

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

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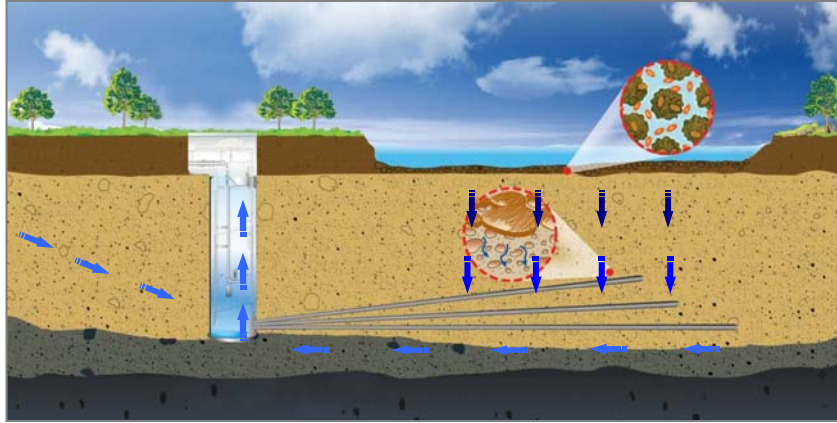
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Institute for Water Education



### Background

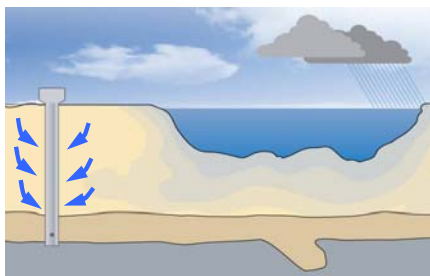
- Bank filtration (BF) has been applied for water treatment in Europe and the United States with little experience in developing countries (Asia and Africa)
- Understanding the fate of bulk organic matter which consists of effluent organic matter (EfOM) and natural organic matter (NOM) through BF is essential to determine post-treatment requirements of bank filtrates
- BF - natural and robust treatment technology capable of attenuating organic micropollutants
- No guidelines to facilitate design and operation of BF systems for optimal removal of organic micropollutants

## Background- Concept of BF

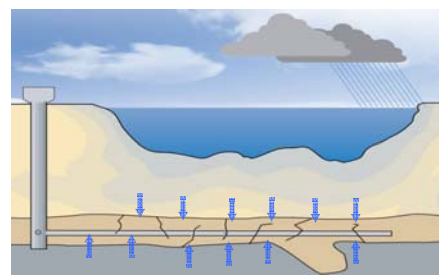


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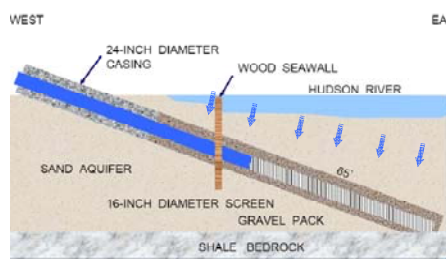
## Types of Bank Filtration System



**Vertical well**



**Collector/Ranney well**



**Angle well**

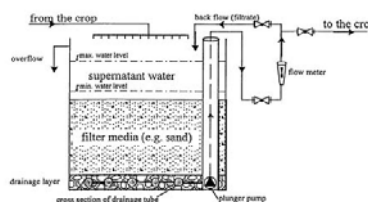
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## Water Quality Benefits of Bank Filtration



- Turbidity
- Bacteria, Protozoa, and Viruses
- Dissolved Organic Carbon (DOC)
- Pharmaceutically Active Compounds (Non-polar compounds)
- Endocrine Disrupting Compounds
- Nitrogen (ammonia and nitrate)

