

ESRP: Not So “Forever” Chemicals: A Study on Removing PFAs From Contaminated Water Through Various Filtration Materials

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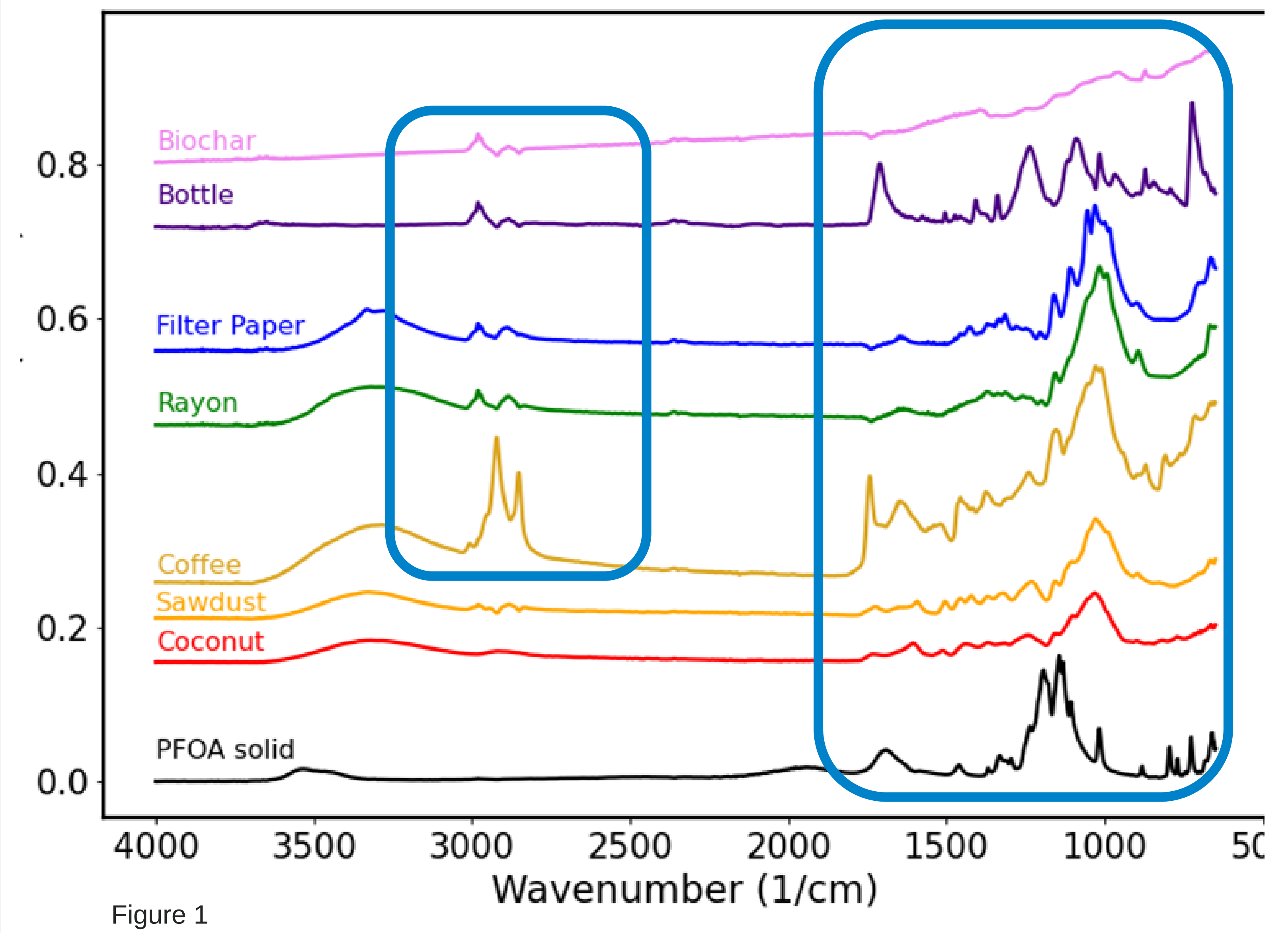
ABSTRACT

