Boron isotopes as a tracer of river catchment eutrophication (Southland, New Zealand)

D. J. BROWN[1]*, C. RISSMANN[23] AND M. I. LEYBOURNE[1]

[1]Laurentian University, Sudbury, Ontario, Canada (*Correspondence: dbrown@laurentian.ca)
[2]Environment Southland, Invercargill, New Zealand
[3]GNS Science, Dunedin, New Zealand

Boron is an essential micro-nutrient that is ubiquitous in crustal settings, commonly added to manufactured products, including fertilizer, detergents, and naturally elevated in animal excreta. Due to its soluble nature, boron redistributes into aqueous environments where it is commonly associated with nutrient-rich solutes. Boric acid and borate dominate the speciation of boron in acidic and alkaline water, respectively. The two naturally occurring stable isotopes are preferentially sequestered in opposite species, ^{11}B in boric acid and ^{10}B in borate. Isotopic fractionation occurs with adsorption/ desorption reactions, mineral precipitation and dissolution, evaporation, and biological processes. Stable isotope fingerprinting is commonly used to trace contamination sources and to distinguish the primary mechanisms of fractionation in water systems. Isotopic signatures of geogenic and anthropogenic boron provide a basis to test whether contamination can be ascribed to natural sources. In the Oreti River catchment in Southland, New Zealand, nutrient loading has resulted in a decline in regional water quality. Eutrophication is associated with a long history of intensive land use, including a more recent shift from sheep to dairy farming. Boron isotopic values in surface water samples decrease with distance from the coast (+20 to +40‰ $\delta^{11}B_{Coast}$; +5 to +30‰ $\delta^{11}B_{Inland}$), and with increasing elevation (+12 to +40‰ $\delta^{11}B_{MSL}$; +5 to +30‰ $\delta^{11}B_{Mtns}$), suggesting a marine influence in accord with seawater aerosols (+40‰). Widespread variance implies that there is an anthropogenic and/ or lithological component to fractionation in the catchment. Isotopic compositions of tile-drainage samples (+15 to +35‰), representative of an agricultural efflux, suggest that the waters are contaminated by cattle manure (+28.6‰), phosphate fertilizer (+14.8‰), or nitrate fertilizer (-2 to +0.7‰). Scatter in the tile-drainage values points to anthropogenic contributors as the primary source of contamination in the middle to lower reaches of the Oreti catchment, but ratio variations in surface water north of the glacio-fluvial plains suggest a stronger geogenic component in the upper reaches. Given that nutrient loading is a global issue, the Oreti River can be used as a model for determining systematic controls when assessing catchments worldwide.