How does salt water intrusion affect coupled iron and sulfur cycling in a coastal freshwater wetland?

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Climate change, sulfur and iron: implications for coastal freshwater wetlands

- Salt water is a large source of sulfate
- Microbes reduce sulfate to sulfide
  - Toxic to many organisms
  - With salt, organizes coastal communities
- Reduced iron binds with sulfide

$$\text{SO}_4^{2-} \xrightarrow{\text{Anaerobic Sulfate-Reducing Bacteria}} \text{H}_2\text{S} \xrightarrow{\text{Fe minerals}} \text{FeS}$$
How do sulfur inputs affect FeS complexing across the salt to fresh water gradient?
• Seasonal intrusion depending on groundwater levels
• 440 ha
• 10 sites

Salt water intrusion as a natural sulfur addition
Indicators of Sulfate Reducing Activity

Traditional $^{35}$S

- Radioisotope
- Uses soil core (5cm diameter)
- Glovebag
- Few samples (expensive and time consuming)
- Proven method

Indicator of Reduction in Soils Method (IRIS, Rabenhorst et al 2010)

- Increased SA (20x15cm)
- Efficient, inexpensive
- Deploy easily
- See biogeochemistry in action
- New method
Predictions

Organic material → Sulfate Reducing Bacteria → H$_2$S → FeS

SO$_4^{2-}$ → Fe minerals

Downstream
Five plates at ten sites
24 hour incubation
June and September

To test this hypothesis:

Hurricane Irene was downgraded early Saturday to a Category 1 storm, but forecasters warned it's still a major threat. Ferocious winds and torrential rainfall lashed coastal North
June sulfate reduction rate ($^{35}\text{S}$) along the saline to fresh gradient

Salt exposure

$p = 0.778$
Salt Exposure
p = 0.0434
Salt exposure
$p \leq 0.0001$
September depth gradient

Salt and Wet

Fresh and Wet

% Cover

% Cover
Analyzing the photos

- Percent cover (abundance of dark areas)
- Intensity of darkness (concentration)
- Why pockets vs bands?
Dextrose and Sulfate

Homogenized Sediment
Future Work

• Improve photography to obtain darkness of compounds and therefore quantitative rates

• Sulfide solution in plastic bag
• Held in glovebox for 24 hours
Use Image J to analyze photos
Convert to greyscale, eliminating greens and blues
Divide photos into 256 shades of grey
Compare greys to standard plates
Obtain % cover of each standard
Obtain mg/L/cm$^2$

Sulfide

1M
100mM
10mM
Meso- and Microcosm Experimental Design

- Water amendments
  - (0, 2.5, 5ppt)
  - Lab and field component
  - 3 treatments, 2 sites, 3 reps (18 total)
- Compare plates to $^{35}\text{S}$

Diagram:
- Salt
- Int
- Fresh

Diagram:
- Organic material
- $\text{SO}_4^{2-}$
- Sulfate Reducing Bacteria
- $\text{H}_2\text{S}$
- FeS
- Fe minerals
Conclusions

• Sulfate reduction increases with intrusion, and is greater in wetter sites
• Sea level rise and periodic salt water intrusion will increase coastal sulfate reduction
  – Impacts of sulfate reduction are heavily mediated by iron availability
• How much exposure is necessary to switch to sulfidic conditions?
Acknowledgements
Indicator of Reduction in Soils Method
(IRIS, Rabenhorst et al. 2010)

• Iron oxide paint on PVC
• Inserted into sediment for 24 hours
• Fe on plate binds with porewater sulfide
  – Black complexes that fade with exposure to O$_2$

• See biogeochemistry in action
  – Visual reaction with sulfide and a way to quantify sulfide concentrations