BIOL 695

ELEMENTS WITH MORE TOXIC EFFECTS

Chapter 20
MENGEL et al, 5th Ed

IODINE

- **Not shown to be essential, stimulating effects reported for some crops at 0.1 μg g^{-1}**
- **Toxic effects at 0.5 - 1.0 μg g^{-1} in soil/nutrient solution**
- **No toxicity of I reported in agric soils**
- **Normal levels are 0 - 0.5 μg I g^{-1} dry matter**
- **High levels of Cl^{-1} can reduce toxic effects**

BROMINE

- Br^{-1} is not as toxic as I^{-1}
- Br^{-1} toxicity does not naturally occur in agric soils
- Use of Br containing soil fumigants (CH_3Br) has caused toxic effects on some sensitive plants:
  - carnations
  - chrysanthemums
  - potato
  - spinach
- Some plants insensitive to Br^{-1} toxicity:
  - carrot, tobacco, tomato
- Br^{-1} can partially substitute for Cl^{-1}

FLUORINE

- F generally occurs in plants in range: 2-20 μg/g
- Commercial tea may contain up to 400 μg/g
  - must ingest very large amounts for toxicity
- F affects respiration (respiratory enzymes)
- F toxicity found in industrial regions where HF is generated
  - have been cases of animal & plant toxicity
- Toxicity symptoms include necrosis and/or interveinal chlorosis
- Soluble F in soils related to pH, Ca & P content
  - CaF_2, $Al_2(SiF_6)_3$, hydroxyapatite

ALUMINUM

- Major element in Earth's crust (8.1 % Al;
  >15 % Al_2O_3 (can you calculate exact % Al_2O_3?)
- Common soil form is hydroxide; ion is Al^{+3}
- Al^{+3} undergoes hydrolysis which increases H^+

  $Al^{+3} + H_2O$ D $Al(OH)^{+2} + H^+$
  $Al(OH)^{+2} + H_2O$ D $Al(OH)^{2+} + H^+$
  $Al(OH)^{2+} + H_2O$ D $Al(OH)_3^{\circ} + H^+$
- Considered as part of soil acidity (with H+)
- Al ions may be toxic to plants (roots) in acid soils
  - causes loss of apical dominance

ALUMINUM, continued

- Al impacts regulatory mechanisms in root tips, probably various enzymatic processes
- Al inhibits formation of microtubes, actin & microfilaments in root tips
- Plant species/cultivars vary significantly in tolerance of excess Al
- Some plants have mechanism for inhibiting Al uptake, others secrete chelates to detoxify
- General ecological damage from Al released by acid precipitation - plants, aquatic spp

NICKEL

- Ni closely related to Co in chem & physiol props
- Can replace other metals from physiologically important centers
- High Ni conc's are toxic to plants
  - sometimes resembles Fe deficiency
  - acute toxicity causes chlorosis
- Most soils contain low levels of Ni (<100 μg/g)
- Long term applications of biosolids may inc Ni

NICKEL, continued

- Soils derived from ultrabasic rocks, esp serpentine, may contain 20-40X as much Ni & toxicity problems are common
- Distinctive plants grow on serpentine soils
- Ni toxicity often alleviated by liming - dec avail of Ni and inc exch Ca & Mg
- Ni is essential for animals
- Strong implications for essentiality in plants but still lacking definitive results

CHROMIUM

- Cr is essential for animals (?)
- No evidence of an essential role in plants
- Conc in most soils from 15 - 100 μg/g
- Incidents of Cr toxicity are uncommon
- Serpentine soils nay contain several % Cr
- Most soil Cr is very insoluble
- Most present in anionic forms
- Hexavalent Cr (Cr^{+6}) is toxic; Cr^{+3} is not

SELENIUM

- Se resembles S in chemical properties
- Occurs as selenide (Se^{-2}), selenite (SeO_3^{-2}) & selenate (SeO_4^{-2})
- Competetive uptake between selenate and sulfate
- Present in low conc in soils; low availability in acid & neutral soils
- May have Se toxicity problems in some alkaline soils
- Some plants can accumulate high conc of Se; not essential for plants

SELENIUM, continued

- Se toxicity relates to incorporation of Se-cysteine into proteins
- Se is essential for animals but required in low conc’ns
- Deficiency causes muscular dystrophy in animals
- Human deficiencies in areas of China & Europe
- Range of 0.1-1μg/g in food suggested
- Conc’s of > 5 μg/g in diet could cause toxocity

