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A millennium of anthropogenic impact: Sedimentary biomarker evidence from Lake San Pablo, Ecuador

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Abstract

In Ecuador, the concept of Rights of Nature is constitutionally anchored, granting ecosystems legal personhood with the right to exist and regenerate. Following decades of untreated wastewater discharge and pollution, Lake San Pablo became the subject of a landmark legal case in 2025, resulting in the formal recognition of its rights and mandates for ecological restoration. Lake San Pablo, located in the Imbabura province at an altitude of 2,660 meters, is vital for the local population but has been under anthropogenic pressure over time. The main focus of this contribution is on how changes in land use and settlement expansion within the catchment have impacted the lake and its associated ecosystem services.

This study offers a temporal reconstruction of anthropogenic environmental change in Lake San Pablo using organic geochemical biomarkers preserved in sediments, based on a sediment core collected in 2024 that captures environmental changes over the past millennium. The analysis of n-alkanes and polycyclic aromatic hydrocarbons (PAHs) enables differentiation between terrestrial and aquatic organic matter inputs as well as combustion sources. While n-alkanes indicate changes in vegetation composition and land-use changes, PAHs serve as markers for combustion processes (such as biomass and fossil fuel burning) and the direct input of fossil fuels due to increasing urbanisation. Preliminary results and interpretations show a clear shift in the distribution of n-alkanes, indicating increasing aquatic primary production due to eutrophication. PAH records show persistent biomass-burning signals over centennial timescales, followed by a recent transition toward fossil-fuel-derived inputs associated with urbanisation, motorisation, and agricultural mechanisation. A significant increase in PAH concentrations for the recent decades further indicates intensifying anthropogenic pressure and its compounding impact on the lacustrine environment.

Ultimately, this millennial-scale investigation provides a baseline of human-induced environmental change, linking molecular proxy records with regional anthropogenic activities and land-use changes (agricultural intensification, forest clearance, etc.). This long-term ecological and environmental perspective provides critical scientific evidence that could support the restoration strategies and helps the stakeholders in lake management and its restoration.

Keywords: High-altitude lakes, land-use change, n-alkanes, pollution history, polycyclic aromatic hydrocarbons (PAHs)

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