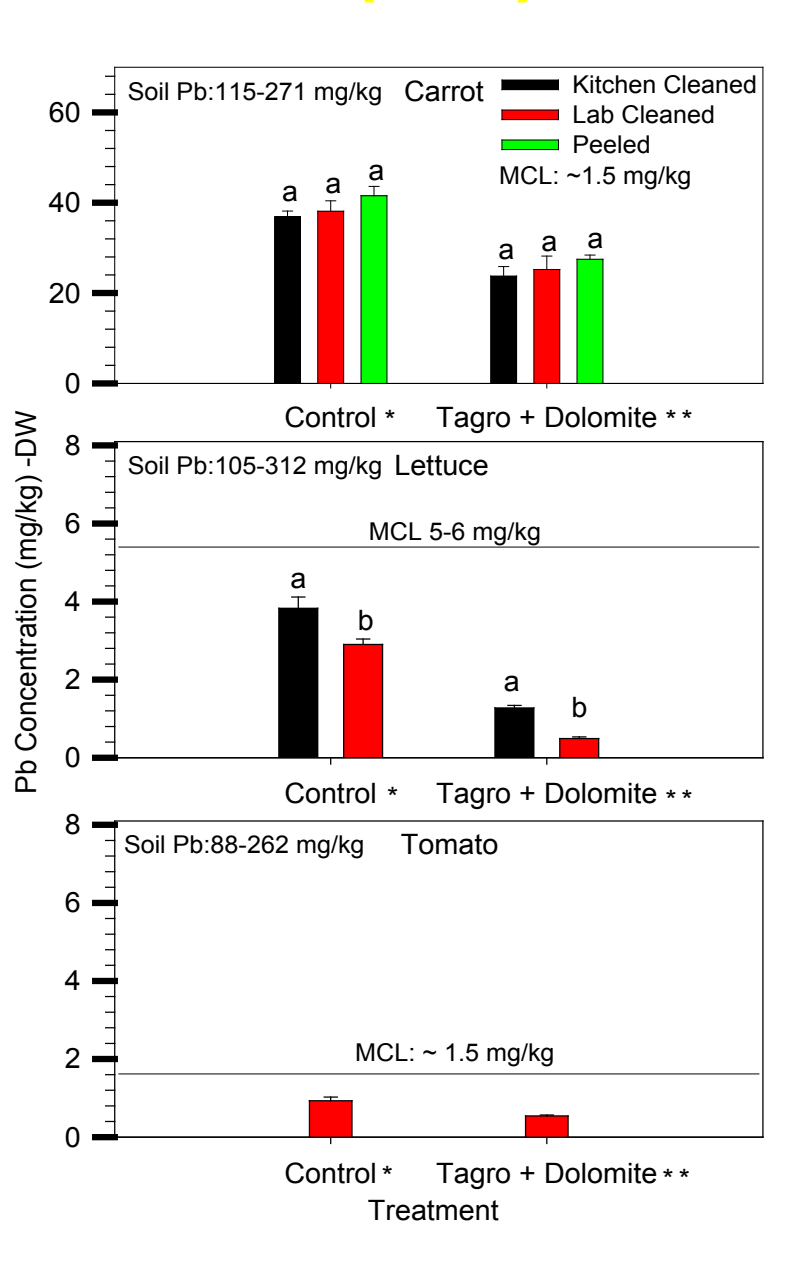

Potential Exposure Pathways

Direct exposure (Ingestion, Inhalation)

Soil → Human

Indirect Exposure

Soil → Plant → Human

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Ways to minimize Human Exposure to Lead in Soils

1. Watch your toddlers!
2. Wash your hands
3. Root vegetables should be washed and peeled before consumption
4. All other vegetables should be thoroughly washed prior to consumption
5. Apply soil amendments to reduce risk

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Before gardening on an urban vacant lot …

Need to know history of site/lot to find out re potential contamination

- Phase I environmental site assessment
  - Title/Records Search
  - Talk to neighbors
  - Visual reconnaissance
- Sampling, if warranted (Phase II ESA)

(EPA, TBA (states/EPA); consulting firms; local Health Departments; DYO)

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Growing In-Ground vs Above Ground

