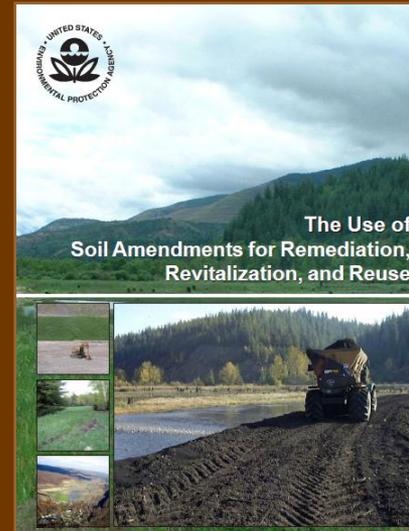


Using Soil Amendments to Reuse Urban Land

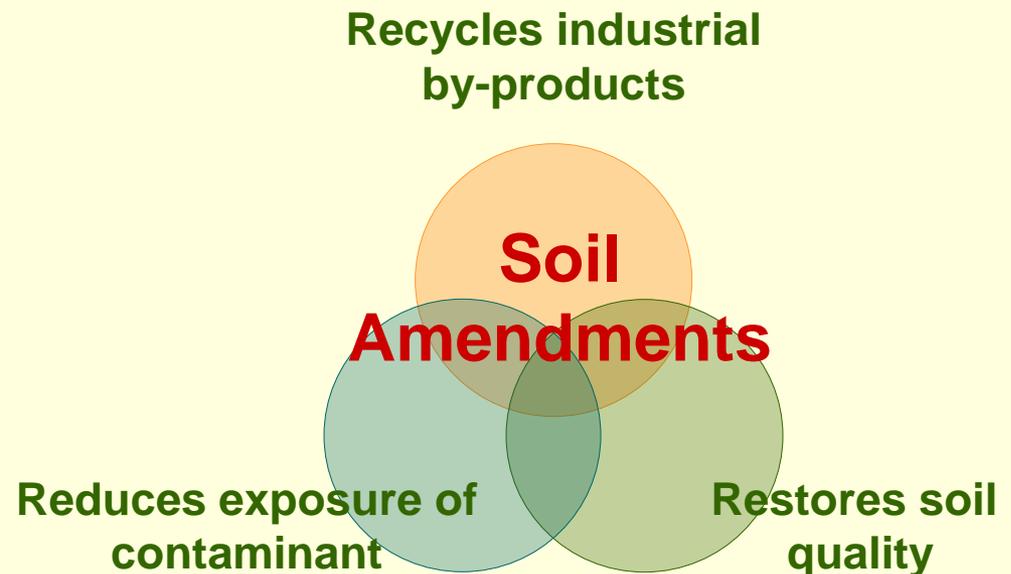
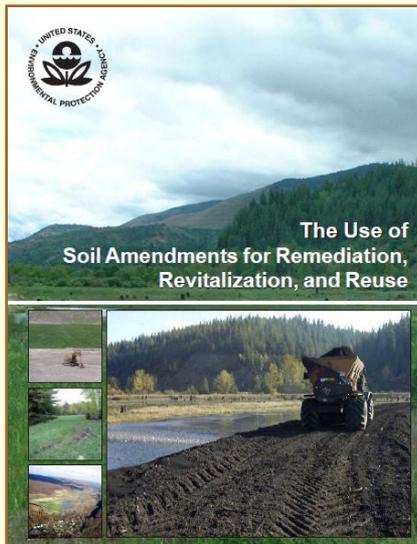


Michele Mahoney, U.S. EPA
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Overview

- ❖ Background on soil amendments
- ❖ Overview of Soil Amendments Paper
- ❖ Soils and Urban Gardening





What are Soil Amendments?

- ❖ Residuals from other processes that:
 - Have beneficial properties
 - Reduce exposure by limiting the exposure pathways and immobilizing contaminants
 - Restore soil quality
 - Enable site remediation, revegetation, and reuse



What are Soil Amendments?

