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Wynants, Maarten

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Determining tributary sources of increased sedimentation in East-African Rift Lakes

Maarten Wynants, Geoffrey Millward, Aloyce Patrick, Alex Taylor, Linus Munishi, Kelvin Mtei, Luc Brendonck, David Gilvear, Pascal Boeckx, Patrick Ndakidemi, William H. Blake

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Abstract

Temporal and spatial sediment dynamics in an East-African Rift Lake (Lake Manyara, Tanzania), and its river inputs, have been evaluated via a combination of sediment tracing and radioactive dating. Changes in sedimentation rates were assessed using radioactive dating of sediment cores in combination with geochemical profile analysis of allogenic and autogenic elements. Geochemical fingerprinting of riverine and lake sediment was integrated within a Bayesian mixing model framework, including spatial factors, to establish which tributary sources were the main contributors to recent lake sedimentation. The novel application of Bayesian source attribution on sediment cores and subsequent integration with sedimentation data permitted the coupling of changes in the rate of lake sedimentation with variations in sediment delivery from the tributaries. These complimentary evidence bases demonstrated that Lake Manyara has experienced an overall upward trajectory in sedimentation rates over the last 120 years with distinct maxima between 0.80 and 0.85 g cm⁻² yr⁻¹ in the 1960s and between 0.84 and 1.81 g cm⁻² yr⁻¹ in 2010. Increased sedimentation rates are largely a result of a complex interaction between increased upstream sediment delivery following changes in land cover and natural rainfall fluctuations. Modelling results identified two specific tributaries as responsible for elevated sedimentation rates, contributing 58% and 38% of the recently deposited lake sediment. However, the effects of sedimentation were shown to be spatially distinct given the domination of different tributaries in various areas of Lake Manyara. The application of source-tracing techniques constrained sedimentation problems in Lake Manyara to specific tributary sources and established a link between upstream land degradation and downstream ecosystem health. This novel application provides a solid foundation for targeted land and water management strategies to safeguard water security and environmental health in Lake Manyara and has potential application to fill knowledge gaps on sediment dynamics in other East-African Rift Lakes.

Keywords

Lake Manyara catchment; Fallout radionuclide dating; Sediment tracing; Geochemical fingerprinting; Bayesian mixing models