Bioremediation in Urban Agriculture

Growing *Yummy Veggies* in Vacant Lots

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Urban Agriculture

- Feeds folks with less access to food
- Sequesters carbon within cities
- Rebuilds and decontaminates toxic soil
- Gives folks a connection to nature!
- Builds neighborhood communities
- Autonomy!
- …and stuff.

Where do you grow food in a city?

Folks with limited food access have limited land access...

- Existing Community Gardens
- Parks
  - Land use restrictions
- Rooftops
  - Require imported, mined topsoil
  - Exposed to rising airborne pollutants
- Planter Boxes/Porches
  - Require imported, mined topsoil
  - Isolated!
  - Limited food-growing capacity
  - Indoors (hydroponics, grow-lights)
  - Backyards
    - Few in number
    - Often small
    - Use controlled by landowner
    - Often contaminated and/or compacted
  - Brownfields
    - Future site plans
    - Very contaminated...
  - Vacant lots
    - Potentially contaminated
      - Bioremediation!!!

Brownfields & Vacant Lots

To be (a garden)...

- “abandoned, idled, or underused industrial and commercial facilities where expansion or redevelopment is complicated by real *or perceived* environmental contamination” – Brady & Weil

...Or not to be?

Sources of Contamination in Brownfields & Vacant Lots

Land use history?

- Old city park
- Orchard
- Incinerator
- Smelter
- Factory
- Dry-cleaner
- Auto repair shop
- Parking lot, garage, or road
- Train yard or railroad tracks
- Paper mill
- Junk yard or landfill (yum!)

Pollution sources

- lead paint
- oil spills
- factory effluent
- fertilizer
- herbicides and insecticides
- demolished building materials
- road run-off
- exhaust or emission deposition
- leakage or leachate

