

Ammonia Removal and pH Adjustment in Aerated Lagoons

WWOA 45th Annual Conference

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Presented by:

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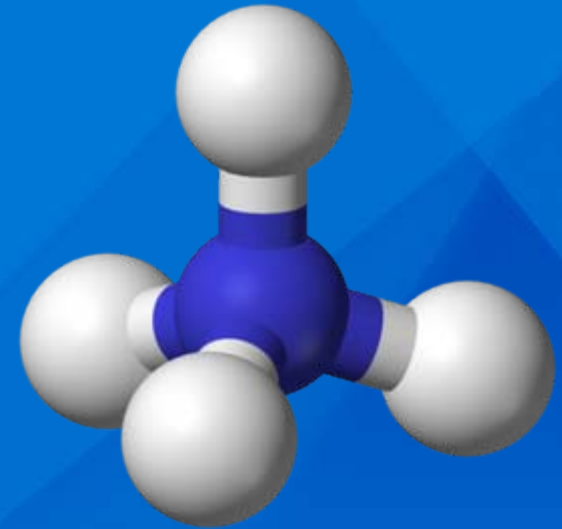
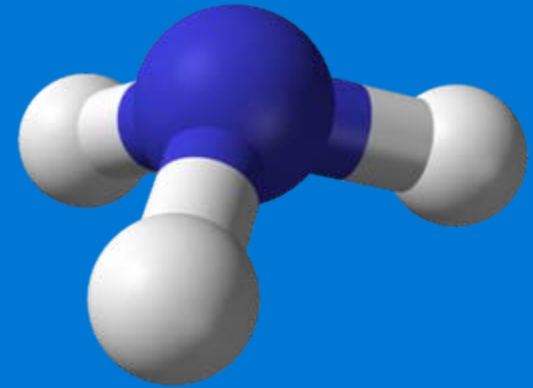


Overview

- Ammonia
 - Background
 - Chemistry
 - Toxicity
 - Reducing Ammonia Toxicity
- Grantsburg WWTP
- Madeline Island WWTP

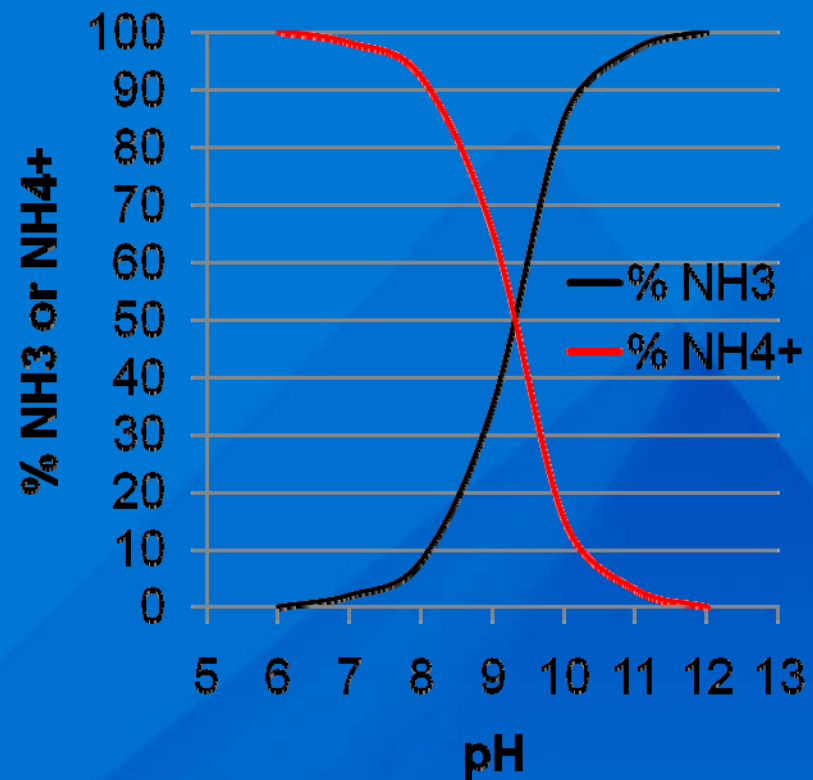
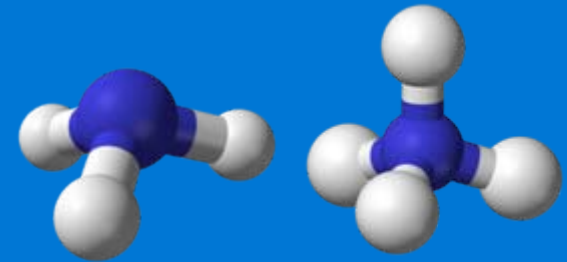
Ammonia Nitrogen