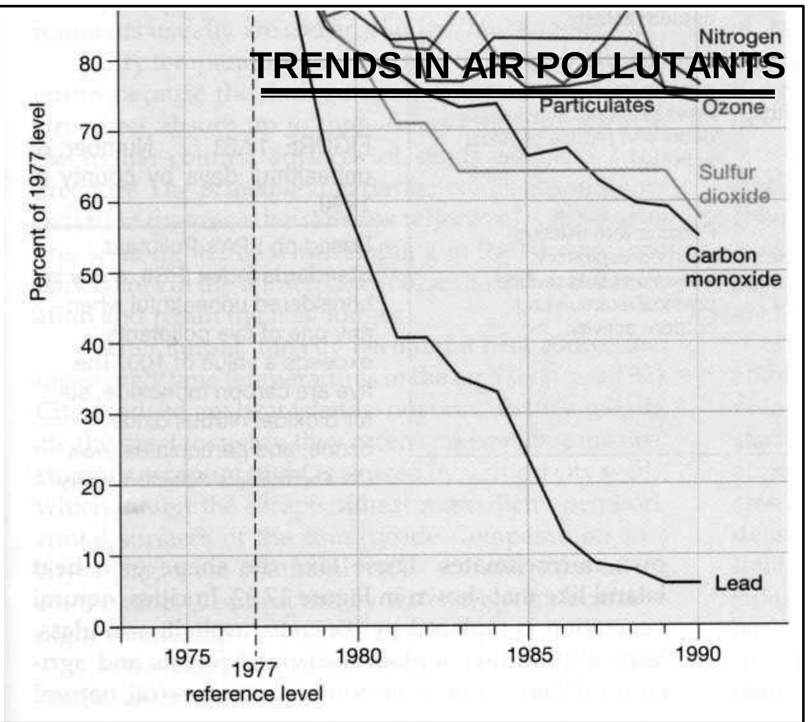
LEAD

- Pb is a major chemical pollutant of the environment
- Major sources are leaded gasoline and paints
- Little atmospheric Pb in USA and other countries where leaded gasoline is banned
- Pb remains in soils long after deposition
- ~50% of Pb in exhaust deposited w/in 100 m
- Pb is toxic because it mimics Ca and inhibits many enzyme systems
- Toxicity causes brain damage, esp in young

SUCCESS STORY!

LEAD LEVELS IN THE ATMOS. SHOW GREAT DECLINE

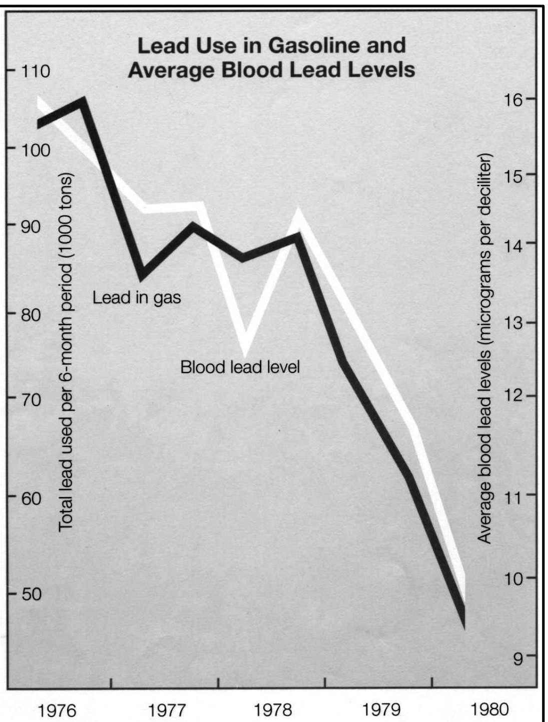
TRENDS IN AIR POLLUTANTS



AVERAGE BLOOD Pb LEVELS

AVERAGE BLOOD LEVELS OF Pb HAVE CONTINUED TO DECLINE, BUT MANY CHILDREN STILL HAVE NOTABLY ELEVATED LEVELS.

THERE ARE MANY SOURCES OF Pb IN THE ENVIRONMENT OTHER THAN GASOLINE.



LEAD, continued

- Pb content of most soils 2 - 200 μg/g
- Few examples of Pb toxicity to plants; those that absorb Pb usually ppt Pb in roots
- Organic forms of Pb are more mobile and available than inorganic forms
- Many human toxicity problems in older houses from leaded paints
  - children ingesting paint chips inside & outside
  - house dust and yard soil high in Pb

CADMIUM

- Cd is chemically similar to Zn
  - mimics behavior of Zn in uptake & metabolic functions
  - Cd is toxic to plants & animals
- Cd is cumulative poison in animals; accumulates in kidneys, liver spleen
- Soil BG concentrations generally < 1μg Cd/g
- More available at lower soil pHs
- Cd is easily translocated to plant tops
- Cereal grain conc's may be relatively high

CADMIUM, continued

- Main source of Cd pollution is metal smelters, especially Zn smelters
- Other sources of Cd includes biosolids & phosphate fertilizers
- Potential for phytoremediation of Cd contaminated soils
- Most hyperaccumulating plants have very low biomass
- Hazard with Cd (& Pb) is that plants rarely act as indicator of levels toxic to animals