Plate 7.5 Types of Groundwater Pollution

Introduction

The composition of groundwater is naturally influenced by the geological units that it traverses (see plate 8.4). However, human activity can also affect its quality (fig. 1). Certain aquifers are only slightly vulnerable to pollution as they are well protected by thick low-permeability protective cover. The quality of others has dramatically deteriorated to the point where the aquifer must be abandoned as a water resource. The fact that over 80 % of drinking water in Switzerland is derived from groundwater highlights the significance of this issue. This plate illustrates the principal factors pertinent to groundwater pollution and the methods used to combat this problem. Various case studies that occurred in different parts of the country serve to reflect the diversity of potential situations.

Origins and types of pollution

The different types of pollution source are presented in table 1. These are defined based on their spatial distribution (diffuse or point source) and their temporal input (continuous or short duration). All types of pollution do not pose the same hazards, nor do they occur with the same frequency (fig. 12).

Subsurface transfer

The transfer of pollutants in the subsurface involves complex processes that are influenced by climatic, pedological, geological, hydrogeological, chemical and biological factors (fig. 7). Based on their behaviour, four categories of pollutants are distinguished, each of which possesses its own specific dynamics (figs. 2 through to 6).

An aspect relating to pollution by free phase organic compounds that needs to be stressed, namely that their behaviour, will differ depending on their density. Those compounds which are denser than water tend to migrate towards the base of an aquifer and can penetrate deeply via discontinuities (fig. 2). On the other hand, should the compounds density be less than that of water, the pollutant will tend to form a free phase lense on the water table (fig. 4).

Preventative measures

Passive measures relate to land-use planning (fig. 8). These include groundwater protection zones around current public sources (S1 to S3), the protection areas for future groundwater supplies and areas of contribution (Z_u) to protect against environmentally persistent substances. In addition, the A_u water protection areas (not illustrated in figure 8) cover the principal aquifers.

Active measures consist of a series of technical measures dealing with the storage, transport and use of potential pollutants (fig. 9).

Remedial actions

Two classes of remedial actions are distinguished when considering pollution incidents:

- decontamination, which deals with the extraction, degradation or immobilisation of a pollutant (fig. 10)
- containment, which isolates the pollutant from zones of active groundwater circulation (fig. 11).

Case studies

Montricher VD

The Montricher Aquifer, an important groundwater resource for the town of Morges, is located in a zone of intensive cultivation. As a consequence of this cultivation, high levels of nitrate have been observed in the aquifer's groundwater. Fertilisers and pesticides tend to leach from the soil, especially in areas where the soil is exposed, either during cultivation, or after harvesting. Where the soil overlies well-drained fluvioglacial gravels, mass transport through the subsoil and in the underlying aquifer is particularly problematic. Measures recently taken by the town of Morges have resulted in a reduction in the levels of unwanted substances [7].

Forch ZH

Winter road salting results in cyclical variations in chloride concentration in the groundwater as illustrated by analyses of samples collected from the observation well and a nearby spring. The Chaltenstein Well is located in the vicinity of a railway line and several roads. Atrazine, which was used as a herbicide along the railway line has been detected at significant concentrations in this well. The restriction (1988) and subsequent ban (1990) on atrazines use on the railroad have resulted in a consistent decline in its concentration [5,10].

Langenthal BE

In 1984 heavy volatile organic compound contamination derived from a dry-cleaning facility was detected in the Tannwäldli Well. Concentrations were close to the limits defined by federal legislation. After regulating the problem at the facility, a two stage remediation programme was implemented; soil vapour extraction to remove contaminants from the unsaturated zone and a groundwater pump and treat programme to remove the contaminant from groundwater by desorption at the surface. The remediation programme has allowed contaminant concentrations to be brought substantially below maximum admissible levels [14].

Gamsenried VS

Lonza SA produced acetylene between 1923 and 1962. The calcium hydrate by-product generated in the production process was disposed of at the Gamsenried waste disposal site. Since 1962, a thick layer of this low permeability by-product has been used as a substrate for the disposal of various organic substances. However, in 1978 groundwater contamination emanating from the site into the underlying unconfined deposits was observed. Remedial measures to deal with this problem have included incineration of the solid organic wastes and importantly, the installation of a hydraulic barrier up-gradient of the pollution source. Furthermore, twelve wells have been installed within the contaminant plume to pump and treat the polluted groundwater. This technique has been particularly useful in permitting aniline to be extracted from the groundwater. Today, in conformance with federal legislation, the site is used to store inert products and stabilised wastes [6,12,13].

Le Chenit VD

Contamination at the Le Brassus spring provides an example of two types of groundwater pollution. On the one hand, the spring has been affected by continuous diffuse pollution by faecal bacteria derived from the numerous mountain pastures in this karstified, and thus vulnerable area. On the other hand, it has been impacted by an untimely manure spill derived from a muck pit located in a mountain pasture to the south of the village of Le Brassus. (It is interesting to note that in the same week, an accident involving a railway locomotive placed the second major groundwater resource in the Joux Valley, the village well at Le Pont, out of service.) After emergency groundwater prospection, newly drilled wells provided the village of Le Brassus with an alternative water supply. In addition, longer-term measures were initiated, most notably the delineation of groundwater protection zones and the initiation of public awareness campaigns for farmers in the surrounding mountain pastures, as well as the modernisation of manure storage facilities. A water treatment facility was finally constructed at Le Brassus Spring [4].

Locarno TI

Between the 13th and the 17th of October 2000 very heavy precipitation occurred in the region of Simplon, causing amongst other things the disaster at Gondo. On the southern side of the Alps, large volumes of water flowed into Lago Maggiore on its western side. Not only was the drainage capacity of the lake at its mouth at Sesto Calende limited, but the large amounts of water discharging into the southern part of the lake had an effect similar to a dam by causing the water entering the lake further to the north to back up. Groundwater levels in aquifers linked to these water bodies rose accordingly and subsequently flooded the basements of houses. The flooding caused some home heating oil tanks to float and empty their contents. The oil sometimes entered the groundwater. This is a typical example of a hydrological chain reaction [3,11].

Orbe VD

On the 6th of April 1998, a truck accidentally veered off the Vallorbe–Orbe dual carriageway. Some 200 l of organic tin derivatives infiltrated through the ground surface before entering the groundwater with a direct hydrogeological link with the La Tuffière Spring, one of the principal groundwater resources for the town of Orbe. The pollutant, arriving rapidly at La Tuffière Spring which was immediately decommissioned, rendered its water unfit for consumption for many years. Fortunately, the Orbe-Plain Well could make-up the sudden groundwater deficit. In order to accelerate aquifer rehabilitation, a programme of focused intensive flushing was carried out which removed significant quantities of the pollutant. Water quality in the Montcherand Spring, which was less seriously affected, could be more rapidly remediated before the spring was put back into service [1,2].

Conclusions

Groundwater pollution, like many other environmental impacts, is a function of many different aspects. Moreover, groundwater pollution is often invisible and its effects are not felt for a long time. Once pollution is detected, it is sometimes too late to save a resource. Similarly, geological conditions in the subsoil, which are often the main control on pollutant propagation, are difficult to characterise precisely. An absence of information concerning these factors frequently complicates risk assessment and remediation activities. Nonetheless, society is not without means to combat this threat to public health and the environment. Approaches linked to land use that account for aquifer vulnerability are certainly the best preventative tool.

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