Slow sand filter EBCT: 3-10 hrs



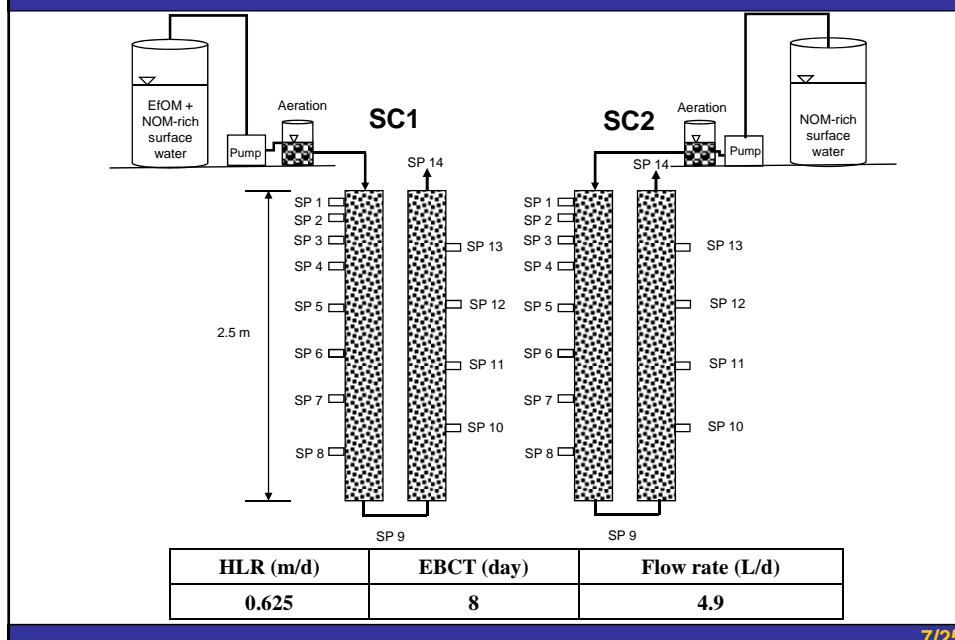
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## Objectives

- To characterize bulk organic matter which consists of EfOM and NOM during bank filtration (BF) using a suite of innovative analytical tools
- To investigate the removal of bulk organic matter under different redox conditions during BF
- To establish the relationship between the dissolved organic carbon (DOC) reduction and the biomass concentration during BF
- To examine the removal extent of organic micropollutants under different site conditions
- To develop guidelines that will give preliminary estimates of removal efficiencies for groups of selected organic micropollutants

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## Materials and methods



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## Results and discussion

### Ripening soil columns

- Influent: Delft canal water + Secondary effluent (Hoek van Holland, 1:1)

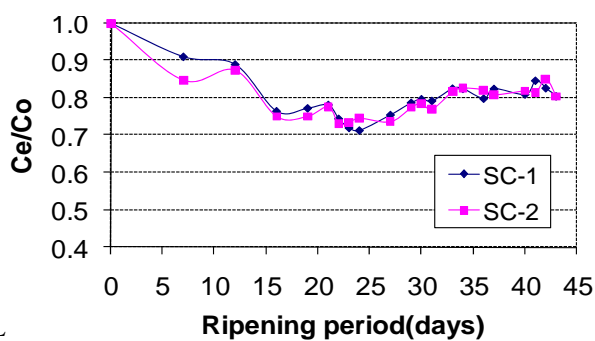
- HLR = 1.25 m/d

- Oxidic conditions

- Avg. influent DOC:  
15.71 ± 1.71 mg/L

- Avg. effluent DOC  
- SC1 = 12.53 ± 1.65 mg/L  
- SC2 = 12.43 ± 1.64 mg/L

- Avg. DOC removal: 20 %

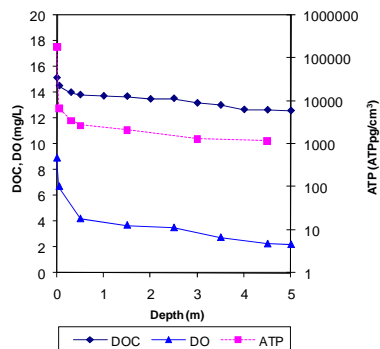


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## Soil column performance under oxic conditions