Dissipation of Organochemicals in Soil

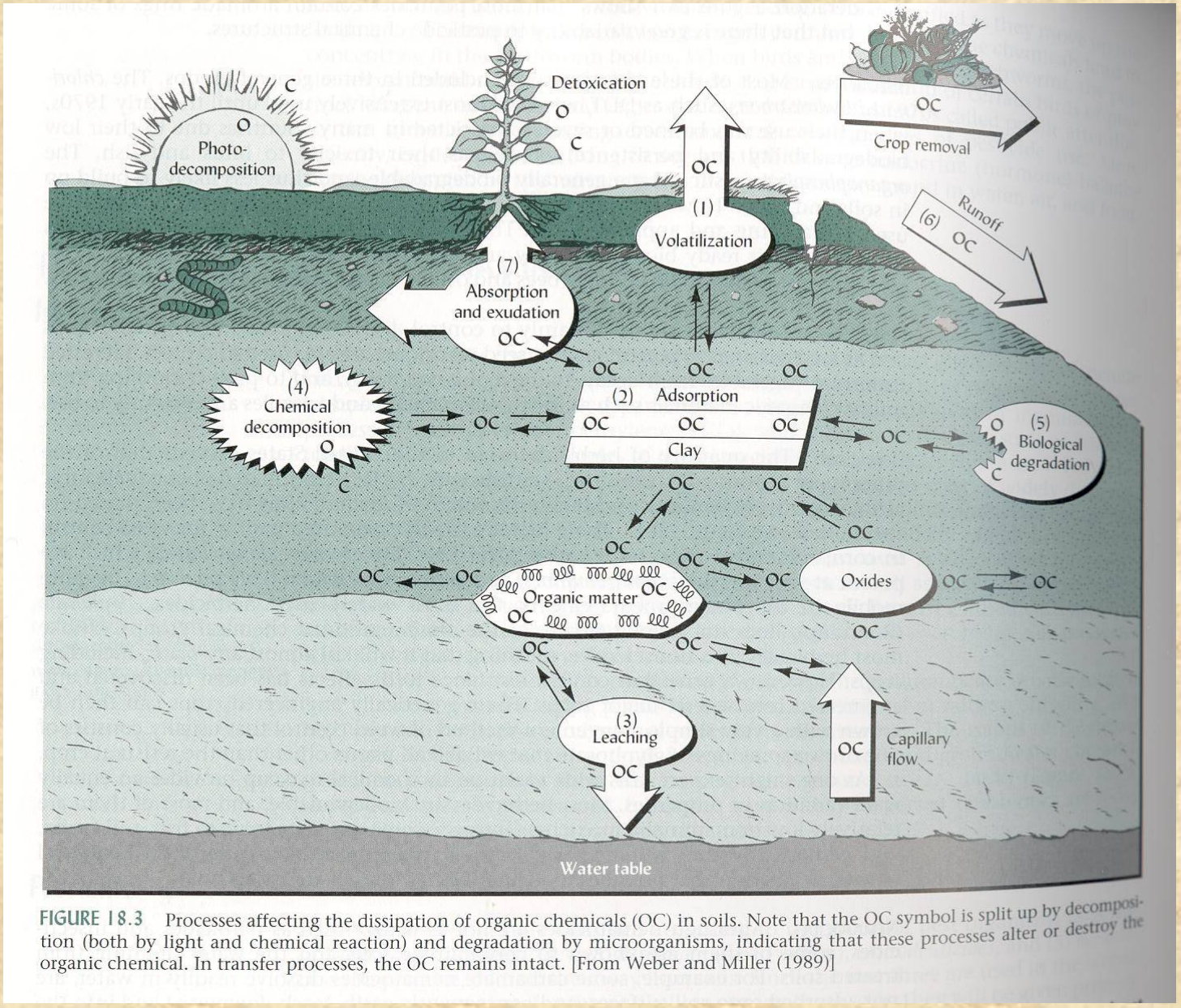


FIGURE 18.3 Processes affecting the dissipation of organic chemicals (OC) in soils. Note that the OC symbol is split up by decomposition (both by light and chemical reaction) and degradation by microorganisms, indicating that these processes alter or destroy the organic chemical. In transfer processes, the OC remains intact. [From Weber and Miller (1989)]

Toxins in Urban Soil

Organic:

- Polycyclic aromatic hydrocarbons
- Pesticides
  - glyphosate, organophosphates, organochlorines, carbamates, triazines, acetanilides, phenoxyalkanoic acids, etc...
- PCE (perchloroethylene)
- TCE (trichloroethylene)
- PCBs (polychlorinated biphenyls)
- PCP (pentachlorophenol)
- TNT (trinitrotoluene)

Inorganic:

– Lead

– Arsenic

– Cadmium

– Chromium

– Mercury

Toxic exposure on city farms

- Inhalation
- Ingestion
  - water
    - leaching to groundwater
  - soil
    - geophagy! kids love to eat dirt.
  - plants
    - bioaccumulation

Examples

Heavy metals: radishes, carrots & lead

Organic toxins: lettuce & PAHs

Bioaccumulation:

- compounds at each trophic level
- one process in remediation

BCF (bioconcentration factor) a measure of accumulation in tissue

Remediation Techniques

- Ex situ vs. in situ
- Bioremediation
  - bioaugmentation
  - biostimulation
    - compost tea
- Phytoremediation
  - phytostabilization
  - phytodegradation
  - phytoextraction
- Mycoremediation
  - mycodegradation
  - hyperaccumulation

