# Field and Laboratory Analysis of Controls on Groundwater Iron Concentration in Marsh and Forested Wetland Sediments

By: Juanita Stevens

Advisor: Dr. Karen Prestegaard

05/06/2004


## Abstract

This study examined the effect of temperature,seasonal and topographical changes on the Reduction – oxidation (redox) process that occur in shallow groundwater environments.

The importance of the site location, sediment chemistry, depth to sediment, microbial activity and changes in bulk parameters such as temperature were all examined as possible controls on the redox processes.These controls ultimately determine the amount of ferrous iron ($Fe^{2+}$) produced after the soil reduction process.

The site location turned out to be the most important control, temperature had no notable effect on the iron concentrations, and it was the intermediate depths in the soil at which the most activity occurred.


## Objectives

- To evaluate field data in order to determine the effect of the various controls, such as depth and microbial activity, on the ground water iron content in a marsh and forested wetland.
- To use the results of the evaluation to design and conduct laboratory experiments to further test and analyze the process.
- To combine the results of both study methods to draw reasonable conclusions about the nature of the redox processes occurring in the natural setting.

## Study Method

- Previous sediment chemistry and groundwater data collected by UMD alumni from the same area was assessed.
- Diagrams were created using this data to establish relationships between Fe concentrations and a number of variables including time, temperature, site location, sample depth, water table elevation, and changes in bulk parameters (pH, temperature, dissolved oxygen).
- The trends observed from these plots were used as a guide for the final laboratory experiments design.
- The results of both the field data analysis and the laboratory experiments were combined to draw conclusions about the nature of the redox processes occurring in the shallow groundwater environments.

## Study Method (continued)

Soil samples were collected from the marsh (at two depths) and the wetland site in MD where the previous data was gathered.

They were placed in small portions in beakers for laboratory analysis. Distilled water (to mimic rain water infiltration in the natural setting) and filtered organic (leaf litter water) water were added to them. One set of the sediment was oven dried prior to water the water addition.

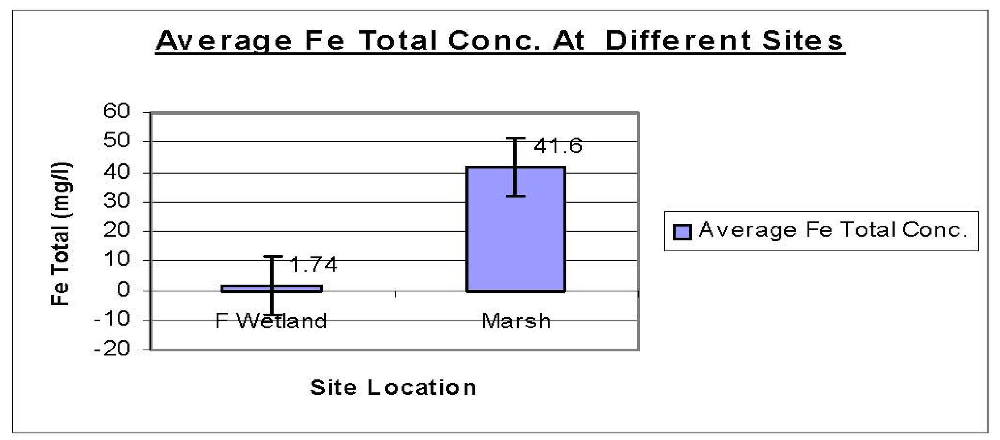
They were covered and placed to sit in a darkened cupboard, at room temperature, for 2 weeks.

At the end of two weeks the amount of visible $Fe^{2+}$ produced on the sediment sample surface was noted.

The water from each sample was also centrifuged out and tested for $Fe^{2+}$ content using the spectrophotometer.

## Results

Comparison of Forested Wetland and Marsh Fe concentrations

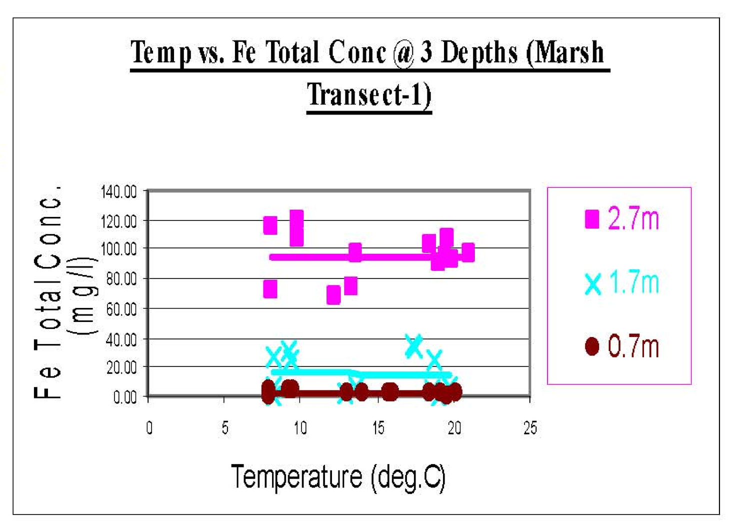



- The concentrations of Fe total differed greatly for the two sites as depicted above. Maximum values for the marsh was 131mg/l, while for the forested wetland the maximum value was 4.84mg/l.

