Evaluating the Performance of Anaerobic Digestion for PFOA Treatment

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Introduction

Per-and Polyfluoroalkyl Substances (PFAS), also known as forever chemicals, are very persistent pollutants widely used in consumer products that are causing significant damage to the environment and human health. PFOA (Perfluorooctanoic acid) is one of the multiple chemicals that are part of the PFAS group. These relentless contaminants are often found in wastewater and remain untreated in conventional methods (aerobic treatment). Anaerobic digestion is a treatment technology that uses microbes in the absence of oxygen to remove conventional contaminants and contaminants of emerging concern such as PFOA. Anaerobic digestion is more of a sustainable and biodegradable method to clean wastewater. Not only can anaerobic digestion reduce PFAS in wastewater but it possesses an opportunity to discover novel organisms capable of digesting PFAS.

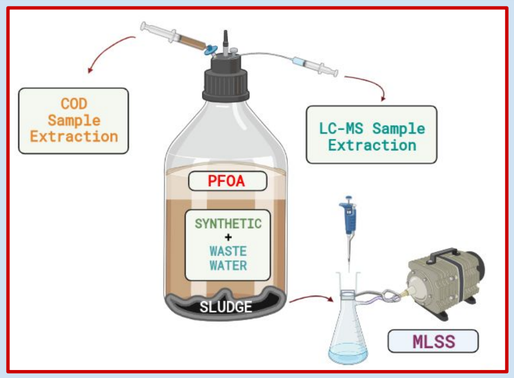
Objectives & Methods

Objectives

- To evaluate Anaerobic Digestion as a treatment method for wastewater and PFOA, a legacy PFAS compound.
- To evaluate the effect of different PFOA concentrations in anaerobic digestion reactor performance.

Methods

- **MLSS:** Mixed Liquor Suspended Solids measures the total amount of processed and unprocessed nutrients.
- **COD test:** Carbon Oxygen Demand measures the total amount of unprocessed nutrients.
- **LC-MS:** Liquid Chromatography Mass Spectrometry measures ions by their mass to change the ratio and a way to separate, filter, and detect molecules. We used it to measure PFOA concentration.



Results

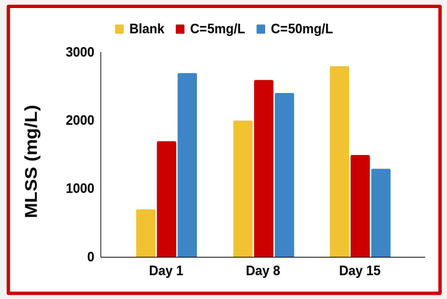


Figure 1. MLSS for blank & PFOA inoculated reactors.

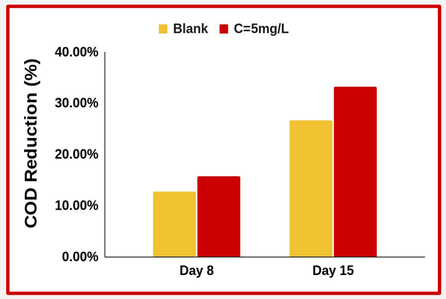


Figure 2. COD reduction for blank and PFOA inoculated reactor at 5 mg/L.

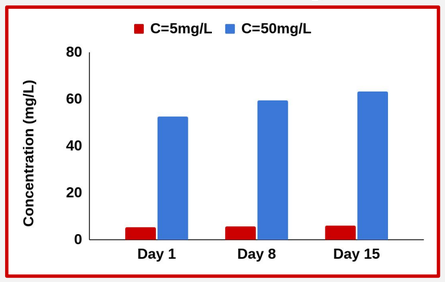


Figure 3. PFOA concentration over time.

Photo 1. Reactor 1 of a low PFOA concentration on the left and reactor 2 of a high PFOA concentration on the right.

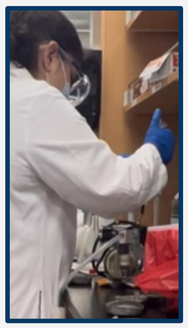


Photo 2. Demonstration of filtration and pipetting.

Discussion

As seen in figure 1, the 50 mg/L reactor showed a decrease in MLSS, likely due to the toxicity of PFOA to some bacteria at that concentration. On the other hand, 5 mg/L concentration showed a slight increase followed by a decrease, implying that at a smaller concentration PFOA was less toxic.

As seen in figure 2, COD results showed a reduction of available energy for the microbes over time in the blank and in the 5 mg/L reactor. While measurements were taken for the 50 mg/L reactor, we got inconclusive results. We speculate that the high PFOA concentration inhibited the signal, likely from PFOA reacting with potassium dichromate (the main reagent used in the test). This is of particular interest since potassium dichromate could be oxidizing PFOA, which has important implications for the development of other methods to measure PFAS.

PFOA concentrations increased slightly in both reactors over time (see figure 3). This could have been caused by other PFAS compounds available in the inoculum that could have degraded into PFOA.

Conclusions

Anaerobic digestion of wastewater was demonstrated for the treatment of PFOA. PFOA at 5 mg/L did not inhibit biological activity. It actually showed a higher reduction of COD compared to the blank.

COD at 50 mg/L yielded inconclusive results, likely from interactions of PFOA with the COD reagent potassium dichromate which requires further research. PFOA accumulated in all tested concentrations, likely from trace amounts of PFOA in the inoculum and as a by-product of other PFAS in the inoculum.

Next Steps and Advice for Future SHINE Students

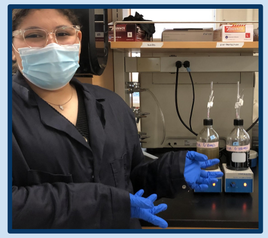
My Future Plans:
I am still unsure if I will continue my STEM journey or what specific field interests me, but learning about the environmental engineering field, taught me that I definitely want to focus my future plans within that field.

Advice for Future SHINE Students:

- Take notes & keep reviewing them.
- Ask questions. Not only to your mentors, but your peers as well.
- Network, hear and learn from other's and especially find people that come from the same background as you.

Skills Learned

Growth Mindset: I started my SHINE experience in a type of lab I did not expect, but quickly learned how to adapt in a wet lab.
Mind Maps: These were extremely useful for me to understand the lab work I was doing, but in a simpler way.
Note Taking: Understanding that I will not always write down everything in the moment, but giving myself time to go back, review, and rewrite my notes.



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Citations

Huang, S., & Jaffé, P. R. (2019). Defluorination of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) by Acidimicrobium sp. strain A6. *Environmental science & technology*, *53*(19), 11410-11419.