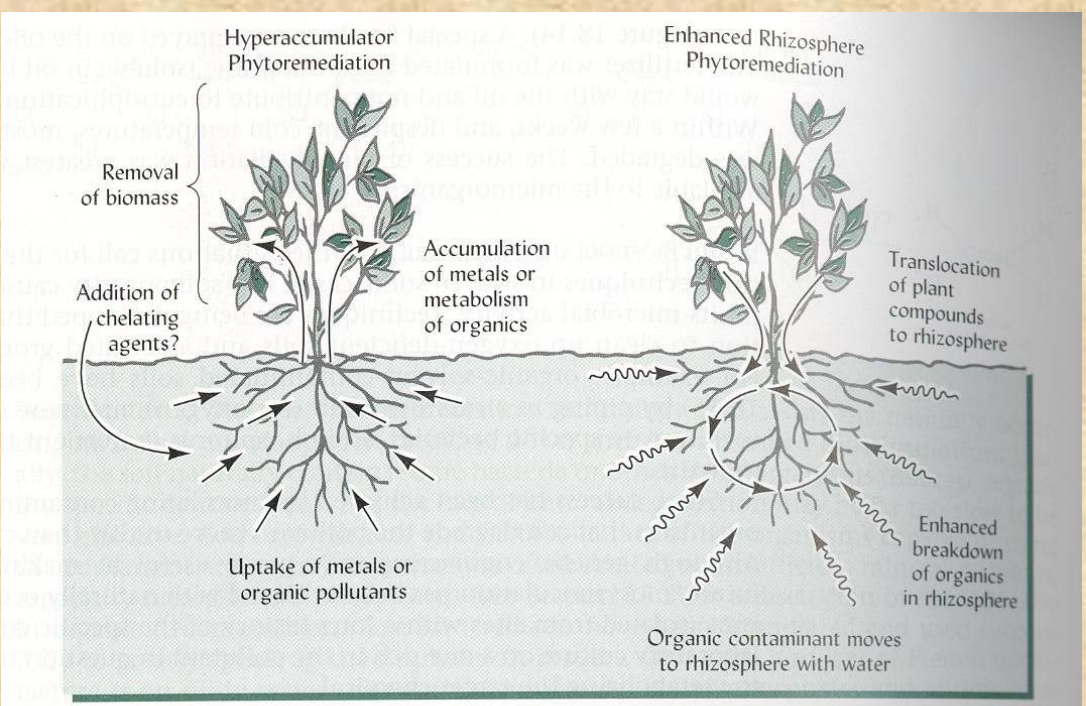


FIGURE 18.16 Two approaches to phytoremediation—the use of plants to help clean up contaminated soils. (*Left*) *Hyperaccumulating plants* take up and tolerate very high concentrations of an inorganic or organic contaminant. In the case of metal contaminants, the addition of chelating agents may increase the rate of metal uptake, but can add a major expense and may allow metals to migrate below the root zone. (*Right*) In *enhanced rhizosphere phytoremediation*, the plants do not take up the contaminant. Instead, the plant roots excrete substances that stimulate the microbes in the rhizosphere soil, speeding their degradation of organic contaminants. Transpiration-driven movement of water and dissolved contaminants to the enhanced rhizosphere zone improves the system's effectiveness. (Diagram courtesy of R. Weil)

Mycodegradation of Organic Toxins

- Soil can be inoculated with mycelial mats
- Low-cost sources:
  - spent mushroom substrate
  - “stem-butt” spawn
  - bunker spawn

Mushrooms with Activity against Chemical Toxins

More species and toxins will be added over time. Several of the species probably act upon more toxins than the ones listed above. I will update this chart on www.fungi.com as more research is published.

	Anthracenes	Benzopyrenes	Chromated Copper Arsenate	Chlorine	Dimethyl methyl phosphonate (VX, Soman, Sarin)	Dioxin	Persistent Organophosphates	Polycyclic Aromatic Hydrocarbons (PAHs)	Polychlorinated Biphenyls (PCBs)	Pentachlorophenols (PENTAs)	Trinitrotoluene (TNT)	Brown (B) or White (W) Rot?
Antrodia radiculosa			X							X		B
Armillaria ostoyae					X							W
Bjerkandera adusta		X						X				W
Gloeophyllum trabeum			X			X						B
Grifola frondosa									X			W
Irpex lacteus								X				W
Lentinula edodes								X	X	X		W
Meruliporia incrassata			X							X		B
Mycena alcalina				X								?
Naematoloma frowardii (=Hypholoma)								X			X	W
Phanerochaete chrysosporium		X								X	X	W
Pleurotus eryngii						X						W
Pleurotus ostreatus		X			X	X		X	X		X	W
Pleurotus pulmonarius						X					X	W
Psilocybe spp.					X		X					W
Serpula lacrymans			X					X				B
Trametes hirsuta										X		W
Trametes versicolor	X		X		X	X	X			X	X	W