Decision-making drivers

- Liability
- Comfort Level of gardeners re. residual contamination
- Soil conditions
- Accessibility
- Cost
- Space

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Dealing with a mildly contaminated Site

Raised Beds, covered paths

Disadvantages:

Loose space

Bring in new soil, $$

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Growing In-Situ

- May need to take some precautions
- Add amendments

General Soil Conditions

- Nutrient Status
- Soil pH
- Organic matter content
- Soil type (clayey vs sandy soils)
- Soil Compaction

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Agronomic Information

- pH
- Organic Matter
- Nutrient Status: Nitrogen, Phosphorus, Potassium, and other macro- as well as micronutrient concentrations

Commercial labs, USDA Cooperative Extension System (universities) There are 105 land-grant universities in the U.S., including 29 tribal colleges.

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Nutrient Status

- Nutrient status: N, P, K
- Nitrogen: healthy leaf and stem growth
- Phosphorus: important for root growth, flower production, binds metals (reduces bioavailability)
- Potassium: overall plant health

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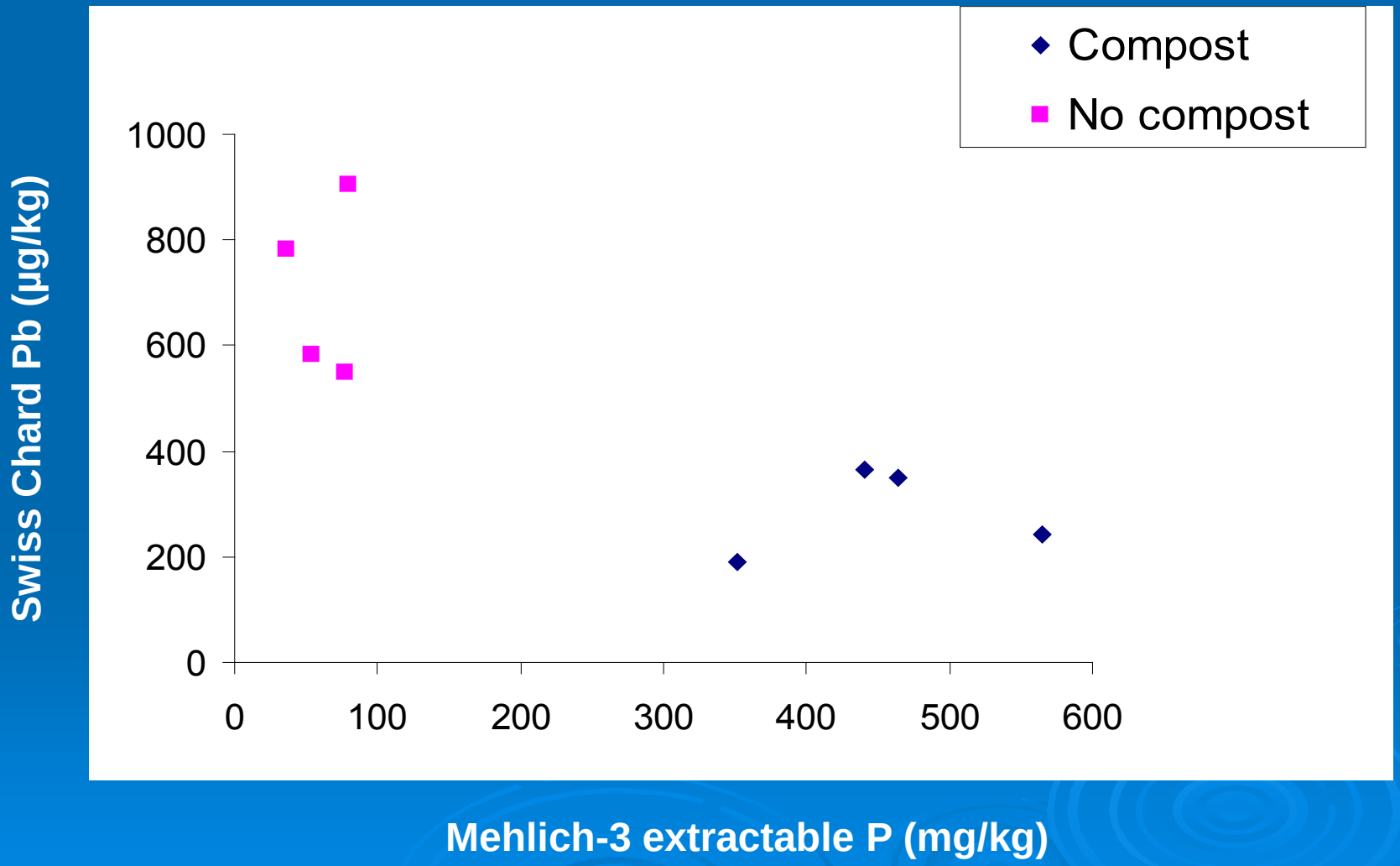
Swiss Chard Pb versus available P in Soils (Wash.Wheatley, Kansas City, MO)



