How much would you pay for Nitrogen Removal?

A Case Study: Birchwood Wastewater Treatment Upgrades

Wisconsin Wastewater Operators Association
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1. Project Background
2. Project Upgrades: MBBR for TN
3. Effluent Performance
4. Project Costs
5. Conclusions
Birchwood WWTF

- Aerated Lagoon System
- Groundwater Discharge
- Design Average Flow = 85,000 gpd
- Design BOD = 126 lb/day
- ~350 Users
Problems Identified

Aerated Lagoons

- BOD Exceedence: 50 mg/L
- Short circuiting: influent to effluent
- Sludge build-up in lagoons: reduced holding time
- Antiquated aeration system: 30 years old
Problems Identified

- Poor Distribution of Effluent Over Seepage Cells
- Obsolete Lift Stations
- No Water Source at Plant
- Limited Area for Expansion
- Future TN Limit of 10 mg/L
Facility Plan Recommendations

- Upgrade Aerated Lagoons
- Add Treatment Process for future TN Limit
- Construction Complete 12/31/2015
Lagoon 1
BOD Removal

- Insulated Cover
- Baffle
- Aeration Upgrade (floating aerators)
Lagoon 2 Becomes Settling Pond

- Insulated Cover
- Keep Existing Aerators
Upgrade Project

In Order of Process

Moving
Bed
Biofilm
Reactor
MBBR Technology – Biofilm on Media
MBBR Technology – Biofilm on Media

- Microanimals (ciliates and rotifers)
- Heterotrophs
- Nitrifiers
3.1 DESIGN SUMMARY

The MBBR equipment is designed per the following design summary:

Table 1: Influent Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow, Max. Month</td>
<td>MGD</td>
<td>0.111</td>
</tr>
<tr>
<td>Flow, Peak Inst.</td>
<td>MGD</td>
<td>0.288</td>
</tr>
<tr>
<td>BOD, Max. Month</td>
<td>mg/L</td>
<td>109</td>
</tr>
<tr>
<td>TSS, Max. Month</td>
<td>mg/L</td>
<td>100</td>
</tr>
<tr>
<td>TKN, Max. Month</td>
<td>mg/L</td>
<td>60</td>
</tr>
<tr>
<td>NH₃-N, Max. Month</td>
<td>mg/L</td>
<td>41</td>
</tr>
<tr>
<td>Temp, Minimum</td>
<td>°C</td>
<td>7.0</td>
</tr>
</tbody>
</table>

Table 2: Effluent Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soluble CBOD₅</td>
<td>mg/L</td>
<td>≤ 15*</td>
</tr>
<tr>
<td>TIN</td>
<td>mg/L</td>
<td>≤ 5</td>
</tr>
</tbody>
</table>

*Effluent achieved is contingent upon adequate molasses dose.
MBBR Technology – Birchwood, WI

MSA’s Birchwood MBBR Layout

[Diagram showing anoxic and aerobic zones with arrows indicating flow directions.]

Anoxic  Aerobic  Aerobic

MBBR Effluent  MBBR Influent
Nitrogen Removal Process

Nitrification

Ammonium ($\text{NH}_4^+$) → Nitrite ($\text{NO}_2^-$) → Nitrate ($\text{NO}_3^-$)

Oxygen ($\text{O}_2$) ↔ Alkalinity ($\text{HCO}_3^-$):

- Ammonium to Nitrite
- Nitrite to Nitrate
- Oxygen to Alkalinity
- Alkalinity to Oxygen
Nitrogen Removal Process

**Denitrification**

- **BOD**
  - (2 to 4 lbs/lb NO$_3^-$)
- **Nitrate** (NO$_3^-$)
- **Anoxic**
- **Oxygen** (O$_2$)
- **Nitrogen Gas** (N$_2$)
- **Alkalinity** (HCO$_3^-$)
Carbon Sources

- Dry Molasses
- Liquid Molasses
- Glycerin
Dry Molasses

- Dry cattle feed
- Mix 1 lb/gal
- BOD ~60,000 mg/L
- Fibrous materials in solution clogged peristaltic pumps
Carbon Sources

Liquid Molasses
- QLF Enhance P+N
- Viscous material
- Could not mix with water
- Still had problems with solids clogging pumps
- BOD ~815,000 mg/L
Carbon Sources

Glycerin

- Biodiesel byproduct from Sun Power (Cumberland, WI)
- Clear, odorless, non-hazardous, viscous liquid
- Mix with water 2:1
- BOD ~1,200,000 mg/L
Effluent Performance

- Molasses
- Glycerin

Concentration (mg/L) and Glycerin Usage (gpd)

- Pond #2 Effluent Total N
- Anoxic Tank NO3
- TN Limit

Dates:
- 9/1/2014 to 10/12/2015
What happened in June?
How Much Did it Cost?

- **Total Project Cost**
  - $4,712,491
- **Community Development Block Grant**
  - -$500,000
- **Clean Water Fund Principal Forgiveness**
  - -$500,000
- **Clean Water Fund Hardship Grant**
  - -$2,937,544
- **Clean Water Fund Hardship Loan**
  - $758,947

**83% Grant**
How Much Did it Cost?

• **Liquid Molasses Cost**
  - Average usage ~11 gallons per day
  - $2.70 per gallon
  - $9,800 per year

• **Glycerin Cost**
  - Average usage ~4.5 gallons per day
  - $0.15/lb = $0.76 per gallon
  - $1,300 per year
Conclusions

- MBBR is a cost-effective lagoon upgrade alternative

- Dry molasses feed was a bust

- Glycerin is a non-hazardous, cost-effective carbon source for denitrification... and it works!
Acknowledgements

Tucker Fee
Village of Birchwood

Kruger
Questions?

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