Project: Using Nitrate Produced From Leachate To Control Landfill Odors

Funded by:

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Tarek Abichou (co-PI, FAMU-FSU COE)

FAMU-FSU Engineering

Problem statement	Proposed solution	Three tasks	Team	Timeline	Education & outreach

Hurricane debris leads to landfill odors

Panama City after Hurricane Michael

Bacteria

odor

$$SO_4^{2-} \rightarrow H_2S\uparrow$$

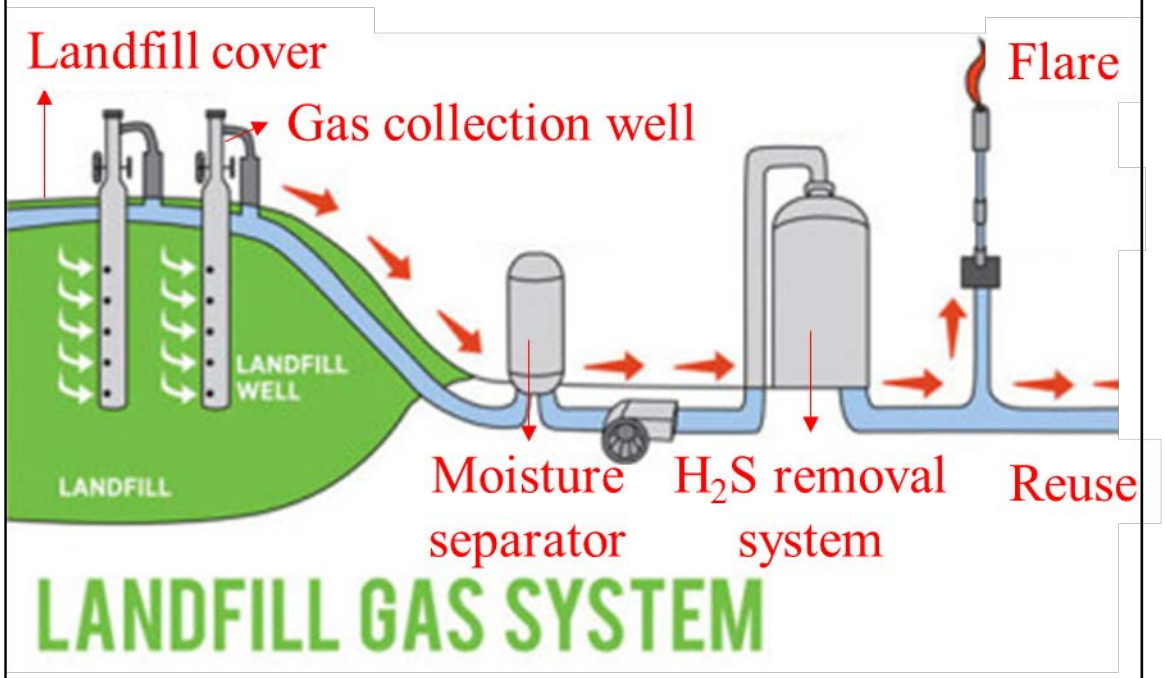
"Hurricane Michael → odors."
https://www.wjhg.com/content/news/Digging-into-the-Debris-504520821.html

"Hurricane Irma → a strong odor."
http://www.winknews.com/2017/10/08/county-wide-stench-coming-from-collier-landfill/

"Hurricane Andrew → severe odors."
http://americancityandcounty.com/mag/government_oxidation_system_stops

Existing landfill odor control methods

Collect & Treat ⟷ **Mask**

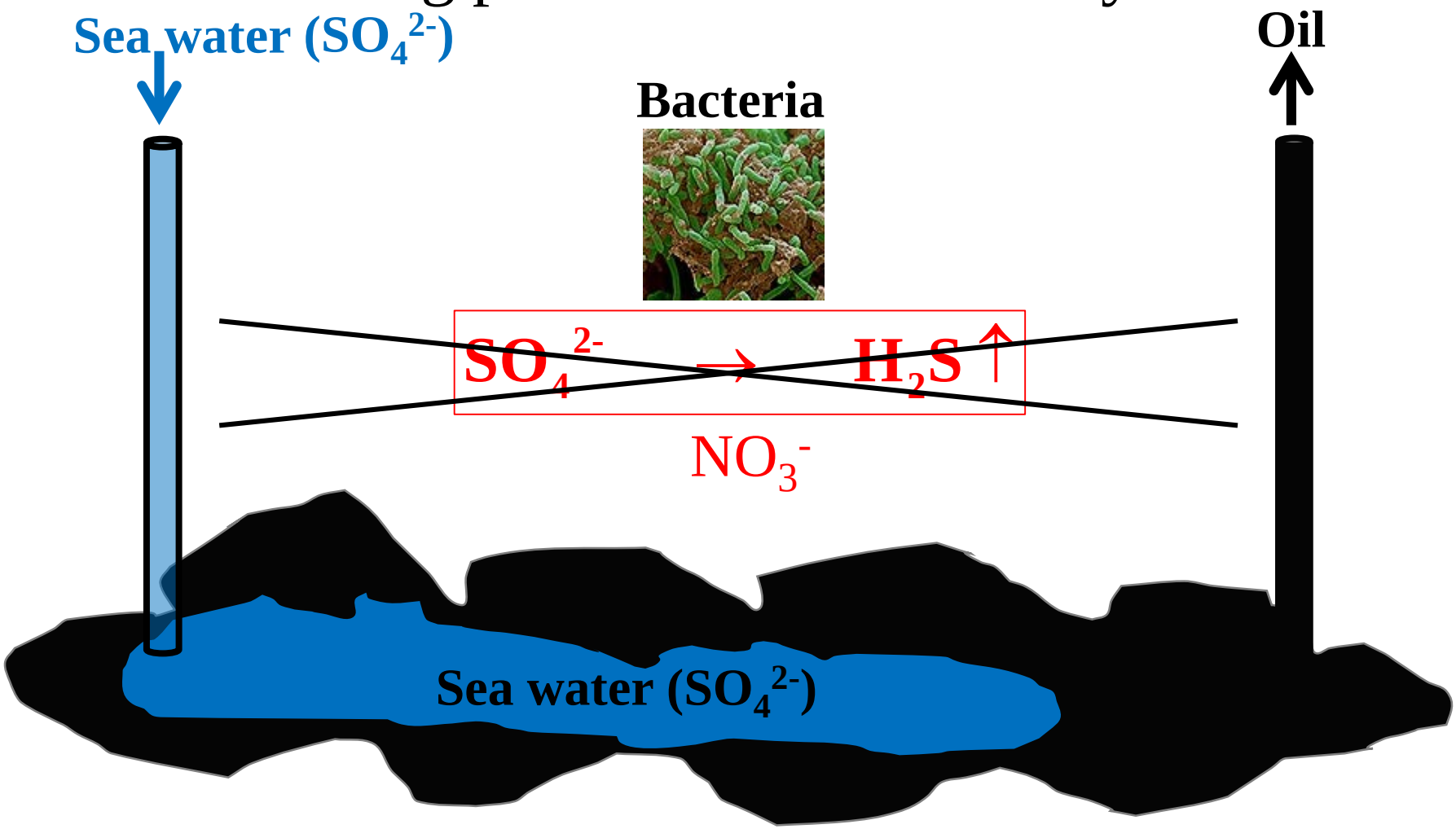


- 50-85% recovery efficiency
- Expensive

- Do not eliminate the odor
- Expensive

Using NO_3^- to suppress H_2S production:

being practiced in oil industry



Reference: Voordouw et al. Sulfide remediation by pulsed injection of nitrate into a low temperature Canadian heavy oil reservoir. *Environmental Science & Technology*, 2009, 43(24), 9512-8.

