Tertiary solids removal with treatment wetlands: what do we know?
26th June 2013

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Overview of current projects

- Requirements
- Kinetics
- Limitations

- Aerated reed beds

- Specialised media for P removal

- Solids
  - Ammonia
  - Phosphorus
  - Very low phosphorus

- Clogging
- Whole Life Costs
- O&M guidance

- Vertical flow reed beds

- Endocrine disruptors
  - Metals
  - Total N

- Chemical dosing ahead of HSSF

- Use of harvested reeds
- Operated by water companies *(UK)*; *Severn Trent Water*
- Collection system *(combined sewers; infiltration; multiples of dry weather flow)*
- Compliance is measured monthly (at most), 95% percentile; final effluent only
Applications covered

Conventional Tertiary HSSF

- Similar HLR
- Similar solids loading rates
- Gravel based


Case studies

Chemically dosed HSSF

Aerated HSSF
Solids Removal

- Storage
- Water level
  - Storage space
  - Loading rates
  - Turbulence

- Settling
  - Normal operational water level is subsurface

- Physical Filtration
  - Pore size
  - Biofilm growth
  - Turbulence
  - Loading rates

- Biological degradation
  - (organic solids only)

We observe the combined effect
Conventional horizontal flow systems performance

- **HLR = 0.4 m/d**
- **TSS loading rate = 5.4 g/m²/d**
- **TSS storage rate = 1.4 kg/m²/year**

**HLR = 0.4 m/d**
- **TSS loading rate = 12.8 g/m²/d**
- **TSS storage rate = 4.1 kg/m²/year**
Solids and clogging

Wastewater characteristics
- Operational strategies
  - Climate, etc
- Surface vs. subsurface
- Recalcitrant organics

Operational strategies
- Pore size
- Degradability
- Loading rate

Clogging

Unless there is some form of solids washout, inert “clog matter” will accumulate and the system WILL POND

Physical
- Settling
- Filtering

Chemical Precipitation

Biological
- Plants
- Biofilm

• Reactive media
• Strong changes in environmental conditions
Clogging
Clogging effects

Performance was **NOT** the issue

- Walkways flooded (H&S concerns)
- Overflowing beds (pollution event)

Very common in 3ry HSSF systems

20BOD/25TSS/5NH$_4^-$N
Case study: chemically dosed sites
Case study: chemically dosed sites

**HLR = 0.24 m/d**

**TSS loading rate = 4 g/m²/d**

**TSS storage rate = 1.1 kg/m²/year**

Limited impact on current management of asset life based on storage and clogging...
Case Study: aerated wetlands

Crude

Storm route
(dedicated CSO reed bed)

Aerated Reed Bed

Control Reed Bed

To receiving
Water course

Control bed:
Positive correlation
between loading rate and
effluent concentration

Aerated bed:
Consistently low
effluent independent of
loading rate

Nitrification
requirements

Vegetation
requirements

Opportunities
and Limitations
Case study: aerated wetlands

• Extended asset life?
  – Aerobic degradation rates are faster than anaerobic ones. Stored organics will be mineralised quickly.
  – Aeration promotes solids detachment and mixing. This mixing results in higher solids in the effluent.

• Reduced asset life?
  – Aerobic microorganisms have faster growth rates, resulting in more biofilm. The system will clog faster.

• ...no change...?
  – Both mechanisms balance each other out. No net change.
Case study: aerated wetlands

<table>
<thead>
<tr>
<th>System</th>
<th>Baseline</th>
<th>Aerated</th>
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<tbody>
<tr>
<td></td>
<td>Sample size</td>
<td>95\textsuperscript{th} TSS (mg/L)</td>
</tr>
<tr>
<td>Combined RB 1</td>
<td>100</td>
<td>7</td>
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<tr>
<td>Combined RB 2</td>
<td>134</td>
<td>14</td>
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</table>
Case study: aerated wetlands

**Table 2**

Summary of additional solids quantification and characterisation analyses.

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<thead>
<tr>
<th></th>
<th>Inlet</th>
<th>Middle</th>
<th>Outlet</th>
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</thead>
<tbody>
<tr>
<td><strong>TSS (kg/m²)</strong></td>
<td></td>
<td></td>
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<tr>
<td>Aerated</td>
<td>0.13</td>
<td>0.02</td>
<td>0.04</td>
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<tr>
<td>Control</td>
<td>0.68</td>
<td>0.32</td>
<td>0.28</td>
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<tr>
<td><strong>VSS (kg/m²)</strong></td>
<td></td>
<td></td>
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<tr>
<td>Aerated</td>
<td>0.05</td>
<td>0.007</td>
<td>0.01</td>
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<tr>
<td>Control</td>
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<td>0.15</td>
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<td><strong>SVI (mL/g)</strong></td>
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<tr>
<td>Aerated</td>
<td>77.7</td>
<td>21.8</td>
<td>13.9</td>
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<tr>
<td>Control</td>
<td>38.9</td>
<td>36.3</td>
<td>28.0</td>
</tr>
<tr>
<td><strong>CST (s/g)</strong></td>
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<td></td>
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<tr>
<td>Aerated</td>
<td>9.7</td>
<td>11.2</td>
<td>6.9</td>
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<tr>
<td>Control</td>
<td>6.3</td>
<td>3.5</td>
<td>4.3</td>
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<tr>
<td><strong>SRF (0.6 bar) mg/kg</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aerated</td>
<td>6 \times 10^{13}</td>
<td>2 \times 10^{12}</td>
<td>6 \times 10^{11}</td>
</tr>
<tr>
<td>Control</td>
<td>5 \times 10^{13}</td>
<td>4 \times 10^{13}</td>
<td>5 \times 10^{13}</td>
</tr>
<tr>
<td><strong>Compressibility factor</strong></td>
<td></td>
<td></td>
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<tr>
<td>Aerated</td>
<td>0.5</td>
<td>0.8</td>
<td>&lt;0.1</td>
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<tr>
<td>Control</td>
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<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>DO (mg/L)</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Aerated</td>
<td>9.4</td>
<td>10.5</td>
<td>9.8</td>
</tr>
<tr>
<td>Control</td>
<td>0.3</td>
<td>0.5</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Less **surface** solids in aerated bed

Control: 10 h
Aerated: minutes

**Moderately easy to dewater sludge**

Impact on clogging development

- Aerated 1
- Control 1
- Aerated 2
- Control 2

No impact long term?
Conclusions

• Understanding the underlying mechanisms is critical for forecasting bed life and conducting the appropriate O&M.
  – Storage vs. degradation
  – Washout vs. permanent storage

• Chemical dosing upstream of CWs has little impact on solids removal efficiency and asset life (clogging triggers)

• Artificial aeration results in solids with different characteristics...but potentially similar effects long term

• Research is ongoing to define the appropriate loading rates and O&M to maximise asset life in all applications of tertiary wetlands
Related Events coming up…

Conference on Low Energy Wastewater Treatment Systems

Tuesday, 24th September 2013

Morning Keynote
"Optimising low energy wastewater treatment systems: radical vs. progressive innovation"
Adam Brookes, Innovation Programme Manager
Anglian Water, UK

Afternoon Keynote
“Achieving high nitrogen removal rates with reed beds”
Dr Günter Langergraber. University of Natural Resources and Life Sciences, Austria.

For more info, contact: g.c.dotro@cranfield.ac.uk

http://www.cranfield.ac.uk/sas/water/cpd/lowenergy.html
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