Lagoon Ammonia Removal Evaluation of Alternatives
Agenda

1. Brief Introduction

2. Overview of the Lagoon Ammonia Problem
   • Causes and Effects of Ammonia Pollution
   • Basics of Ammonia Removal

3. Review Conventional Wisdom

4. Compare Ammonal Treatment Options
   • Qualitative Comparison
   • Compare Ammonia Treatment Option Costs
1. Triplepoint Environmental is dedicated to providing Wastewater Lagoon Process solutions in North America.

2. 30 years of Wastewater Lagoon & Operation Expertise

3. We provide Lagoon Process Solutions, including:
   - Lagoon Aeration Rehabilitation & Efficiency Upgrades
   - Lagoon Process Optimization
   - Lagoon Expansion
   - Lagoon Ammonia Removal
What is Ammonia?

- Ammonia is a compound of Nitrogen and Hydrogen
- A colorless gas with a putrid smell
- When in water, most of the ammonia is converted to Ionized Ammonia (a.k.a. Ammonium)
Nitrogen: Forms & Categories

Total Kjeldahl Nitrogen (TKN) = Total Inorganic Nitrogen (TIN) + Organic-N

- Ammonia-N (NH₃, NH₄)
- Nitrite (NO₂⁻)
- Nitrate (NO₃⁻)

Organic-N
Where does it come from?

Urine

Cleaning Products

Industrial Sources

Food Processing
Why: Ammonia is Toxic to Fish

• Ammonia consumption is not an issue for humans because we have a mechanism to deal with it.
• At dilute concentrations NH3-N is highly toxic to fish/amphibians
• If unchecked, will deplete fish # and size.

This Michigan caught bass could be a thing of the past
Why Lagoons?

• 1/3 of all wastewater treatment facilities has a lagoon
• Approximately 6,000 lagoons nationwide
• Lagoons typically discharge to small streams
• Affecting all 50 states, practically every American watershed
Why: Pounds of Ammonia

<table>
<thead>
<tr>
<th>Item</th>
<th>Number</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Lagoons</td>
<td>3,000</td>
<td>Lagoons</td>
</tr>
<tr>
<td>Average Flow</td>
<td>0.3</td>
<td>MGD</td>
</tr>
<tr>
<td>Ammonia Conc.</td>
<td>40</td>
<td>Mg/L</td>
</tr>
<tr>
<td>Ammonia Discharge</td>
<td>299,857</td>
<td>Lb/Day</td>
</tr>
</tbody>
</table>

4 months of winter discharge would provide enough fertilizer for 145 Million tons of corn each year!
Why: Gulf of Mexico Deadzone

- The Deadzone in the Gulf of Mexico is a massive 6,765 square miles in size off the coast.
- Low oxygen conditions persist with virtually no aquatic or marine life.
How? Nitrification.

- *Nitrification* is the process by which ammonia is converted to nitrites (NO2-) and then nitrates (NO3-).
- This conversion is performed by Nitrifiers: Nitrosomonas & Nitrobacter.
Autotrophs Vs Heterotrophs

Nitrifiers
- Slow: Longer to mature
- Weak: Less competitive
- Fickle: Specific Needs

BOD Eating
- Faster: Develop faster
- Stronger: Less sensitive
- Hungrier: Consume more
1. Nitrification Conditions: BOD

• Heterotrophic bacteria outcompete Nitrifiers
• In order to nitrify BOD levels in the wastewater need to be between 20-30 mg/L
2. Nitrification Conditions: Aeration

• Nitrification consumes large quantities of Oxygen

<table>
<thead>
<tr>
<th>Constituent</th>
<th>BOD5</th>
<th>Ammonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lb/O2/day</td>
<td>1.5-2.0</td>
<td>4.6</td>
</tr>
<tr>
<td>DO (mg/L)</td>
<td>0.5-3.0</td>
<td>4.0-8.0</td>
</tr>
</tbody>
</table>

• Aeration system Mixing is essential
3. Nitrification Conditions: pH & Alkalinity

- Optimal levels pH for Nitrification is 7.5-8.0
- Most Municipal Wastewater is within range

- Nitrifiers are “Attached Growth Organisms”
- More Surface Area = more nitrifiers = more nitrification
- Ordinarily they will grow on any surface area available:
  - Lagoon slopes
  - Baffles
  - Aerators
5. Nitrification Conditions: Temperature

- Nitrifiers are temperature sensitive
- The ideal range is between 82-97 deg F
- Minimum temperature is 39.2-42 Deg F (4-5 Deg C)
Why Lagoons Fail To Nitrify

✓ BOD
✓ PH & Alkalinity
✓ Toxins

✗ Nitrifier Mass
✗ Temperature
✗ Oxygen
✗ Mixing

• How to optimize?
Nitrification Options

1. Mechanical Plant Conversion
2. Modified Discharge
3. Process Solutions
   1. In-Lagoon Media
   2. Aerated Rock Filters
   3. Lagoon Covers & Tertiary Reactors
   4. Thermally Regulated Nitrification Reactor
Mechanical Plant Conversion

1. Conventional Engineering Wisdom
   i. Extremely High capital costs
   ii. Increased operational complexity
   iii. Decreased flexibility
   iv. More staff needed and more time
   v. Class III Operator License
   vi. Non-Option
Discharge Modification

1. Land Application
2. Seasonal Discharge
3. Constructed Wetlands
Process Modification: Modified Discharge

**Pros**
- Avoids Compliance issues
- Minimizes Mechanical Equipment
- Inexpensive
- Ideal if Obtainable

**Cons**
- High Land Requirements
- Irrigation requires careful monitoring
- Local Regulation Dependent
- Difficult to Obtain Permit

