ATMOS

Landfill Leachate Solution

2026 SWANA FL Summer Conference |
July 19-21 | Orlando, FL

Presented by
Wenjun Liu, PhD | VP of Technology
Chip Benjamin | Director of New Product Development

www.atmos -technologies.com

Florida Landfill Leachate Story

Path from off-site hauling to direct discharge

Industry Concerns with leachate disposal

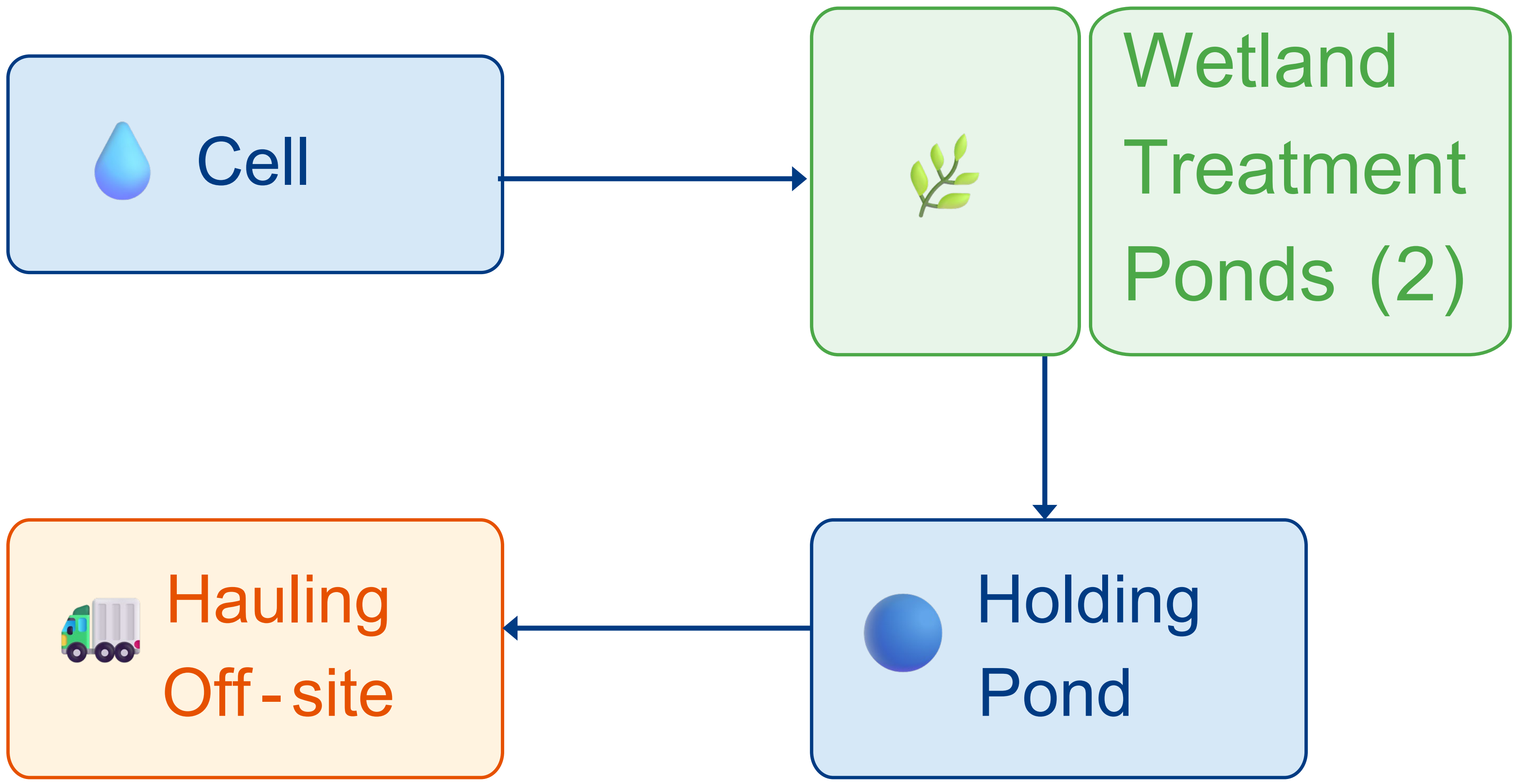
- Changing regulation landscape
- POTW/WWTP restrictions
- Hauling costs
- Leachate quantity, quality variability