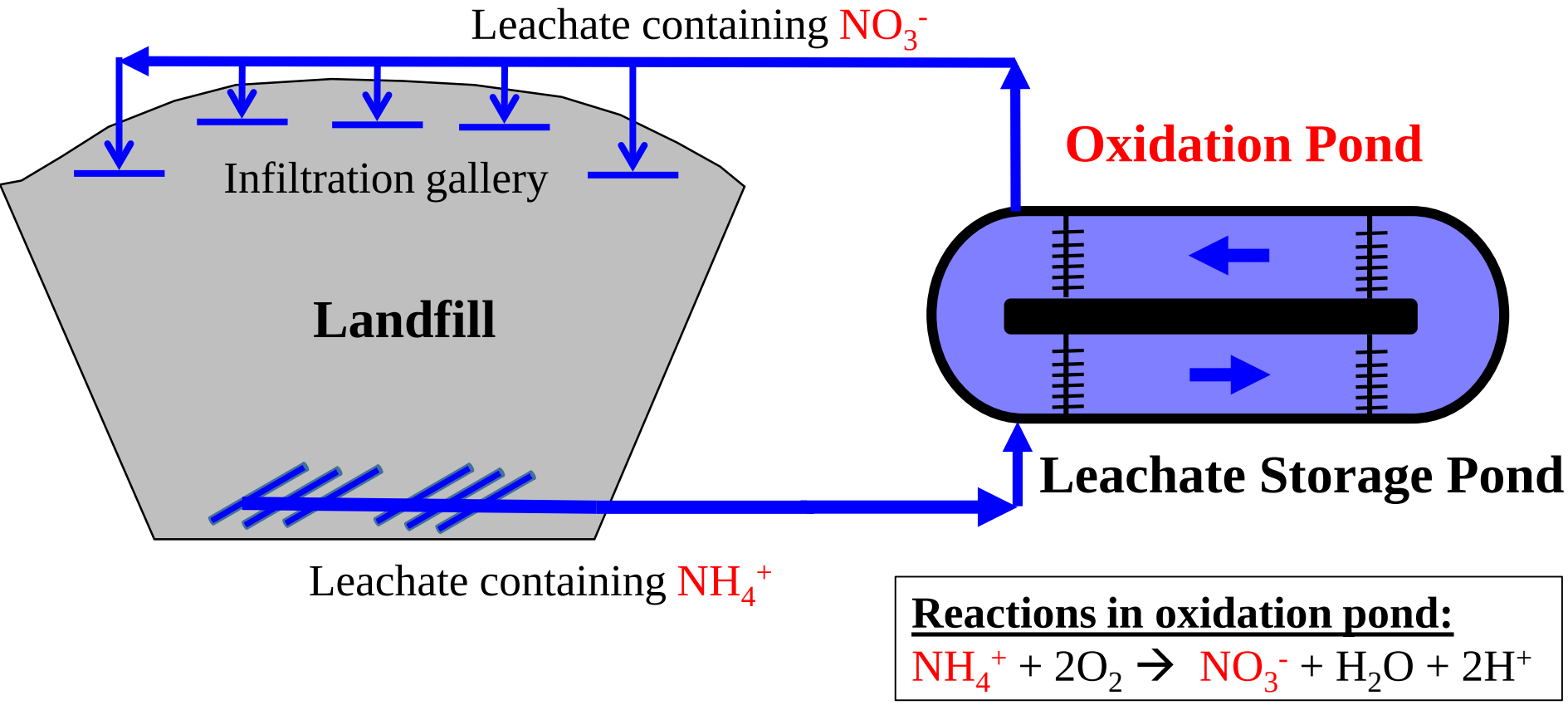
Where is nitrate from?

Bacteria

$$NH_4^+ \rightarrow NO_3^-$$

Landfill leachate: 1000 mg NH_4^+-N/L

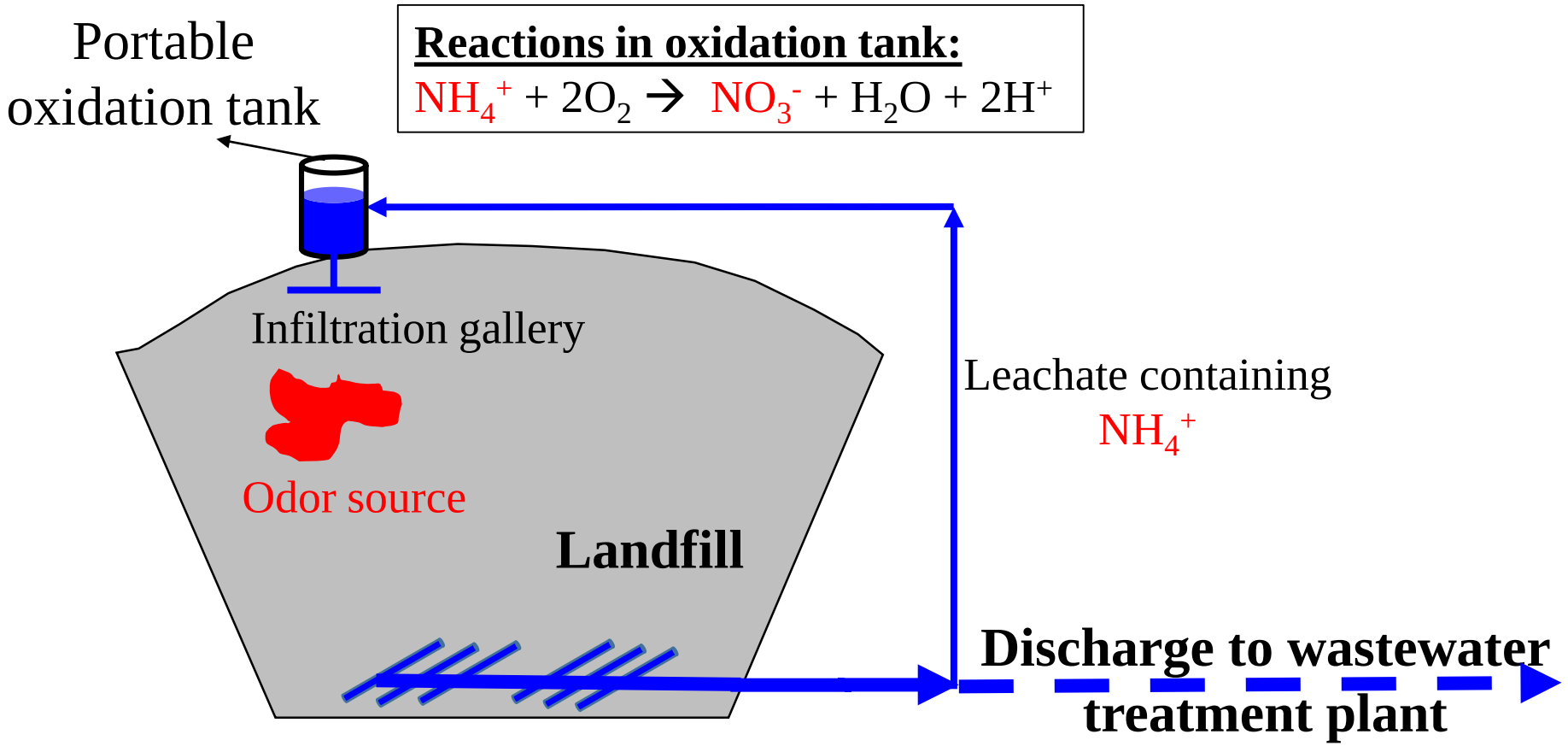
Case 1: Control odor temporally (*e.g.*, after hurricanes)



Reactions in oxidation pond:

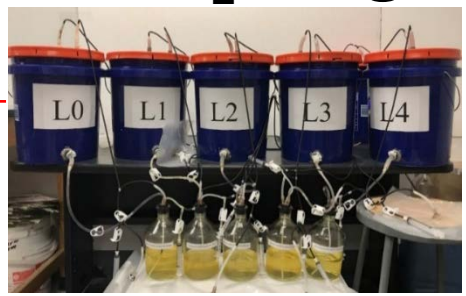
$NH_4^+ + 2O_2 \rightarrow NO_3^- + H_2O + 2H^+$

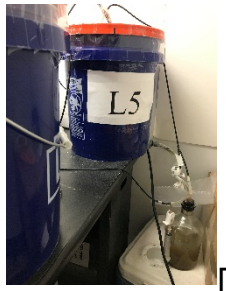
Case 2: Control odor locally (*e.g.*, one cell or one portion of a cell)