Non-Technology Options
Process Solutions: In-Lagoon Media

Pros
✓ Lower Capital Costs
✓ No Extra Land Requirement
✓ Easy to Operate
✓ Ideal for Supplemental Use
✓ Ideal for Seasonal Limits

Cons
✗ Ineffective below 50°F
✗ Potential for clogging & Maintenance
✗ Risk of short-circuiting
✗ Not Ideal for strict NH3-N Limits
✗ Cannot address TIN
In-Lagoon Media: Performance
Enhanced Treatment Performance

Process Treatment Performance

- Lagoon Inf. NH3
- Lagoon Eff. NH3
- Nit. Reactor Eff. NH3
- Lagoon Temp
Process Solutions: Aerated Rock Filter

**Pros**
✓ Very Reliable At Cold Temps
✓ Ideal for Strict <1mg/L Limits
✓ Simple to Operate
✓ Proven Winter Performance

**Cons**
✗ High Capital Cost
✗ Extra Land Requirement
✗ Potential Breaches During Seasonal Transitions
✗ Unknown Long term Cleaning Requirements
✗ Does not address TIN
Process Solutions: Cover & Reactor

**Pros**
- Very Reliable At Cold Temps
- Ideal for Strict <1mg/L Limits
- Minimal Extra Land Requirement
- Proven Performance
- Treats BOD and NH3-N

**Cons**
- Re-doing entire System
  - Capital Cost
- High Operating Costs
- Ill suited for Shallow/Facultative Ponds
- High maintenance on aeration equipment
- Difficult Maintenance
- Does not address TIN
NitrOx™ Process
Lagoon Ammonia Removal

1. BOD Removal
2. Temperature Regulation
3. NitrOx Reactor I
4. NitrOx Reactor II
5. Polishing
Process Solutions:
Thermally Regulated Nitrification Reactor

Biofilm Concentration

• Biofilm carriers give bacteria a place to grow
• Aeration provides mixing & oxygen
• Resulting in faster treatment kinetics at lower temperatures
Process Solutions: Thermally Regulated Nitrification Reactor

- Current Surface Area of Sample Project aerated lagoons is 167,000 square feet
Process Solutions:
Thermally Regulated Nitrification Reactor

**Pros**
- Ideal for Strict <1mg/l Limits
- Operates at any temperature
- Controlled Biomass
- Controlled Aeration
- Low Capital Costs
- Easy Operation
- Proven Performance
- Can also treat BOD and TIN

**Cons**
- Requires some additional land
- Likely requires final polishing lagoon, clarifier, or flocculation
- May require additional utilities connection
- Increased winter operating costs
Cost Case Study: Sample WWTP

Location: Your Lagoon, MI
Size: 500,000 gpd
Process: Aerated Lagoon
Depth: 12’
## Sample Case: Lifecycle Costs

1. **Cover & Polishing Reactor**
   - Equipment: $1,800,000
   - Installation: $450,000
   - Yearly Electricity: $49,945
   - Yearly Maint.: $13,296
   - **20 Year Cost:** $4,486,728

2. **In Lagoon Media**
   - Equipment: $1,700,000
   - Installation: $283,000
   - Yearly Electricity: $26,904
   - Yearly Maint.: $2,000
   - **20 Year Cost:** $3,018,000

3. **Aerated Rock Filter**
   - Equipment: $1,400,000
   - Installation: $933,333
   - Yearly Electricity: $38,071
   - Yearly Maint.: $1,000
   - **20 Year Cost:** $3,356,000

4. **Thermally Reg. Nitrification Reactor**
   - Equipment: $1,000,000
   - Installation: $315,000
   - Yearly Electricity: $45,237
   - Yearly Maint.: $1,500
   - **20 Year Cost:** $2,596,000
Sample Case: Lifecycle Costs

Year 1
Year 2
Year 3
Year 4
Year 5
Year 6
Year 7
Year 8
Year 9
Year 10
Year 11
Year 12
Year 13
Year 14
Year 15
Year 16
Year 17
Year 18
Year 19
Year 20

$0.00
$500,000.00
$1,000,000.00
$1,500,000.00
$2,000,000.00
$2,500,000.00
$3,000,000.00
$3,500,000.00
$4,000,000.00
$4,500,000.00
$5,000,000.00

NitrOx Reactor
Cover & Reactor
Lagoon Media
Rock Filter
Take-Away’s

1. Meeting your new effluent permit can be accomplished \textbf{without} replacing your lagoons

2. New limits can be met by optimizing your lagoon for nitrification.
Q & A
Pilot Update: DeSoto, Iowa

- Projected to wrap up on June 15th 2015
- Pilot Successfully removing 97-99% Ammonia
Pilot Update: DeSoto, Iowa

DeSoto NitrOx Pilot:
Influent vs Effluent NH3-N

Influent NH3-N
Effluent NH3-N
Influent Temp
Pilot Update: Bishop, California

- Projected to wrap up on June 15\textsuperscript{th} 2015
- Pilot Successfully removing both Ammonia and Nitrates
Pilot Update: Bishop, California

Bishop NitrOx Pilot: Influent vs Effluent TIN

- Influent TIN
- Effluent Nitrate
- Effluent TIN
- Influent Temperature
Pilot Update: Ellington, Missouri

• Projected to wrap up on June 15th 2015
• Pilot Successfully removing Ammonia
Pilot Update: Bishop, California

Ellington NitrOx Pilot: Influent vs Effluent Ammonia