Modelling diffuse nitrogen inputs to lakes – groundwater time lags and attenuation in Rotorua and Taupo

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Nitrogen limits phytoplankton growth in several lakes in the central volcanic plateau, North Island, New Zealand. Since the 1940s the intensification of livestock farming has increased nitrogen exports from pasture and contributed to deterioration in lake water quality. These changes went undetected for many years because much of the nitrate exported from pasture is transported to the lakes via deep aquifers with mean residence times of decades to centuries. However, increasing trends are now apparent in stream nitrogen concentrations, and modelling is being undertaken to help managers decide how best to reduce lake loads.

The ROTAN model has been developed, based on the HBV model (Pettersen et al. 2001). It simulates land use, aquifers, springs, streams and total input to the lake from 1900-2100 using a daily or weekly time step. Nitrogen exports are estimated using the OVERSEER® model (http://www.overseer.org.nz), and from historic land use maps and agricultural statistics. Mean residence times estimated from measured tritium tracer concentrations (Morgenstern et al. 2005) are used to size the aquifers. ROTAN has been calibrated using data from the nine major streams that flow into Lake Rotorua, and in the Tutaeuaua, a sub-catchment of Lake Taupo.

In Rotorua the modelling indicates that nitrogen attenuation is negligible in catchments with low streamflow yields and few riparian wetlands in their headwaters. The likely reason is that, in the headwaters, nitrate infiltrates into deep groundwater and only emerges in springs near the lake edge. Groundwaters are well aerated and denitrification is negligible. Streams are short and there are few wetlands. However, in catchments where stream flow yields are high and wetlands are abundant, significant nitrogen attenuation is observed. In the Tutaeuaua, streamflow yield is high in the headwaters, and there are abundant riparian wetlands. Measured stream loads at the catchment outlet are less than the sum of the OVERSEER® exports, implying significant attenuation. However, groundwater lags complicate the comparison between exports and stream loads. Attenuation is likely to occur in the riparian wetlands (Rutherford et al. 2009). There is evidence of anaerobic conditions in parts of the groundwater (Hadfield 2001) where denitrification may also contribute to attenuation.

The ROTAN model is being used to quantify groundwater lag times, wetland attenuation, groundwater denitrification, and stream attenuation in order to help managers reduce the adverse impacts of diffuse source nitrogen.

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