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Identification of groundwater nitrate sources in pre-alpine catchments: a multi-tracer approach

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Porous aquifers in pre-alpine areas are often used as drinking water resources due to their good water quality status and water yield. Maintaining these resources requires knowledge about possible sources of pollutants and a sustainable management practice in groundwater catchment areas. Of particular interest in agricultural areas, like in pre-alpine regions, is limiting nitrate input as main groundwater pollutant. Therefore, the objective of the presented study is i) to identify main nitrate sources in a pre-alpine groundwater catchment with current low nitrate concentration using stable isotopes of nitrate (d18O and d15N) and ii) to investigate seasonal dynamics of nitrogen compounds. The groundwater catchment areas of four porous aquifers are located in Southern Germany. Most of the land use is organic grassland farming as well as forestry and residential area. Thus, potential sources of nitrate mainly are mineral fertilizer, manure/slurry, leaking sewage system and atmospheric deposition of nitrogen compounds. Monthly freshwater samples (precipitation, river water and groundwater) are analysed for stable isotope of water (d2H, d18O), the concentration of major anions and cations, electrical conductivity, water temperature, pH and oxygen. In addition, isotopic analysis of d18O-NO_3- and d15N-NO_3- for selected samples is carried out using the denitrifier method. In general, all groundwater samples were oxic (10.0$\pm$2.6mg/L) and nitrate concentrations were low (0.2 – 14.6mg/L). The observed nitrate isotope values in the observation area compared to values from local precipitation, sewage, manure and mineral fertilizer as well as to data from literature shows that the nitrate in freshwater samples is of microbial origin. Nitrate derived from ammonium in fertilizers and precipitation as well as from soil nitrogen. It is suggested that a major potential threat to the groundwater quality is ammonia and ammonium at a constant level mainly from agriculture activities as well as continuously release of nitrogen stored in agricultural soils due to mineralization processes. In all groundwater and river water samples a seasonal variation of nitrate sources and concentration is absent but nitrate in precipitation shows a clear seasonal variation with peaks in spring and fall according to agricultural activity. This points to dilution effects of high nitrate inputs due to the large groundwater volume and mean residence time and highlights the function of soil as initial sink for nitrogen compounds delivered by fertilizer. Even though nitrate contamination was low in the study area, the results emphasize the importance of reducing additional nitrate sources in pre-alpine oxic aquifers. This will maintain the good water quality status of the aquifers and enable its use for drinking water supply.