Assessing New Developments in IRIS Technology – A Mesocosm Study

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ABSTRACT

Reducing soil conditions may impact many soil characteristics, including more static properties like soil morphology, as well as more dynamic soil chemical properties and the microbial ecology. Identifying reducing conditions is especially important when evaluating wetland soil systems. Indicator of Reduction in Soils (IRIS) tubes have been approved by the National Technical Committee for Hydric Soils (NTCHS) as a method to identify reducing soil conditions. Recently, a new development in IRIS technology called IRIS films has occurred. IRIS films are strips of vinyl sheeting painted with Fe oxide or Mn oxide paint. The films are intended to simplify field work and to facilitate acquisition and computer analysis of IRIS images . This mesocosm study compares the performance of IRIS films and IRIS tubes and assesses the ability of the new device to effectively document reducing soil conditions.

INTRODUCTION

- The Hydric Soils Technical Standard (HSTS) was developed by the NTCHS to identify soils that satisfy the definition of a hydric soil where Field Indicators are lacking, or to aid in the development or evaluation of Field Indicators
- To this end, numerous methods have been developed to identify reducing conditions, including Indication of Reduction In Soils (IRIS) tubes, which are 60-cm pieces of ½ inch scheduled 40 PVC pipe painted with Fe (or now Mn) oxide paint.
- Under reducing conditions, the oxides in the paint become reduced and are removed from the tube, resulting in a distinctive pattern that can be quantified to identify reducing conditions.
- The limitations of IRIS tubes include the challenges of converting the 3-D device to a 2-D image for analysis, abrasion upon insertion and removal from the soil, and storage.
- IRIS films are 10-mil vinyl sheets painted with Fe or Mn oxide paint. They are cut into 3-inch wide strips, rolled, and inserted into the soil in a polycarbonate delivery tube, which is then removed.
- IRIS films improve upon IRIS tubes because they are two-dimensional and therefore easier to analyze using image analysis software. In addition, they are protected from abrasion by the delivery tube during insertion, and they use less storage space.
- See also Rabenhorst, M.C. 2017. *Oxide-Coated Films – an Improved IRIS Technology*. SSSA, Oct. 25, 2017. Tampa, FL. (347-3).

METHODS

Mesocosm Study

- This study used a total of six 19 L (5 gallon) mesocosms perforated at the bottom, and two soil materials: Elkton A horizon (Mky SIL, 8.4% OC, mesocosms A, B and C) and Downer A horizon (LS, 1.5% OC, mesocosms D, E and F).
- Geotextile fabric was placed at the bottom of each mesocosm to prevent soil loss.
- Each mesocosm contained six replicates of each device (Fe films, Fe tubes, Mn films, Mn tubes) (Fig. 1). Therefore each mesocosm contained 24 devices, with a grand total of 144 IRIS devices.
- Each mesocosm was instrumented with 5-7 Pt electrodes installed at 5 cm and 15 cm depths and 1 reference electrode. Eh measurements were taken daily and pH was measured at the beginning, middle, and end of the study (Fig. 2).
- The 19 L mesocosms were placed into 38 L pails and saturated to the soil surface (Fig. 3). Two replicates of each IRIS device were removed from each bucket after one week, two weeks, and four weeks. As devices were removed, they were replaced by a blank PVC tube to maintain mesocosm volume. After four weeks, all devices had been removed.

Image Analysis

- Once devices were removed, they were scanned on a modified flatbed scanner. The scanned images of each device were then cropped and composited into a single image using Adobe Photoshop (Fig. 4).
- The color images were converted to grayscale, then binary images were created using the threshold tool of ImageJ software, and this image of the paint removal was also quantified using ImageJ.

RESULTS

- Measured Redox potentials dropped below both the Technical Standard line and the ferrihydrite stability line within two or three days (Fig. 5).
- There was significantly more paint removed from Mn devices than from Fe devices at one, two, and four weeks (Figs 6 & 7).
- There was very little Fe paint removed within two weeks, but there was a significant increase in the amount of paint removed from Fe devices, between weeks two and four.
- For Fe devices removed from the Downer soil after four weeks, there was significantly more paint removed from the tubes than the films. This effect was not seen in the Elkton soil (Figs 8 & 9).
- Eighty-five to ninety percent of the Mn paint was removed within the first week (Figs 6, 7, 10 & 11).
- After the first week Mn films showed slightly less paint removed than from the tubes, and there was slightly more paint removed in the Downer soil than the Elkton soil (Figs 10 & 11).