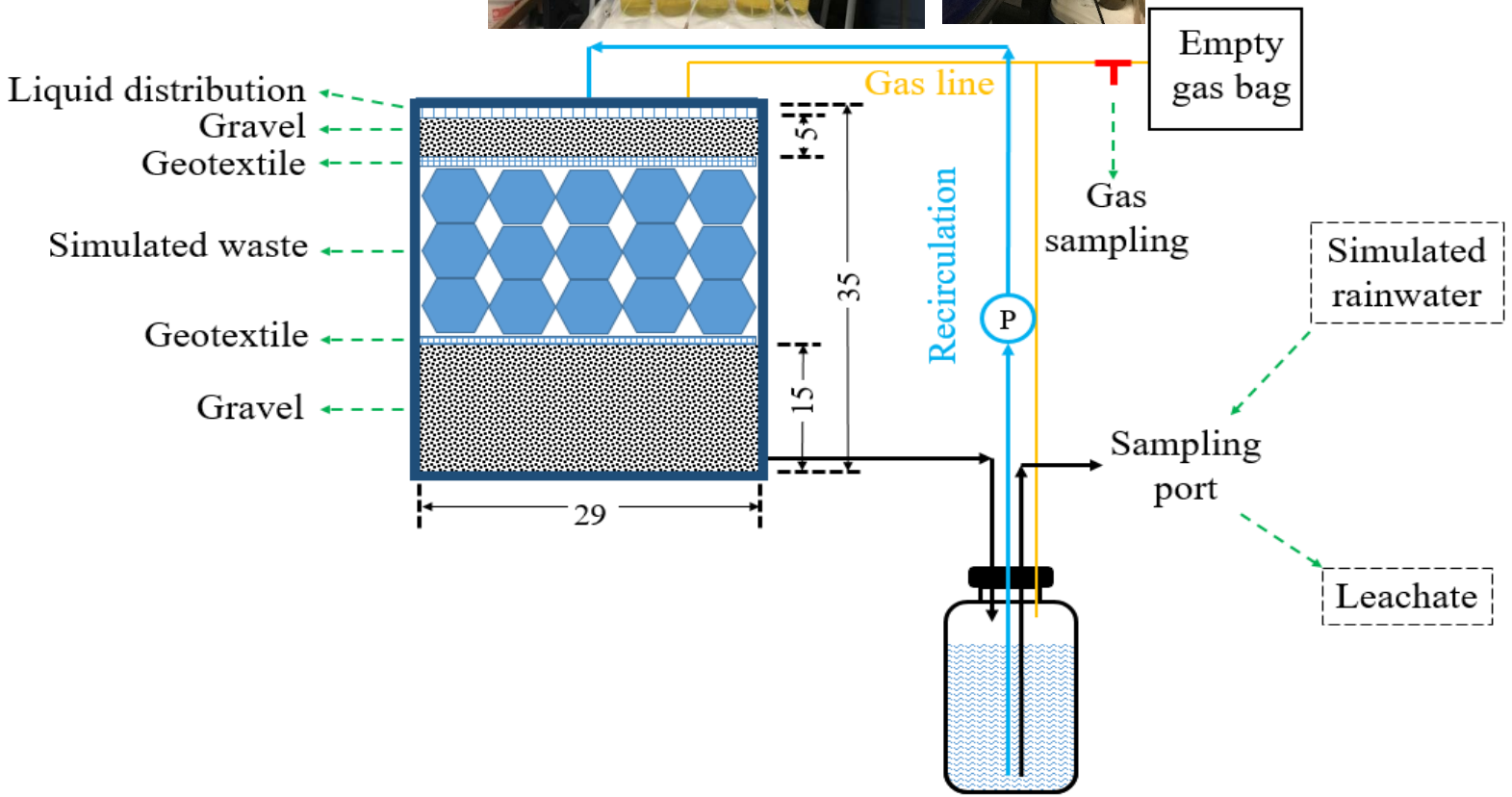


Task 1: Test six lab-scale landfills until H_2S is generated

L0 is the control





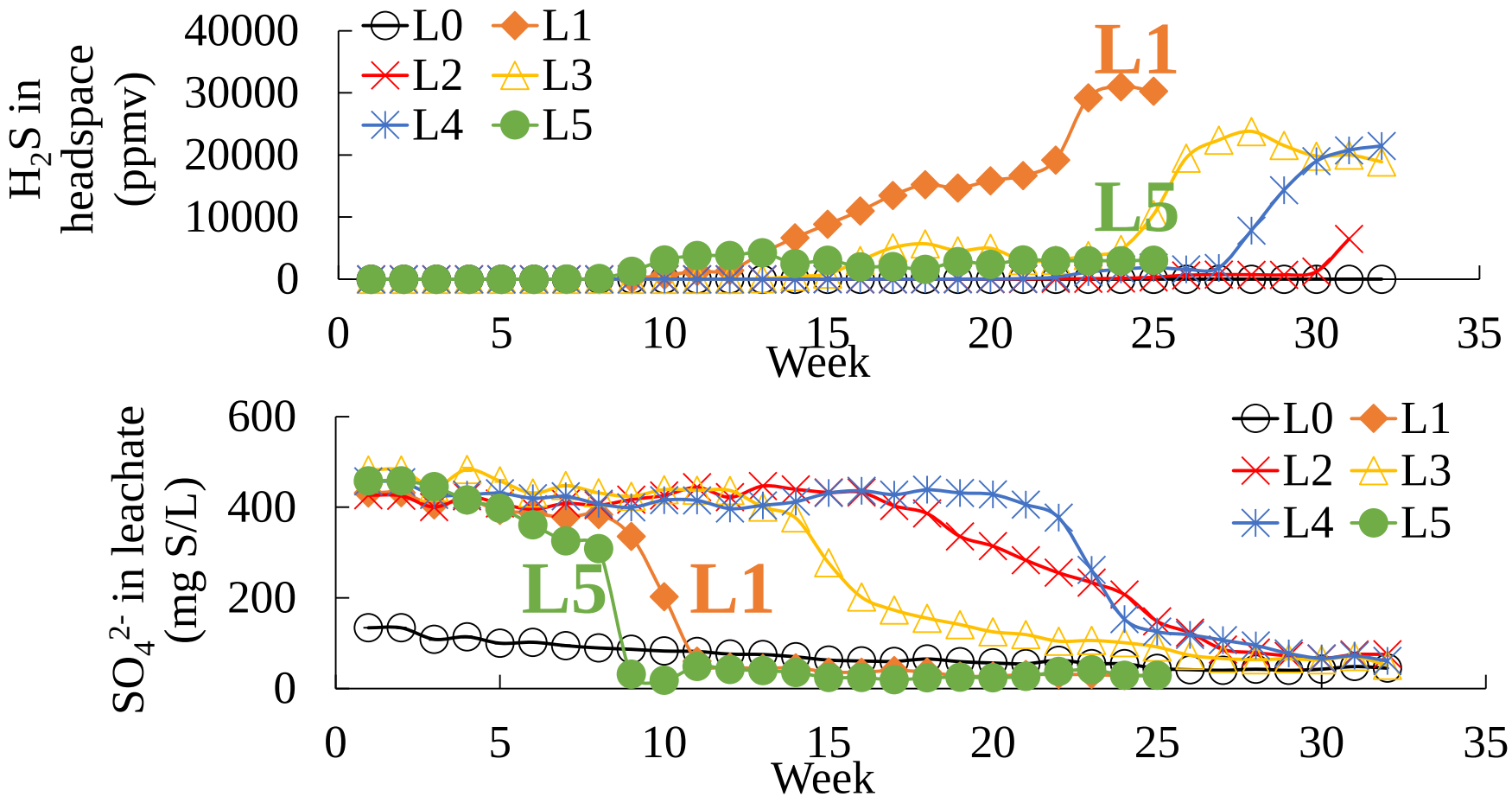


Composition of solid waste mixture

Categories	Component	Composition (wet weigh)
Drywall, major source of sulfate (10%)	Drywall	10%
Municipal solid waste, major source of organic matters (90%)	Grass	6%
	Leaves	5%
	Branches	4%
	Wood	7%
	Food	19%
	Plastic	7%
	Metal	5%
	Glass	5%
	Coated paper	2%
	Old newsprint	8%
	Corrugated containers	18%
	Office paper	4%

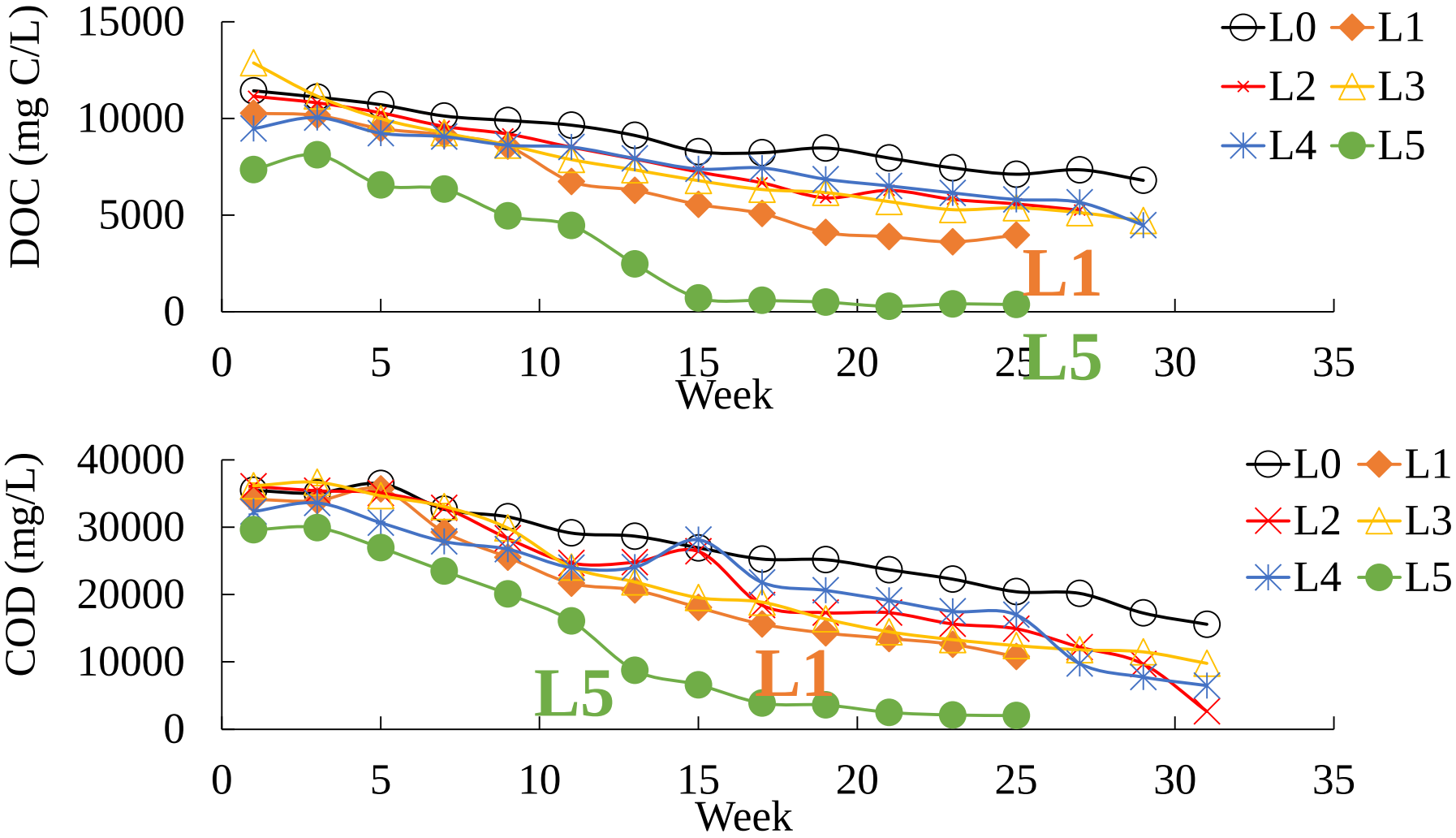
Note: Modified based on Barlaz (1998)

