our future through science

Simple technologies for complex problems: *in situ* denitrification

S CLARKE
CSIR, PO Box 395, Pretoria, South Africa, 0001
Email: sclarke@csir.co.za – www.csir.co.za

INTRODUCTION

Nitrogen concentrations in groundwater have been studied and the distribution in the country has been highlighted (Tredoux et al., XXXX; Maherry et al, 2011). In South Africa, the ideal drinking water guideline (DWAF, 1998) has less than 6 mg/L nitrate (plus nitrite) as N ('blue' or Class 0), while the 'marginal' water quality guideline is a maximum concentration of 20 mg/L ('yellow' or Class II). This is generally in agreement with the World Health Organization guidelines. However, in many areas of South Africa, nitrate levels exceed the maximum concentration of 40 mg/L of 'poor' water quality, with levels of 100 mg/L or even greater than 200 mg/L found in some places. Water with nitrate exceeding 40 mg/L belongs to the category of 'unacceptable' drinking water quality ('purple' or Class IV).

In this study we considered denitrification of groundwater using low cost robust techniques. Laboratory testing of the methods took place between 2004 and 2006 and was published in 2005, 2007 and 2009. The field implementation of denitrification using what is termed permeable reactive barrier (PRB) was conducted at an industrial site. A schematic of the method is shown in **Figure 1**.

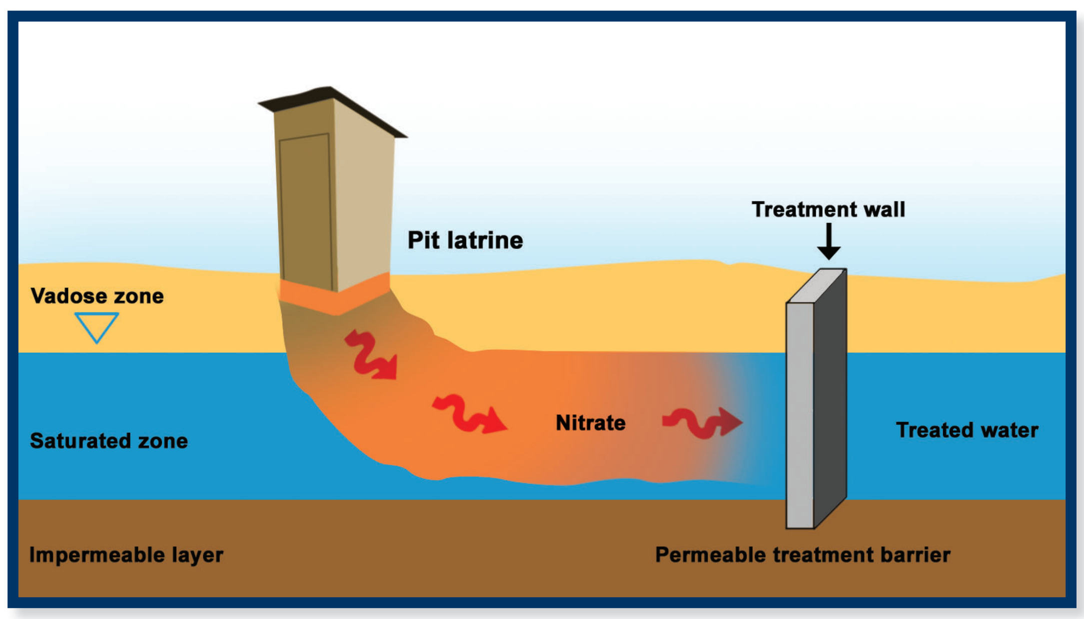

Figure 1: Schematic drawing of field set-up for permeable reactive barrier-type method of denitrification

This method involves using cheaply available material as a substrate for denitrification. Denitrification is a natural process and an integral part of the nitrogen cycle that converts NO_3- to nitrogen gas with a few probable intermediates. Oxidation states of nitrogen species changes throughout the cycle, with NO_3- being the most oxidised form, and NH_4+ the most reduced form of nitrogen. The reactive material has to be placed in such a way that the groundwater is intercepted and allowed to react with the carbon substrate.

THE SITE

A study site was obtained for testing this technology in the Somerset West area (**Figure 2**).

