DECLARATION:

I declare that: **The assessment of the causes of high nitrate concentrations in groundwater in Bochum district, Limpopo Province** is my own work, which has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Name: **S.C. Mutheiwana**

Signed: **……**

Date: **22 NOVEMBER 2010**

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ABSTRACT

Groundwater 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 groundwater resource study in the Taaibosch Karoo graben, part of an International Atomic Energy Agency regional study, environmental isotope, hydrochemical and hydrogeological data 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, taken from boreholes equipped with either hand pumps or motorised pumps, were analysed for major ion chemistry and both stable and cosmogenic radioactive isotopes.

The groundwater 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 of a phreatic aquifer with shallow fracture development. The stable isotopes show similar rainfall selectivity at recharge, but without evaporative enrichment due to surface ponding observed in the flatter topography at Taaibosch. There is a distinctive difference in hydrochemical development between the two aquifer groups with an absence of ion exchange, also 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. The frequency of high NO_3 values is similar to that observed at Taaibosch.

Nitrate concentrations show an increase with increasing groundwater residence time but not with mineralisation, suggesting sub-surface production. The striking co-incidence of high concentrations of Si with high NO_3 that characterises Taaibosch groundwater is also encountered in the Bochum area. There is no clearly discernible correlation with the aquifer environment. Nitrogen isotope ratios, which may be diagnostic of anthropogenic pollution, show no correlation with nitrate concentration, but a pronounced dependence on the dissolved oxygen in groundwater. This is ascribed to denitrification that may in turn indicate the 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 anthropogenic pollution.

It is concluded from this study that although high nitrate concentrations at Bochum have an anthropogenic component, the natural, tree root driven process, proposed at Taaibosch may also contribute in spite of pronounced hydrogeological differences. The study has emphasised that isotopic information is essential in understanding the hydrological and chemical processes that underlie phenomena such as nitrate development in groundwater.

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