Sediment and Aquatic Vegetation Effects on Phosphorus Concentrations in Farm Drainage Water

Samira Daroub[1], Timothy Lang[1], Manohardeep Josan[1], and Olawale O. Oladeji[2]
[1]UF/IFAS Everglades Research and Education Center, Belle Glade, FL
[2]Environmental Monitoring & Research Division, Metropolitan Water Reclamation District of Greater Chicago, Cicero, IL

Introduction

Shallow aquatic systems in south Florida are dominated by submerged aquatic vegetation (SAV), and often show better water quality (clarity, total suspended solids, pH, total-P and total-N) than other aquatic systems (O'Dell et al., 1995). The high rate of photosynthesis by SAV can raise water column pH, which in turn may lead to co-precipitation of soluble reactive P (SRP) with $CaCO_3$ (Murphy et al., 1983). Since photosynthesis-induced pH elevation is critical for reaching the supersaturated conditions necessary for $CaCO_3$ precipitation, all submerged photosynthetically active plant communities with access to needed light have the potential to co-precipitate P with $CaCO_3$ in hard water environments (Reddy et al., 1987). Optimizing P co-precipitation in main farm canals of Everglades Agricultural Area (EAA) can sequester P in less mobile canal sediments and allow for eventual recycling of canal sediments back to farm fields.

Hypothesis:* *Elimination of Floating Aquatic Vegetation (FAV) will enhance light penetration to SAV communities and should provide conditions that optimize P co-precipitation with calcium carbonate from the canal water column.

Objectives

- Evaluate impacts of FAV management practices on varying forms of P in farm drainage water and sediment properties.
- Evaluate efficacy of FAV managements to reduce soluble P loads of farm drainage water.

Statistical Analyses

- Repeated measures analysis of variance (ANOVA) was used to determine if treatment effects were statistical significant (P<0.05) on parameters of water samples taken during each exchange.
- Analysis of variance was also performed on sediments, plants and other data using PROC GLM to determine significance treatment effects (SAS, 2008).
- Regression analyses were performed between the initial and final SRP concentrations using PROC REG.

References

1. Murphy, T., K. Hall, and I. Yasaki. 1983. Coprecipitation of phosphate and calcite in naturally eutrophic lake. Limnol. Oceanogr. 28:28-67.
2. O'Dell, K.M., J. VanArman, B.H. Welch, and S.D. Hill. 1995. Changes in water chemistry in a macrophyte-dominated lake before and after herbicide treatment. Lake Res. Manage. 11 4, pp. 311–316.
3. Reddy, K.R., J.C. Tucker, and W.F. DeBusk. 1987. The role of *Egeria* in removing nitrogen and phosphorus from nutrient enriched waters. J. Aquat. Plant Manage. 25:14-19.
4. SAS Institute. 2008. SAS for Windows, Version 9.2. SAS Inst, Cary, NC.

Materials and Methods

- Everglades Agricultural Area drainage canal waters (TP ranging from 0.08 – 0.54 mg L^{-1}) were used for the glasshouse incubation study.
- Waters were incubated weekly for 8 weeks using 115-liter PVC drums (47cm diameter x 75 cm height) (Fig. 1) with and without water lettuce (*pistia stratiotes*) as FAV, and at three sediment P levels (Table 1).
- The drums were all filled with lime rock to 5 cm depth. Additional 5 cm depth of either of the three sediments treatments (High P, low P, and lime rock) was added with and without FAV.
- First incubation water was added after sediments but before FAV treatments.
- Incubation waters were exchanged weekly (Fig. 1) with fresh water from the canal.
- Water samples were taken at day 0, 1, 2, 3, and 7 after each of the weekly water exchanges and analyzed for total-P(TP), Dissolved organic P (DOP), and SRP.
- Hyrolab™ Data Sonde® were used to measure *in-situ* pH and dissolved oxygen.
- Sediment samples were collected at the start and at the end of study.