- Chemical Compound
 - NH_3 (unionized)
 - NH_4^+ (ionized - ammonium)
- Used by plants to form amino acids
- Amino acids digested by animals, excreted as urea
- Urea converted to ammonia by microorganisms
- Manmade substances
- Ammonia in WWTP influent



Ammonia/Ammonium

- Relationship between NH_3 and NH_4^+ is based on pH.
 - Lower pH means more H^+ ions available, thus more NH_4^+ .
 - $\text{pH} < 6.75$ – 100% NH_4^+
 - $\text{pH} = 9.25$ – 50% NH_4^+
 - $\text{pH} > 11.75$ – 100% NH_3
- Relationship between NH_3 and NH_4^+ is based on temperature.
 - Lower temperature means more NH_4^+ .



Ammonia Toxicity/Limits

- Ammonia is toxic to plants and animals above certain concentrations.
- NH_3 is approximately 100 times more toxic than NH_4^+ , so NH_3 will almost always be our concern.
- Effluent limits are based on total ammonia, but are usually relaxed or nonexistent for low temperature and/or pH.
- Effluent limits vary by stream classification because toxicity varies by species.
 - NH_3 acute toxicity for fish is as low as 2 mg/L
 - NH_3 chronic toxicity for fish may be as low as ~0.05 mg/L
 - NH_3 can also cause DO depletion as nitrification occurs.

Reducing Ammonia Toxicity

- pH Adjustment
- Temperature “Adjustment”
- Breakpoint Chlorination
- Biological Ammonia Removal (Nitrification)

Nitrification

- Chemical process of converting ammonia to nitrite and nitrate
 - $\text{NH}_3 + \text{CO}_2 + 1.5 \text{O}_2 + \text{AOB} \rightarrow \text{NO}_2^- + \text{H}_2\text{O} + \text{H}^+$
 - $\text{NO}_2^- + \text{CO}_2 + 0.5 \text{O}_2 + \text{NOB} \rightarrow \text{NO}_3^-$
- Necessary components
 - Air (oxygen, carbon dioxide)
 - Bacteria (AOB-nitrosomonas, NOB-nitrobacter)
 - Temperature (40-45 degrees Fahrenheit)
 - Alkalinity (~7 grams per gram Ammonia-N)
 - Absence of toxic compounds

