Simplified Modeling of Surface Water Sulfate Dynamics in the A.R.M. Loxahatchee National Wildlife Refuge, Florida

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The Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge), a remnant of the historic soft-water Everglades, overlays Water Conservation Area 1 (WCA-1), in Palm Beach County, Florida, USA. Sulfate contamination has been identified as a serious environmental issue for the Everglades ecosystem including the Refuge. Studies have shown that even the most interior marsh in the Refuge has been affected by nutrient-laden canal water. Sulfate concentration in the Refuge perimeter canals are also elevated, and impact surface water in marsh areas near the canals, and to a lesser degree, more interior marsh.

High levels of sulfate entering Everglades marshes stimulate microbial sulfate reduction, the buildup of sulfide in porewater, and the production of methylmercury (MeHg, a neurotoxin to fish and other wildlife), change redox conditions in the underlying soil, and remobilize nutrients, thus affecting macrophyte growth and vegetation distribution. Studies of sulfate transport and transformation within the Refuge marsh have been constrained by our limited understanding of hydrology within the Refuge. The research reported here integrates simple hydrological and water quality models to support investigation of sulfate dynamics within the Refuge. This integration not only contributes to our understanding of sulfate dynamics in the Refuge, but also contributes to our understanding of the Refuge hydrodynamic.

In this research, we developed a water budget and a Completely Mixed Flow (CMF) water quality model for the Refuge that is implemented in Berkeley Madonna, a differential equation solver. We used the CMF model to examine the response of surface water sulfate in the Refuge to changes in sulfate loading and hydrological processes. In the model, the Refuge was divided into four compartments along a gradient from rim canal to marsh interior: canal, perimeter marsh, transitional marsh and interior marsh. The hydrologic, meteorological, and water quality data were primarily obtained from the South Florida Water Management District DBHYDRO online database. The CMF model calculates flow between the canal and marsh, groundwater recharge including levee seepage loss as well as evaporation and transpiration. Sulfate loss is modeled using a Monod relationship, in which the maximum sulfate disappearance (apparent setting) rate was obtained from model calibration process. Apparent settling of sulfate from the marsh water column is assumed to represent loss by sulfate reduction.

The model has been calibrated and validated using long-term monitoring data (1995-2006). Model results showed that the simple sulfate model is capable of capturing big-picture spatial, inter-annual, and seasonal variations in sulfate concentrations in the Refuge. Our simulations indicate that sulfate-elevated canal water intrusion into the marsh notably influences the surface water sulfate levels in the Refuge marsh areas.