Table 1. Properties of the lime rock and canal sediments used for the study

Parameter	Lime Rock	Low P Sediment	High P Sediment
Total-P (mg kg^{-1})	131(17)	954(133)	1128(100)
Ash content (%)	95(1)	55(7)	41(7)
Organic matter (%)	5.0(1)	45(7)	59(7)
Bulk density (g cm^{-3})	1. 73(0.16)	1.07(0.02)	1.11(0.02)

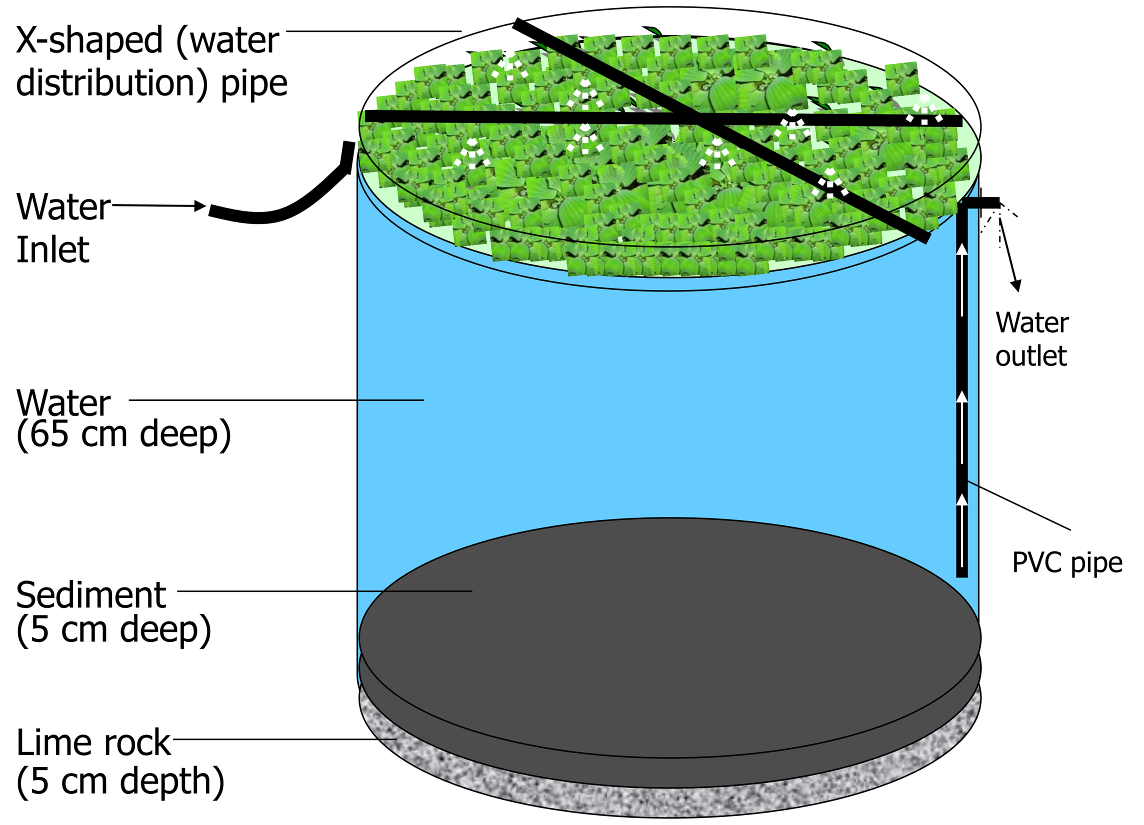

Figure 1. An experimental unit showing the lime rock, sediment, water and FAV treatments in a 115-L PVC drum.

