Seasonal and Spatial Patterns of Surface Water in Large-Scale Treatment Wetlands with Different Vegetation Communities

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Introduction

- The Stormwater Treatment Areas (STAs) were built strategically to remove excess phosphorus (P) and protect the natural Everglades areas.
- The STAs are predominantly colonized by two types of vegetation communities: emergent aquatic vegetation (EAV) and submerged aquatic vegetation (SAV), which vary considerably in key biogeochemical processes.

Objective of This Study

- Investigate the differences in seasonal changes and spatial patterns of surface water physicochemical properties within large-scale constructed wetlands dominated by different vegetation communities.

Experimental Approaches

- This study was conducted in two parallel flow ways (FWs) in STA-2, which is located between the Everglades Agricultural Areas and Water Conservation Areas (**Fig 1**).
  - FW1 is an EAV-dominated FW with primarily cattail (*Typha domingensis)* vegetation and patches of sawgrass *(Cladium jamaicense)* and water lily (*Nymphaea odorata)*.
  - FW3 is SAV-dominated, with a mix of southern naiad (*Najas guadalupensis*), musk grass (*Chara sp.*), hydrilla (*Hydrilla verticillate*), and coontail (*Ceratophyllum demersum*); approximately 20% of its treatment area in the south-eastern region populated by EAV (primarily *Typha domingensis).*

