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Dating of Streamwater Using Tritium in a Post Nuclear Bomb Pulse World: Continous Variation of Mean Transit Time With Streamflow

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Introduction

The source of the baseflow component in streams is usually groundwater. This truism and the fact that baseflow is often the dominant component of streamflow shows that in order to understand the quantity and quality of streamflow, we need to understand the dynamics and volumes of the underlying groundwater resource feeding the stream. Currently we still have limited understanding of the dynamics of the groundwater component that is transmitting much of the water from rainfall to streams. According to the dynamics of these underlying groundwaters, the streams' response is modulated in flow and strongly damped and delayed in hydrochemical composition compared to rainfall.

The age of the groundwater is a fundamental parameter of the groundwater dynamics, and accurate groundwater ages can greatly improve our conceptual understanding of streamflow generation.

Methods and Results

Now that bomb-test tritium has effectively disappeared from hydrological systems in New Zealand, tritium dating of stream water is possible with single tritium measurements without the need for time-series data. Tritium measurements of streamwater draining the Toenepi catchment, a small dairy farming area in Waikato, New Zealand, have shown a continuous variation of mean transit time with streamflow rate.

Conclusion

The mean transit time of the water varies with the flow rate of the stream. Mean transit times are 2–5 years during high baseflow conditions (in winter), becoming older (3-4 decades) as streamflow decreases (in summer), and then quite dramatically older during drought conditions, with ages of more than 100 years. Older water seems to be gained in the lower reaches of the stream, compared to younger water in the headwater catchment. The groundwater store supplying baseflow was estimated from the mean transit time and average baseflow to be 15.4 x 10+6 m3 of water, about 1 m water equivalent over the catchment and 2.3 times total annual streamflow. Nitrate is relatively high at higher flow rates in winter, but is low at times of low flow with old water. This reflects both lower nitrate loading in the catchment several decades ago as compared to the current intensive dairy farming, and denitrification processes occurring in the older groundwater. Silica, leached from the aquifer material and accumulating in the water in proportion to contact time, is high at times of low streamflow. There was a good correlation between silica concentration and streamwater age, which potentially allows silica concentrations to be used as a proxy for age when calibrated by tritium measurements.