



The AmmEI Process for the Treatment of Ammonia in Wastewater

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Outline of Presentation

- ◆ **Background**
- ◆ **Electrochemical treatment principles**
- ◆ **Results City of Guelph pilot test**
- ◆ **Summary**
- ◆ **Upcoming pilot tests**

Ammonia (NH₃)

- ◆ Ammonia considered “*toxic*” to aquatic life as defined in Section 64 of CEPA, 1999
- ◆ Lethal limit is 0.2 mg/L (free NH₃)
- ◆ < 5 mg NH₃-N /L at pH 7 - 8

NH_3 - N in Mining Effluent

- ◆ ANFO explosives
- ◆ Flotation reagents in milling
- ◆ Cyanide destruction
- ◆ pH regulator in Uranium mining

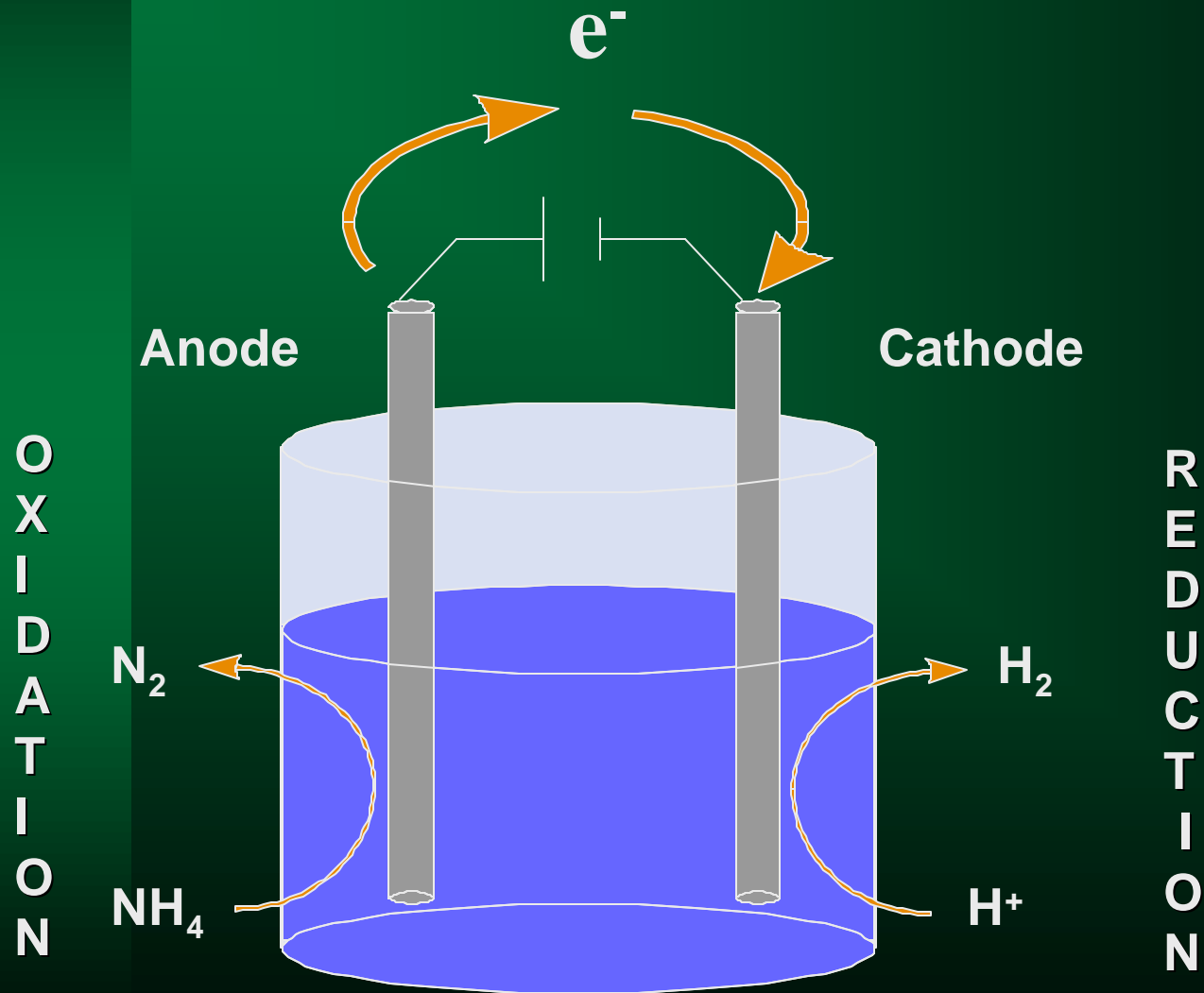
Current Approach

- ◆ pH adjustment - $\text{NH}_4^+/\text{NH}_3$ equilibrium
- ◆ Biological



Electrochemical Treatment of Ammonia in Wastewater

Electrochemical Principles



Electrochemical Treatment of Ammonia

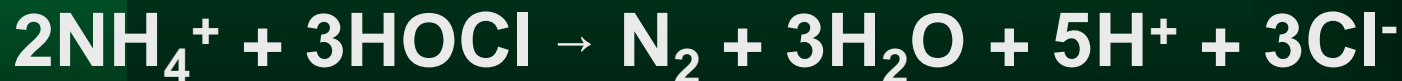
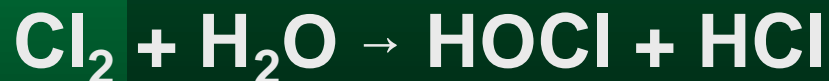
- ◆ **Composition of solution important**
- ◆ **Two-stage approach for low ionic strength solutions**
- ◆ **Direct treatment in sea water possible**

Scientific Basis

- ◆ **Electrode (anode) reactions:**



- ◆ **Bulk reactions:**



Two-Stage Approach

- ◆ **Low ammonia concentration streams**
 - IX/electrochemical combination

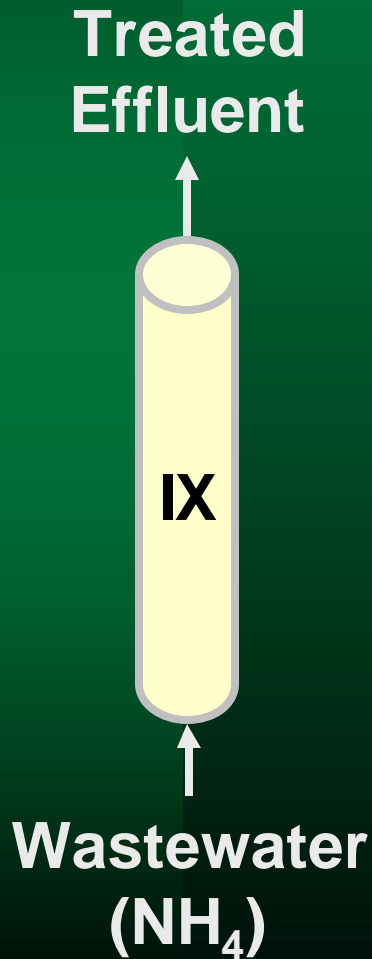
- ◆ **High ammonia concentrations**
 - 1) hybrid electro-membrane reactor
 - 2) air strip/scrub combined with electrochemical reactor