Sulfate (SO_4^{2-}) reduction and odor (H_2S) production



- Odor production was higher in all landfills compared to the control (L0)
- Significant SO_4^{2-} reduction in all landfills compared to the control (L0)
- L1 and L5 reached steady state and were chosen to be first tested in Task 3

Other data confirmed that L1 and L5 were most active and firstly reached steady state



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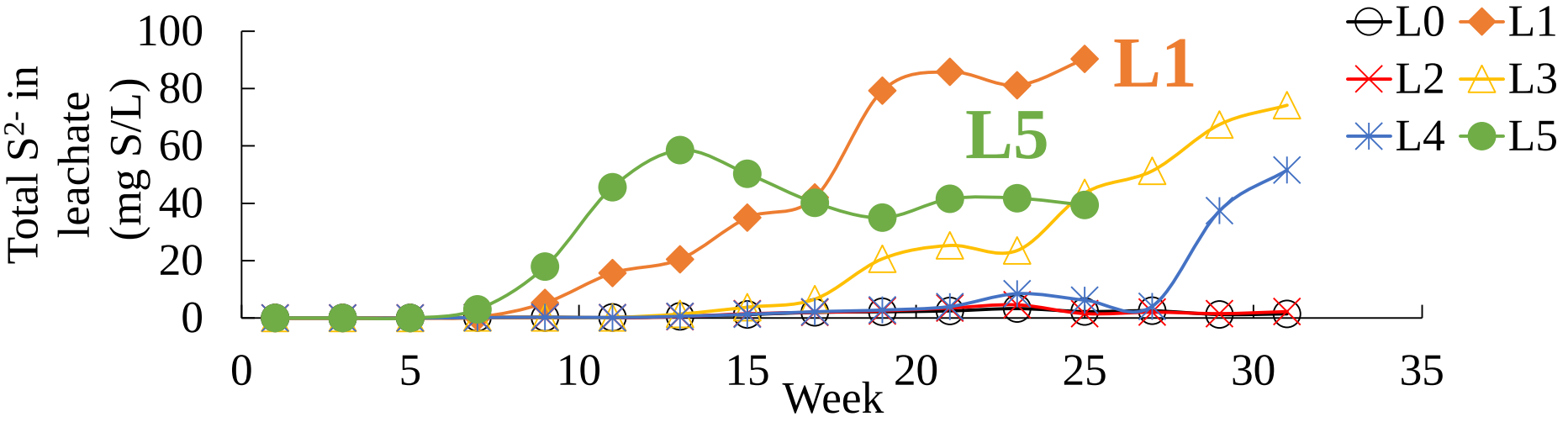

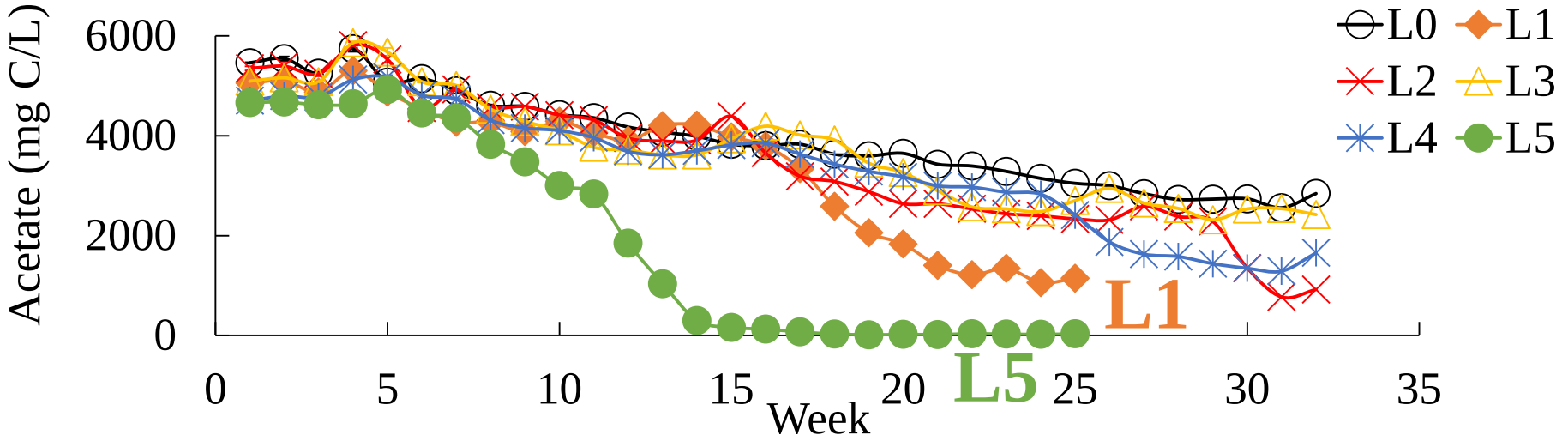

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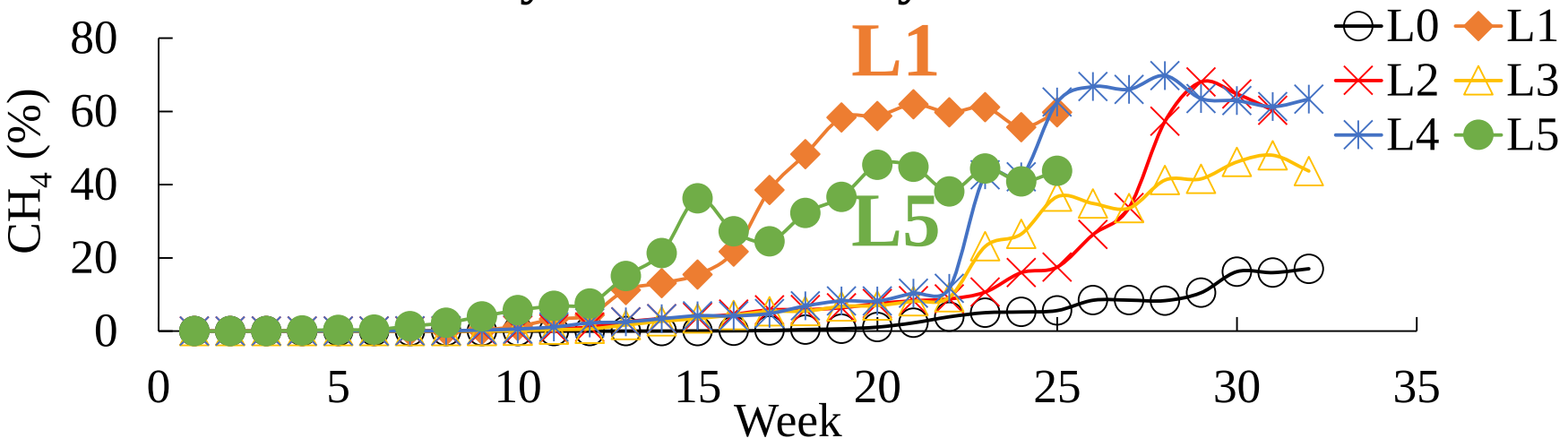
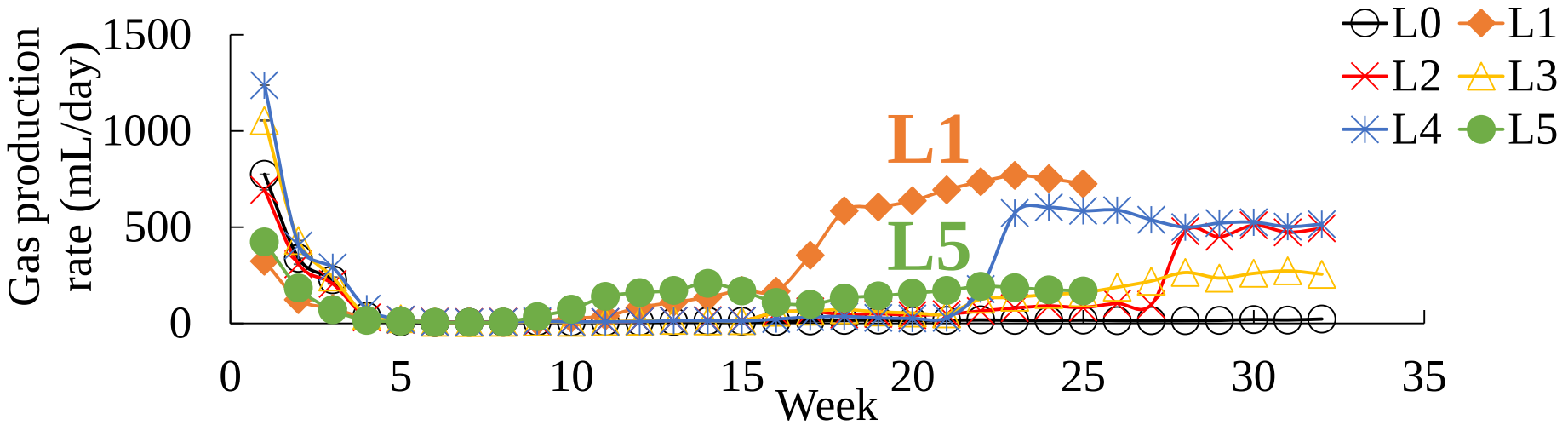