Results

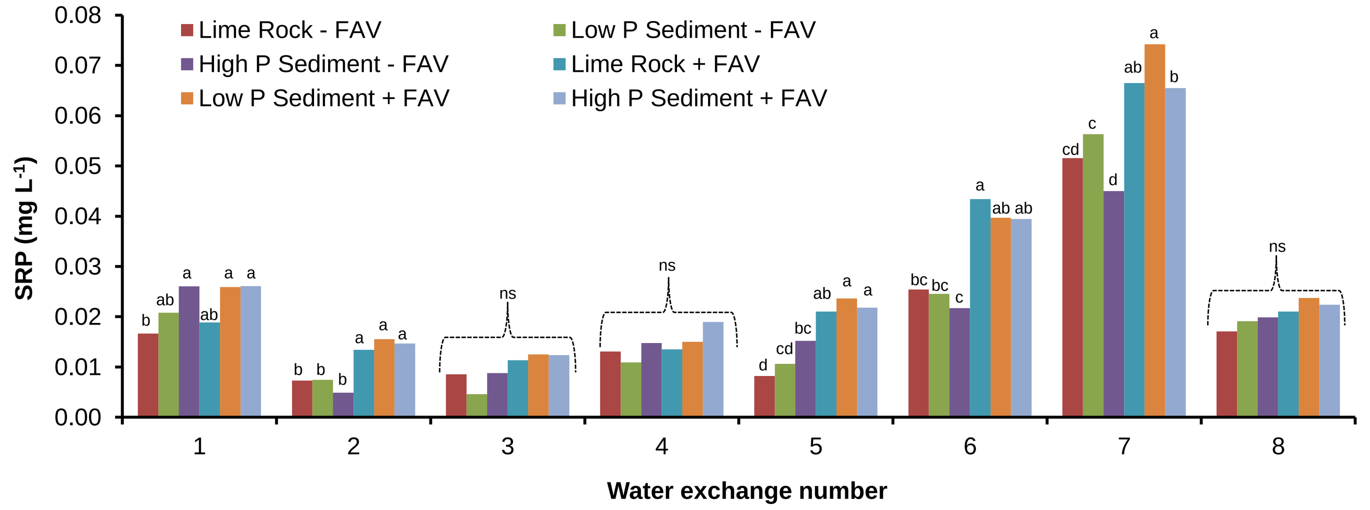

Figure 2. Soluble reactive P (SRP) in water column on day 7 during the eight weekly water exchanges. † Treatments with same water exchange number with same letter are not significant at $P > 0.05$ by Tukey's test.

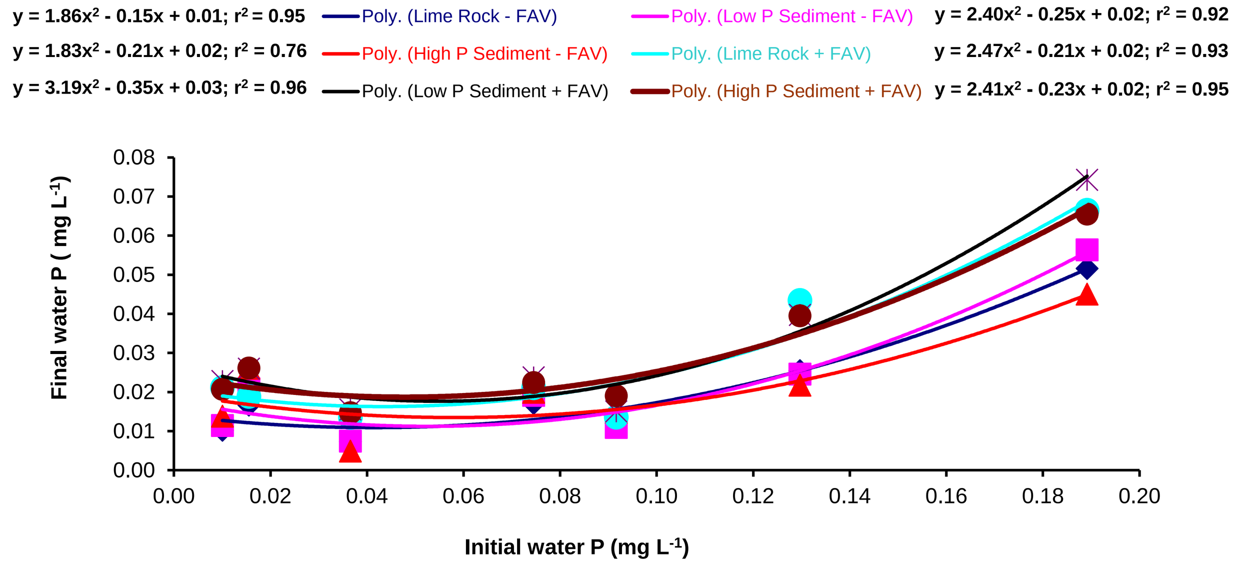

Figure 3. Relationship between the initial and final water column P concentrations of water samples taken at the start and on the 7th day of the eight weekly exchanges.

