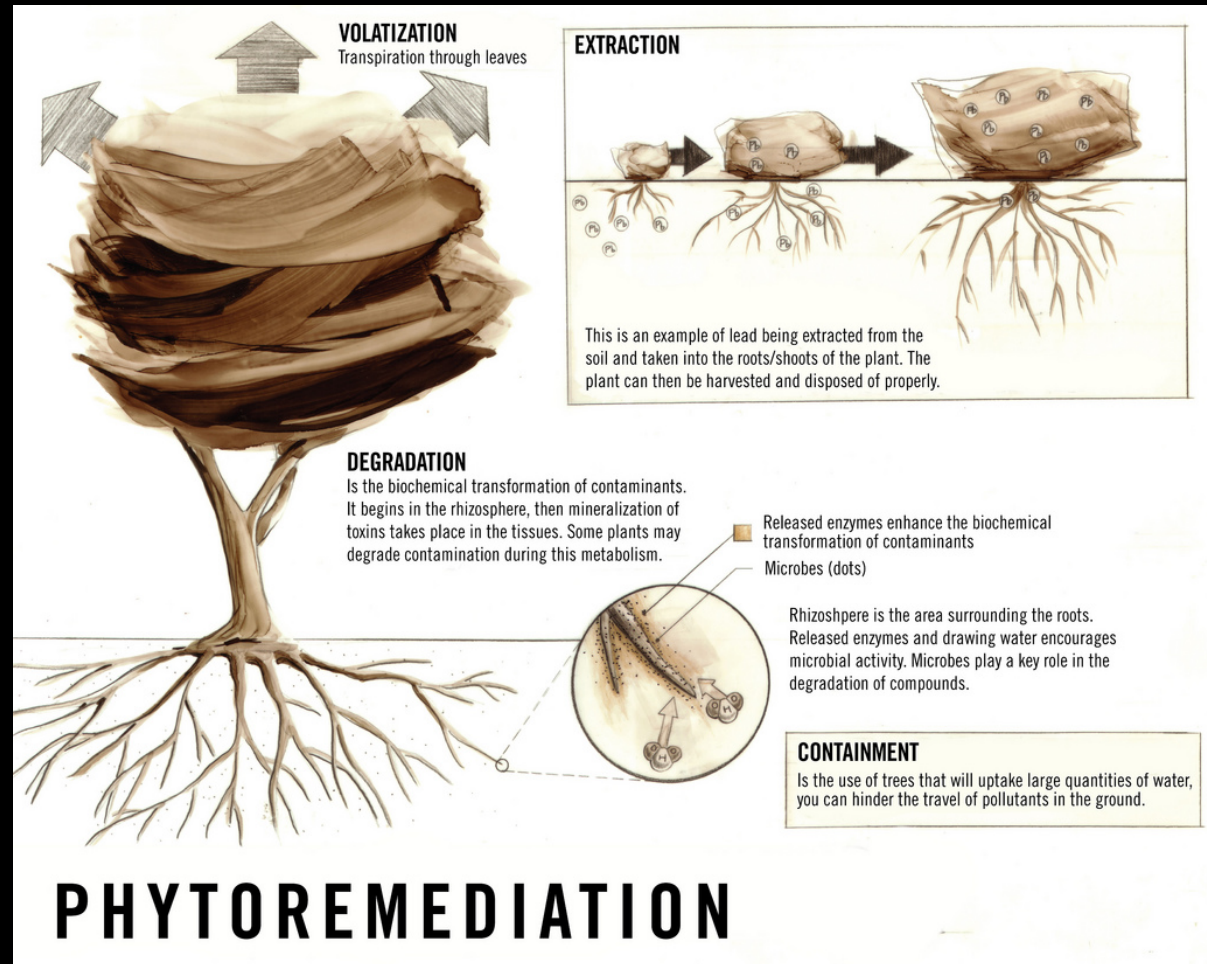


Phytoremediation

Alexis Durham



What is Phytoremediation?

Phytoremediation is the use of plants to remove contaminants from the soil and the water.

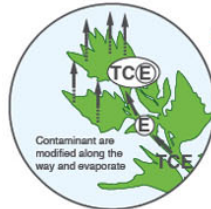
Benefits

- Harnesses the natural abilities of plants to clean groundwater, toxic soils, surface water, and sediments
- Low cost alternative to traditional cleanup

How Does It Work?

