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Separating streamflow components to reveal nutrient flowpaths: Toenepi Stream

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Separating streamflow into its components is valuable for understanding the sources and flowpaths of water and solutes in catchments, in particular nutrient flowpaths. Tracers give an objective basis for hydrograph separations, but such tracer data is usually quite limited in time even if available for a catchment. A new separation method (the bump and rise method or BRM, Stewart 2014) gives a filter that can be calibrated by fitting to tracer separations and then applied to the whole streamflow record. Or if no tracer data is available, can be calibrated more approximately by fitting to the recession hydrograph.

The value of the procedure is illustrated by applying it to Toenepi Stream, which drains a lowland dairy farming catchment of 15.1 km^2 in Waikato, New Zealand. Tracer (chemical and tritium) measurements show that streamflow is made up of three major end-members or components in varying proportions: high-nitrate quickflow, young nitrate-bearing fast groundwater from a shallow aquifer, and old nitrate-free slow groundwater from a deeper aquifer. Hydrographs of these three components were determined by applying the BRM filter twice, once to the streamflow and then again to the baseflow. The results show that (1) quickflow responds rapidly to rainfall but contributes only a minor part of the stream peak, (2) fast groundwater also responds rapidly and contributes most of the stream peak, and (3) slow groundwater shows little immediate response but begins a very gradual rise in contribution after rainfall. By assuming constant nitrate concentrations for the three components, the continuous variation of nitrate in the streamflow was calculated and showed good agreement with spot streamflow measurements. Nitrate concentrations reached very low levels during very low flows when the stream was dominated by the slow groundwater, and increased with flow as the proportions of quickflow and fast groundwater increased. The BRM method was flexible enough to enable separation of the streamflow into three components, and the procedure gave results comparable to the modelling study of Woodward et al. (2013).

References

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