Salinisation processes in the Kalahari Sediments of Western Zambia: Machile Basin

K.E. Banda[1,3], R. Jakobsen[2], F. Larsen[2], P. Bauer- Gottwein[1], I. Nyambe[3]
[1]Department of Environment, Technical University of Denmark, 2500 Kgs-Lynby, Denmark
[2]Department of Geochemistry, Geological Survey of Denmark and Greenland (GEUS), 10, Øster Voldgade, DK-1350 Copenhagen K, Denmark
[3]Department of Geology, University of Zambia - Integrated Water Resources Management Centre, C/O School of Mines, Lusaka, Zambia

ABSTRACT

Approximately 18% of the earth's land drains to interior depressions such as inland seas, lakes or salt pans. In southern Africa, the Okavango and Lake Makgadikgadi is such an endorheic basin, occupying the northern parts of Botswana and southwest parts of Zambia. We have studied the salinization processes in this semi-arid Machile basin in Zambia, where high groundwater salinity has led to rural inhabitants drinking from polluted surface water or worse still brackish/saline groundwater. It is hypothesised that saline terrestrial sediments hosted in the Kalahari sediments from the Lake Palaeo-Makgadikgadi maybe the source of present saline groundwater in the Machile Basin. This study investigates the processes that have affected mobilization of large amounts of salts in the groundwater. To resolve this, various methods were used including borehole geophysical logging, sediment core characterisation, pore water hydrochemistry and stable isotopes. Further, X-Ray Diffraction (XRD) and Scan Electron Microscopy (SEM) were combined to establish the presence of evaporite minerals. Geophysical borehole logging and sediment characterisation showed a sediment pack with intercalations of sand and clay indicating a depositional environment of varied climatic conditions. A clayey-silt formation hosts the high salinity groundwater which terminates over impervious basalt rock. Comprehensive studies on sediment cores of pore water hydrochemistry and stable isotopes showed high concentration of Na^+, SO_4^{2-}, Ca^{2+} and Mg^{2+} with precipitates of gypsum, calcite and dolomite formed by evapo-concentration. Geochemical modelling using PHREEQC suggests mixing of fresh water with saline connate groundwater in different amounts with depth dissolving predominantly gypsum. Besides these changes in recharge composition and mixing, chemical reaction including ionic exchange of Na^+ on the clay for Ca^{2+} and Mg^{2+} in solution and dissolution of carbonate minerals in response to the cation exchange have altered the hydrochemistry. This study demonstrates that the aquifer geochemistry within the saline groundwater region could be as a result of the interplay between physical and chemical changes.

Contact information: Kawawa E. Banda, e-mail: kawab@env.dtu.dk