Lecture 1: Introduction to Soil Remediation Engineering

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Faculty of Engineering & Applied Science
1.1 Definition of soil remediation engineering

- a sub-discipline of environmental engineering
- the development and implementation of strategies to clean up (remediate) the environment by removing the disposed hazardous soil contaminants
- Multi-disciplinary involvement
- Various sources and complex cocktail of contaminants
1.2 Sources of soil contamination

(1) Originating on the ground surface

- Infiltration of contaminated surface water
- Land disposal of solid and liquid wastes
- Accidental spill
- Fertilizers and pesticides
- Disposal of sewing and water treatment plant sludges …
(2) Originating above the water table (Vadose Zone)

- Waste disposal in excavations
- Landfills
- Leakage from underground storage tanks
- Leakage from underground pipelines …

(3) Originating below the water table (Saturated Zone)

- Waste disposal in wet excavations
- Deep well injection
- Mines …
1.3 Common soil contaminants

- Heavy metals (Pb, Cd, Cr, Ni…)
- Arsenic (inorganic and organic forms)
- Chlorinated solvents (PCE, TCE, TCA, MC…)
- Polycyclic aromatic hydrocarbons (PAH)
- Polychlorinated biphenyl (PCBs)
- Pesticides (organochlorines, organophosphates and carbamates)

1.4 Selecting and/or designing a right remediation technology

(1) Site characterization:

- complex contaminants as well as unique site features (geology, hydrology, etc) → tailored technologies are required on a site-by-site basis
(2) Comprehensive consideration for a particular site

- end goal for clean-up ➔ how clean the site is required to be
- risk
- stakeholder concerns
- technological feasibility and convenience
- effectiveness/practicality
- ease of integration into remediation systems
- cost and acceptance
Steps involved in remedial action

Site discovery

Preliminary assessment

Site inspection

Hazard ranking analysis

National priorities list

Remediation investigation

Feasibility study

Remedy selection/Record of decision

Remedial design

Remedial action

Project closeout

No federal remedial action required

Source: USEPA, 1991
1.5 Overview of Remediation technologies

(1) Technologies to remediate contaminated soil fall into two principal clean-up approaches

- In-situ (which is always done on-site) → deals with contamination without removing material from the ground

- Ex-situ (which can be done on- or off-site) → requires the removal of contaminated soil for treatment or land-filling
(2) Technologies to remediate contaminated soil fall into two classes

- **Source control** ➔ technologies to contain or treat sources of contamination

- **Management of migration** ➔ technologies to control the movement of contaminants away from sources
(3) Popular remediation technologies

- Soil remediation
  - Soil Vapor Extraction
  - In Situ Bioremediation
  - Soil Flushing
  - Soil Fracturing
  - Phytoremediation
  - Stabilization and solidification
  - Surface capping
Groundwater remediation

- In situ Air Sparging
- Vacuum Extraction
- In Situ Bioremediation and Natural Attenuation
- Pump and Treat
- In situ reactive walls
✓ Soil Vapor Extraction

Schematic of SVE implementation in the field

Source: Suthersan, 1997
SVE treatment

Source: WRScompass, 2008
In Situ Bioremediation

In-situ bioremediation implementation

Source: Hardisty, 2005
Injection of enhanced bioremediation product

Source: G&R Remediation, www.envirocoregr.com
Natural Attenuation

Schematic of natural attenuation

Source: Hardisty, 2005
Contaminant plume formed during natural attenuation

Source: NAVFAC POC, 2009
Soil Flushing

Typical in-situ soil flushing in vadose zone

Source: Sharma and Reddy, 2004
Soil washing plant

Source: LITAI, www.dllitai.com
Soil Fracturing

Two types of soil fracturing

Source: Sharma and Reddy, 2004
Hydraulic Fractures

Source: Slack, 1998
✓ Phytoremediation

Phytoextraction of heavy metals

Source: Suthersan, 1997
Hybrid poplar tree for phytoextraction

Source: Chappell, 1997
Stabilization and Solidification

In-situ S/S process

Source: Suthersan, 1997
Application of reagents to the S/S treatment site

Source: Jones, 2009
✓ Surface Capping

![Diagram of Landfill Cap]

- vegetation
- protection layer
- drainage layer
- geomembrane/soil barrier layer
- 60 cm topsoil
- 30 cm granular or geotextile filter
- geomembrane with overlying protective geotextile
- geotextile gas collection layer

Landfill Cap

Source: Federal Remediation and Technologies Roundtable, 2003
Source: Fernald Environmental Management Project, 2002
In situ Air Sparging with VES

Schematic of AS-VES

Source: Hardisty, 2005
✓ Pump and Treat

Schematic of pump and treat

Source: Hardisty, 2005
A well for PAT

Source: G&R Remediation, www.envirocoregr.com
 ✓ In Situ Reactive Walls

Source: Grubb, D. G. and N. Sitar, 1994
Building reactive walls