Boron used to track water movements along the Tarawera River, in the Bay of Plenty Region of New Zealand

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This paper focuses on the water quality aspect of water management using boron isotope compositions to trace the origin of contaminated water being released into the Tarawera River, New Zealand, in both a direct and diffuse manner. The paper describes the benefits of using this technique and briefly introduces the use of boron isotope compositions for water consumption applications.

The Tarawera River receives wastewater from a pulp and paper manufacturer, geothermal power plants, a municipal liquid waste treatment facility, discharges from natural geothermal vents, and runoff from farming practices (dairy and horticulture) during its sinuous 59 km journey across the eastern portion of the North Island from Lake Tarawera to the Bay of Plenty. A small section, approximately 10 km, of the river accounts for the majority of natural and anthropogenic discharges responsible for increasing the concentration of toxic chemicals and modifying the physical appearance of the river. Surface water quality studies conducted by other researchers and the local council identified suitable suites of chemical constituents and physical and aesthetic parameters to target in order to quickly assess the quality of water in the most cost-effective way. However, these analyses do not include tests for chemicals that can help distinguish between the different sources of contamination.

Boron can be used to identify the origin of diffuse pollution and also provide insight into the movement of water by tapping into the natural properties of this element (Vengosh *et al.* 1998; Barth 1998; Vengosh *et al.* 2005).

By harnessing the different isotopes of boron, isotope composition (™$_{11}$B) values can be calculated from the $_{11}$B/$_{10}$B ratios obtained by negative thermal ionisation mass spectrometry (TIMS). Born is found in the majority of natural water, it is present in common manmade products extensively used in households, industry and farming, and through use is released into wastewater that is discharged into rivers or permeates into groundwater. Boron isotopes fractionate under different physicochemical conditions therefore water originating from a unique environment carries with it a unique ™$_{11}$B value. This value is independent of concentration eliminating the influence of the Tarawera River's high dilution capacity that is responsible for decreasing the concentration of many other chemical constituents below the maximum contaminant levels, which provides an inadequate picture of the health of the waterway.

To ensure that the samples collected were representative of the diversity of inputs to the river, sampling locations included the source, Lake Tarawera, the upper and lower reaches of the river, streams entering from the north, canals from the south, geothermal vents from the banks of the river, and wastewater discharges from the pulp and paper mill. Temperature, pH and conductivity measurements were all obtained in the field. Trace metal(loid), major cation and anion concentrations were analysed in the laboratory either at Duke University (USA) or at The University of Auckland (NZ). Boron isotope ratios were obtained using negative TIMS at Duke University. This study revealed the boron isotope signature of the Tarawera River and isolated distinct ™$_{11}$B signatures for the contributions from the different inputs along the length of the river. More intensive sampling was dedicated to the 10 km contamination zone with the highest incidence of inputs.

The ™$_{11}$B values of groundwater, from bores around the pulp and paper solid waste site which sits adjacent to the Tarawera River, illustrate the ability to use boron to enhance our understanding of how groundwater is moving, recharging and interacting with surface water in a highly altered environment. Making connections between the surface water and groundwater unravels the chemical history of water collected at any point in this hydrologic system. However, understanding how water migrates in any hydrologic system by uncovering the chemical history of the water. This provides the relevant authorities, in this case the Kawerau District Council and Environment Bay of Plenty, with information necessary to improve the management of water quality and consumption in their jurisdiction.

References

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