Dredged Material and Acid Sulfate Soils

Biogeochemistry of Upland Placement of Dredged Sediments on Delta Peatland Soils

Sediment pH and Attenuation of Arsenic, Copper, TDS/salinity, Nitrate Nitrogen, and Dissolved Organic Carbon (DOC)

Robert R. Northup, Ph.D.

rnorthup@nature.berkeley.edu

Dredged Material & Acid Generation

1. Sulfur Oxidation (e.g. Pyrite):

$FeS_2 + O_2 = H_2SO_4$

pyritic sulfur + oxygen = sulfuric acid

2. Ammonia Oxidation (Nitrification):

$NH_4^+ + O_2 = HNO_3$

ammonium + oxygen = nitric acid

Perception Problem: Acid = Bad

Concepts about acid dredged material (pH 4-6) are biased by prejudices based on acid mine materials (pH 1-3)

Fact: pH 4-6 is ideal for attenuation of contaminants

Fiction: dredged material pH is a problem to be corrected

Maximum Contaminant Attenuation at pH 4-6

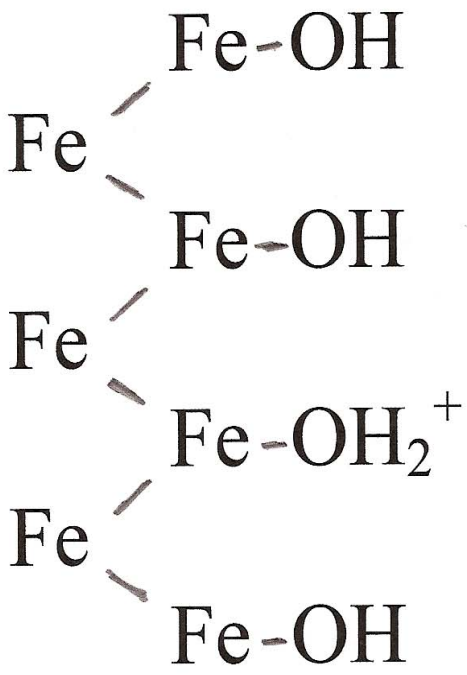
Oxidized dredged materials develop acidic pH ranging from 4-6. This moderately acidic condition creates the maximum attenuation capacity for arsenic, copper (and other heavy metals), TDS/salinity, nitrate nitrogen, and dissolved organic carbon (DOC). Highest quality groundwater occurs beneath pH 4-6 dredged materials.

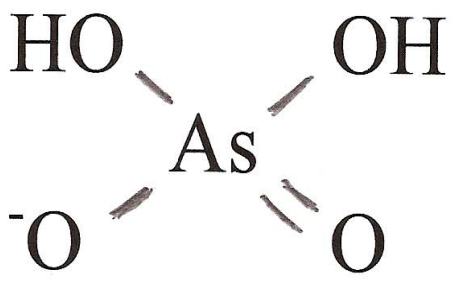
Arsenic Attenuation at pH 4-6

Anion exchange capacity for adsorption of arsenic oxyanions on to (hydr)oxides of iron, aluminum, and manganese is favored by lower pH

Solubility of dissolved organic carbon (DOC) is reduced by lower pH - fewer organic anions to compete for anion exchange sites, less organic carbon for reductive dissolution of ferric iron.

