Hydrochemical Processes in a Pristine Basaltic Catchment: Establishing a Baseline for Volcanic Island River Systems (Black River, Mauritius)

Deejaysing JOGEE
Lecturer, University of Mauritius
Email: d.jogee@uom.ac.mu

Manta Devi NOWBUTH
Associate Professor, University of Mauritius
Email: mnowbuth@uom.ac.mu

Virendra PROAG
Associate Professor, University of Mauritius
Email: virenproag@gmail.com.

Jean-Luc PROBST
Emeritus Research Director at CNRS
jean-luc.probst@toulouse-inp.fr

Abstract

Research on the water quality of pristine environments is globally scarce, and studies focused specifically on the hydrochemical properties of basaltic formations of volcanic origin are almost non-existent. Understanding the baseline water chemistry of such undisturbed systems is critical for providing a fundamental benchmark for future environmental assessments of catchments impacted by anthropogenic activities and a changing climate. This study addresses this significant research gap by investigating the physico-chemical characteristics and natural geochemical evolution of the Black River catchment, a legally protected and pristine forest reserve in southwestern Mauritius primarily composed of the Older and Intermediate Lava Series. The catchment was selected as an ideal ecological model due to its 98% native forest cover and lack of human-based activities, allowing for an accurate representation of natural hydrochemical processes. Water samples were systematically collected during both wet and dry seasons along the 14 km main river stem and at three distinct source locations to ensure seasonal and spatial variations were captured. Basic physico-chemical parameters were analyzed at the University of Mauritius, while major chemical ions were examined at LEFE, Toulouse INP in France. The results revealed that pH values increased from an acidic range of 5.2 to 5.4 in the wet season to neutral values reaching 7.1 in the dry season, driven by natural mineral dissolution and a higher proportional contribution of groundwater baseflow during drier months. Total dissolved solids varied from 26.8 mg/l at the headwaters during the wet season, influenced by dilution effects, and increased to 147 mg/l downstream during the dry season. Major ion concentrations remained well below the World Health Organization's prescribed limits for drinking water, with negligible sulphate and phosphate levels confirming the absence of pollution. Analysis through Piper plots identified a transition from rainwater influence at the sources toward a calcium-magnesium-bicarbonate dominance downstream. Gibbs diagrams highlighted that precipitation dominance governs the headwaters, while water-rock interactions control the chemistry in the downstream river valley. The dominance of magnesium ($Mg^{2+}>Na^{+}>Ca^{2+}$) and bicarbonate ($HCO_3^{-}>Cl^{-}$) reflects the active carbonic acid weathering of olivine, pyroxene, and plagioclase minerals. Consistently high dissolved oxygen (mean 8.8 mg/l) and negligible nutrient levels confirm the absence of anthropogenic pollution. Trace element analysis reveals a natural geogenic signature (U>Fe>Sr>V), with concentrations remaining well below WHO standards. Furthermore, normalized plots of Rare Earth Elements against local bedrock confirm that the dissolved load is strictly controlled by the congruent weathering of the underlying basaltic lithology. By establishing these pristine geochemical benchmarks, this research provides a vital reference for evaluating water quality degradation and climate change impacts in volcanic watersheds across the African region.