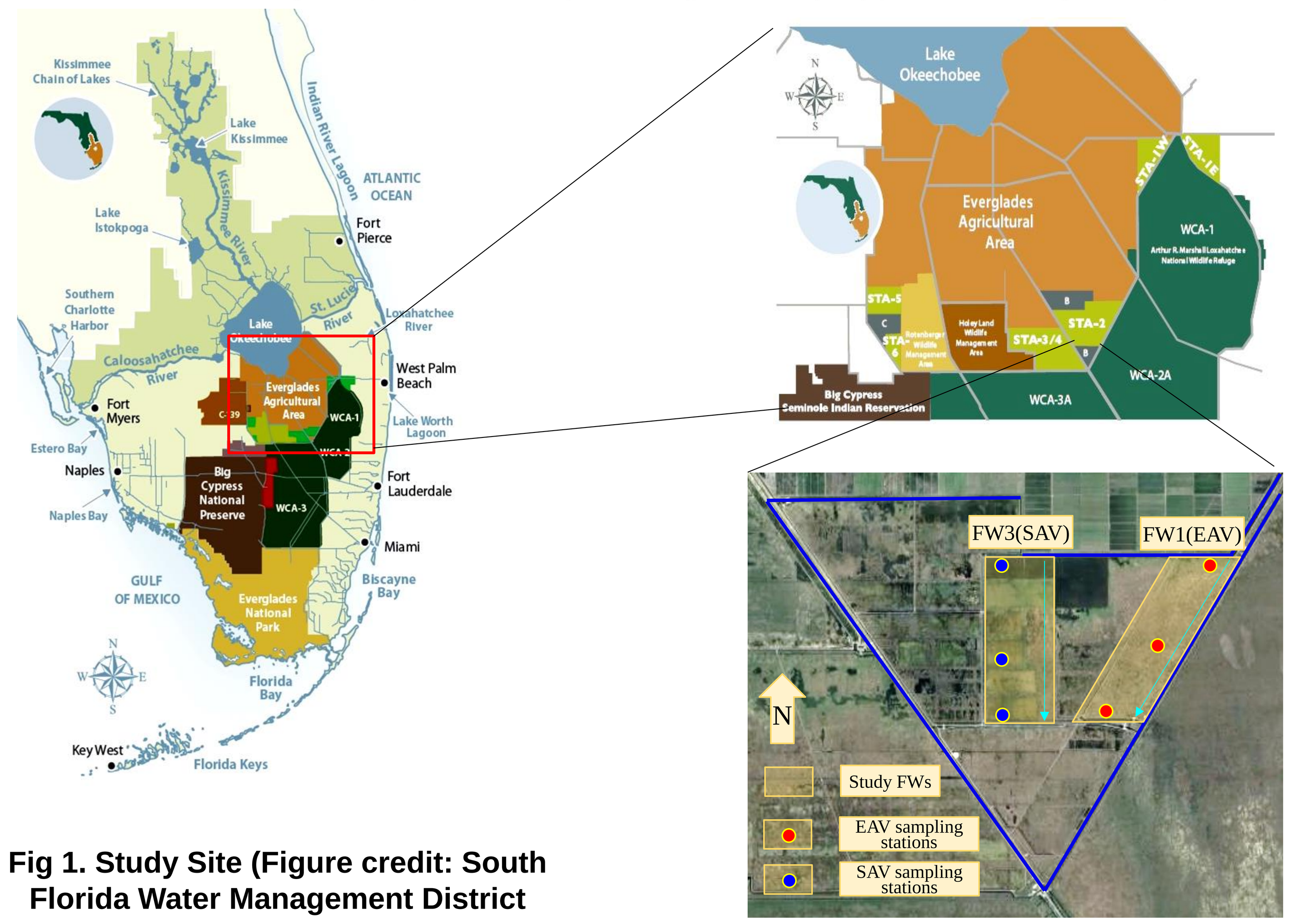

Fig 1. Study Site (Figure credit: South Florida Water Management District

- Surface water samples were obtained four times:
  - Fall 2016 (September), Spring 2017 (March), Fall 2017 (October), and Spring 2018 (March).
  - Of four samplings, two (Fall2016 and Spring2017) were before Hurricane Irma and two (Fall2017 and Spring 2018) were after.
- Water samples were collected from three stations: near the inflow (IN), middle flow (MID), and outflow (OUT) of each flow-path (**Fig 1**).