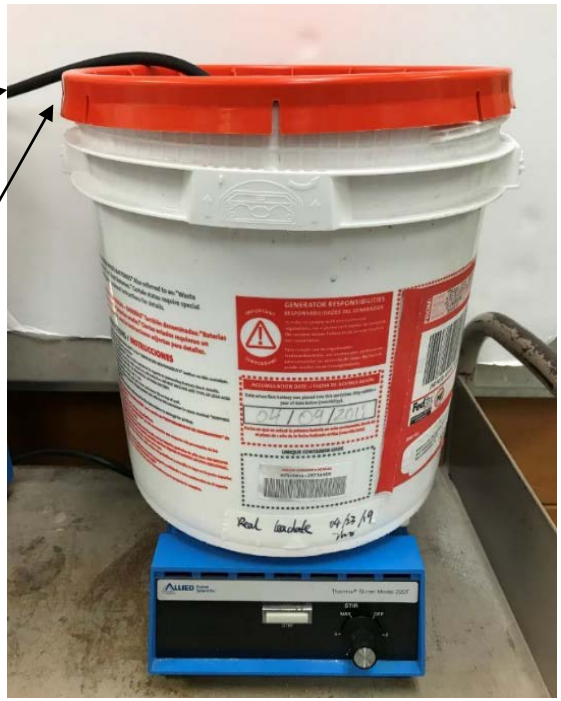


Task 2: Test two lab-scale leachate treatment reactors until ammonium is converted to nitrate

Laboratory leachate

Air supply

Real-world leachate



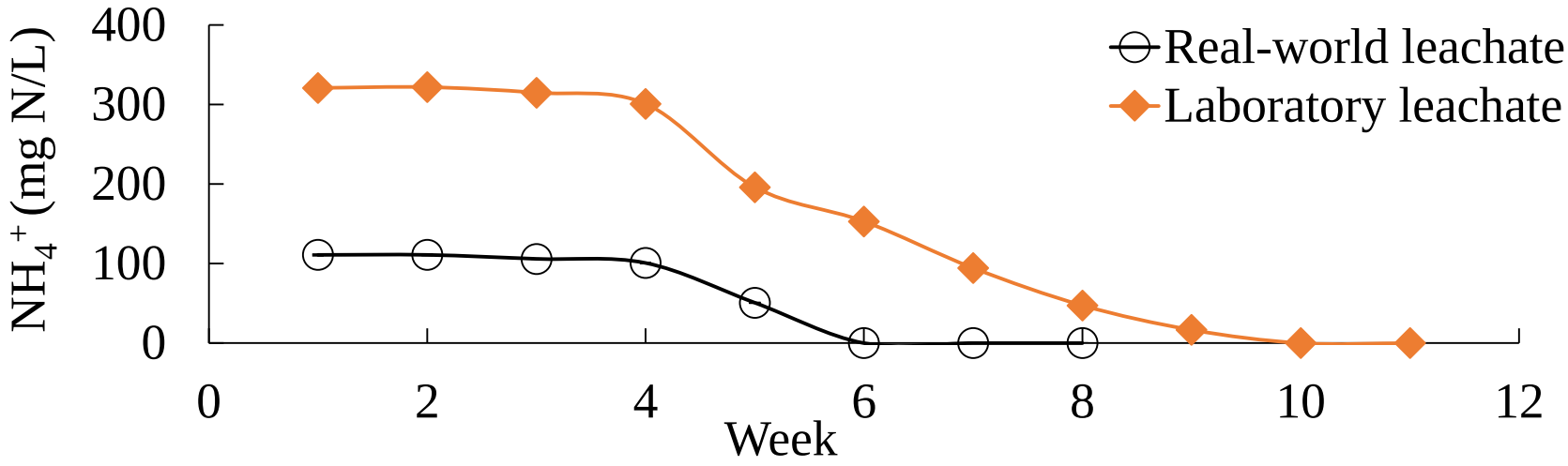
Leon County Solid Waste Management

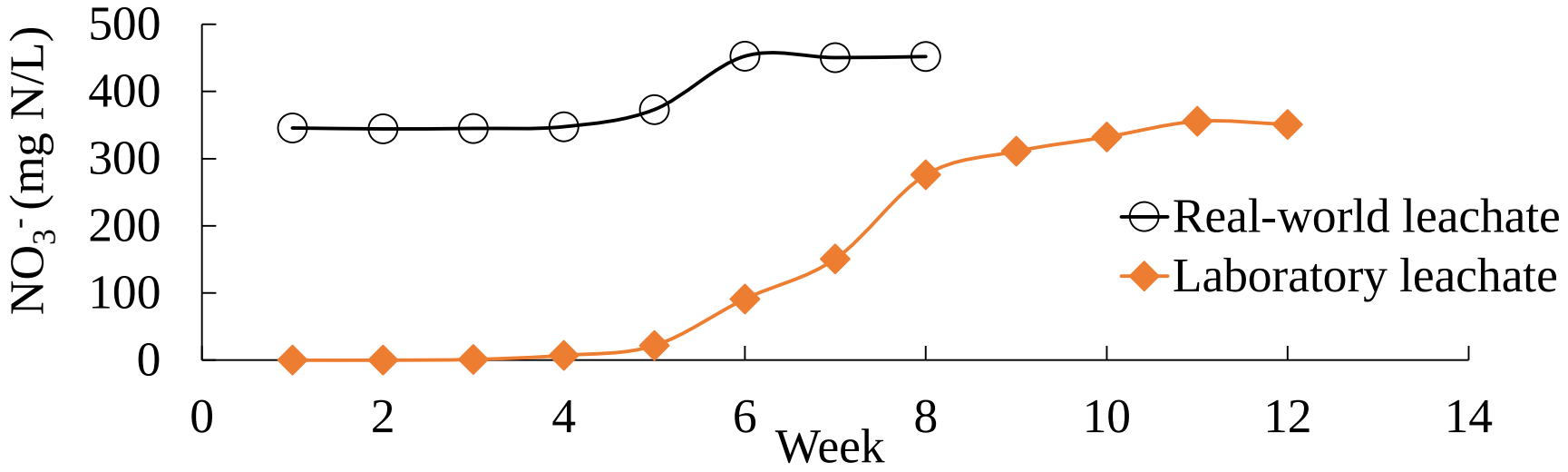
Reactions:

$NH_4^+ + 2O_2 \rightarrow NO_3^- + H_2O + 2H^+$

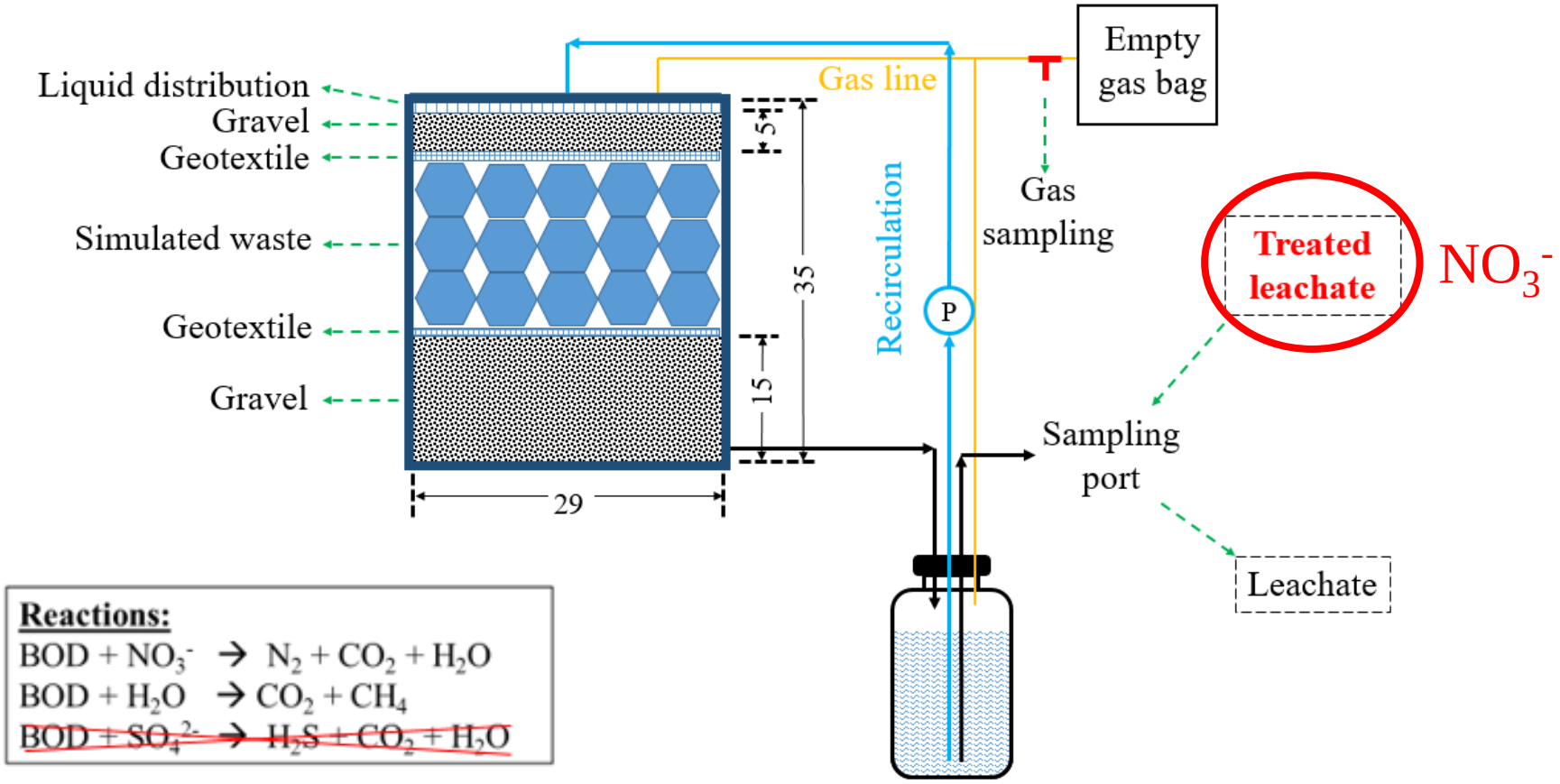
$BOD + O_2 \rightarrow CO_2 + H_2O$

Conversion of ammonium to nitrate (two types of leachate)





Task 3: Apply the nitrate-containing leachate at different doses to the H_2S-generating landfills



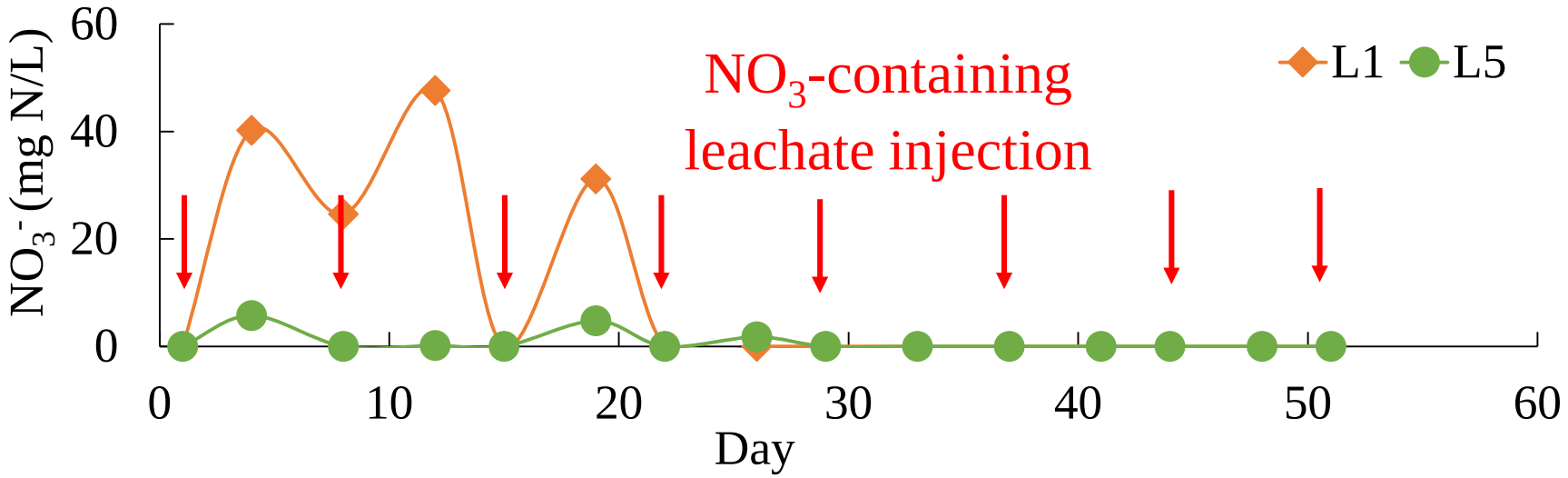
On-going research:

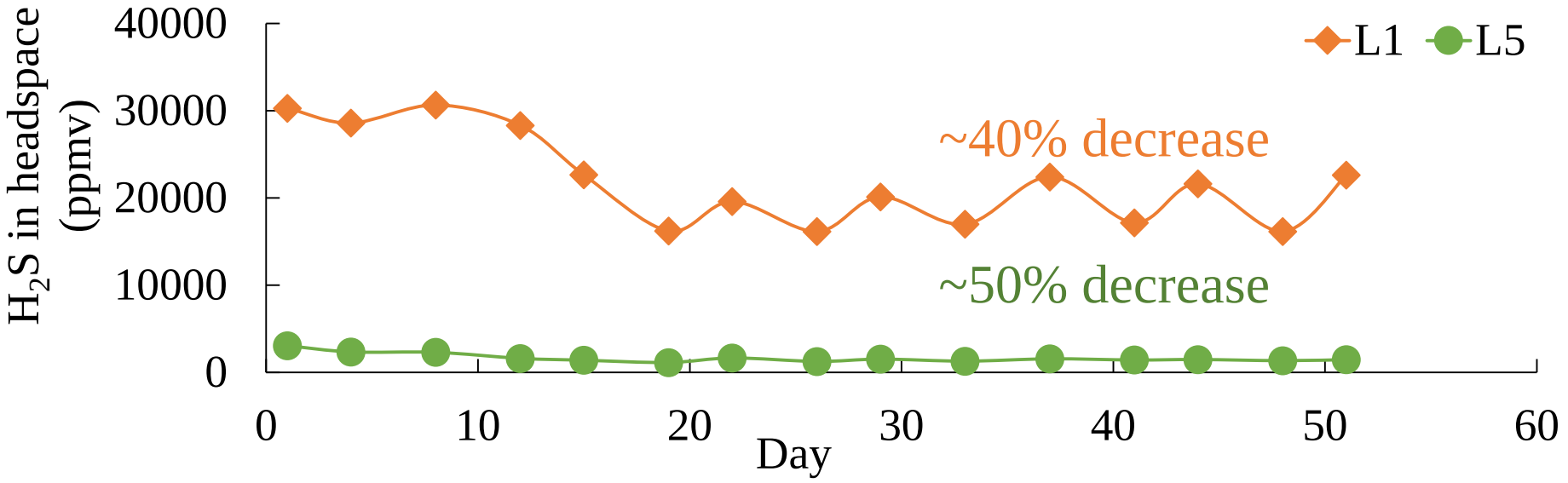
Task 3.1: Tests of L1 and L5 with pretreated real-world leachate

Future research:

Task 3.2: Tests of other landfills (L0, L2, L3, and L4) with pretreated laboratory leachate

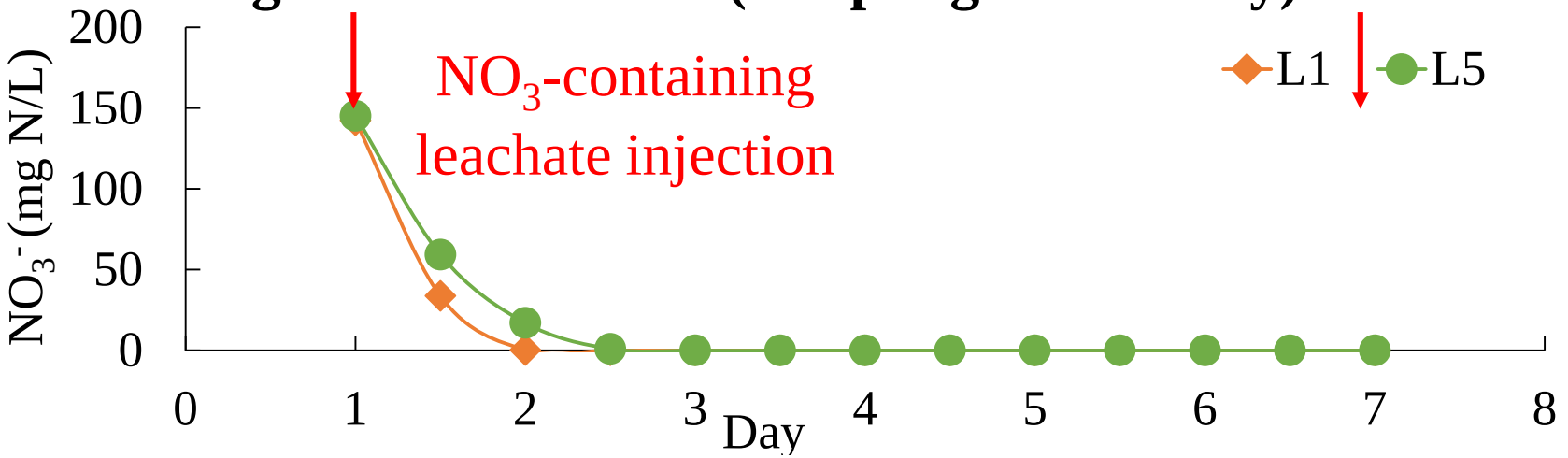
First dose: NO_3^- (mg N/L):SO_4^{2-} (mg S/L)=1:1

