

# Bank filtration as a robust and effective barrier for bulk organic matter and organic micropollutant elimination

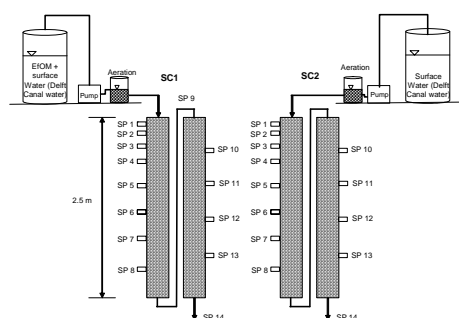
S.K. Maeng, S.K. Sharma, G. Amy

UNESCO-IHE Institute for Water Education, P.O. Box 3015, 2601 DA Delft, The Netherlands.  
e-mail: s.maeng@unesco-ihe.org

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## Introduction

Understanding the fate of bulk organic matter which consists of effluent organic matter (EfOM) and natural organic matter (NOM) through riverbank filtration is essential to assess the impact of wastewater effluent on the post treatment requirements of riverbank filtrates. Furthermore, their fate of bulk organic matter during drinking water treatment can significantly determine the process design. EfOM also consists of humic substances which are derived from the drinking water sources and serve as a precursor to disinfection by-product (DBPs) while soluble microbial products (SMPs) in EfOM represent a precursor to nitrogenous DBPs (N-DBPs) (Amy and Drews, 2007). The objective of this study was to characterize bulk organic matter during riverbank filtration using a suite of innovative analytical tools under different redox conditions and develop a water quality performance assessment tool that would possibly facilitate design and operation of bank filtration systems in the reduction of selected groups of organic micropollutants.



**Figure 1.** Schematic diagram of the soil column experimental setup

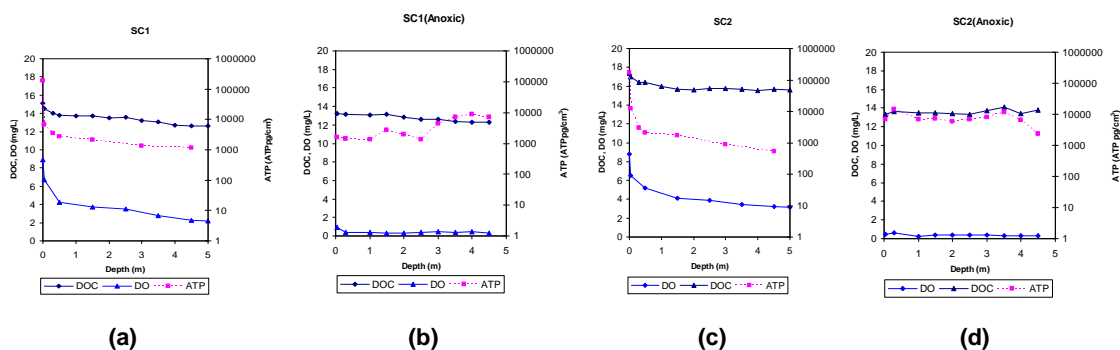
## Materials and Methods

Wastewater effluent-derived surface water (Hoek Van Holland, The Netherlands) and surface water (Delft canal water, The Netherlands) were used as source waters in experiments with soil columns. Laboratory-scale column studies, simulating RBF were conducted using the experimental setup shown in Figure 1. The soil columns were constructed from PVC pipe with internal diameter of 100 mm and there were two sets of column. Each set consisted of two columns, with each 2.5 m in height, connected in series to simulate a 5 m depth of a one dimensional aquifer. For developing a water quality performance assessment tool for organic micropollutants, the compilation of a database on the removal of trace organics from soil column and field studies was carried out and these datasets were analyzed using MS-Excel/VBA, SPSS and Slidewrite to establish generalized relationships between the variables and the selected trace organics. The methods employed in the analysis were correlation analysis, bi/multi-regression analysis, clustering of data, and factor analysis.

## Results and Discussion

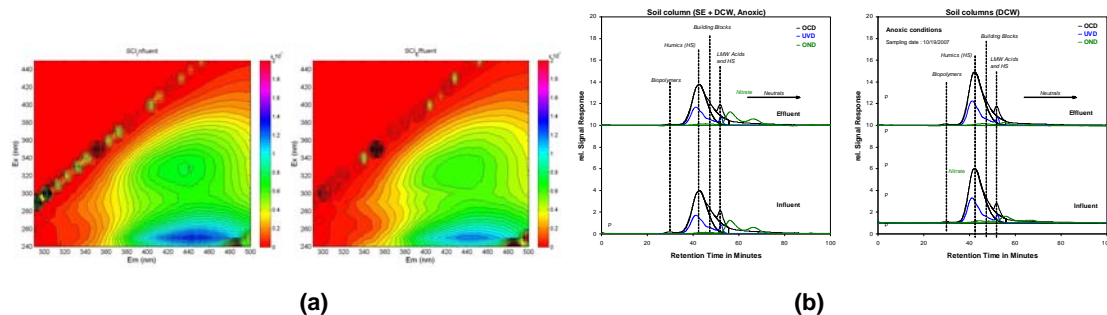
Surface water (Delft canal water) had a relatively higher SUVA value (3.22 L/mg-m) as compared to wastewater effluent (Hoek van Holland, The Netherlands) (2.68 L/mg-m). This indicates the dissolved organic carbon (DOC) compounds in Delft canal water are more aromatic than the DOC compounds in the