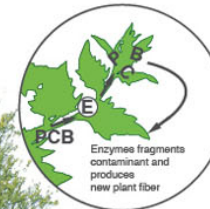
PHYTO VOLATILIZATION:

Some plants take up volatile contaminants and release them into the atmosphere through transpiration. The contaminant is transformed or degraded within the plant to create a less toxic substance before and then released into the air.



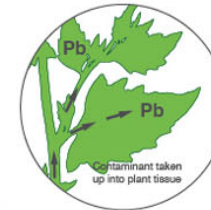
PHYTO DEGRADATION:

Plants take up and break down contaminants through the release of enzymes and metabolic processes such as photosynthetic oxidation/reduction. In this process organic pollutants are degraded and incorporated into the plant or broken down in the soil.



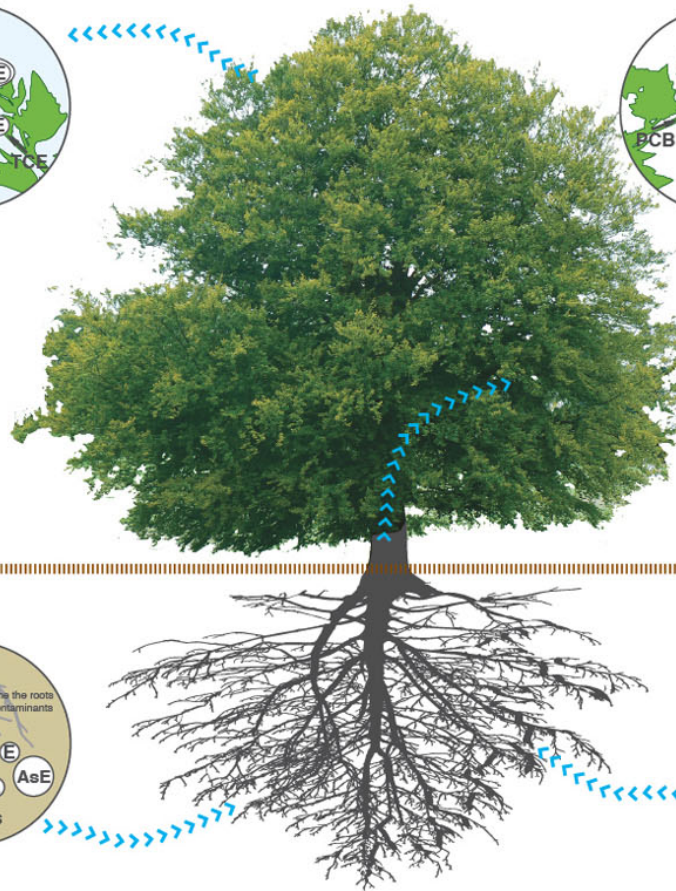
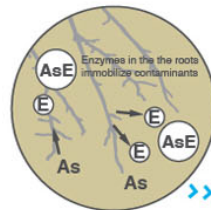
PHYTO EXTRACTION:

Plants take up contaminants - mostly metals, metalloids and radionuclides - with their roots and accumulate them in large quantities within their stems and leaves. These plants have to be harvested and disposed as special waste.

