Upgrading Lagoons to Remove:
Ammonia – Nitrification &
Phosphorus

Friday - 11:00 to 11:30am
Todd Latchaw
Nelson Environmental Inc.
www.nelsonenvironmental.com
Choosing an appropriate WWTF

- **Facultative lagoon**
- **Aerated lagoon** with TAN/TP Removal
- **Aerated Lagoon**
- **Mechanical Plant**
- **Membranes (MBR)**

Meets all anticipated effluent requirements (TAN, BOD, TSS, TP, TN)

You do not have to go high-tech to meet stringent effluent requirements

**SIMPLE**

**COMPLEX**
Cold climate nitrification facts

- Stops at temperatures below 4°C in conventional treatment
- Full nitrification requires temperatures at 8-10 °C
  “Nitrification precedes Total Nitrogen removal”
- Lagoon effluent in Northern USA & Canada is typically < 1°C for 3 to 5 months
- Nitrification occurs once cBOD levels are low
  (Back end of a lagoon system)
Nutrient Removal

- BOD
- TSS
- Ammonia
- Total Nitrogen
- Phosphorus
Treatment Process

Aerated or Facultative Lagoons (BOD & TSS Removal)

SAGR (Nitrification)

AN-SAGR / Effluent Recycle (Denitrification)

Coagulation/Filtration (TP Removal)

- CBOD, TSS and TP levels to 5/5/0.3 mg/l
- Total Ammonia levels to 1 mg/l
- Total Nitrogen levels to 5-10 mg/l
Why is removing ammonia important?

**Terminology**

Ammonia NH₃?

Ammonium NH₄⁺?

Ratio determined by pH and Temperature

NH₃ + NH₄⁺ = TAN (Total Ammonia)

“Ammonium”

“Un-ionized Ammonia”

Toxic

Why is removing ammonia important?
### Ammonia toxicity relation to temperature & pH

#### Example – Lagoon System that reduce TAN down to 10 mg/L

<table>
<thead>
<tr>
<th></th>
<th>10 mg/L</th>
<th>10 mg/L</th>
<th>10 mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total (NH₃ + NH₄⁺)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.8</td>
<td>7.8</td>
<td>8.8</td>
</tr>
<tr>
<td>Temperature</td>
<td>5°C</td>
<td>20°C</td>
<td>20°C</td>
</tr>
<tr>
<td>Un-ionized Ammonia</td>
<td>0.078 mg/L</td>
<td>0.22 mg/L</td>
<td>2.00 mg/L</td>
</tr>
</tbody>
</table>

- 2.9 times more toxic
- 25.6 times more toxic

To return to a level of \( \text{NH₃ 0.078 mg/L} \)
Requires an effluent **TAN level of 0.4 mg/L**
Continuous discharge lagoons with TAN & TP Removal

Influent

Aerated or Facultative Ponds
CBOD/TSS removal

SAGR
Nitrification/BOD & TSS Polishing & Disinfection

Tertiary Filtration
TP removal

Effluent
POST – LAGOON NITRIFICATION AND EFFLUENT POLISHING
What is a SAGR?

Fully aerated coarse gravel bed reactor.

Stable dense rock media which is not susceptible to temperature shock.

Designed for cold water treatment (0.5°C).

The SAGR removes ammonia through nitrification and provides BOD/TSS polishing & disinfection.
Demo Site:
Avg. Flow Rate: 10,500 – 13,200 GPD
(municipal)
Lagoon Influent BOD: 150 to 180 mg/L
Steinbach, MB Data

SAGR Following Aerated Lagoon Treatment Cycle

- SAGR Influent TAN
- SAGR Effluent TAN
- SAGR Influent cBOD5
- SAGR Effluent cBOD5
- Water Temperature
### University of Manitoba Third Party Winter Operation Verification Data (JANUARY 13 – APRIL 21, 2010)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>SAGR Influent Averages (mg/L)</th>
<th>SAGR Effluent Averages (mg/L)</th>
<th>Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>cBOD</td>
<td>47</td>
<td>2.1</td>
<td>95.5%</td>
</tr>
<tr>
<td>TSS</td>
<td>30</td>
<td>1.3</td>
<td>95.7%</td>
</tr>
<tr>
<td>TAN</td>
<td>24.9</td>
<td>0.12</td>
<td>99.5%</td>
</tr>
<tr>
<td>TKN</td>
<td>32.5</td>
<td>1.8</td>
<td>94.5%</td>
</tr>
<tr>
<td>FC (cfu /100 ml)</td>
<td>253000</td>
<td>13.5</td>
<td>99.99%</td>
</tr>
<tr>
<td>Average water temperature (°C)</td>
<td>0.3</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>
Typical SAGR Applications