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pH

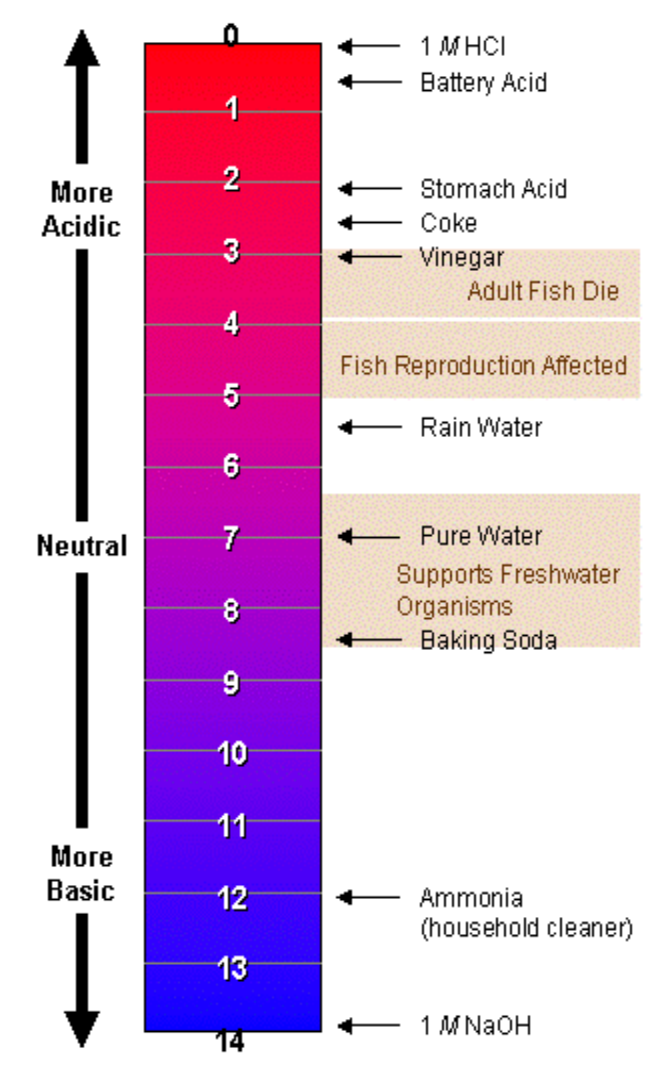
- Measure of soil acidity or basicity/alkalinity
- Has a great impact on numerous soil chemical reactions

Example: adsorption

Low soil pH means:

– higher mobility of cationic metals

↓ lower mobility of anions



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Organic Matter

- Enhances soil color
- Improves soil structure
- Improves soil drainage and aeration (clayey soils)
- Retains Water (sandy soils)
- Provides soil nutrients
- Encourages microbial activity
- Binds contaminants, reduces bioavailability
- Ideal OM content depends on soil type