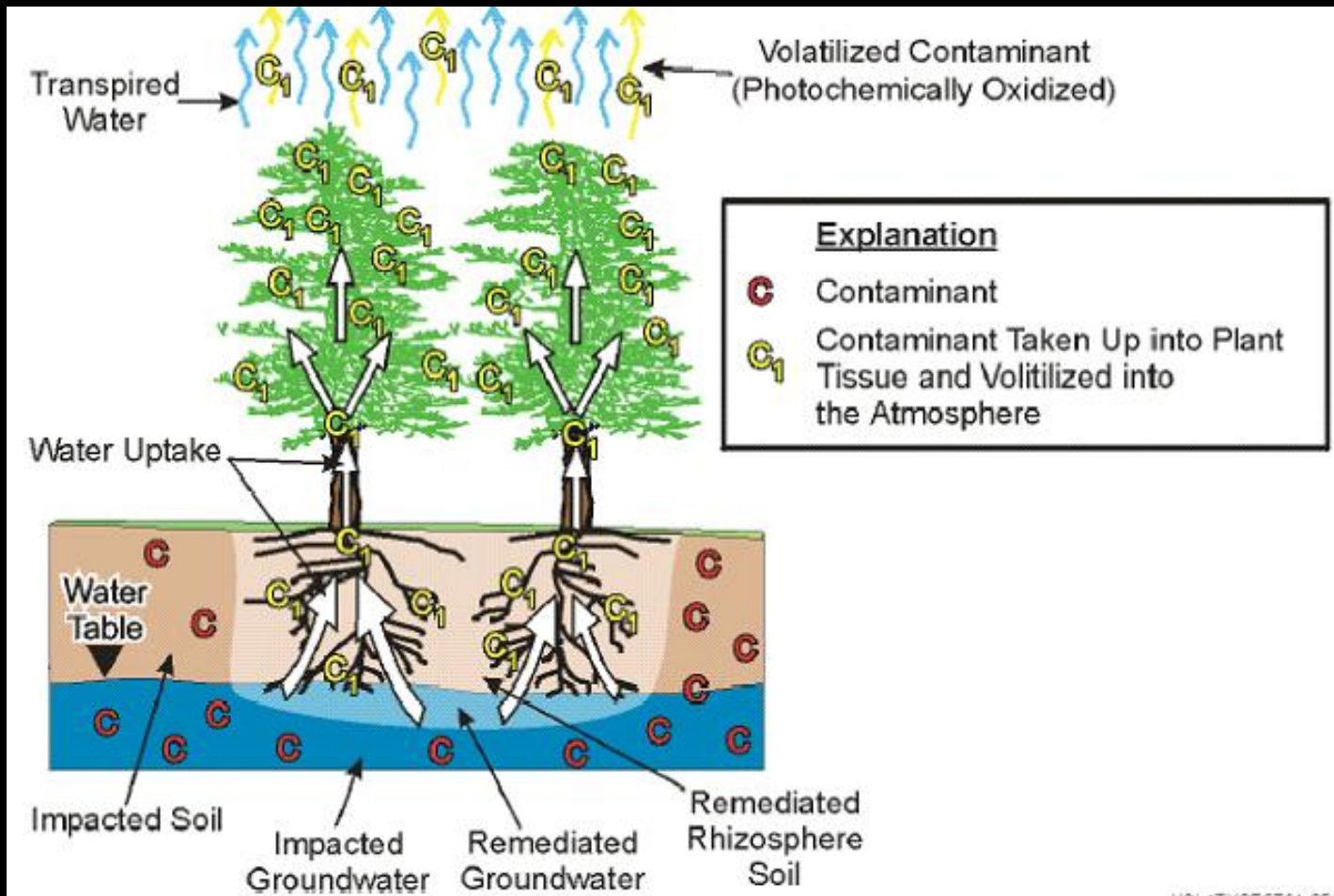


PHYTO STABILIZATION:

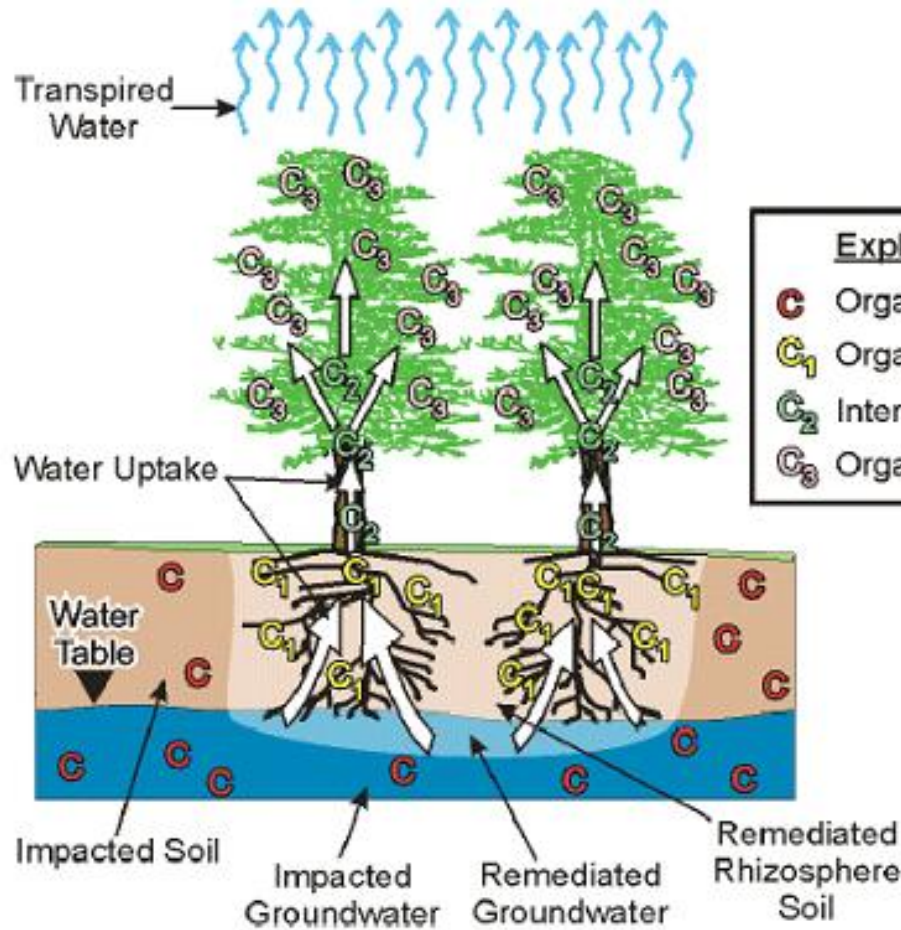
Some plants can sequester or immobilize contaminants by absorbing them into their roots and releasing a chemical that converts the contaminant to a less toxic state. This mechanism limits the migration of contaminants through water erosion, leaching, wind, and soil dispersion.



