



UNIVERSITY of  
**LOUISIANA**  
L A F A Y E T T E



**METRO HORT GROUP**

An Association of Horticultural Professionals in the New York Tri-State Region

# The Hidden Mystery Behind Soil Contamination and Simple Ways to Defeat It

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**Anna Paltseva, PhD**

Endowed Assistant Professor in Environmental  
Sciences

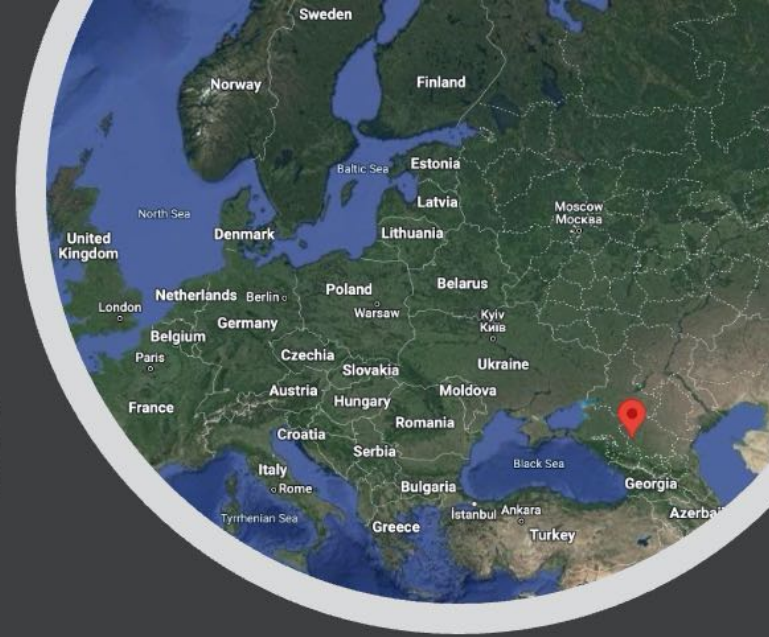
University of Louisiana at Lafayette

Chair-Elect, Urban & Anthropogenic Soils Division

Soil Science Society of America



# My background



# Outline

1 Soil Basics

2 Urban Soils

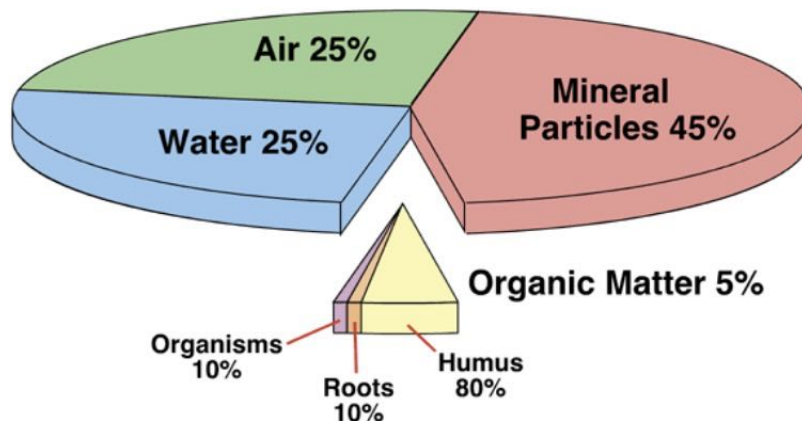
3 Soil Contamination

4 Contamination  
remediation

5 Delta Urban Soils Laboratory

# Soils are More than Dirt!

- ✓ Soil is a living system
- ✓ There are more microorganisms in a handful of soil than there are people on earth
- ✓ It takes ~100 years to produce just 1 cm of soil
- ✓ Soil provides all the nutrients required for successful plant growth
- ✓ % of sand, clay and silt → soil textures
- ✓ 6 layers: horizons O, A, E, B, C and R



# Why is Soil Important?



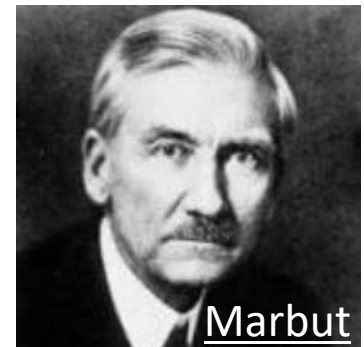
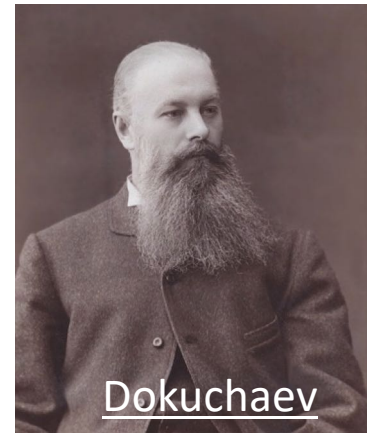
# How is Soil Formed?

Soil is a very slow renewable resource

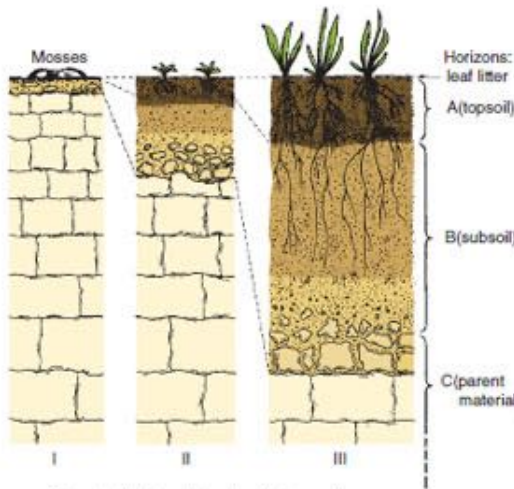
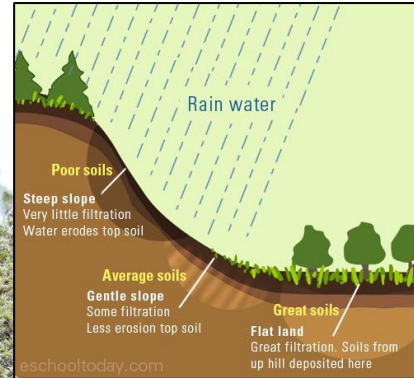
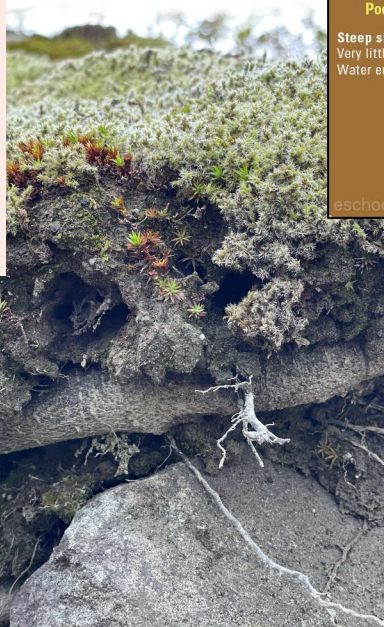
**Edaphology** studies the influences of soils on organisms  
(plants)

