Saltworks™

Ammonia Splitter Treatment of Wastewater Treatment Plant Centrate & Landfill Leachate

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Ammonia Treatment and Technology

The Project:

- Remove & destroy ammonia in Wastewater Treatment Plant (WWTP) Centrate circuit; beneficially increase capacity of WWTP
- Overcome challanges of biological processes through use of a direct controllable electrochemical process

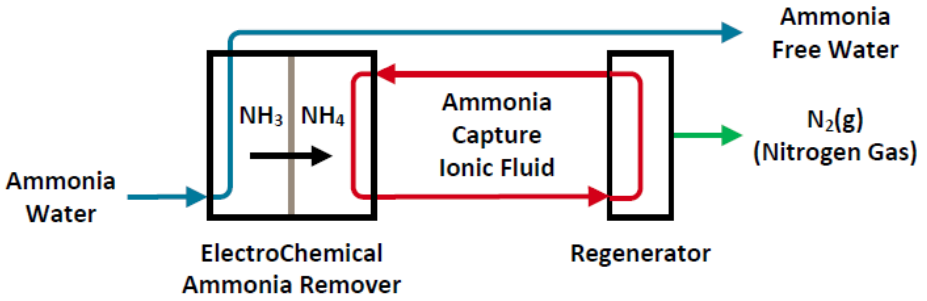
The Ammonia Splitter Technology:

- Destroys ammonia, produces nitrogen gas (N_2)
- Reliable, adjustable electrochemical treatment
- Excess capacity: add more power to remove more NH_3
- Compact modular system
- Fully automated
- Solar photovoltaic direct power option

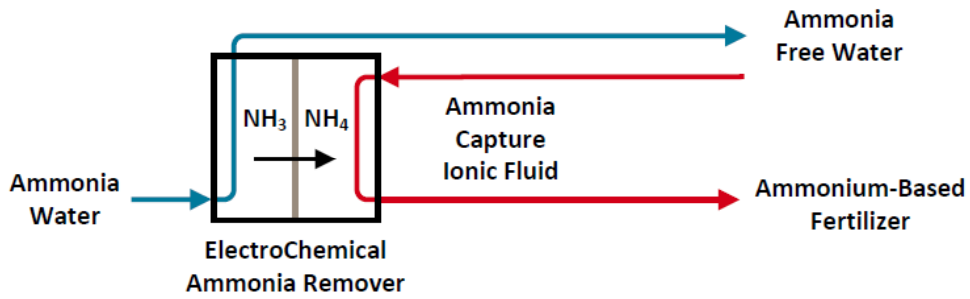
Two options: destroy ammonia or make fertilizer

Process Option	By-product	Pros	Cons
1. Full destruction Electrolyze to nitrogen gas	N_2 (air)	**Full destruction, no waste disposal liability**	**Higher cost and energy. Solar PV offset option.**
2. Fertilizer production Conversion to $(NH_4)_2SO_4$	Ammonium Sulfate $(NH_4)_2SO_4$	**Lowest cost option**	**Low value by-product (7% solution)**
3. High quality fertilizer production Conversion to NH_4NO_3	Ammonium Nitrate $(NH_4)NO_3$	**High quality by-product, lower cost than full destruction**	**Process more complex.**

