Environmental Chemicals I

Principles of Environmental Toxicology
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Learning Objectives

- Understand the major environmental chemicals and major groups of environmental chemicals of concern.
- Describe lists and categories of environmental chemicals.
- Use a case study to explore the contamination and clean-up challenges of the Berkeley Pit in Butte, MT.

Learning Objectives

- Use a case study to explore the relationship between lead pollution and children's blood lead levels in the Bunker Hill Superfund site in Northern Idaho.
- Use a case study to explore the results of an industrial sulfur fire near Cape Town, South Africa.

Environmental Chemicals

- Chemical type (e.g. heavy metals, pesticides, solvents, etc.).
- Physical properties (e.g. DNAPLs, VOCs, RCRA characteristic waste).
  - PBT: Persistent, Bioaccumulative and Toxic.
- Regulatory or other lists (e.g. priority pollutants, dirty dozen, RCRA listed wastes, CERCLA Hazardous Substances).
- Source, pathway or endpoint (e.g. fungal mycotoxin, snake venom, air pollutant, etc.).

Environmental Chemicals

- Priority Pollutants
  - A group of toxic chemicals or classes of chemicals listed under section 307(a)(1) of the Clean Water Act of 1977 (U.S.C. 466).
  - List was established for the purpose of providing guidelines for regulating industrial effluent discharge with the primary goal of protecting public health.

Priority Pollutants

- Antimony, thallium, asbestos, acrolein, acrylonitrile, carbon tetrachloride, chlorobenzene, 1,2-dichloroethane, 1,1-dichloroethylene, …nitrobenzene, …mercury …1,2-dichloropropane, …2-chloronaphthalene, chrysene, dibenzo(a,h)anthracene …endosulfan sulfate 2-chlorophenol, …butylbenzyl phthalate polychlorinated biphenyls.

Persistent, Bioaccumulative and Toxic

- Highly toxic, long lasting substances.
- Can multiply up the food chain.
- Potential for reproductive, developmental, mutagenic, carcinogenic or neurotoxic effects.

Persistent, Bioaccumulative and Toxic

- Aldrin/dieldrin
- Alkyl-lead
- Benzo(a)pyrene
- Chlordane
- DDT, DDP, DDE
- Dioxins and furans
- Hexachlorobenzene
- Mercury and its compounds
- Mirex
- Octachlorostyrene
- PCBs
- Toxaphene

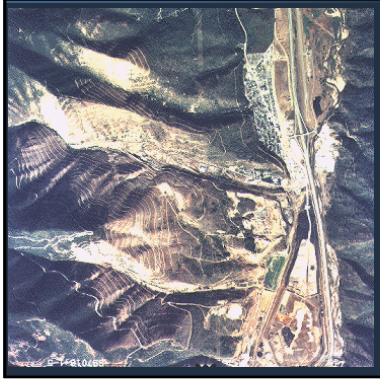
Bunker Hill Superfund Site

Bunker Hill

- Former mining and smelting complex located in Kellogg, Idaho in the Silver Valley in northern Idaho.
- 21 square miles in size.
- Affects approximately 5,000 people.
- One of the largest and most complex abandoned hazardous waste sites in the nation.

US ACE

Bunker Hill Site



Bunker Hill, 2

- Mining and smelting operations started around 1900.
- Lead, zinc, cadmium, silver, gold.
- Primary contaminants include lead, arsenic, cadmium, and zinc.
- Contamination sources include mine tailings, past air emissions, smelter complex materials and residuals, acid mine drainage.

US ACE

Bunker Hill, 3

- A 1973 fire at the smelter damaged the air emissions controls and dramatically increased the lead emissions from the smelter until repairs were completed.
- The smelter and other Bunker Hill company activities ceased operation in late 1981.

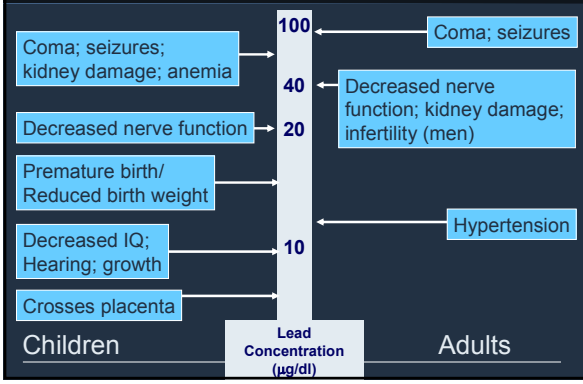
US ACE

Lead Toxicity

- In 1974, 98 percent of 1- to 9-year-old children living within 1 mile of the smelter had blood lead levels in excess of 40 μg/dl.

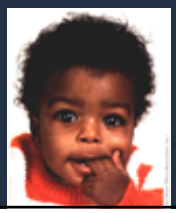
"lead makes the mind give way"
–Greek physician, 200 B.C.

Lead Toxicity



House Dust: Primary Exposure Pathway

- Children.
  - More frequent hand-to-mouth activity.
  - Ingest 200 mg soil and dust/day.
  - Significant in explaining blood lead levels.



