An Analysis of Long-Term Everglades Stormwater Treatment Areas Performance Using Structural Equation Models

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Phosphorus (P) retention in Stormwater Treatment Areas (STAs) is influenced by various external and internal variables, making it necessary to employ multivariate techniques to understand the complex relationships among them. This study used 14 years of monthly data from four STAs (STA-1E, -1W, -2, and -3/4) to achieve the objective of exploring the factors influencing long-term STA performance and function related to P retention. Structural Equation Model (SEM) with predictive variables of inflow total P (TP), total nitrogen (TN) and calcium (Ca) concentration, hydraulic loading rate (HLR), and water pH and temperature was applied to evaluate similarities and differences among individual STA performance. The SEM results suggested an improvement in the operational performance of STAs over time. All models explained a substantial portion of the variation in retention rate of TP ($R^2 > 0.63$), but only a small portion of the variation in outflow TP concentration ($R^2 < 0.24$). Notable differences were observed among the four STAs. The relationship between inflow and outflow TP concentration differed among the STAs. Furthermore, inflow TN concentration was positively correlated with the TP retention rate in STA-1W, and outflow TP concentration in STA-2, while the co-precipitation of P with Ca likely played a critical role in STA-3/4. These findings highlight the complexity of P removal in STAs and emphasize the need for site-specific management strategies. Further studies should consider incorporating long-term observation of key vegetation and soil variables (e.g. vegetation coverage and soil TP content, etc.) to inform more effective approaches to optimize P removal and enhance the performance of STAs in water treatment and ecosystem restoration efforts.