# Identification of sources and infiltration regimes of nitrate in the semi-arid Kalahari: Regional differences and implications for groundwater management

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## Abstract

The Kalahari region of southern Africa offers much potential for nitrogen input into its groundwater. High nitrate concentrations in Kalahari groundwater are therefore quite common and are caused by both anthropogenic and natural sources. Forecasting groundwater nitrate concentrations remains challenging. Source identification of nitrate contamination in groundwater is an important first step for groundwater management and quality prediction, and is aided by isotope analysis of nitrate in the water. Comparative data from 3 groundwater study sites in the Kalahari of Botswana and Namibia with widely different characteristics are presented. Two of the sites (Ghanzi and Gobabis) have shallow water tables in fractured quartzite. These aquifers were affected by pollution from cattle wastes (manure) and septic tank outflows resulting in groundwater nitrate levels exceeding 1 000 mg $NO_3/\ell$ and in $\delta^{15}N$ values of between +7 and +20 ‰ AIR. Short-term increases of groundwater nitrate concentrations were triggered by exceptional rainfall events occurring every 10-20 years. At the third site (Serowe in Botswana) there is similar land use and land cover, yet the aquifers are deeper, groundwater dates to Late-Pleistocene age and borehole levels do not show a response to present-day high-rainfall episodes. Nitrate levels up to 219 mg/ℓ are found, but lower $^{15}N$ content ($\delta^{15}N$ of +3 to +8 ‰) indicates a natural origin of the nitrate. In this area pollution nitrate is sufficiently delayed in the vadose zone, reaching the saturated zone much later. The data from all 3 sites suggest that nitrogen management options can only be evaluated once an understanding of sources, processes and flow patterns has been established.

**Keywords:** nitrate**,** groundwater contamination, stable isotopes, $^{15}N$, recharge, flow, aquifer