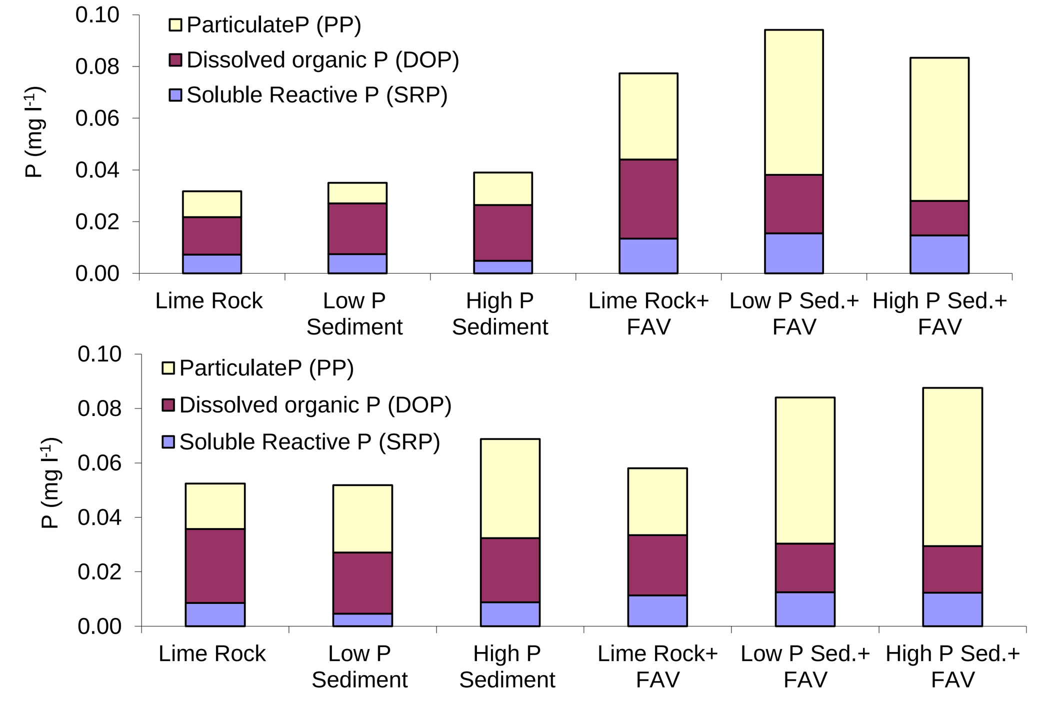

Figure 4. Soluble Reactive P, dissolved organic P, and particulate P in water column on day 7 of water exchanges 1(upper), and 4 (lower).

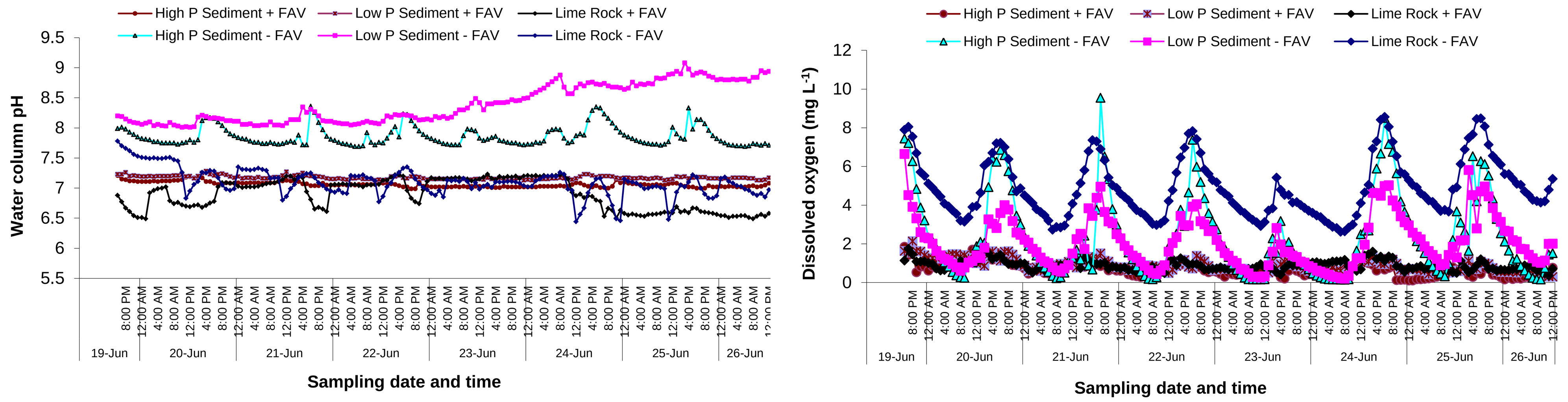

Figure 5. Hourly pH and dissolved oxygen concentrations of incubated water measured with DataSonde® between June 19 and June 26, 2009.