## What Could Have Caused This Difference?

- The sites are in close proximity to each other.
- Bulk parameters were essentially the same for both sites over time.
- Temperature is ruled out as being a major control as suggested by the graph here.
- Water elevations are also quite similar.

Thus these four above are not very important controls!




The effect of Temp. on Fe concentration

## What else could have caused this difference?

- Other possible controls left to explore included:
  - Sediment Chemistry
  - Microbial activity
  - Depth was seen as a new control based on plots and so this possibility was also explored.
  - Rooting depth of vegetation at the two sites
  - Water residence time and pore water velocities.

## Microbial activity as a control

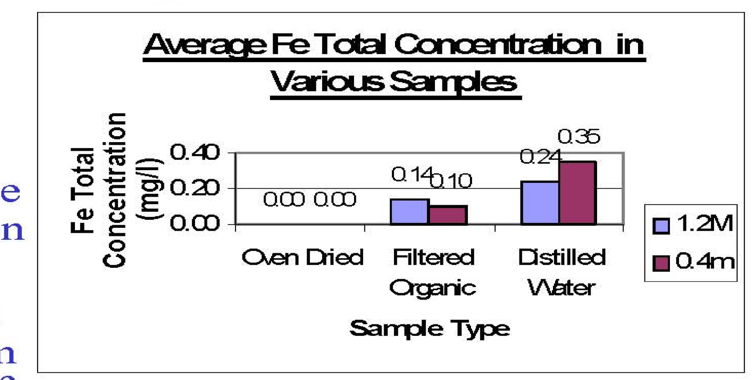
- Laboratory incubation experiments did suggest that the presence of microbes affected the production of reduced iron in the sediment samples.
- The sediment that was oven dried showed no change in color at the end of the test period; tests done using the spectrophotometer produced 0 mg/l ferrous iron content
- All other samples showed vivid color changes; the pictures beside here illustrate this


Sediment sample on day 1

Sediment sample on day 14

## How did the microbes affect the reduction process?

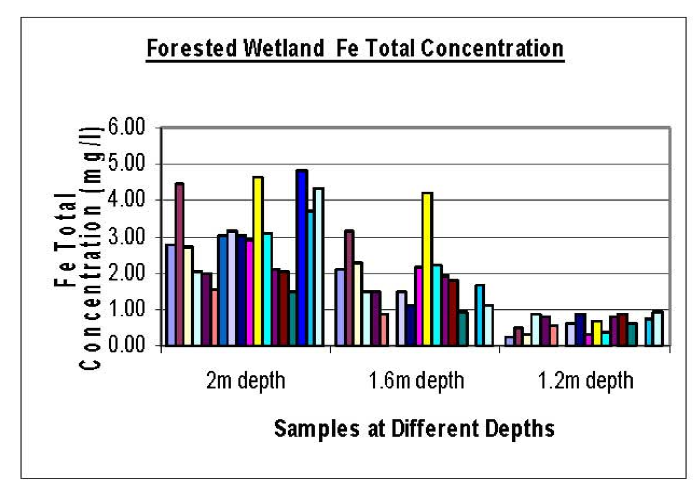
- The laboratory experiments indicated that the microbes incorporated into the sediment portions were somehow counter-productive to the ferrous iron production process.
- In fact, the samples that had distilled water added to them produced greater amounts of $Fe^{2+}$

