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Towards a history of Holocene P dynamics for the Northern Hemisphere using lake sediment geochemical records

Madeleine Moyle, John Boyle, and Richard Chiverrell
University of Liverpool, Geography and Planning, Liverpool, United Kingdom of Great Britain – England, Scotland, Wales (m.moyle@liv.ac.uk)

Present day phosphorus (P) enrichment and accelerated P cycling are changes superimposed on a dynamic Holocene history of landscape recovery from glaciation, changes in climate, and long-term low-intensity human activity. Knowledge of the changing role of human activity in driving long-term P dynamics is essential for understanding landscape P export and managing both terrestrial and aquatic environments.

Here we apply a simple process model to published lake sediment geochemical P records from 24 sites distributed across the Northern Hemisphere, producing Holocene records of landscape P yield and reconstructions of lake water TP concentrations. These records are a first attempt to produce values for average P export for the Northern Hemisphere over the Holocene, which can be used for constraining long-term landscape P cycling models.

Individual site trajectories of reconstructed Holocene landscape P yield and lake water TP varied systematically, with differences attributable to landscape development history, in turn driven by climate, human impact and other local factors. Three distinct traits are apparent across the records. Mountain sites with minimal direct human impact show falling Holocene P supply, and conform to conceptual models of natural soil development (Trait 1). Lowland sites where substantial (pre-)historic agriculture was present show progressively increasing Holocene P supply (Trait 2). Lowland sites may also show a rapid acceleration in P supply over the last few centuries, where high intensity land use, including settlements and farming, are present (Trait 3).

This long-term perspective is pivotal to understanding drivers of change in coupled terrestrial and aquatic P cycling. Our reconstructions of long-term lake water TP are particularly useful for target-driven management of aquatic systems.