Results and Discussion

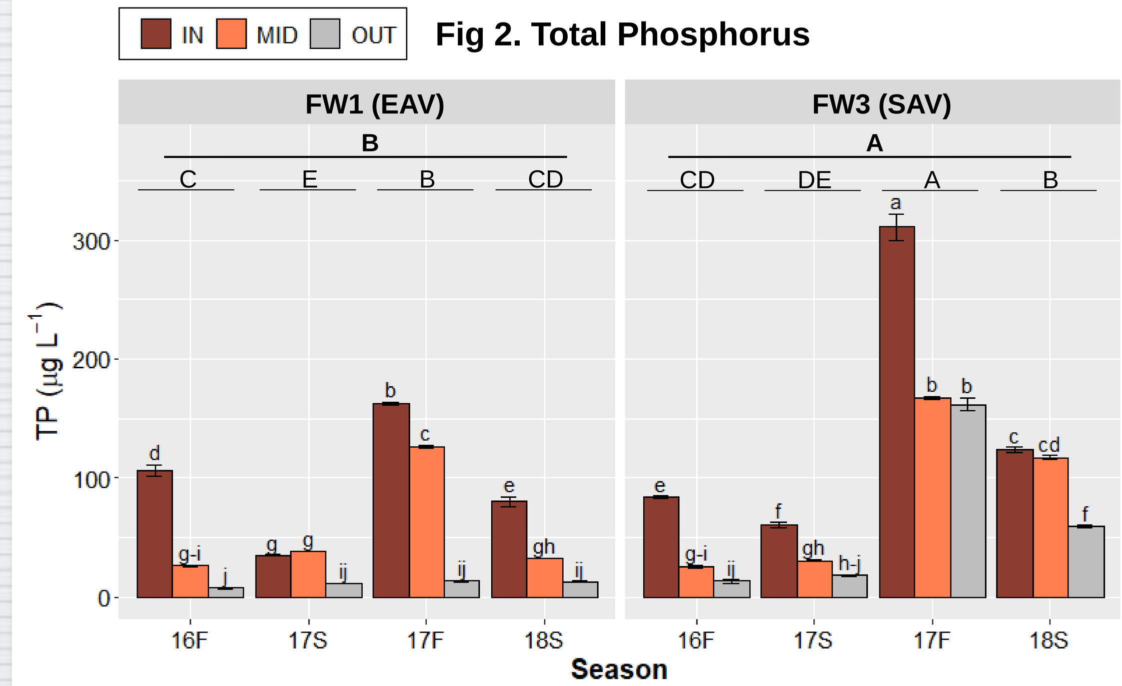

Fig 2. Total Phosphorus

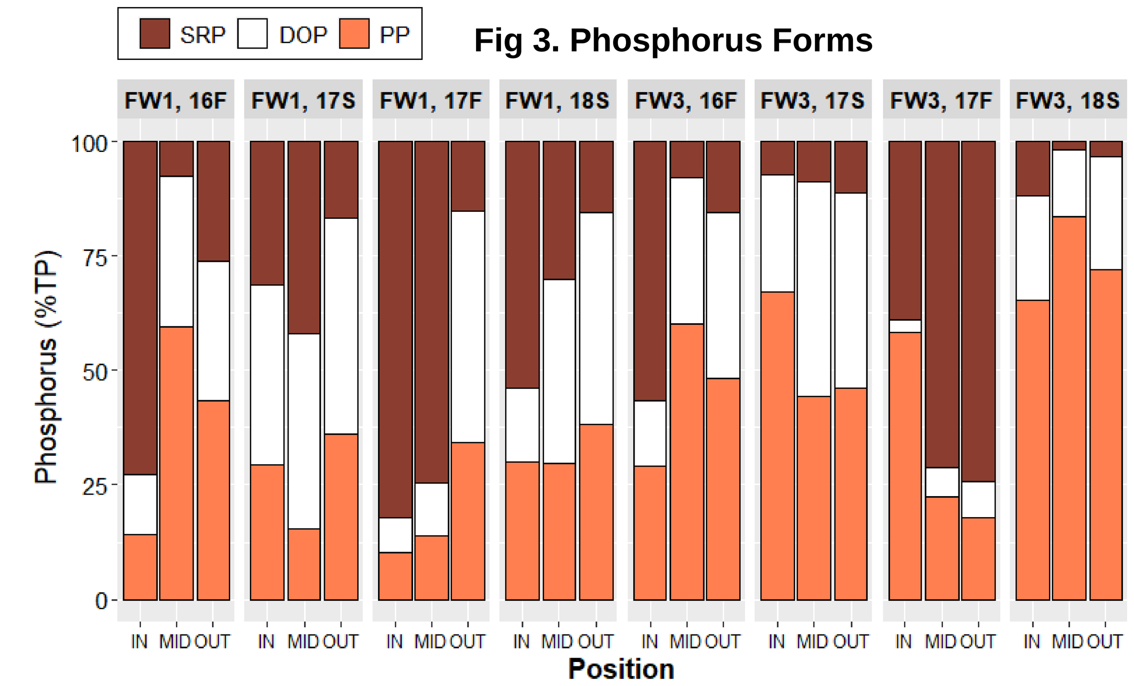

Fig 3. Phosphorus Forms

- TP concentrations showed a distinct gradient along the flow-path in both FWs (**Fig 2**). Specifically, SRP was removed highly efficiently from the water column compared to DOP and PP (**Fig 3**), possibly due to the fast biological uptake of SRP by microbes, algae, and vegetation.
- Higher TP concentration during Fall was possibly attributed to the greater inflow hydraulic and P loadings, and slower vegetation growth rate.
- FW3 (SAV) showed a greater TP increase after the hurricane than FW1 (EAV).