Phytovolatilization



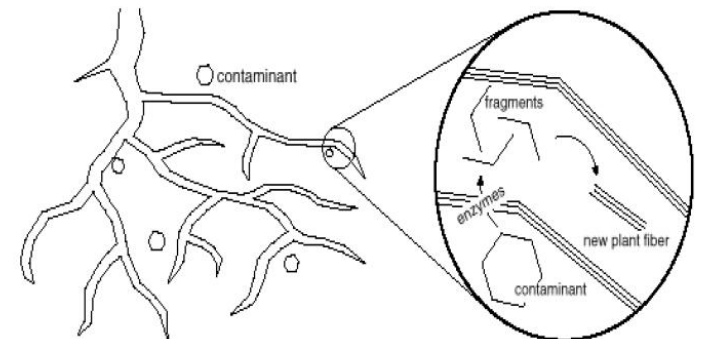
Phytodegradation



Explanation

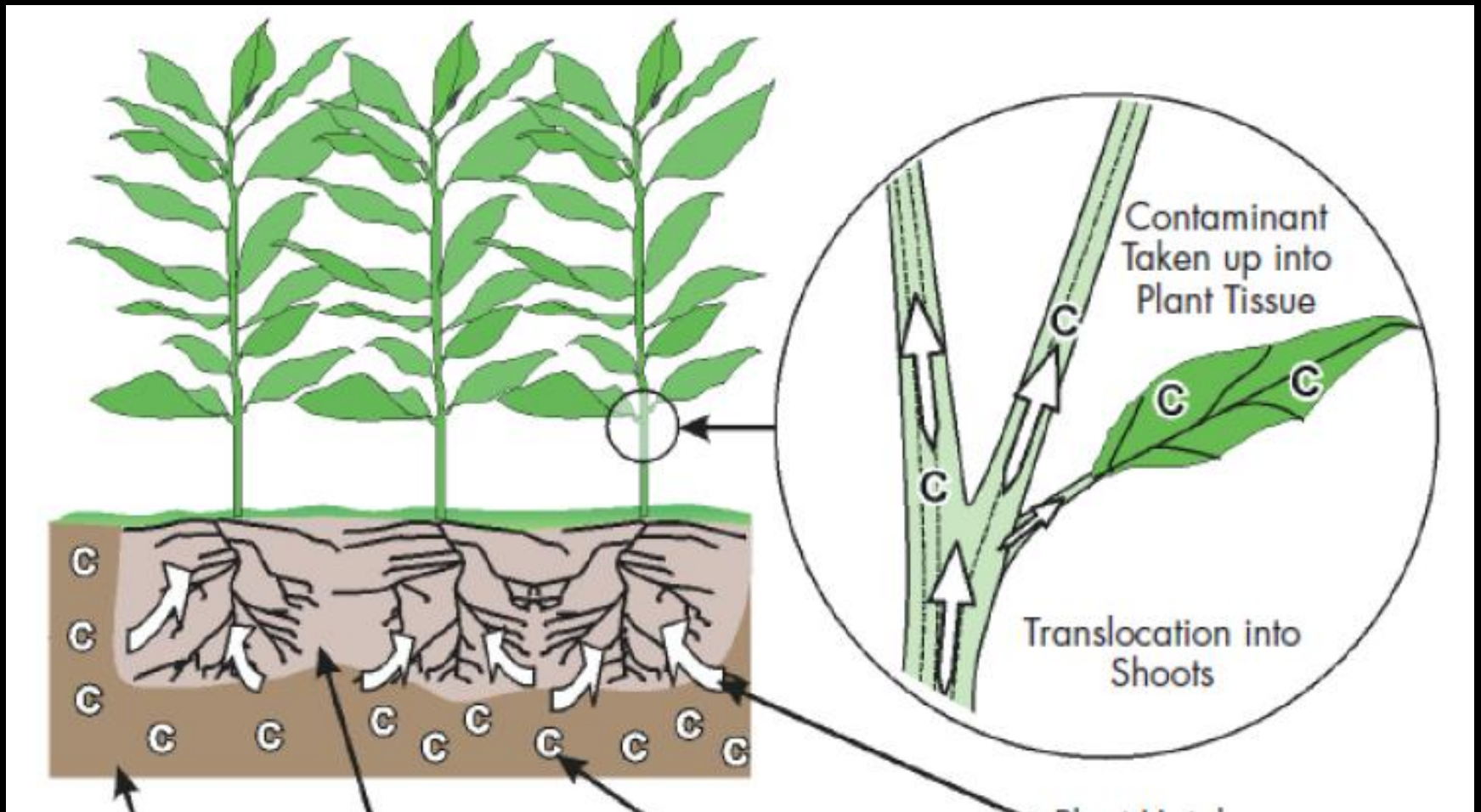
- C** Organic Contaminant
- C₁** Organic Taken Up into Plant Tissue
- C₂** Intermediate Compound
- C₃** Organic Incorporated into Biomass