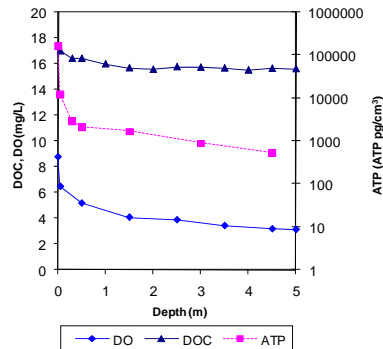
### Delft canal water and secondary effluent, 1:1

SC1(OXIC, HLR: 0.625 m/d)



### Delft canal water

SC2(OXIC, HLR: 0.625 m/d)



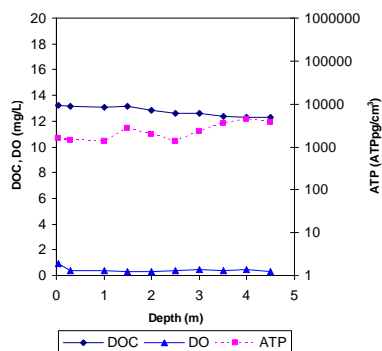
The profile of DOC, DO and ATP for soil column 1 and 2 (Column depth: 5 m and media size: 0.8 -1.25 mm)

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## Soil column performance under anoxic conditions

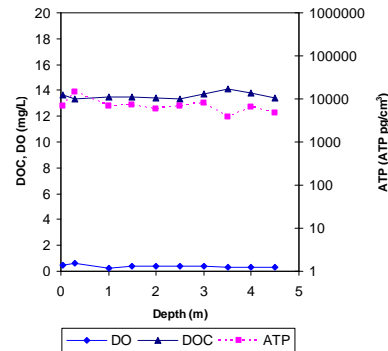
### Delft canal water and secondary effluent, 1:1

SC1(ANOXIC, HLR: 0.625 m/d)



### Delft canal water

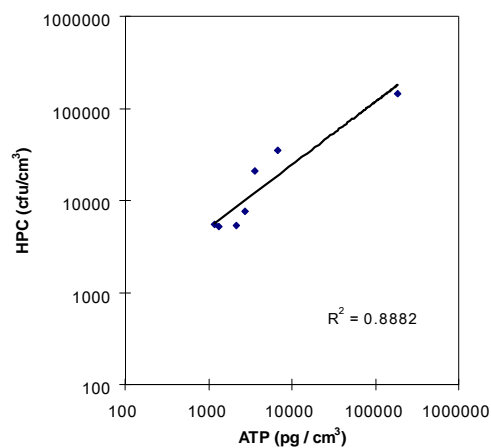
SC2(ANOXIC, HLR: 0.625 m/d)



The profile of DOC, DO and ATP for soil column 1 and 2 (Column depth: 5 m and media size: 0.8 -1.25 mm)

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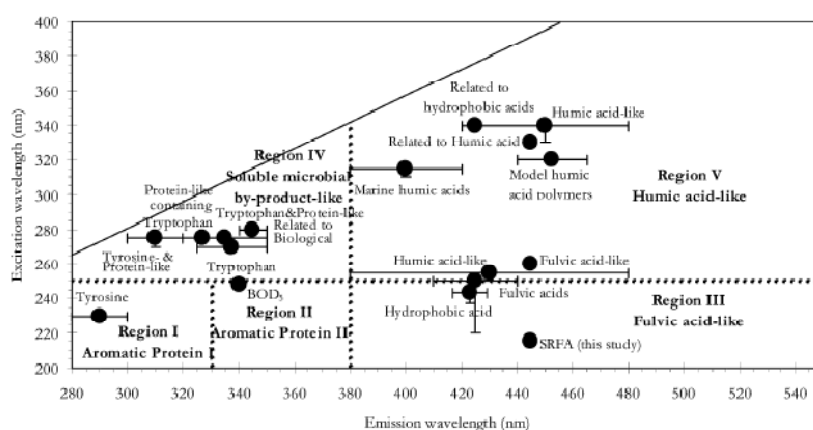
## ATP vs. HPC



Correlation between ATP concentrations and HPC measurements in different depths of SC1 (Delft canal water and wastewater effluent)

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## F-EEM peaks based on literature reports

