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Research paper

Hydrochemistry and fluoride contamination in Ndali-Kasenda crater lakes, Albertine Graben: Assessment based on multivariate statistical approach and human health risk

Walter Ojok [a,b,*], William Wanasolo [d], John Wasswa [c], James Bolender [e], Emmanuel Ntambi [a]

[a] Department of Chemistry, Faculty of Science, Mbarara University of Science and Technology, P.O Box 1410, Mbarara, Uganda
[b] Department of Chemistry, Faculty of Science, Muni University, P.O Box 725, Arua, Uganda
[c] Department of Chemistry, College of Natural Sciences, Makerere University, P.O Box 7062, Kampala, Uganda
[d] Department of Chemistry, Faculty of Science, Kyambogo University, P.O Box 1, Kyambogo, Kampala, Uganda
[e] Department of Chemistry and Biochemistry, University of San Diego, 5998 Alcalà Park, San Diego, CA, 92110, USA

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ABSTRACT

Hydrochemistry of crater lakes (n = 15) in the Ndali-Kasenda cluster was deciphered using standard methods of the American Public Health Association to understand the major ion chemistry; spatial distribution, occurrence, and non-carcinogenic health risks due to exposure to fluoride levels in the lakes in Ndali- Kasenda cluster, Albertine Graben. Numerous economic activities take place in and around the crater lakes which serve as major sources of domestic water whose origin of potential contaminants is ambiguous. In this study, WHO (2017) regulatory limit exceedance included F^-, pH, Ca^{2+}, Fe^{2+}, Mn^{2+}, and TDS. A strong positive correlation was observed between F^- and TDS; F^- and pH; F^- and EC; F^- and HCO_3^-. However, concerning hydrogeochemical signature, the lakes are mainly of Ca–HCO_3 type and low in Na–K–HCO_3 type due to rock water interaction in the geology of the area. Principal component analysis (PCA) performed on Ndali-Kasenda hydrogeochemical data resulted in six principal components (PCs) explaining 88.6% of the total variance. The PCs represented the primary processes that control the crater lake hydrogeochemistry in the Ndali-Kasenda area which include; weathering of rocks reactions, ion exchange, and evaporation processes. The hazard quotient (HQ) for non-carcinogenic health risks associated with exposure to Ndali- Kasenda fluoride levels via ingestion revealed that HQ for infants surpassed the acceptable HQ limit for all the lakes studied, while 86.67 % of the sampled lakes exceeded the HQ value for children via ingestion. Based on the hydrogeochemical parameters analyzed, aside from L. Murigamire and L. Wankenzi, water from the other studied lakes is chemically not acceptable for drinking purposes. An urgent need to take ameliorative action in this area to protect the inhabitants from exposure to excess fluoride in drinking water was recommended.

1. Introduction

Volcanic crater lakes are unique important natural resources with the capacity to provide drinking water and several other ecosystem services to humans (Nankabirwa et al., 2019; Rubaihayo et al., 2008). However, this ability is threatened by the occurrence of elevated levels of mineral ions of geogenic and anthropogenic origins (Nankabirwa et al., 2019; Tumwebaze et al., 2019). For instance, over 37% of the inhabitants in the Ndali-Kasenda area obtain their water for domestic use from crater lakes (Rubaihayo et al., 2008) whose origin of potential contaminants is ambiguous. Fluorine is the 13th most abundant mineral in the earth crust and occurs in water resources in varying proportions depending on the plethora of fluoride-bearing minerals in the underlying rocks (Ali et al., 2018, 2019; Kashyap et al., 2020; Thakur et al., 2013). Fluoride in water sources emanates from anthropogenic and geogenic sources (Ali et al., 2019; Dongzagla et al., 2019; Kashyap et al., 2020; Ali et al., 2016; Thakur et al., 2013; Tiwari et al., 2020). The application of pesticides and fertilizers containing organic fluorine is the predominant anthropogenic source of fluoride in surface waters. However, groundwater in the study area is predominantly impacted by geogenic sources of soluble fluoride-containing minerals (Ijumulana et al., 2020; Kimambo et al., 2019; Smedley et al., 2002). More than 150 fluoride-rich minerals occur

* Corresponding author. Department of Chemistry, Faculty of Science, Mbarara University of Science and Technology, P.O Box 1410, Mbarara, Uganda.
E-mail address: w.ojok@muni.ac.ug (W. Ojok).

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