



WHEN WATER TURNS DEADLY

- Investigating Nitrate in SA Groundwater

Nitrogen is an essential part of our environment. It makes up 78% of the air we breathe and is the most important nutrient for plant growth. But excessive levels of nitrogen – in the form of nitrate – are dangerous. In South Africa, excessive nitrate levels are the main reason for many groundwater resources to be declared unfit for drinking.

Lani Holtzhausen reports.

Rural water supply is being extended and improved with great urgency as authorities strive to provide clean drinking water to all. In remote areas, groundwater is often cited as the cheapest and most sustainable form of water supply to previously unserved communities. However, surveys show that high nitrate levels are common in groundwater is common in arid and semi-arid regions of southern Africa, often exceeding drinking water specifications (i.e. above 10 mg/ℓ). The problem is that, for many communities, this is the only available drinking water they have.

Dr Gideon Tredoux with his colleagues, Dr Pannie Engelbrecht and Siep Talma all of CSIR Environmentek, have been studying the occurrence of nitrate in groundwater for many years. "Rural villages and small towns from the Northern Cape to the far southeast of Limpopo are severely affected by these

nitrate concentrations," he tells *the Water Wheel*. "Concentrations range from 50 – 100 mg/ℓ and even well above 100 mg/ℓ in some areas, while in the southern Kalahari concentrations of up to 500 mg/ℓ of nitrate occur in certain areas."

Excessive levels of nitrate (above 40 mg/ℓ) are dangerous to people's health, and may result in infant methaemoglobinaemia. While these health effects are known to occur in South Africa, no comprehensive statistics exist. Dr Tredoux explains that, while methaemoglobinaemia or 'blue baby syndrome' is a notifiable disease, the infants usually arrive at the clinic in such a state that correct diagnosis is very difficult. Thus it is highly likely that the symptoms are not recognised and correctly identified. Often the high nitrate water is also bacterially polluted and other conditions, such as diarrhoea, may mask

the nitrate effect and also aggravate the problem.

In fact, one of the only countries with official statistics is Hungary, and only because the country's Department of Health launched a specific campaign to identify and eliminate the occurrence of methaemoglobinaemia. Hundreds of cases with several mortalities were recorded each year in the 1970s until it was virtually eliminated in the early 1990s. Where alternative supplies were unavailable, mothers and infants were even supplied with nitrate-free bottled water.

HIV/Aids is increasing infants' risk of ingesting high nitrate water as HIV positive mothers are advised to refrain from breast-feeding their babies and rather bottle-feeding them. Thus the pandemic has introduced an urgency element for groundwater nitrate control measures in our region.

THE ORIGIN OF NITRATE

Nitrate accumulates naturally in groundwater under certain conditions. Along the western and south-western edge of the Kalahari, and in the Springbok Flats, for instance, elevated nitrate concentrations are derived from natural soil nitrogen. However, the greatest nitrate contribution is through human activities.

In South Africa, excessive nitrate levels are usually caused through point source pollution. This includes sewage sludge drying beds, land application of sludge, and irrigation of partly treated wastewater. Groundwater pollution of this nature usually occurs around urban centres.

In rural areas, pollution can be caused by the high concentration of livestock at watering points near boreholes, and by inappropriate on-site sanitation. In Delmas, Mpumalanga, many people still make use of the bucket sanitation system. While the causes of the present typhoid outbreak are still under investigation, research into a similar

