

Hazardous waste management I

Today's lecture

- Introduction to hazardous wastes
- Hazardous waste regulation in the US
- Soil and groundwater remediation techniques
 - pump and treat systems
 - soil vapor extraction
 - air sparging

Hazardous waste

- Any waste or combination of wastes that poses a substantial danger, now or in the future, to human, plant, or animal life
- Must be handled or disposed of with special precautions

Hazardous waste

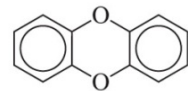
- Consequences of failure to manage hazardous wastes



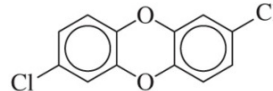
Some examples of hazardous wastes

- Dioxins
 - Refers to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD), or to the family of a chemical group called polychlorinated dibenzo-*p*-dioxins (PCDDs)
 - By-product that may be generated during the manufacture and burning of chlorophenols, 2,4,5-T, etc.

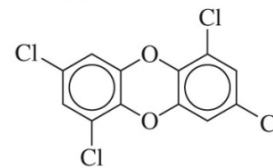
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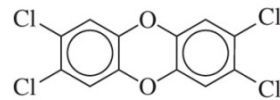
Unsubstituted dioxin



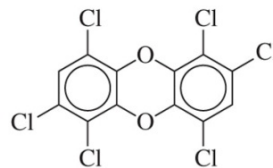
2,7-DCDD



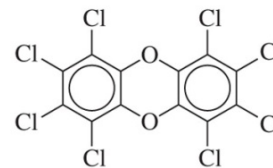
1,3,6,8-TCDD



2,3,7,8-TCDD



1,2,4,6,7,9-HEXA-CDD



OCDD

Examples of PCDDs

Some examples of hazardous wastes

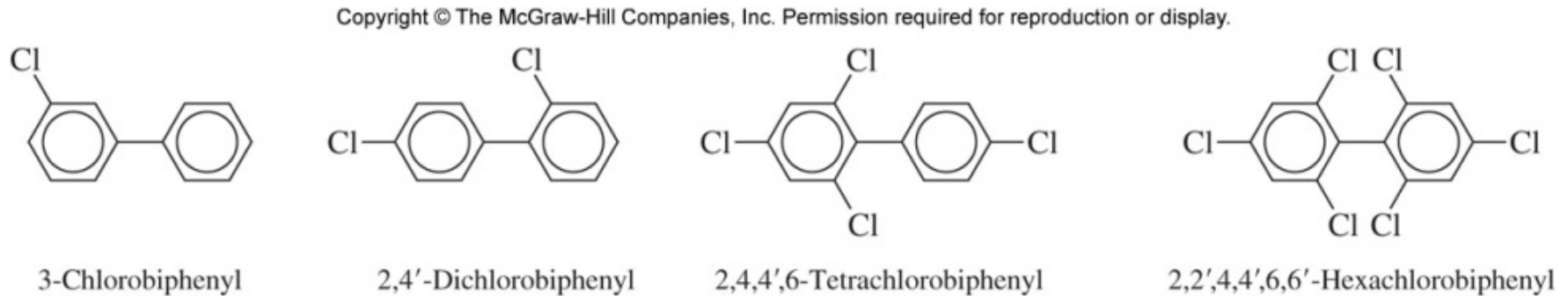
- Dioxins
 - 2,3,7,8-TCDD is probably the most poisonous of all synthetic chemicals
 - 2,3,7,8-TCDD is a “known” human carcinogen, and other dioxins are “likely” human carcinogens

Table. Approximate acute LD₅₀s of some chemical agents

Agent	LD ₅₀ (mg/kg)	Agent	LD ₅₀ (mg/kg)
Ethyl alcohol	10000	Hemicholinium-3	0.2
Sodium chloride	4000	Tetrodotoxin	0.1
Morphine sulfate	1500	2,3,7,8-TCDD	0.001
Nicotine	1	Botulinum toxin	0.00001

Some examples of hazardous wastes

- Polychlorinated biphenyls
 - A class of organic chemicals produced by the chlorination of a biphenyl molecule
 - 209 “congeners” exist