PHYTODEGRADATION

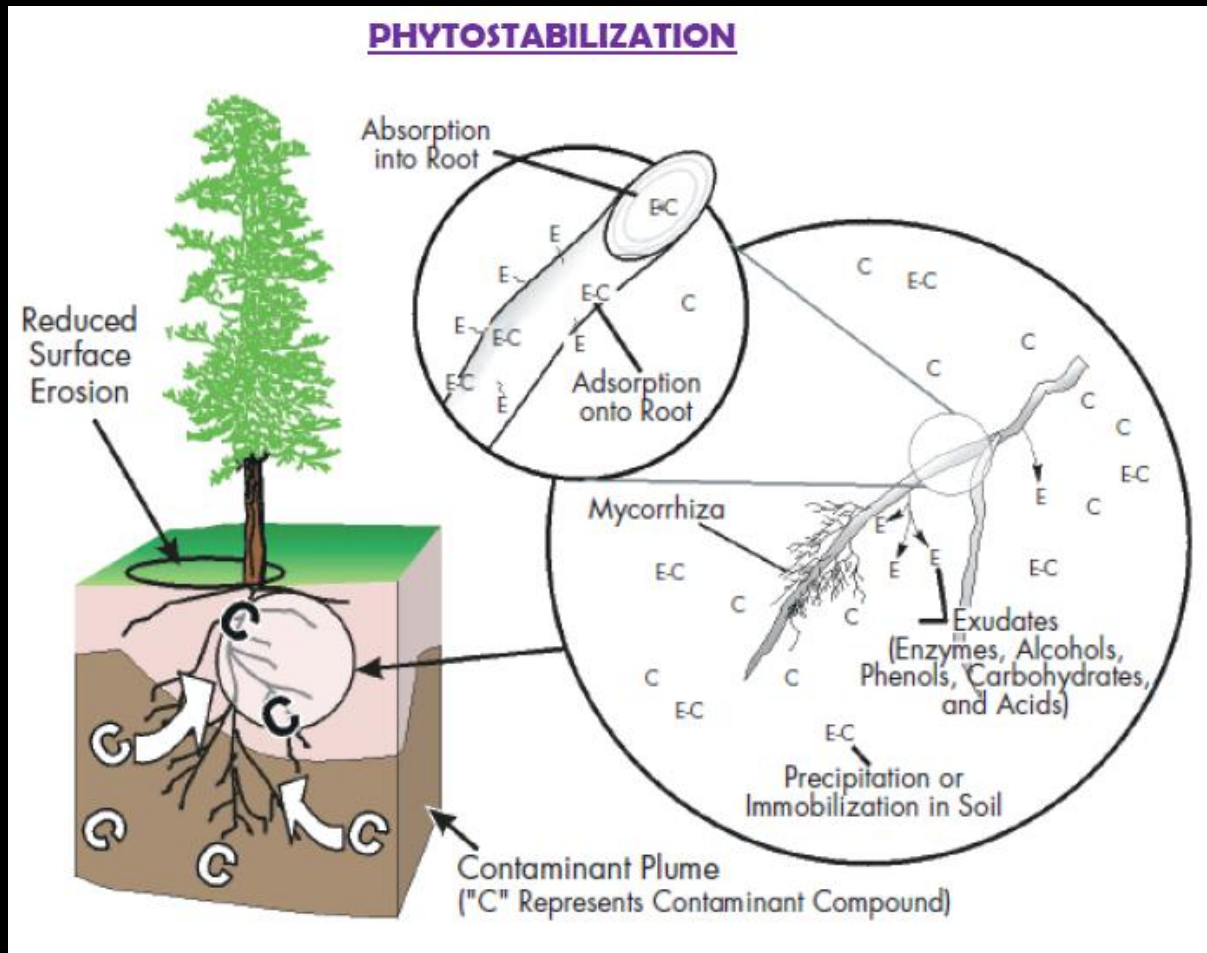


P/S: Rhizodegradation is similar to phytodegradation except fungi and bacteria living in the soil around the roots of the plants degrade the contaminants

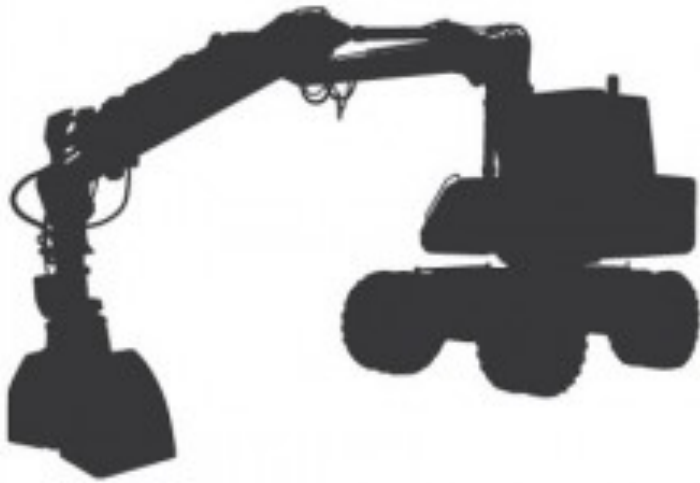
Phytoextraction



Phytostabilization



Excavation and Fill



\$50,000 - 100,000

Phytoextraction



\$5,000 - 8,000

The costs associated with remediating lead contamination on a 2,500sf lot through phytoextraction using Indian Mustard can be reduced to 10% of the cost of excavation and fill.

Potential in Urban Areas

- Urban designer Kaja Kuhl (with Lisa Brunie, Erik Facticeau, and Jay Tsai) created the handbook, *A Field Guide to Phytoremediation*, to provide a smaller scale, cost-effective approach to removing contaminants from the land using plants.
- <http://urbanomnibus.net/2010/11/from-brownfields-to-greenfields-a-field-guide-to-phytoremediation/>



Collect a Soil Sample

Gather soil samples by taking them from at least 4 different areas per every 400sf of space. Samples should come from approximately 6 inches below the surface and should not contain any gravel, grass, trash, etc. Send samples to a lab.



Create a Remediation Plan and Start Planting



- Based on the results of soil testing, determine if/how contaminants should be remediated.
- Transplant seedlings to your site after the last spring frost when they are about 3" tall. Give them love, attention, and thanks.

Harvest and Re-Plant Site

- It will take the plants approximately 14 weeks to accumulate and become saturated with heavy metals and other toxins. Harvest the entire plant (roots, stems, and leaves) and repeat the entire growing process as often as climate permits.