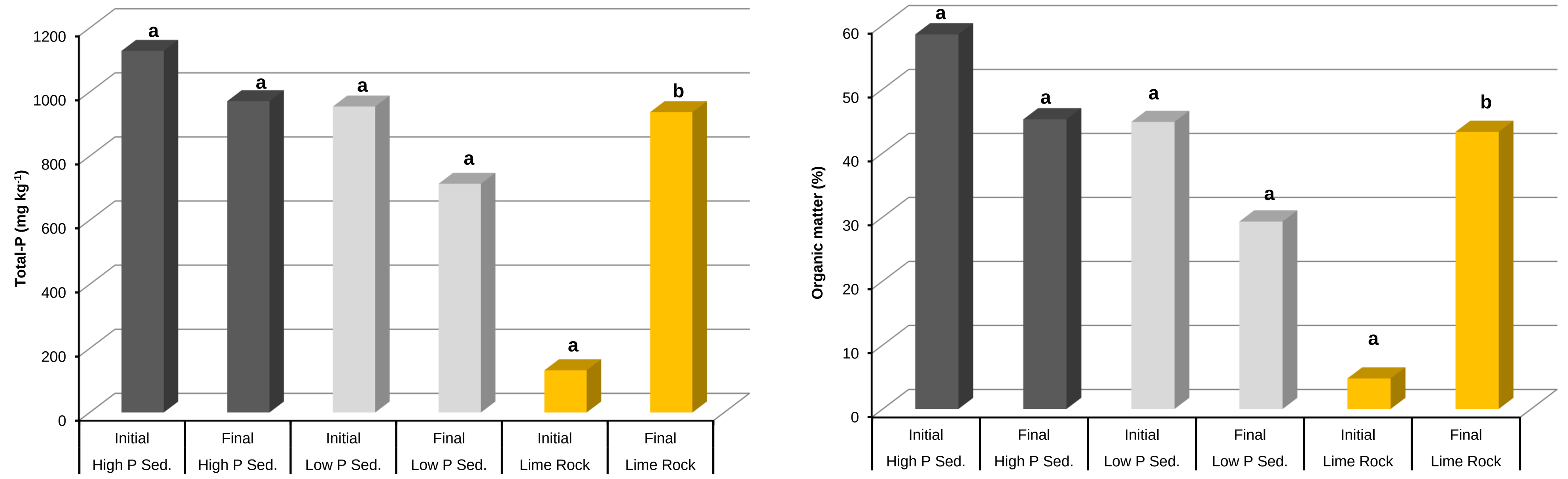

Figure 6. Effect of time (8 weeks) on total-P and organic matter content of sediments incubated with ambient canal water. Adjustment for multiple Comparison was done by the Tukey's test (P<0.05).

Discussion

- Higher SRP concentrations were observed in FAV treatments (SRP = 0.011 – 0.074 mg L^{-1}; TP = 0.055 – 0.094 mg L^{-1}) than in the absence of FAV (SRP = 0.005 – 0.056 mg L^{-1}; TP = 0.032 – 0.087 mg L^{-1}) (Fig. 2).
- Effects of sediment P loads on water soluble P was not significant, however, all of the sediment treatments had significantly higher (P<0.05) total-P concentrations. (Fig. 2)
- Final SRP concentrations of water samples were a function of initial water SRP concentrations (Fig. 3).
- Particulate P fraction was the dominant fraction in most of the water exchanges (Fig. 4).
- The pH of FAV treatments was consistently low and did not show a diurnal variation, treatments without FAV (low and high P sediments) exhibited a marked pH increase in the afternoon (Fig 5).
- Characteristic daily fluctuations were observed in DO concentrations without FAV treatments, whereas treatments with FAV show DO of <2 mg l^{-1} and did not show diurnal changes (Fig. 5).
- Significant increase in total-P and organic matter in lime stone treatment can be due to the sedimentation of organic material present in the water column (Fig. 6). FAV treatments did not show any significant changes in P or organic matter content.

Conclusions

- ✓ Canal water without FAV exhibited high pH and reduced P loading due to co-precipitation and plant uptake.
- ✓ Characterization of newly form sediments under different treatments will be required to understand the nature of P using advanced solid state assessment techniques.