Examples of PCBs

Some examples of hazardous wastes

- Polychlorinated biphenyls
 - Used as coolants, lubricants, and coating materials until the 1970s
 - PCB manufacture and use were banned in the 1970s in developed countries
 - Chronic exposure could result in hazards to human health and the environment (PCBs are “likely” human carcinogen and endocrine disrupting compound)

Regulation for hazardous wastes (US)

- Resource Conservation and Recovery Act (RCRA)
 - Passed Congress in 1976
 - Amended in 1984 by the Hazardous and Solid Waste Amendments (HSWA)
 - A cradle-to-grave system for the management of hazardous waste: tracks whole life cycle (generation, transportation, treatment, storage, and disposal)
 - Requires permits for the treatment, storage, or disposal
 - Applies mainly to **active facilities** but not for abandoned or closed waste disposal sites or spills

Regulation for hazardous wastes (US)

- Comprehensive Environmental Response, Compensation, and Liability Act (1980)
 - Enacted in 1980
 - Commonly referred to as “Superfund” act
 - Addresses inactive or abandoned hazardous waste disposal sites
 - Extended in 1986 by the Superfund Amendments and Reauthorization Act (SARA)

Regulation for hazardous wastes (US)

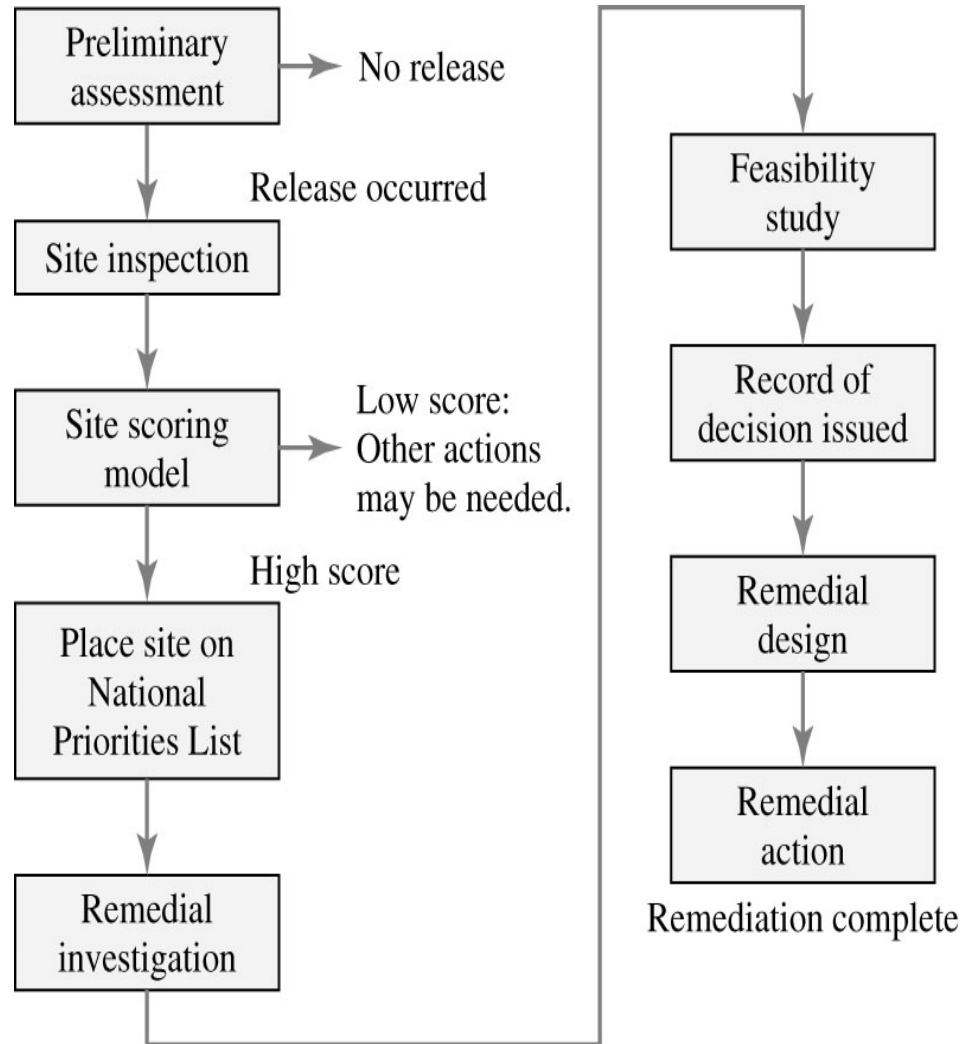
- Comprehensive Environmental Response, Compensation, and Liability Act (1980)
 - Major provisions
 - Generate a fund (the “Superfund”) to pay for investigations and remediation at sites where the responsible people cannot be found or will not voluntarily pay
 - A priority list of abandoned or inactive hazardous waste sites for cleanup (“the National Priority List”)
 - The mechanism for action at abandoned or inactive sites (the “National Contingency Plan”)
 - Liability for those responsible for cleaning up

