GROUNDWATER CONTAMINATION DUE TO PIT LATRINES LOCATED IN A SANDY AQUIFER
A CASE STUDY FROM MAPUTALAND

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SUMMARY

There is a widespread perception that pit latrines should not be used in areas where the groundwater is used for domestic water consumption. South Africa=s groundwater protocol does not forbid pit latrines in such areas, but advises caution and moreover recommends that pit latrines are located at least 75 metres from water sources.

This paper describes local and international research in this field, and examines the justification of the 75 metre rule. What exactly are the hazards posed by pit latrines, and what are the real risk situations?

The paper describes field research which has been conducted in the Maputaland area of KwaZulu-Natal, where there are large numbers of both pit latrines and shallow wells. The paper describes the observations of water quality in a range of well types spread throughout the area, and also describes the water quality in the groundwater sampled close to pit latrines. The latter were monitored for faecal coliform bacteria and nitrates.

The paper concludes that a fine sandy soil is an effective filter medium and that pit latrines pose a negligible health risk in such an area, with the safe distance for water abstraction being more like 20 metres. The paper shows that water quality in wells depends on well design and how the well is used. The paper shows that properly designed and maintained wells produce water of good quality.

1. INTRODUCTION

There is a widespread perception that pit latrines should not be used in areas where the groundwater is used for domestic water consumption. South Africa's groundwater protocol does not forbid pit latrines in such areas, but advises caution and moreover recommends that pit latrines are located at least 75 metres from water sources.

One such area is the coastal plain of northern KwaZulu-Natal, home to several hundred thousand people. These people have traditionally collected water from shallow unprotected wells, which are dug in or near to river beds and pans. There is no waterborne sanitation in the area. All defecation is either carried out in the bush, or using pit latrines. The water table depth varies according to the topography, but is generally between 5 and 20 metres below the surface.

A blind application of the groundwater protocol would indicate that, due to all the pit latrines of the area, the water under the surface must be contaminated, and that the groundwater is therefore unsafe to drink. Is this in fact the case?

2. HEALTH RISKS ASSOCIATED WITH FAECAL WASTE IN SOIL

There are a number of pathogens which are found in faecal waste, including viruses, bacteria, protozoa and helminths (parasitic worms). The latter two types are effectively filtered out by soil, while the former can be carried some distance with seepage water. The travel distance varies according to a number of factors, the most important of which are: the seepage flow; the size of soil particles; the soil pH; and the temperature. The evidence from many studies which have been conducted into this topic over the years (ref. van *Ryneveld and Fourie, 1997,* and *Crane and Moore*, *1983*) is that all pathogens are removed within metres of the disposal site. However, there are cases where the right combination of conditions have led to pathogens being detected as far away as 30 metres, or in very rare cases, with very specific conditions, even further. As a result most guidelines and regulations require pit latrines to be 30 metres or more from water sources (boreholes, streams etc).

A second concern is the effect of faecal wastes on levels of nitrates in the soil. High nitrates in the water supply can pose a minor health risk to breastfeeding infants. The preferred level of Nitrogen in groundwater is less than 10 mg/litre, but sustained levels of over 20 mg/litre are required before any significant health risk is posed (Water Research Commission, *Quality of Domestic Water Supplies*, 1998 refers). In reality nitrate concentrations are reduced by dilution and by natural denitrification processes in the soil, so that concentrations in excess of 20 mg/l would require heavy and continuous applications of waste.

Another area of interest is the lifespan of pathogens in soil. Studies quoted by van Ryneveld and Fourie (1997) indicate that most die-off occurs within 10 days, although certain organisms under certain conditions will last for up to 100 days, and times of as long as a year are recorded in special cases.

In any discussion on contamination of water, it should be stressed that faecal coliforms are *indicator* organisms, and are not themselves pathogens. They occur naturally in very large numbers in the digestive tracts (and on the bodies) of healthy individuals and do not of themselves cause illness. Their presence in water merely indicates that the water may be exposed to pathogens which are associated with faecal waste.

