EXECUTIVE SUMMARY

Ground water in Limpopo Province of South Africa is characterised by the wide spread occurrence of high nitrate concentrations which were generally accepted to be of anthropogenic origin. In a ground water resource study in the Taaibosch Karoo graben, part of an International Atomic Energy Agency regional study, environmental isotope, hydrochemical and hydrogeological suggested a model for the natural production of high nitrate concentrations in a basalt aquifer. This was investigated further under a WRC contract, which foresaw a second phase in a different (hydro)geological environment. The area chosen was Bochum, with numerous rural villages, underlain by metamorphic granite and sandstone. Two sets of samples were taken from boreholes equipped with either hand pumps or motorised pumps that were analysed for major ion chemistry and both stable and radioactive isotopes.

The ground water from both the crystalline and sedimentary aquifers at Bochum was found to be quite recent showing none of the older component and mixtures that characterises the Taaibosch area, conforming to the model for a phreatic aquifer with shallow fracture development. The stable isotopes show similar rainfall selectivity of recharge as at Taaibosch, but without evaporative enrichment due to ponding. Hydrochemical development shows distinctive differences between the two aquifer groups with an absence of ion exchange, already suggested by the carbon-13/carbon-14 relationship. The trend is from an initial expected Ca,Mg-HCO_3 dominance to a more Na, Cl and SO_4 mineralised type. An incidence of high NO_3 values similar to Taaibosch was observed.

Nitrate concentrations show an increase with increasing ground water residence time but not with mineralisation, suggesting sub-surface production. The increase of Si with increasing NO_3 that characterises Taaibosch is absent. There appears also to be no correlation with the aquifer environment. Nitrogen isotope ratios that may be diagnostic of anthropogenic pollution show no correlation with nitrate concentration, but a pronounced dependence on the dissolved oxygen in ground water. This is ascribed to dentrification that may in turn indicate widespread presence of dissolved organic carbon. An extreme case of sewage pollution in a borehole shows complete denitrification. These observations caution against simply regarding nitrate concentrations as a measure of pollution.

We conclude from this study that although high nitrate concentrations at Bochum have an anthropogenic component, the natural, tree-root driven process may also contribute. This particular and pronounced process may well be a characteristic of basalt aquifers in general. The study has shown that isotopic information is essential in understanding the hydrological and chemical processes that underlie phenomena such as nitrate development. It is recommended that isotope studies be more widely applied in hydrogeology; that a reliable, routine facility for nitrogen isotope analysis in water be established and that the occurrence of nitrate in (Karoo) basalt aquifers, such as underlying the Springbok Flats, be re-visited.