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Comparison of Soil Phosphorus Concentration in Farm Restored and Reference Wetlands in Lake County, IL

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ABSTRACT The soil in the Midwest is fertile for agriculture use and therefore a lot of the wetlands have been turned into farmland. Wetlands can act as a sink for excess nutrients such as phosphorus. In part due to their value for nutrient storage, restoration of wetlands has become more frequent, including restoration of wetlands on former farmland. I am interested in phosphorus and the potential of wetlands to either store or release phosphorus. I compared differences in soil reactive phosphorus of restored and reference wetlands. This study compares Prairie Wolf Slough (PWS), a restored wetland, to two reference wetlands, both located less than 10 miles from Prairie Wolf Slough with similar hydrology, soils, and vegetation. I measured soil reactive phosphorus (SRP) in soil cores (to a depth of 0.15 meters). ANOVA analysis found no significant difference in SRP in the restored wetland compared to the reference wetlands. Although the hypothesis was not supported, the findings can be used as preliminary data for further investigation of phosphorus in wetlands.

INTRODUCTION

Wetlands are water-saturated transitional ecosystems characterized by hydric soil and hydrophytic vegetation (Mitsch & Gosselink, 2007). Wetlands may serve as a sink for excess nutrients, storing these materials in the sediment (Wilen & Bates, 1995) which can help reduce the prevalence of algal blooms in lakes and oceans and provide protection against the creation of hypoxic zones (Mitsch & Gosselink, 2007). Wetlands may also benefit humans via ecosystem services, which are services that a certain ecosystem provides to wildlife or other humans. Wetlands provide the service of high species biodiversity, flood control and water purification (Wilen & Bates, 1995). Figure 1 explains the phosphorus cycle that occurs in wetlands, showing the role of wetlands in phosphorus uptake and storage (Mitsch and Gosselink, 2007). Phosphates in surface runoff may be taken up by plants and microbes, or bind with Ca and Fe to form insoluble compounds that precipitate out of solution.

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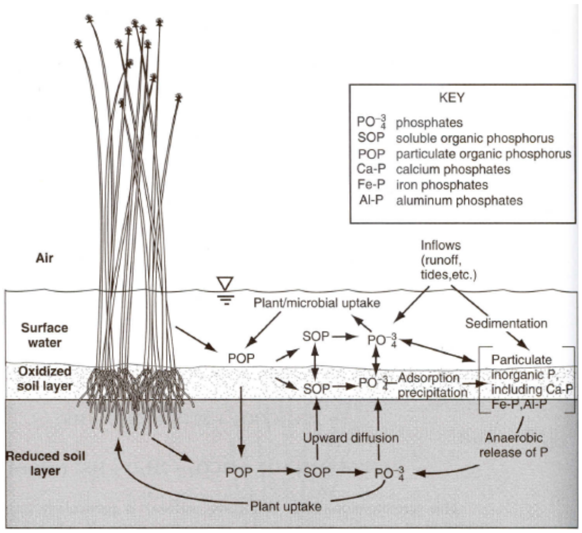

Figure 1: The Phosphorus Cycle in Wetlands. (Mitsch & Gosselink 2007, pg. 194).

With the growing need for agricultural land, farmers in the 20th century had a strong incentive to drain wetlands for more growing space (Gelso et al, 2008). The idea that wetlands represent a financial cost (from foregone farming income) is still common, however, farmers now see the ecosystem service that wetlands provide. Through surveying farmers and a review of the literature, Gelso et al (2008) found that increased size and permanence of wetlands increases farmers' perceived high cost of wetlands on their property. On the other hand, more educated farmers have a greater appreciation for these ecosystems (Gelso et al, 2008). However, economic costs of foregone income dominate farmers' perceptions of wetlands: 71% would drain the wetlands if allowed and 56% of farmers in this study would fill the wetlands if allowed. In both instances, the motive is to provide more room for farming (Gelso et al, 2008). This indicates the mismatch between the ecosystem services provided (which benefit society) and the cost of foregone farming revenue (borne by the farmer).