Project Goals for Landfill

- Leachate disposal optionality
- Reduce Costs
- Long Term solution for leachate management; less reliant on third parties

Site Background

- Class III C&D landfill in Florida Panhandle
- Generates between 6,000 and 15,000 gallons per day of leachate, hauled off -site
- Cell expansion leading to 30% increase in leachate volume
- Existing wetland pond leachate treatment added little value
- Wetland permit in place, additional treatment requiring permit modification through DEP



Site Request

Reduce reliance on third party haulers, POTW for leachate disposal – own the process

- On-site treatment leading to direct discharge
- Clean leachate to meet FDEP Ground Water Limits +EPA 40 CFR Part 258 Appendix I

Path to On -site Discharge

1. Analyze raw leachate versus discharge data
2. Propose design to meet tight direct discharge (GW) limits
3. Run pilot to confirm design success
4. Permit mod application, approval
5. On board, commission, testing
6. Additional tests, looping water while awaiting construction certificate

Site Assessment

The Challenges

- Existing wetland system added little value
- Very tight, almost potable, GW limits to meet for direct discharge
    - Specifically elements such as boron, arsenic
- Permit modification needed
- Limited Capex availability
- Big fluctuations in leachate generation

The Advantages

- 200,000 gallon landfill pond availability – save cost of water tanks for bio pre-treatment
- Low ammonia leachate
- Willing, creative owner
- Available 3 phase power on site

1-5

truckloads/day hauled off-site

Reliant on 3rd parties for leachate disposal
- Hauler
- POTW

Compliance and permitting complexity

2

ponds available

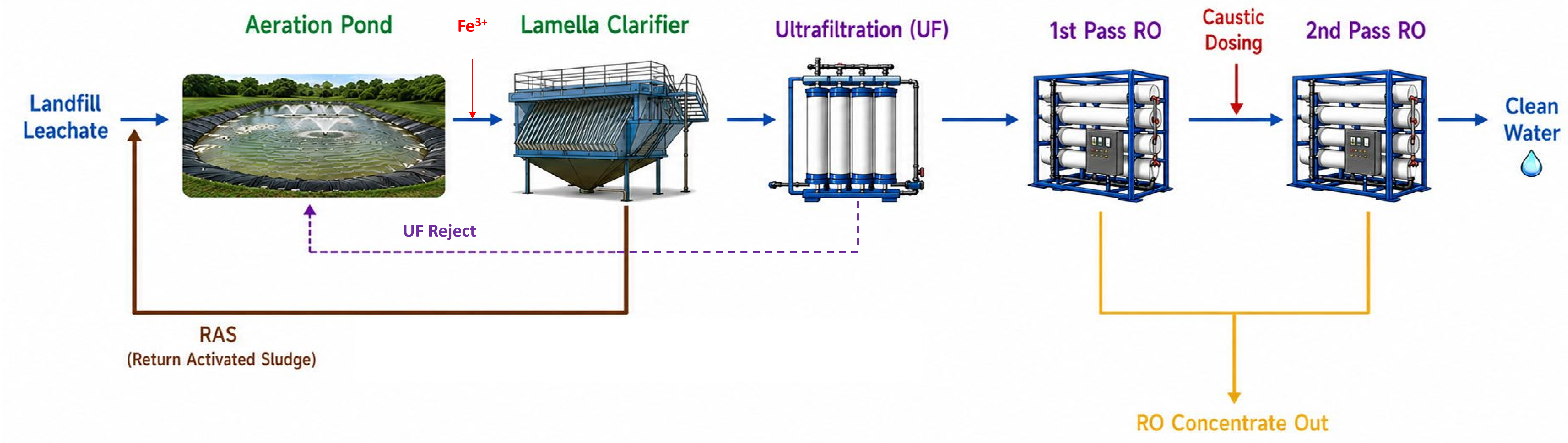
The Solution started with the data…data drives the design

- Reviewed raw leachate characteristics
- Evaluated treatment goals (GW limits) plus 40 CFR Part 258 Appendix I parameters
- 24 metals – Aluminum to Zinc
- General Chemistry limits such as ammonia, chloride, nitrate, hydrogen sulfide, TDS
- Identified contaminants of concern – boron, arsenic, ammonia

