

Class #19

NUTRIENT ELEMENTS

ORGANIC SUBSTANCES

CONTROLS ON MAJOR DISSOLVED CONSTITUENTS' CONCENTRATIONS

"Steady state"

Input processes

Removal processes

NUTRIENT ELEMENTS

Photosynthesis requires ~ 30 nutrient elements

$\text{CO}_2 + \text{H}_2\text{O} + \text{nutrients} \rightarrow \text{"Organic Matter"} + \text{O}_2$

A FEW species in sea water are **"critical" or "limiting" nutrients**

i.e., concentration is much less than amt. that could be used by algae if they were not limited

So... algae grow until they run out of one of these scarce nutrients:

- 1) P -- present as dissolved PO_4
- 2) N – the dissolved NO_3 form (plants can't use dissolved N_2)
- 3) SiO_2 diatoms won't grow unless it is available
- 4) Fe -- Iron is not very soluble, and its scarcity probably limits growth in many places (new discovery)

And... The amount of algae and other food producers for the oceans is controlled by the availability of these limiting nutrients.

Nutrients are non-conservative – concentrations vary strongly, controlled by life processes

Variation with depth:

Surface waters are usually nutrient-depleted:

Photosynth. extracts nutrients, locks them up in organic matter

Deeper waters: Re returns nutrients as organic matter is decomposed

Very important: Upwelling of deep water returns nutrients to surface waters where they are used again -- a cyclic process.

ORGANIC SUBSTANCES

Partially decomposed molecules or fragments from living organisms

Present in small amounts (< a few mg/kg)

- 2) dissolved
- 2) small particles

Ultimate fate:

Recycled – broken down for respiration/ food OR...

Buried in sediments

WHAT CONTROLS CONCENTRATIONS OF MAJOR DISSOLVED SPECIES (like Na^+ , Mg^{2+} , Cl^- , etc.)?

- Evidence from rocks and fossils implies constant salinity of sea water
 - for at least 1.5 b.y. (probably longer).
- But dissolved species continually enter the oceans in river water
- Implication: sea-water salts are in a "steady state"....
 - Input balanced by output.

Inputs and outputs go on continuously.

"Steady state" in this context means no concentration change over time

Input Processes

- 1) Volcanic eruptions
 - Release of gases containing Cl, S, and C
 - Deposition on land and oceans as acids (and anions)
- 2) Hydrothermal alteration of young ocean crust
 - Water heated in hot young crust
 - Releases Ca, K, and metals (Fe, Mn, Cu, Zn, etc.)
- 3) Weathering of continental rocks -- the most important
 - Acidic waters + Rocks -----> New minerals + Ions
 - Acids: (HCl, S-gases, H_2CO_3 , organic acids)
 - Cations released: (Na, K, Ca, Mg)
 - Anions Released: (Cl, HCO_3^- , SO_4^{2-})

Output (Removal) Processes

- 1) Biological processes
 - Formation + burial of CaCO_3 + SiO_2 skeletons
 - Adsorption of trace elements on organic matter
- 2) Precipitation of "evaporite" minerals
 - NaCl (halite) and $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ (gypsum)
 - Removes Na, Cl, SO_4^{2-}
- 3) Chem. Reactions: Seawater with ocean crust or sediments
 - Adsorption of ions on fine clay particles
 - Hydrothermal reactions- alteration of new oceanic crust
 - Removes Mg and SO_4 to form new minerals

Input and output process are connected globally through plate tectonic processes:

- 1) Formation of new oceanic crust
 - Hydrothermal reactions
- 2) Collision and subduction
 - Ocean sediments and water --> the mantle
 - Some of this released in volcanoes
- 3) Formation and uplift of new continental crust
 - Weathering and erosion of continental crust

A continuous, long-term cycle of matter through the lithosphere, atmosphere, and oceans.