Ammonia Destruction Option



Ammonia Fertilizer By-Product Option

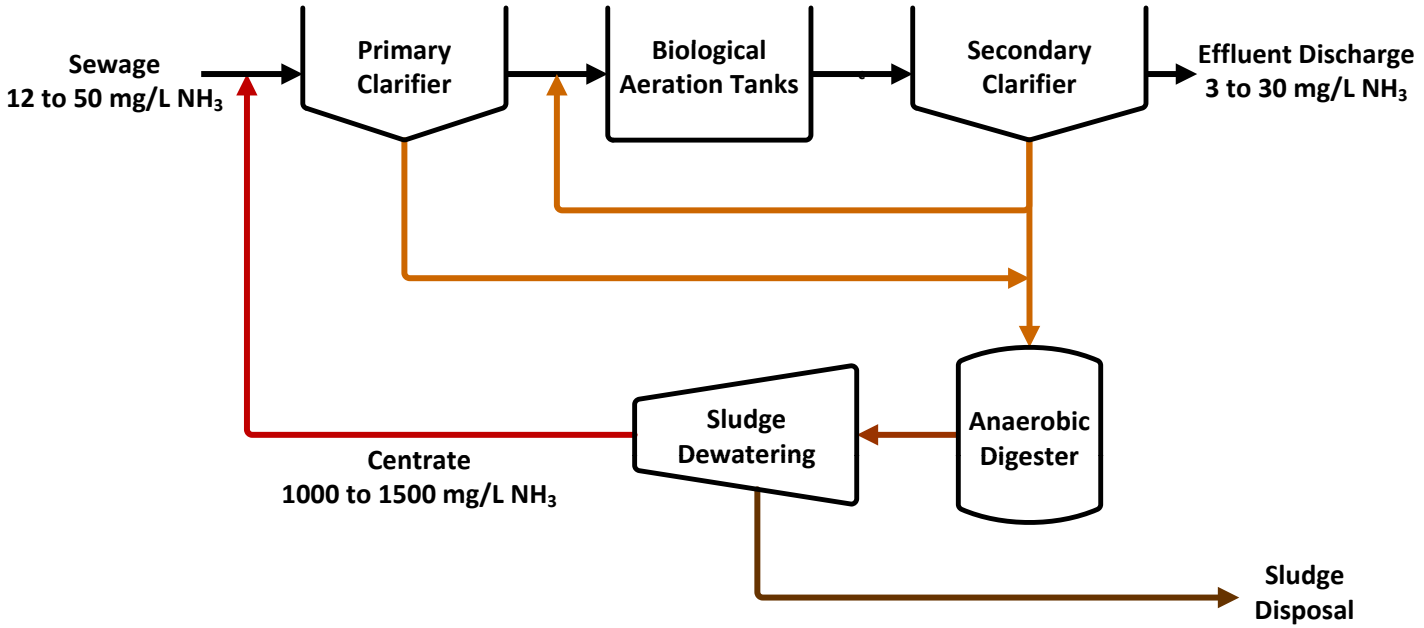


Regenerator for Ammonia Destruction Option

Regenerator: Readily available off the shelf equipment

- Solar photo-voltaics option to offset energy requirements
- DC power used directly, no expensive inverters required

Wastewater Treatment Plant (WWTP)