**Pedology** is the study of:

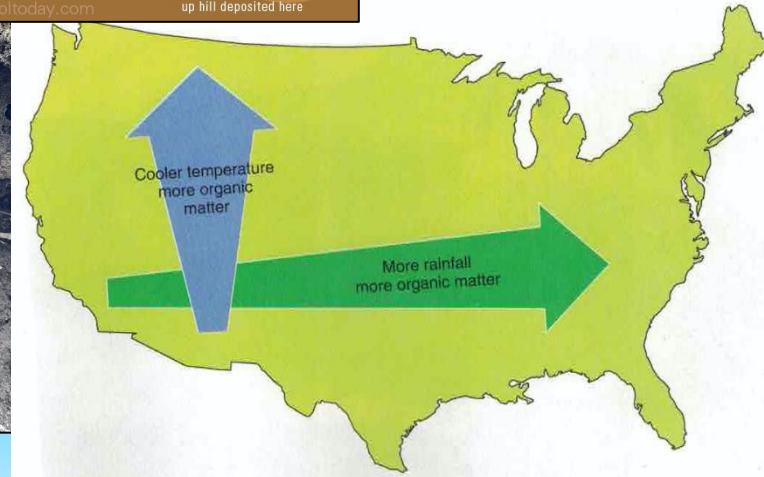
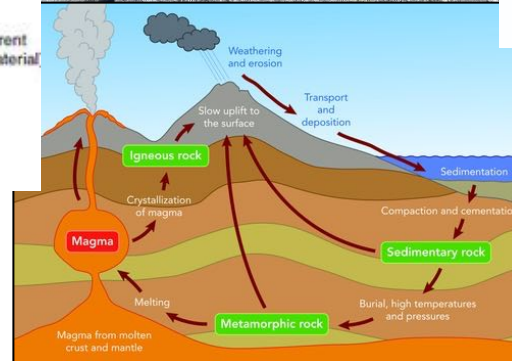
- Soil formation (or soil genesis)
  - Soil classification
  - Soil mapping
- Beginning in 1870, the Russian school of soil science under the leadership of [V. V. Dokuchaev](#) (1846–1903) was developing a new concept of soil.
  - Under the leadership of [C. F. Marbut](#) (1863–1935), the Russian concept was broadened and adapted to conditions in the United States.



# 5 Soil Formation Factors



Stages in the formation of sedentary soils



**Soil-forming factors**

**Human**

climate

organisms

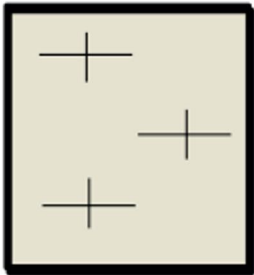
topography

time

Parental materials (bedrock)



**SOIL**

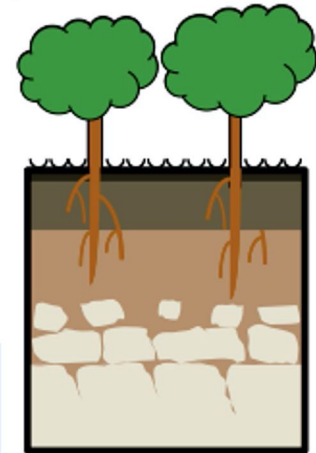


Physical processes

Chemical processes

Biological processes

- 4 basic processes of soil formation:**
- additions
  - losses
  - transformations
  - translocations



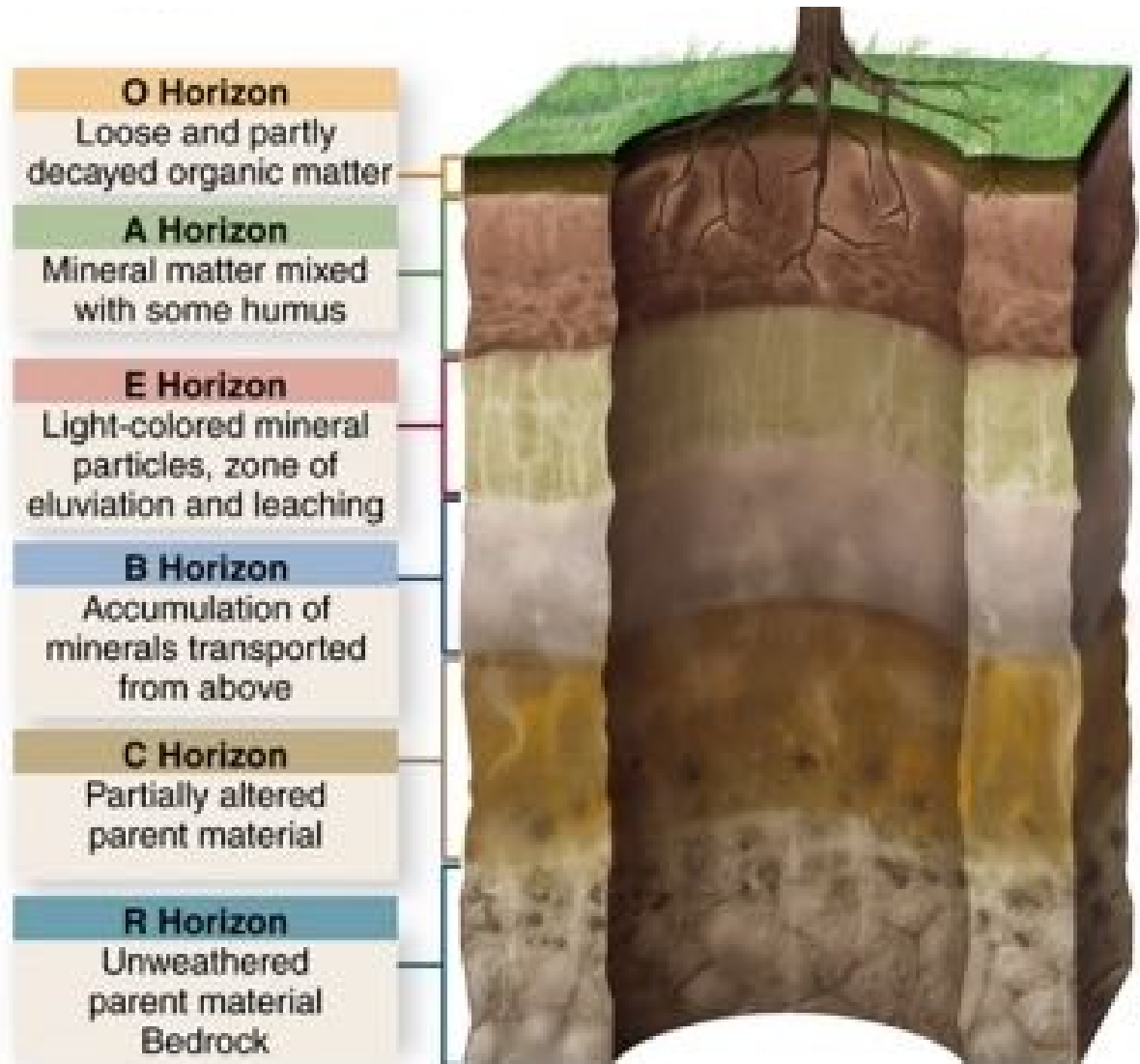
Profile development

Huot et. al, 2013



# Soil Profile and Horizons

- Layers develop over time called **soil horizons**
- The **soil profile** is a vertical section that shows all the horizons
- Processes occur differently at different depths