Regulation for hazardous wastes (US)

- Comprehensive Environmental Response, Compensation, and Liability Act (1980)
 - National Priority List (NPL)
 - Identify sites that appear to present a significant risk to public health or the environment
 - To wisely use the Superfund money
 - Use “Hazard Ranking System (HRS)” to estimate the potential hazard to a score (added to the list if HRS score ≥ 28.50)
 - Updated three times a year: new sites are added to the list and sites are deleted from the list when remediation is completed
 - 1322 sites in the list in October 2014

Regulation for hazardous wastes (US)

- Superfund cleanup process Summary

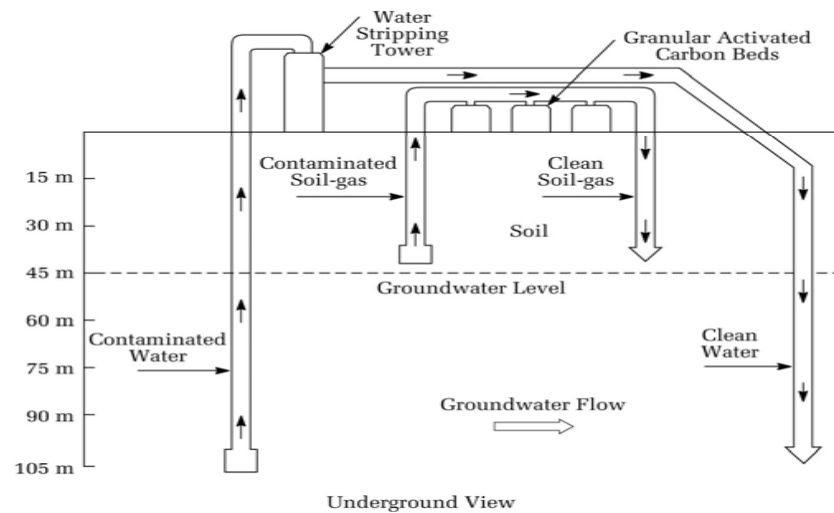
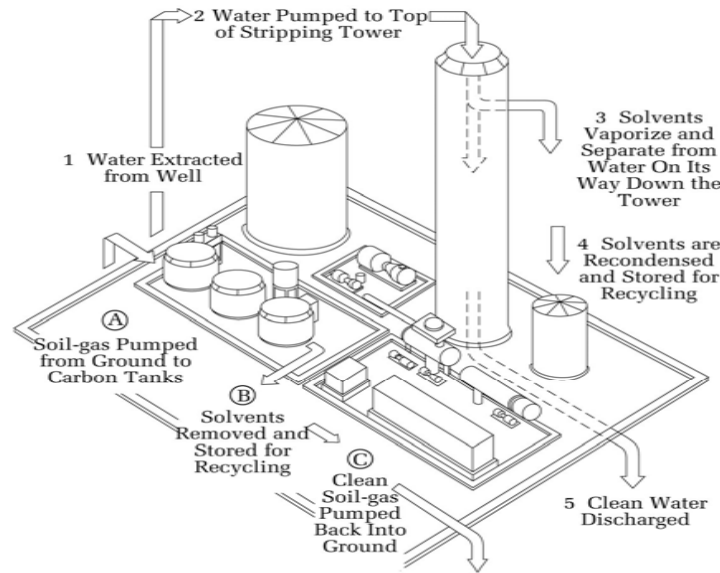


