Water Quality Gradients in the Arthur R. Marshall Loxahatchee National Wildlife Refuge

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The Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge) is the last soft water remnant of the northern Everglades ecosystem. The Refuge developed as a rainfall-driven system with surface waters low in nutrients and inorganic ions, and is characterized as a low conductivity oligotrophic ecosystem. Water discharged into perimeter canals consists of both treated and untreated water with nutrient and mineral concentrations that have increased over the past several decades. Areas of its pristine marsh have been impacted by canal water intrusion containing elevated concentrations of nutrients and minerals. Stormwater originates in the 280,000 ha^{-1} Everglades Agricultural Area in the west and urban and horticultural sources in the east, and is treated in large constructed wetlands called stormwater treatment areas (STAs). Treated water is pumped into the Refuge from STA-1E into the eastern canal and from STA-1W into the western canal, both of which form a perimeter inside the Refuge levee. Untreated water also is discharged to the canals through STA bypass structures. We examined Refuge water quality relative to zones based on distance from the canal into the Refuge marsh on a north-to south gradient. The Refuge was divided into four zones: canal, perimeter, transition, and interior, based on conductivity patterns from the canal to the interior. The canal zone includes the canals surrounding the Refuge. The perimeter zone is from the canal to 2.5 km into the interior; the transition zone is from 2.5 to 4.5 km into the interior; and the interior zone is > 4.5 km into the Refuge interior. The Refuge was further divided into northern, central, and southern areas.

Surface water grab samples were collected monthly by South Florida Water Management District and Refuge staff at 48 marsh and 5 canal sites from November, 2004 through August, 2007. Marsh sites were accessed by float helicopter and sampled by wading to collect 3 L of undisturbed water, and to measure temperature (T), specific conductivity (SpC), dissolved oxygen (DO), and pH. Samples were not collected when water levels dropped below 10 cm and only 500 mL of water were collected when water levels were between 10 and 20 cm to avoid sediment introduction. Samples were stored on ice at 4 C_o, filtered within 4 hr of collection, and then sent to the laboratory for analysis. Alkalinity (ALK), total organic carbon (TOC), dissolved organic carbon (DOC), total dissolved solids (TDS), total dissolved nitrogen (TDN), turbidity (TB), total suspended solids (TSS), $NO_3 + NO_2$ (NO_x), total phosphorus (TP), total nitrogen (TN), SO_4, Cl, Ca and Si were measured using standard methods described in the Standard Methods for the Examination of Water and Wastewater.

Alkalinity, pH, TOC, TDS, TSS, TB, SpC, T, and Ca, Cl, NO_x, Si, SO_4 and TP concentrations were greater in the canal than in perimeter, transition and interior zones. Alkalinity, DOC, TOC, TDS, SpC, Ca, Cl, Si and SO_4, were greater in the perimeter zone than in the transition or interior zone. Alkalinity, SpC and SO_4 were greater in the transition than in the interior zone. Alkalinity, SpC and TDS correlated in curvilinear relationships with distance from the canal toward the Refuge interior (r^2 = 0.73, 0.64 and 0.64, respectively). Calcium, Cl, and SO_4 concentrations correlated in curvilinear relationships with distance from the canal toward the Refuge interior (r^2 = 0.77, 0.57 and 0.62 respectively). In the perimeter and transition zones, ALK, DOC, TOC, TDS, TB, Ca, Cl, NO_x, Si, SO_4, TP and TDN concentrations decreased in a July 28 - August 1, 2008 in a north-to-south direction. In the canal, TSS, TB and TDN were higher in the north than in the central area. In the perimeter zone, ALK, pH, TOC, TDS, TSS, TB, Ca and SO_4 concentrations were higher in the northern and central areas than the southern area. In the perimeter zone, the TP concentration was greater in the northern than the southern area. In the transition zone, DOC, TOC, TDS, Ca, SO_4 and TDN were greater in the northern and central areas than the southern area.

Important findings relevant to Refuge management are:

● mineral and nutrient concentrations generally decrease with increasing distance from the canal toward the Refuge marsh;

● in the perimeter and transition zones, mineral and nutrient concentrations in Refuge water generally decrease in a north-to-south latitudinal direction;

● classifying the Refuge into zones relative to latitudinal gradients provides additional insight into how stormwater intrusion affects Refuge water quality.

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