  Below 1-3 % OM can be considered as low

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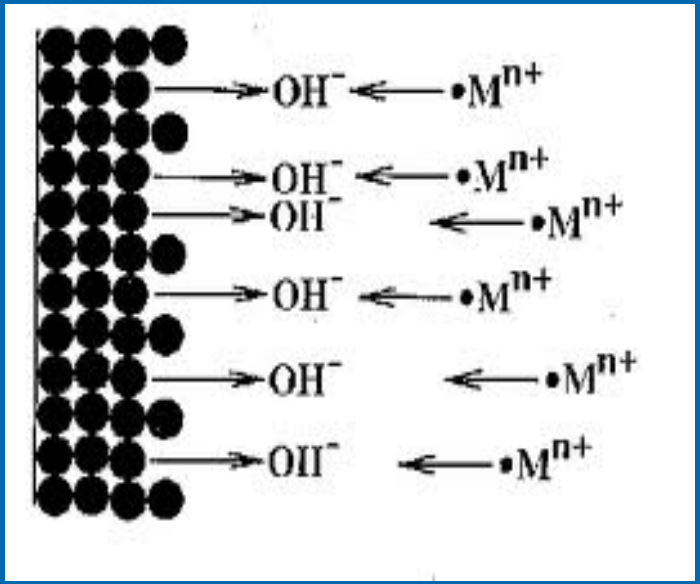
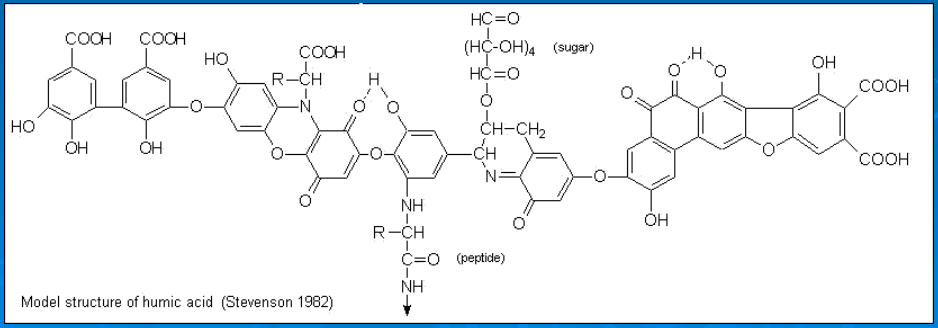
Soil Type

Clayey soils:

- Contaminants will adsorb to the clay mineral surfaces
- Adding OM will loosen soil, improve aeration, water infiltration, and also reduce bioavailability by binding contaminants





Sandy Soils and Zinc

Courtesy of CSIRO, Land & Water, Australia

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Clayey Soil and Zinc

Courtesy of CSIRO, Land & Water, Australia

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Compaction

- Reduces soil porosity
- Air movement and root penetration are restricted
- Water runs off or ponds instead of infiltrating
- Roots grow sideways instead of downward
- Remedies: Tilling and addition of compost

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Compost

- Compost = Soil Conditioner
- Animal derived compost (cured manure)
- Plant derived compost (leaves, grass clippings, kitchen scraps, plants, straw, wood chips, sawdust, etc.)
- High in OM - Binds contaminants, reduces bioavailability

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Contaminant Dilution through Compost Addition

Washington Wheatley Site, Kansas City, MO

Plot #	Total Pb (mg/kg)	
	Prior to Compost Addition	After Compost Addition
1	288.5	203.2
2	254.8	120.2
5	252.9	146.4
8	185.7	114.0
Average total Pb	245.5	146.0

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Addition of Soil Amendments Can Reduce Contaminant Bioavailability

Bioavailability: the fraction of the chemical(s) of concern in soil that is accessible to an organism (human or plants) for absorption

Metal contaminated soils- unamended

With Lime

With Beringite
modified aluminosilicate

With Red Mud
Fe oxide rich residue

Courtesy of CSIRO, Land & Water, Australia

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Tacoma, WA

Lime+ Tagro added

Control

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Crop Selection

- Root crops vs leafy and fruit bearing vegetables
- Root crops take up more metals compared to leafy and fruit bearing crops

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BMPs - Summary

- Till and add compost to mitigate compaction
- Add compost/biosolids to improve soil structure, mitigate compaction, provide nutrients and reduce bioavailability of metals
- Add lime or acidulating materials to adjust pH (more basic or acidic)
- Maintain optimum nutrient levels - provide P to reduce bioavailability of metals
- Select suitable crop types

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