- Post Lagoon Nitrification
- Post Lagoon BOD/TSS
- Airport De-icing Fluid Treatment
- Decentralized Treatment
Project Examples
# SAGR projects

## Completed Municipal SAGR Projects

<table>
<thead>
<tr>
<th>Project Details</th>
<th>Capacity (MGD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steinbach (Demo), MB</td>
<td>0.010</td>
</tr>
<tr>
<td>Lloydminster (Demo), SK</td>
<td>0.017</td>
</tr>
<tr>
<td>Perth (Demo), ON</td>
<td>0.053</td>
</tr>
<tr>
<td>Blumenort (Demo), MB</td>
<td>0.016</td>
</tr>
<tr>
<td>Doaktown, NB</td>
<td>0.169</td>
</tr>
<tr>
<td>Dawson Creek, BC</td>
<td>1.058</td>
</tr>
<tr>
<td>Mentone, IN</td>
<td>0.120</td>
</tr>
<tr>
<td>Glencoe, ON</td>
<td>0.456</td>
</tr>
<tr>
<td>Long Plain FN, MB</td>
<td>0.264</td>
</tr>
<tr>
<td>Sylvan Lake, SD</td>
<td>0.045</td>
</tr>
<tr>
<td>Walker, IA</td>
<td>0.222</td>
</tr>
<tr>
<td>Lamar, MO</td>
<td>0.770</td>
</tr>
<tr>
<td>Shellbrook, SK</td>
<td>0.217</td>
</tr>
<tr>
<td>Balcarras, SK</td>
<td>0.085</td>
</tr>
<tr>
<td>Misipiwistik FN, MB</td>
<td>0.115</td>
</tr>
<tr>
<td>Greenbryre, SK</td>
<td>0.091</td>
</tr>
<tr>
<td>Kennard, IN</td>
<td>0.100</td>
</tr>
<tr>
<td>Guthrie School, ON</td>
<td>0.003</td>
</tr>
<tr>
<td>Kingsley, IA</td>
<td>0.300</td>
</tr>
<tr>
<td>Sundridge, ON</td>
<td>0.315</td>
</tr>
<tr>
<td>New London, IA</td>
<td>0.885</td>
</tr>
<tr>
<td>Colesburg, IA</td>
<td>0.241</td>
</tr>
<tr>
<td>Hull, IA</td>
<td>0.700</td>
</tr>
</tbody>
</table>

## Completed Airport SAGR Projects

<table>
<thead>
<tr>
<th>Project Details</th>
<th>Capacity (MGD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffalo, NY Airport*</td>
<td>1.216</td>
</tr>
<tr>
<td>Edmonton, AB Airport*</td>
<td>0.159</td>
</tr>
<tr>
<td>LI MacArthur Airport, NY*</td>
<td>0.144</td>
</tr>
<tr>
<td>Grand Rapids, MI Airport*</td>
<td>1.000</td>
</tr>
</tbody>
</table>

* Airport Glycol De-icing Treatment

## Currently Under Construction

<table>
<thead>
<tr>
<th>Project Details</th>
<th>Capacity (MGD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berne, IN</td>
<td>1.920</td>
</tr>
</tbody>
</table>
Mentone, Indiana

- Influent
- SAGR Beds for nitrification
- Facultative lagoon
- Facultative lagoon
Mentone, Indiana Data

(Total Ammonia)

NPDES Permit Requirements:
- \( \text{cBOD}_5 = 25 \text{ mg/L} \)
- \( \text{TSS} = 70 \text{ mg/L} \)
- \( \text{TAN} = 9.6/10.4 \text{ mg/L} \) (summer/winter)

Design flow = 0.12 MGD (454 m\(^3\)/day)
Mentone, Indiana

Mentone SAGR: Influent & Effluent TAN

TAN (mg/L)

WWTP Influent TAN

SAGR Effluent TAN

Glencoe, Ontario

Two (2) cell controlled discharge lagoon converted into a three (3) cell continuous discharge aerated lagoon

SAGR for nitrification

Disk filter with alum addition for TP removal
Glencoe, Ontario

Influent

Aerated Lagoon

Effluent discharge

Alum addition

SAGR

Disc Filter
Glencoe, Ontario

SAGR: Influent & Effluent TAN (2013-2014)

Permit Requirements:
- TAN = 3 mg/L
- Design flow = 0.46 MGD

Influent SAGR TAN
Effluent SAGR TAN
Water Temperature
Glencoe, Ontario

Glencoe WWTP - Influent and Effluent TAN

Permit Requirements:
- cBOD$_5$ = 13.7 mg/L
- TSS = 13.7 mg/L
- TAN = 3 mg/L

Design flow = 0.46 MGD (1746 m$^3$/day)
Lamar, MO (upgraded facility)