Contaminant	Raw Leachate mg/l	GW Discharge Limits mg/l
Ammonia	62.6	2.8
Arsenic Total	0.317	.01
Boron Total	22	1.4
Sulfate	1390	250
TDS	4730	500

Proposed Treatment Design Based on Data Analysis

ATMOS



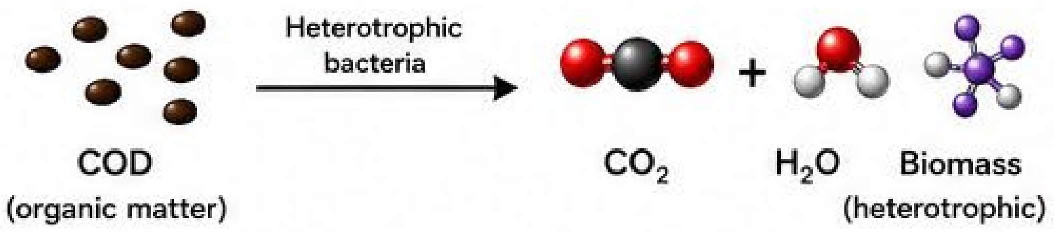
- Convert wetland into aeration bio pre-treatment pond
- Scalable to accommodate rain events, up to 40,000 gpd influent
- Starlink connection enables remote PLC monitoring, data logging, operations, warnings

Key Reactions and Mechanisms in an Aerobic Pond

High-DO, Completely Mixed System for High Alkalinity Leachate (e.g., Florida)

1. Organic Matter Removal (Heterotrophic Oxidation)

Heterotrophic bacteria oxidize organic matter (COD) to CO_2, H_2O and heterotrophic biomass.



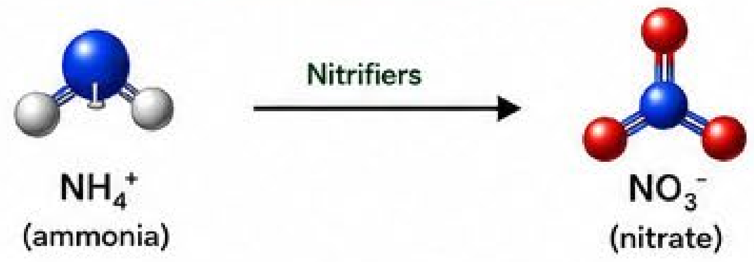
Overall Reaction (conceptual):

$$COD + O_2 \longrightarrow CO_2 + H_2O + \text{Heterotrophic Biomass}$$

- Consumes DO
- Reduces COD
- Produces biomass

2. Nitrification (Consumes Alkalinity)

Nitrifying bacteria oxidize ammonia to nitrate. This reaction consumes alkalinity.



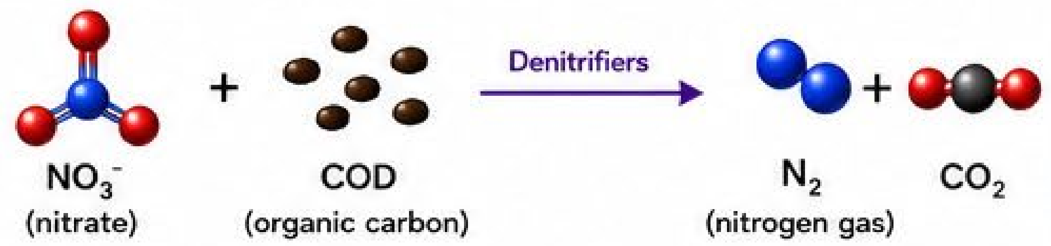
Overall Reaction (simplified):

$$NH_4^+ + 2\,O_2 \longrightarrow NO_3^- + H_2O$$

Alkalinity Consumption:
1 mole of nitrification consumes
2 moles of alkalinity (as $CaCO_3$)

3. Denitrification (Recovers Alkalinity – Not Desired Here)

Nitrate is reduced to nitrogen gas using organic carbon (COD) as the electron donor. This reaction recovers alkalinity.



Overall Reaction (simplified):

$$NO_3^- + COD \longrightarrow N_2 + CO_2 + H_2O$$

Alkalinity Recovery:
1 mole of denitrification recovers
1 mole of alkalinity (as $CaCO_3$)

Not desired in this aerobic pond. We want to maximize alkalinity destruction by nitrification.

