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THE BEHAVIOUR OF ORGANIC POLLUTANTS IN A NATURAL RIVER - GROUNDWATER INFILTRATION SYSTEM

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INTRODUCTION

The fate of organic pollutants during groundwater infiltration is of great interest since many waterworks use bank filtration as the first step in the treatment of river water for public water supplies. To elucidate the processes responsible for the behaviour of organic substances during infiltration (e.g., sorption/desorption, biological transformation) laboratory studies and field measurements are necessary. In this paper we summarize some results of an ongoing field study on the behaviour of volatile organic pollutants and dissolved organic carbon (DOC), fractionated with a new method (ref. 1), in a natural river - groundwater infiltration system. The results of a related laboratory study on the transport of volatile organic compounds in the ground are presented elsewhere in this volume (ref. 2).

METHODS

The volatile organic compounds in river and groundwater samples were enriched by the closed-loop gaseous stripping/adsorption/elution procedure described by Grob and Zürcher (ref. 3). Gas chromatography and gas chromatography/mass spectrometry (GC/MS) were used for quantification and identification.

The DOC fractionation (ref. 1) is based on the different adsorption behaviour of the organic compounds present in the water on a non-polar surface (octadecylsilica; LiChrosorb RP-18, Merck, Darmstadt, G.F.R.). With this new method the DOC is separated into three fractions:

Fraction 1:	hydrophilic at pH 2 (not adsorbed on RP-18)
Fraction 2:	hydrophobic at pH 2 (adsorbed on RP-18) and hydrophilic at pH 8 (eluted with buffer solution)
Fraction 3:	hydrophobic at pH 2 and pH 8 (adsorbed on RP-18, eluted with organic solvents)

During the fractionation procedure fractions 2 and 3 are enriched on the HPLC-column (RP-18) while fraction 1 passes through the column without adsorption. Fraction 2 was eluted with pH 8 buffer solution. Total DOC and fractions 1 and 2 were determined with an on-line DOC-detector described by Gloor and Leidner (ref. 4). Fraction 3 was determined by difference.

DESCRIPTION OF THE FIELD STUDY SITE

At the field study site in the lower Glatt Valley (Switzerland) the River Glatt infiltrates with an average rate of 0.25 m^3 water per m^2 river bed per day. The infiltrated water stratifies in the top layer of the groundwater stream and remains there over quite long distances (> 100 m). Figure 1 shows schematically some of the observation wells which were installed to study the behaviour of water contaminants during infiltration and in the top layer of the aquifer.

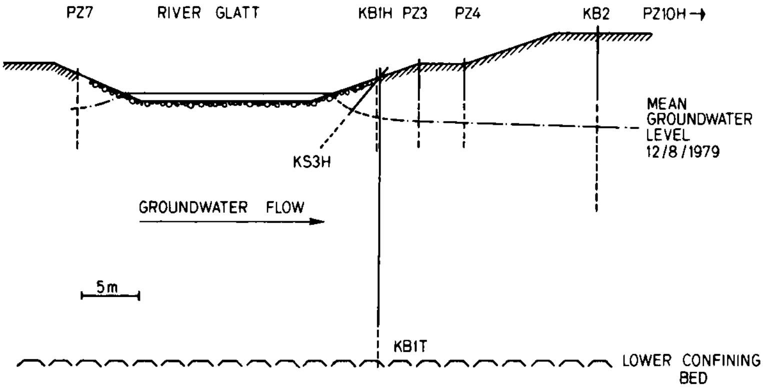

Fig. 1. Some of the observation wells installed at the field site.

RESULTS

Volatile organic pollutants

Trichloroethylene, perchloroethylene (PER), 1,2-dichloropropane, 1,4-dichlorobenzene (DCB), toluene, xylenes and higher alkylated benzenes were always among the most abundant volatile organic pollutants detected in the River Glatt. The concentrations of these compounds in the river varied in the range 0.05 - 5 µg/l. Figure 2 shows the average concentrations of two selected compounds (PER, DCB) determined in the River Glatt and in groundwater samples from the top layer of the aquifer at different distances from the river. Whereas similar average concentrations were found for PER at all these sampling sites, a significant decrease in concentration was observed for DCB within the first 15 meters of the infiltration path.