- Single cell facultative lagoon
- Two (2) SAGR beds for nitrification
Lamar SAGR®: Effluent TAN

**Lamar Effluent Requirements:**
- BOD = 10 mg/L
- TSS = 10 mg/L
- TAN = 1/7 mg/L (summer/winter)
Lamar SAGR: Influent and Effluent TAN

**Effluent Requirements:**
- TAN = 1.3/2.8 mg/L (summer/winter)

**Design Flow**
2910 m3/Day (0.770 MGD)

- Water Temperature (°C)
- Effluent TAN
Lamar, Missouri

Lamar, MO: SAGR Effluent TAN

Design Flow
2910 m³/Day
(0.770 MGD)
Kennard, Indiana

Two (2) SAGR beds for nitrification

Influent

Cell #3
Partial Mix & settling

Cell #1
Partial Mix

Cell #2
Partial Mix
Berne, Indiana

Cell # 1
Aerated (Partial Mix)

Cell # 2
Facultative Lagoon

Four (4) SAGR Beds
For nitrification

Influent
Berne, Indiana

• Construction start-up in November 2014
TOTAL PHOSPHORUS REMOVAL
East Selkirk, MB
Aerated lagoon with TP removal

- Rapid mix tank for chemical dispersion and contact.
- Slow mix tank for coagulation and flocculation.
- Floc settles in cell 2
Disk Filter

The opTPhos Disk Filter is a user-friendly, small footprint, low backwash, high performance tertiary filter for both small and large flow applications.

The opTPhos Disk Filter removes suspended solids as small as 5 microns.
Sand Filter Process Diagram

Lagoon Effluent → Contact/Settling Tank → Sand cleaning chamber → Sand bed

Alum/ Ferric addition for TP
Carbon for TN

Airlift pumps sand and removed solids to the top of the filter for cleaning

Clean Water

Reject Stream back to primary lagoon
Alum In-house jar testing at 18°C

Jar Testing: TP Removal vs. Al$^{3+}$/TP mole ratio

<table>
<thead>
<tr>
<th>Trial</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 min RM, 30 min SM, 30 min settling</td>
</tr>
<tr>
<td>2</td>
<td>1 min RM, 0 min SM, 30 min settling</td>
</tr>
<tr>
<td>3</td>
<td>0 min RM, 30 min SM, 30 min settling</td>
</tr>
<tr>
<td>4</td>
<td>1 min RM, 3 min SM, 30 min settling</td>
</tr>
<tr>
<td>5a</td>
<td>1 min RM, 30 min SM, 0 min settling</td>
</tr>
<tr>
<td>5b</td>
<td>1 min RM, 30 min SM, 5 min settling</td>
</tr>
<tr>
<td>5c</td>
<td>1 min RM, 30 min SM, 15 min settling</td>
</tr>
<tr>
<td>5d</td>
<td>1 min RM, 30 min SM, 120 min settling</td>
</tr>
<tr>
<td>6</td>
<td>1 min RM, 60 min SM, 30 min settling</td>
</tr>
<tr>
<td>7</td>
<td>4 min RM, 0 min SM, 30 min settling</td>
</tr>
<tr>
<td>8</td>
<td>4 min RM, 30 min settling</td>
</tr>
</tbody>
</table>

**Legend:**
- Trial 1
- Trial 2
- Trial 3
- Trial 4
- Trial 5a
- Trial 5b
- Trial 5c
- Trial 5d
- Trial 6
- Trial 7
- Trial 8
- Trial 9a
- Trial 9b
Alum In-house jar testing at 0.5°C

Jar Testing: TP Removal vs. Al$^{3+}$/TP mole ratio

**Trial 10:** 1 min RM, 30 min SM, 30 min settling
**Trial 11:** 0 min RM, 30 min SM, 30 min settling
**Trial 12:** 1 min RM, 4 min SM, 30 min settling
**Trial 13:** 1 min RM, 0 min SM, 30 min settling
**Trial 17:** 4 min RM, 0 min SM, 30 min settling
**Trial 18:** 4 min RM, 30 min SM, 30 min settling
Conclusion

- SAGR process provides nitrification to < 1mg/L ammonia at 100% design flow
- Consistent BOD/TSS <5/10 mg/L (lower with tertiary filtration)
- Systems can handle significant variation in incoming water quality without upset
- Phosphorus <1 mg/L (or 0.3 mg/L if required)
- ANSAGR TN removal to effluent levels <10 mg/l are being demonstrated
- Your lagoons are likely paid for so use them
Questions?

www.nelsonenvironmental.com