# Outline

1 Soil Basics

2 Urban Soils

3 Soil Contamination

4 Contamination  
remediation

5 Delta Urban Soils Laboratory

# Urban Soils

Urban soil is a key component of urban ecosystems, because it performs **essential functions**:

- regulation of water flow and quality
- carbon storage
- reservoir of biodiversity
- platform for buildings
- support for food and biomass production



# Urban soils:

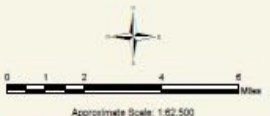
- high heterogeneity
- modified temperatures
- artifacts in soil profiles
- limited soil resource



# New York City Reconnaissance Soil Survey

## Legend, NYC Reconnaissance Soil Survey

- Symbol and Map Unit - Acres
- 1 Pavement & building, pathological substratum, 0 to 0 percent slopes - 312 acres
  - 2 Pavement & building, sil substratum, 0 to 0 percent slopes - 3433 acres
  - 3 Pavement & building, shallow substratum, 0 to 0 percent slopes - 8723 acres
  - 4 Pavement & building, wet substratum, 0 to 0 percent slopes - 1033 acres
  - 5 Meadows, low flooded - 1323 acres
  - 6 Gravelly-arenaceous tillaceous peats, tide flooded - 4548 acres
  - 7 Laganella-Skotts-Pavement & building, wet substratum complex, 0 to 8 percent slopes - 6977 acres
  - 8 Laganella-Skotts-Pavement & building complex, 0 to 8 percent slopes - 1203 acres
  - 9 Water, marsh - 538 acres
  - 10 Laganella-Pavement & building, 0 to 8 percent slopes - 228 acres
  - 25 Water, wet - 182 acres
  - 66 Moruya-Foreville complex, 0 to 8 percent slopes - 1303 acres
  - 67 Pavement & building-Croftville-Moruya complex, 0 to 8 percent slopes - 1677 acres
  - 68 Pavement & building-Pavement-Croftville complex, 0 to 15 percent slopes - 2440 acres
  - 69 Moruya-Foreville complex, 15 to 25 percent slopes - 1033 acres
  - 77 Padubun-Pavement & building, 0 to 8 percent slopes - 1718 acres
  - 78 Padubun-Pavement complex, 0 to 8 percent slopes - 1021 acres
  - 80 Pavement & building, wet substratum-sagapon-verdequo complex, 0 to 8 percent slopes - 4548 acres
  - 81 Laganella-Pavement complex, 0 to 8 percent slopes - 1021 acres
  - 86 Maguea-Fortuna complex, 0 to 8 percent slopes - 314 acres
  - 100 Pavement-Laganella-Skotts complex, 0 to 8 percent slopes - 1003 acres
  - 101 Pavement & building, wet substratum-Aguate-Skotts complex, 0 to 8 percent slopes - 1038 acres
  - 108 Sagapon-Verdequo, wet substratum-Pavement-Skotts complex, 0 to 8 percent slopes - 384 acres
  - 113 Laganella, gravelly (low substratum-Pavement) sandy clays, 0 to 35 percent slopes - 1738 acres
  - 126 Pavement & building-Laganella-Skotts complex, 0 to 8 percent slopes - 1032 acres
  - 128 Hudson-Croftville complex, 0 to 25 percent slopes - 102 acres
  - 134 Croftville-Skotts complex, 0 to 8 percent slopes - 288 acres
  - 135 Croftville-Skotts-Pavement & building complex, 15 to 50 percent slopes - 324 acres
  - 137 Croftville-Skotts complex, 0 to 8 percent slopes - 171 acres
  - 138 Croftville-Skotts complex, 8 to 15 percent slopes - 214 acres
  - 139 Croftville-Skotts complex, 15 to 50 percent slopes - 424 acres
  - 165 Moruya-Foreville complex, 8 to 15 percent slopes - 1223 acres
  - 171 Pavement & building-Croftville-Skotts complex, 8 to 15 percent slopes - 503 acres
  - 176 Croftville-Skotts complex, 0 to 8 percent slopes - 30 acres
  - 204 Pavement & building-Croftville-Skotts complex, 0 to 8 percent slopes - 503 acres
  - 206 Pavement & building-Croftville-Skotts complex, 15 to 50 percent slopes - 571 acres
  - 207 Croftville-Skotts complex, 15 to 50 percent slopes - 673 acres
  - 208 Pavement & building-Hudson-Moruya complex, 0 to 8 percent slopes - 1803 acres
  - 210 Jamaica-Water, silty, 0 to 3 percent slopes - 5571 acres
  - 211 Pavement & building-Padubun-Croftville complex, 0 to 8 percent slopes - 30577 acres
  - 212 Pavement & building-Croftville-Skotts complex, 0 to 8 percent slopes - 3693 acres
  - 214 Croftville-Skotts-Pavement & building complex, 0 to 8 percent slopes - 1348 acres
  - 223 Croftville-Skotts-Pavement & building complex, 15 to 50 percent slopes - 1058 acres
  - 225 Padubun-Pavement & building complex, 0 to 8 percent slopes - 585 acres
  - 226 Pavement & building-Plymouth-Padubun complex, 0 to 8 percent slopes - 677 acres
  - 228 Croftville-Skotts-Pavement & building complex, 0 to 8 percent slopes - 633 acres
  - 231 Croftville-Skotts complex, 0 to 8 percent slopes - 223 acres
  - 232 Laganella-Skotts complex, 0 to 15 percent slopes - 407 acres
  - 234 Pavement & building-Croftville-Skotts complex, 15 to 50 percent slopes - 345 acres
  - 235 Croftville-Skotts-Pavement & building complex, 0 to 8 percent slopes - 1032 acres
  - 236 Skotts-Pavement & building complex, 0 to 8 percent slopes - 897 acres
  - 237 Croftville-Skotts-Pavement & building complex, 0 to 15 percent slopes - 43 acres
  - 238 Windsor-Windsor, sandy substratum-Croftville-Skotts complex, 0 to 8 percent slopes - 245 acres
  - 240 Windsor-Windsor-Pavement & building complex, 0 to 8 percent slopes - 743 acres
  - 242 Hudson-Windsor-Pavement & building complex, 0 to 8 percent slopes - 763 acres
  - 243 Moruya-Foreville-Pavement & building complex, 8 to 15 percent slopes - 1033 acres
  - 244 Moruya-Foreville-Pavement & building complex, 0 to 8 percent slopes - 288 acres
  - 245 Laganella-Windsor-Pavement & building complex, 0 to 8 percent slopes - 374 acres
  - 246 Windsor-Croftville complex, 0 to 8 percent slopes - 167 acres
  - 247 Laganella-Padubun complex, 8 to 15 percent slopes - 178 acres
  - 248 Windsor-Moruya complex, 0 to 8 percent slopes - 357 acres
  - 250 Laganella-Windsor-Pavement & building complex, 0 to 8 percent slopes - 423 acres
  - 252 Laganella-Croftville-Pavement & building complex, 0 to 8 percent slopes - 258 acres
  - 254 Croftville-Foreville-Pavement & building complex, 0 to 8 percent slopes - 243 acres
  - 260 Pavement & building-Foreville-Moruya complex, 0 to 8 percent slopes - 3177 acres
  - 262 Wetlanded Laganella-Hudson complex, 0 to 8 percent slopes - 3077 acres
  - 264 Wetlanded Laganella complex, 0 to 15 percent slopes - 808 acres
  - 266 Greenwood-and-Croftville-Skotts complex, 0 to 8 percent slopes - 1088 acres
  - 268 Padubun-Foreville complex, 0 to 8 percent slopes - 174 acres
  - 270 Wetlanded-Croftville complex, 0 to 8 percent slopes - 278 acres
  - 274 Pavement & building-Padubun-Croftville complex, 0 to 8 percent slopes - 1778 acres
  - 276 Wetlanded-Croftville-Pavement & building complex, 15 to 25 percent slopes - 218 acres
  - 282 Wetlanded-Croftville-Pavement & building complex, 0 to 8 percent slopes - 4653 acres
  - 283 Wetlanded-Croftville complex, 0 to 8 percent slopes - 423 acres
  - 284 Wetlanded-Croftville complex, 0 to 15 percent slopes - 18 acres
  - 285 Wetlanded-Croftville complex, 0 to 8 percent slopes - 388 acres
  - 304 Pavement & building-Verdequo-Verdequo complex, 0 to 8 percent slopes - 938 acres
  - 308 Water-Foreville-Cheshire clays, 15 to 50 percent slopes - 278 acres
  - 311 Wetlanded Laganella complex, 15 to 50 percent slopes - 188 acres
  - 314 Greenbelt-Croftville-Pavement & building complex, 0 to 8 percent slopes - 478 acres
  - 322 Laganella-Windsor complex, 0 to 8 percent slopes - 115 acres
  - 324 Pavement & building-Croftville-Croftville complex, 0 to 8 percent slopes - 1273 acres
  - 346 Water-Foreville-Pavement & building complex, 15 to 50 percent slopes - 483 acres
  - 348 Wetlanded-Foreville-Pavement & building complex, 8 to 15 percent slopes - 375 acres
  - 349 Pavement & building-Verdequo-Skotts complex, 15 to 50 percent slopes - 277 acres
  - 354 Hudson-Hudson complex, 0 to 3 percent slopes - 148 acres
  - 370 Hudson-Hudson complex, 0 to 8 percent slopes - 471 acres



