

Groundwater pollution: Are we monitoring appropriate parameters?

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Abstract

Groundwater pollution is a worldwide phenomenon with potentially disastrous consequences. Prevention of pollution is the ideal approach. However, in practice groundwater quality monitoring is the main tool for timely detection of pollutants and protection of groundwater resources. Monitoring groundwater quality is a specialised task for a hydrogeologist and a water quality monitoring expert. Although general prescriptions for waste management facilities exist these may not be applicable in all cases. In the literature, divergent approaches have identified various sets of pollutants and pollution indicators. This paper discusses international and local trends in groundwater monitoring for baseline studies and on-going pollution detection monitoring for a variety of situations. Cemeteries, a pollution source for which no local monitoring requirements exist, are also included. The effectiveness of some commonly prescribed monitoring parameters is considered, as well as the use of “bulk parameters” for reducing the number of analyses and the associated costs, while still achieving the optimum result. Although not considered in detail in this paper, cost-effective groundwater quality monitoring should be a key part of the design of a monitoring programme.

Introduction

Groundwater pollution threatens many valuable water resources. The consequences are often more serious than for surface water due to the relatively long subsurface residence times. Also, groundwater pollution may go undetected for years, while remediation is difficult and costly, or sometimes even impossible. For the lay person, groundwater is an elusive entity shrouded in mystery and generally out of sight and out of mind. Any attempt to evaluate groundwater pollution, requires an understanding of the particular aquifer system, its recharge and pollution pathways. Using this information, a conceptual hydrogeological model can be formulated and only then can a groundwater monitoring network be designed.

Groundwater pollution occurs widely from a variety of anthropogenic sources. These include point sources such as waste disposal facilities, industrial pollution, wastewater treatment works, on site sanitation, cemeteries and many others. Diffuse pollution includes agricultural practices, atmospheric fallout and other sources. Changes in land use, such as the clearing of vegetation, over-abstraction of groundwater, or excavation below the water table, can also contribute significantly to groundwater pollution.

A large number of inorganic, organic and microbiological pollutants have been detected in groundwater because of polluting activities. The chemical and hydrological changes caused by such activities can also mobilise groundwater constituents that were originally present in the aquifer. With such a cocktail of pollutants that may occur at a contaminated site, the question arises: Which parameters should be monitored for pollution detection, and at what frequency? Should inorganic and organic chemical constituents, physical variables, isotopes, and other parameters be included?

For certain practices, such as waste management, monitoring procedures and parameters are prescribed by the authorities. The system of issuing permits or licences provides a certain degree of flexibility for stipulating the analytical parameters to be monitored but the question remains whether these are the most effective in detecting pollution. Experience has shown that a site-specific approach is often needed, rather than a generalised procedure for a certain type of activity.

The aim of this paper is to address groundwater pollution in general, but in view of the wealth of information available on waste disposal facilities, and specifically landfills, this aspect is considered in more detail. The information gained from this field could provide guidelines for handling other polluting activities.

Background

As groundwater occurs in a variety of aquifer types, the flow regime will generally differ in each situation and any particular pollution event will need to be assessed in the specific context. In addition, physical, hydrogeochemical and biogeochemical processes in the subsurface may remove or modify the pollutants.

Aquifer types

Three main aquifer types are generally recognised (see for example DWAF, 1998):

- Porous or “primary” aquifers
- Fractured or “secondary” aquifers
- Dolomitic aquifers

A primary aquifer could consist of unconsolidated material (e.g. in an alluvial bed) or be cemented (e.g. by calcium carbonate). It could also be fully consolidated (e.g. as a sandstone) and then also be fractured due to tectonic activity. In such cases the groundwater flow is complicated due to the so-called “double porosity” in the aquifer. The aquifer types often occur in combination with a primary aquifer (e.g. soil or weathered material) covering a second-

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