Adsorption of arsenic to (hydr)oxides of iron, aluminum, or manganese

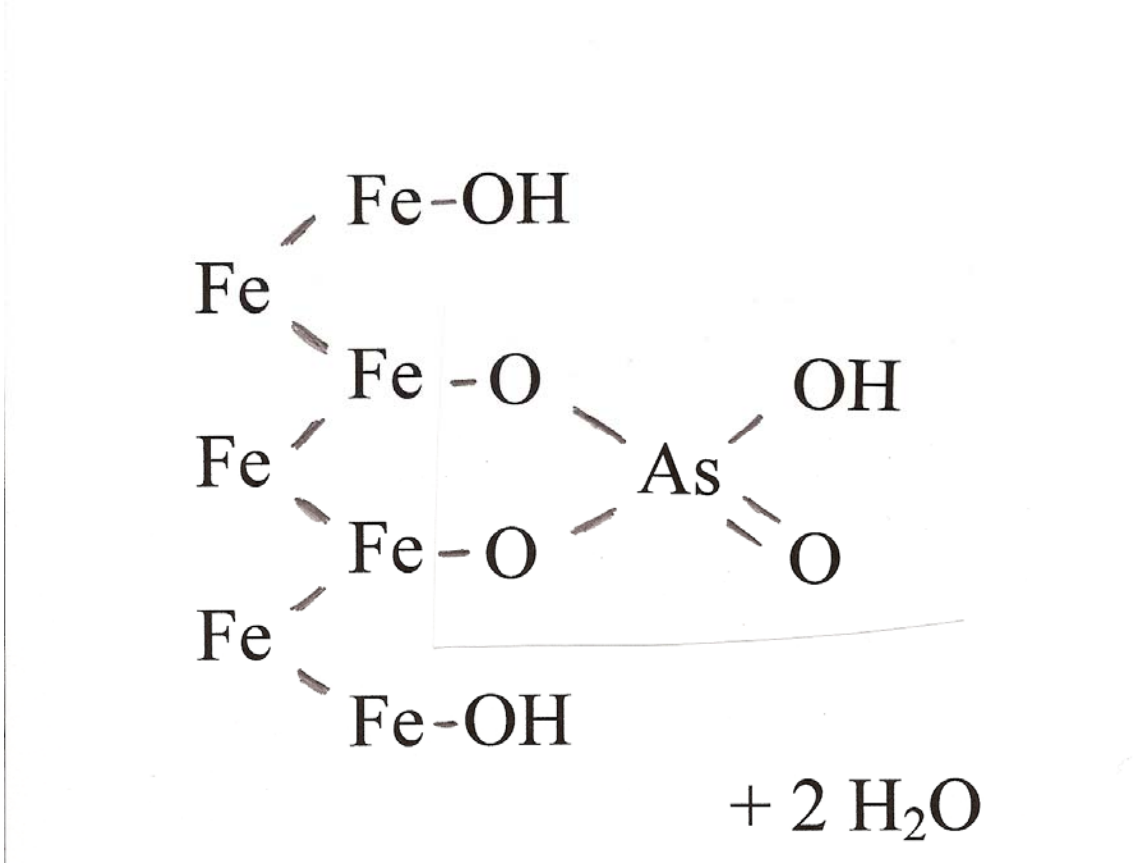




Arsenate
Arsenic(V)

Arsenic is attenuated, strongly bound to (hydr)oxide surface

favored by lower pH



Release of Bound Arsenic into Pore Water or Ground Water

Under low oxygen conditions, ferric iron can be used by microorganisms to take advantage of available organic carbon

Reductive dissolution of ferric iron by organic carbon releases bound arsenic into solution

Copper Attenuation at pH 4-6

Copper and other heavy metals are often complexed or chelated by organic acids

Most dissolved copper and other heavy metals in soil water is complexed by organic acids

The solubility and metal-complexing power of organic acids is reduced by low pH

Nitrogen Attenuation at pH 4-6

Dredged materials and peatland soils contain high concentrations of ammonia nitrogen

Oxidation of ammonia to nitrate (nitrification) causes nitrogen leaching to ground water and nutrient loading to surface water

Nitrification is strongly inhibited at pH < 6

Retention and Loss of Ammonia versus Nitrate Nitrogen

Ammonia in dredged materials and peatland soils occurs as ammonium ion, a positively charged cation strongly held to CEC sites.

Nitrate is a negatively charged anion that has very little affinity for adsorption to surfaces, is easily lost to leaching, and under low oxygen conditions is lost to denitrification.

Attenuation of DOC at pH 4-6

Cultivated peatland soils release *lots* of dissolved organic carbon (DOC)

DOC can cause release of arsenic, copper, and other heavy metals into groundwater

Solubility of DOC is lower at pH 4-6

TDS/salinity Attenuation

Drained peatland soils produce heavy annual loads of TDS and salinity as they oxidize

Placement of dredged materials on peatland soils acts as a “cap” to limit their oxidation

Significant improvement of underlying groundwater quality (TDS/salinity) occurs

Dredged material pH – HIGH POINTS

Moderately acidic condition (pH 4-6) of oxidized dredged materials is not like acid mine materials, should not be presumed to be a “problem”

Maximum attenuation of arsenic, copper, nitrogen, and organic carbon is favored by pH 4-6

Adverse impacts to water quality when dredge material pH is forced higher (pH > 6) by addition of lime

Upland Placement – HIGH POINTS

Drained peatland soils are large source of TDS/salinity and dissolved organic carbon

Dredged materials on peat soils acts as “cap” to limit oxidation and release of DOC, etc.

Significant improvement to ground water occurs as result of dredged material placement