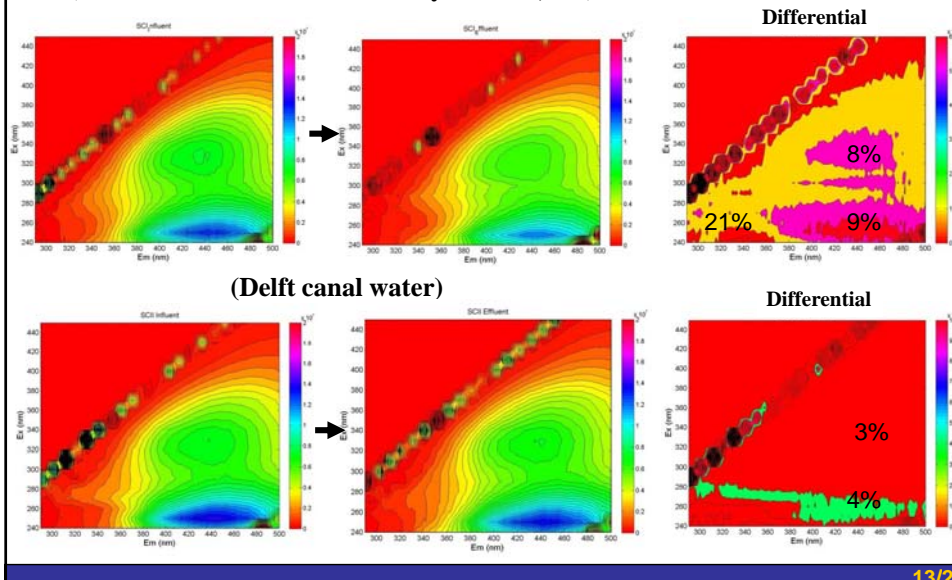


(source: Chen et.al, 2003)

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## Fluorescence EEM (oxic conditions)

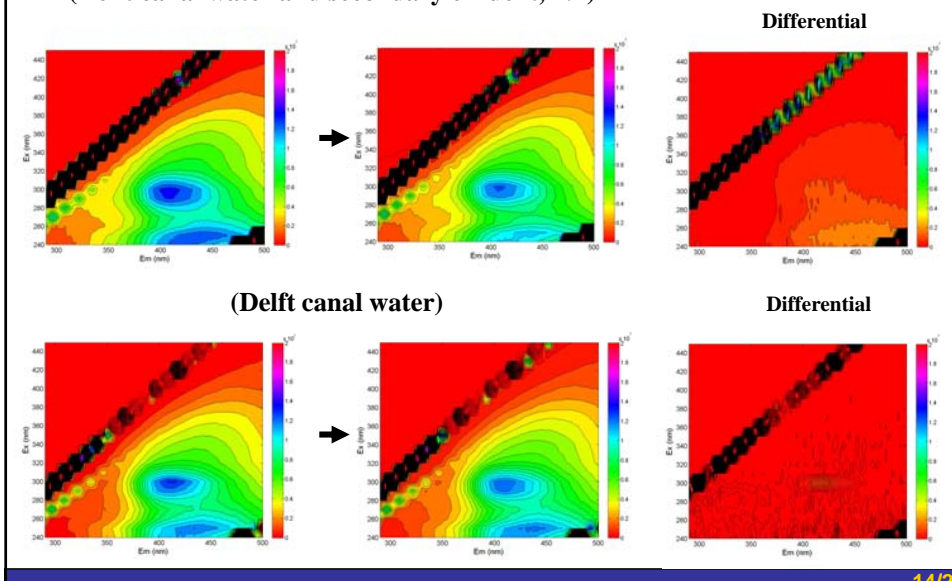
(Delft canal water and secondary effluent, 1:1)