The New York City Reconnaissance Soil Survey is a product of the United States Department of Agriculture, National Resources Conservation Service, in cooperation with the New York City Board of Environmental Control and the New York City Office of Environmental Planning. The map projection is NAD 83 UTM Zone 18. Orthorectified means that New York City landscape features are shown as they would appear from space. The map is based on the National Hydrographic Survey of the United States and the National Oceanic and Atmospheric Administration's (NOAA) data of hydrography. © 2008.

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United States Department of Agriculture

**NRCS** National Resources Conservation Service

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**NEW YORK CITY SOIL AND WATER CONSERVATION DISTRICT**  
61 South Avenue, 8th Fl., New York, NY 10038-2722 (407) 897-7800 Fax: 212 693-7146



Scioto series – soils formed in lacustrine or alluvial deposits  
Bay Park, Bronx



Deerfield series – soils formed in glaciofluvial deposits  
Wood, State Park, New York



Charlton series – soils formed in eolian deposits over till  
Inwood Hill Park, Manhattan



**Rikers series  
Greenbelt , S**



**Bigapple series  
sandy materials  
Brooklyn**



**Laguardia series - soils formed in  
construction debris Bronx**

Learn more about soils under your feet

California Soil Resource Lab – UC Davis

**Soilweb** for GPS-enabled cellphones

<http://casoilresource.lawr.ucdavis.edu/soilweb-apps/>



**SoilWeb** UC DAVIS

Map Unit Name: **Sycamore silty clay foam, drained** Symbol: SF

**Map Unit Composition**

- 85% - **Sycamore**  
Geomorphic Position: alluvial fans / toeslope
- 3% - **Maria**  
Geomorphic Position: alluvial fans  
Horizon data n/a | [View Similar Data](#)
- 3% - **Merritt**  
Horizon data n/a | [View Similar Data](#)
- 3% - **Tyndall**  
Horizon data n/a | [View Similar Data](#)
- 3% - **Yolo**  
Horizon data n/a | [View Similar Data](#)
- 3% - **Brentwood**  
Horizon data n/a | [View Similar Data](#)

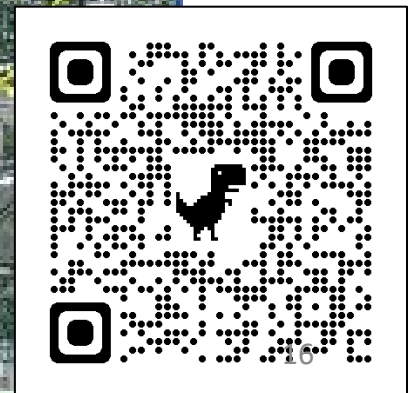
**Map Unit Data**

Map Unit Key: 459205

Type: **Concretion**

Farmstead Class: **Prime farmland if irrigated**

Available Water Storage: 0.460cm<sup>3</sup>/cm<sup>3</sup>

A satellite map showing a landscape with yellow lines delineating soil units. A red location pin is placed on the map. The map includes a compass and zoom controls in the top right corner.



