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Using macronutrient stoichiometry to improve water quality

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Freshwater over-enrichment with nitrogen (N) and phosphorus (P) is a global issue and conventionally tackled using N and P source control. However, catchment processing of N and P depends also on the amount and form of organic carbon (C) and there is potential to improve water quality and ecosystem health by rebalancing stoichiometric ratios of catchment soils and waters with that of microbial communities. Environmental stoichiometry (the study of elemental balances/imbalances from cellular to landscape scales) of C:N:P can inform on the ability of key ecosystem players to perform vital regulating functions influencing, and being influenced by, their environment. Since C regulates heterotrophic processes within streams and rivers, there is potential, through organic C addition, to sequester N and P in the medium- (as living biomass) and long-term (as stored organic matter) given appropriate catchment C sources, carbon bioavailability and C:N:P balances.

This idea of rebalancing the C:N:P ratio to increase N and P uptake was supported by an in-stream nutrient enrichment experiment that demonstrated enhanced biomass N and P sequestration in the presence of bioavailable C, and a model-based study of major Scottish rivers that found within-river P sequestration was related to the aquatic C:P ratio. To extend this concept relating C:N:P stoichiometry with water quality to a broader land-use types and climate settings, an extensive global database of N, P and organic C bioavailability, and catchment soil, runoff, effluent and river water C:N:P ratios, was compiled. These ratios were compared with appropriate microbial C:N:P ratios and the results highlight those catchments and ecosystems where there is a major nutrient ratio imbalance and where there are opportunities for stoichiometric rebalancing to improve water quality.

Given the widespread need to reduce N and P in lowland rivers, then the results show the reintroduction of wetlands and riparian woodlands into catchments and their reintegration with streams and rivers offers good prospects of reducing stream water N and P concentrations given the likely increase in beneficial organic C forms. Ecological stoichiometry, C bioavailability and landscape C sources require to be recognised and incorporated in data collection, modelling and management. If the potential for within-river processing is used alongside source control measures, eutrophication may be tackled with more success.