3. DESCRIPTION OF THE MBAZWANA CASE STUDY

For the last six years Partners in Development have been engaged in both well construction and VIP latrine construction programmes in the region around the town of Mbazwana in Maputaland. Since 1998 water quality samples have regularly been taken from a variety of different types of well (protected/unprotected, private/public, tube/ring). These samples have been analysed for faecal coliforms as well as for nitrates. In addition to the sampling from wells, a monitoring site was set up around a pit latrine which has been in existence since 1995. Monitoring wells were installed in the direction of groundwater flow at increasing intervals from the pit latrine (1, 10, 20, 30 and 50 metres), as well as one background well set 90 metres away perpendicular to the groundwater flow direction.

The sampling methods used were as follows:

<u>Pit Latrine Site Monitoring Procedure</u>

1) All monitoring holes at the latrine sites are bailed one day before testing. Bailing was carried out with a small galvanised iron bucket. It was not sterilised in any way. Monitoring holes were bailed until all water had been bailed out (bucket came up only 1/4 to 2 full).
2) Agar plates were also prepared one day before monitoring and were stored in the fridge.
3) Before monitoring the bailer and rope were wiped down with a small amount of Ethanol. The inside of the bailer was not rinsed with anything. The sampler wore rubber gloves during monitoring (when they were available). Care was taken not to touch the bucket once it had been wiped with the Ethanol. Care was also taken to make sure the bucket touched nothing else before it was lowered down the monitoring hole.
4) The bucket was then lowered down the hole and one bucket full of water was removed, this was carefully poured into the sterile sampling bottles which were then placed into a cool box.
5) Between each monitoring hole, the bucket was once again wiped down with Ethanol.
6) Samples were taken back the lab where they were tested for faecal coliforms.

<u>Monitoring Family Tube and Ring Wells</u>

(Preparations and testing - same as above)

1) Five to six buckets of water (25 - 30 litres) were bailed from tube wells before a sample was taken.
2) The sample was taken using the home owner's bucket.
3) The sample was then poured into a sterile sampling bottle and placed in a cool box.
4) Samples taken from ring wells were taken straight from the well using what ever bucket was used by the family or community for drawing water.

4. RESULTS

4.1 Travel of Faecal Coliforms from Pit Latrine Monitoring Site

Figure 1 below shows the faecal coliform counts per 100 millilitres of sample at various distances from the pit latrine, in the direction of water flow. Counts of more than 10/100 ml are not observed except at only one metre from the pit latrine. In terms of contamination, a count of 10 or less faecal coliforms per 100 ml is very low, and may be attributable to experimental error. Other samples taken during the winter months (not shown here) had even lower counts. A background sample located 90 metres from the pit latrine perpendicular to the direction of groundwater flow typically registered no faecal coliforms.

