Investigating Biological Filtration for the Effective removal of Manganese (Mn) in water treatment

Daniel Wesley, Michael Brophy & Graham Gagnon
Concerns With Manganese in Drinking Water

• Mn has been identified as a neurotoxin
• Mn causes staining, taste and odour issues.
• Current Guideline is AO of 0.05 mg/L
  – High levels (>1-2 mg/L) of Mn are often found in groundwater and anaerobic surface water.
• High levels of Manganese in Drinking water are found in parts of Nova Scotia, New Brunswick, southern Quebec and other parts of the world

Treatment Background

- Biological treatment used in 1980’s in France\(^2\)
- Biological treatment introduced to Atlantic Canada in 1999
- Currently 4 plants in New Brunswick that have almost complete removal of up to 1mg/L Mn

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How Biological Treatment Works

Diagram showing “field of activity” for biological Mn (and Fe) removal (Mouchet, 1992)
Previous Studies at Dalhousie

• Mark Burger, MASc (2008)
  – Evaluation of operating range
  – Role of oxidation
  – Identification of species

• Heather Granger, MASc (2013)
  – Evaluation as a surface water roughing filter

Assessment of Full-Scale Treatment Plants in New Brunswick

- Six Mn biofiltration plants in New Brunswick
- Water is aerated and passed through sand filter, where biofilm builds up


**Picture:** Shediac WTP, 2007
### Assessment of Full-Scale Treatment Plants in New Brunswick

<table>
<thead>
<tr>
<th>Utility</th>
<th>Sample Point</th>
<th>Dorchester</th>
<th>Memramcook</th>
<th>Shediac</th>
<th>Woodstock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw</td>
<td>Filtered</td>
<td>Raw</td>
<td>Filtered</td>
<td>Raw</td>
</tr>
<tr>
<td><strong>Manganese (µg/L)</strong></td>
<td>930</td>
<td>&lt;30</td>
<td>860</td>
<td>&lt;30</td>
<td>860</td>
</tr>
<tr>
<td><strong>Iron (µg/L)</strong></td>
<td>&lt;200</td>
<td>&lt;200</td>
<td>&lt;200</td>
<td>&lt;200</td>
<td>260</td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td>7.25</td>
<td>7.18</td>
<td>6.46</td>
<td>6.46</td>
<td>7.5</td>
</tr>
<tr>
<td><strong>ORP (mV)</strong></td>
<td>295</td>
<td>415</td>
<td>343</td>
<td>370</td>
<td>338</td>
</tr>
</tbody>
</table>

Assessment of Full-Scale Treatment Plants in New Brunswick

- (1) 100 bp EZ Load Molecular Ruler (BioRad),
- (2) *L. discophora* SP-6 with PS-1 primer,
- (3) *L. discophora* SP-6 with PSP-6 primer,
- (4) *E. coli* with PSP-6 primer,
- (5) Woodstock with PSP-6 primer,
- (6) Shediac with PSP-6 primer,
- (7) Dorchester with PSP-6,
- (8) Memramcook with PS-1 primer
- (9) Memramcook with PSP-6 primer.
Assessment of Bench-Scale Treatment in Nova Scotia Surface Water

- Used biofiltration for treatment of iron and manganese from surface water
- Investigated pH ~ 6
- Compared GAC/sand to anthracite/sand

Assessment of Bench-Scale Treatment in Nova Scotia Surface Water
Figure 2: Manganese trends comparing how the two media types differ in phosphorus, pH, and the control. The error bars represent the 95% confidence interval for the average Mn concentrations over a 132 day experiment duration.

Mean Influent Mn: 319 ± 278 µg/L

pH 6 filters had 91% removal and met 50 µg/L aesthetic guideline the majority of the time.
Overall – Where we Stand?

- pH operating range is broad 6-9
- *Leptothrix* is desirable but not critical
- Media specificity is not required
On – going Work…

• Comparison of media for biological treatment
  – Sand, Anthracite, Glass beads
  – Growstone

• Evaluation in lab and at pilot scale
  – Seeded and non-seeded
Types of Media
Growstone

- Made from recycled glass
- Cost effective
- Tested as biofilter media for aquaculture applications but has never been used for drinking water treatment
- Highly porous with a very low density
Laboratory Studies

Table 1. Bench Scale Set-Up Seeded with *L. Discophora*

<table>
<thead>
<tr>
<th>Media Type</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand/Anthracite</td>
<td>1 Seeded/ 1 Control</td>
</tr>
<tr>
<td>Sand</td>
<td>1 Seeded/ 1 Control</td>
</tr>
<tr>
<td>Glass Beads</td>
<td>1 Seeded/ 1 Control</td>
</tr>
<tr>
<td>Growstone</td>
<td>1 Seeded/ 1 Control</td>
</tr>
</tbody>
</table>

Table 2. Bench Scale Set-Up Seeded with an Established Biofilm

<table>
<thead>
<tr>
<th>Media Type</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthracite</td>
<td>2 Seeded/ 1 Control</td>
</tr>
<tr>
<td>Sand</td>
<td>2 Seeded/ 1 Control</td>
</tr>
<tr>
<td>Glass Beads</td>
<td>2 Seeded/ 1 Control</td>
</tr>
<tr>
<td>Growstone</td>
<td>2 Seeded/ 1 Control</td>
</tr>
</tbody>
</table>
Bio-filter setup for media comparison

Photo: Michael Brophy
Bio-filter setup for media comparison

AC Filter

Reservoir

Simulated Ground-water

Nutrient Cocktail

MnSO₄

NaOH/NaHCO₃

Compressed Air

Filter Columns (8 or 12)

Effluent
Manganese concentrations for Columns Seeded with an *established* biofilm

![Graph showing manganese concentration for different media types.](image)
Manganese concentrations for Columns Seeded with *Leptothirx discophora*

![Bar chart showing manganese concentrations for different media types](image-url)
Pilot Studies

• 3 stage process
  – 5 micron cartridge filter
  – Biological filter for iron removal
  – Biological filter for manganese removal

• 3 bio-filters in parallel for media comparison
Pilot System

Photo: Michael Brophy
Raw Water Conditions

- pH: 6.37 to 7.11
- Temp: 11.9 to 15ºC
- ORP: 116 to 283 mV
Pilot iron and manganese concentrations

- **Concentration (µg/L)**
  - Iron
  - Manganese

- **Media Type**
  - Influent
  - Iron Filter
  - Sand
  - Anthracite
  - Growstone

- **AO for Iron**
- **AO for Manganese**
Summary

• Anthracite and a sand anthracite combination showed the highest Manganese removal
• Pilot results meet Drinking water quality guidelines for Iron and Manganese but we were not able to compare media
Acknowledgements

- Dr. Lisbeth Truelstrup Hansen and Dr. Jennie Rand
- CWRS lab staff Heather Daurie and Elliott Wright
- Mike Chalk and Ben Bickerton from CBCL Limited
- Staff at Benner Lake Water Treatment Plant
- Kyle Slaunwhite and Jim Chisholm
- Lab members in the CWRS group.
Questions?