Geophysical Research Abstracts
Vol. 15, EGU2013-13188-1, 2013
EGU General Assembly 2013

Memory of the Lake Rotorua catchment - time lag of the water in the catchment and delayed arrival of contaminants from past land use activities

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The transit time distribution of streamflow is a fundamental descriptor of the flowpaths of water through a catchment and the storage of water within it, controlling its response to landuse change, pollution, ecological degradation, and climate change. Significant time lags (catchment memory) in the responses of streams to these stressors and their amelioration or restoration have been observed. Lag time can be quantified via water transit time of the catchment discharge.

Mean transit times can be in the order of years and decades (Stewart et al 2012, Morgenstern et al., 2010). If the water passes through large groundwater reservoirs, it is difficult to quantify and predict the lag time. A pulse shaped tracer that moves with the water can allow quantification of the mean transit time.

Environmental tritium is the ideal tracer of the water cycle. Tritium is part of the water molecule, is not affected by chemical reactions in the aquifer, and the bomb tritium from the atmospheric nuclear weapons testing represents a pulse shaped tracer input that allows for very accurate measurement of the age distribution parameters of the water in the catchment discharge.

Tritium time series data from all catchment discharges (streams and springs) into Lake Rotorua, New Zealand, allow for accurate determination of the age distribution parameters. The Lake Rotorua catchment tritium data from streams and springs are unique, with high-quality tritium data available over more than four decades, encompassing the time when the bomb-tritium moved through the groundwater system, and from a very high number of streams and springs. Together with the well-defined tritium input into the Rotorua catchment, this data set allows for the best understanding of the water dynamics through a large scale catchment, including validation of complicated water mixing models.

Mean transit times of the main streams into the lake range between 27 and 170 years. With such old water discharging into the lake, most of the water inflows into the lake are not yet fully representing the nitrate loading in their sub-catchments from current land use practises. These water inflows are still 'diluted' by pristine old water, but over time, the full amount of nitrate load will arrive at the lake. With the age distribution parameters, it is possible to predict the increase in nitrate load to the lake via the groundwater discharges.

All sub-catchments have different mean transit times. The mean transit times are not necessarily correlated with observable hydrogeologic properties like hydraulic conductivity and catchment size. Without such age tracer data, it is therefore difficult to predict mean transit times (lag times, memory) of water transfer through catchments.

References:

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