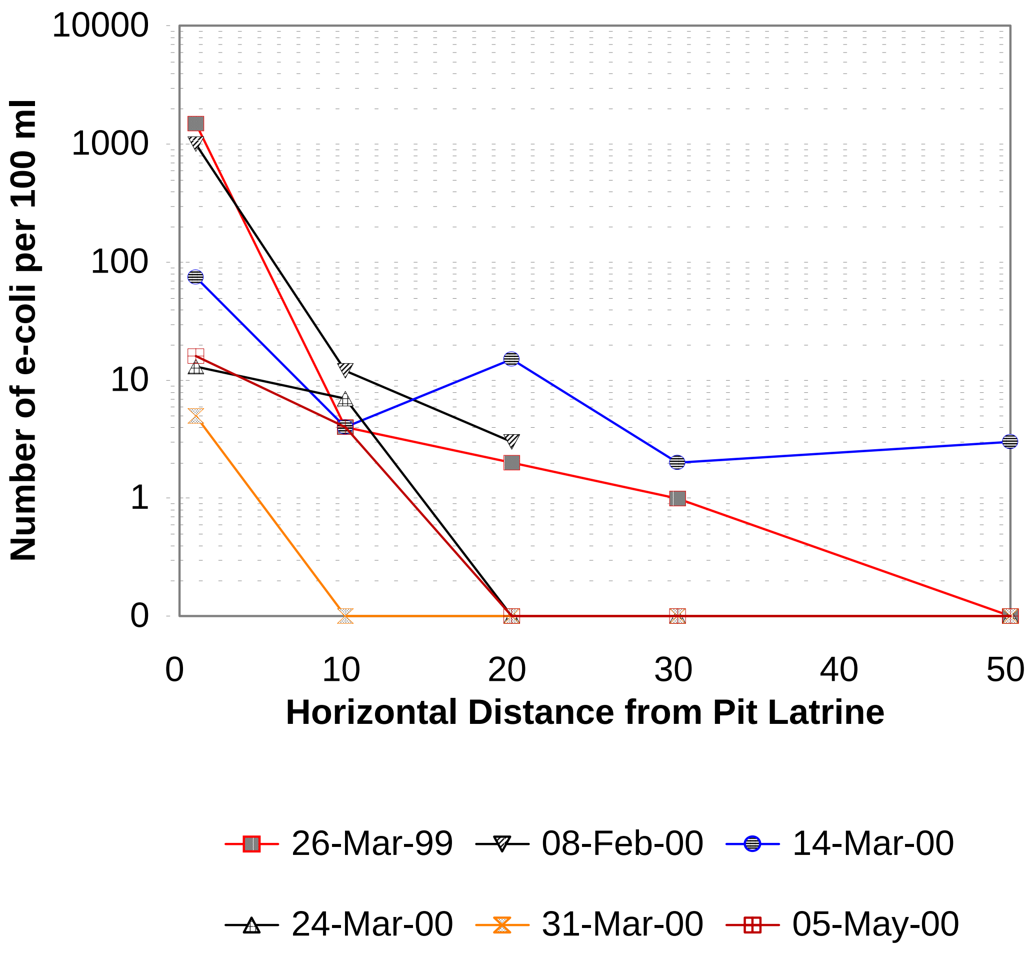


Figure 1: **Incidence of of faecal coliform in the groundwater at increasing distance from a pit latrine built in 1995 (Site E3 - George Ncube).**

4.2 Effect of Pit Latrine on Nitrate Concentration in the Soil

A number of samples from the monitoring holes around the same pit latrine were sent away for nitrate analysis. Mostly the results (see Figure 2 below) indicate an elevated level of nitrates close to the pit latrine, although it is noteworthy that even as close as one metre to a five year old pit latrine the levels are still within acceptable health limits. The samples taken on 26 May 1999 show an anomaly at 50 metres, but this may be due to experimental error. Background samples were taken at 90 metres from the latrine perpendicular to the groundwater flow direction, and the nitrate levels were found to be low (the mean from three samples was 0.79 mg/l as N).

