QUARTERLY PROGRESS REPORT

[October 1, 2022 – December 31, 2022]

PROJECT TITLE: Fate of PFAS and Other Contaminants During Leachate Evaporation

PRINCIPAL INVESTIGATOR:

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PROJECT WEBSITE:

https://web1.eng.famu.fsu.edu/~ytang/leachate_evaporation.html

Project summary: As more wastewater treatment plants reduce or cease acceptance of landfill leachate, more solid waste facilities have been moving to implementation of leachate evaporation using heat from the combustion of landfill gas and/or heat from the exhaust of landfill gas-to-energy generators. Residuals (*i.e.*, leachate concentrate) from this process are dried and then returned to the landfill. The objective of this project is to answer the following questions:

1) What happens to per- and polyfluoroalkyl substances (PFAS) and other contaminants when the leachate is evaporated? Do they concentrate within the residue? Are they emitted into the atmosphere?
2) What affects the distribution coefficient of PFAS (= PFAS in gas emission due to evaporation/PFAS in leachate residue after evaporation)?
3) What are the effects of the reintroduction of the concentrated leachate residuals into the landfill on the chemical concentration of future leachate?

The project, if successful, will provide information to landfill managers who plan to move from the discharge-to-sewer method to the leachate evaporation method.

Work Accomplished during this Reporting Period:

We started the project in late November, 2022. The project has three tasks. We have completed ~15% of Task 1. The completed work in Task 1 is further described below:

<u>Task 1: Effects of leachate evaporation on the fate of PFAS and contaminants regulated by 40 CFR 445.11</u>

We purchased a lab-scale evaporator and took leachate samples from three municipal solid waste (MSW) landfills in Florida. Key to successful completion of this task is being able to measure various contaminants that are summarized in Table 1. In this reporting period, we focused on using gas chromatography–mass spectrometry (GC-MS) to measure some contaminants regulated by 40 CFR 445.11. The 14 contaminants regulated by 40 CFR 445.11 include five-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), ammonia, α-terpineol, aniline, benzoic acid, naphthalene, p-cresol, phenol, pyridine, arsenic, chromium, zinc, and pH. We have determined the electron impact spectra (Figure 1) and the retention times (Table 2) of five contaminants regulated by 40 CRF 445.11, including α-terpineol, aniline, naphthalene, p-cresol, and phenol.

Table 1. Leachate characterization methods

Parameters	Methods	Equipment	References
Metals (arsenic, chromium, zinc)	EPA method 3050B	Microwave plasma-Atomic emission system (4100 MP-AES, Agilent Technology)	U.S. EPA[1], 1996
α-terpineol, aniline, benzoic acid, naphthalene, p-cresol, phenol, pyridine, Volatile PFAS	Mass spectrometry method	Gas chromatography mass spectrometry (GC-MS)	Simões et al., 2007
Biological oxygen demand (BOD_5)	5210 B Method	Bottles with a ground-glass stopper	APHA 2005
pH	Electrometric method	Multi-parameter meter (HQ440D, Hach)	Rice et al., 2012
Conductivity	Electrometric method	Multi-parameter meter (HQ440D Hach)	Rice et al., 2012
Total suspended solids (TSS)	Standard methods 2540 D	Filters and drying oven	Nasrabadi et al., 2016
Ammonia	Ion-specific electrode method	HQ440D (Hach)	Rice et al., 2012
Less-volatile PFAS	USEPA method (537 modified)	Liquid chromatography with mass spectrometry in tandem	USEPA 2020