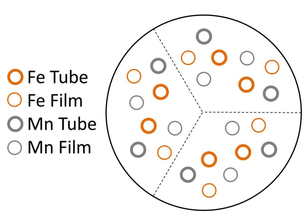

Fig. 1. Diagram of mesocosm layout showing tubes and films coated with Fe and Mn oxides.

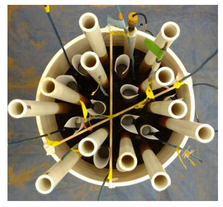

Fig. 2. Completed mesocosm, including reference electrode and Pt electrodes.

Fig. 3. Mesocosms (19 L buckets, perforated in the bottom) were inserted into larger (38 L) containers for saturation.

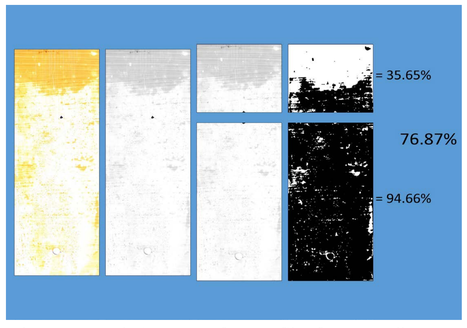

Fig. 4. Example images of an Fe film from an Elkton mesocosm removed after four weeks. The image was analyzed in two sections (ImageJ IA software) to capture paint removal more accurately.

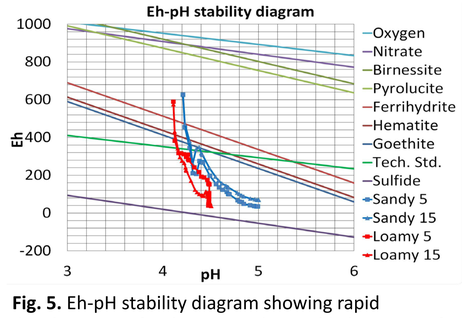

Fig. 5. Eh-pH stability diagram showing rapid development of reducing conditions (daily means of 5-7 electrodes) over the 28 day experiment.

RESULTS cont'd.

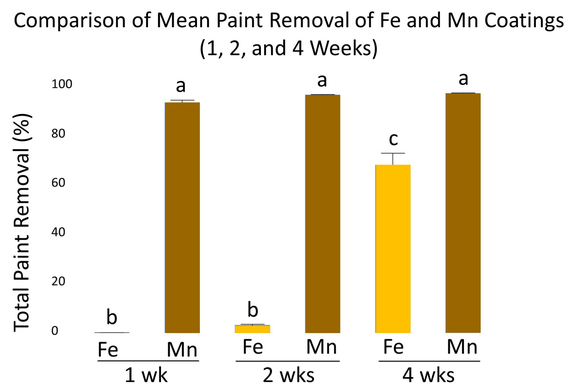

Fig. 6. Comparisons of mean paint removal between Fe and Mn coated devices, after one, two, and four weeks. There is significantly greater paint removal from Mn coatings than Fe coatings at each time point; there is also a clear increase in Fe paint removal between week 2 and 4. In this initial examination, both soils and device types were combined.

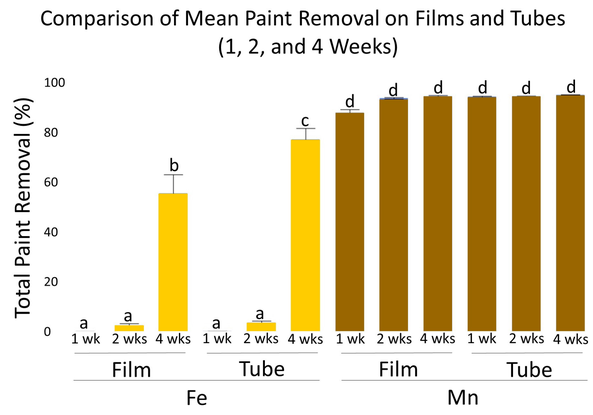

Fig. 7. Comparison of mean paint removal from films and tubes after one, two, and four weeks. These data demonstrate the much greater (and more rapid) removal of Mn over Fe coatings. Data also show that at four weeks, there is significantly more removal from Fe tubes than Fe films (statistical groups "b" and "c"). In this examination, soils were combined.