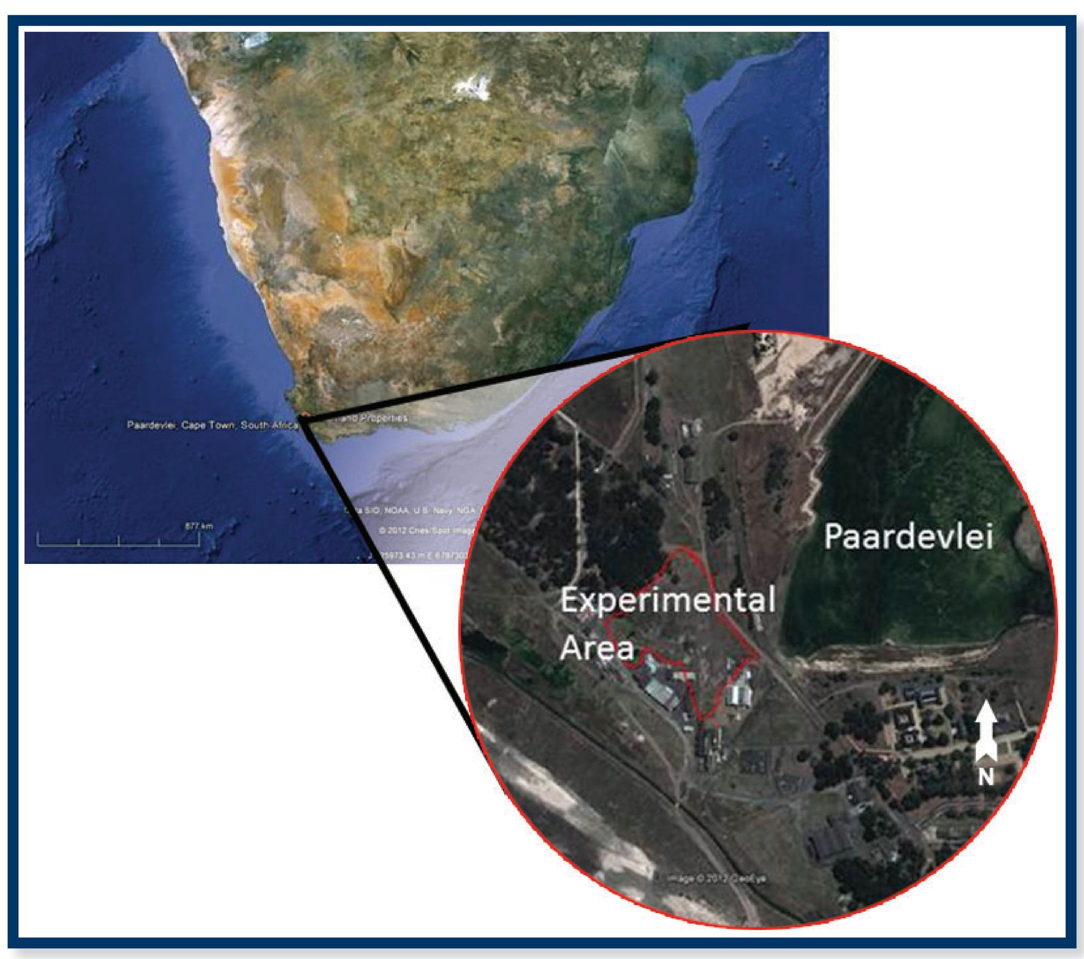

Figure 2: Location of study site in Somerset West, South Africa

The site experienced historical spill events and a contaminant plume was evident. Testing of denitrification at the site proved to be in favour of both the CSIR and AECI. The reactive material used was wood chips located on the AECI site from trees that were removed and run through a wood chipping machine. The aim of the experiment was to evaluate whether denitrification of industrially high nitrate would occur using sawdust, and to determine how effective the sawdust will be in denitrifying. The lifespan of sawdust as a carbon source was also investigated.

Figure 3: Steps during the emplacement of the vessel of carbon amendment for denitrification

The site was monitored for nitrate, ammonia, sulphate, Ph and EC since emplacement during 2010. Monitoring was done biweekly, then monthly after the first year. The first few months' performance is illustrated in **Figure 4**.