- Biosolids
- Manures/Litters
- Sugar beet lime
- Wood ash
- Log yard waste
- Yard trimmings
- Composted food waste
- Neutralizing lime products
- Composted biosolids
- Composted agricultural byproducts
- Traditional agricultural fertilizers



Some Benefits

- ❖ Restore soil health and structure
- ❖ Decrease bioavailability of contaminants
- ❖ Decrease mobility of contaminants
- ❖ Decrease erosion
- ❖ Reduce cost for remediation



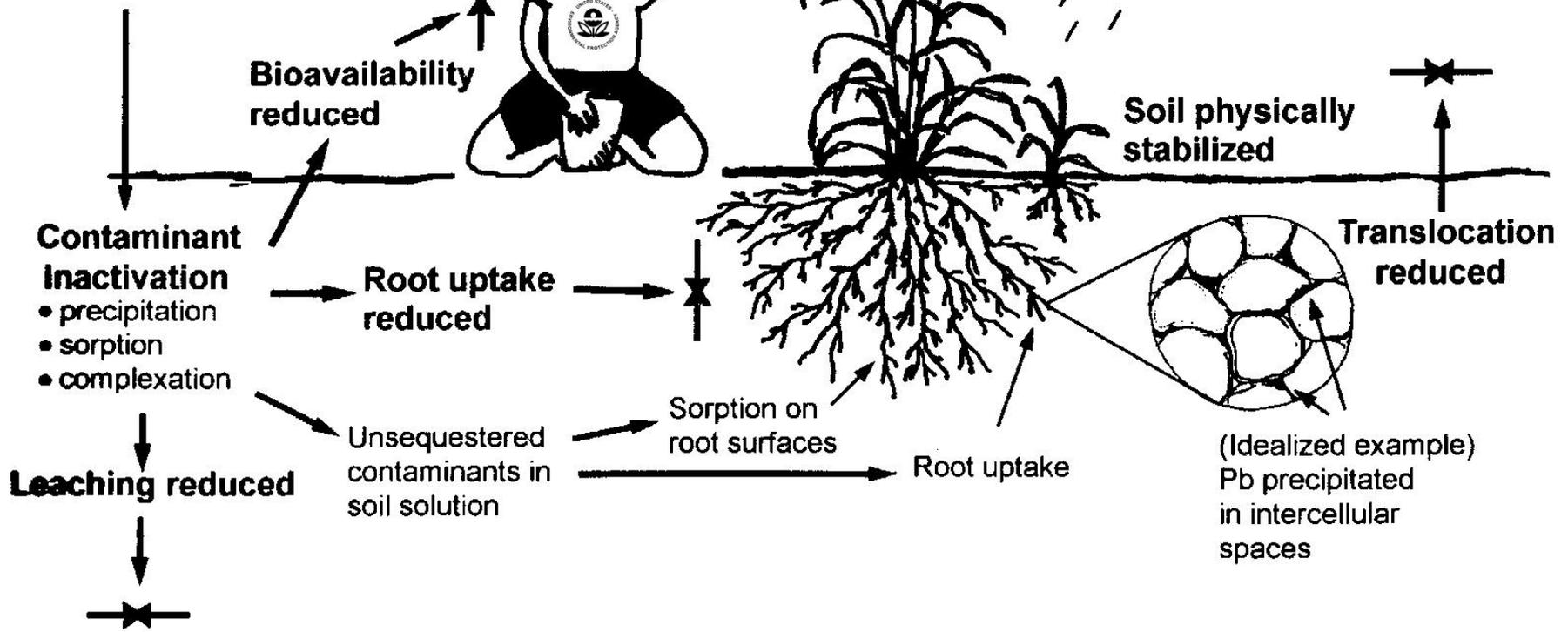
Mitigate Exposure

Plant Characteristics

- quick and easy establishment
- excellent soil cover
- high evapotranspiration rate
- poor translocator of contaminants
- fast growth

Soil Amendments

- phosphate fertilizers
- Fe oxide materials
- organic materials
- inorganic clay minerals





Problems at Sites addressed by Soil Amendments

- ❖ **Toxicity from contaminants**
- ❖ **pH**
- ❖ **Excess Sodium**
- ❖ **Excess Salts**
- ❖ **Soil Physical Properties**
 - Density, aggregation and texture
- ❖ **Nutrient Deficiencies**
 - Micronutrients (Zinc and Manganese)

Types of Problems Addressed by Soil Amendments

❖ Contaminant Bioavailability/Phytoavailability

- Toxicity (inorganic)
- Toxicity (organic)

❖ Poor Soil Health/Ecosystem Function

- High or Low pH
- Sodicity or Salinity
- Changes in Soil Physical Properties
- Nutrient Deficiencies and Low Fertility