Soil and groundwater remediation techniques

- Pump-and-treat systems
 - 1) pump contaminated groundwater to the surface
 - 2) remove the contaminants
 - 3) either recharge the treated water back into the ground or discharge it to a surface water body or municipal wastewater treatment plant

Soil and groundwater remediation techniques

- Example of pump-and-treat systems



Soil and groundwater remediation techniques

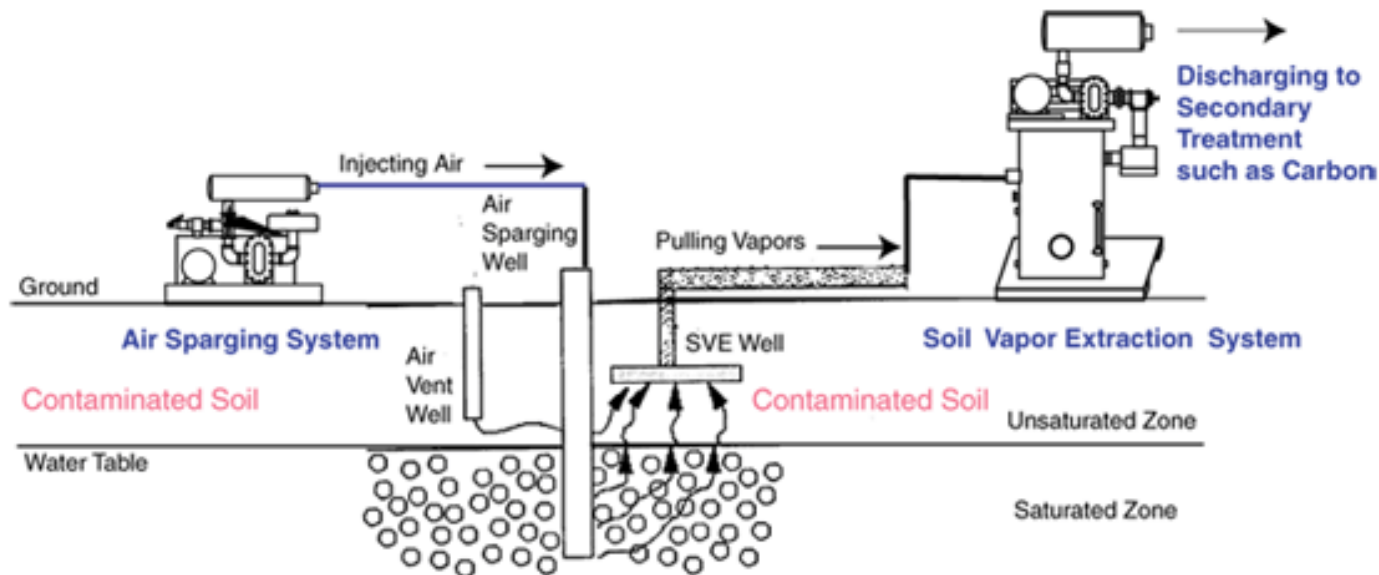
- Soil vapor extraction (unsaturated zone)
 - 1) Install vertical extraction wells or horizontal extraction pipes at the contaminated site
 - 2) Apply vacuum
 - 3) Collect volatilized contaminants
 - 4) Treat the air containing contaminants above ground

Soil and groundwater remediation techniques

- Air sparging (saturated zone)
 - Usually applied together with soil vapor extraction technique
 - Inject contaminant-free air into the saturated zone to convert dissolved contaminants into vapors
 - The contaminant vapor moved to the unsaturated zone is collected by the vapor extraction system
- Limitations of soil vapor extraction and air sparging: applicable to volatile compounds in high-permeability zones

Soil and groundwater remediation techniques

- Soil vapor extraction and air sparging



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