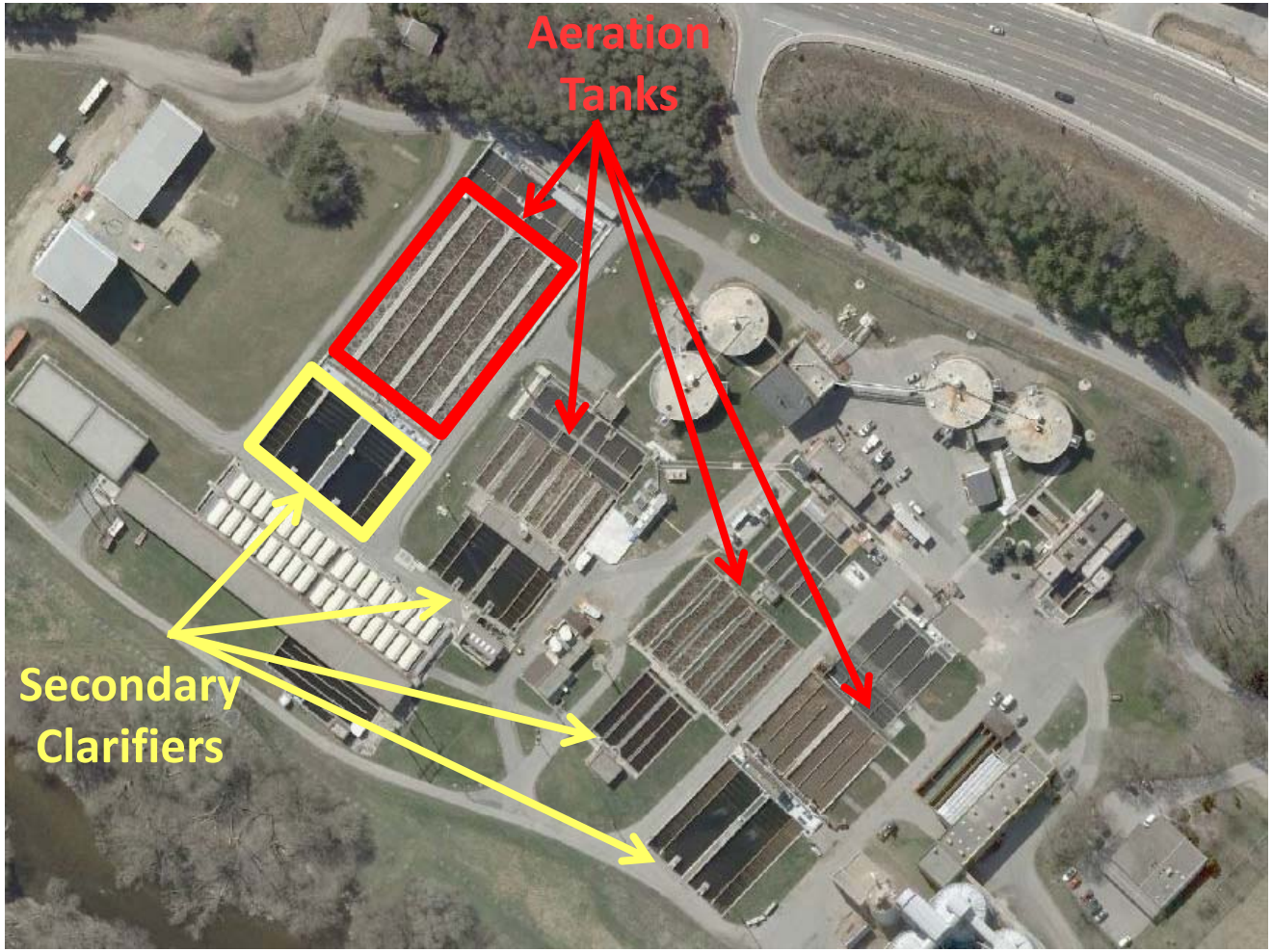


Algae Bloom from WWTP Effluent Discharge

- Increased nutrient loads discharged to local water bodies
- Algae blooms damage aquatic ecosystems

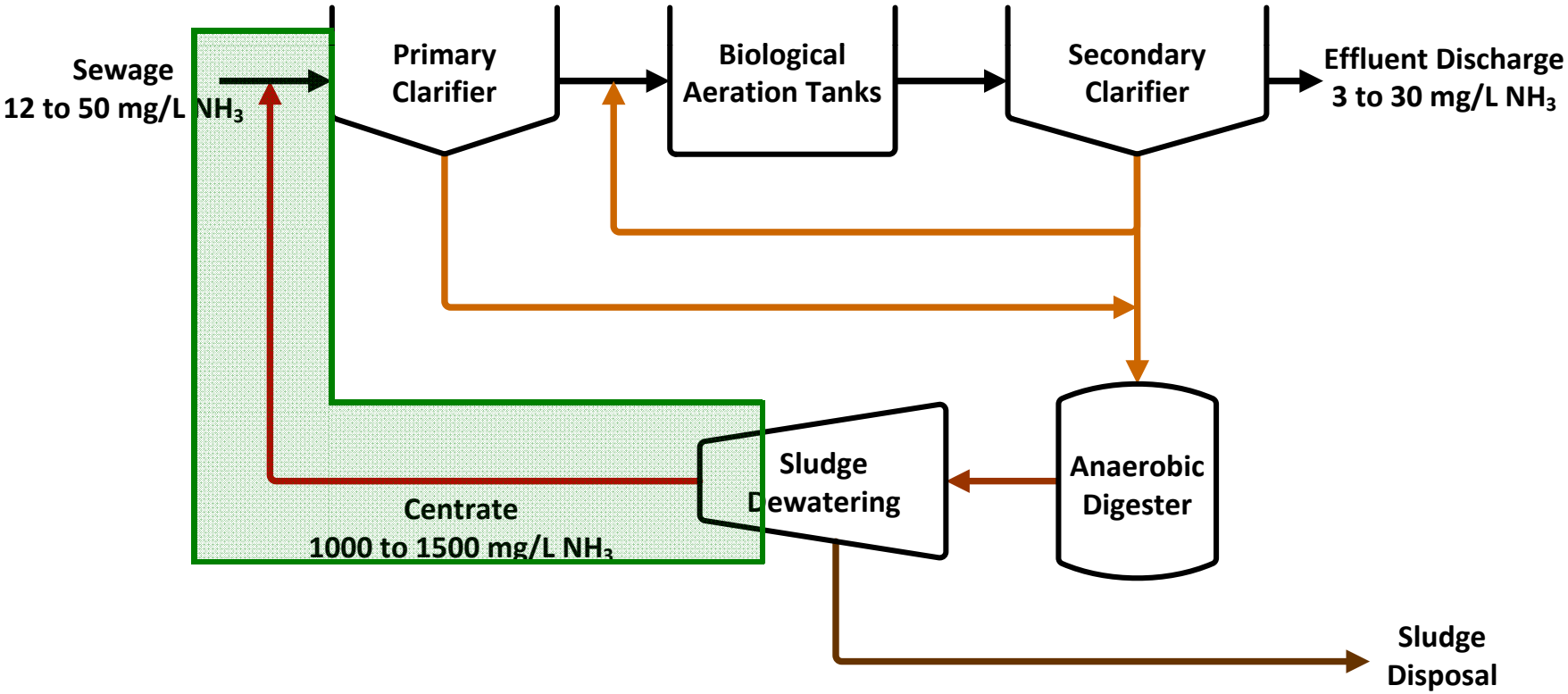
WWTP: 3 options for increased nutrient loads

