OVERVIEW OF CHEMISTRY, SOLUBILITY, pH, REDOX, SALINITY
(read 32-37; 231-232 in Dodson)

INTRODUCTION TO CHEMISTRY

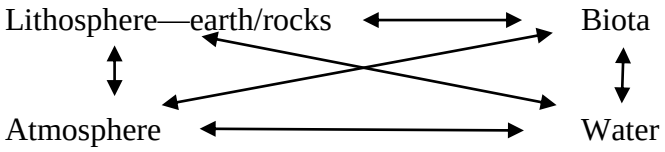
- Water is a good solvent of various polar chemicals
    - Examples of soluble chemicals include:
        - Acids, bases, salts, sugars, alcohols. . .
    - Freshwater studies generally focus on:
        - Carbon
        - Oxygen
        - Nitrogen
        - Phosphorus

- Remember that there is a strong relationship between water temperature and solubility of gases.
    - Higher temperatures → lower dissolved concentrations.
    - Lower temperature→higher dissolved concentrations.

- Chemicals can be quantified as:
        - Mass (gm)
        - Mass concentrations (gm/L)
        - Molar concentrations (M/L)
        - Molar equivalents

- Chemicals cycle between compartments within freshwaters. This cycling can occur very rapidly (phytoplankton nutrient uptake) or very slowly (rock erosion).
    - Compartments can be:
        - different forms of the chemical

        - different reservoirs:



- *Biogeochemistry*—large-scale cycling of chemicals, including living organisms. Term developed by Hutchinson (1944)

- *Loading*—total amount of chemical added per unit time.

- Human activities have globally altered chemical cycling. For example, increased rates of erosion generally increase loading of nutrients from the lithosphere to freshwaters.

BIOE 155, Fall 2010

DISSOCIATION AND PH

- The water molecule often dissociates into two ions
  $H_20 \rightleftharpoons H^+ + OH^-$
  - Hydrogen ion (H^+)
  - Hydroxyl ion (OH^-)
  - Two ions are in chemical equilibrium

- pH
  - A quantification of the concentration of hydrogen ions
  - pH = -log[H+]
  - Acid (pH < 7)
  - Alkaline (pH > 7) – more "basic"
  - Neutral (pH ~ 7)- but this is temperature dependent

- *Buffering*—ability of water to absorb a lot of acid without changing pH

- Acid rain or acid deposition
  - Wet and dry deposition with excess H^+
  - H+ generally associated with sulfate and nitrate ions
  - SOx production—the most important source of acid for acid deposition
    - Sources
      - Fossil fuel burning (70 Tg per year)
      - Wildfires (2.8 Tg per year)
      - Volcanoes (7-8 Tg per year)
    - Worst in NE US (and also industrial Europe and China)
  - NOx production—increasing importance as source of acid as regulation of sulfur emissions increase.
    - Sources
      - Auto exhaust (emissions increasingly regulated)
      - Coal plants
      - Lightening

- Factors controlling acidity of freshwaters
  - Hydrogen ion loading
  - Acid Neutralizing Capacity (ANC)—ability of water to absorb a lot of acid without pH. In other words, the water is well-buffered.
    - Calcium carbonate is the dominant source of ANC
    - Granitic soils—little/no buffering capacity
    - Limestone (lots o' calcium carbonate)—high buffering capacity.
  - Biological alkalinity generation
    - Alkalinity production can buffer lakes

- Acidity of water controls which organisms can thrive.
  - D.W. Schindler (1985) did a whole-lake experiment demonstrating the dramatic impacts of acidity on lake communities.

pH of Rainfall, 1993

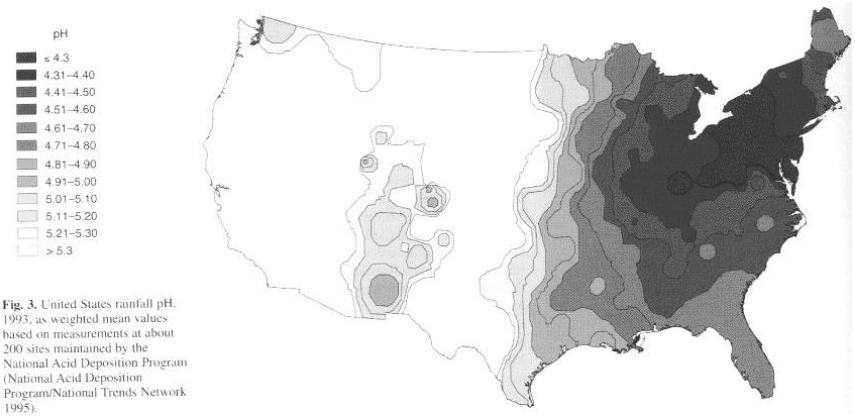


Fig. 3. United States rainfall pH. 1993, as weighted mean values based on measurements at about 200 sites maintained by the National Acid Deposition Program (National Acid Deposition Program/National Trends Network 1995).

REDOX POTENTIAL

- Different chemical reactions can take place in oxygenated water vs. anoxic water (water w/o oxygen).

- Redox—quantifies the potential for reduction-oxidation reactions

    - Oxidation reactions—increase positive charge; loss of electrons; few available free electrons
        - Occurs in the presence of oxygenated water.

    e.g., Fe++ (ferrous iron—soluble) → Fe+++ (ferric iron—insoluble)

    - Reduction reactions—become more negatively charged

SALINITY AND OTHER DISSOLVED CHEMICALS IN WATER

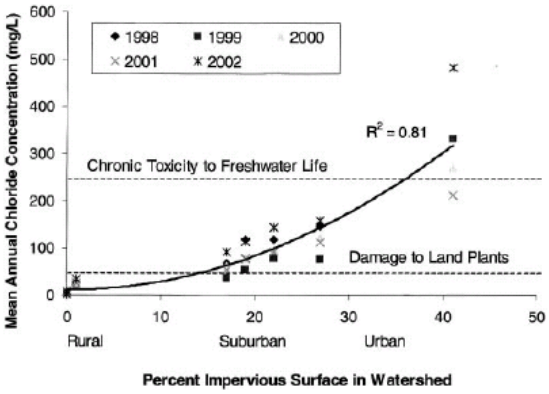
- Salinity—total concentration (mg/L) of ions dissolved in water.

- Common ions (salt) include:
    - Calcium (Ca^+)
    - Magnesium (Mg^+)
    - Bicarbonate (HCO_3^-)
    - Sodium (Na^+)

- Potassium (K+)
- Chloride (Cl-)

- Salinity is quantified as water conductivity, given that ions concentration controls conductance of electricity.

- Ion concentrations depend on:
  - Water flow
  - Evaporation
  - Atmospheric input
  - Lithosphere (rocks)
  - Biological activity
    - Human activities—paper by Kauschal et al. 2005 (PNAS) showed that salt from roads in NE US is causing dramatic increases in concentrations of chloride. Graph above is from this paper.



- Total Dissolved Solids—concentration of all dissolved ions and non-ions in water, including organic compounds.

- Water hardness
  - Hard—high concentrations of dissolved calcium and magnesium carbonates.
  - Soft—low concentrations of dissolved calcium and magnesium carbonates.