	Expected Problem and Major Effect	Interactions	Solutions
Sulfur (S)	Phytotoxicity	Low pH + S = toxic High pH + S = toxic	Amend with lime Use acid sulfate
Selenium (Se)	Toxicity Deficit	High pH = toxic Low pH = toxic	Amend with lime Amend with sulfur
Sulfur (S) / Zinc (Zn)	Toxicity Deficit	High pH = toxic Low pH = toxic	Amend with lime Amend with sulfur
Tungsten (W)	Toxicity	Low pH = toxic High pH = toxic	Amend with lime Amend with sulfur
Vanadium (V)	Toxicity	Low pH = toxic High pH = toxic	Amend with lime Amend with sulfur
Trace metals (As, Cd, Cr, Cu, Pb, Hg, Mn, Ni, Zn)	Toxicity	Low pH = toxic High pH = toxic	Amend with lime Amend with sulfur
Trace metals (Al, Fe, Mn, Zn)	Toxicity	Low pH = toxic High pH = toxic	Amend with lime Amend with sulfur
Trace metals (Co, Ni, Pb, Zn)	Toxicity	Low pH = toxic High pH = toxic	Amend with lime Amend with sulfur
Trace metals (Ba, Be, Bi, Br, Ca, Cs, K, Li, Na, Rb, Sr, Tl, U, V, Y, Zr)	Toxicity	Low pH = toxic High pH = toxic	Amend with lime Amend with sulfur
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Table 1

Types of Problems Addressed by Soil Amendments

Table 1: Types of Problems Addressed by Soil Amendments

	Exposure Pathways and Adverse Effects	Interactions	Solutions
<i>Contaminant Bioavailability/Phytoavailability Problems</i>			
Toxicity (inorganic)			
Aluminum (Al)	Phytotoxicity Runoff Leaching	Low pH ² = more toxic; Low P = more toxic; High calcium (Ca) = less toxic	Raise pH greater than 6.0, add OM and P; add gypsum or other high soluble Ca source
Arsenic (As)	Soil Ingestion Runoff Leaching	High pH ² = more toxic; High P = more soluble	Add organic matter (OM) and adjust pH to between 5.5-6.5
Borate (BO ₃ ³⁻)	Phytotoxicity	Low and High pH ² = more toxic	Add iron oxide and acidify (pH between 6.0-7.0)
Cadmium-to-Zinc Ratio (Cd:Zn) ¹	Food chain	High ratio = greater bioavailability (risk) of Cd	Add Zn to reduce the Cd:Zn ratio

Table 1

Types of Sites Where Soil Amendments Can Be Used

Site	Contaminant	Problem	Solution
Eastern (acid-forming)	Pyrite and associated metals	Existing and potential acidity; Physical problems; Acid mine drainage	Add lime to correct existing and potential acidity plus additional 25 to 50% safety factor is sufficient; Add organic soil amendments to revitalize soil; Modify surface texture where possible.
Sand/Gravel mines	In Eastern sites, may have associated acidity problems	Coarse texture or rocky and very infertile; Heavy soil compaction and low water retention and/or rooting depth	Add lime and organic soil amendment (generally high application rate beneficial) with appropriate C:N ratio to minimize nitrate leaching.
Western (Na and salts)	Na, salts, Se	Salinity, sodicity, and physical problems; Se leaching and aquatic biomagnification	Add OM and Ca-rich soil amendments; Irrigate to remove salts where possible; Segregate Se bearing materials and avoid Se accumulating plant species for revegetation.
Refineries/Smelters			
Aerial Deposition	Metals (see mining sites above)	Metal toxicity; Acidity, Possible infertility; In urban environment, soil ingestion may be dominant risk	See metals-specific remedies above.
Smelter Process Waste/Slag		Metal acidity; Salts; Dark color (which causes heat kill of seedlings); Cementation	See metals-specific remedies above; For color, surface mulch to modify temperature or surface apply light-colored mixtures of alkaline fly ash and biosolids; For cementation, modify physical properties; For salts, irrigate and if electrical conductivity (EC) is excessive, capping may be necessary.
Tailings	Metals (see mine sites above); Cyanide	Metal toxicity; Acidity (associated acid drainage) or alkalinity; Infertility; Physical properties; Cyanide in gold (Au) tailings	See metals-specific remedies above; modify physical properties. ¹
Construction Sites	See sand and gravel; urban contaminants	See sand and gravel; Compaction, mixed soil and geologic materials, imbalanced pH and low fertility all common	Site-specific remedies based on contaminants.
Mixed Contaminants	Low levels of metals and organics	Often former industrial sites will have soil physical and nutrient problems	Soil amendments to improve nutrient and physical characteristics and pH adjustment as needed can often reduce contaminant availability; Site-specific evaluation