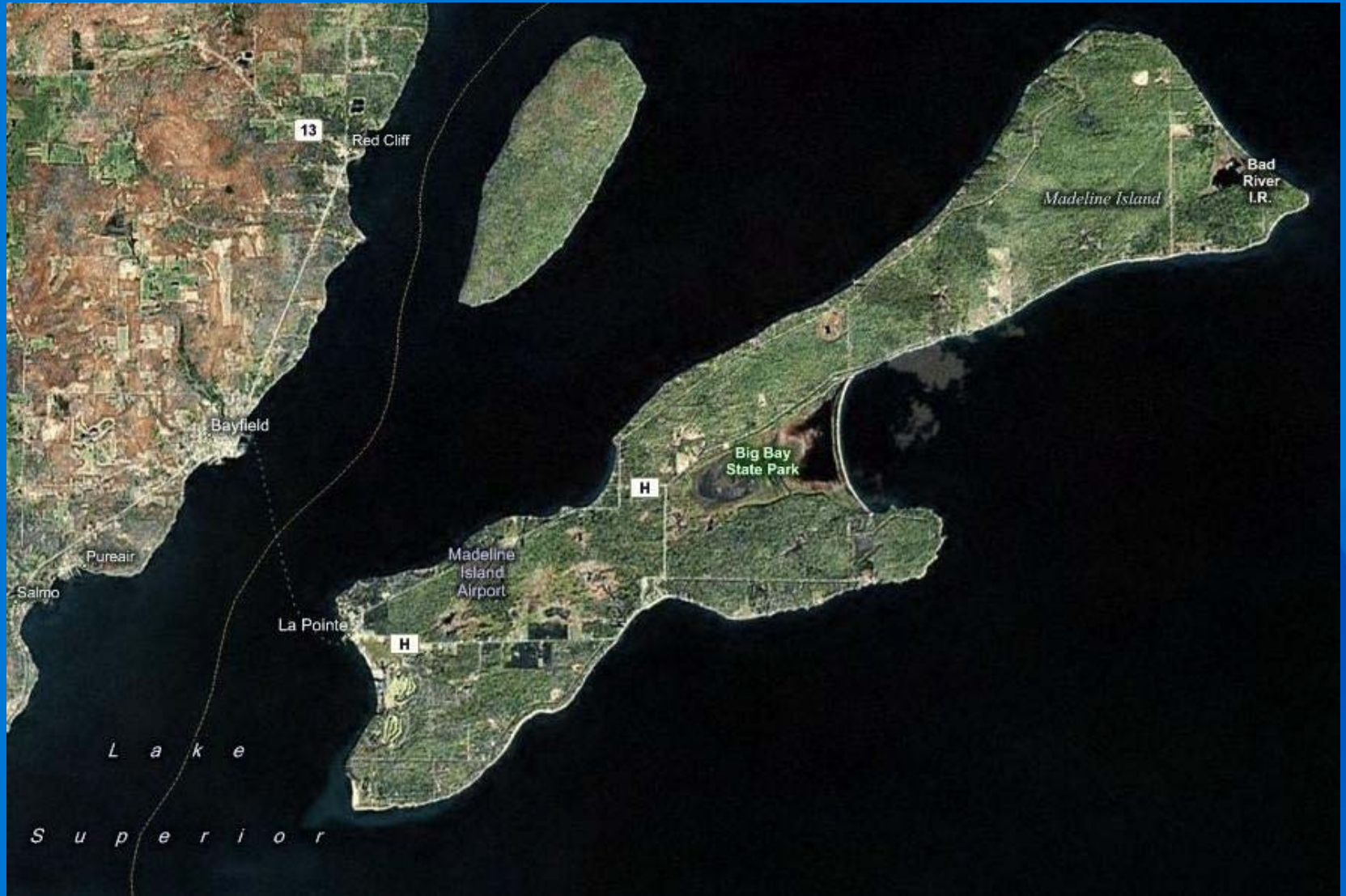
Grantsburg, WI

- Proposed effluent limit of 17 mg/L daily maximum for ammonia
 - Based on assumed maximum effluent pH of 8.0
 - Average effluent pH of 7.7
 - If maximum effluent pH was 7.5, no effluent ammonia limit would be required.

Grantsburg, WI

- Alternatives Considered:
 - Fill and Draw Operation
 - Breakpoint Chlorination
 - 224 gpd sodium hypochlorite
 - pH Adjustment
 - Carbon Dioxide Injection
 - 2.8 gpd sulfuric acid
- Acid addition satisfies permit and involves minimal capital/operational cost.
 - Additional operator attention

Madeline Island



Madeline Sanitary District WWTP



Population and Flows

- Year-round population of approximately 250
- Summer population of approximately 4,000
- Flows vary from:
 - 25,000 gpd during winter months
 - 65,000 gpd during summer months
- Approximately 15% of flow is hauled waste from holding tanks located outside of the sewerered downtown LaPointe area.

