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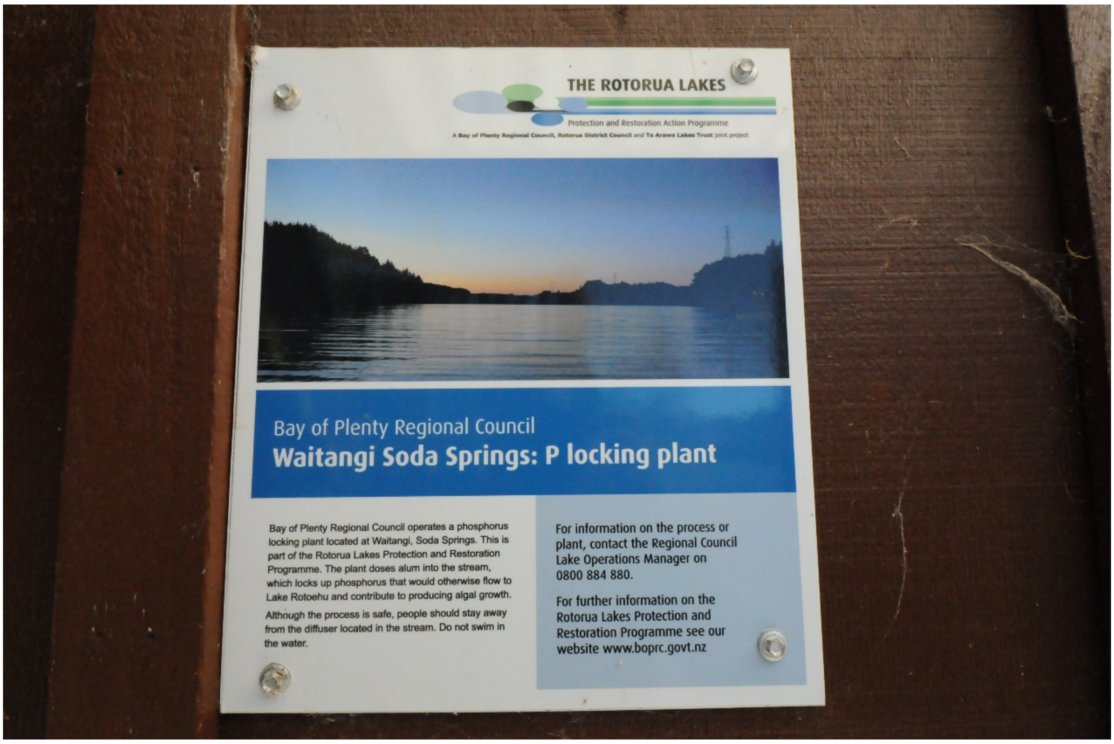
Alum Dosing at Waitangi Soda Springs – bioavailability of aluminium in 2016



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Summary

Continuous alum dosing of the Waitangi Soda Springs at Lake Rotoehu commenced in 2010 to reduce inflows of dissolved reactive phosphorus to Lake Rotoehu. Analyses of bioaccumulation in the tissues of kōura and goldfish from Lake Rotoehu were undertaken on animals collected in November 2016 for comparison with data from previous years and control locations to determine the bioavailability and bioaccumulation of aluminium to satisfy annual resource consent conditions 11.7 and 11.8 of resource consent 65966. Lake Rotoehu goldfish showed slightly elevated aluminium concentrations in the gills indicating enhanced exposure to aluminium as a result of alum discharge from the Waitangi Soda Springs but no evidence of significant bioaccumulation in internal tissues.

Contents

Introduction

The Lake Rotoehu Action Plan (Bay of Plenty Regional Council, 2007) proposed to lower the trophic level index (TLI) of Lake Rotoehu from 4.6 to 3.9 by reducing internal and catchment-derived nutrients (N and P). The Action Plan proposed a wide variety of actions to improve water quality and, following the successful establishment of continuous alum dosing plants on other streams in the Rotorua lakes district, an alum dosing plant was subsequently constructed in 2010 on one of the major inflows to the lake, the geothermal Waitangi Soda Springs. Alum dosing of this inflow is estimated to reduce dissolved phosphorus inputs to Lake Rotoehu by up to 0.7 tonnes per annum.