1. No Action: Increased nutrient discharge → exceed discharge limits
2. More aeration tanks and secondary clarifiers → footprint



Option 3: Treat Side Stream (Centrate)

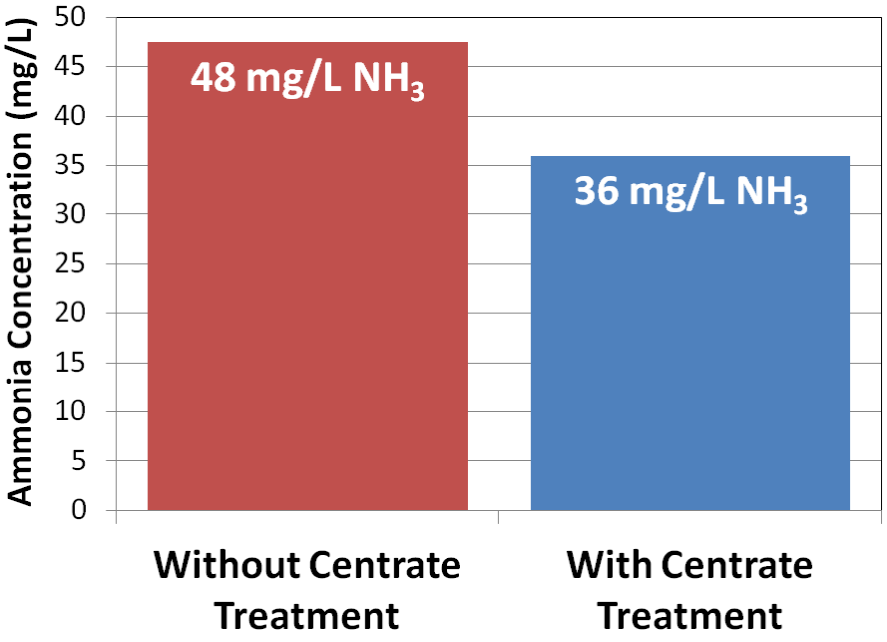
- Centrate recycle accounts for 1% WWTP flow, but 20% of ammonia load
- Treat centrate to remove ammonia mass, and increase ammonia processing capacity