Per- and polyfluorinated substances, also known as ‘Forever Chemicals’, such as PFAs and PFOAs, have become increasingly present in our daily environment. These chemicals are widely used in everyday products and are toxic even at low levels, increasing the risk of cancer by damaging the liver and immune system. Chemically, they are synthetic organofluorine compounds that consist of multiple fluorine atoms attached to an alkyl chain. They are not biodegradable, making it difficult to dispose of them safely. This research aimed to find effective methods to filter PFOAs out of water. Several materials were tested: coffee grounds, Biochar (fertilizer), ground coconut, sawdust, rayon, and cut-up water bottles. Each filter sample was 5g. The perfluorooctanoic acid solution included 0.5L distilled water and 0.5g of PFOA, representing concentration found in highly contaminated areas. The solution was heated and stirred until the PFOA had completely dissolved into the water. Three trials were conducted per filter sample, including a base trial where no filtrate was present, and the solution went through filter paper, simulating the filter-sample-included trials.

Each sample was assessed by the Infrared spectroscopy in attenuated total reflectance mode (ATR-IR) and High-performance liquid chromatography (HPLC). The ATIR results show bands that could be assigned to vibration modes encountered in the PFOA compound for all filtrates. The HPLC results showed the presence of PFOA in the filtrate, and quantification analysis was carried out to determine the exact amount of PFOA removed. Both results indicated the filtrates were capable of removing some amount of PFOAs from the sample. The best filtration materials were coffee grounds and Biochar, while plastic bottles and rayon fabric were the worst at filtering out PFAs, filtering out as much as regular filter paper. Sawdust and coconut were also not effective options. No options fully filtered out PFAs in the first filtration attempt; however, both coffee grounds and Biochar were somewhat successful.

ATIR

The highlighted peaks are the PFOAs that remain in the filtered solution. The plastic bottle filtration displays the most amount of peaks, indicating it was the least effective filtration material. The biochar has almost no spectrum, meaning it absorbed the most amount of PFOAs out of the filtration materials tested. However, results from the HPLC need to corroborate. The data from the ATIR can only confirm the existence of the PFOAs, not quantify.



METHOD

Make Solution

Prepared with adequate safety equipment

Added .5 mg of each PFA to 1 L of distilled water in a 1 L volumetric flask, heated up and stirred using a Stir Plate

Prepare Filtration Materials

Amount of distilled water: 20.0 ml

Amount of filtering material: 5.0 g

21 100 ml beakers

Filter Solution

Prepared 21 500 ml samples of PFA solutions

Funneled the solution into a 600 ml beaker, placed 5.0 g of filtration material into the filter paper held by funnel