Effluent Ammonia Limit

- DNR requirements based on:
 - Temperature
 - pH
 - Water body classification
 - Effluent discharge rates
 - Available dilution
 - Presence of early life stage aquatic species
- Daily limit of 16 mg/L for November through April
- Variable limit based on effluent pH

Effluent pH	Ammonia Limit (mg/L)
7.1	>40
7.2	39
7.3	35
7.4	31
7.5	27
7.6	23
7.7	19
7.8	16
7.9	14
8.0	11
8.1	9.3
8.2	7.6
8.3	6.3
8.4	5.2
8.5	4.3
8.6	3.5
8.7	2.9
8.8	2.5
8.9	2.1
9.0	1.8

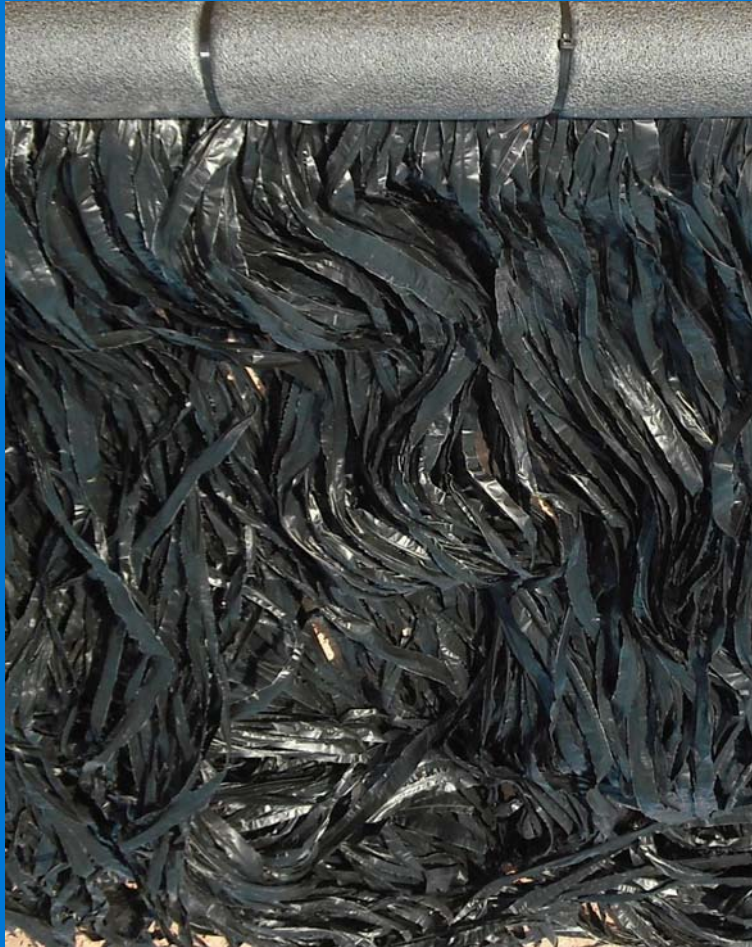
Ammonia Removal Options

- Mechanical WWTP
- Mechanical addition to aerated lagoon WWTP
- Treatment in existing lagoons
 - Aeration upgrades
 - Media for attached growth of nitrifying bacteria
 - Insulated cover for heat retention

Aeration Upgrades



Attached Growth Media



Insulated Floating Cover

- R-20 insulation value
- 5-inch thick polystyrene encased in HDPE
- Modular, removable
- Access panels for diffuser removal
- Prevents algae blooms, retains heat
- Installed Fall/Winter 2009