# Outline

1 Soil Basics

2 Urban Soils

3 Soil Contamination

4 Contamination  
remediation

5 Delta Urban Soils Laboratory

# Urban Gardening and Its Benefits

- ✓ Nutritious food to locals
- ✓ Grocery bill reduction
- ✓ Health benefits
- ✓ Minimizing criminal activities
- ✓ A deeper connection to agriculture and nature



# of community gardens:

~18,000 in the US and Canada

~1500 in NYC

~ 50 in NOLA



## Lead and Arsenic are Important Environmental Contaminants



**Pb** is a neurotoxin affecting cognitive development, quite immobile

Main sources:

- lead-based paint,
- point source emitters,
- leaded gasoline emissions.



**As** is a human carcinogen, very slowly leached through soils.

Main sources :

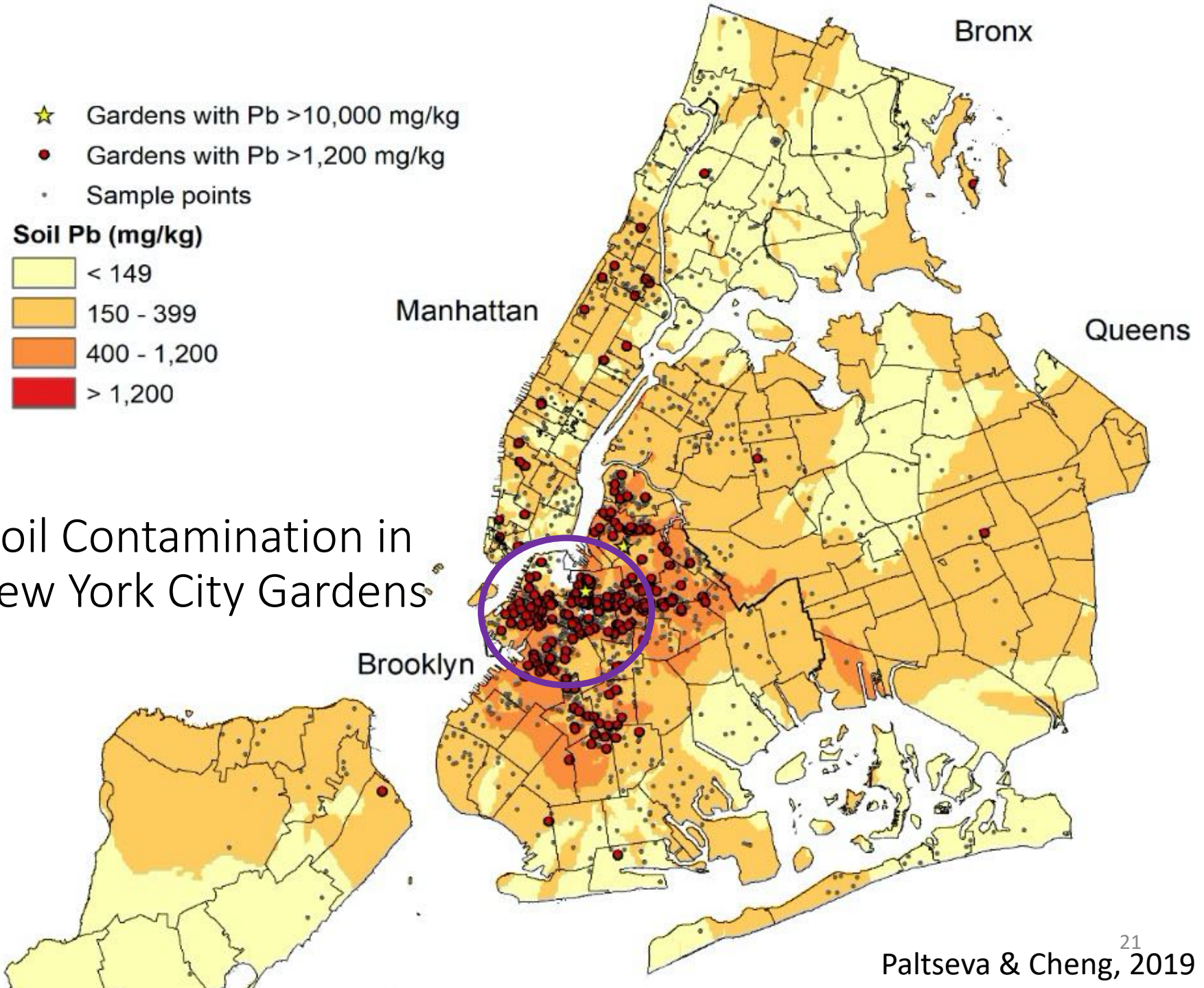
- pesticides,
- pressure treated lumber.



# Comparison of Mean Heavy Metal Concentrations in Urban Soils in Different Cities

	# samples	Cr	Ni	Cu	Zn	As	Cd	Pb	Type of samples	References
<i>Cities over 1 million people</i>										
New York City	1652	49	28	77	248	10	1.2	355	Garden soil	(Cheng et al., 2015)
Bangkok	30	25	23	27	38	-	0.15	29	Topsoil	(Wilcke et al., 1999)
Hong Kong	236	17	4	10	78	-	0.33	71	Urban	(Lee et al., 2006)
Beijing	~770	34	27	21	62	7.8	0.12	27	Topsoil, mean	(Chen et al., 2005)
London - Richmond	214	-	-	30	108	-	<0.2	158	Topsoil	(Kelly et al., 1996)
London - Wolverhampton	295	-	-	62	231	-	0.80	106	Topsoil	(Kelly et al., 1996)
Vienna	96	80	-	18	97	8	0.2	65	Urban, 0-20 cm	(Simon et al., 2013)
Warsaw	nd	32	12	31	166	-	0.73	57	nd	(Czarnow 1980)
Madrid	55	75	14	72	210	-	-	161	0-20 cm	(De Miguel et al., 1996)
Moscow	224	-	17	30	105	4	0.5	30	Public areas, 0-20 cm	(Romzayl et al., 2006)
Berlin	2182	25	8	31	129	3.9	0.35	77	0-20 cm	(Birke and Rauch, 2006)
Damascus	51	51	35	30	84	-	-	10	Topsoil, agriculture	(Möller et al., 2005)
Manila	286	114	21	99	440	-	0.57	214	Metropolitan area, 0-5 cm	(Pfeiffer et al., 1988)
Dublin	1058	44	41	51	248	15.5	1.8	123	0-10 cm	(Glennon et al., 2011)
Torino	123	129	153	71	147	-	-	94	1-10 cm	(Briatore et al., 2006)
Coruna	15	39	28	60	206	-	0.3	309	Garden soil, 0-5 cm	(Cal-Priet et al., 2006)
Quezon City	64	370	150	445	1540	-	-	594	Metropolitan area, 0-15 cm	(Navarret et al., 2011)
Mumbai (Bombay)	30	79	144.5	147	-	-	1.3	42.5	Urban soil	(Ratha and Sahu, 1996)