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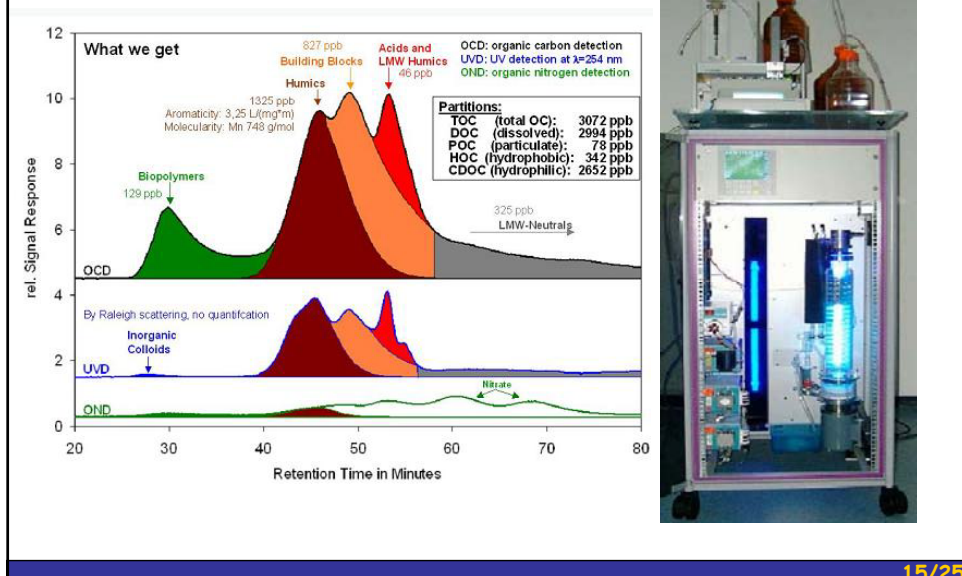
## Fluorescence EEM (anoxic conditions)

(Delft canal water and secondary effluent, 1:1)



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## LC-OCD/OND

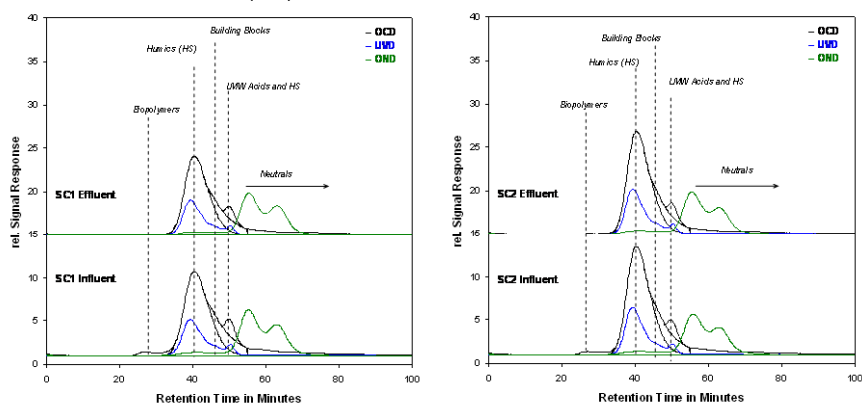


## NOM/EfOM characterization: LC-OCD

(Oxic conditions)

SC-1: Delft canal water + secondary effluent (1:1),

SC-2: Delft canal water

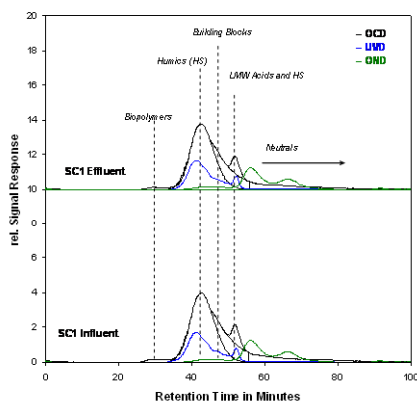




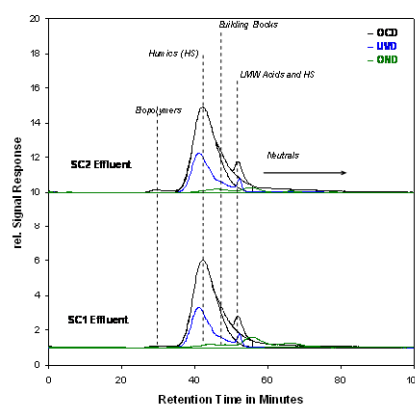
## NOM/EfOM characterization: LC-OCD

(Anoxic conditions)