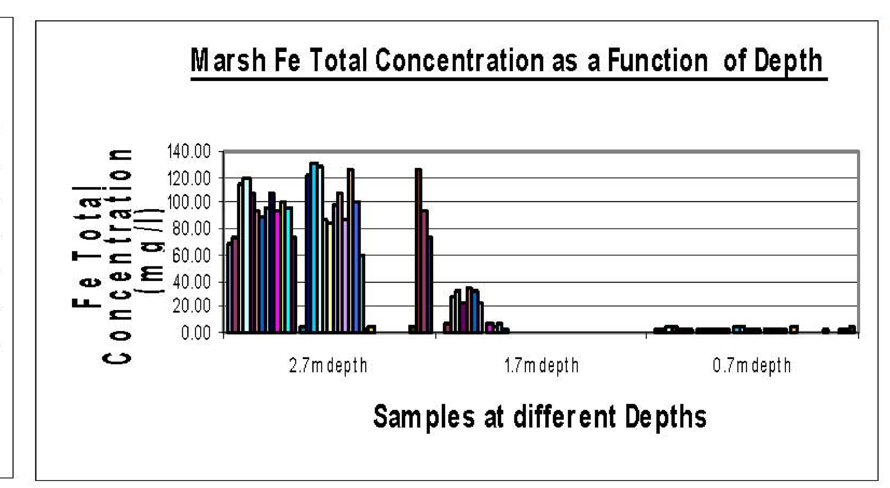



Comparing Fe content in the various samples

## Depth as a control.

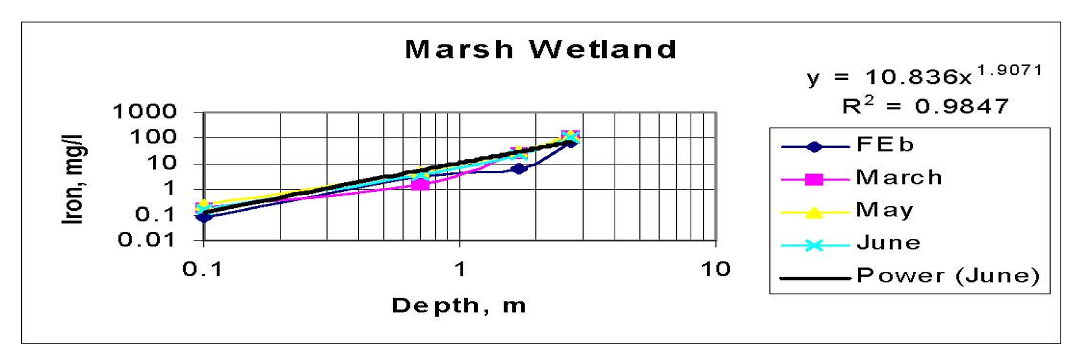
- For both sites increased depth corresponded with increased iron total concentrations.




Changes in Fe concentration with Depth for the two sites.

## Depth as a control.




Trend of Fe concentration with changing depth

- In the marsh, the iron concentration is a power function of depth of the sample.

## Other possible Controls

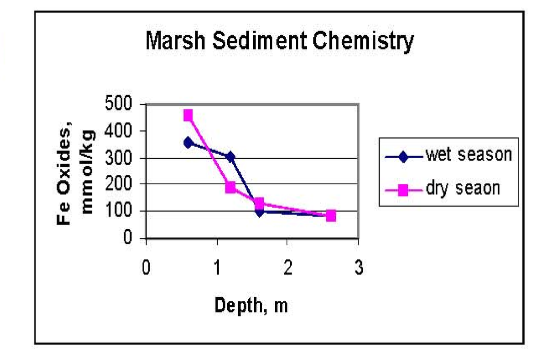
- Rooting depths of the vegetation at the two sites- Roots in wetland systems are sites for local iron oxidation. The density and depth of the roots may control the balance between oxidation and reduction of iron and thus iron concentration.
- Residence time and pore water velocity- This control has not been explored for this study but could form the

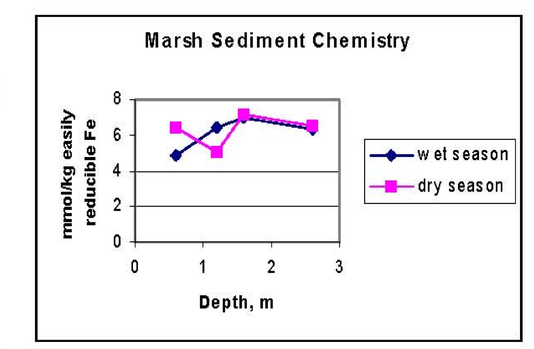
## Discussion of Results

- The sediment used in the final laboratory analysis was taken from two depths in the marsh.
- This color of the sediment indicated that sediment was already somewhat reduced, thus it was a matter of further reducing the sediment in the lab over the testing period.
- The sample containing distilled water turned out to be the sample that produced the most ferrous iron.
- The samples containing organic matter produced much less ferrous iron than expected; this suggests that the microbes introduced into the system by adding leaf litter water may have counteracted the Fe reduction process.

## Discussion of Results

- The most activity occurred at intermediate depths in the sediment.
- The amounts of Iron varied more at the shallow and intermediate depths. This is seen in the diagrams of changes in Fe oxides and reducible Fe.
- This trend is supported by previous studies, namely (Keith,1998 - UMD MS Thesis).




The most active depths for Reduction in the Marsh

## Conclusions

Site location, whether marsh or forested is the most important control.

- Depth of the sediment is the next most important control. The most active depths are the intermediate depths.
- Microbes are necessary for the Fe reduction process, but those introduced in this experiment in the leaf litter water did not aid much in the further reducing of the sediment.
- Temperature was not a major control as hypothesized.


## Acknowledgements

- I extend special thanks to Dr. Prestegaard, my advisor on this project; I truly appreciate your patience and willingness to offer sound guidance to me.
- I would also like to thank Karen Phemister for spending time with me in the laboratory and field to teach me how to use the equipment that I used in my study.