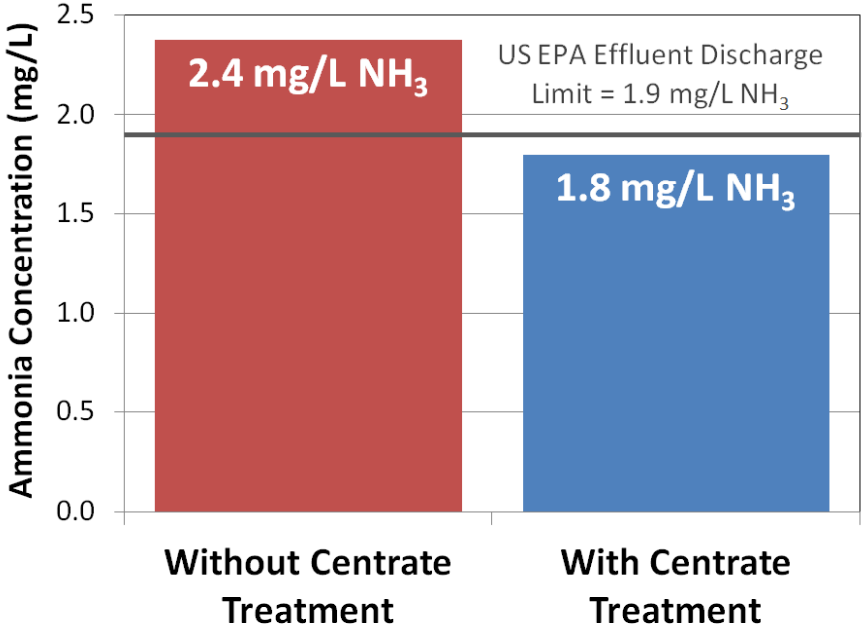
WWTP Side Stream (Centrate) Treatment

- Saltworks' Ammonia Splitter to destroy NH_3 to N_2 gas
- Low foot print and fit into existing plant

Reduce Ammonia Load in Main WWTP



Meet EPA Discharge Limits Treating 1% of Inlet Flow



Built on Electrodialysis Reversal (EDR)

- Well established technology; 2nd most dominant membrane desalination system after reverse osmosis
- 50 years operational history
- Organic fouling resistant (no membrane water flux & pressure difference)
- Self “cleaned” through reversal
- Easy to service: plate and frame
- Modular

Ammonia Splitter builds on EDR

- Special membranes inside
- Patented process

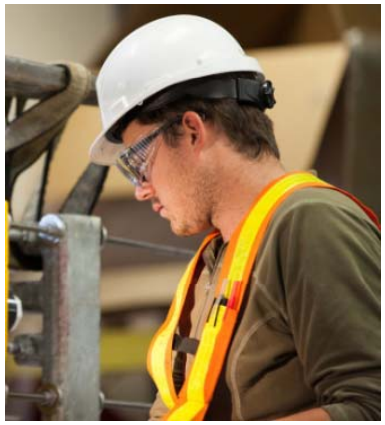
Advanced Ion Exchange Membranes

- Ductile and conductive base polymer
- pH 0-13, 0-60^{o}C
- 1/10th thickness of traditional membranes but tougher and smoother (less fouling potential)
- High multivalent ion transport, high selectivity
- Selective ion removal – tuned for ammonia removal

ElectroChem Commercial Production and Services




ElectroChem Stack Production and Assembly



Quality Assurance

Customer Training Center

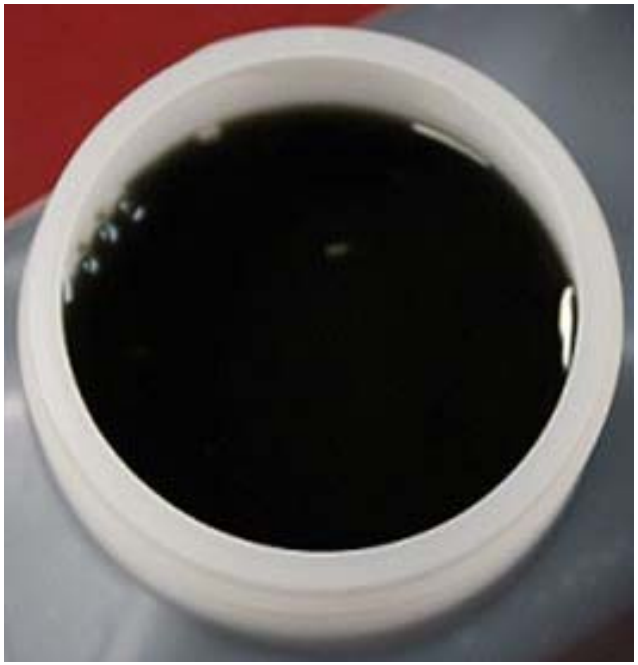
24/7 Remote Customer Support

Testing on WWTP Centrate

- Centrate from Municipal WWTP
- Pretreatment for TSS
- 50 µm microfiltration

Parameter (mg/L)	RAW WWTP Centrate
pH	8.07
Total Suspended Solids	900
Ammonia-N	1300
Total Kjeldahl (TKN)	1250
Ortho-Phosphate	186
Total Phosphorus	204

