A three-tier approach to protect groundwater resources in South Africa

Y Xu[1]* and AG Reynders[2]

[1] *Directorate of Geohydrology, Department of Water Affairs and Forestry, Private Bag X313, Pretoria 0001, South Africa*

[2] *Water Research Commission, PO Box 824, Pretoria 0001, South Africa*

Abstract

The quality of groundwaier is affected by many activities occurring on the surface of the earth. A pro-active protection approach is required to avoid the costly and technologically difficult exercise of groundwater remediation. This paper reviews various approaches for groundwater protection and documents recent developments in this field. A comprehensive protection strategy consists ol'many elements, ranging from the protection of entire aquifers to localised water-supply sources. A three-tier protection concept, with the emphasis on a zoning approach, is proposed for South Africa. This will facilitate the protection of groundwater at various leveis (national, regional and local) and will ensure that protection needs in the short, medium and long term are addressed.

Introduction

Early in 1991 a committee to investigate Groundwater Quality Management Policies and Strategies for South Africa was established (Braune and Hodgson, 1991). This committee not only provided focus and direction for the existing fragmented groundwater protection efforts but drew the attention of those both within and outside the groundwater community to the great need for groundwater protection in this country. Prior to this, most hydrogeological activity was tactical rather than strategic, being directed towards the location of sustainable sources of water supply at various levels. The Department of Water Affairs and Forestry has embarked on a programme of groundwater quality management and the formulation of policies and strategies which has again emphasised the need for country-wide groundwater protection. An immediate need is the formulation of a guideline for groundwater protection for the Community Water Supply and Sanitation Programme (CWSS) which is apart of the government's Reconstruction and Development Programme (RDP).

Groundwater protection has for some time been implemented in most European countries and North America. Review of overseas literature would appear to indicate that they do not experience the sanitation problems associated with rural development as evidenced in this country. Local literature on water supply and sanitation supports this view (Palmer Development Group, 1993; Jackson, 1994). There is consequently a great need to review international practices of groundwater protection in an attempt to adapt them to the South African situation.

An obvious feature of European groundwaier prot*ection* practice is to designate the area immediately surrounding public (and some private) water supply sources for a high degree of protection. Isochrones of 50 to 400 d from sources are used for demarcating protection zones against degradable pollutants in Europe (an isochrone refers to the travel-time-related capture zone of a hypothetical pollutant coincident with groundwater movement). There is, however, no fixed rule regarding the number of days required for primary and secondary zones as summarised in Table 1. The primary zone is equivalent to a travel-time-related capture zone as often referred to in the literature.

A number of factors contribute to groundwater being vulnerable to contamination, these being the often considerable time lag between the entry of a particular contaminant into the groundwater system and its detection at supply or monitoring boreholes and springs; the fact that groundwater is not readily visible; and the persistence of many chemicals in subsurface environments. Many contaminants, originating from industrial, agricultural and mining activities, for example, are persistent or biodegrade very slowly and are not filtered out or adsorbed by the soil. A pro-active approach to groundwater protection is consequently required.

Contaminants can enter an aquifer through a variety of pathways, from simple percolation through soils to preferential pathways such as biochannels, cracks, joints, and solution channels in the unsaturatcd zone. Preferential pathways are particularly significant as they result in a short-circuiting of the favourable environment for contaminant attenuation found in the soil horizon.

Groundwater contaminants may be microbial. organic or inorganic in nature. They may also be sub-divided into persistent and non-persistent. The latter are capable of being removed naturally by chemical, physical and microbiological processes occurring selectively within the aquifer and overlying vadose zone. Bacteria in water are filtered out readily in soil and granular media though they may be carried for considerable distances in some flow regimes. As a precautionary approach, aquifer vulnerability classification and wellhead (source) protection programmes are in place in most of Europe and the USA. Table 1 provides a summary of groundwaier protection zoning features evident in some European countries.

Prior to proposing a protection concept for South African conditions, a comprehensive review of commonly adopted approaches in the rest of the world is presented.

Classification approach

Most groundwater contamination incidents involve substances released at or slightly below land surface. Consequently it is shallow groundwater that is affected initially by such releases. Depicting the results of groundwaier vulnerability classification in the form of maps provides a valuable tool for groundwater protection. The advent of Geographical Information Systems (GIS)has greatly facilitated the compilation and updating of such maps (Rundquist et al., 1991).

* To whom all correspondence should he addressed.

(012)299-3373; 0012)326-1780; e-mail wd5@dwaf-pta.pwv.gov.za

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