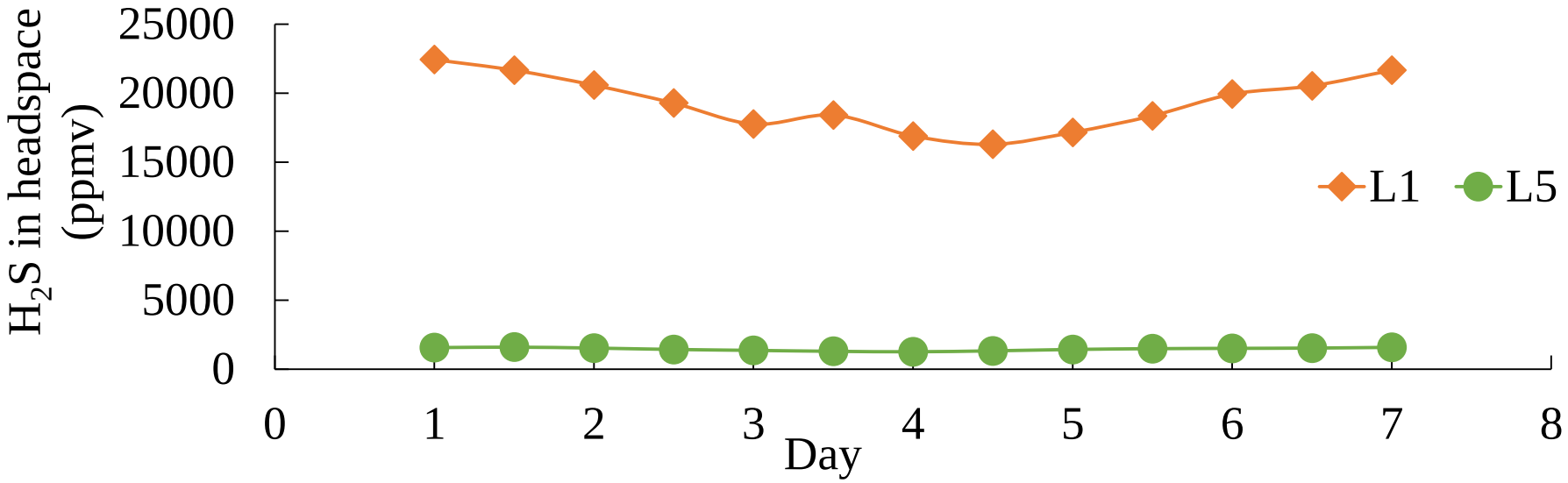




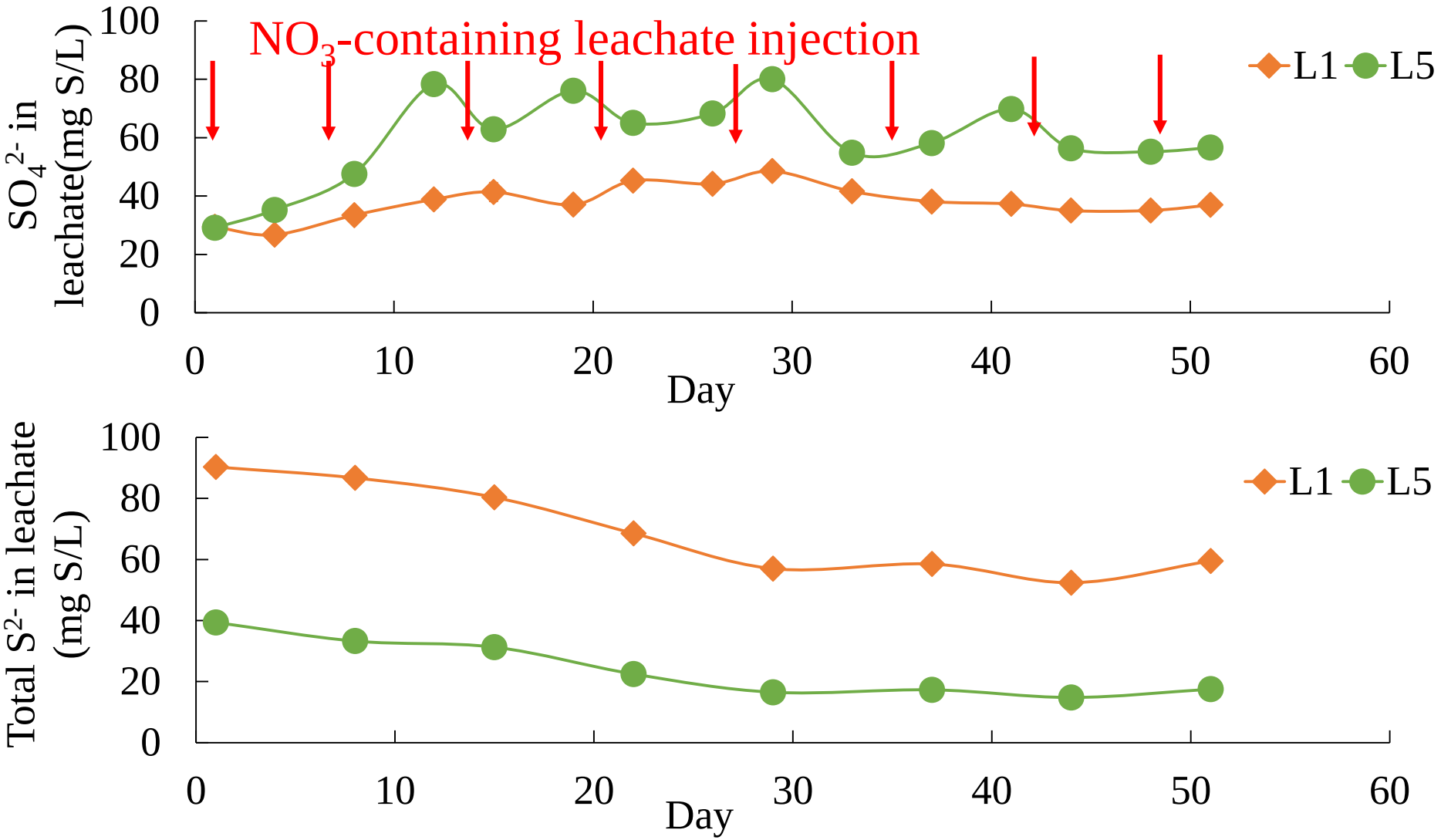
First dose: NO_3^- (mg N/L):SO_4^{2-} (mg S/L)=1:1

High resolution tests (sampling twice a day)





First dose: NO_3^- (mg N/L):SO_4^{2-} (mg S/L)=1:1



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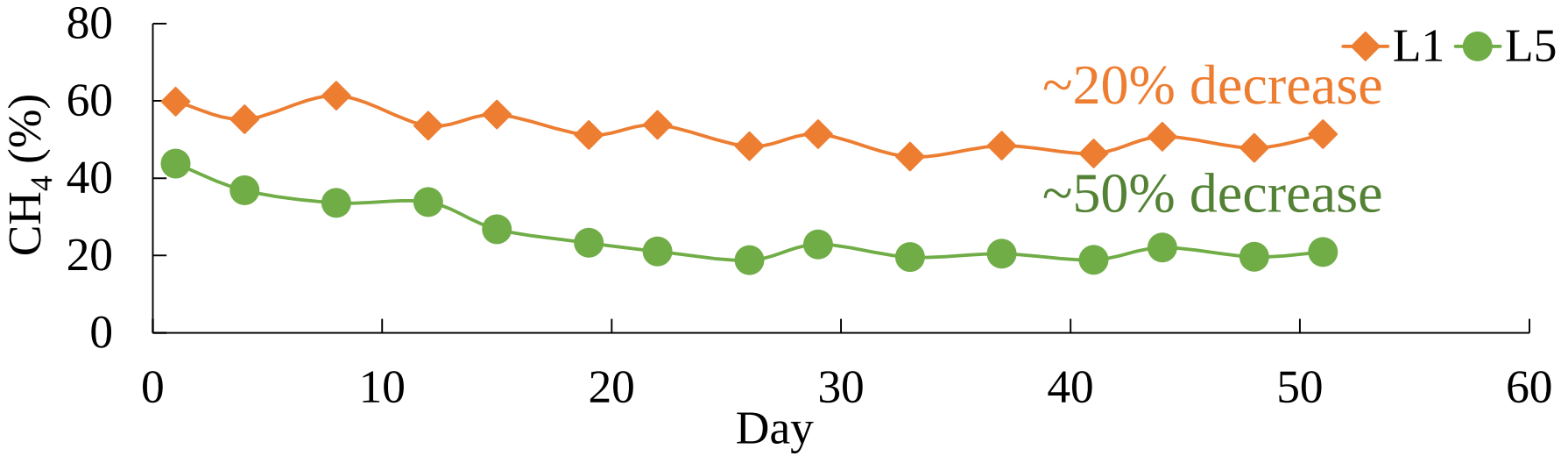
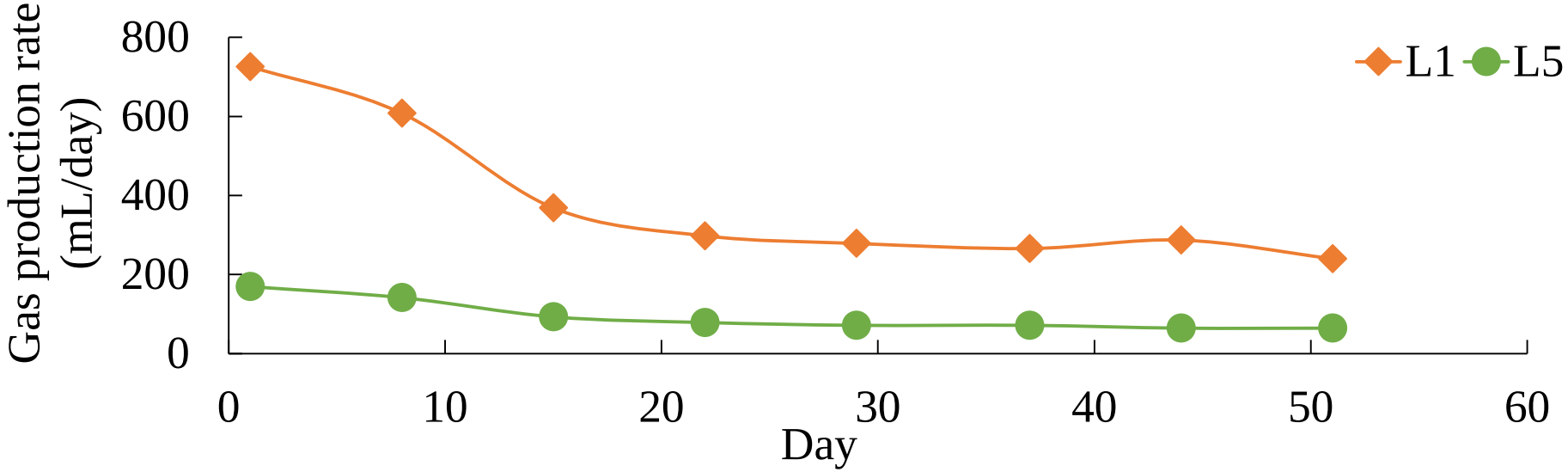




