Development of experimental testing for the mobility assessment of chemicals during river-bank filtration.

P. Shrestha[1], S. Trapp[2], K. Mosthaf[2], D. Skodras[1], S. Hahn[3], D. Hennecke[1].

[1]Fraunhofer Institute for Molecular Biology and Applied Ecology IME, Schmallenberg, Germany

[2]Technical University of Denmark, Lyngby, Denmark

[3]Fraunhofer Institute for Toxicology and Experimental Medicine ITEM, Hannover, Germany

Introduction

- River-bank Filtration (RBF) is a widely accepted technology which utilizes the natural filtration to remove contaminants of the extracted water.
- Highly mobile and non-degradable compounds may be carried across RBF and contaminate drinking water.
- To protect drinking water sources from such mobile chemicals, the mobility criteria "M" based on the organic carbon (OC) normalised adsorption coefficient (K_{OC}) has been proposed under EU REACH Regulation[1].
- The K_{OC} approach does not account for I) sorption to clay and mineral surfaces II) non-linear sorption (Freundlich isotherms) III) aging processes, slow adsorption to the inner particles, entrapment and irreversible sorption (non-extractable residues NER).
- Aquifers in RBF have particularly low OC, and the bank passage may take weeks or months. Thus, afore mentioned interactions could be key parameters for mobility considerations for RBF.
- This study aims to develop a column testing approach with aquifer material for the assessment of sorption processes during RBF accompanied by a modelling approach for evaluation.

Development of Test Setup

- A column testing approach was designed with the test setup inspired from DIN 19528 test[2] (see Figure 1).
- Two different column sizes with diameter 14 cm and 5 cm will be tested.
- Columns will be packed with aquifer material (height ~40 cm).
- Upward flow will be maintained in the column for saturated conditions.
- Application of the test substance will be done via the eluent prepared in tap water.
- Initial test item concentration in eluent 1 – 10 µg /L (also depending upon analytical sensitivity).
- Test will be carried out at 20 ± 2°C in dark conditions.

1 storage bottle
2 eluent (purified water)
3 pump (adjustable)
4 filter or fine mesh
5 column filled with aquifer
6 column cap
7 pipe
8 ventilation
9 screw cap
10 eluate
11 collection vessel

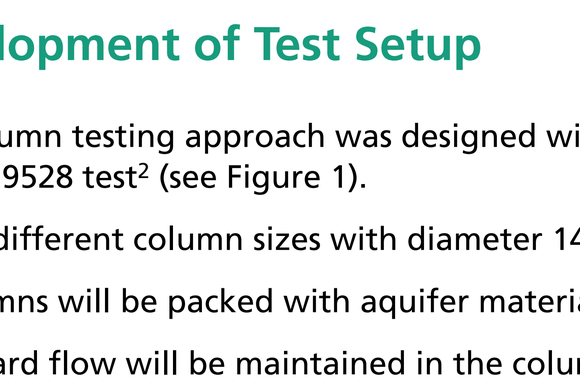


Figure 1: A scheme of test system used for performing the DIN 19528:2023-03 test (Leaching of solids - Percolation method for joint investigation of the leaching behaviour of inorganic and organic substances) [Figure taken from DIN 19528 (2023)].

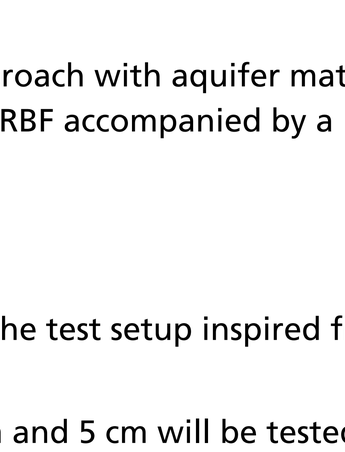


Figure 2: A picture of a exemplary test setup that will be used for the column testing under this study. The picture shows a column Ø = 5 cm filled with coarse textured sediment to height of 40cm.The test item will be loaded into a saturated sediment column via eluent from bottom to the top with the use of a pumping pressure.

