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Water transit time distributions as indicators of nitrate transport systematics in different agriculturally used catchments

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The transit time distribution (TTD) of water is a fundamental parameter in hydrogeology, revealing information about the distribution of flow pathways and the origin of water in a catchment. Hence, the TTD of groundwater or of water discharging from a catchment may be used as an indicator to assess the transport of solutes like nitrate in groundwater wells or streams of agriculturally used catchments. Here we present hydrochemical and isotopic data from 4 subcatchments of the Weisse Elster basin, Germany, which range from the small to the meso scale. Catchment TTDs have been modeled using measured time series of the stable (18O and 2H) and radioactive (tritium) isotopes of water (sampled weekly to bi-weekly). In case of groundwater wells additional environmental tracers (tritiogenic 3He, CFCs) were used to further constrain the groundwater TTD.
Mean residence times for baseflow range from 3 to 10 years (exponential and dispersion model) and most probably are mainly controlled by the geological characteristics of the subcatchments. However, all investigated catchments showed a positive relationship between nitrate and stream discharge indicating that a major part of the nitrate load is released during and after storm runoff. TTDs based on stream samples during baseflow as well as stormflow conditions show substantially lower mean residence times of less than 1 to about 4 months. However, the calculation of a reliable TTD on the event time scale is limited by the ‘steady state’ assumption required for the modeling of the TTD with lumped parameter models.
If the temporal variation of nitrate input into the subsurface is known, the TTD calculated from environmental tracers and isotopes can be used to estimate the development of nitrate concentrations in water and hence to evaluate management options and measures. This has been done in a small groundwater catchment used for drinking water purposes. The derived TTDs with high mean residence times of >30a suggest, that nitrate levels will remain below the drinking-water limit because the shallow and therefore most vulnerable part of the aquifer is not connected to the well screens.