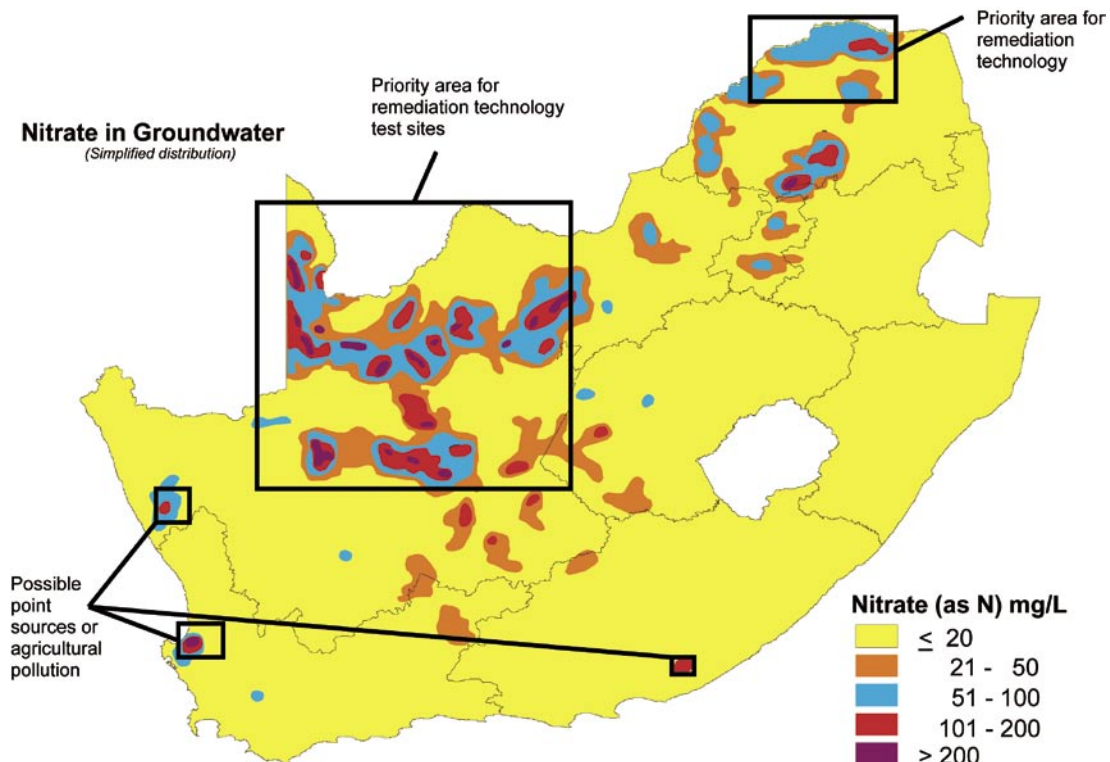
outbreak 12 years ago showed nitrate in the groundwater in addition to faecal pollution.

On-site sanitation has also been identified as a cause of high nitrate levels. In Botswana, for example, in the village of Ramotswa, located south of Gaborone. The problem is usually compounded by the fact that surface waste disposal practices, for example, manure, wastewater and refuse disposal, usually occur in the close vicinity of the water source, and all jointly increase the likelihood of pollution.

There is a feeling that to date the nitrate problem has largely been ignored. One reason could be the fact that groundwater in general has only received attention in the last ten years as a viable and sustainable water supply source. The main reason, however, argues Dr Tredoux, is ignorance of the extent of the nitrate problem. "In Namibia, a countrywide groundwater quality survey was undertaken from 1967 to 1982. During this time all farms and rural areas were visited, most of the existing boreholes sampled, the



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water analysed and the results provided to the farmers and communities free of charge. Feedback on the quality of the water was also provided and hazards, such as high nitrate, fluoride, sulphate and salinity were mentioned and explained. This created an awareness that lasted for at least a generation.”

In South Africa, while we have a fair idea of the geographical extent of the occurrence of nitrate in groundwater, i.e. the potential problem areas, we do not know the nitrate values accurately and certainly not the range of variation in concentration. “The latter is the bigger problem as nitrate concentrations in groundwater can vary widely in certain areas, mostly where it is semi-arid to arid, and the water level is relatively shallow,” explains Dr Tredoux. The variability is such that in certain cases water that is suitable for human consumption may become poisonous even for cattle and will lead to nitrate poisoning and livestock losses.

The instability of nitrate in water samples due to bacterial denitrification also leads to inaccurate results when unpreserved samples are stored any length of time before analysis. This presents a serious problem as it is impossible to know which of the thousands of results stored in databases are reliable.