Mycoextraction of heavy metals

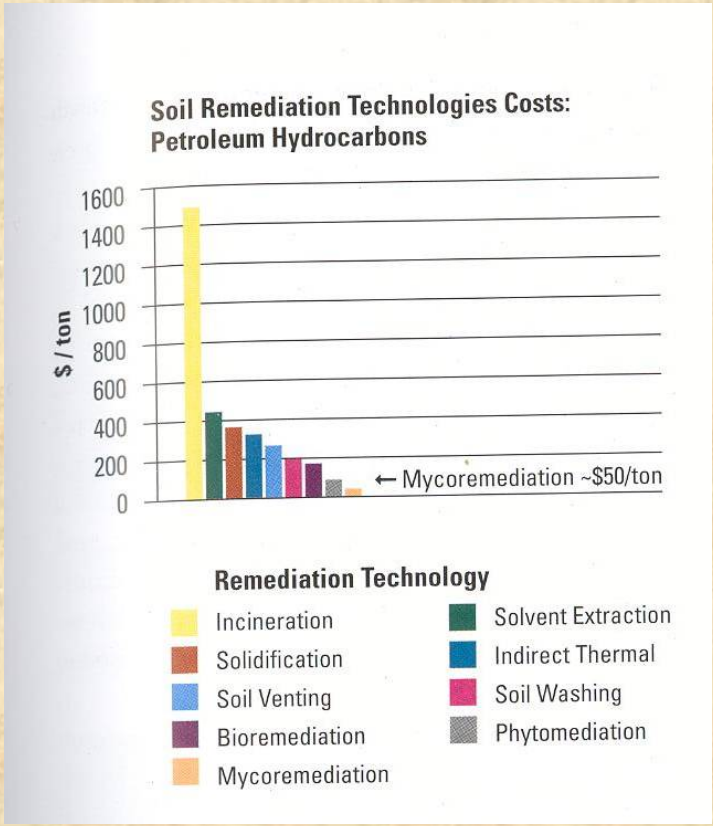
- Longer period of time
- Agaricus bisporus, oysters, and turkey tail important hyperaccumulators!
- Source mycelium from mushroom farms

Mushrooms versus Heavy Metals

This chart gives a general, preliminary guide to the bioaccumulation coefficients—concentration factors—of a mushroom species' ability to upchannel heavy metals from its myceliated habitat. This chart is a work in progress. Please consult the scientific literature cited in the text for more information.

	Arsenic	Cadmium	Radioactive Cesium	Lead	Mercury	Copper
Agaricus arvensis		X			150X	
Agaricus bisporus		X			X	
Agaricus bitorquis		X		23X	165X	
Agaricus brasiliensis		X			X	
Agaricus brunnescens	X	X			X	
Agaricus campestris		X		10X	10X	
Amanita muscaria		X			X	
Amanita rubescens		X				
Boletus badius			X			
Boletus edulis		10X	X	X	250X	X
Cantharellus cibarius			2X			
Cantharellus tubaeformis (Craterellus tubaeformis)			X			
Chlorophyllum rachodes	X			X	X	X
Clitocybe inversa	X	X				
Coprinus comatus	21X	8X			27X	
Coprinus spp.		X				
Flammulina velutipes	X					
Gomphidius glutinosus			10000X			
Laccaria amethystina	X		X			
Lactarius helvus			X			
Lactarius turpis			X			
Leccinum scabrum			X		X	
Lepista nebularis	X					
Lepista nuda					100+X	X
Lycoperdon perlatum			X	2X	100X	X
Marasmius oreades					X	
Macrolepiota procera					230X	
Morchella spp.				70–100X		
Morchella atretomentosa				X	X	
Paxillus atrotomentosus			1180X			
Pleurotus ostreatus		X			65–140X	
Pleurotus pulmonarius		X			X	X
Rozites caperata			X			
Suillus tomentosus				67X	6X	
Trametes versicolor					X	
Tricholoma magnivelare	22X					

Feasible for folks with less resources?