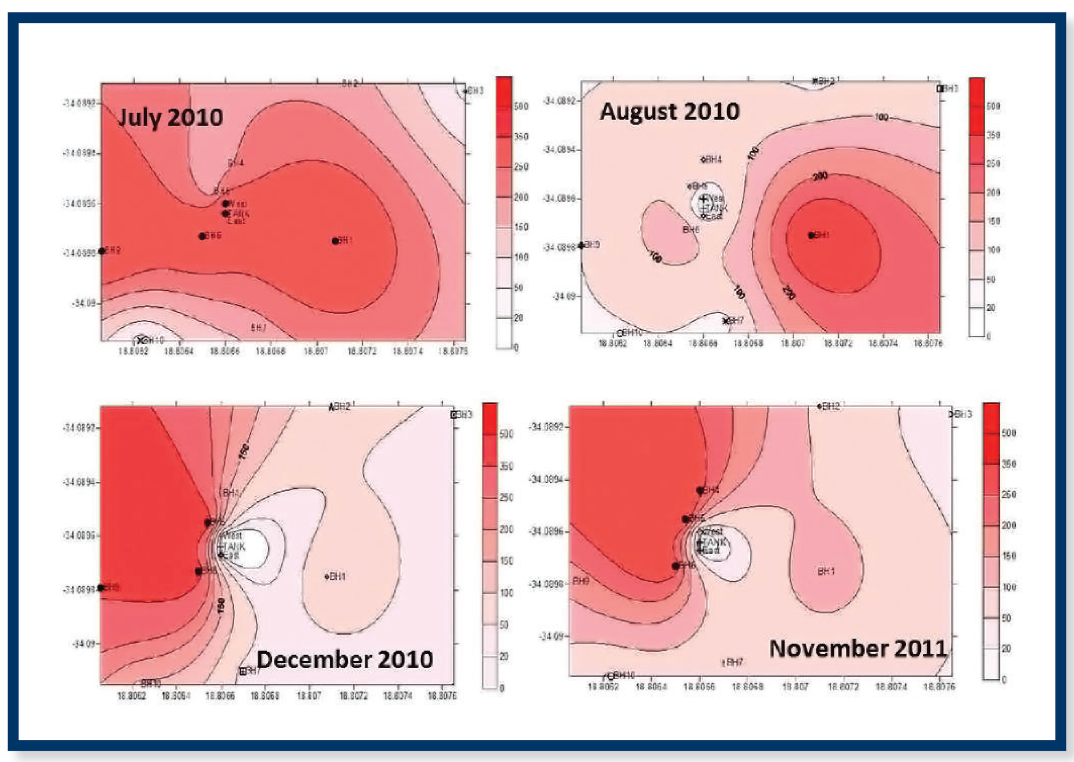

Figure 4: Surface interpolation of the changes in concentration across the AECI site in July 2010 (before emplacement of vessel), and months after the emplacement of the reactive vessel

Figure 4 shows that the wood chips, freely available in some areas, effectively reduced the nitrate concentration in the vessel/tank, as well as the area around it, for as long as one year and six months. Monitoring of this site is still underway. The length of time for which the sawdust denitrifies effectively is important for determining the lifespan of a denitrification barrier.

DISCUSSION AND CONCLUSIONS

This technology is intended to be applied in areas where rural communities have large amounts of groundwater of inferior quality that could be improved to yield safer water. Testing was done at an industrial site for which concentrations are much higher than for that of groundwater, with only extreme cases in groundwater being comparable. The experiment has shown thus far that industrially-high nitrate concentrations in groundwater can be successfully denitrified using wood chips for longer than two years.

In this study, 5 000 kg of sawdust was effectively used to denitrify an industrially-high contaminated site. Total removal of nitrate concentration of up to 600 mg/L NO_3 as N was achieved.

Since monitoring is still underway, the only conclusion that can be made regarding the lifespan is that continual denitrifying for over two years has been achieved using 5 000 kg of sawdust. Total removal of nitrate concentration of up to 600 mg/L NO_3 as N has been achieved at the experimental site.

REFERENCES

DWAF and the Department of Health. 1998. Quality of Domestic Water Supplies, Volume 1: Assessment Guide, Water Research Commission Report No: TT101/98.

Israel, S. 2007. *In situ* denitrification of nitrate rich groundwater in Marydale, Northern Cape. MSc thesis, Faculty of Agriculture, Department of Soil Science, Stellenbosch University.

Israel, S., Tredoux, G., Fey, M.V. & Campbell, R. 2005. Nitrate removal from groundwater and soil. Biennial Ground Water Conference, 7–9 March 2005, CSIR International Convention Centre.

Israel, S., Engelbrecht, P., Tredoux, G., & Fey, M.V. 2009. In Situ bath denitrification of nitrate rich groundwater using sawdust as a carbon source – Marydale, South Africa. Water Air and Soil Pollut., 204:177-194.

Tredoux, G., Talma, AS. & Engelbrecht, J.F.P. 2000. The increasing nitrate hazard in groundwater in the rural areas. Paper presented at WISA 2000, Sun City, RSA, May 2000.

World Health Organization (WHO). 1998. WHO Guidelines for drinking water quality. 2nd edition, addendum to Volume 1: Recommendations. Geneva: WHO, 1998, p-8–10; and addendum to Volume 2: Health Criteria and other Supporting Information.

K-10032 [www.kashan.co.za]