wastewater effluent. More than 50% of total DOC removal with significant reduction of dissolved oxygen (DO) was observed in the top 50 cm of the soil columns for both surface water and wastewater effluent-derived surface water (Figure 2) under oxic conditions. This was due to biodegradation by soil biomass which was determined by adenosine triphosphate (ATP) concentrations and heterotrophic plate counts (HPC). The trends of ATP concentrations in the columns are very similar to that of the DOC removal and the DO concentrations. High concentrations of ATP in the first few centimeters of infiltration surface reflect the highest microbial activity which correlates with the extent of DOC reduction. HPC was also carried out to enumerate the number of cultivable heterotrophic bacteria cells associated with sand from SC1. Cultivable bacteria are commonly a minor fraction of bacterial communities and HPC can not elucidate entire biomass activity (Vale et al., 2005). But, in this study, ATP concentrations were fairly correlated to the HPC data.



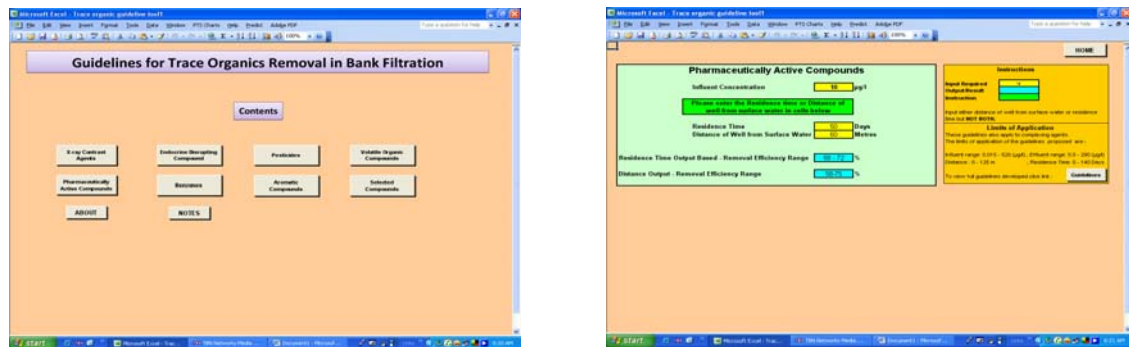
**Figure 2.** ATP, DO and DOC profile of SC1 (Delft canal water and wastewater effluent, 1:1) and SC2 (Delft canal water) at a HLR 0.625 m/day under oxic and anoxic conditions (SC1: oxic (a), anoxic (b); SC2: oxic (c), anoxic (d))

The fluorescence analysis on both SC1 and SC2 filtrates revealed the reduction of humic like materials after soil passage was not significant under oxic and anoxic conditions (Figure 3a, SC1 under oxic conditions). Results of LC-OCD/OND depicted four peaks that are characteristics of DOC in water: biopolymers (polysaccharides), humic like material, building blocks of humic substances, and low MW acids. LC-OCD/OND showed an almost complete removal of biopolymers believed to be polysaccharides under oxic condition compared that of anoxic, however, other three fractions were not significantly removed (Figure 3b, LC-OCD/OND chromatograms for anoxic conditions are not shown). This result is consistent with results from LC-OCD measurements at a bank filtration site at Lake Tegel (Berlin, Germany) that only the fraction of polysaccharides shows a better removal under oxic conditions compared that of anoxic conditions (Jekel and Gruenheid, 2005). Humic-like organic matter in surface water and wastewater effluent-derived surface water persisted through the soil passage. The bulk organic matter characteristics between wastewater effluent-derived surface water and surface water were similar after 5 m soil passage in laboratory column experiment.



**Figure 3.** F-EEM (a) and LC-OCD/OND chromatogram (b) for SC1 (Delft canal water and wastewater effluent, 1:1) and SC2 (Delft canal water)

The proposed water predictive removals performances are incorporated into a simple spreadsheet using MS Excel/VBA to enable preliminary estimation of the removal of the seven groups of trace organic compounds; X-ray contrast agents, Pharmaceutical active compounds (PhACs), Endocrine disrupting compounds (EDCs), Pesticides, Benzenes, Aromatic compounds and volatile organic compounds (Figure 4). However, some background knowledge on the behaviour of some of the target compounds would be necessary to effectively use this tool. The developed water quality removal predictive spreadsheet can be useful for the preliminary estimation of the removal of selected trace organic compounds and groups of compounds.



(a)

(b)

**Figure 4.** Introduction page of the water quality prediction tool (a); typical computation worksheet for guidelines of a group of trace organic compounds (b)

## References

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