Stage 1- IX Ammonia Removal

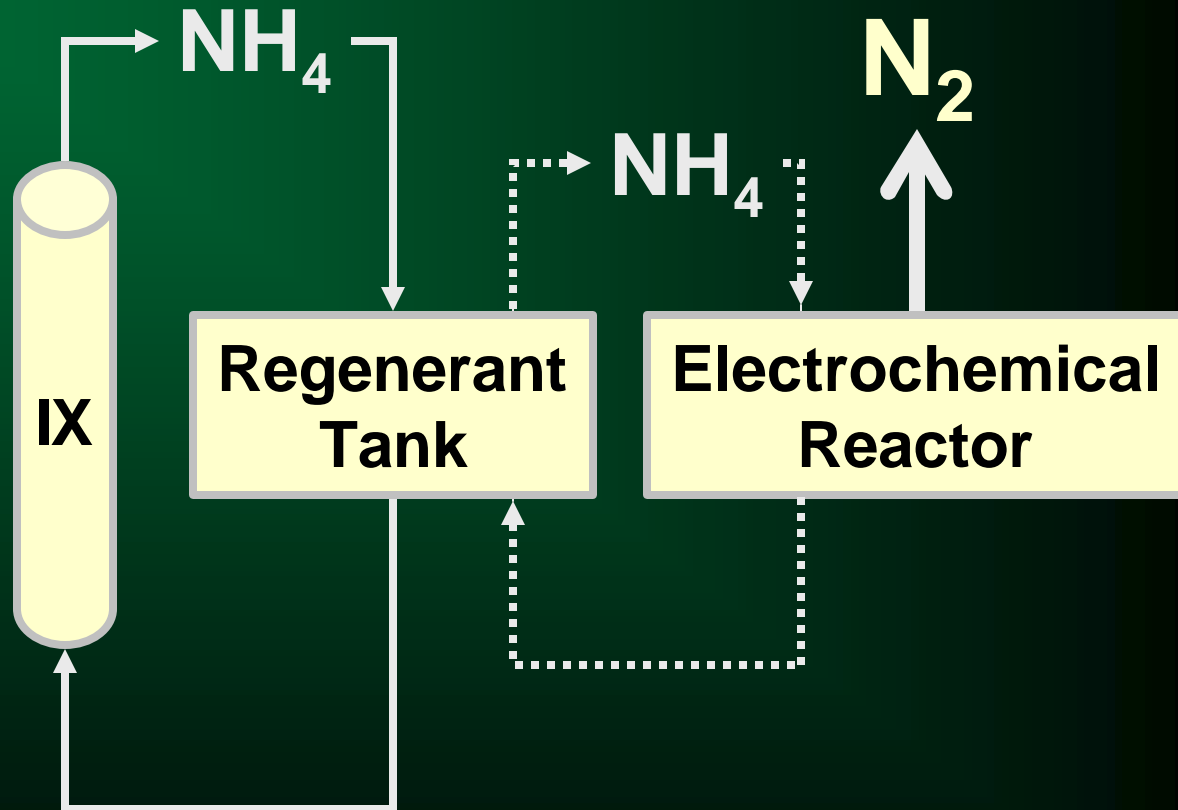
- ◆ Natural mineral - zeolite
- ◆ Inexpensive and durable
- ◆ In use since early 1980's
- ◆ Collaboration with a US Company
 - WRT - Arvada, CO

The Process

Ion-exchange Loading



Regeneration Cycle





Pilot Testing at The City of Guelph Wastewater Treatment Plant

Why?

- ◆ **Reduction in allowable $\text{NH}_3\text{-N}$ discharge to 1 mg/L with expansion of WWTP**
- ◆ **Alternative to biological treatment**