Note:
[1] USEPA = United States Environmental Protection Agency

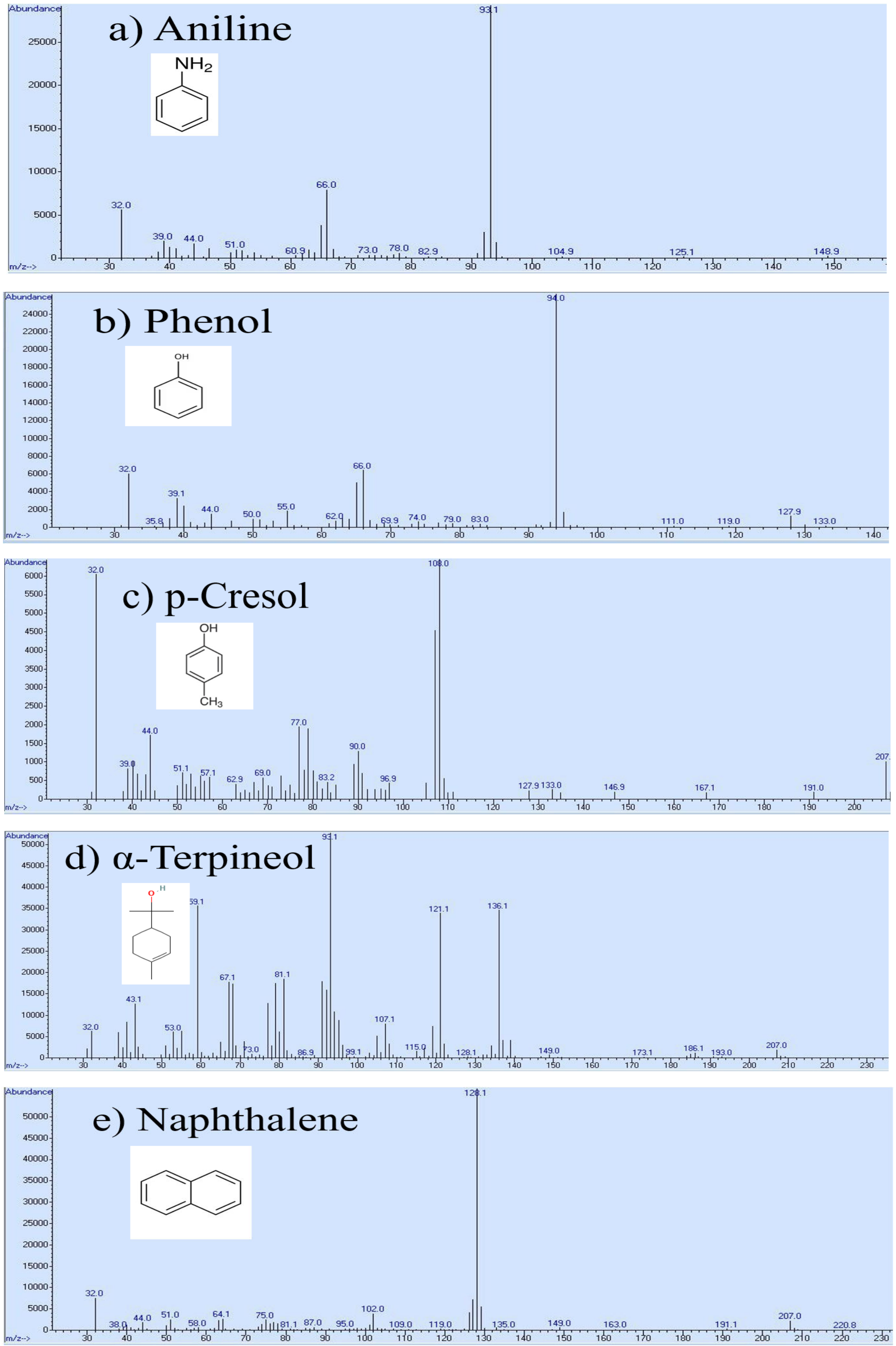

Figure 1. Electron impact spectra of a) Aniline, b) Phenol, c) p-Cresol, d) α-Terpineol, e) Naphthalene when measured by GC-MS

Table 2. Selected mass to charge ratios and retention times for five contaminated regulated by 40 CFR 445.11 when measured by GC-MS

Compounds	Selected mass to charge ratio	Retention time (min)
Aniline	93, 66, 65	19-20
Phenol	94, 66, 65	20-21
p-Cresol	108, 107, 77	21-22
α-terpineol	93, 121, 136	23-24
Naphthalene	128, 127, 129	23-24

Based on Figure 1 and Table 2, we detected aniline and α-terpineol in the first landfill leachate sample. Figure 3 shows the extracted ion chromatograms of Leachate #1.

