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Sulphur Bay Baseline Monitoring for the Puarenga Stream Alum Discharge

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INTRODUCTION

The Lakes Rotorua and Rotoiti Action Plan seeks to restore Lake Rotorua to pre-1970 conditions by reducing internal nutrient cycling and catchment-derived nutrient inputs. The Action Plan proposes phosphorous-inactivation using aluminium sulphate (alum) dosing in up to three streams to reduce a total 6 tonnes of dissolved phosphorous from entering Lake Rotorua on an annual basis. The Utuhina Stream was the first stream selected by the Bay of Plenty Regional Council (EBOP) for the alum P-inactivation trial and has undergone semi-continuous alum dosing since July 2006. The second stream targeted for P-inactivation is the Puarenga which enters Lake Rotorua via Sulphur Bay, an active geothermal zone and a designated wildlife sanctuary.

In a recent review of the potential ecotoxicological impacts of alum on Sulphur Bay biota (Landman and Ling 2008), recommendations for monitoring were proposed. Based on these recommendations, this is the first report examining background aluminium levels in the environment and resident biota of Sulphur Bay prior to the commencement of Puarenga Stream dosing.

MATERIALS AND METHODS

Sampling

Baseline monitoring of Sulphur Bay biota for the Puarenga Stream alum discharge consent was performed during the week of January 26-30, 2009. Three sampling locations were selected within Sulphur Bay (Sites 1-3) and an additional site outside the bay (Site 4) for reference purposes (Fig. 1).

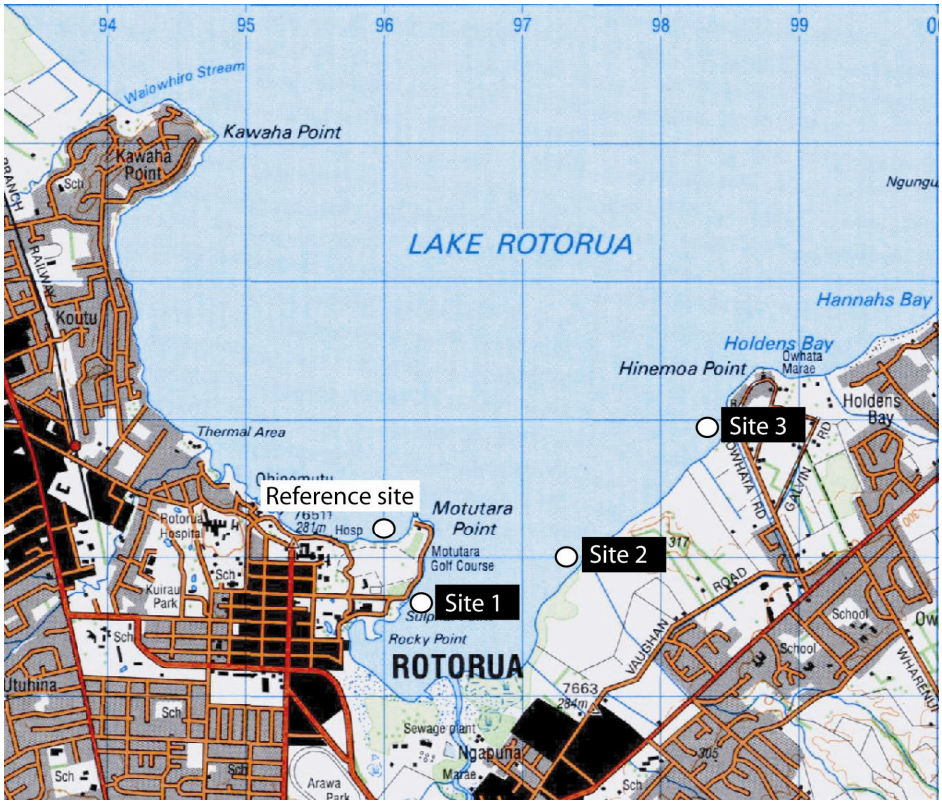

Fig. 1. The four monitoring locations selected in and around Sulphur Bay, Lake Rotorua.

Water and sediment samples were collected at each of the sampling sites. A selection of plants and animals were collected from each the sites where they could be found, as shown in Table 1. Not all species could be obtained from every site, but each plant or animal species was obtained from at least 2 sites so that inter-site comparisons could be made.

