

EXECUTIVE SUMMARY

Background

A National Microbial Monitoring Programme for surface water is currently being implemented by the Department of Water Affairs and Forestry (DWAF) [DWAF, 2002a]. This research report contains the background to the development of a monitoring design for microbial pollution, specifically faecal pollution, in groundwater. This report provides this supplementary information in the sense of a "record of decisions". These form the basis of the monitoring design captured in the associated implementation manual.

Objectives

The eventual overall aim of this project was to extend the existing National Microbial Water Quality Monitoring Programme for surface waters to include groundwater. The specific aim was to develop a prototype manual that formally describes a detailed groundwater monitoring system design and all aspects of subsequent implementation of the programme.

Results and conclusions

Fundamental to any monitoring programme is a clear definition of its objectives. This report describes how the proposed objectives were developed from those of the equivalent surface water programme, other national monitoring programmes as well current and envisaged groundwater monitoring within the Department.

A formal review of the literature is also presented that focusses on pathogens in groundwater. How contamination occurs, the movement and survival of microorganisms and various traditional and recent indicators of faecal pollution are discussed.

A relatively simple analysis is performed the results of which provide one tool for deciding on the most appropriate monitoring variables. Factors relating to analytical methods (like costs, available capacity etc.), the presence and survival of microorganisms in groundwater and their likelihood of reaching the saturated zone are considered. Even though variables like faecal coliforms and *E. coli* seem the most appropriate, all suffer from a logistical problem of having to maintain the time between sampling and analysis to within 24 hours. This and other issues are considered and the conclusion is reached that *E. coli* is the most appropriate monitoring variable at this time. Although detection of viruses is important to achieve the objectives of the monitoring programme, their inclusion in the programme is not possible at this time

because of sample preparation difficulties and uncertainties in respect of available capacity.

An overall monitoring philosophy is developed that aims at maximising the ability to make general statements about the microbial quality of aquifers as a whole while minimising the number of monitoring boreholes. This philosophy is based on the realisation that faecal contamination in groundwater is likely to be highly localised. This is because groundwater moves relatively slowly, faecal microorganisms are physically filtered (so their movement is restricted) and most faecal microorganisms have limited survival times in groundwater environments.

The monitoring focusses on the ability to confirm that faecal pollution from a significant faecal pollution source is contained in the immediate down-gradient flow path from the source. This enables general statements to be made about the likely faecal quality of groundwater in aquifers as a whole down-gradient of the so-called "containment monitoring borehole". A "source monitoring borehole" at the limit of the attenuation zone of the faecal pollution allows more accurate monitoring of the behaviour of the source. Given the inevitable uncertainty associated with making general statements about the down-gradient aquifer, these are backed up by monitoring at strategic points of use. It is this philosophy that forms the basis of the more detailed design considerations captured in the implementation manual.

A process for prioritising areas for inclusion in the monitoring programme in the initialisation phase of the programme is also recommended. This is driven by the need to demonstrate monitoring successes as early as possible in order to ensure perceived cost-effectiveness, sustained interest and hence resource allocation. This process is three-tiered. The first involves identifying general areas of possible concern. This uses a general aquifer classification map and a map indicating vulnerability of aquifers to faecal pollution. Having identified such an area, the second tier involves confirming that there is indeed a local cause for concern in that area. This is based largely on local knowledge that establishes whether a significant pollution source actually exists up-gradient of a strategic point of groundwater use. Finally, the third tier requires careful consideration of various managerial factors that will affect the likelihood of monitoring success in that local area.

A framework is also recommended for a pilot study exercise that addresses two focus issues. First, the core design and practicality of the monitoring philosophy must be thoroughly tested before initialising the monitoring at full scale. This should test all aspects of the implementation manual and ultimately produce a mock annual report. Secondly, the issue of inclusion or exclusion of detection of viruses must be carefully examined and sound recommendations made. This should include a detailed costing exercise.

Extent to which objectives achieved

The objectives of this project have been achieved in their entirety. In particular, a novel approach to monitoring faecal contamination of groundwater has been proposed and captured in a prototype implementation manual. In respect of one of the original tasks, namely to recommend possible pilot study sites, this report goes further and proposes a framework for the studies as well.

Capacity building

The following were employed and trained during their studies for BSc (Hons) Medical Virology, University of Pretoria.

WLF van Wyk (Project: An assessment of the microbiological quality of groundwater)
BM Goosen (Project: Efficiency of recovery from and detection of rotaviruses in selected water sources)

Recommendations for further research and technology transfer

Given the novelty of the proposed monitoring design and the fact that this was primarily a desktop study, it is essential that the overall design and various detailed monitoring protocols, especially with respect to sampling, be thoroughly tested in a series of pilot studies. The implementation manual, the primary instrument of the technology transfer, can then be refined and become a confident basis for full-scale implementation of the monitoring programme throughout South Africa.