RAPID FORMATION OF POTENTIAL ACID SULFIDE SOILS FOLLOWING WETLAND RESTORATION

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Project Partners

US Army Corps of Engineers

ERDC

The Nature Conservancy

GreenTrust Alliance

New Jersey DEP

Wetlands Institute

LSU

EMRRP

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Need for wetland restoration:
Coastal wetlands degradation
Urban development, sea level rise, salt H2O intrusion, lack of sediment inputs
Degradation linked to marsh drowning; fragmentation; subsidence; sea level rise
Dredged materials $\rightarrow$ potential sediment source
Thin layer placement restoration implemented
Little data on biogeochemical effects

Potential formation of FeS/acid sulfate soils?
Iron sulfate soils (FeS)

Naturally occurring in wetlands

Microbial SOM oxidation $\rightarrow$ Anaerobic conditions

$\text{Fe}^{3+} (s) \rightarrow \text{Fe}^{2+} (aq)$

$\text{SO}_4^{2-} (aq) \rightarrow \text{S}^{2-} (aq)$

$\text{Fe}^{2+} (aq) + \text{S}^{2-} \rightarrow \text{FeS}_2 (s)$

Stable under anaerobic conditions

Generate acidity when oxidized

$\text{FeS}_2 (s) + 3.75 \text{O}_2 + 3.5 \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4 (aq) + \text{Fe(OH)}_3 (s)$

Cat clay soils or poison earth soils

Aerobic soil incubation pH $<$4; may reach $<$2
Sediment added for restoration

Black FeS

Marsh soil
Objectives:
1. Investigate potential FeS formation
2. Implications for restoration

Approach
1. Case studies - Reports of black soils forming following restoration activities
2. Laboratory - incubation to investigate FeS formation in simulated restoration context
Case studies - field data

- Document FeS formation
- H2O2
- HCl
- IRIS tubes
Case studies - lab data

16wk aerobic incubation documents soil pH $\rightarrow < 4$

FeS present in BOTH native marsh and restored areas
Incubation experiment
Can we form FeS in the lab?
3 treatments: Drained, flooded, simulated tidal treatments

Sediment added for “restoration”
Marsh soil
Soil morphology

Sediment added for “restoration”

- Black FeS
- Gray depleted matrix
- Marsh soil

4-6 wks
Soil morphology

a) Continuously inundated
   - Dredged material 2.5Y 5/3
   - Depleted matrix 10YR 5/1
   - FeS N 2.5/0
   - Marsh soil 2.5Y 4/2

b) Simulated tidal

Iron sulfide formation (% of the soil profile)
Incubation time (days)
Soil morphology

a) Continuously inundated
   Dredged material 2.5Y 5/3
   Depleted matrix 10YR 5/1
   FeS N 2.5/0
   Marsh soil 2.5Y 4/2

b) Continuously drained

c) Continuously drained
Redox potential

a) Dredged material
- Continuously inundated
- Simulated tidal
- Continuously drained

b) Marsh soil
Symbol indicates period when soil was chemically reduced with respect to S
- Continuously inundated
- Simulated tidal
- Continuously drained
Soil pH - drainage induced acid condition

c) Dredged material

d) Marsh soil
Total soil
Fe lost from marsh soil

Constant in dredged material

Fe$^{2+}$ originating in marsh soil
Total soil S lost from marsh soil

Migrating into dredge material
Dissolved Fe\textsuperscript{2+} concentrated in depleted layer

![Graph showing dissolved Fe\textsuperscript{2+} concentrations in different conditions.](image)
Dissolved $S^{-2}$ throughout profile

c) Continuously inundated

d) Simulated tidal

$S^2-$ in soil solution (mg L$^{-1}$)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Dredged</th>
<th>Depleted Soil layer</th>
<th>FeS</th>
<th>Marsh</th>
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<tbody>
<tr>
<td>c)</td>
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<tr>
<td>d)</td>
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For c) and d), there are similar trends, with the $S^2-$ levels decreasing from Dredged to Marsh, and the height of the bars representing the concentration levels.
Conclusions

Few restoration projects consider biogeochemistry
FeS formed rapidly
Changed soil morphology

FeS >>> Flooded >> Tidal > Drained

$S^{2-}$ and $Fe^{2+}$ migrating in profile
Potential for soil acidification
Implications for restoration
Questions?

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