OPERATIONAL STRATEGY FOR THE AEROBIC POND

- Maintain HIGH DO (~2–3 mg/L) throughout the pond
- Provide COMPLETE MIXING (surface aerator)
- Favors nitrification over denitrification
- Maximizes alkalinity consumption and minimizes alkalinity recovery
- Critical for high alkalinity leachate (Florida) to lower LSI (Langelier Scaling Index), and reduce RO scaling potential

BENEFIT

High DO + Complete Mixing
↓
Maximize Nitrification (Alkalinity Consumption)
↓
Lower Alkalinity
↓
Lower LSI (Scaling Index)
↓
Reduce RO Scaling Potential

WHY IT MATTERS

- Florida leachate has very high alkalinity.
- Lower alkalinity → lower LSI → less scaling in RO system
- Less cleaning, longer membrane life and better overall performance.

4. Phosphorus Control (Prevent Algae Growth)

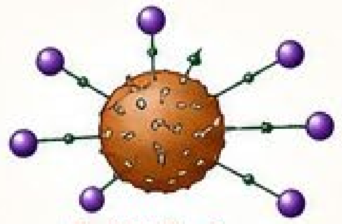
Leachate phosphorus is typically low, but in an open pond with strong sunlight, algae can grow if phosphorus is available. We control phosphorus by ferric dosing.

Ferric Dosing (e.g., $FeCl_3$)

$$FeCl_3 + 3\,H_2O \longrightarrow Fe(OH)_{3(s)} + 3\,H^+ + 3\,Cl^-$$

Formation of ferric hydroxide flocs

$Fe(OH)_3$ floc adsorbs / co-precipitates phosphate (PO_4^{3-}) from the water.



$Fe(OH)_3$ floc

Adsorbs / Co-precipitates PO_4^{3-} (phosphate)

Benefits:

- ✔ Removes available phosphorus
- ✔ Limits algae growth (no P to support algae)
- ✔ Improves floc formation and settleability
- ✔ Reduce ultrafiltration membrane fouling
- ✔ Reduces alkalinity, lowers LSI, and reduces RO scaling potential

Alkalinity Impact: Ferric dosing consumes additional alkalinity. Each mole of $FeCl_3$ hydrolysis produces 3 moles of H^+, which consume 3 moles of alkalinity (as $CaCO_3$) per mole of $FeCl_3$ added.

5. Arsenic Removal (Oxidation of As(III) to As(V))

Permit requirement: Total arsenic < 10 µg/L (10 micrograms per liter)

Arsenite [As(III)] must be oxidized to arsenate [As(V)] under aerobic conditions.

Overall Oxidation Reaction (balanced in water):

$$\underset{\text{Arsenite (As III)}}{H_3AsO_3} + \underset{\text{Oxygen}}{\tfrac{1}{2}\,O_2} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Arsenate (As V)}}{H_3AsO_4}$$

Requires good DO in the pond.

Benefits:

- ✔ Converts As(III) to As(V) for effective removal by downstream membrane system, ion exchange, or adsorption media.

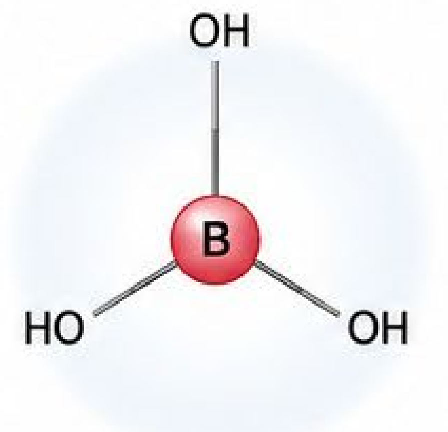
Why Boron Rejection Increases at High pH

