Elevated concentrations of nutrients, particularly nitrate, in groundwater and springs in Florida is a growing resource management concern. Stormwater infiltrations basins, which are a common stormwater management practice in the well-drained karst terrain areas of Florida, are a potentially important source of nutrients to the groundwater system because stormwater exits the basin by only evaporation or infiltration. To better understand the biogeochemical processes integrating stormwater infiltration impacts on groundwater resources in a field-scale setting, a study was conducted at two stormwater infiltration basins receiving runoff from predominantly residential watersheds in north-central Florida.

Comparison of hydroclimatic, soil, water-quality, and microbiological conditions at the two stormwater infiltration basins indicated soil properties control whether (1) aerobic conditions prevail and nitrogen is leached to groundwater as nitrate and organic carbon is oxidized (Hunter’s Trace basin), or (2) anoxic conditions prevail leading to highly reducing conditions and preservation of organic carbon, which serves as an electron donor for a progression of terminal electron accepting processes ranging from denitrification to methanogenesis (South Oak basin). Differences in moisture retention capacity between fine- and coarse-textured soils resulted in median volumetric gas-phase contents of 0.04 beneath the clayey South Oak basin and 0.19 beneath the sandy Hunter’s Trace basin, inhibiting surface/subsurface oxygen exchange beneath the South Oak basin leading to reducing condition conducive to denitrification. At the South Oak basin, cyclic variations in biogeochemical processes generally coincided with wet and dry hydrologic conditions. Such cyclic conditions effectively controlled the nitrogen cycle, switching nitrogen fate beneath the basin from nitrate leaching to reduction in the shallow saturated zone.

Soil beneath the Hunter’s Trace basin was amended using biosorption activated media (BAM) to study the effectiveness of this technology in reducing inputs of nitrogen and phosphorus to groundwater. The functionalized soil amendment BAM consists of tire crumb, silt and clay, and sand, which was applied to develop an innovative best management practice (BMP) utilizing nutrient reduction and flood control sub-basins. The components of BAM function to increase sorption capacity and soil moisture retention while providing sufficient infiltration capacity for stormwater volume control. Biogeochemical data (denitrifier activity derived from real-time polymerase chain reaction and variations in major ions, nutrients, dissolved and soil gases, and stable isotopes) indicate BAM contributed to removal of nitrogen and phosphorus before infiltrating stormwater entered the groundwater.

In order to quantify potential processes leading to observed nitrogen losses beneath the new BMP, an integrated infiltration basin-nitrogen reduction (IBNR) system dynamics model was developed. Based on two simulation periods, the IBNR model indicated denitrification accounted for a loss of about one-third of the total nitrogen mass inflow and was occurring predominantly in the BAM layer. The IBNR model results in combination with the field-based biogeochemical assessment demonstrated that the new BMP using the functionalized soil amendment BAM is a promising passive, economical, stormwater nutrient-treatment technology. Further field- and lab-scale research on the long-term sustainability of nutrient losses and further elucidation of causative physicochemical and biogeochemical mechanisms would contribute to improved BAM performance and green infrastructure development.

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