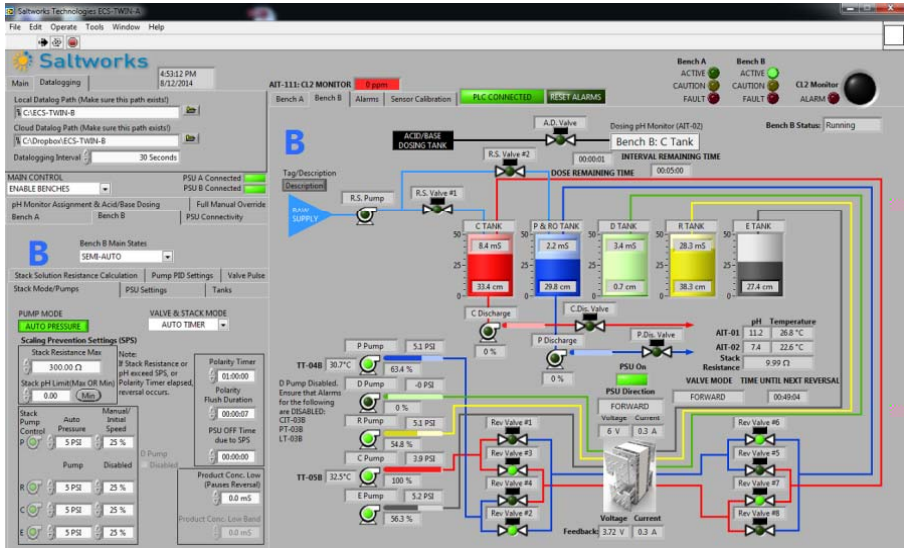
WWTP Centrate



50 µm self cleaning filter for > 50 um solids

Ammonia Splitter Micro Pilot Setup on Centrate

- Fully automated DAQ: pH, stack voltage and current
- Manual checks: non-DAQ data, observations, confirm sensor calibration
- Analytical: internal bench top analysis and independent 3rd party analysis