Allowed filter paper to dry and weighed

Moved the final solution from the beaker

Placed paper and materials into plastic bags, sealed with minimum air

Analyze Data

Used ATIR spectroscopy to detect the existence of PFAs in the filtered solution

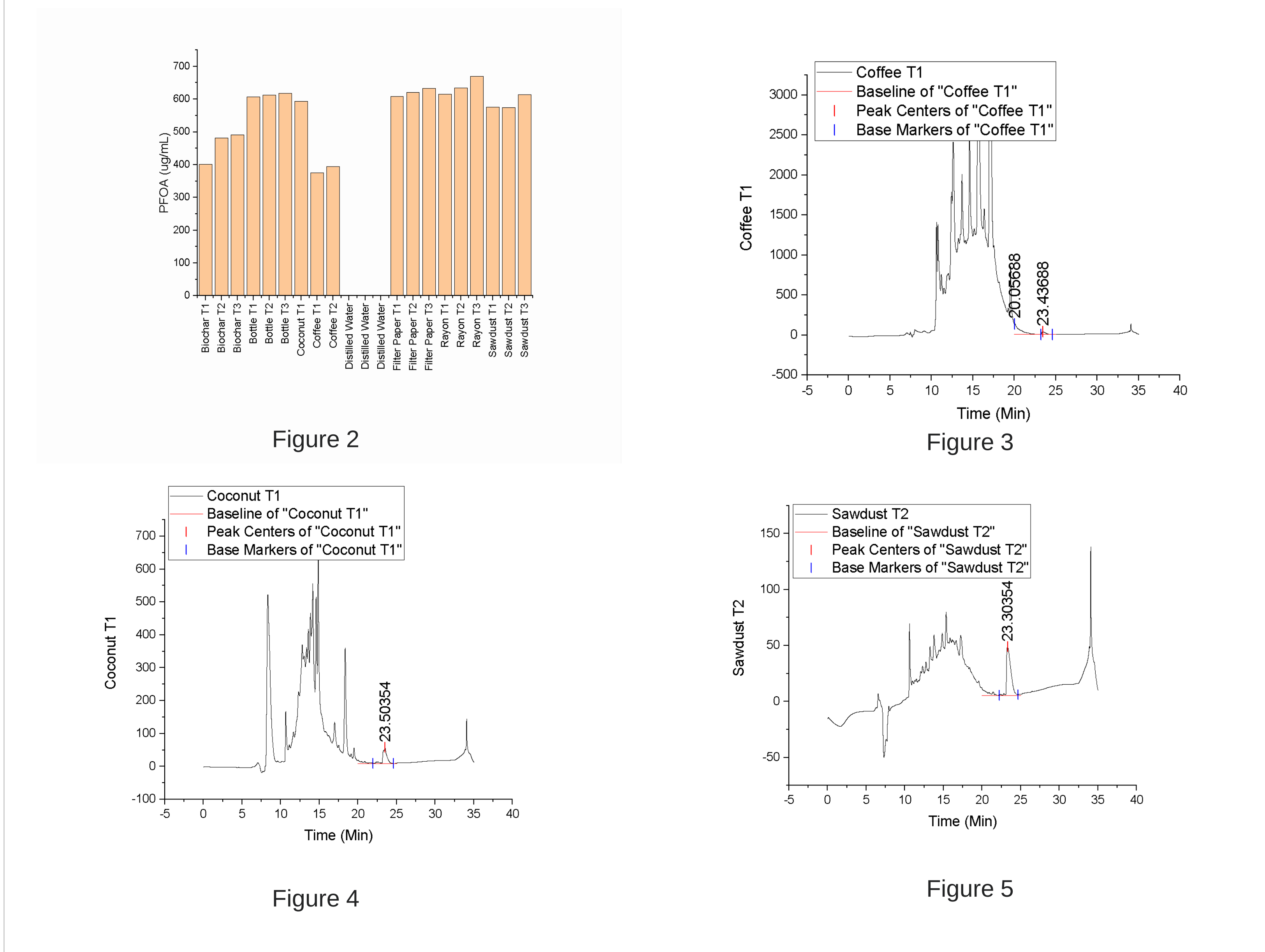
Used HPLC analysis to detect amount of PFAs in the filtration material

Determined the effectiveness of various filter materials after PFA analysis

MATERIALS	
• Rayon	• Filter paper
• Coconut	• Funnel
• Water Bottles	• 600 ml beakers
• Coffee Grounds	• Triangular holder
• Sawdust	• Parafilm
• Biochar	• Safety goggles and gloves
• Control (filter paper)	

HPLC

By HPLC it appears that coffee and biochar reduce the quantity of PFOA in water as in Figure 2, the amount of PFOA is smallest. While coffee at first appears to have very little PFOA in the sample, the y-axis is observed to be much larger than the other chromatograms due to soluble organic materials in the coffee. Similar, though less dramatic, results are observed with coconut and sawdust.



CONCLUSIONS

Only two of the tested materials showed promise in filtering out PFOAs from contaminated water. The coconut, the rayon, the bottles, and the sawdust were not effective in decreasing the amount of PFOAs in the contaminated water by a statistically significant amount. Both coffee grounds and biochar were successful at filtering out some, but not all of the PFOAs. No materials were successful at filtering out all of the PFOAs in the contaminated water with a single pass through the filter. In conclusion, biochar and coffee grounds proved to be the most effective filtration materials.

NEXT STEPS

There are three potential avenues of further research on this subject:

- Further testing of separate materials containing similar properties to coffee grounds and/or Biochar.
- Testing coffee grounds and Biochar for PFOA filtration after multiple rounds of the filtration process; i.e. testing if repeated filtrations attempts make a significant difference in the concentrations of PFOAs in contaminated water after filtration.
- Testing different types of PFOAs filtered through Biochar and coffee grounds.

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