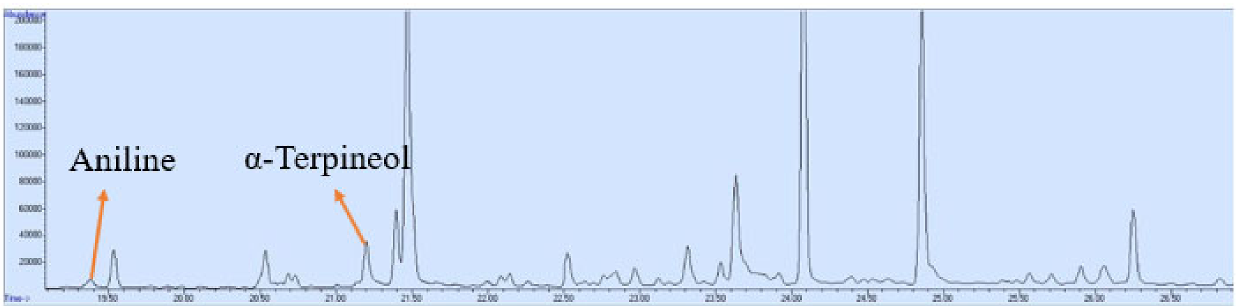

Figure 3. Extracted ion chromatograms of Leachate #1

__Task #2: Distribution coefficients of PFAS__

Progress to be reported in the next quarterly report.

__Task #3: Effects of reintroduction of the concentrated leachate residuals on the fate of PFAS and other contaminants__

Progress to be reported in the next quarterly report.

References:

American Public Health Association. "APHA standard methods for the examination of water and wastewater." *Standard methods for the examination of water & wastewater. Washington, DC: American Public Health Association* (2005).

Nasrabadi, T., Ruegner, H., Sirdari, Z. Z., Schwientek, M., & Grathwohl, P. (2016). Using total suspended solids (TSS) and turbidity as proxies for evaluation of metal transport in river water. *Applied Geochemistry*, *68*, 1-9.

Qiu, Y., Frear, C., Chen, S., Ndegwa, P., Harrison, J., Yao, Y., & Ma, J. (2020). Accumulation of long-chain fatty acids from Nannochloropsis salina enhanced by breaking microalgae cell wall under alkaline digestion. *Renewable energy*, *149*, 691-700.

Rice, E.W., Baird, R.B., Eaton, A.D. and Clesceri, L.S., 2012. Standard Methods for the Examination of Water and Wastewater, 22nd Edition. American Public Health Association, American Water Works Association, Water Environment Federation.

Simões, N. G., Cardoso, V. V., Ferreira, E., Benoliel, M. J., & Almeida, C. M. (2007). Experimental and statistical validation of SPME-GC–MS analysis of phenol and chlorophenols in raw and treated water. *Chemosphere*, *68*(3), 501-510.

U.S. Environmental Protection Agency (USEPA) (2020).Method 537.1—Determination of select per-and polyfluorinated alkyl substances indrinking water by solid phase extraction and liquid chromatography/tandem mass spectrometry (LC-MS-MS).

U.S. Environmental Protection Agency, 1996. Method 3050B: Acid digestion of sediments, sludges, and soils. https://www.epa.gov/sites/production/files/2015-06/documents/epa-3050b.pdf.

van Zomeren, A. and Comans, R.N., 2007. Measurement of humic and fulvic acid concentrations and dissolution properties by a rapid batch procedure. Environmental Science & Technology, 41(19), 6755-6761.

Metrics:

1. List research publications resulting from THIS Hinkley Center project.

None in this reporting period.

2. List research presentations resulting from (or about) THIS Hinkley Center project.

None in this reporting period.

3. List who has referenced or cited your publications from this project.

None in this reporting period.

4. How have the research results from THIS Hinkley Center project been leveraged to secure additional research funding? What additional sources of funding are you seeking or have you sought?

None in this reporting period.

5. What new collaborations were initiated based on THIS Hinkley Center project?

None in this reporting period.

6. How have the results from THIS Hinkley Center funded project been used (not will be used) by the FDEP or other stakeholders?

None in this reporting period.

Pictures:

- A new gas chromatography–mass spectrometry system was recently installed in the lab.