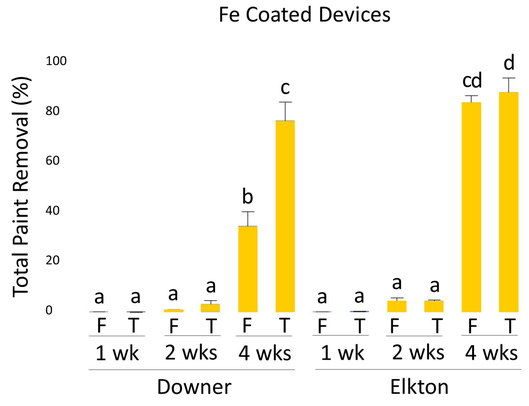

Fig. 8. Quantification of paint removal from Fe-coated devices showing that a significant difference in Fe coating removal between films (F) and tubes (T) only occurs in the Downer soil but not in the Elkton soil and only at week 4.

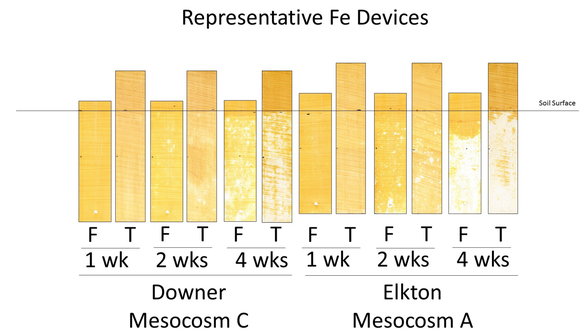

Fig. 9. Images of representative Fe films (F) and tubes (T) showing an increase in the removal of the Fe coating with time (especially between weeks 2 and 4) for both the Downer and Elkton soils. Differences between soils are also evident (especially at week 4).

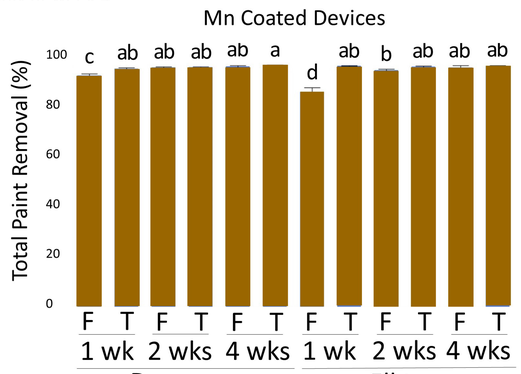

Fig. 10. Quantification of paint removal from Mn devices showing that at week 1 (only) there was slightly less paint removal from films than tubes, and also that Mn films in the Downer soil demonstrated slightly more paint removal than Mn films in the Elkton soil. Overall, Mn paint removal was very rapid (<1 week) and extensive (90%) in both soils.

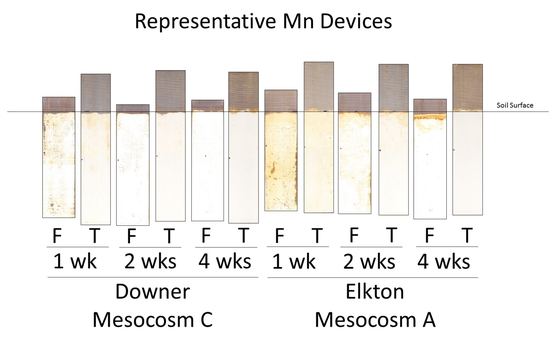

Fig. 11. Images of representative Mn films (F) and tubes (T) showing how quickly (<1 wk) nearly all of the Mn coating has been reduced. Note the light brown coating on some of the Mn devices which is due to early reoxidation and reprecipitation of Fe. Over time, this Fe oxide is rereduced and lost.

CONCLUSIONS AND FUTURE WORK

- Overall, the films appeared to perform comparably to tubes.
- There was significantly more removal of coatings from Mn devices than Fe devices at one and two weeks, which is consistent with predicted mineral stability of the Fe and Mn oxides under reducing conditions.
- Despite strongly reducing conditions, the Fe devices showed little paint removal until week four. Under the warm (22C) lab conditions, most of the Mn oxide coatings were reduced and removed within a week.
- In the Downer (but not Elkton) mesocosms, there was more paint removal from Fe tubes than Fe films (week 4 only).
- Future work should address responses in different soils. To better understand Mn dynamics, additional attention should also be given to shorter time scales and responses under lower (more realistic for field conditions) soil temperatures.

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