Dispose of Plant Matter

- Some plants are **hyperaccumulators** and must be disposed of as hazardous waste.
 - These plants store toxins in their plant tissue and will become toxic themselves throughout this process
 - Look for Special/ Hazardous Waste drop-off in your area



https://en.wikipedia.org/wiki/List_of_hyperaccumulators

Re-test Soil

- Re-test the soil at the end of the growing season to track any improvements
- This process may take a few years to remediate the contamination



Contaminants and Plant Remediators

CONTAMINANT		MAXIMUM LEVELS OF CONTAMINANT FOR:				TYPICAL PLANTS				
		Multi Family Housing... ..Recreation..Park	Single Family Houses..Gardening.. Playground	Farming Animals.. ..Growing Food						
As	Arsenic	16ppm 	16ppm 	13ppm 	Often found in lead-acid batteries, light-emitting diodes, paints, dyes, metals, pharmaceuticals, pesticides, herbicides, soaps, and semiconductors.	 Chinese Brake Fern <i>Pteris vittata</i> L.	 Sunflower <i>Helianthus annuus</i>	 Highland Bent Grass <i>Agrostis castellana</i>		
Cr	Chromium	180ppm 	36ppm 	30ppm 	PHYTO EXTRACTION	 Alpine Pennycress <i>Thlaspi caerulescens</i>		 Giant Duckweed <i>Spirodela polyrhiza</i>		
Pb	Lead	400ppm 	400ppm 	63ppm 	PHYTO STABILIZATION	 Blue Sheep Fescue <i>Festuca ovina</i>	 Indian mustard <i>Brassica juncea</i> L.	 Common Wheat <i>Triticum estivum</i>	 Common Ragweed <i>Brassica oleracea</i>	
Hg	Mercury	0.81ppm 	0.81ppm 	0.18ppm 	PHYTO STABILIZATION			 Seapink Thrift <i>Armeria maritima</i>	 Rapeseed Plant <i>Brassica napus</i>	
PCB	Polychlorinated biphenyls	1ppm 	1ppm 	0.1ppm 	Colorless to light yellow oily liquids or waxy solids. Accumulate in fish and marine mammals at much higher levels than in sediments and water	 Paul's Scarlet Rose <i>Rosa</i>	 Zucchini <i>Curcubita pepo</i>			
TCE	Trichloroethylene	21ppm 	10ppm 	0.47ppm 	PHYTO DEGRADATION	 Willow <i>Salix</i>	 Pine <i>Pinus</i>	 Eastern cottonwoods <i>Populus deltoides</i>		
MTBE	Methyl tertiary butyl ether	100ppm 	62ppm 	0.93ppm 	Typically used as a fuel additive in gasoline. Common in areas that were exposed to leakage from the gasoline storage and distribution systems.	 Pine <i>Pinus</i>	 Pumpkin <i>Curcubita</i>			
DDT	Dichlorophenyltrichloroethane	7.9ppm 	1.7ppm 	0.0033ppm 		 White rot fungus <i>Phanerochaete chrysosporium</i>	 Pumpkin <i>Curcubita</i>	 Crested Wheatgrass <i>Agropyron cristatum</i>		
PCP	Pentachloropheno	6.7ppm 	2.4ppm 	0.8ppm 	PHYTO DEGRADATION	 White rot fungus <i>Phanerochaete chrysosporium</i>		 Crested Wheatgrass <i>Agropyron cristatum</i>		

<http://urbanomnibus.net/2010/11/from-brownfields-to-greenfields-a-field-guide-to-phytoremediation/>