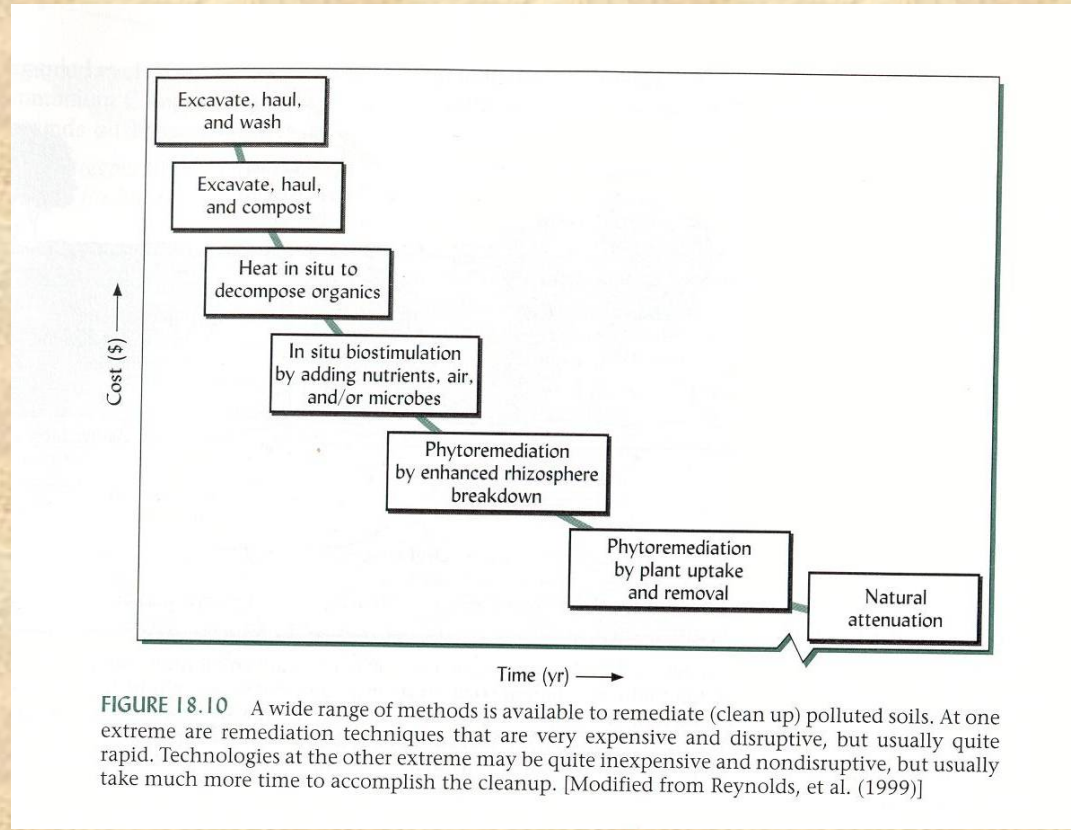


FIGURE 18.10 A wide range of methods is available to remediate (clean up) polluted soils. At one extreme are remediation techniques that are very expensive and disruptive, but usually quite rapid. Technologies at the other extreme may be quite inexpensive and nondisruptive, but usually take much more time to accomplish the cleanup. [Modified from Reynolds, et al. (1999)]

Government Subsidized Remediation??

EPA:

- Superfund
- Brownfield Cleanup Grants

Transnational NGOs (NATO, WTO, etc):

- Conferences on Urban Agriculture and bioremediation “for economic ‘sustainability’”

Lower 9th Ward, New Orleans

The Rhizome Collective

Grove Brownfield Cleanup:

- donated by the city of Austin
- plans for a park and garden

- Austin, TX Educational Center for Urban Sustainability and Center for Community Organizing
- systems taught include:
  - soil building
  - Bioremediation
  - urban livestock
  - rainwater harvesting,
  - aquaculture ponds
  - constructed wetlands for cleaning wastewater
  - “humanure” and worm composting
  - DIY air purification
  - passive solar and bicycle windmills
  - bio-gas and biofuels
  - natural construction methods
  - restoring brownfields
  - gentrification and struggles for land in the city

More Gardens, NYC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