WHY IS EXCESSIVE NITRATE SO DANGEROUS?

Excessive nitrate levels (above 40 mg/l) can be very dangerous to human health.

When bottle-fed infants digest water containing too much nitrate, this nitrate, when converted to nitrite in the infant’s body interferes with the oxygen carrying capacity of the child’s blood (it replaces the oxygen on the red blood cells).

Children with methaemoglobinaemia, as it is known, will show signs of blueness around the mouth, hands and feet, hence the common name ‘blue baby syndrome’. These children may also have trouble breathing as well as vomiting and diarrhoea. In extreme cases, there is marked lethargy, an increase in the production of saliva, loss of consciousness and seizures. Some cases may be fatal.

Expectant mothers are also at risk as spontaneous miscarriage or still birth may occur when too much nitrate is ingested.

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DANGER TO LIVESTOCK

The risk of livestock loss through nitrate poisoning is largely unknown among the local population



except in Namibia. No statistics are available and information is mostly anecdotal.

One of the largest recently recorded incidences of livestock losses in southern Africa occurred in 2000 on Ghanzi River in the Ghanzi-Karakubis area in Botswana. At least 356 heads of cattle died as a result of nitrate poisoning. In 2002 a further incident of livestock loss occurred at Kautsha, north of Ghanzi, where 28 heads of cattle died. Livestock losses are a sensitive issue as the farmers are at risk not to be able to market their cattle when this is due to a disease, and the farmers may not be aware that nitrate poisoning is non-contagious.

Another confirmed case of nitrate poisoning occurred in 2001 when at least 60 heads of cattle died on a farm near Thabazimbi, Limpopo.

More research is needed to understand the nitrogen cycle in the context of natural groundwater recharge, particularly in the (semi) arid areas. "In the developed countries extensive research has been carried out under humid conditions. However, in the arid zone the transport of nitrate from the soil zone into the groundwater is not fully understood." says Dr Tredoux.

It would seem that in the drier regions a large load of nitrate (and other salts) is stored in the subsurface and this only reaches the groundwater table after intense rainfall events. Preferential flow and other phenomena significantly add to the complexity.

MANAGING THE PROBLEM

Once an aquifer is polluted it will remain in that state indefinitely. Rehabilitation is a tedious, expensive, and time-consuming operation with limited success. While efficient methods exist to treat nitrate-rich groundwater, these require high technology, are expensive or both. Present treatment methods range from biological denitrification to ion exchange and reverse osmosis although *in-situ* methods (i.e. treating the water within the aquifer) are increasingly being researched.

The cost implications make prevention of the problem all the more important. Although the development of natural soil nitrogen cannot be controlled, anthropogenic nitrogen inputs are manageable and hence most groundwater nitrate problems can be avoided by reducing releases into the soil and subsurface environment.

Dr Tredoux feels that while short- and medium-term action is needed to remedy present nitrate pollution, a long-term groundwater quality monitoring network, geared to measure nitrate accurately, needs to be implemented in strategic and vulnerable

Pregnant heifer that died of nitrate poisoning after being watered.



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areas so as to determine reliable trends over time.

Increasing public awareness is crucial, not only to convey the seriousness of the problem, but to procure funding for developing locally workable management solutions. "While legislation and control are indispensable tools for groundwater protection and management, polluting activities in remote areas cannot be controlled by the authorities," Dr Tredoux points out. "For this reason, the public, including the farming community and rural communities have to be convinced to voluntarily take all necessary steps that will ensure a reduction in environmental nitrogen inputs, and particularly, nitrate leaching to groundwater."

Elevated nitrate levels in drinking water present one of the greatest challenges to sustainable water quality worldwide. It is only with concerted, long-term effort that the deterioration of our precious groundwater resources can be overcome.

FURTHER READING:

- The feasibility of *In Situ* Groundwater Remediation as Robust Low-Cost Water Treatment Option (**WRC Report No 1325/1/04**)
- Nitrate and Associated Hazard Quantification and Strategies for Protecting Rural Water Supplies (**WRC Report No 1058/1/04**)

