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Flexible tools for interpreting tracer measurements and recent applications

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Steady increase of groundwater abstraction and nitrate concentrations in groundwater due to agricultural and industrial practices is a major concern for groundwater availability and deterioration of groundwater quality in New Zealand. Studies on groundwater in the Waimea Plains (for example) have shown effects of nitrate input from both diffuse and point sources since 1940. Groundwaters in gravel aquifers under Christchurch have also been studied since 1970 to characterise their flowpaths and recharge sources. In these and other cases, the mixing of waters from different recharge sources following different flow paths can be determined with the use of various tracers and the future course of nitrate concentration in the groundwaters predicted.

The input of radionuclides to hydrological systems from nuclear weapons testing in the 1950s and 60s revealed that outflows from such systems often comprise mixtures of water with very wide ranges of ages. Many authors have described methods of deconvolving such outputs with the use of lumped parameter models (LPMs). LPMs are evaluated using specialized software or Excel spreadsheets to compute simulations to measurements of system outputs and therefore estimate parameters of the age distribution. Excel allows easy modification of the code to enable application to individual hydrological features and for a variety of isotopes and chemicals. For the New Zealand studies, Excel spreadsheets with coded Visual Basic functions are used to deduce age distributions based on stable isotope, SF6, CFCs, 3H and 14C data (in order of ages). In particular, 3H is becoming increasingly useful as an age tracer due to the decrease of ambiguity from nuclear testing provided that the measurements can be made with high accuracy (Stewart et al., 2012).These age distributions allow us to derive the input histories of chemicals (e.g. nitrate) and the groundwater recharge sources. In addition, recent developments in modelling groundwater flow and tracer transport (e.g. 3H) with distributed parameter models (DPMs) are allowing high levels of complexity unavailable in LPMs (Gusyev et al., 2011). However, LPMs in relatively simple Excel spreadsheets still remain an attractive alternative to expensive and complex DPMs, and will continue to provide useful insights for interpreting tracer measurements in surface and subsurface waters.

References:
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