Water and Sediment Phosphorus Gradients in Everglades Stormwater Treatment Areas

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Introduction

The six Everglades Stormwater Treatment Areas (STAs) are comprised of multiple wetland cells, many of which have extremely long flow paths (up to 7 km). To date, several STAs, most notably STS 3-4 and STA-2, have performed well, providing a long-term mean outflow total phosphorus (TP) concentration of approximately 0.8 λg/L. By contrast, STA-5 has consistently underperformed (Petro et al., 2005), but the reason for this wetland’s substandard P removal performance is not well understood. We evaluated gradients (inflow to outflow) profiles in water column and soil P levels in both STA-2 and STA-5 flow paths (Figure 1) to determine whether internal P gradients can provide insight into differences in the P removal efficiencies of these wetlands.

Methods

We reviewed and summarized historical mass P loadings and removal rates for a flow path in STA-2 (Cell 3), and in STA-5 (Cells 2a and 2b, which comprise the central flow path). Submerged aquatic vegetation (SAV) communities (i.e., Najas guadalupensis, Potamogeton illinoensis, Chara spp., and Hydrocharis verticillata) cover nearly two-thirds of the 896 ha STA-2 Cell 3 footprint, and the remaining one-third (eastern side) of the cell is populated by emergent macrophytes. In September 2005, we collected soil samples (0-10 cm depth) using a 10 cm diameter coring device at locations along transects oriented perpendicular to the inflow (Figure 1). Soil porewater was obtained by centrifugation and analyzed for soluble reactive P (SRP) and total soluble P (TP). Disolved organic P (DOP) was calculated as TSP – SRP, and particulate P (PP) was calculated as TSP – TSP. Soil hydraulic loading rate (HLR) was determined during the two weeks prior to water sampling was 0.04 mm/day. We performed a similar sampling effort in the 831 ha central flow path of STA-5 in late 2007 (Figure 1). The upstream wetland in the flow path (Cell 2a) is dominated by emergent macrophytes (i.e., Typha domingensis and Potamogeton spp.), and flows into the mostly open water Cell 2b, which at the time of sampling supported sparse populations of SAV (i.e., Ceratophyllum demersum and Myriophyllum verticillata). In this flow path, sample sites were established in a similar configuration as in STA-2, with transects situated at various distances perpendicular to the inflow (Figure 1). Soil samples were collected in the same manner as in STA-2. Porewater samples were collected at a 6 – 10 cm depth in the soil profile using a “soppe”. Due to the shallow water depth and water clarity for water quality was limited to one station along each of the B, D, and E transects. The water quality transects were sampled one month prior to the porewater and soil sampling effort, during a period of no flow.

Results and Discussion

From 2002 through 2007, mean inflow and outflow TP concentrations for STA-2 Cell 3 are 1.6 and 0.8 λg/L, respectively, which were lower than those for the STA-5 central flow path (209 and 128 λg/L, respectively) (Figure 2). During this period, STA-2 Cell 3 removed an average of 82% of the inflow water P load of 1.4 g P/m²-yr, whereas only 56% of the 2.4 g P/m²-yr load entering the STA-5 central flowpath was screened. In 2007, P loads entering STA-5 Cells 2a and 2b were considerably reduced due to drought conditions and construction activities. Portions of the wetland dried out during this period, which caused a subsequent export of P upon refilling (Figure 2).

Internal water quality sampling along transects in STA-2 Cell 3 revealed a rapid decline of all P species (SRP, DOP and PP) within the first half of the cell, with little further reduction observed in the back half of the wetland (Figure 3). Other sampling events in this cell (2005) under a range of inflow conditions have revealed a similar pattern, with low inflow TP concentrations dominated by PP and DOP fractions (DB Environmental, Inc., unpublished data). In contrast to the trends observed in STA-2 Cell 3, the STA-5 central flow path revealed relatively constant water column TP levels through the emergent macrophyte-dominated Cell 2a, markedly higher TP levels at the inflow of the STA-5 central flowpath, and then a reduction in [TP] with distance through this open water/SAV wetland (Figure 3). Accumulated phosphorus (P) was the principal P species present in the water column throughout the central flow path of STA-5. The prevalence of PP may have been due to phytolakton in the water column, since the wetland was stagnant (no inflow) at the time of sampling, and previous studies have demonstrated that phytolakton can proliferate in STA cells, even under flowing conditions (Fisher et al., 2008). In STA-2 Cell 3, soil TP concentrations ranged from 98 to 514 mg/kg, and exhibited a slight decline from inflow to outflow regions (Figure 3). The upstream cell (2a) of the STA-5 central flow path exhibited a similar range in soil TP, with no further decrease observed in the downstream cell (2b).

Conclusions

STA-2 Cell 3 has consistently provided lower outflow TP concentrations than the STA-5 Cells 2a + 2b flowpath, the latter of which has received enhanced inflow TP concentrations and P loads during the past 5 years. Our internal sampling in STA-2 Cell 3 demonstrates a consistently declining inflow to outflow gradient in both soil porewater and surface water P concentrations. A porewater SRP gradient was observed in STA-2 Cell 3 (Cell 2a and 2b (both of which are SAV wetlands). Although concentrations in Cell 3 were markedly lower than those in Cell 2b. By contrast, the upstream STA-5 Cell 2a lacked a well-defined porewater gradient, which may have been due to the deposition of labile soil P pools by emergent vegetation in this cell. Additional internal sampling will better define sediment and water column P profiles along the STA-5 flow path, and should provide insight into factors influencing P removal performance of these treatment wetlands.

Acknowledgements

Financial support was provided by the South Florida Water Management District and the Everglades Agricultural Area Environmental Protection District. The authors wish to thank Michelle Kharbanda and Kevin Grace for data analysis and Stacy Cole and Nancy Hill for field assistance. Laboratory analyses were performed by James Henry, Nichole Larson, and Karen Wiggins.

References


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