Schematic of Pilot System

Loading

Regeneration

Electrochemical Cell

DC Power

pH Controller

Off gas

Ammonia Sensor

NH_4

Wastewater

Ammonia Sensor

Treated Wastewater

NaOH

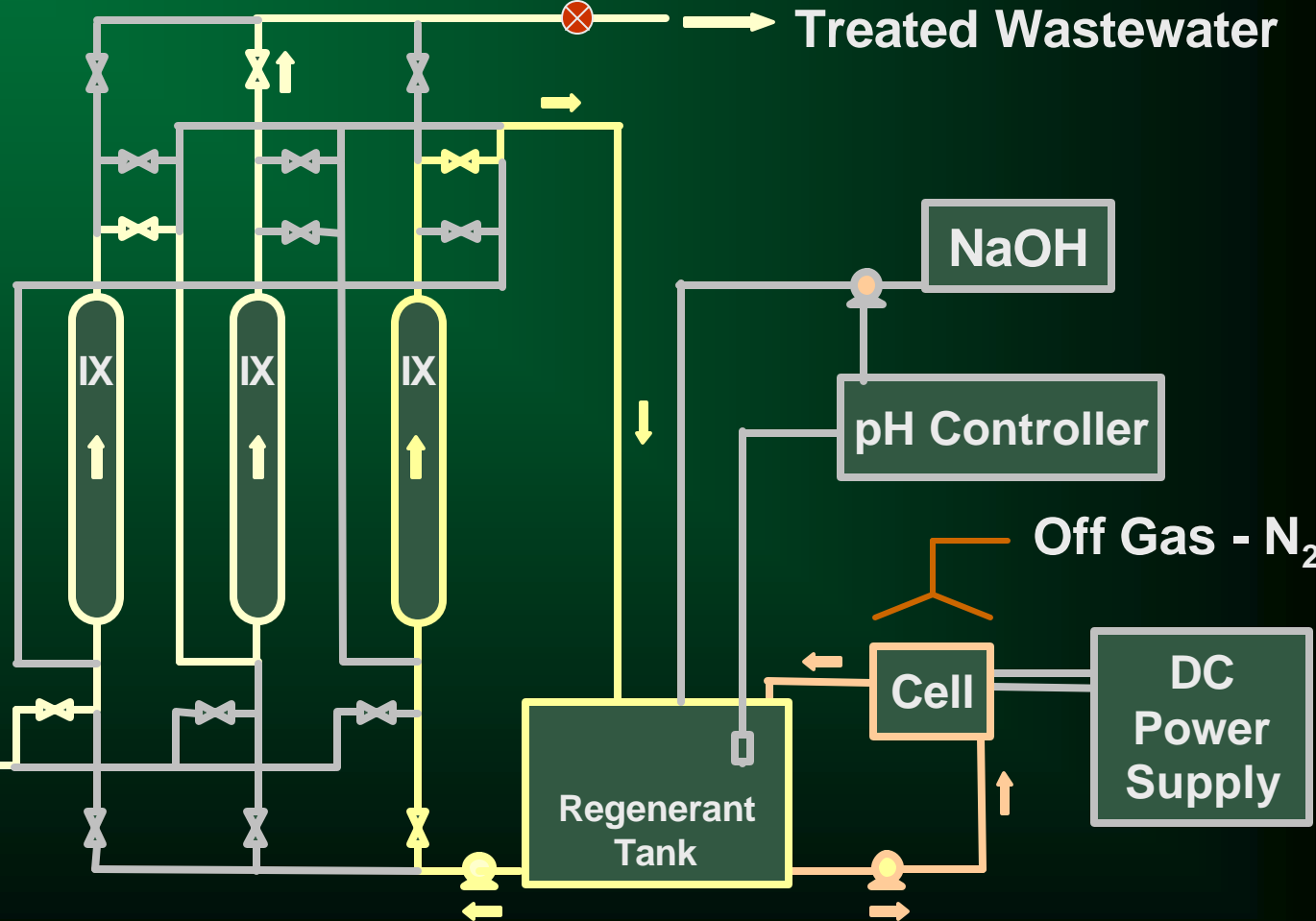
pH Controller

Off Gas - N_2

Cell

DC
Power
Supply

Regenerant
Tank



Pilot System



- ◆ Consists of 3 IX columns