Table 2

Site	Contaminant	Problem	Solution
Eastern (acid-forming)	Pyrite and associated metals	Existing and potential acidity; Physical problems; Acid mine drainage	Add lime to correct existing and potential acidity plus additional 25 to 50% safety factor is sufficient; Add organic soil amendments to revitalize soil; Modify surface texture where possible.
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Types of Soil Amendments

Table 3: Types of Soil Amendments

Amendment	Availability	Uses	Public Acceptance	Cost	Advantages	Disadvantages	Links
Organics							
Biosolids	Sustainable supply; Higher quantities in urban areas	Nutrient source; Organic matter (OM) source; Sorbent ¹ properties increase with increasing iron content.	Largely odor-driven; Pathogen concerns; Concerns largely driven by perception.	Materials generally free; Municipalities may pay for transport and use.	Multi-purpose, multi-benefit soil amendment; highly cost-effective; EPA regulated ² ; well characterized consistent quality.	Public concern/public perceptions; High nutrient loadings in some settings; Some sources have high moisture content.	National Biosolids Partnership (http://www.biosolids.org/index.asp)
Manures	Sustainable supply; Higher quantities near CAFOs	Nutrient source; OM source.	Well accepted.	Materials generally free; Transport and application fee.	Widespread and readily available.	Not consistently regulated ² ; Variable quality; Not routinely treated for pathogen reduction; Generally uncharacterized.	Industry Residuals: How They Are Collected, Treated and Applied (http://www.clu-in.org/studentpapers/)
Compost	Location-dependent; Volumes limited; Competing users	Nutrient source; OM source.	Readily accepted.	Product and transport costs can be high.	Readily accepted; Stable product; Can be used in or near water.	High cost; Limited availability; N quantity usually significantly lower than non-composted materials.	U.S. Composting Council (http://www.compostingcouncil.org/section.cfm?id=37) Association of Compost Producers
Digestates ³	New material; Very location dependent	Nutrient source; OM source.	May have odor problems.	To be determined; Transport and application fee.		New enough so that not regulated ² ; Variable quality; Not routinely treated for pathogen reduction; Generally uncharacterized.	

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Application Rates

- ❖ The appropriate application rate depends on the specific concern to be addressed.
- ❖ The amount of amendments added to the soil can be a qualitative or quantitative decision.
- ❖ Typically, higher application rates of soil amendments are required when rebuilding soil, rather than simply enhancing damaged soil.

Logistics and Other Considerations in Using Soil Amendments

❖ Other considerations include:

- Availability
- Public considerations
 - Public outreach
 - Odor
 - Demonstrations
- Costs
- Long-term maintenance
- Monitoring

Regulatory Requirements for Sites Using Selected Soil Amendments

Table 6: Regulatory Requirements for Sites Using Selected Soil Amendments

Organics	
Biosolids	Clean Water Act (40 CFR Part 503) Class B permit required (site restrictions); may be possible to compost or otherwise treat the biosolids on site to reach Class A quality (with no site restrictions); For CERCLA actions, no permit required, but should adhere to spirit of state and local permit requirements (ARARs) when possible; State-specific regulations also may apply.
Manures	Federal and state BMP nutrient management; CAFOS may have bookkeeping requirements.
Pulp Sludges	Dioxin concentrations restricted - voluntary or required by state standard 10 ppt TEQ (toxic equivalent) for dioxin incorporated; may have high sodium which can limit applications.
pH	
Lime	State-specific lime labeling requirements.
Wood Ash	May be regulated as a caustic material; pH will decrease to 8.3 with exposure to air; state-specific soil amendment or liming material regulations.
Coal Combustion Products	State-specific regulations; NAS recommended increased study; coal mining site regulation under SMCRA expected by 2008.
Red Mud	Regulated as mining waste <i>in situ</i> , but labeled for application as soil amendment by many states/localities.

Table 6

Includes Federal and State Regulations



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The Use of Soil Amendments for Remediation, Revitalization, and Reuse
<http://www.clu-in.org/download/remed/epa-542-r-07-013.pdf>