Quantification of Iron Monosulfides in Arid-Land Wetlands

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BACKGROUND

Iron monosulfide (FeS) concentrations are commonly observed in coastal and estuarine systems, however, few studies have investigated the formation and effects of FeS in freshwater or saline wetland environments.

The identification of FeS is not widely understood throughout the literature, nor acknowledged as a formal hydric soil Field Indicator among the soil science community.

While FeS reduction is an accepted tool for hydric soil identification, Vaughan et al. (2016) suggests SO4 reduction to FeS indicates stronger reducing conditions (Figure 1), and >2% FeS precipitation on IRIS tubes accurately indicates anoxic soil conditions (Figure 2).

Therefore, improved identification methods and understanding of FeS hold the potential to enhance hydric soil identification, wetland delineations, and wetland management efforts.

RESULTS

Soil Morphology:

- Iron oxide paint was synthesized following the procedure outlined by Rabenhorst and Buch (2006), and IRIS tubes were constructed using 1 inch-diameter, 60 cm long PVC tubing.
- In April 2018, IRIS tubes were deployed in sets of 5 at all wetland and upland sites, following removal of the NTCHS (Figure 5).
- After one month in situ, IRIS tubes were extracted, immediately rinsed with water, and photographed before the FeS disappeared due to exposure to O2 and later analyzed for %FeS cover using ImageJ.
- By NTCHS criteria, “2 of 5 tubes having at least 10% removal over 15 cm of tube, top of removal zone considered within 15 cm of surface,” deemed a soil as hydric. Therefore, we propose the same 3 of 5 method for the presence of FeS, for all tubes that display >2% FeS, or greater.

IRIS Tubes:

- Both wetland and upland sites showed evidence of FeS.
- Evidence of FeS was present on the full extent of IRIS tubes ranging 0 to 50 cm.
- All five IRIS tubes at the wetland sites showed evidence of >2% FeS (Figure 7 and Figure 8).
- All five IRIS tubes at upland sites showed evidence below the 2% FeS criteria (0.2-0.6%) (Figure 8).

Soil samples were analyzed for FeS, using the procedure described by Rabenhorst and Buch (2006), and subsequently analyzed for FeS abundance FeS obtained from a playa in Las Vegas National Wildlife Refuge, NM.

We investigated anomalous riparian soils containing previously un-identified FeS, as a Field Indicator in western Nebraska. Our objective was to identify and quantify the presence and abundance of FeS within these soils using: 1) IRIS tubes; and 2) soil morphology.

We expect wetland sites to show stronger morphological evidence of FeS and a greater amount of black color change (FeS) on IRIS tubes, compared to upland sites, due to anoxic conditions present.

Soil Morphology:

- IRIS tubes demonstrated evidence of FeS at both upland and wetland sites (Table 1).
- Most wetland IRIS tubes demonstrated >4% FeS well above the recommended 2% abundance, which suggests these environments possess anaerobic and strongly reducing conditions.
- IRIS tubes result are extremely dependent on season, and the varying position of the groundwater table; therefore, it is best to monitor annually, or during the wet season.

The extent of FeS ranged from 0 to 50 cm across all wetland sites, is an accepted field method for identifying FeS, it can also help determine manganese and organic bodies from FeS (FeS demonstrates color change; manganese and organic bodies bubble upon reaction H2O2).

CONCLUSIONS

Soil Morphology:

- IRIS tubes concentrations are evident in the morphology of the soil, particularly at wetland sites.
- Formal identification methods and protocol need to be established to acknowledge FeS in the soil on a uniform basis.

IRIS Tubes:

- IRIS tubes demonstrated evidence of FeS at upland and wetland sites, with the highest abundance at wetland sites.
- Evidence of FeS on wetland site IRIS tubes was well above previous thresholds proposed to identify a soil as hydric.

Overall, our research suggests that IRIS tubes capture a more accurate scope of the 5 threshold for FeS in the soil, compared to morphological evidence. Our data propose that IRIS tubes could serve as a useful tool for identifying FeS in soil, with broader implications of identifying new hydric soils in sand regions.

Future research will focus on how FeS form and what %FeS best represent hydric soil conditions. Together these data will ultimately be used to propose a new hydric soil Field Indicator to the NTCHS, used to identify problematic soils, such as those in the arid west.

ACKNOWLEDGEMENTS

This research was made possible by the support of a USDA-ARS Graduate Research Grant. Chelsea E. Duball acknowledges Dr. C. Miller, Dr. S. Jacobson, Dr. M. Vepralks, Dr. J. Berkowitz, Dr. T. Rabenhorst, and Dr. M. Burch for their help with field sampling and soil analyses. The authors also wish to thank the USDA-ARS for their continued support.

METHODS

Site Selection:

- In Spring 2018, we selected five wetland study sites in western Nebraska (Figure 1).
- The National Technical Committee for Hydric Soils previously identified these sites as “problematic,” because they did not meet criteria for any hydric soil Field Indicators.
- Sampling plots were established in upland and wetland zones for comparison at each site.

Soil Morphology:

- Updated and upland soils were described following the protocol used by the USDA-ARS Field guide book.
- Soils were described at 3 wetland sites and 2 upland sites.
- Presence of FeS was determined in the field by immediate discernable color change upon addition of H2O2 (Figure 4), via the reaction

FeS + H2O2 → Fe3+ + SO42- + H2O + H2S

3.0

150

60

90

120

150

FeS

Reduced Conditions

Development of Field Indicator After Reduction

Figure 4: Field demonstration of the reduction of FeS in situ. FeS reduced to FeS- upon addition of H2O2 in the soil (Figure 5), where no reaction occurred in a control site (Figure 6).

Indicator of Reduction in Soil (IRIS) Tubes – (A) An iron-oxide coated tube inserted into the soil and used to assess, (B) reducing conditions (white & grey color change), and (C) the presence of iron monosulfides (black color change).