Pilot System



- ◆ Consists of 3 IX columns
- ◆ Electrochemical cell

Pilot System



- ◆ Consists of 3 IX columns
- ◆ Electrochemical cell
- ◆ Maximum flow rate of 20 L/min

Scope

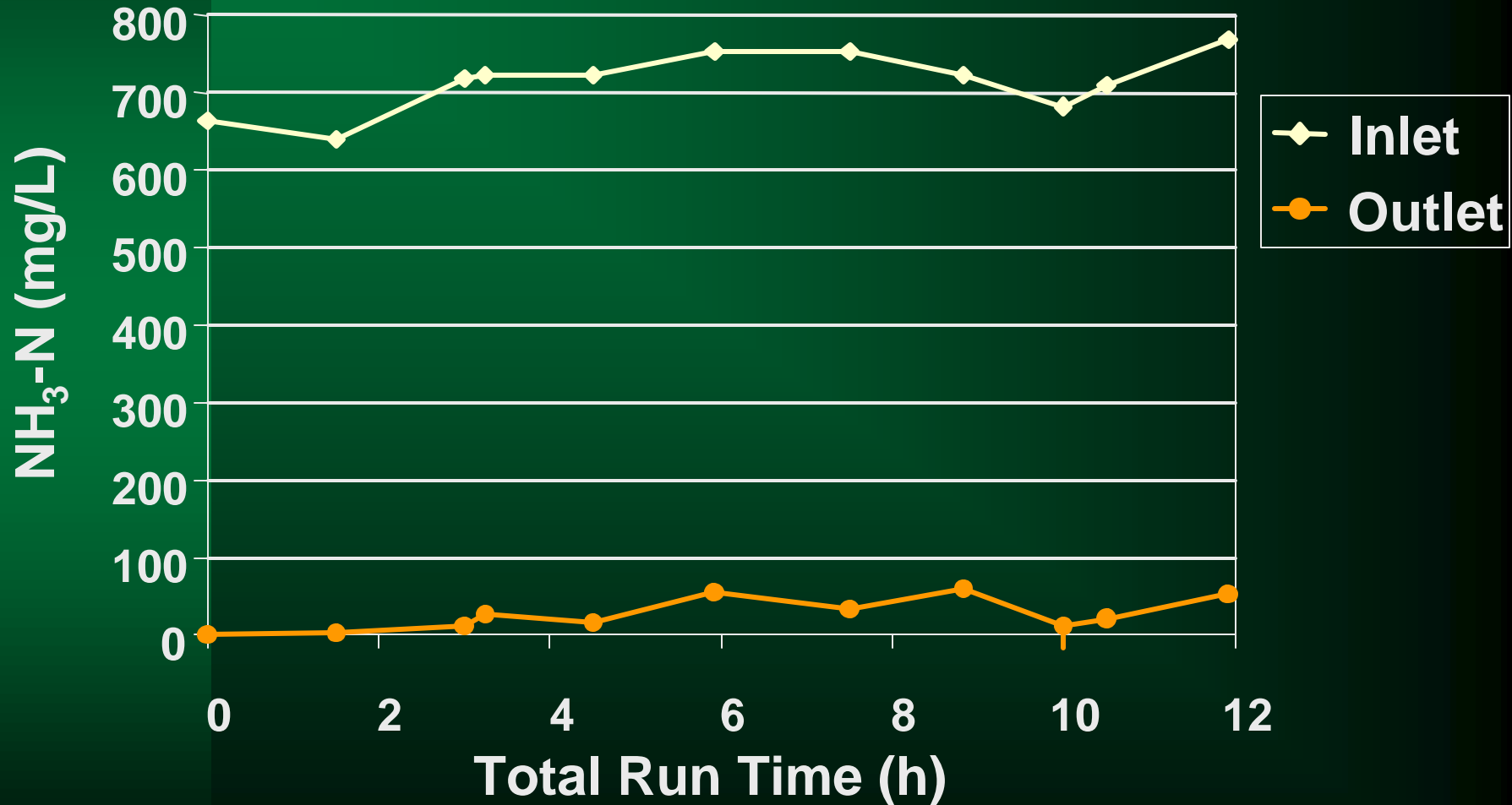
- ◆ **Treat two distinct waste streams**
 - Sludge dewatering effluent
 - Clarified secondary effluent