Two Mechanisms Act Together

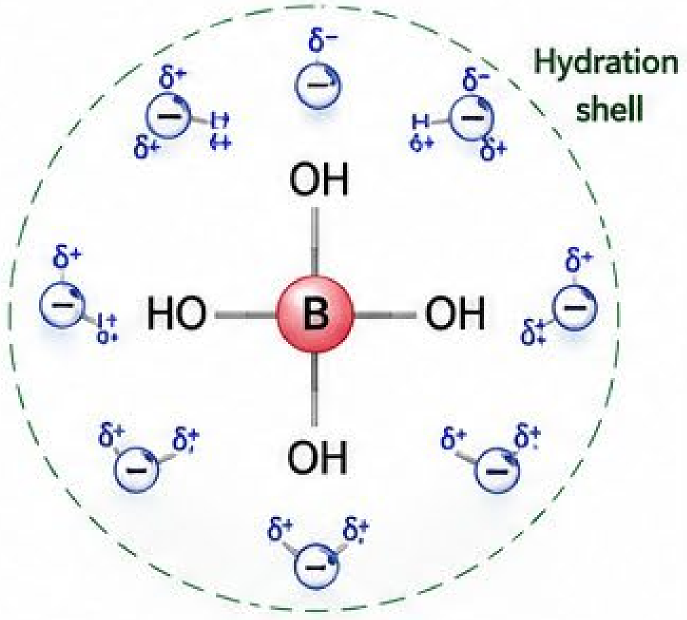
1. Boron Speciation Changes

pH ~7 (Neutral)
Boron exists mainly as
Boric Acid (H_3BO_3)

pH ~10.5 (High pH)
Boron exists mainly as
Borate Ion ($B(OH)_4^-$)



Hydrated radius
≈ 1.55 Å



Hydrated radius
≈ 2.6 Å

Size increase after ionization

Approximate hydrated radius:

H_3BO_3 ≈ 1.55 Å

$B(OH)_4^-$ ≈ 2.6 Å

Therefore:

~1.7× larger radius

~5× larger hydrated volume

- Neutral molecule (no charge)
- Small hydrated size
- Easily passes through RO membrane

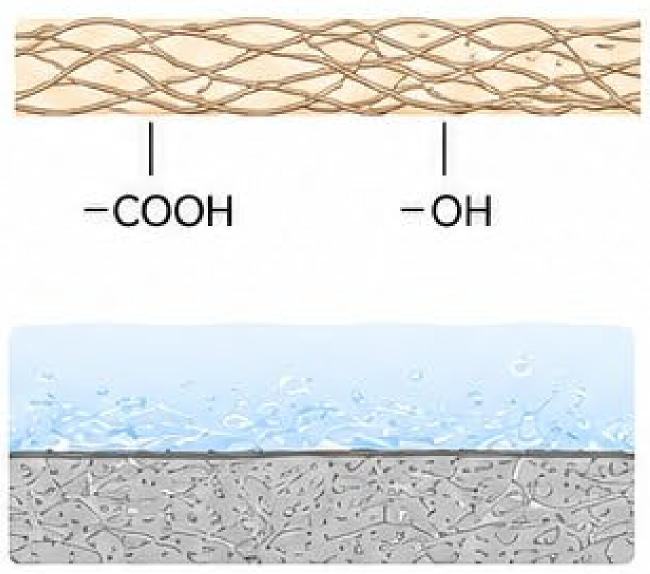
- **Negatively charged ion (−1)**
- **Surrounded by hydration shell**
- **Much larger effective size**
- **Strongly repelled by RO membrane**

2. Membrane Surface Becomes More Negative

pH ~7 (Neutral)
Membrane functional groups are mostly in neutral form

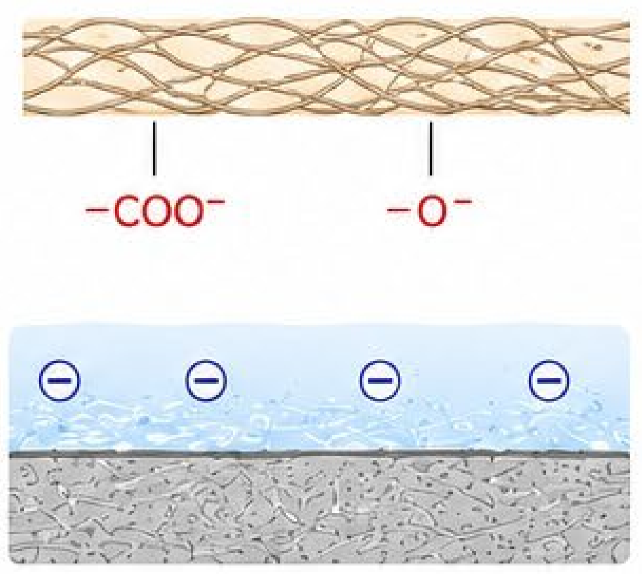
pH ~10 (High pH)
Membrane functional groups are ionized