Alum dosing of the Utuhina Stream inflow to Lake Rotorua began on a trial basis in 2006 and the Bay of Plenty Regional Council granted a resource consent in November 2008 for the continuation of alum dosing until 2018. The Utuhina Stream carries an estimated 7.6 tonnes of P into Lake Rotorua each year, of which approximately 2 tonnes is in the form of dissolved reactive phosphorus (DRP). The Puarenga Stream discharges a similar annual phosphorus load to Lake Rotorua and continuous alum dosing began on the Puarenga Stream in early 2010. The Puarenga Stream discharges into Sulphur Bay, a continuously active geothermal area and a designated wildlife reserve on the southern shores of Lake Rotorua. Landman & Ling (2009) measured bioaccumulation of aluminium in a variety of Lake Rotorua biota to provide baseline data on natural aluminium bioavailability prior to the commencement of alum dosing and subsequent studies have assessed the potential for aluminium bioaccumulation as a result of alum dosing of both the Utuhina and Puarenga streams (Ling 2013a, Ling 2013b). An initial assessment of aluminium bioavailability and bioaccumulation in goldfish and kōura from Lake Rotoehu was undertaken by Ling (2015), however, because no baseline assessments of aluminium bioaccumulation were undertaken on biota from Lake Rotoehu prior to the commencement of alum dosing, comparisons were made with the same organisms sampled from other lakes in the region (Lakes Rotorua and Rotoiti), albeit that the Rotorua lakes may differ substantially from one another with respect to water and sediment chemistry due to the differing influences of catchment, groundwater and geothermally derived inflows. This report provides data on aluminium concentrations in adult kōura and goldfish from Lake Rotoehu in 2016 for comparison with data collected since 2013. This study aimed to assess whether alum dosing of the Waitangi Soda Springs is providing bioavailable aluminium to lake macrobiota resulting in bioaccumulation and potential toxicity.

Methods

Sampling

Samples of frozen adult kōura (*Paranephrops planifrons*) and goldfish (*Carassius auratus*) from Lake Rotoehu and Waitangi Soda Springs, respectively, were collected and supplied by Ian Kusabs in November 2016.

Sample analysis

Samples of liver (goldfish) or hepatopancreas (kōura), flesh and gills were carefully dissected using acid-washed instruments. A suite of 28 elements was measured in samples based on established methods (USEPA, 1987). Samples were dried at 60°C for 24 h, weighed to the nearest 0.0001 g and digested using tetramethylammonium hydroxide, heat and mixing. The colloidal suspension was then partially oxidized by the addition of hydrogen peroxide and the metals were solubilised by acidification with nitric acid and heating. Samples were diluted and filtered prior to analysis by inductively-coupled plasma mass spectrometry (Waikato Mass Spectrometry Facility, School of Science, University of Waikato, Hamilton, NZ; http://www.mass-spec.co.nz/). All tissue element concentrations were determined on a dry weight basis. Method blanks and matrix certified reference material standards (DOLT and DORM; Canadian Research Council) were run in parallel with all samples. Only results for aluminium are presented here.

Results

Total tissue aluminium

Values for total tissue aluminium are presented in Figures 1 and 2. Tissue aluminium in all tissues of kōura from Lake Rotoehu in 2016 were comparable to concentrations determined in 2015 and do not indicate significant bioaccumulation of aluminium compared with animals from lakes Rotorua and Rotoiti, or any increase in average tissue concentrations over time.

No significant differences in flesh concentration were apparent in goldfish from lake Rotoehu in 2016 compared with samples from 2015, however, aluminium in the gills of Lake Rotoehu goldfish is slightly elevated compared with fish sampled from Lakes Rotorua and Rotoiti.

