our future through science

State of Nitrate Pollution in Groundwater in South Africa

A MAHERRY, G TREDOUX, S CLARKE AND P ENGELBRECHT
CSIR Natural Resources and the Environment, PO Box 395, Pretoria, 0001, South Africa
Email: amaherry@csir.co.za – www.csir.co.za

INTRODUCTION

The study of nitrate concentrations in South and southern Africa is not a new subject (Tredoux and Talma, 2006, Tredoux et al., 2004), with the publication of a nitrate distribution map in 2001. However, these studies were constrained by the amount of data obtained, GIS software and computer processing power, making it difficult to determine the levels of and extent to which nitrate occurs (Tredoux et al., 2001).

The aims of this study were to:

1. Produce an updated view of the nitrate distribution for the country;
2. Identify whether there are any gaps or significant changes in the distribution of nitrate concentration over the last two decades;
3. Evaluate high priority areas based on their nitrate levels, population and dependence on groundwater as a source of drinking water; and
4. Identify areas for priority research and nitrate remediation.

As is customary in South Africa, all nitrate and nitrite concentrations in this paper are expressed as an equivalent quantity of nitrogen (N) except where explicitly stated otherwise (**Table 1**).

RESULTS AND DISCUSSION

Plots of the count, minimum, average and maximum levels of nitrate were compiled for the entire country. Categories selected were based on the guideline values for drinking water nitrate levels. The results of the point analysis are shown in **Figure 1**.

Table 1: South African water quality guideline values for potable use and livestock watering

Drinking water class	as N	as NO3	Comments
Nitrate plus Nitrite (mg/L)			DWAF (1998)
Ideal	<6	<26	Negligible health effects
Acceptable	6-10	26-44	Insignificant risk
Marginal	10-20	44-89	Slight chronic risk to some babies
Poor	20-40	89-177	Possible chronic risk to some babies
Unacceptable	>40	>177	Increasing acute health risk to babies
Livestock watering	as N	as NO3	DWAF (1996)
Nitrate(mg/L)	0-90.3	0-400	
Livestock watering	as N	as NO2	DWAF (1996)
Nitrite (mg/L)	0-12.3	0-40	

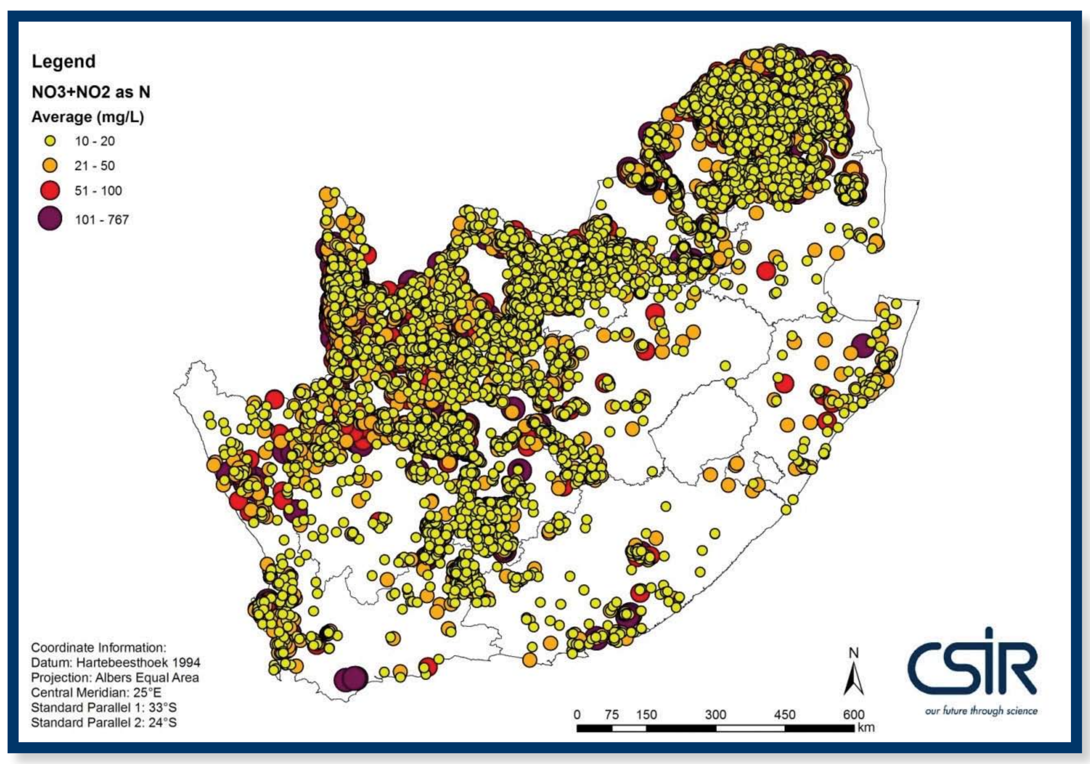

Figure 1: Average NO3+NO2 as N greater than 10 mg/L per sampling station until 2008

