Part 3

Treatment of Landfill Leachate Using Natural Systems

Presented by:
Dr Kevin Ryan,
Executive Scientist,
Cork City Council
Introduction

- A demonstration scale wastewater treatment plant was designed and constructed at Kinsale Road Landfill Site in 2008

- Incorporated varying alternative natural treatment processes:
  - Reed Beds / Constructed Wetlands
  - Bio-based filter beds (compost and timber chippings)
  - Willow bed treatment units
  - Grass bed polishing units
  - Composite filter bed material

- Emphasis on meeting leachate treatment and discharge limits / regulations in the most cost effective manner

- Low technology, low maintenance, low cost with the aim of mitigating the associated environmental impacts

- Possibility of up-scaling plant based on results
Description of Treatment Units

Project consisted of 14 no. treatment units

- 10 no. circular cells (Ø 1.8m concrete cells)
  Area of cells = 2.54m²
- 4 no. reed beds (4 x 25m²) - consisting of:
  2 Vertical Flow (VF) Reed Beds
  2 Horizontal Flow (HF) Reed Beds
- Critical component of the design process was that it could be easily up-scaled and brought into full-scale operation if results so warranted
- Trial plant mimicked as closely as possible the conditions that could be expected within a full scale leachate treatment plant
Challenges for System Design and Performance

- Challenges to advancement and increased use of natural treatment systems include:
  - Perceived lack of buy-in from design engineers, construction & wastewater treatment industry
  - Competing with conventional technology
  - Requirement large footprint of treatment systems
  - Poor understanding of performance capabilities
  - Overloading - exceed tolerance of treatment media / plants / microorganisms
  - Poor maintenance regime –
    - Low maintenance does NOT mean no maintenance
  - Often lack of long-term performance data across a wide range of parameters
  - How do we know if they will work?
Possible Solutions

• Networking and data sharing between academics, practitioners, consulting engineers and scientists
• Combination of different technologies tailored to specific waster-water streams
  • Pre-treatment / roughing filters
  • Parameter specific treatment units
  • Overcome issues of overloading
  • Switching of unit sequences during treatment
  • Rest periods for treatment beds
• With the correct design, hydraulic loading and parameter loading rates as well as adequate system capacity

➢ Footprint can be significantly reduced
Sampling and Analysis

- Samples tested monthly for a range of parameters & pollution indicators
- Occasional sampling was carried out for a wider range of determinands including major ions and heavy metals

Parameters Monitored

- Ammonium
- NO$_2$ and NO$_3$
- BOD$_5$
- COD
- Suspended Solids
- Electrical Conductivity
- pH
- Methane (dissolved)

- Metals & Ions (Fe, Mg, Mn, Cu, Pb, Cr, Zn, Na, K)
- List I and II Substances (PAH, VOC, Organo-phosphorus Pesticides, Chlorinated Pesticides, PCB, Acid Herbicides etc.)
- Pathogens (*E. coli*, Total Coliforms)
- Toxicity Tests
- Physical analysis of treatment units was carried out using the Tröels-Smith Sediment Classification System
Operation & Results

• Units were operated individually and in a range of combined configurations
• Initially operated for 42 months, of results - Aug 2007 – Dec 2011
• The optimum sequence of treatment units achieved a high percentage removal for:
  • Ammoniacal nitrogen (99%)
  • Biological Oxygen Demand (BOD$_5$) (85%)
  • Iron (94%) and Manganese (98%)
• A significant percentage removal of Chemical Oxygen Demand (COD) (48%) and suspended solids (64%)
• The final effluent quality was similar that which would be expected from a conventional aerobic biological treatment process, possibly better with respect to COD and Fe
• Almost total pathogen removal (E. coli)
• Leachate toxicity most likely associated with Ammonium concentration
• De-nitrification rate of 42% was achieved for a limited period
### Results (continued)