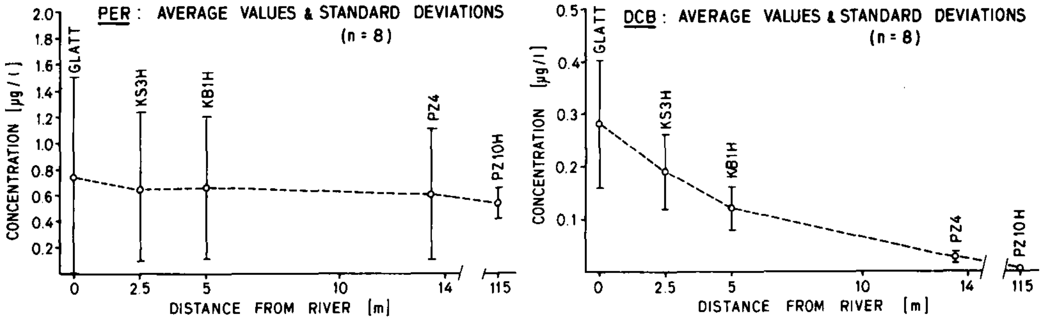

Fig. 2. Average values and standard deviations for the measured concentrations of PER and DCB in the River Glatt and in the top layer of the groundwater at various distances from the river (samples taken monthly, n = number of samplings).

Dissolved organic carbon (DOC)

Figure 3 summarizes the results of the DOC measurements:

- The total DOC was reduced significantly during the first several meters of infiltration. Molecular weight distribution measurements indicated that the DOC decreased over the entire molecular weight range (ref. 1).
- The concentrations of the hydrophilic compounds (fraction 1) were slightly reduced during the first meters of infiltration and then remained more or less constant. In the deep groundwater (KB1T; see Fig. 1) fraction 1 was the major fraction (> 70 %).

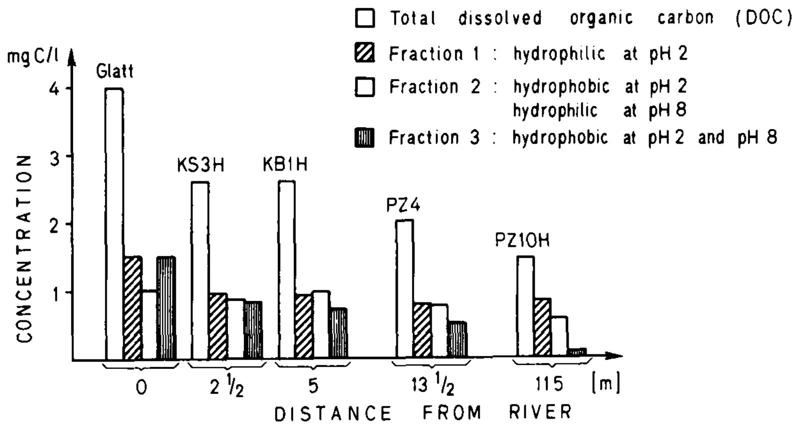

Fig. 3. DOC and DOC fractions 1-3 in the River Glatt and in the top layer of the groundwater at various distances from the river (average values).

- The concentrations of the compounds of fraction 2 remained almost constant. This fraction includes the "fulvic acids".
- The majority of the compounds of the hydrophobic fraction 3 were "eliminated" during infiltration.

CONCLUSIONS

(1) Since volatile organic pollutants have been shown to be very mobile in the ground (ref. 2), the observed decrease in concentration of DCB during infiltration can probably be explained by biological transformation and/or mineralisation of this compound in the ground. However, very little is known about the nature of the compounds (which may be refractory) formed by such processes.

(2) If a river is continuously charged with volatile organic components which are not "eliminated" by biological or chemical processes during infiltration (e.g., PER), large groundwater areas and therefore large groundwater supplies may be contaminated.

(3) The DOC-fractionation method gives insight into the behaviour of various components of the DOC during infiltration. However, the DOC fractionation results are more difficult to interpret than those for individual compounds. A tentative conclusion is that the practically constant concentration of fraction 1 is maintained by the decreasing concentration of fraction 3 (and/or fraction 2 which could be maintained by the decreasing fraction 3).

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