SC-1: Delft canal water + secondary effluent (1:1),



SC-2: Delft canal water



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## Research methodology-Bank filtration guidelines for organic micropollutant elimination

Database

Data mining

Scatter plots, Clustering data points, Bins

Data analysis and interpretation

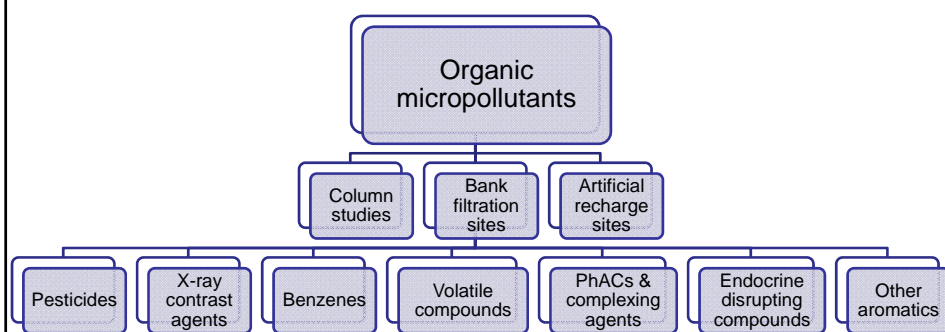
PCA, Multi linear regression

Data Driven Model (QSPR)

BF system model for organic micropollutant elimination

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## Research methodology-Bank filtration guidelines for organic micropollutant elimination



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## Bank filtration (BF) guidelines for organic micropollutant elimination

Microsoft Excel - Trace organic guideline tool1

File Edit View Insert Format Tools Data Window PTS Charts Help Predict Adobe PDF

Type a question for help

### Guidelines for Trace Organics Removal in Bank Filtration

Contents

- X-ray Contrast Agents
- Endocrine Disrupting Compound
- Pesticides
- Volatile Organic Compounds
- Pharmaceutically Active Compounds
- Benzenes
- Aromatic Compounds
- Selected Compounds
- ABOUT
- NOTES

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## BF guidelines for pharmaceutically active compounds

**Pharmaceutically Active Compounds**

Influent Concentration: 10 µg/l

Please enter the Residence time or Distance of well from surface water in cells below.

Residence Time: 50 Days

Distance of Well from Surface Water: 60 Metres

Residence Time Output Based - Removal Efficiency Range: 58 - 72 %

Distance Output - Removal Efficiency Range: 58-75 %

**Instructions**

Input Required: 2

Output/Result: 2

Instruction: Input either distance of well from surface water or residence time but NOT BOTH.

**Limits of Application**

These guidelines also apply to complexing agents. The limits of application of the guidelines proposed are:-

Influent range: 0.015 - 520 (µg/l); Effluent range: 0.0 - 290 (µg/l)

Distance: 0 - 125 m; Residence Time: 0 - 140 Days

To view full guidelines developed click link: [Guidelines](#)

Demonstration of this spreadsheet will be given during this presentation!

## Conclusions

- Residual bulk organic matter characteristics after bank filtration were similar for surface water (Delft canal water) and wastewater effluent derived surface water
- 50% of total DOC removal with significant reduction of DO was observed in the top 50 cm of the soil columns. This was presumably due to biodegradation of organic matter by the biomass associated with the sand, and the role of first few centimeters in BF system is important in order to maintain good water quality.
- Good correlation of DOC removal with DO and biomass development was observed in the soil columns.

## Conclusions

- FEEM of both SC1 and SC2 filtrates revealed the reduction of humic like materials was not significant after soil passage. No protein-like material was observed.
- LC-OCD/OND showed an almost complete removal of biopolymers (believed to be polysaccharides). However, other three fractions were not significantly removed.
- Bank filtration guidelines were developed for the removal of seven groups of organic micropollutants: can be used for preliminary estimates of removal efficiency

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## Acknowledgements



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**Thank you for your attention!  
and  
Questions?**

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