# Soil Contamination in New York City Gardens



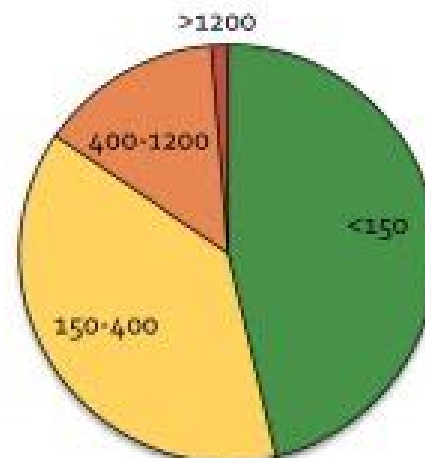
# Lead (Pb) levels in soils as measured by XRF

Updated: 10/4/17

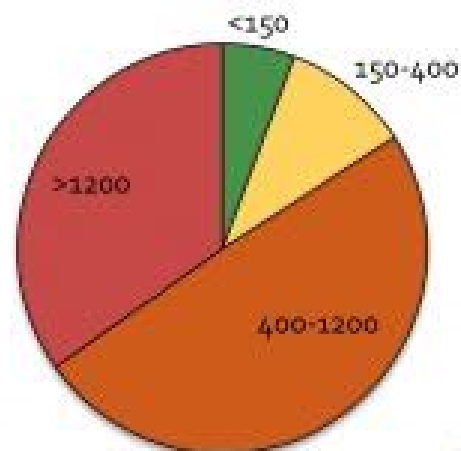
Map of public samples only



Public samples n= 463



Private samples n= 264



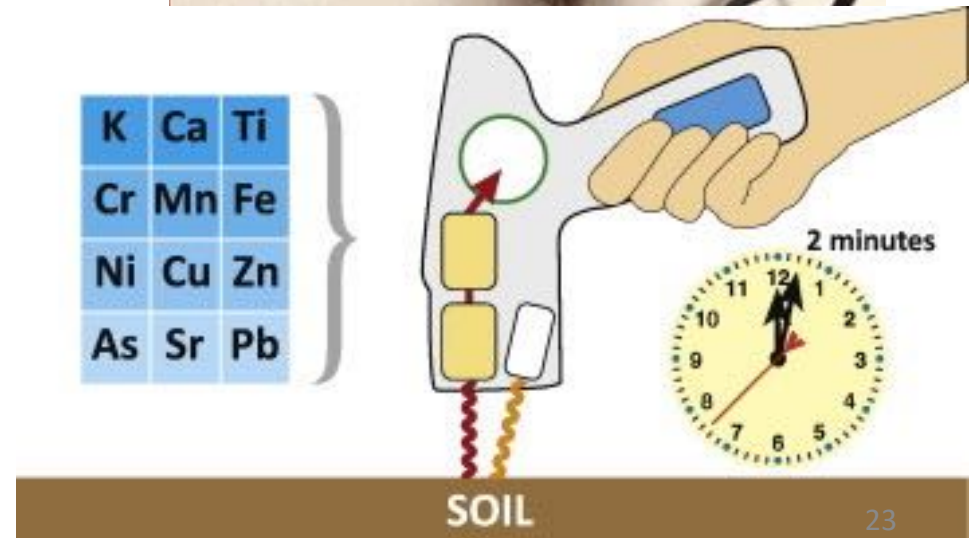
Landes et al (2017)

Data collected as part of the Columbia/ Barnard Soil Lead Study 2017. Please contact [lead\\_study@ldeo.columbia.edu](mailto:lead_study@ldeo.columbia.edu) or [fc12115@columbia.edu](mailto:fc12115@columbia.edu) with questions.