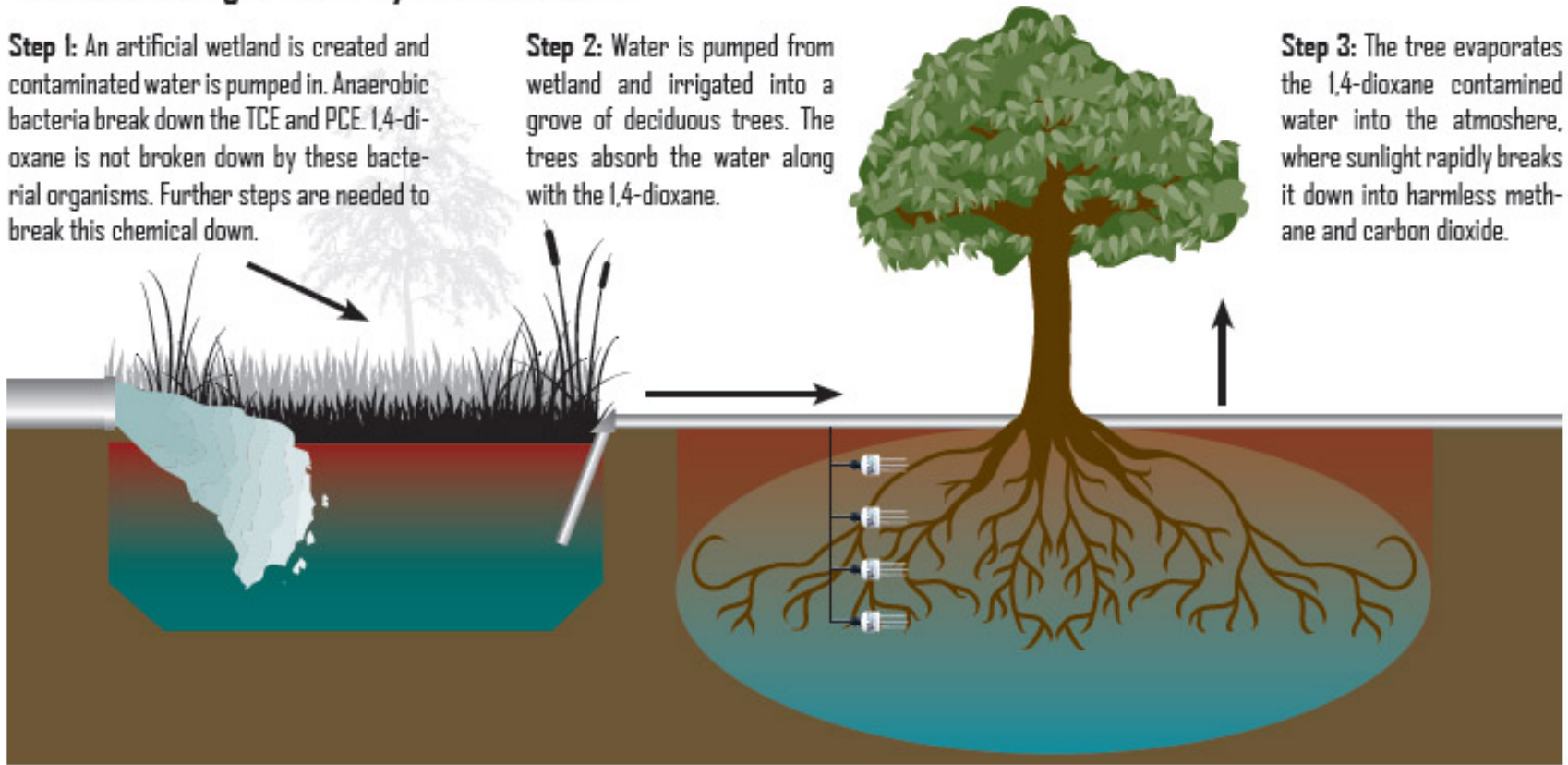
Cleaning Water Systems

An illustrated guide to Phytoremediation:

Step 1: An artificial wetland is created and contaminated water is pumped in. Anaerobic bacteria break down the TCE and PCE. 1,4-dioxane is not broken down by these bacterial organisms. Further steps are needed to break this chemical down.

Step 2: Water is pumped from wetland and irrigated into a grove of deciduous trees. The trees absorb the water along with the 1,4-dioxane.

Step 3: The tree evaporates the 1,4-dioxane contaminated water into the atmosphere, where sunlight rapidly breaks it down into harmless methane and carbon dioxide.



Portland-area Phytoremediation Projects



Albany Talking Water Gardens, a constructed wetland project and the Woodburn Waste Water Treatment Plant, a poplar remediation plantation.

Other Opportunities



- Brownfield Programs

- [http://
www.groundworkportland.org/
programs/page-brownfield/](http://www.groundworkportland.org/programs/page-brownfield/)

Phytoremediation in the Home

Pollutant	Sources	Solutions	
Formaldehyde	Foam insulation, pluwood, clothes, carpeting, furniture, paper goods, household cleaners	Philodendron Spider Plant Golden Pothos Bamboo Plant Corn Plant Chrysanthemum Snake Plant	
Benzene	Tobacco smoke, gasoline, synthetic fibers, plastics, inks, oils, detergents, rubber	English ivy Chrysanthemum Gerbera daisy Peace lily	
Trichloroethylene	Dry cleaning, inks, paints, varnishes, lacquers, adhesives	Gerbera daisy Chrysanthemum Peace lily	

More Resources

- Sampling of plant species studied for phytoremediation
 - <http://www.superorg.net/archive/proposal/plant%20species%20phyto.pdf>
- EPA's Phytoremediation Resource Guide
 - <http://www.epa.gov/tio/download/remed/phytoresgude.pdf>