Selection of Aquifer Material

Two aquifer materials have been collected from two different RBF sites in Germany:

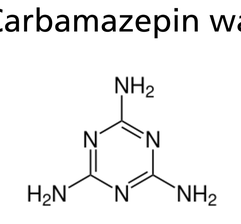
- Berlin Wasserbetrieb
- Haltern am See

Figure 3: A picture of aquifer material that was collected from the riverbank filtration test facility in Haltern am See (left) and Berlin Wasserbetrieb (on the right)

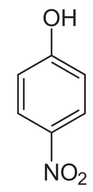
Phys.-chem. properties and the sediment texture need to be determined.

Selection of Test substances

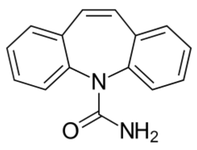
- Three test substances were selected for this study.
- Melamine and 4-Nitrophenol are fulfilling PMT/vPvM criteria[3].
- Carbamazepin was detected in drinking water and groundwater[3].



Melamin



4 - Nitrophenol



Carbamazepin (^{14}C labelled)

Experimental Setup for Column Testing

- Step 1: At first the pumping pressure will be adjusted to the column material and the expected retardation of the compound to obtain breakthrough curves within a reasonable time frame.

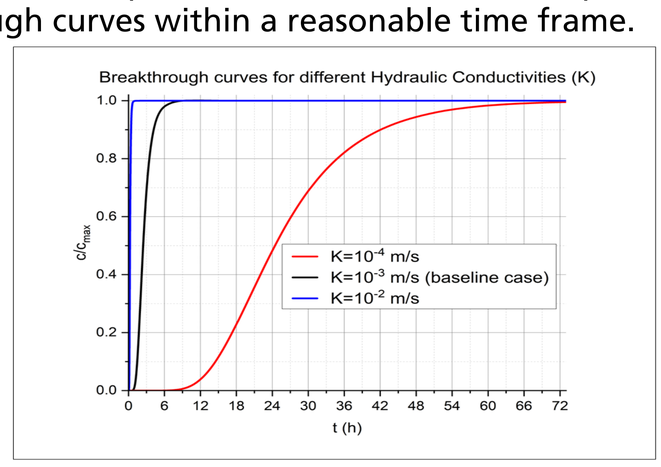


Figure 4: Exemplary breakthrough curves calculated using sediment material with different hydraulic conductivities.

- Step 2: Column packing with the aquifer material and column saturation with eluent.
- Step 3: Loading of test item into the column over a predefined time period via eluent until equilibrium is reached.
- Step 4: Desorption with the same flow rate and eluent to catch possible hysteresis effects of sorption.
- Step 5: Determine sorption/desorption parameters of the test item based on the breakthrough curves of the compound and a conservative tracer (KBr, NaBr) and modeling".

1 DIN 19528:2023-03 (Draft); Leaching of Solid Materials-Percolation Method for the Joint Examination of the Leaching Behaviour of Inorganic and Organic Substances. Beuth: Berlin, Germany, 2023.

2 Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 Concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (Reach), Establishing a European Chemicals Agency, Amending Directive 1999/45/Ec and Repealing Council Regulation (Eec) No 793/93 and Commission Regulation (Ec) No 1488/94 as Well as Council Directive 76/769/Eec and Commission Directives 91/155/Eec, 93/67/Eec, 93/105/Ec and 2000/21/Ec, (2006).

3 Neumann, M, Schliebner, I. (2019). Protecting the sources of our drinking water - The criteria for identifying Persistent, Mobile, and Toxic (PMT) substances and very Persistent, and very Mobile (vPvM) substances under EU REACH Regulation (EC) No 1907/2006. German Environment Agency

Acknowledgement : We would like to thank Barbara Hengesbach and Mike Kruse from Fraunhofer IME for their technical support in the lab. The authors would also like to thank CEFIC for funding this project.