Toxicity assessment of organic micropollutant removal during River Bank Filtration

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River Bank Filtration (RBF) can be used as a drinking water treatment technique to remove organic micro pollutants.
Context
The issue of metabolites

• Organic micro pollutant (OMP) removal during River Bank Filtration (RBF) has been investigated in numerous studies

• Studies focused on the removal of parent compounds

• In certain cases the transformation products can be more toxic than the parent compound

• Effect measurements investigated
  • AMES-II assay indicates the risk of genotoxicity and mutagenicity, oxidative stress assay is a measure of the reactivity of the compounds in the tested sample

• Does OMP biodegradation by RBF also ensure a reduction in toxicity??
River Bank Filtration Pilot
Overview RBF pilot

Three pilots:
- A oxic: 2 oxic columns (O₂)
- B sub anoxic: 4 oxic + 6 anoxic columns (NO₃ reducing)
- C deep anoxic: 4 oxic + 18 anoxic columns (Fe/Mn reducing)

<table>
<thead>
<tr>
<th>Redox conditions</th>
<th>Average NO₃ removal (%)</th>
<th>DOC removal (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O₂</td>
<td>~0</td>
<td>9</td>
</tr>
<tr>
<td>O₂ + NO₃</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>O₂ + NO₃ + Fe/Mn</td>
<td>&gt;98</td>
<td>19</td>
</tr>
</tbody>
</table>
2,4-D
Atrazine
Bentazon
Caffeine
Carbamazepine
Chloridazon
Cis-1,2-dichlooretheen
Clofibric acid
Diatrizoic acid
Dichlorprop
Diclofenac
Diglyme
Dimethoate
Diuron
Phenazon
Fluoxetine
Gentfibrozil
Hydrochlorothiazide
Ibuprofen
Iomepil
Ketoprofen
Lincomycin
MCPA
MCPP
Mebendazole
Metformin
Metoprolol
MTBE
Naproxen
NDMA
Paracetamol
PFOA
PFSO
Phenazone
Pindolol
Pirimicarb
Propranolol
Prosulfocarb
Ranitidine
Salicylic acid
Simazine
Sotalol
Sulfamethoxazole
Terbutalin
Terbutylazine
Tetrachlooretheen
Tetrahydrofuraan (THF)
Theophyline
TPPO
Trichlooretheen
Triclopyr
Dimethoate
Insecticide
AMES TA100 positive
Lincomycin
Antibiotic
AMES TA98 and TA 100 positive
Mebendazole
Anthelmintic
AMES TA98 and TA100 positive
NDMA
By product drinking water treatment
AMES TA100 have shown positive effects
Sulfamethoxazole
Antibiotic
AMES TA98 and TA100 positive

50 compounds each dosed in a concentration of 500 ng/L
# Organic Micro Pollutant removal of RBF pilot

## Removal percentage

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Feed (ng/L)</th>
<th>Oxic</th>
<th>Sub anoxic</th>
<th>Deep anoxic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimethoate</td>
<td>430</td>
<td>&lt;90%</td>
<td>&lt;90%</td>
<td>&lt;90%</td>
</tr>
<tr>
<td>Lincomycin</td>
<td>634</td>
<td>&lt;75%</td>
<td>&lt;75%</td>
<td>&lt;75%</td>
</tr>
<tr>
<td>Mebendazole</td>
<td>~100</td>
<td>&gt;DL</td>
<td>&gt;DL</td>
<td>&gt;DL</td>
</tr>
<tr>
<td>NDMA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfamethoxazole</td>
<td>560</td>
<td>&gt;DL</td>
<td>&gt;DL</td>
<td>&gt;DL</td>
</tr>
</tbody>
</table>

## AMES II expectations

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Feed</th>
<th>Oxic</th>
<th>Sub anoxic</th>
<th>Deep anoxic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimethoate</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lincomycin</td>
<td>+</td>
<td>-?</td>
<td>-?</td>
<td>-?</td>
</tr>
<tr>
<td>Mebendazole</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>NDMA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfamethoxazole</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
For the AMES II test the detection limit is calculated based on the negative control where the chance of getting a false positive response is less or equal to 1%

\[ P[X \leq k] = \sum_{i=0}^{k} \binom{n}{i} p^i (1 - p)^{n-i} \geq 99\% \]
Sample scheme

• Day 0 – influent (plus two ‘Blanco’s”) in triple
  • Blanco A is river water,
  • Blanco B is river water with OMPs (influent) and
  • Blanco C is demi water with OMPs.

• Day 4 - effluent oxic pilot (oxic conditions) in duplo

• Day 20 - effluent sub anoxic (nitrate reducing no oxygen) in duplo

• Day 45 - effluent deep anoxic (nitrate, iron and manganese reducing) in duplo
Results – Sum positive responses
Results – Average positive responses

TA98-S9
2-9-2014

Average

NC  Blanco A  Blanco B  Blanco C  Day 4 RBF  Day 20 RBF  Day 45 RBF
River water  River water + OMP’s  Demi water + OMP’s

TA98-S9
9-9-2014

Average

NC  Blanco A  Blanco B  Blanco C  Day 4 RBF  Day 20 RBF  Day 45 RBF
River water  River water + OMP’s  Demi water + OMP’s
Results – Sum positive responses

TA100-S9
2-9-2014

TA100-S9
9-9-2014

SUM

SUM

NC Blanco A Blanco B Blanco C Day 4 RBF Day 20 RBF Day 45 RBF

NC Blanco A Blanco B Blanco C Day 4 RBF Day 20 RBF Day 45 RBF
Results – Average positive responses

TA100-S9
2-9-2014

Average

NC | Blanco A | Blanco B | Blanco C | Day 4 RBF | Day 20 RBF | Day 45 RBF
River water | River water + OMP’s | Demi water + OMP’s

TA100-S9
9-9-2014

Average

NC | Blanco A | Blanco B | Blanco C | Day 4 RBF | Day 20 RBF | Day 45 RBF
River water | River water + OMP’s | Demi water + OMP’s
Conclusions

• OMP mixture added seems to do little to the positive responses of the samples

• Most of the found positive responses are from the river water

• No significant additional positive responses are created by RBF filtration

• With cell line TA100 there even seems to be a decrease in positive responses in the RBF pilot that is time and microbial community dependent
Additional remarks

• We are testing the same samples with the oxidative stress assay too, but do not have the results yet

• We hope that this assay will enable us to expand upon the conclusions from the AMES II assay

• Finally we hope by comparing the results from these two very different effect assays, that we will gain some insight on how to use and choose assays to assess drinking water source quality, and the efficiency of drinking water treatment techniques