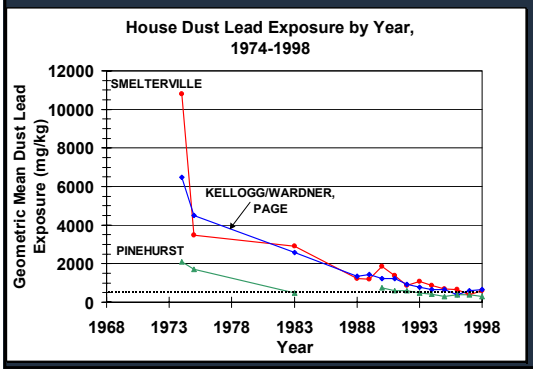
Bunker Hill Superfund Site

	1974 Lead Levels	Current Standards
Children's Blood (μg/dl)	70	10
Ambient Air (μg/m^3)	17	1.5
Yard Soil (mg/kg)	7400	500-1000
House Dust (mg/kg)	12,000	500-1000

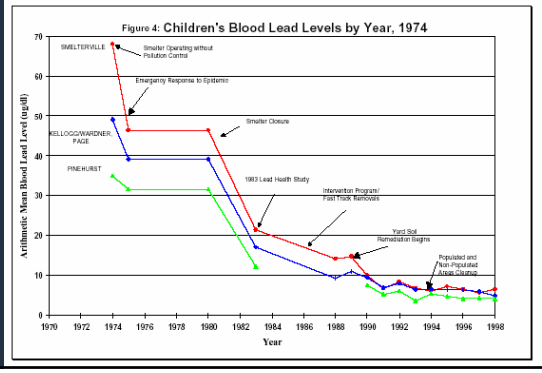
Bunker Hill Superfund Site

- Blood remedial objectives.
  - < 5% of children ≥ 10 μg/dl
  - < 1% of children ≥ 15 μg/dl
- Soil and dust remedial objectives.
  - Mean house dust lead levels < 500 mg/kg
  - Mean yard soil lead levels < 350 mg/kg

House Dust Lead Exposure



Bunker Hill Children's Blood Pb Levels



Case Presentation

- Jerry Cobb, Idaho Panhandle Health District

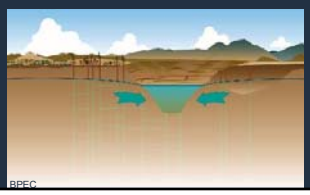
Berkeley Pit

- Inactive open pit copper mine in Butte, Mt.
- Flooded with ~30 billion gallons of AMD.
- Largest US highly contaminated water body.

Berkeley Pit, 2

- An open pit copper mine operated from 1955 to 1982.
- When the Pit closed in 1982, the owners shut down the pumps which had been preventing the pit and the adjacent mine shafts from filling with water.

Gunthner



BPEC

Berkeley Pit, 3

- From 1982 until April of 1996, 6 million gallons of water entered the pit every day.
- Presently, surface water has been diverted and the water level is now rising at a level of 3 million gallons per day
- The ongoing concern is the eventual (2015) rise of the pit water to the local water table level.

Gunthner

Berkeley Pit, 4

- The water in the Berkeley Pit is known to be toxic to waterfowl.
- In November of 1995, 342 snow geese who stopped overnight during their migration were killed by the water.

Berkeley Pit, 5

- The rocks forming the walls of the Berkeley Pit and interconnected mine workings are highly mineralized with sulfide-based minerals.
- Naturally occurring geochemical reactions involving the oxidation, leaching, and dissolution of these sulfide minerals have caused the water to be highly contaminated by heavy metals, acid, and sulfate.

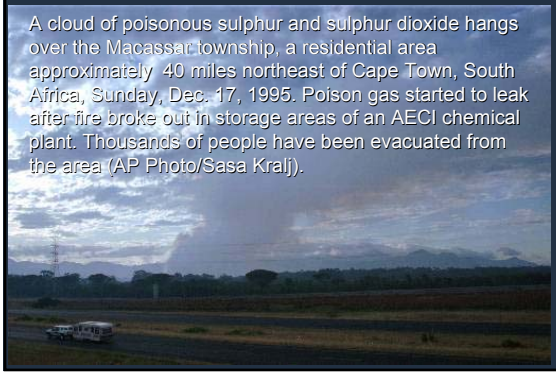
Berkeley Pit Water Chemistry

Aluminum	260 mg/L
Copper	172 mg/L
Zinc	550 mg/L
Sulfate	7,600 mg/L
Total dissolved solids	13,040 mg/L
Eh	405 mV
pH	2.85

Case Presentation

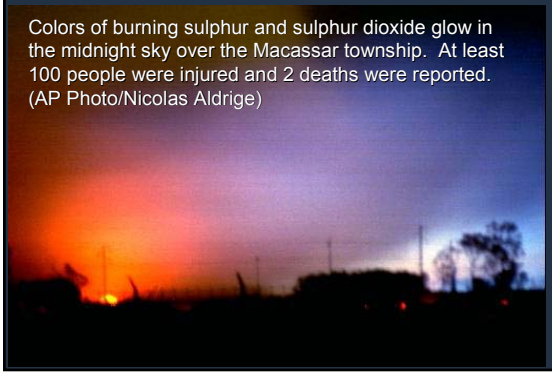
- Carl Lannis, Butte/Silverbow, MT community member and former Berkeley Pit mine worker.

AECI Fire, Cape Town-SA



A cloud of poisonous sulphur and sulphur dioxide hangs over the Macassar township, a residential area approximately 40 miles northeast of Cape Town, South Africa, Sunday, Dec. 17, 1995. Poison gas started to leak after fire broke out in storage areas of an AECI chemical plant. Thousands of people have been evacuated from the area (AP Photo/Sasa Kralj).

AECI Fire, Cape Town-SA, 2



Colors of burning sulphur and sulphur dioxide glow in the midnight sky over the Macassar township. At least 100 people were injured and 2 deaths were reported. (AP Photo/Nicolas Aldrige)

AECI Fire, Cape Town-SA, 3

- A large industrial pile of elemental sulfur burns, causing production of sulfur dioxide.
- Contact with water produces sulfuric acid.
  - Respiratory membranes, environmental water.
- Large tract of land and shallow aquifer contaminated with S, sulfate, low pH.
- Site management complicated by the nearby presence of explosives contaminated lands.

Case Presentation

- Prof. Martin Fey, University of Cape Town; University of Stellenbosch.