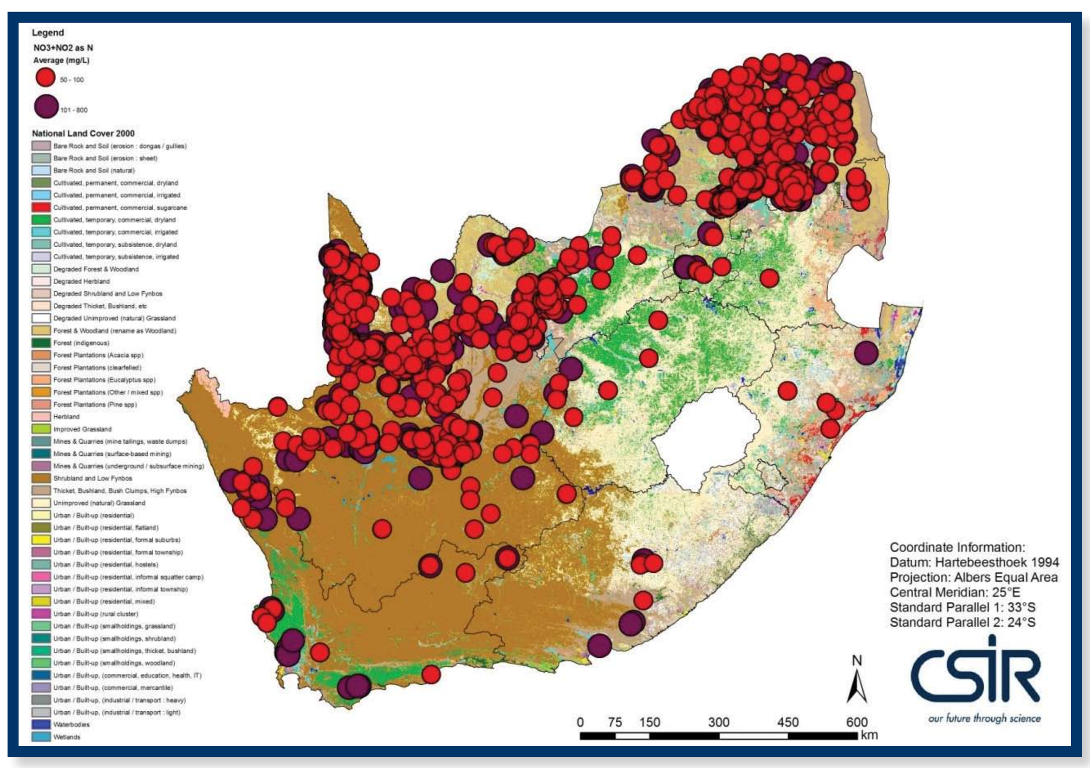

Figure 2: Average NO3+NO2 as N greater than 50 mg/L per National Landcover 2000 class

Table 2: Average nitrate and nitrite values per National Landcover 2000 class

NLC2000 landcover classes	Average NO3+ NO2 as N	NLC2000 landcover classes	Average NO3+ NO2 as N
Bare rock and soil (erosion: dongas / gullies)	4.1	Mines and quarries (underground / subsurface mining)	40.8
Bare rock and soil (erosion: sheet)	8.8	Shrubland and low fynbos	8.7
Bare rock and soil (natural)	3.2	Thicket, bushland, bush clumps, high fynbos	9.9
Cultivated, permanent, commercial, dryland	15.3	Unimproved (natural) grassland	6.6
Cultivated, permanent, commercial, irrigated	3.9	Urban / built-up (residential)	7.9
Cultivated, permanent, commercial, sugarcane	3.9	Urban / built-up (residential, formal suburbs)	5.1
Cultivated, temporary, commercial, dryland	14.4	Urban / built-up (residential, formal township)	18.5
Cultivated, temporary, commercial, irrigated	6.8	Urban / built-up (residential, hostels)	0.0
Cultivated, temporary, subsistence, dryland	12.3	Urban / built-up (residential, informal squatter camp)	6.8
Cultivated, temporary, subsistence, irrigated	3.4	Urban / built-up (residential, informal township)	13.0
Degraded forest and woodland	16.2	Urban / built-up (residential, mixed)	3.3
Degraded shrubland and low fynbos	6.2	Urban / built-up (rural cluster)	18.9
Degraded thicket, bushland, etc	9.6	Urban / built-up (smallholdings, grassland)	2.9
Degraded unimproved (natural) grassland	4.2	Urban / built-up (smallholdings, shrubland)	8.0
Forest (indigenous)	2.4	Urban / built-up (smallholdings, thicket, bushland)	8.8
Forest plantations (Acacia spp)	0.4	Urban / built-up (smallholdings, woodland)	9.6
Forest plantations (clearfelled)	2.1	Urban / built-up, (commercial, education, health, IT)	7.2
Forest plantations (Eucalyptus spp)	3.1	Urban / built-up, (commercial, mercantile)	5.8
Forest plantations (Other / mixed spp)	0.6	Urban / built-up, (industrial / transport : heavy)	5.4
Forest plantations (Pine spp)	1.3	Urban / built-up, (industrial / transport : light)	2.4
Herbland	2.9	Waterbodies	9.4
Improved grassland	4.5	Wetlands	12.6
Mines and quarries (mine tailings, waste dumps)	3.9	Woodland (previously termed forest and woodland)	10.9
Mines and quarries (surface-based mining)	8.7		

