Combining fluidized IEX and coagulation / flotation for NOM removal

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De Watergroep
De Watergroep

- Drinking water utility in the Flanders
- +- 3 million domestic customers
- Yearly production +- 120 million m³
  - 71% ground water
  - 29% surface water
- Production plants
  - 85 ground water abstractions
  - 5 surface water treatment plants
## Surface Water NOM Levels

**Water Treatment Works**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Kluizen</th>
<th>Blankaart</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPOC (mg C/l)</td>
<td>10,3</td>
<td>13,1</td>
</tr>
<tr>
<td>Alkalinity (meq/l)</td>
<td>4,0</td>
<td>3,8</td>
</tr>
<tr>
<td>pH (-)</td>
<td>8,0 – 8,7</td>
<td>8,0 – 9,2</td>
</tr>
<tr>
<td>Conductivity (µS/cm)</td>
<td>574</td>
<td>859</td>
</tr>
<tr>
<td>Chloride (mg/l)</td>
<td>48</td>
<td>121</td>
</tr>
<tr>
<td>Sulfate (mg/l)</td>
<td>55</td>
<td>88</td>
</tr>
<tr>
<td>Hardness (°F)</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>1,9</td>
<td>4,4</td>
</tr>
<tr>
<td>Suspended solids (mg/l)</td>
<td>2,6</td>
<td>9,7</td>
</tr>
<tr>
<td>Manganese (µg/l)</td>
<td>114</td>
<td>102</td>
</tr>
<tr>
<td>NH₄⁺ (mg/l)</td>
<td>0,2</td>
<td>0,6</td>
</tr>
<tr>
<td>Nitrate (mg/l)</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Orthofosfate (mg/l)</td>
<td>0,3</td>
<td>0,8</td>
</tr>
<tr>
<td>Chlorofyl (µg/l)</td>
<td></td>
<td>32</td>
</tr>
<tr>
<td>C perfringens (/100 ml)</td>
<td>51</td>
<td>166</td>
</tr>
<tr>
<td>Coli (/100 ml)</td>
<td>591</td>
<td>1009</td>
</tr>
<tr>
<td>Enterococcus (/100 ml)</td>
<td>18</td>
<td>67</td>
</tr>
<tr>
<td>E. Coli (/100 ml)</td>
<td>58</td>
<td>230</td>
</tr>
<tr>
<td>HPC 22°C (/100 ml)</td>
<td>1612</td>
<td>5910</td>
</tr>
</tbody>
</table>
NOM removal WTW Kluizen


- Fluidized bed IEX reliable enough for full scale application
- >80% reduction in coagulant demand
- Improved overall NOM removal
- Lower mineralisation
- Investment cost IEX compensated by decrease in operational costs
- Need for further research on waste water treatment
NOM removal WTW De Blankaart

Current treatment scheme

Future treatment scheme

- Prefiltration
- Biological ammonia oxidation
- Enhanced coagulation
- Decantation
- Filtration
- Ozonation
- Dual stage GAC filtration
- Disinfection UV/NaOCl

- Ion Exchange
- Enhanced coagulation
- Flotation
- Filtration
- Ozonation
- Dual stage GAC filtration
- Disinfection UV/NaOCl
Pilot research WTW De Blankaart
Fluidized bed IEX – coagulation – flotation (2015 – now)
Fluidized bed IEX

Working principle

- Regeneration brine
- Spent brine
- Loaded resin
- Regenerated resin
Coagulation - flotation
Research questions

- IEX
  - Impact on overall NOM removal efficiency
  - Impact on coagulant demand and optimal coagulation pH
  - Is algae bloom a problem?

- Flotation
  - Can FeCl₃ be applied as a coagulant?
  - Time required for flocculation?
  - What is the maximum surface loading?
  - Operation at low temperature and during algae blooms
Some results

• NOM removal
• Fluidized bed IEX and algae blooms
• IEX waste water treatment
• Flotation
Results NOM removal

NPOC (mg C/l)

- Raw water
- IEX
- Flotation
- IP sedimentation
- IP RSF

Dates:
- 1-11-2015
- 31-1-2016
- 2-5-2016
- 1-8-2016
- 1-11-2016
- 31-1-2017
- 3-5-2017
- 2-8-2017
Results NOM removal

- Raw water
- IEX
- Flotation
- IP sedimentation
Results NOM removal

- IEX NOM removal efficiency shows strong seasonal variation
- Combination of fluized bed IEX and coagulation / flotation performs slightly worse than the full scale plant with respect to NOM removal
- Less chemicals used

<table>
<thead>
<tr>
<th></th>
<th>IEX - flotation</th>
<th>Full scale plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂SO₄ (mg/l)</td>
<td>15</td>
<td>67</td>
</tr>
<tr>
<td>FeCl₃ (mg Fe/l)</td>
<td>12</td>
<td>31</td>
</tr>
<tr>
<td>NaOH (mg/l)</td>
<td>13</td>
<td>76</td>
</tr>
<tr>
<td>Resin Purolite PPA860S (ml/m³)</td>
<td>1 – 1.5</td>
<td>-</td>
</tr>
</tbody>
</table>
Fluidized bed IEX and algae

• 2016: accumulation of algae in resin bed results in stratification

- decayed algae
- IEX resin
Fluidized bed IEX and algae

• 2016: accumulation of algae in resin bed results in stratification
Fluidized bed IEX and algae

• 2017: more algae, no accumulation in resin bed, no stratification
• Increased upflow velocity: 20.0 m/h ↔ 17.3 m/h
• Increased regeneration frequency: 2 ml/l ↔ 1 ml/l
IEX waste water treatment

- Coagulation with FeCl$_3$ at pH 4.0 and dewatering with filter press
- Recirculation of filtrate to regeneration
- Accumulation of sulfate in regeneration brine seems to have a negligible impact on NOM removal efficiency
- Long-term operation feasible
- Filter cake is a waste
IEX waste water treatment

- Water balance is important!
Flotation

- FeCl$_3$ can be applied as a coagulant
- A flocculation time of 15 minutes is sufficient
- Hydraulic loading of the separation zone of 20 m/h is a good design value
- Low effluent turbidity, even at low temperature and during algae blooms without coagulation or flocculation aids
What options do we have?

• IEX with higher resin dose
  ⇒ Concentration step in waste water treatment required!
  ⇒ Caroussel system (no freshly regenerated resin to regeneration system & positive impact on algae accumulation)
  ⇒ Costs will increase

• Coagulation – flotation on raw water
  ⇒ High coagulant demand and low coagulation pH

• Combination of coagulation – flotation with NOM removal step after RSF
  ⇒ IEX in fixed bed system
IEX with higher resin dose

Caroussel system

Regeneration brine

Spent brine

Feed

To coagulation/flotation
IEX with higher resin dose

NOM removal efficiency

- UV254 (m-1)
- NPOC (mg C/l)
Coagulation / flotation / RSF / IEX

• Can chemicals usage in the coagulation step be reduced if turbidity removal is the main target?

• Pilot plant RSF and IEX in fixed bed
• Achievable NOM removal?
• Resin choice
• Additional cost?