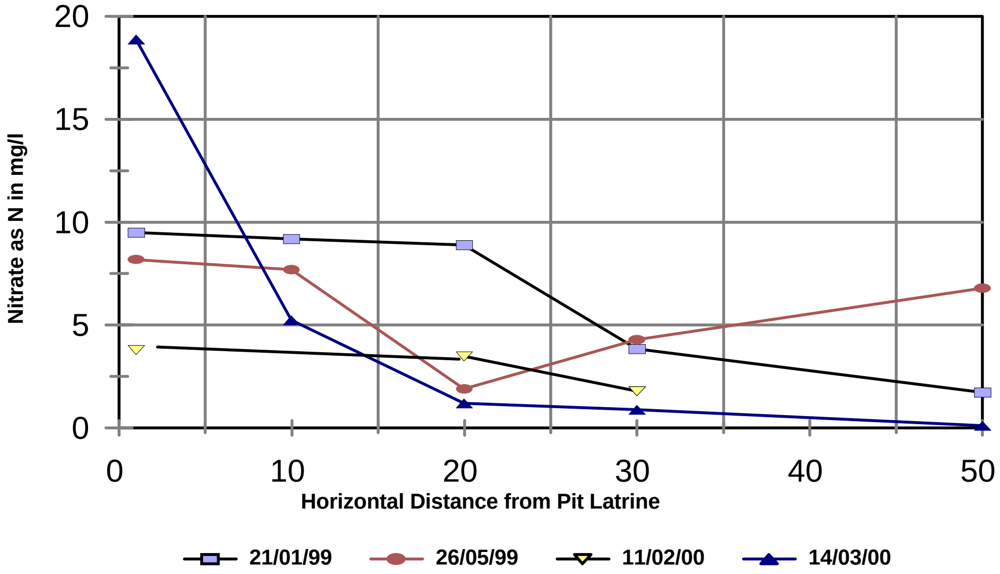


Figure 2: Observations of Nitrate level in monitoring wells near a five year old pit latrine (Site E3)

4.3 Nitrate Levels in Groundwater in the Region

During November 2001 a researcher from the groundwater programme of the CSIR, Stellenbosch, spent a month with Partners in Development at the Mbazwana office, taking water samples from more than fifty wells.

These wells differed in that some were private, while other were shared by ten or more families. Figure 3 shows the range of nitrate (measured as Nitrogen) concentrations observed in these wells. The majority show low levels, and all are within health limits. The higher levels shown in some wells are apparently associated with wells which are used by greater numbers of families. Higher use will tend to cause more water spillage around the well.

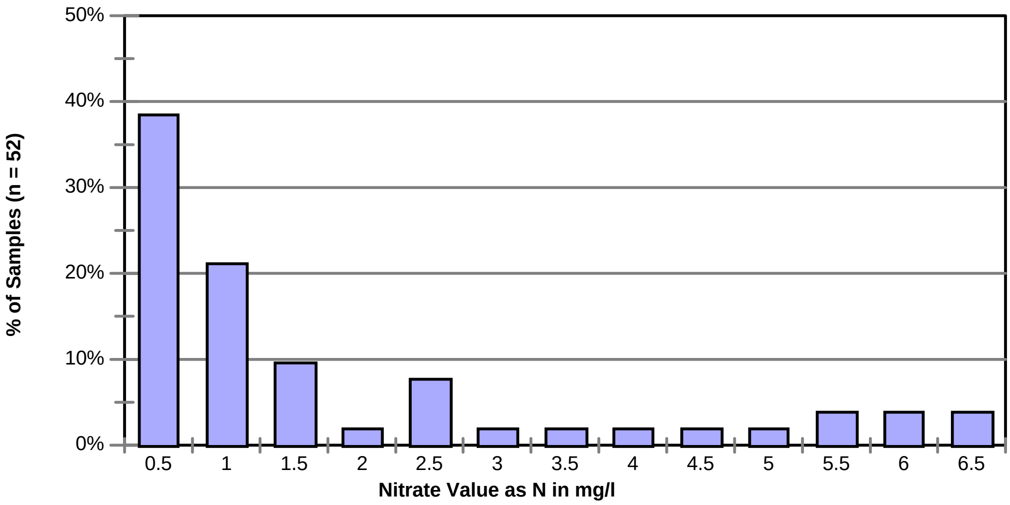


Figure 3: The incidence of Nitrate (measured as Nitrogen in mg/l) in groundwater sources in the Mbazwana area. 52 different water sources were sampled over a one month period in November 2001. The higher nitrates are generally associated with wells where there are more users and therefore more wastage. Levels of below 10 mg/l are acceptable.