Polyamide RO Membrane Surface



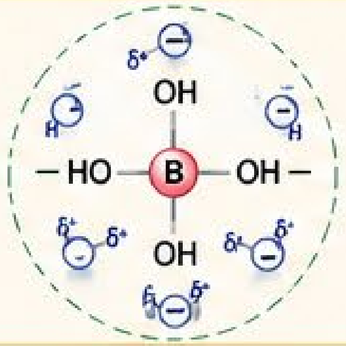
COOH and OH are not ionized
Surface charge ~ neutral
Zeta potential ≈ 0 mV

Polyamide RO Membrane Surface



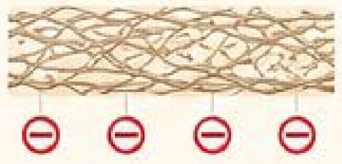
COOH → COO⁻ (ionized)
OH → O⁻ (ionized)
Surface charge = negative
Zeta potential < 0 mV

At high pH (~10.5):



Boron is mainly $B(OH)_4^-$, large and negatively charged

+



RO membrane surface is highly negative

=

Strong electrostatic repulsion + size exclusion = High boron rejection

Confirm Design Success with Pilot

- Verified treatment performance
- Tested assumptions before system deployment
- Generated data for design decisions
- Helped support stakeholder confidence

Contaminant	Raw Leachate mg/l	GW Discharge Limits mg/l	Pilot Results mg/l
Ammonia	62.6	2.8	.8
Arsenic Total	0.317	.001	Non Detect
Boron Total	22	1.4	.21
Sulfate	1390	250	32
TDS	4730	500	41

Design Detail Step-1

Aerated Biological Treatment

Bio-treatment Pond with 5 HP Aerators

- Ammonia, BOD reduction
- Low Capex, use 200,000 gallon ponds vs. water tanks
- Replaced water tank; tank costs exceed pond prep costs

Design Detail Step–2

Gravity Clarifier

Gravity Clarifier

- TSS reduction
- Low capex, Opex
- RAS returned to aeration pond

Design Detail Step-3

Ultrafiltration + Double Reverse Osmosis

UF + Double RO

- Boron, Arsenic, Sulphate reduction
- TDS reduction first pass RO
- Need licensed operator
- RO reject generation

Leachate System Design

Bio-treatment Pond with Aerators
Ammonia, BOD reduction

Clean water held for testing prior to discharge

UF + Double RO
Boron, Zinc, TDS reduction

Gravity Clarifier
TSS reduction

Leachate System Design

Leachate System Design

Footprint 40’ x 40’

- Skid mounted versus container

Data Results: Meeting and exceeding GW; Part 258 limits

Contaminant	Raw Leachate mg/l	GW Discharge Limits	Production Results mg/l	Reduction
Ammonia	62.6	2.8	.4	99.4%
Arsenic Total	0.317	.001	Non Detect	100%
Boron Total	22	1.4	0.243	98.9%
Sulfate	1390	250	Non Detect	100%
TDS	4730	500	30	99.4%

Permitting Collaboration
Another Success Story

ATMOS

- Permit modification required
- Collaborative approach including provider, Tetra Tech, owner
- Coordination with engineering and regulatory stakeholders
- Data-backed design helped move the project forward
- Compliance considerations built into implementation
- Running system in a loop to maintain bio activity in pond, testing, awaiting construction certificate

Lessons Learned

- Start with data – data drives design
- Define treatment goals early – direct discharge? Simple ammonia reduction to maintain POTW relationships?
- Pilot before scaling
- Align design with permitting requirements
- Build for operational realities, not just lab performance
- Design lessons at the FL Landfill
- Biological activity must be managed
- RO reject must be managed
- Consider upsizing system for rain events
- Plan for varying leachate levels (add capacity)

Value Delivered

Original Request

- More control, ownership of leachate disposal
- Less reliance on third parties to dispose leachate
- Budgeting accuracy, cost savings
- Scale for landfill expansion
- Long term operational plan for leachate disposal

Q&A / Discussion

obligatory before and after picture here!

ATMOS

THANK YOU

Booth #4

Jeffrey Palutis | jpalutis@atmos-technologies.com

Chip Benjamin | cbenjamin@atmos-technologies.com

Wenjun Liu | wliu@atmos-technologies.com

www.atmos -technologies.com