As land transitions out of farming, wetland restoration on former farmland is becoming more popular due to ecosystem service provisions of wetlands. Prairie Wolf Slough (PWS), the study site for this project, is one example of a wetland restoration project on previous agricultural land (Montgomery & Eames, 2011).

Wetland restoration can bring ecological benefits, often termed ecosystem services. In an Ohio study (Lenhart and Lenhart, 2014), there was an increase in plant diversity along with carbon and phosphorus storage once land was converted into a wetland habitat. However, restoration can also include some ecological costs. Rewetting drained wetlands initially increases the flow of nutrients, such as phosphorus, leaving the wetland (Surridge et al, 2012). This is termed an ecosystem dis-service, defined as something that reduces productivity or increases production costs, (Zhang et al, 2007) as the ecosystem service of nutrient uptake is reversed. This ecosystem disservice has been documented at PWS. Mean soluble reactive phosphorous (SRP) concentration at the inlet, where storm water enters PWS, and outlet, where water exits PWS into the Chicago River, was 0.066 mg/L (± 0.03 mg/L) and 0.299 mg/L (± 0.05 mg/L), respectively. This represented a 392% increase (Montgomery and Eames, 2008). SRP continues to be exported from PWS fifteen years after the restoration was completed. (Montgomery and Eames, 2008).

Elevated levels of exported phosphorus may be due to elevated levels of soil SRP. Therefore, I expect to find more soil reactive phosphorus present in the restored wetland, than our reference wetlands. Ultimately, this study will provide preliminary data to determine whether soil SRP concentrations may indicate differences between restored and reference wetlands in terms of phosphorus export potential. This is important to determine whether there are consequences in restored wetlands because they may provide a disservice rather than a service.

METHODS

STUDY SITES

Prairie Wolf Slough (PWS), is a nature preserve located in unincorporated Lake County, IL (42.1977149 N, -87.8581272 W). Prairie Wolf Slough was drained about 80 years ago using tile drains, and in 1995 it was converted back into a wetland. Restoration of the wetland includes a mesic prairie, a wet prairie, marsh and savannah

(Montgomery and Eames, 2011). In addition, two other reference sites were selected using the following criteria: A wetland located in Lake County, Illinois with similar hydrology, vegetation, and soil type to PWS. I visited each site to survey the vegetation for similarity between sites. I compared soil SRP levels at two native reference wetlands (reference sites) to the soil SRP levels at a restored wetland. The reference sites included Derwen Mawr (Ref 1) and Skokie River (Ref 2) nature preserve. Transects were installed at the three sites. Three transects at the restored site, (PWS), ran W-E, traversing a vegetative and topographic gradient that extended from forest, through prairie, and into the cattail marsh section of the restored wetland. Samples were taken every 50 meters along the length of each transect. Samples from forest were excluded from the study because the forest was not comparable with the reference sites. Derwen Mawr and Skokie River Nature Preserve had smaller wetland areas. Each had one transect, about 600 m long, which traversed the wetland. Samples were taken every 10 meters alternating along every 50 meter on the transect. There were 13 samples taken at each reference wetland.

PHOSPHORUS SAMPLING AND ANALYSIS

Soil samples were taken at a depth of 0.15 meters using a 2¼ in bucket auger and placed in a sampling bag. Samples were dried at 105 degrees Celsius for 24 hours. After drying, they were rolled with a 15.8 kilogram rolling pin and passed through a #10 sieve, which caught anything less than 2 mm. The material that did not pass through the sieve was taken out and rerolled until all the oven dried soil was processed. The soil was measured for pH and soil reactive phosphorus (SRP). pH was determined using a 1:1 ratio of soil and DI water, shaken for 10 minutes and then measured with a pH probe. Soluble reactive phosphorus was extracted using Mehlic III solution (1:10 soil:extractant volume). SRP filtrate was analyzed with a Chinchilla™ Easychem colorimetric auto analyzer. The Chinchilla™ was calibrated with blanks and solutions, composed of different percentages of phosphorus, every 10 samples.