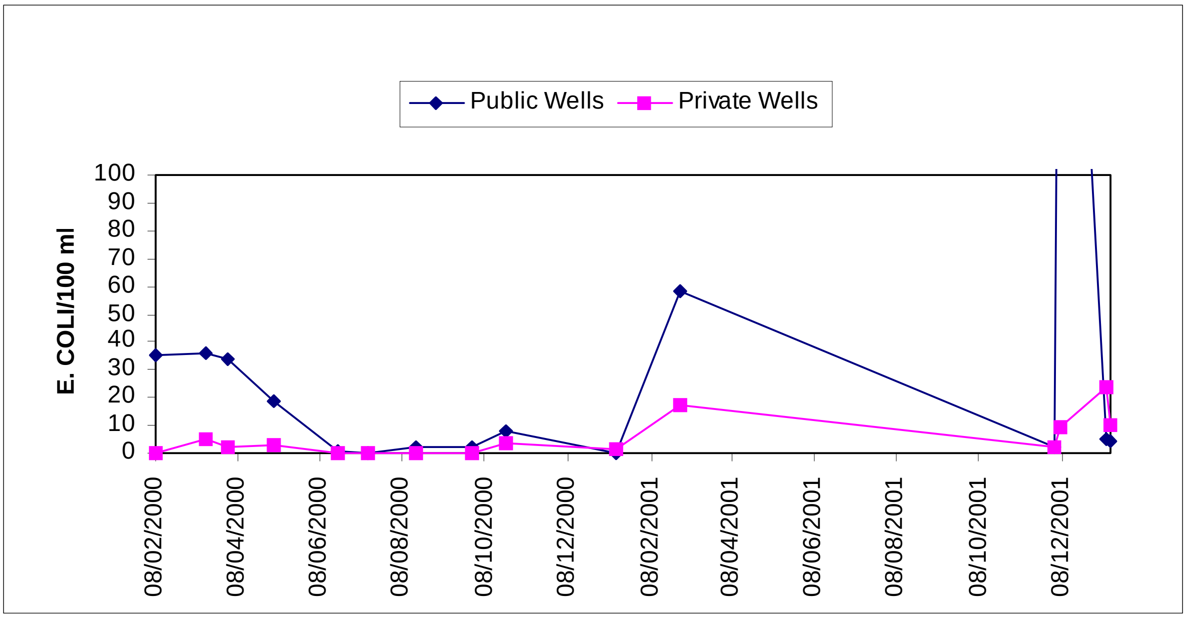
This waste water then percolates down to the ground water table, carrying with it nitrates from organics and waste around the well area. A more heavily used well should thus show a higher level of nitrate, so the results make sense. A Hydrogen Suphide faecal coliform indicator stip test was also done at all the same sites simultaneously, and there appears to be little correlation between those wells which did show some presence of coliforms, and those which had high nitrates. The sand around the well is fine and acts as an effective filter against bacteria. The bacteria observed in the wells (refer to section 4.4. as well) is almost certainly introduced by the users from above, rather than being present in the groundwater.

4.4 Observations of Faecal coliforms in Public and Private Wells

The fourth element of this research has been to test private and public wells for faecal coliform bacteria. Over a period of two years thirteen wells have been monitored. These have included the following:

- three protected public tube wells
- three protected private tube wells
- three protected private ring wells
- two protected public ring wells
- two unprotected public ring wells

The manner in which the wells are constructed and protected is described in more detail in Still and Nash (2002).



In all wells bacterial concentrations are in general higher in the warmer summer months. Average concentrations in the protected private tube wells are very low, whereas the concentrations in the public tube wells are somewhat higher. An extract from the data is shown graphically in Figure 4 above. As can be expected, the e-coli counts in the unprotected public wells is much higher. For example, one *unprotected* public well had counts of above 10 000 e-coli/100 ml on four of the nine occasions on which it was sampled. Another partially protected public well had much better quality.

The results show that the water quality in protected wells is much better than that in unprotected wells, and that similarly the water quality in private wells is better than that in public wells.

5. CONCLUSIONS

The evidence from this case study demonstrates that the fine sand of this region is an effective filter with regard to bacteria and that pit latrines do not appear to pose a major threat to the contamination of ground water in Maputaland.

With regard to nitrate contamination, pit latrines and public water points do influence nitrate concentrations in the ground water. The effects are, however, localized and not significant from a public health point of view.

Water quality in protected family wells is found to be good, while shared community wells, particularly the older unprotected wells, show signs of contamination.

ACKNOWLEDGEMENTS

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