< 150 mg/kg    150 – 399 mg/kg    400-1200 mg/kg    >1200 mg/kg

# How do we test for metals?

## XRF measurements



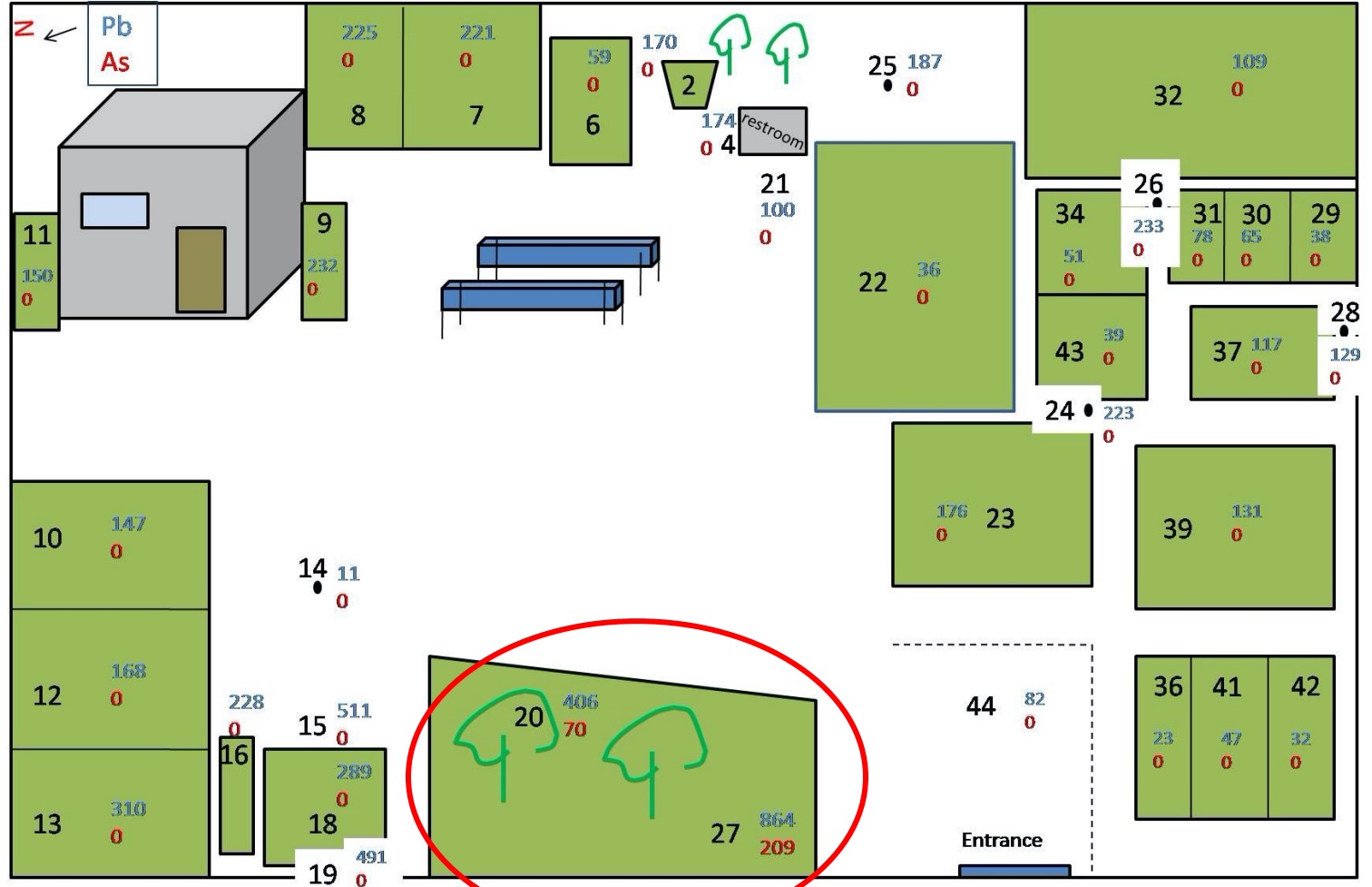
METRO EXCLUSIVE

# Why NYC's toxic community gardens may give you cancer

By Gary Buiso



Catherine Bryant says she had no idea the community garden was toxic. J.C. Rice







Contamination is not just urban but also suburban problem

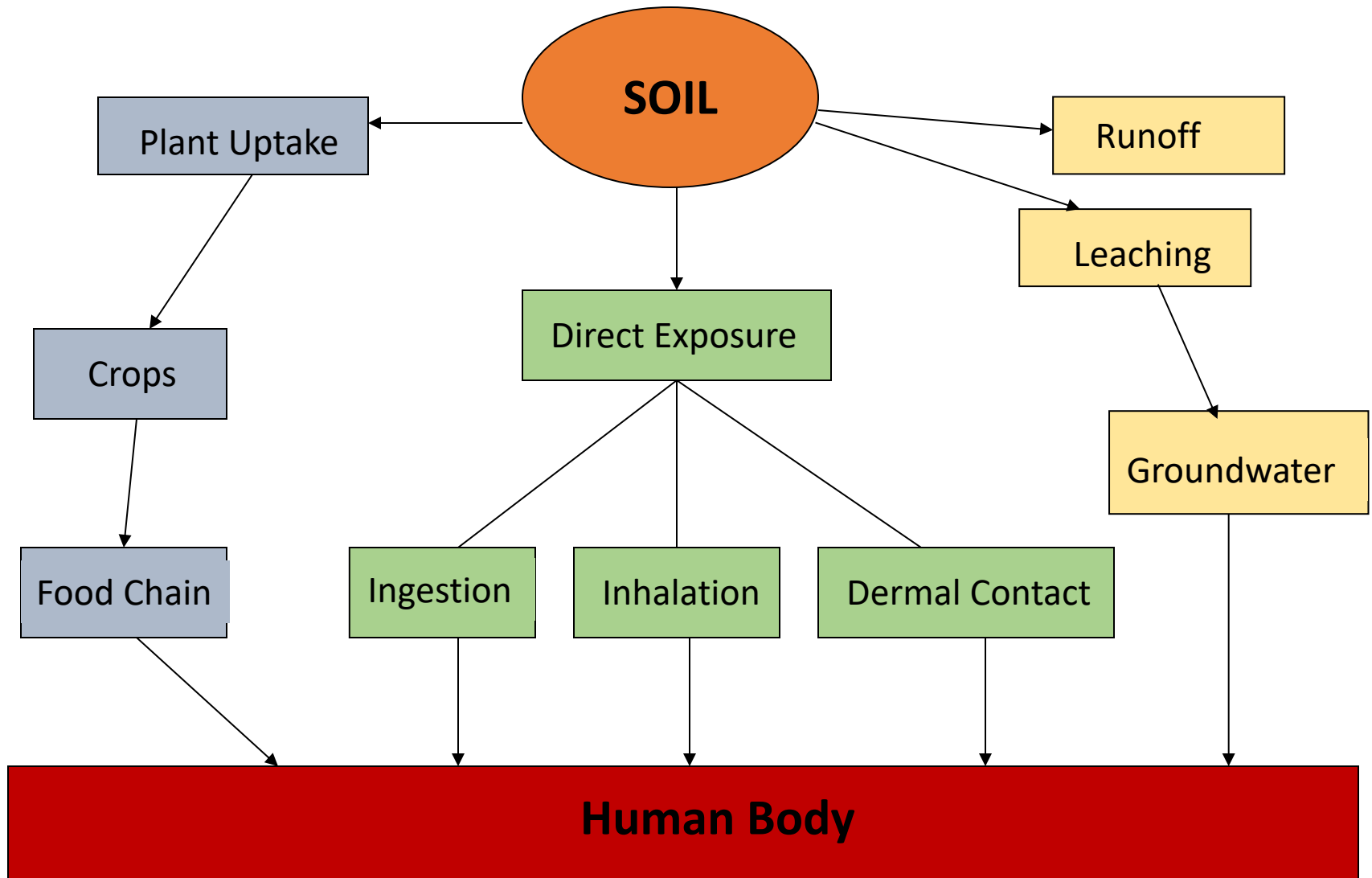


Suburban Duke Farm, NJ

# Soil Guidelines

	New Jersey	New York	Connecticut
Residential, mg/kg			
Arsenic	22	16	10
Copper	3100	270	2500
Cadmium	71	2.5	34
Chromium	--	36	100
Mercury	23	0.81	20
Nickel	1600	140	1400
Lead	--	400	400
Zinc	23000	2200	20000