Figure 2 shows the average NO_3 and NO_2 as N per class greater than 50 mg/L for the National Landcover 2000 and summarised in **Table 3**. Elevated levels of nitrate can be seen in the mines and quarries landcover class with an average in excess of 40. **Table 2** shows that urban areas have elevated levels of nitrate, in particular the rural cluster, formal and informal townships.

Indigenous forests and forest plantations have low nitrate concentrations in groundwater. Woodland has a higher nitrate while degraded forest and woodland have even higher nitrate levels. One can also see elevated levels of nitrate within the agricultural sector namely, permanent and temporary commercial dryland and temporary subsistence dryland farming.

Although it would seem obvious that the elevated nitrate has to be related to the application of fertiliser to land, Conrad *et al.* (1999) found that the nitrate had the isotopic character of soil nitrogen and not of fertiliser. Thus, it was concluded that the tilling of the soil caused nitrification of the soil nitrogen and leaching of nitrate into the subsurface.

CONCLUSIONS

This exercise proved to be invaluable to the project. Specific areas can now be selected for further investigation. Conclusions drawn from the updated nitrate distribution maps include the following:

- The Western Cape would seem to be more affected by elevated nitrate concentrations over the last decade than before;
- Limpopo and Kalahari region are still strongly affected by elevated nitrate concentrations;
- There is a scarcity of data points in certain urban centres as well as in the central part of the country;
- Scarcity of data points may affect the interpolation process; and
- A part of the Northern Cape now lacks data which were used in the previous 2001 map. This may indicate abandonment of well field, a halt to sampling or an error in the database. This area previously had elevated nitrate levels.

A CSIR study identifies the Northern Cape and Limpopo as areas for priority research and implementation for remediation technologies. It is within these rural communities where untested groundwater is used as the main drinking water source.

Elevated nitrate levels are associated with mining areas, urban areas, in particular the rural cluster, formal and informal townships. Elevated levels of nitrate occur within the agricultural sector namely, the NLC2000 classes of 'permanent and temporary commercial dryland' and 'temporary subsistence dryland farming'. Nitrate pollution and elevated nitrate concentrations in South Africa still persist. The extent and distribution would seem to be increasing with new areas being affected. The lack of data in certain parts of the country may be obscuring the actual extent of the state of nitrate pollution in South Africa.

Although actual site selection should only be done following site visits and evaluation for suitability to the remediation technology criteria, regions selected as areas for priority research and implementation for remediation technologies include: the Western Cape (west and south east coastal areas), the Northern Cape and Limpopo.

REFERENCES

Conrad, J.E., Colvin, C., Sililo, O., Görgens, A., Weaver, J. and Reinhardt, C. 1999. Assessment of the impact of agricultural practices on the quality of groundwater resources in South Africa. Water Research Commission Report 641/1/99.

Tredoux, G., Engelbrecht, J.F.P. and Talma, A.S. 2001. Nitrate in groundwater in Southern Africa. (In Seiler and Wohnlich (eds.), New approaches characterising groundwater flow. Swets & Zeitlinger Lisse, p. 663-666.

Tredoux, G., Engelbrecht, J.F.P. Talma, A.S. and Israel, S. 2004. Groundwater nitrate: a rural water supply threat. 5th WaterNet/WARFSA Annual Symposium, Windhoek, Namibia, XXX, XXX, XXX: XXX.

Tredoux, G. & Talma, AS. 2006. Nitrate Pollution of Groundwater in Southern Africa. In: Groundwater Pollution in Africa, edited by Y. Xu and B. Usher, Taylor and Francis plc, London, UK.

Van den Berg, E.C., Plarre, C., Van den Berg, H.M. and Thompson, M.W. 2008. The South African National Land Cover 2000. Agricultural Research Council, Institute for Soil, Climate and Water. Report No. GW/A/2008/86.

K-8106 [www.kashan.co.za]