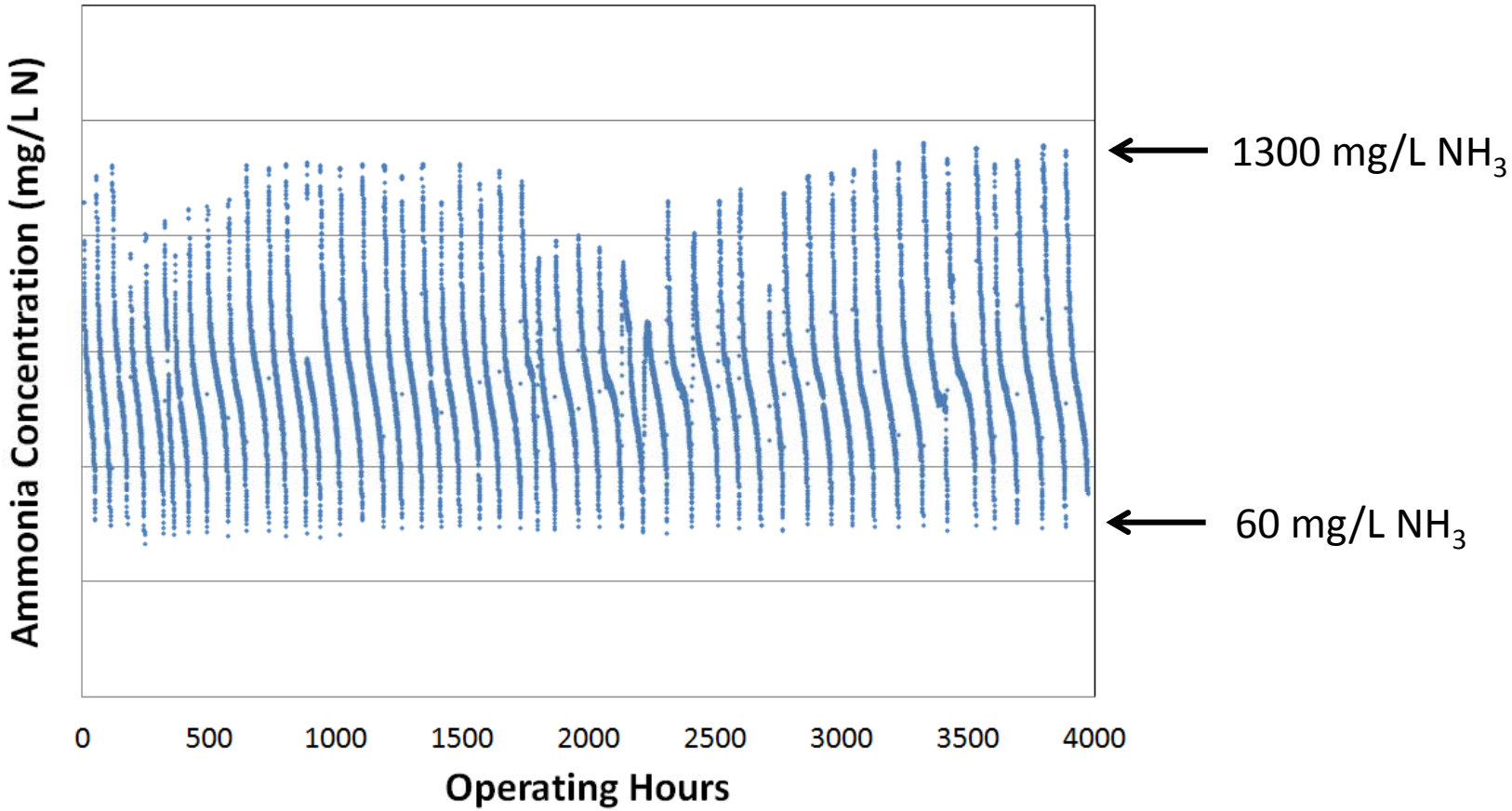
Pilot HMI

Micro Ammonia Splitter Pilot

Ammonia Splitter Test Stack

Centrate: Ammonia Splitter Micro Pilot Test Results

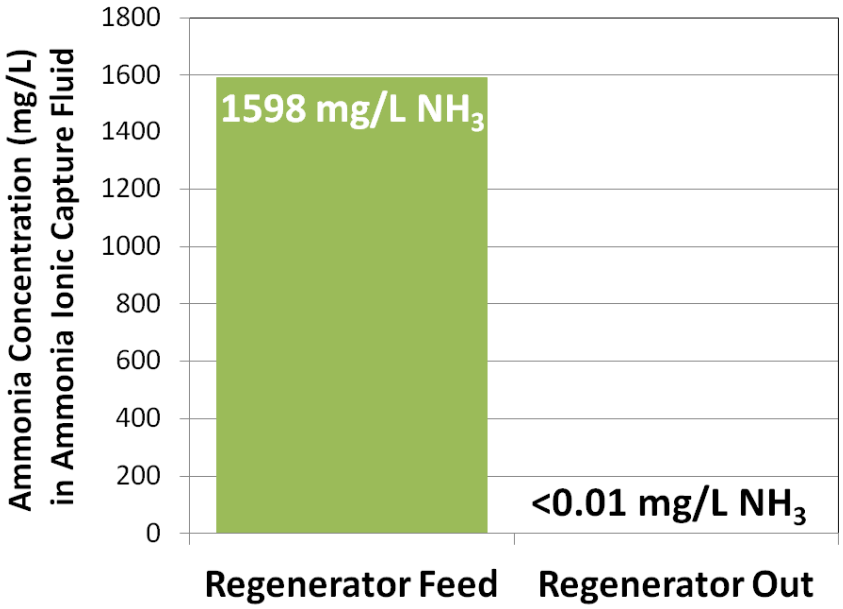
- Reliable continuous 24/7 operation for 4000+ hrs (6 months)
- Removed ammonia in centrate from 1300 mg/L to 60 mg/L
- Automated self cleaning and clean in place maintained reliable operation