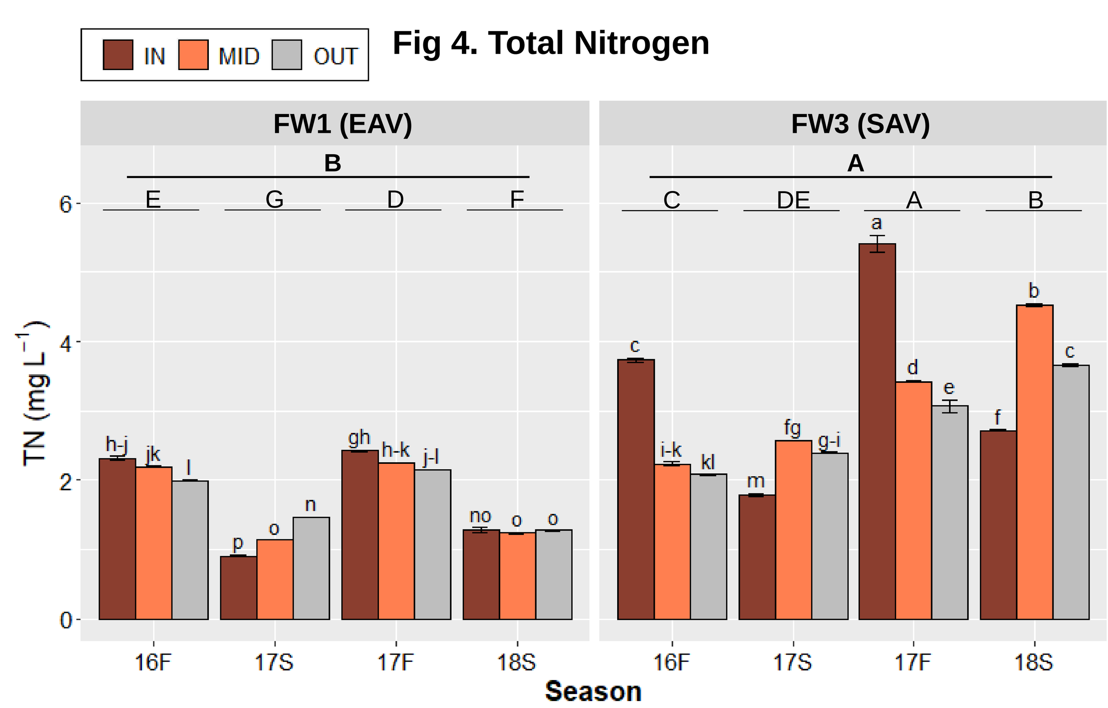

Fig 4. Total Nitrogen

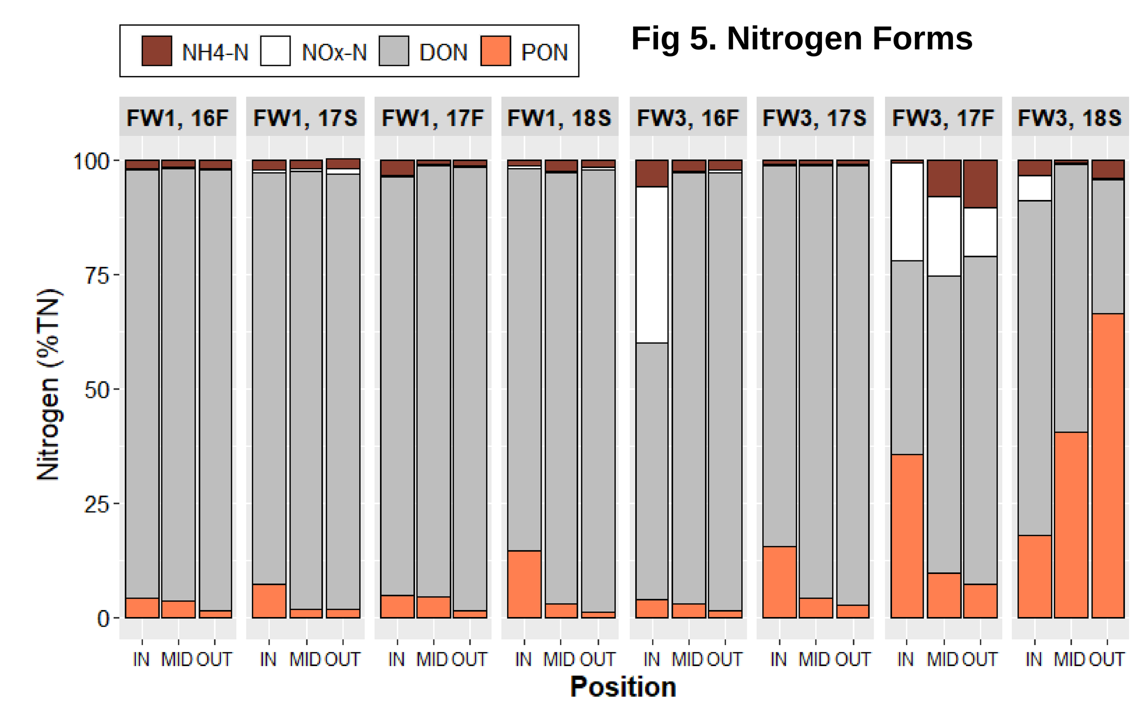

Fig 5. Nitrogen Forms

- TN did not show a consistent trend with the concentration generally decreased in Fall and increased or did not change in Spring along the flow-path (**Fig 4**).
- Inorganic N (NH_4-N and NO_x-N) accounted for a very small portion of TN, especially for FW1 (**Fig 5**). The inorganic N was rapidly depleted in both FWs as a result of high N demand in upstream areas.
- TN had a substantial increase in FW3 (SAV) which was mainly caused by the higher PON concentration.