- ◆ **Monitor off gas**

Sludge Dewatering Effluent

- ◆ **Concentration**
 - 200 - 1000 mg/L $\text{NH}_3\text{-N}$
- ◆ **Flow rate**
 - wastewater 2 L/min
 - total column flow 18 L/min

Results (typical)



Clarified Secondary Effluent

- ◆ **Concentration**
 - 5 mg/L $\text{NH}_3\text{-N}$
- ◆ **Flow rate**
 - 14 to 16 L/min
- ◆ **System bypassed at concentrations**
 - < 1 mg/L $\text{NH}_3\text{-N}$

Results (typical)



Off-Gas Analyses

- ◆ **>99.99% as N₂**
- ◆ **No VOC's**
- ◆ **No chlorinated hydrocarbons**
- ◆ **1 - 8 ppm of Cl₂**

Treatment Costs

- ◆ **Operating costs (power and chemicals)**
 - \$2.20 to 2.40/kg of $\text{NH}_3\text{-N}$ removed

Capital Cost Comparison

- ◆ Add on tertiary removal post-lagoon
- ◆ 1 ML/day at 20 mg/L $\text{NH}_3\text{-N}$ to <5 mg/L
 - AmmEI \$1.6 M
- ◆ Attached growth - nitrification only
 - \$1.65 to \$2.8 M

AmmEI Summary

- ◆ AmmEI system readily achieves an average of 0.6 mg/L $\text{NH}_3\text{-N}$
- ◆ Eliminates nitrogen loading by converting ammonia directly into innocuous N_2
- ◆ Does not convert ammonia to nitrate
- ◆ Does not produce greenhouse gases (No Nitrogen Oxides)

AmmEI Summary

- ◆ **Less expensive than conventional methods**
- ◆ **Intermittent operation -- no start-up delays**
- ◆ **Efficiency not temperature dependent**
- ◆ **Fully automated -- low maintenance**
- ◆ **Remotely monitored**

Upcoming Tests

- ◆ **Region of Niagara, ON, Canada**
 - storm water pond 10 mg/L $\text{NH}_3\text{-N}$
 - 3 mg/L required for discharge

- ◆ **City of Guelph, ON, Canada**
 - alternative approaches for filtrate treatment
 - electro-membrane reactor
 - strip/scrub electrochemical combination
 - ammonia recovery option

Acknowledgements

- ◆ Funding provided by IRAP
- ◆ Staff at the City of Guelph WWTP
- ◆ WRT, Arvada CO



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