A preliminary analysis of water chemistry of the Mkuze Wetland System, KwaZulu-Natal: A mass balance approach

K Barnes[1]*, W Ellery[1] and A Kindness[2]

[1] *School of Life and Environmental Sciences, University of Natal, Durban 4041, South Africa*

[2] *School of Pure and Applied Chemistry, University of Natal, Durban 4041, South Africa*

Abstract

The Mkuze Wetland System in northern KwaZulu-Natal constitutes an important source of freshwater to Lake St Lucia. The St Lucia System, including both the Mkuze Wetland System and Lake St Lucia, is recognised as a Wetland of International Importance under the Ramsar Convention. The long-term survival of Lake St Lucia depends on an adequate supply of freshwater. Consequently, the role of the Mkuze Wetland System in water quality enhancement is essential.

In order to investigate the water chemistry of this system, water samples were collected throughout the study area from surface water, groundwater, pan and reed swamp sites, as well as a rainwater sample. These were analysed for chloride, sodium, potassium, calcium, magnesium, iron and silicon. Four main water bodies were identified using the multivariate techniques, classification and ordination. Of these four groups, two represented the major water sources to the system, these being the Mkuze River and floodplain and the Mbazwane System. The third represented outflow into Lake St Lucia, while the fourth represented scattered ground and surface water samples some distance away from the main watercourses.

The solute concentrations of the two water sources were compared using a mass-balance approach. Chloride was identified as a conserved solute and the increasing chloride concentration from the less concentrated inflows (especially the Mbazwane System) to the concentrated outflow into Lake St Lucia, is considered to reflect evapotranspiration. By considering chloride to be conserved, the degree of evaporative enrichment was estimated in the Mkuze Wetland System and used to determine the percentage of solutes retained in the swamp. The wetland was found to be an important sink for calcium (~50% retention), potassium (~70% retention) and silicon (~80% retention), with magnesium and sodium being retained to a lesser extent. The TDS value supports these findings as it is lower than expected in the outflow by a similar percentage to the magnesium and sodium retention. The removal of solutes by the Mkuze Wetland System, not only has far-reaching implications for Lake St Lucia in maintaining a freshwater supply, but could also have significant impacts on the ecology and geomorphology of the Mkuze System itself. The fate of solutes and the processes of solute retention are subjects of ongoing research.

Introduction

Wetlands occupy positions within the landscape that are transitional between terrestrial and aquatic systems. They are habitats where the water table is at or near the land surface, or where the land is covered by shallow water for a sufficient length of time to cause anaerobic conditions within the root zone of plants (Cowardin et al., 1979). As such they are dominated by hydrophytes.

Despite their position within the landscape, wetlands exhibit features that one would not expect along a gradient from terrestrial to aquatic. This is particularly true with respect to biogeochemical processes. Terrestrial habitats are typically sources of solutes in runoff that drains catchments, whereas aquatic ecosystems are either transporters (rivers) or sinks (lakes and oceans) of such solutes. Wetlands are viewed as sources, sinks or transformers of dissolved solutes within the landscape (Mitsch and Gosselink, 1993), features that are not predictable based simply on their position in the landscape. The source, sink or transformer status of wetlands depends on the type of wetland and its landscape position. For example endorheic pans would be solute sinks, having no surface or subsurface outlet, while peatlands are more likely to function as transformers with inorganic nutrients being incorporated into organic compounds (Mitsch and Gosselink, 1993).

Primary productivity is clearly related to water availability, so one might expect increased productivity on a scale from terrestrial to wetland to aquatic ecosystems. Thus, it is surprising that wetalnds are amongst the most productive habitats on earth. This high biological productivity may contribute in important ways to the ability of wetlands to act as chemical sources, sinks or transformers, since plant biomass and resulting peat deposits may act as chemical sinks (Moore and Bellamy, 1974). In addition, high transpiration rates, and particularly the high ratio of transpiration to evaporation, due to a high degree of plant cover, within wetlands may lead to the accumulation of solutes in wetland soils (McCarthy and Ellery, 1995). During transpiration the plants selectively exclude solutes from the water drawn up by their roots, allowing solutes to concentrate in the groundwater. Under the influence of this concentration mechanism, solutes will reach saturation point at a degree of concentration depending on their chemical nature. Thereafter, compounds will be precipitated, and will accumulate in the soil.

A mass-balance approach is useful in examining the extent to which a wetland acts as a source or sink of dissolved solutes. Such an approach requires comparison of long-term solute inputs and outputs. In situations where inputs are greater than outputs, the wetland would act as a sink, but where inputs are less than outputs, the wetland would be a source. Transformation refers to alteration of solute chemical form (the state in which the solute is transported) from inflow to outflow waters, without changing the total solute mass that entered the system.

In general, wetlands are viewed as sinks for plant macronutrients such as nitrogen and phosphorus (Mitsch and Gosselink, 1993), forming the basis of the widespread use of wetlands for wastewater treatment (Rogers et al., 1985). There is vast and growing literature

* To whom all correspondence should be addressed.

☎(031) 260-2416; fax: (031) 260-1391; e-mail: 961055623@nu.ac.za

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