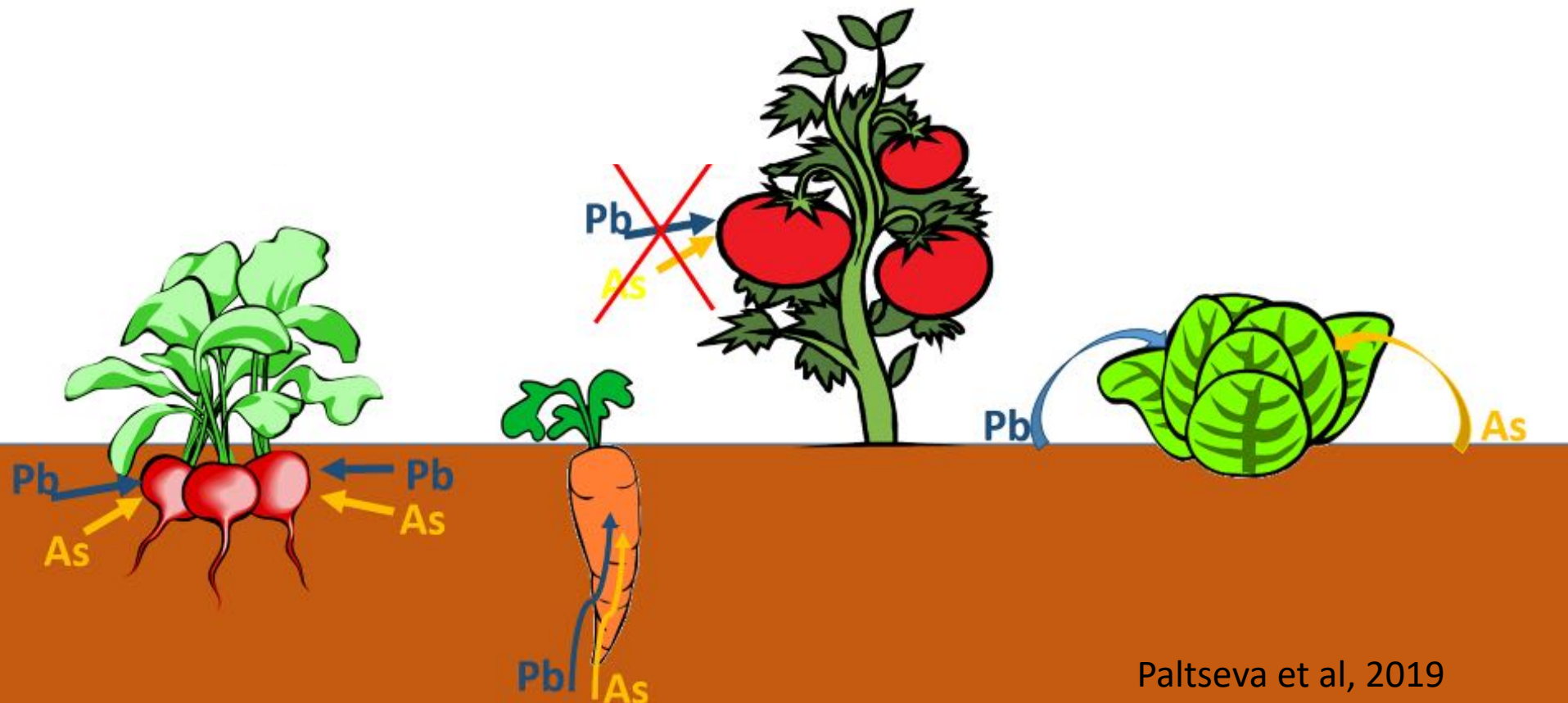
# Exposure Pathways



Plant type is more important than amendment type



# Surface contamination, not plant uptake



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# Emerging agricultural waste by-products as soil amendments



# NYC Clean Soil Bank provide sediments to community-based organizations



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## NYC CLEAN SOIL BANK

### What is the NYC Clean Soil Bank?



The NYC Clean Soil Bank (CSB) is a no-cost soil exchange operated by the NYC Office of Environmental Remediation that enables clean native soil excavated from deep below the ground surface during construction of new buildings in NYC to be directly transferred to nearby construction projects that need soil.

### Is the NYC Clean Soil Bank an actual pile of soil stored somewhere?

### Why was the NYC Clean Soil Bank created?

### What are the benefits of the NYC Clean Soil Bank?

### Are there other environmental benefits?

### What are the other benefits of the NYC Clean Soil Bank?



# Strategies and Techniques to Mitigate Soil Contamination

## ORGANIC MATTER

### How:

Add compost · biosolids · biochars to soils

### Benefits:

Promote soil aggregates that adsorb contaminants · Improve soil structure · Reduce erosion · Reduce fine particle suspension in air

## LIMING

### How:

Add Ca and Mg rich material in soils

### Benefits:

Increase in soil pH · Reduce trace metal availability to organisms · Increase soil aggregates and texture

**What is a soil aggregate?** These are soil particle groups that are bound together stronger than the particles around them. Pore space is formed around these which helps the soils move or retain water and helps the movement of air within the soils.

## CONSERVATIVE TILLAGE PRACTICES

### How:

Use no-till · ridge-till · strip-till methods · Have stable vegetation coverage

### Benefits:

Immobilize metals in soils · Reduce topsoil erosion · Lower organic mineral decomposition rates · Longer remediation rates from organic matter · Increase soil aggregates · Reduce fine particle suspension in the air

## PLACEMENT

### How:

Install garden areas at least 50 meters from heavy traffic areas

### Benefits:

Directly avoid accumulation of contaminants in soils

## DUST CONTROL

### How:

Add mulch on contaminated soils · use drip irrigation

### Benefits:

Reduce fine particle suspension in air · Reduce flooding and spashing · Decrease risk of recontamination of surface soil or plant tissues





## Community Service in Low-Income Areas

- *EPA Soil Kitchen Events, Soil-SHOP, NAG, USI workshops*

Conducting XRF analysis of soils brought by the public, advising on remediation strategies

- *Brooklyn Bloom, NYC Housing Authority, NAG, NYC Compost, Understory, USI annual events*

Lecturing with hands on activities on soil basics and soil interpretations. Presenting issues associated with urban gardening and how to mitigate the hazards.

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UNIVERSITY OF  
**LOUISIANA**  
LAfayette

Ray P. Authement College of Sciences | School of Geosciences

# DELTA URBAN SOILS LABORATORY



We can help you to find the best way to remediate contaminated soils; promote organic waste recycling and conservation practices; use smart technologies to evaluate soil resources



Environmental stewardship



We offer informal education via social media channels; publish in academic and non-academic media; facilitate research partnerships

Science communication



Community engagement

We collaborate with citizen scientists, artists, gardeners; lead workshops for communities



Sustainability



We provide expert recommendations for management practices to increase carbon storage and reduce greenhouse gases; promote urban agriculture in food deserts

# Coming soon...

## THE URBAN SOIL GUIDE: FIELD AND LAB MANUAL

By Anna A. Paltseva, Ph.D



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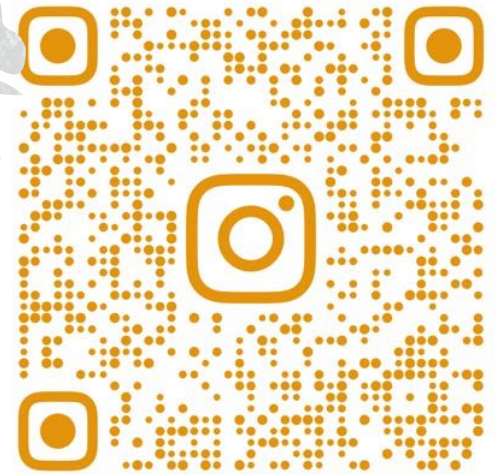
A small green seedling with two leaves is growing out of a crack in dry, cracked earth. The background is a blurred, sunlit landscape of cracked soil.

# Key Points

- Soil is heterogeneous with various properties
- 5 soil formation factors
- Urban soil testing should be prioritized
- Different remediation options exist for contaminated soils
- Certain crops are much less susceptible to contamination than others
- Raised beds filled with upcycled local mineral and organics are preferred.

# Stay Connected

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- Subscribe to my **YouTube** Channel at **Anna Paltseva**
- For more information on my projects go to [annapaltseva.com](http://annapaltseva.com)



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