Centrate: Ammonia Splitter Analytical Results

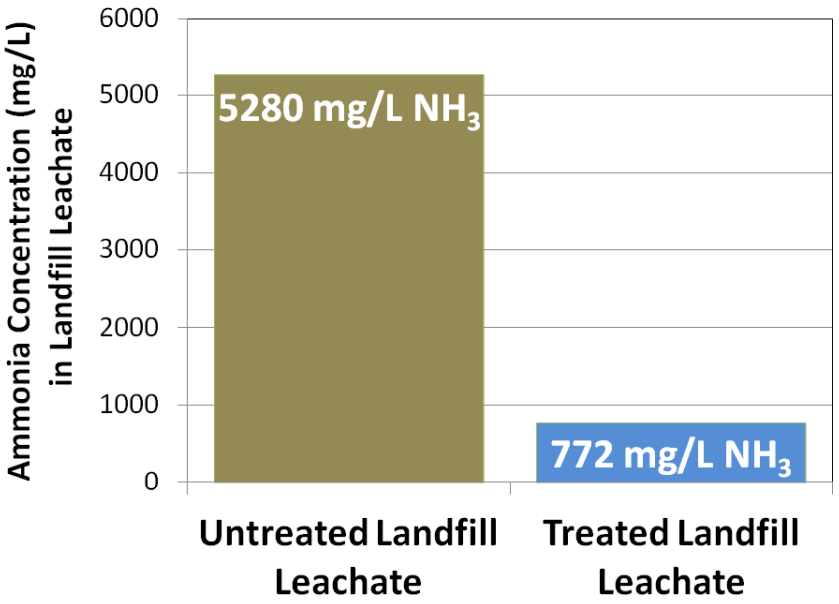
- 95% of ammonia in centrate removed
- Some phosphate also removed ~10%
- Regenerator destroyed all of the ammonia to N_2 gas
- 100% recovery: to date, no waste by-product generated

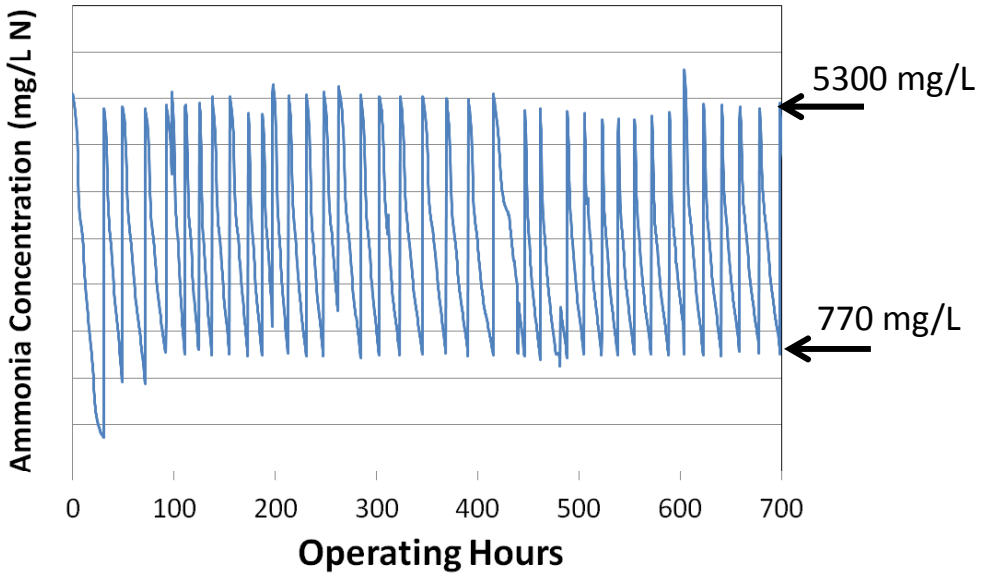
Parameter (mg/L)	Untreated WWTP Centrate	Treated WWTP Centrate	% Reduction by Ammonia Splitter
pH	8.07	7.27	-
Ammonia-N	1300	64	95%
Total Kjeldahl (TKN)	1250	116	91%
Ortho-Phosphate	186	167	10%
Total Phosphorus	204	177	13%



Ammonia Splitter Micro Pilot: Landfill Leachate

- Ammonia Splitter tested on landfill leachate for 3 months
- Removed ammonia in leachate from 5280 mg/L to 772 mg/L, meeting the project requirements of reducing the ammonia load for further treatment by a downstream process
- Pilot demonstrated that Ammonia Splitter can operate on any concentration of ammonia





Conclusions

- Demonstrated reliable 24/7 operation for 6+ months
- Reliable, automated, and no fouling (self cleaning systems function well)
- Removes ammonia from wastewaters at any concentration: centrate at 1300 mg/L and leachate at 5800 mg/L, to meet any treatment goal.
- All ammonia permanently destroyed to nitrogen gas
- 100% recovery; no waste by product produced from testing to date

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