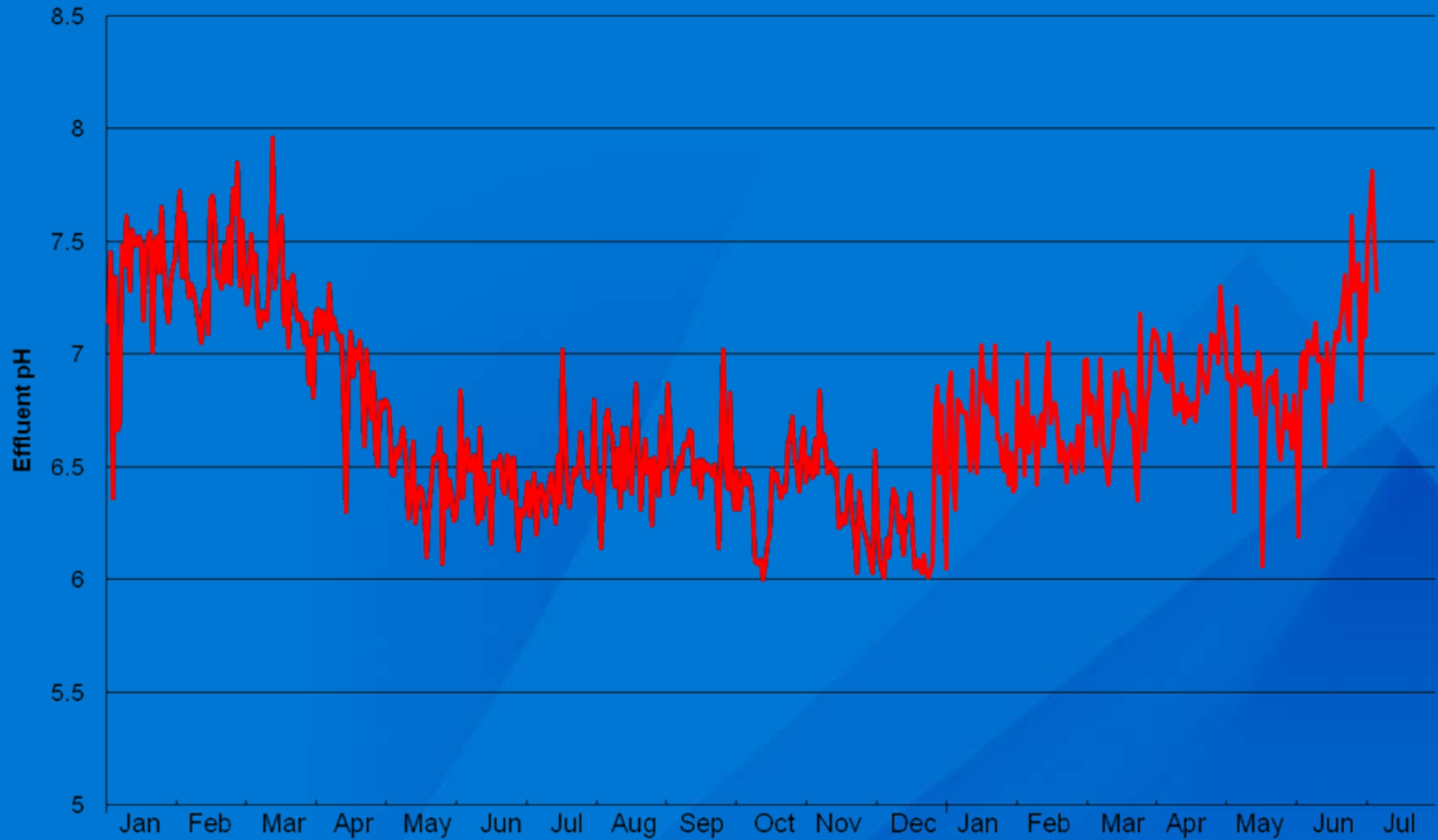


Insulated Floating Cover



pH Effluent Results

2010-2011 Madeline Island Effluent pH



Why are we losing nitrification in the summer?

- Low pH can inhibit nitrification, but the data doesn't show this correlation.
- Temperature can inhibit nitrification, but the high ammonia is during the summer.
 - Checked detention time of lagoons: in case of true plug flow, what is discharged in summer may come in during winter months.
 - 3 month detention time doesn't explain it.
 - Entire lagoon contents are heated during the summer, so nitrification should pick up anyway.
- Toxic Compounds?
 - Quaternary Ammonia Compounds

Conclusions

- Ammonia toxicity is variable, and can be addressed in a variety of ways.
- Cold weather lagoon nitrification is possible, but lagoon nitrification in general can be touchy – have a backup plan.
- Know who is discharging what to your collection system.

Questions?