DATA ANALYSIS

Differences in soil SRP and pH by site were analyzed via ANOVA, using the statistical program R (R Development Core Team, 2008). SRP data was log transformed prior to analysis. I considered results to be significantly different if the p-values were equal or below 0.05.

RESULTS

There was no statistical significant difference between PWS, Ref 1 and Ref 2 ($p=0.139$, $df=2$, $F=2.016$).

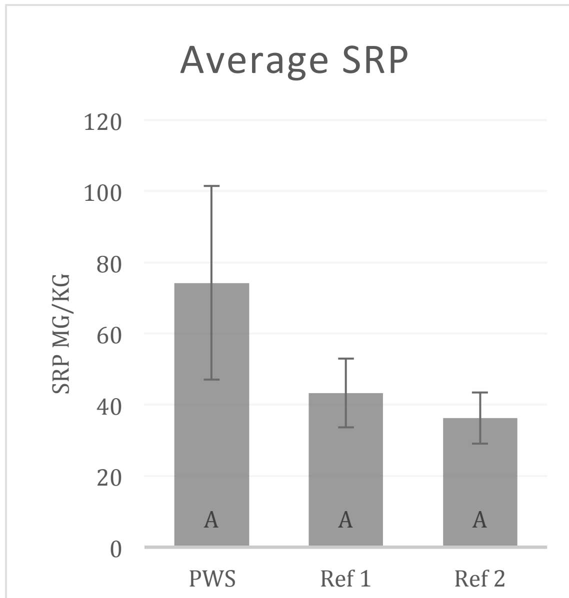

Figure 2: Graph of SRP average between PWS and the two reference sites shown with standard error bars. Letters indicate whether habitats were significantly different from one another in reference to SRP.

DISCUSSION

I did not find any significant difference between SRP at the reference sites. Figure 2 shows that standard deviation bars overlap and therefore show no significant difference. Additionally, the p-value of 0.139 is greater than 0.05, meaning that there is no statistical difference in the average SRP between sites. These results are similar to other studies involving restored wetlands. Aldous et al (2005) found no significant difference in soil SRP in restored wetlands (vs. reference). The amount of time that it takes for soil SRP to leave the wetland is dependent on the residence time of superficial P in the superficial sediments (James & Pollman, 2011). Reddy et al. (2011) found that while soil SRP accounts for 65% of the total phosphorus in basins, only 10-25% of that phosphorus is expected to leave (Reddy et al, 2011).

The question was whether soil SRP levels differ in restored wetlands versus reference or unrestored wetlands. I did not find any significant evidence to suggest that there is a difference between these two types of wetlands. Other processes that affect phosphorus concentrations in soil and water include direct uptake by plants, periphyton and microbial communities, adsorption to sediments, and precipitation of insoluble Fe, Ca, Mg and Al-phosphate minerals under aerobic conditions (Reddy et al, 1979; Mitsch & Gosselink 1993). Further exploration of biogeochemical processes may illustrate the links between soil SRP and P export. SRP can be taken up my plants or microbes and when the soil is over saturated with SRP, it can be exported into the water. This occurs when the detachment of P particles are eroded into the water as water passes through the soil (McDowell et al, 2001).

Additionally, plant ecology is an important factor in the make-up of soil and could provide more information about the wetlands tested (Brady and Weil, 2009). More evidence on the similarities of the microbial communities and the similarities of the soil type could help identify better comparisons to the restored wetland PWS.

This study could have been improved by investigating water phosphorus content going in and out of each wetland in order to get data on whether there are increased SRP levels in water leaving restored wetlands. Future studies should include more restored study sites and more reference sites.

In an effort to reduce the export of phosphorus in restored wetlands, Reddy et al (2011) determined ways to stabilize phosphorus in ecosystems like basins. They found that the storm water treatment areas are effective in managing phosphorus through chemical treatment or dredging of accumulated soil (Reddy et al, 2011). The use of storm water treatment areas could help reduce the load of phosphorus entering the wetland.

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