Sample analysis

All reagents used for tissue digestion and analysis by ICPMS were ultrapure grade. Water samples were filtered (0.4 µm) and acidified (1% HCl, 1% HNO_3) for ICPMS analysis.

Sediments were freeze-dried and approximately 0.5 g of dried sediment was extracted according to USEPA method 200.2. Approximately 0.5 g of dried sediment was extracted in aqua regia for 18 h at room temperature followed by 90°C for 2 h in sealed polycarbonate tubes. 0.25 ml of sample was then filtered and diluted to 10 ml with ultrapure water (including 1% HCl and 1% HNO_3) for ICPMS analysis.

Plant tissues were washed in ultrapure water and freeze dried. Between 0.2 and 0.5 g dried tissue was digested according to the method of Valitutto et al. (2006). Briefly, 6 ml ultrapure nitric acid (65%) was added to the tissue and digested at 65°C for 3 h in 50 ml sealed polycarbonate tubes followed by addition of 3 ml hydrogen peroxide (30%) and digestion for a further 3 h at 65°C. Samples were then diluted to 50 ml and 1 ml of filtered (0.4 µm) sample was diluted to 10 ml with ultrapure water (including 1% HCl and 1% HNO_3) for ICPMS analysis.

Animal tissues were freeze dried and 0.1 to 0.5 g of dried tissue was digested according to USEPA method 200.11. Briefly, 2 ml of ultrapure tetramethylammonium hydroxide was added to the tissue, vortex mixed and digested at 65°C for 1 h in sealed polycarbonate tubes. Samples were again vortex mixed and digested for a further 1 h at 65°C. Samples were cooled and 0.5 ml ice-cold hydrogen peroxide added. Samples were stored overnight at 4°C followed by addition of 2 ml ultrapure nitric acid and further digestion at 90°C for 2 h. Samples were cooled and diluted to 50 ml with ultrapure water. 1 ml of filtered (0.4 µm) sample was diluted to 10 ml with ultrapure water (including 1% HCl and 1% HNO_3) for ICPMS analysis.

Table 1. Summary of plant and animal species availability at each of the selected monitoring sites in and around Sulphur Bay.

Site 1	Water (in duplicate) Sediment (in duplicate) Chironomids (*Chironomus* spp.; 5 samples)
Site 2	Water (in duplicate) Sediment (in duplicate) *Eleocharis sphaceolata* (5 samples – stems, rhizome, roots) *Eleocharis acute* (5 samples – stems, roots) Chironomids (*Chironomus* spp.; 5 samples) Kakahi (*Echyridella menziesi*; 5 samples – foot muscle & digestive gland)
Site 3	Water (in duplicate) Sediment (in duplicate) *Eleocharis sphaceolata* (5 samples – stems, rhizome, roots) *Eleocharis acute* (5 samples – stems, roots) *Glossostigma elatinoides* (5 samples – whole plants) Chironomids (*Chironomus* spp.; 5 samples) Kakahi (*Echyridella menziesi*; 5 samples – foot muscle & digestive gland) Common bully (*Gobiomorphus cotidianus*; 5 samples – whole fish)
Site 4 **Reference**	Water (in duplicate) Sediment (in duplicate) Eleocharis acute (5 samples – stems, roots) *Glossostigma elatinoides* (5 samples – whole plants) Chironomids (*Chironomus* spp.; 5 samples) Kakahi (*Echyridella menziesi*; 5 samples – foot muscle & digestive gland) Common bully (*Gobiomorphus cotidianus*; 5 samples – whole fish)

RESULTS AND DISCUSSION

A summary of aluminium results measured in water, sediment and biota samples is presented in Figure 2. These results indicate that dissolved aluminium is greatest within Sulphur Bay, decreasing outwards into Lake Rotorua. Sediment aluminium was relatively high at all sites and increased in concentration along the geothermal gradient/plume (i.e. Site 1→ Site 3) into Lake Rotorua. Total tissue aluminium concentrations were highest in chironomid samples at all sites, although the greatest concentrations were observed at the reference site (Site 4) outside the bay. Aluminium was generally low in both kakahi and fish samples. Low to moderate aluminium concentrations were observed in rushes (*Eleocharis* sp.) with greatest concentrations typically observed in the roots. Aluminium concentrations in the submerged *Glossostigma elatinoides* were similar to those observed in the roots of rushes. As for chironomids, greatest macrophyte aluminium concentrations were found at the reference site.

