Anthropogenic Geochemistry – Outline

(1) Local – Regional – Global scale emissions

(2) Types of emissions:

- solid waste
- liquid waste
- acid mine drainage
- volatile emissions
- fine particle emissions to the atmosphere
- “natural pollution”, e.g. arsenic in Bangladesh well waters.

(3) Regional and global scale anthropogenic emissions. some elements of particular interest:

- Lead (Pb): globally, the most anthropogenically enhanced element; emitted to the atmosphere by high temperature industrial processes (smelting, coal combustion, etc.) and by automobiles using leaded gasoline.

- Mercury (Hg): one of the most volatile toxic elements; emitted from high temperature industrial activities (similar to lead); exists in toxic organic mercury compounds. Also used in industrial processing and gold mining, released into natural waters. Mercury is high in fish in lakes located downwind of coal combustion regions. It bioaccumulates in predatory fish such as salmon and swordfish.

"Minamata Bay Disease" from industrial mercury release into a fished harbor is one of the most infamous pollution episodes. Minamata is a small town in Japan facing an ocean embayment. From 1932 to 1968, a company dumped approximately 27 tons of mercury compounds into the bay. Thousands of people who ate fish from the bay developed symptoms of methyl mercury poisoning.

- Cadmium (Cd): also volatile and used in industrial activities (Ni-Cd batteries; Cd-plated metals, etc.). "Itai-Itai" disease is perhaps the second most infamous pollution episodes. In the early years of the 20th century, villagers along the Jinzu River basin in Japan developed a painful disease that was dubbed "Itai-Itai" ("it hurts, it hurts"). Research didn't begin until the 1950s when and in May 1968 it was determined that it was due to chronic cadmium poisoning caused by commercial mining operations. It impairs kidney function and leads to calcium deficiency and brittle bones.

- Nitrogen – as NO_3^-, usually from fertilizers. Too much nitrate in waters damages infant's brain development. It also can lead to "eutrophication" of coastal seawaters (e.g. Gulf of Mexico "dead zone").
- Phosphorus – as PO_4^{3-} - usually from fertilizers now although also from detergents in the past. Can lead to "eutrophication" of lakes and rivers.

Acid Mine Drainage

Pyrite oxidation:

$$2\ FeS_2 + {}^{15}/_2\ O_2 + 4\ H_2O \dashrightarrow Fe_2O_3 + 4\ SO_4^{=} + 8\ H^+$$

Sulfide ores are common sources of Fe, Zn, Cd, and H_2SO_4. Coal deposits often contain sulfide minerals, so acid mine drainage commonly affects both sulfide ore and coal tailings (the waste leftover after mining).

Acidic waters are in themselves damaging to organisms (e.g. fish do not live in low-pH waters, perhaps because of enhanced aluminum solubility at low pH). The low pH can also mobilize toxic trace metals such as Cd, As, and Pb.

Example: Rio Tinto mining complex (Spain): drains into pH ~ 2 rivers that enter the Atlantic coastal waters of southern Spain having more than a millionfold more Zn than normal ocean surface waters, along with other metals such as Pb, Cd, and As. This effluent can be traced into the Mediterranean Sea.