**Averaged concentrations (mg/l) for raw leachate and effluent from individual units**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Raw</th>
<th>Reactor 1</th>
<th>Reactor 2</th>
<th>Reactor 3</th>
<th>Reactor 4</th>
<th>Reactor 5</th>
<th>Reactor 6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>wood chip/compost</td>
<td>wood chip/compost</td>
<td>reed bed</td>
<td>reed bed</td>
<td>grass plane</td>
<td>grass plane</td>
<td></td>
</tr>
<tr>
<td><strong>NH₄</strong></td>
<td>323</td>
<td>246</td>
<td>132</td>
<td>42</td>
<td>12</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td><strong>BOD₅</strong></td>
<td>20</td>
<td>29</td>
<td>28</td>
<td>14</td>
<td>6</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td><strong>COD</strong></td>
<td>279</td>
<td>268</td>
<td>244</td>
<td>212</td>
<td>184</td>
<td>134</td>
<td>145</td>
</tr>
<tr>
<td><strong>SS</strong></td>
<td>30</td>
<td>27</td>
<td>14</td>
<td>9</td>
<td>8</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td><strong>Chloride</strong></td>
<td>404</td>
<td>397</td>
<td>396</td>
<td>397</td>
<td>380</td>
<td>312</td>
<td>347</td>
</tr>
<tr>
<td><strong>Iron</strong></td>
<td>8.3</td>
<td>4.0</td>
<td>1.7</td>
<td>1.0</td>
<td>0.6</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Mn</strong></td>
<td>2.99</td>
<td>2.78</td>
<td>2.95</td>
<td>2.70</td>
<td>2.36</td>
<td>0.31</td>
<td>0.06</td>
</tr>
<tr>
<td><strong>Nitrate</strong></td>
<td>83</td>
<td>360</td>
<td>590</td>
<td>917</td>
<td>967</td>
<td>807</td>
<td>928</td>
</tr>
</tbody>
</table>

*Initial Influent*  *Final Effluent*
Conclusions

- Combination of units described achieved a high degree of treatment
- Matched or exceeded conventional aerobic biological treatment plants
- Results achieved with low cost, readily available materials
- Factors favourable to low technology passive system described:
  - Mild Irish climate (low temp. range, low frost occurrence, high precipitation)
  - Long growth season
  - Mild – moderate leachate strength at Kinsale Road Landfill Site
- Up-scaled plant at 100m³/day leachate through put requires 4,000 – 5,000m² footprint
- To attain discharge permit - system requires a de-nitrification package plant or a de-nitrification wetland

Further Experimental Work

- Installation of SMART Sensors to allow for increased data capture (Ammonium, Nitrate, pH)
- Trial similar system using higher strength leachate
- Locations with greater temp range (routine sub zero)
- Installation of De-nitrification Units
Use of SMART Sensors for Wastewater Trail Plant Operations

- Natural Treatment Systems often fail to attract widespread attention / application due to lack of long term continuous data for treatment efficiencies and operational parameters
  - Often due to dry up of funding / project completion etc.
- SMART Sensors could create the opportunity to establish study cluster groups for similar type systems
- Real Time data comparisons for:
  - Treatment efficiencies
  - Operational and Treatment Process Variances
  - Weather and Climate norms and extremes
- Data used to establish Scale-Up criteria for full scale wastewater treatment plants
End of Wastewater Treatment Presentation
Thank you to the following people / groups for assisting with the tour to Tramore Valley Park:

- All in the GrowSmarter Cork Team
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Further Details / Contact

Robin Bateman,
Landfill Gas Technician,
Irish Biotech Systems Ltd.
Tel: +353 (0)87 232 3750
E-mail: r.bateman@irishbiotechsystems.ie
www.irishbiotechsystems.ie

Garret Fallon,
Company Director,
Irish Biotech Systems Ltd.
Tel: +353 (0)87 245 5229
E-mail: garret.fallon@irishbiotechsystems.ie
www.irishbiotechsystems.ie

Dr Rafal Lewicki,
Mechanical Engineer,
ENVIRAF Ltd.
Tel: UK +44 7976 72 69 61
    PL +48 691 264 217
E-mail: rafal.lewicki@enviraf.com
www.enviraf.com


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