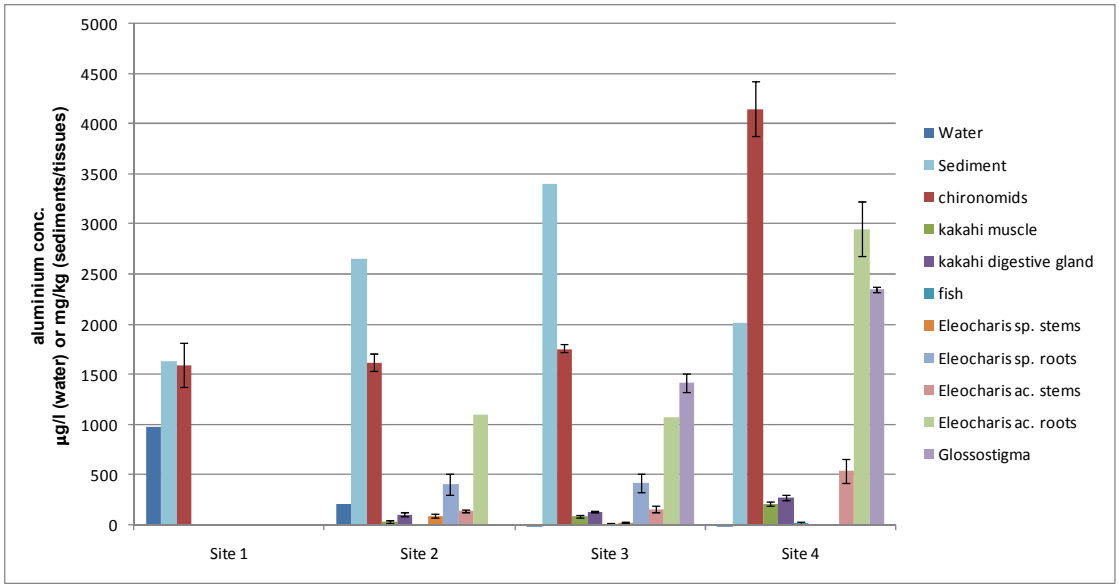

Fig. 2. Aluminium concentration in water (µg/l), sediment (mg/kg) and tissues (mg/kg) of plant and animal species sampled within and around Sulphur Bay.

The moderate to high concentrations of aluminium in water and sediment samples are the likely result of a combination of factors specific to this particular environment. It was

previously suggested (Landman and Ling, 2008) that low pH in the lower Puarenga Stream and Sulphur Bay may result in acid leaching of aluminium from soil (Gensemer and Playle, 1999). However, geothermal fluids are also known to be significant sources of environmental aluminium (Martin et al., 2000). Interestingly, the highest environmental concentrations of aluminium were not mirrored in biota. This implies that natural aluminium present within Sulphur Bay is less bioavailable than at the reference site. Aluminium bioavailability can be influenced by a number of factors such as the complexation of aluminium with dissolved organic matter and silicon (Sparling et al., 1997; Gensemer and Playle, 1999) which may be different within the geothermally active Sulphur Bay.

REFERENCES

Gensemer, R.W. and Playle, R.C. (1999). The bioavailability and toxicity of aluminum in aquatic environments. Critical Reviews in Environmental Sciences and Technology 29: 315-450.

Landman, M. and Ling, N. (2008). Potential environmental impacts of Puarenga Stream alum dosing: a review of aquatic toxicological data on aluminium, possible impacts on Sulphur Bay biota, and recommendations for impact monitoring. Scion technical report prepared for Environment Bay of Plenty, October 2008.

Martin, R., Rodgers, K.A. and Browne, P.R.L. (2000). Aspects of the distribution and movement of aluminium in the surface of the Te Kopia geothermal field, Taupo Volcanic ZOnes, New Zealand. Applied Geochemistry 15: 1121-1136.

Sparling, D.W., Lowe, T.P. and Campbell, P.G.C. (1997). Ecotoxicology of aluminium to fish and wildlife. In: Yokel RA, Golub MS ed. Research Issues in Aluminium Toxicity. Washington, Taylor Francis.

Valitutto, R.S., Sella, S.M., Silva-Filho, E.V., Pereira, R.G. and Miekeley, N. (2006). Accumulation of metals in macrophytes from water reservoirs of a power supply plant, Rio de Janeiro State, Brazil. Water Air and Soil Pollution 178: 89-102.