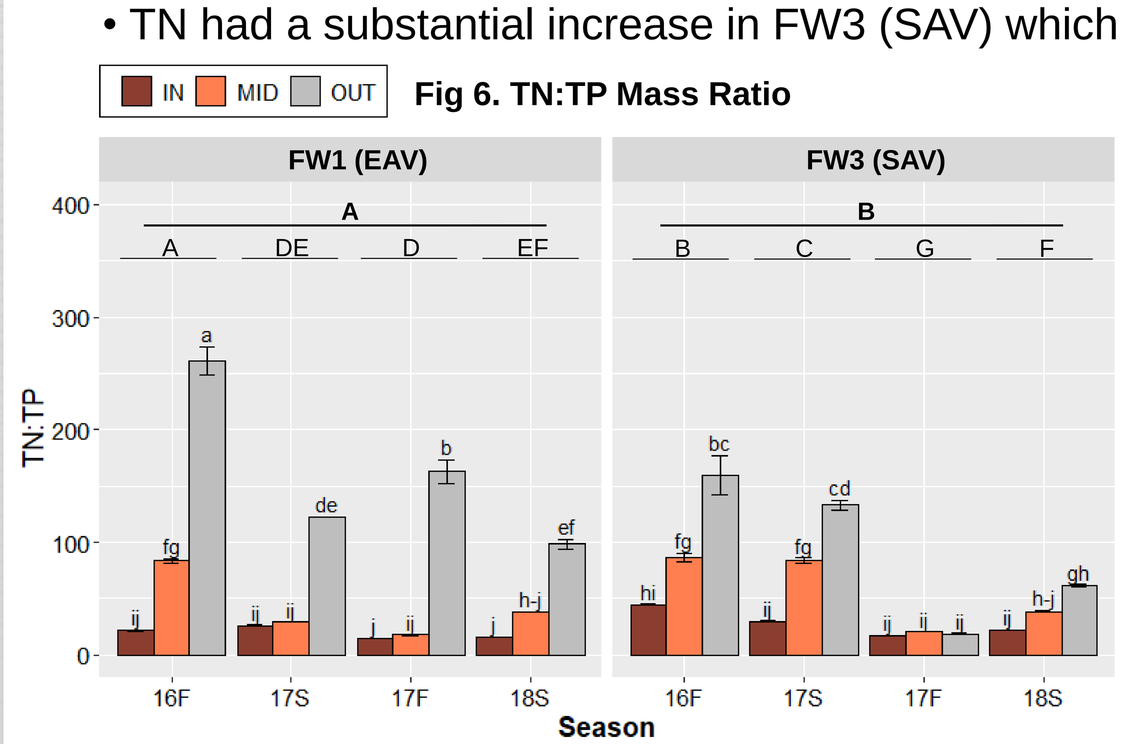

Fig 6. TN:TP Mass Ratio

- TN:TP significantly increased along the flow-path in both FWs, with the ratio at OUT and MID stations being approximately 9 and 2 times higher than that at IN station in FW1 (EAV), and 5 and 3 times higher in FW3 (SAV) (**Fig 6**).
- TN:TP was significantly higher in Fall than Spring in FW1 (EAV) while the seasonal changes was not obvious in FW3 (SAV).
- In FW3 (SAV), TN:TP at OUT station decreased from 133-160 before-hurricane to 19-62 after-hurricane. The change was not as considerable in FW1 (EAV).