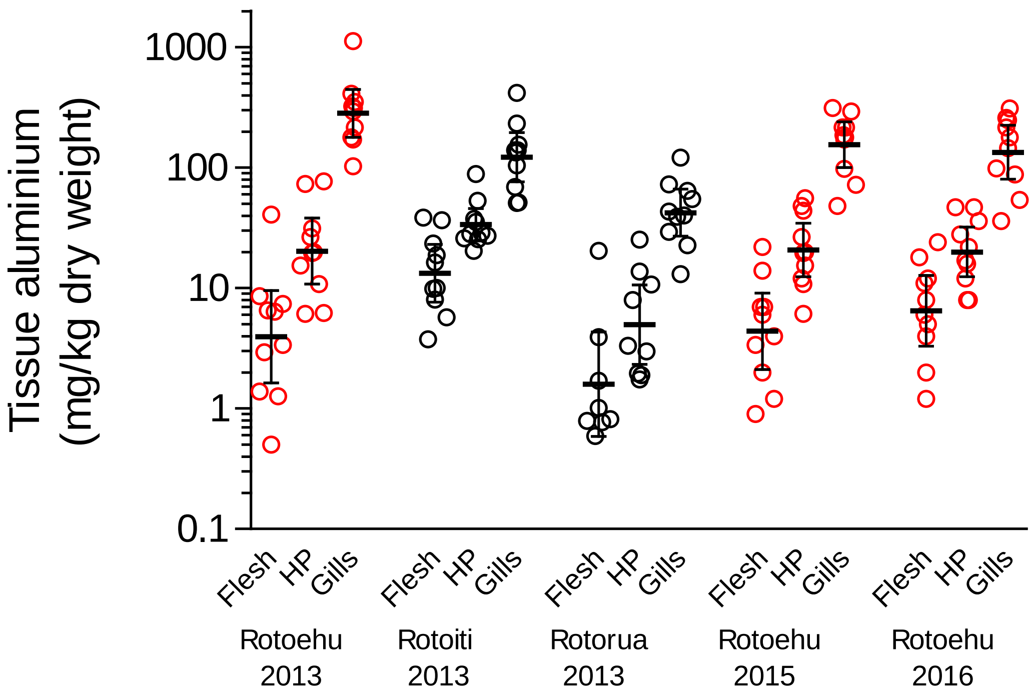

Figure 1. Aluminium concentrations in tissues of kōura from lakes Rotoehu, Rotoiti and Rotorua. Transverse bars are geometric means with 95% confidence intervals.

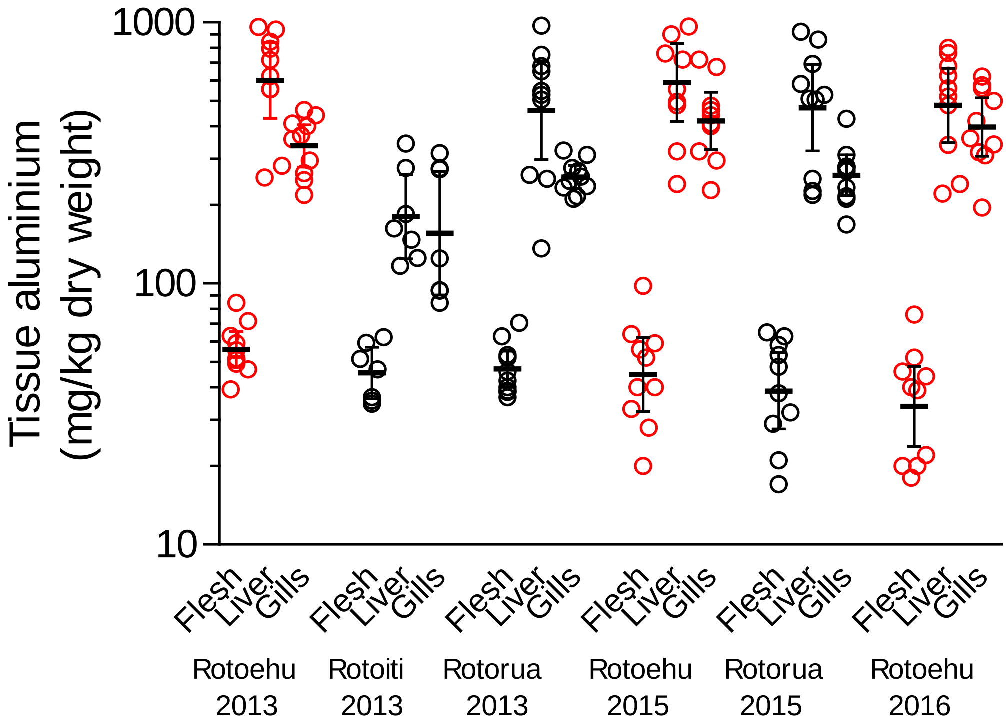

Figure 2. Aluminium concentrations in tissues of goldfish from lakes Rotoehu, Rotoiti and Rotorua. Transverse bars are geometric means with 95% confidence intervals.

Conclusions

Higher levels of aluminium in the gills of goldfish from Lake Rotoehu (sampled from the Waitangi Springs wetland) compared with other lakes is evidence of greater water-borne exposure to this element, presumably resulting from addition of alum to the Waitangi Soda Springs inflow. Concentrations in gill tissue are generally much higher than any internal tissue in fish (Howells et al. 1990) although this generally does not cause uptake and accumulation in internal tissues. The relatively greater concentrations in goldfish livers compared with the gills is unusual in fish. Common bully downstream of the alum dosing station on the Utuhina Stream accumulated around 8-fold greater aluminium in the gills compared with the liver (Ling 2013b), and during short-term (48 hours) exposures, aluminium accumulated in the gills of common carp was approximately ten-fold greater than in visceral tissues (Muramoto 1981). Bioaccumulation in goldfish liver is presumably due to dietary uptake arising from sediment ingestion but this has not been studied in goldfish.

No significant differences in the average concentration of aluminium were found in internal tissues of either kōura or goldfish when compared with the same species sampled from either one or both of the comparison lakes in 2013 or 2015. Although the Waitangi Soda Springs alum dosing would appear to elevate the bioavailability of aluminium as indicated by slight elevation of aluminium accumulation in the gills of goldfish sampled from the adjacent wetland, internal body burdens of aluminium appear little different compared with the same species in other lakes and the alum dosing of the Waitangi Springs inflow does not appear to have any adverse effect on either goldfish or koura in Lake Rotoehu.

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