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Estimating subsurface water volumes and transit times in Hokkaido river catchments, Japan, using high-accuracy tritium analysis

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The goal of this study is to estimate subsurface water transit times and volumes in headwater catchments of Hokkaido, Japan, using the New Zealand high-accuracy tritium analysis technique. Transit time provides insights into the subsurface water storage and therefore provides a robust and quick approach to quantifying the subsurface groundwater volume.

Our method is based on tritium measurements in river water. Tritium is a component of meteoric water, decays with a half-life of 12.32 years, and is inert in the subsurface after the water enters the groundwater system. Therefore, tritium is ideally suited for characterization of the catchment's responses and can provide information on mean water transit times up to 200 years. Only in recent years has it become possible to use tritium for dating of stream and river water, due to the fading impact of the bomb-tritium from thermo-nuclear weapons testing, and due to improved measurement accuracy for the extremely low natural tritium concentrations.

Transit time of the water discharge is one of the most crucial parameters for understanding the response of catchments and estimating subsurface water volume. While many tritium transit time studies have been conducted in New Zealand, only a limited number of tritium studies have been conducted in Japan. In addition, the meteorological, orographic and geological conditions of Hokkaido Island are similar to those in parts of New Zealand, allowing for comparison between these regions. In 2014, three field trips were conducted in Hokkaido in June, July and October to sample river water at river gauging stations operated by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). These stations have altitudes between 36 m and 860 m MSL and drainage areas between 45 and 377 km2. Each sampled point is located upstream of MLIT dams, with hourly measurements of precipitation and river water levels enabling us to distinguish between the snow melt and baseflow contributions to the river discharge. For the June sampling, the tritium and stable isotope results indicate below normal river discharges with a strong contribution of snow melt at some sampling points, and relatively short groundwater transit times. The tritium concentration results are used to interpret mean transit times (MTTs) for each sampling point using a tritium input curve constructed from historical International Atomic Energy Agency and available Japanese data, and subsurface volumes are estimated from the MTTs and measured river discharges.