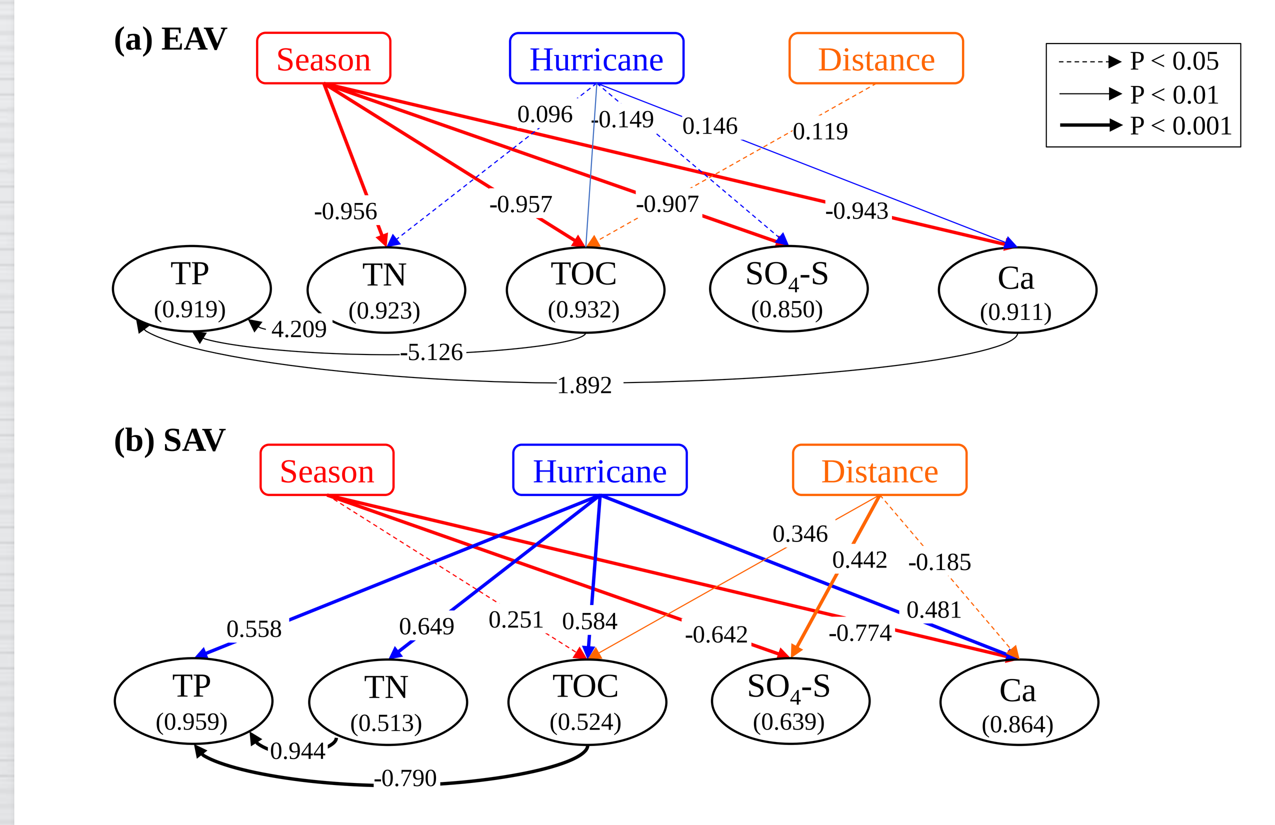

Fig 7. Partial squares structural equation modeling (PLS-SEM). Values associated with the arrows are standardized path coefficients. Values in the parentheses represent the variance explained by the model (R^2). In the PLS-SEM, numeric values were assigned to the categorical variables. For Season, 1 = Fall and 2= Spring; For Hurricane, 1 = before hurricane (Fall 2016 and Spring 2017) and 2 = after hurricane (Fall 2017 and Spring 2018).

- In FW1 (EAV), season had the most profound direct and indirect effects on nutrients (**Fig 7**). Season changing from Fall to Spring directly decreased TN, TOC, SO_4-S and Ca, and indirectly affected TP through TN, TOC and Ca.
- In FW3 (SAV), hurricane made the most contribution to variations in water nutrient content. Direct positive effects of hurricane on TP, TN, TOC and Ca were observed where indirect effects of hurricane on TP were found through TN and TOC.

Conclusions

- Short-term monitoring and assessment of selected biogeochemical parameters including P and its forms in the water column showed distinct differences in internal spatial gradient and seasonal patterns of P and associated elements in EAV and SAV flow-ways of STAs.
- Seasonal variation in surface water quality was more obvious in EAV systems while SAV systems were susceptible to extreme events such as hurricane.
- A hybrid system with both EAV and SAV could be an option to maintain stability and high efficiency in removing nutrients and protect the downstream ecosystems.

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