Future plan for Task 3 (dosage test)

Task 3.1			Task 3.2		
Landfills	Leachate	Dosage (N:S)	**Landfills**	Leachate	Dosage (N:S)
L1, L5	Real-world	1:1	**L0, L2, L3, L4**	Laboratory	1:1
		5:1			5:1

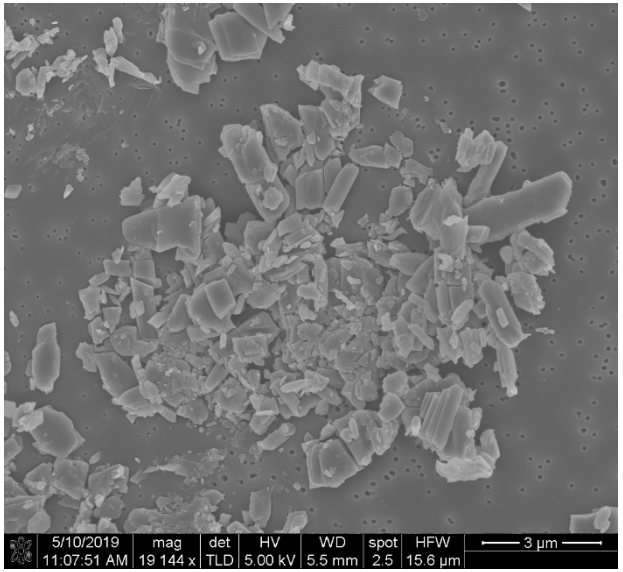
Green: completed

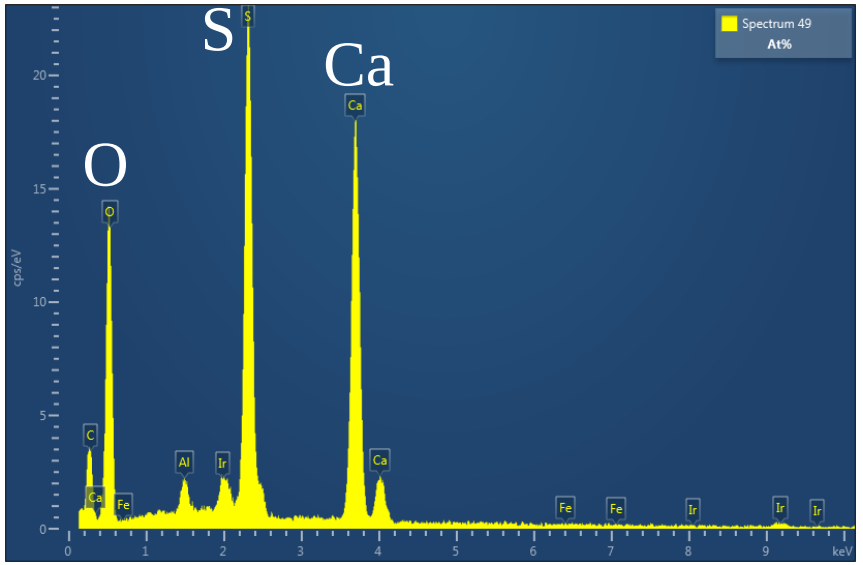
Orange: on-going

Red: future work

Future plan for Task 3 (dosage test)

Before experiment





After experiment

?

?

Conclusions

- **Task 1, Task 2 and half of Task 3** have been completed.
  - **Task 1**: The combination of municipal solid waste and drywall debris leads to the generation of hydrogen sulfide (up to 30,000 ppmv).
  - **Task 2**: Biological conversion of ammonium to nitrate in leachate could be achieved in a simple oxidation tank.
  - **Task 3**: At a nitrate (N) dose of N:S = 1:1, the odor production decreased by 40-50%.

Benefits to end users

- Might be considered by landfill managers to control landfill odors temporally or locally.
  - **Effective**: >40-50%.
  - **Inexpensive**: nitrate from on-site leachate
  - **Sustainable**: leachate reuse.
  - **Environmentally friendly**: no harmful products

PI
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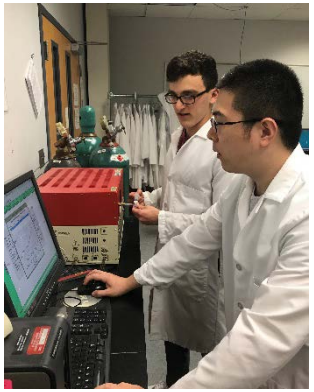
FAMU-FSU COE)

Co-PI
(Dr. Tarek Abichou,
FAMU-FSU COE)

Graduate student
(Zhiming Zhang)

Undergraduate student
(Karam Eeso)



Green: completed
Red: on-going

Project timeline, milestones, and deliverables

Project Duration	09/01/2018 – 08/31/2019											
Tasks **Month**	1	2	3	4	5	6	7	8	9	10	11	12
Task 1: Landfill tests	X	X	X	X	X	X	X	X				
Task 2: Leachate treatment tests								X	X	X		
Task 3: Landfill + leachate tests										X	X	X
Deliverables												
Abstract submission	X											
Project website development	X											
TAG-1: Technical Awareness Group Meeting 1		X										
TAG-2: Technical Awareness Group Meeting 2											X	
Quarterly reports (#)			#			#			#			
Draft final report (†), final report (*), journal papers and conference presentations (+)											†	*+

Problem statement	Proposed solution	Three tasks	Team	Timeline	Education & outreach

- **High school research & education**

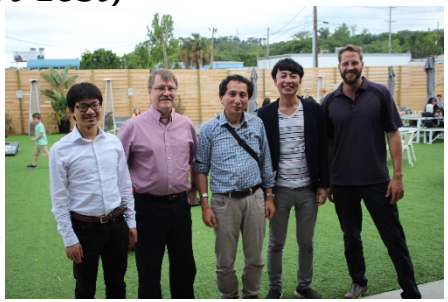
Adams, N.; Acosta, J.; Eeso, K., Zhang, Z.; Tang, Y. Characterization of lab-scale landfill leachate. *Program of Excellence in STEM*, Florida A&M University, Tallahassee, FL, Jun. 2019.

- **New collaboration and projects** *(Biogas Harvester Pilot Test)*

THE Water Research FOUNDATION

Brown AND Caldwell

MIAMI-DADE COUNTY Water & Sewer Department



- **Developed a project website**

https://ww2.eng.famu.fsu.edu/~ytang/project9.html

Acknowledgement

Staff
(John Schert, Wester Henderson III)

Proposal Selection Committee

D.J. Newsome, Leon County Solid Waste Management

Joseph Cheatham, Thomas P. Smith Water Reclamation Facility

Liang Li, Florida Department of Environmental Protection

Runwei Li, Florida State University

Comfort Adedeji, Florida State University

Technical Advisory Group

Technical awareness group (TAG)

Name	Affiliation
Ashvini Chauhan	Florida A&M University
Chao Zhou	Geosyntec Consultants
Dawn Templin	Florida Department of Environmental Protection (FDEP)
Dean Chaaban	Thomas P. Smith Water Reclamation Facility
Edward A. Bettinger	Florida Department of Health
Joseph B. Cheatham	Thomas P. Smith Water Reclamation Facility
Joseph Dertien	(FDEP)
John Schert	Bill Hinkley Center for Solid and Hazardous Waste Management
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