Fingerprinting the Environment Distribution of Microplastics: A Procedure for Extracting and Analyzing Microplastics from Water, Soil and Sediment

Shuhuan Li, Asal Jaberansari, Lisa Yu, Benjemin Lei, Hang Nguyen, Steph Slowinski, Fereidoun Rezanezhad and Phillip Van Cappellen

Ecohydrology Research Group, Department of Earth and Environmental Science, University of Waterloo, Ontario, Canada

Introduction

Environmental Issue:
Plastic production has increased exponentially from a few tons to 400 million tons in 2018 [5]. The astronomical increase in plastic production increases concern as plastic waste is determined to be pervasive and relatively non-biodegradable [2].

Figure 1: Large amount of plastic waste washed on shore at the Zouq Mosbeh costal town, Lebanon, Jan. 22, 2018 [1]

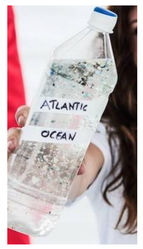


Figure 2: Assortment of microplastic fragments, filaments, and fibers from the North Atlantic Subtropical Gyre [4]

Additionally, plastic waste loses its mechanical integrity and is degraded into to micro- and nano-plastics which pose an immeasurable danger to the environment [3]. The increased distribution of micro- and nano-plastics in different ecosystems is currently raising concerns. Quantifying microplastics (MPs) in environmental compartments such as soil, sediment, ground water and surface water is crucial to understanding and predicting the fate of microplastic in the environment. **Two major challenges** are faced when analyzing microplastics which are integrated within environmental matrices:

1) The surface chemistry of the plastic should not be altered by the extraction process
2) The MP particles should be accurately isolated and separated from their matrix with a high recovery efficiency

Objectives and Approach

- Optimize an extraction procedure which incorporates density separation using a salt brine ($ZnCl_2$) and wet peroxide oxidation to separate MPs from water, soil and sediment samples.
- Evaluate the effect of MP particle size on the recovery efficiency of the extraction procedure.
- Develop a high throughput method for analyzing the size and polymer type distributions of MP particles that have been extracted from environmental samples.

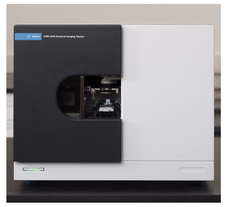


Figure 3: Laser Direct Infrared Imaging System

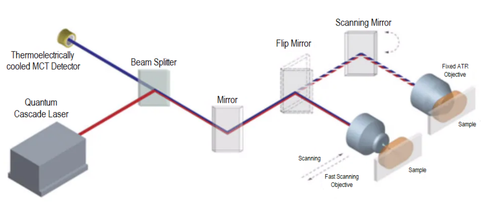
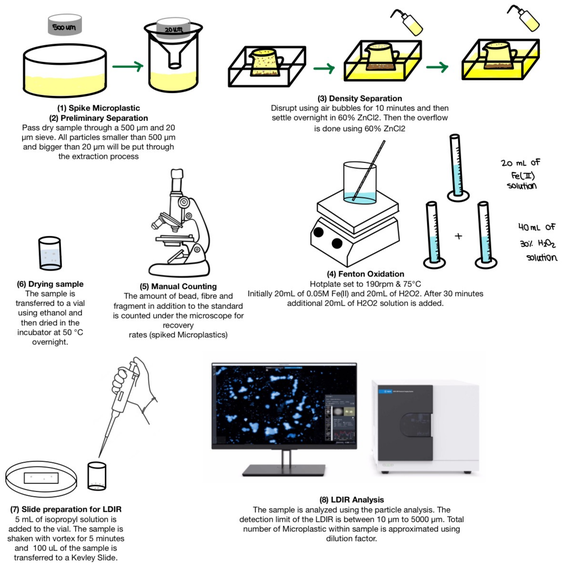


Figure 4: LDIR imaging system for the LDIR

In addition to manual counting, Laser Direct Infrared (LDIR) Imaging is being implemented to detect/identify microplastic (MP) polymer types and to map the distribution of polymer types and particle dimensions within samples.

Identification of Polymer type	• Determines polymer type based on IR spectrum comparison with a built-in library
Measures Particle dimension	• Able to measure the particle size using high quality imaging
Faster than Previous Techniques	• Utilizes a quantum cascade laser as the IR source, targets and focuses on particles, and ignores empty spaces to reduce the analysis time dramatically

Method



Recovery Efficiency vs. Particle Size

Recovery efficiencies of different sizes of microplastic standard particles (PE beads) spiked:

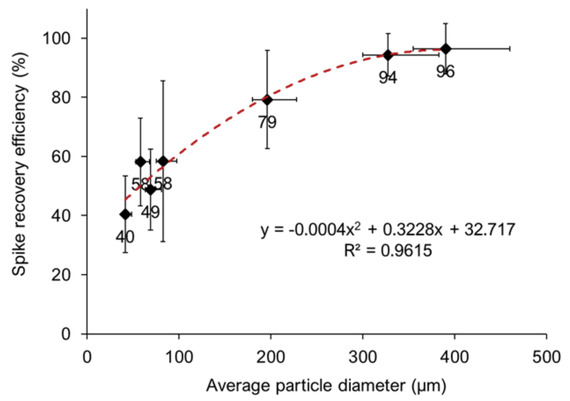


Figure 6: Spike recovery efficiency versus mean particle diameter of PE bead spiked for 27 extractions of fine-grained pond sediments by 2 different operators

References

[1] *12 plastic pollution facts that show why we need to do more*. Global Citizen. (n.d.). Retrieved February 16, 2023, from https://www.globalcitizen.org/en/content/effects-of-plastic-pollution-facts-you-should-know/
[2] Amobonye, A., Bhagwat, P., Raveendran, S., Singh, S., & Pillai, S. (2021). Environmental impacts of microplastics and Nanoplastics: A current overview. *Frontiers in Microbiology*, *12*. https://doi.org/10.3389/fmicb.2021.768297
[3] Amobonye, A., Bhagwat, P., Singh, S., & Pillai, S. (2021). Plastic biodegradation: Frontline microbes and their enzymes. *Science of The Total Environment*, *759*, 143536. https://doi.org/10.1016/j.scitotenv.2020.143536
[4] Bates, S. (2021, June 25). *Scientists use NASA data to track ocean microplastics from space*. NASA. Retrieved February 16, 2023, from https://www.nasa.gov/feature/esnt2021/scientists-use-nasa-satellite-data-to-track-ocean-microplastics-from-space
[5] Syberg, K., Nielsen, M. B., Westergaard Clausen, L. P., van Calster, G., van Wezel, A., Rochman, C., Koelmans, A. A., Cronin, R., Pahl, S., & Hansen, S. F. (2021). Regulation of plastic from a circular economy perspective. *Current Opinion in Green and Sustainable Chemistry*, *29*, 100462. https://doi.org/10.1016/j.cogsc.2021.100462

Plastic Identification by LDIR

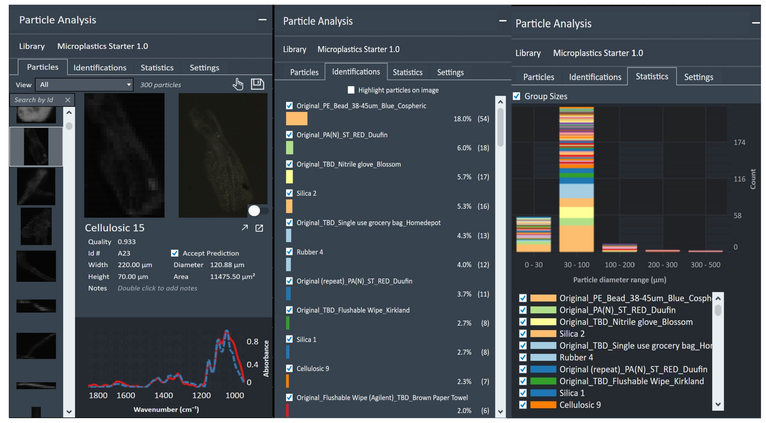


Figure 7: LDIR identification & classification of microplastics extracted from Kitchener Shirley Pond sediment

Particle Type Percentage based on Agilent + ERG Library

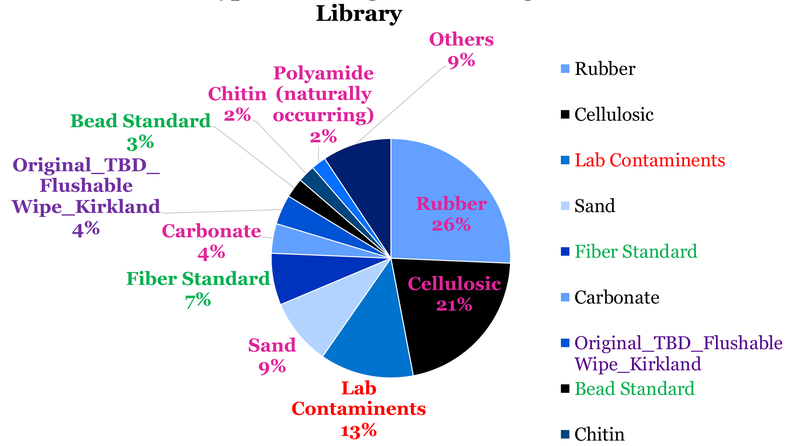


Figure 8: Sum of identified particles by LDIR in the Kitchener Shirley Pond sediment

Conclusions

- Our extraction procedure successfully overcomes the two challenges faced when extracting MPs from soil, sediment and water:
  - Maintaining natural surface chemistry
  - Isolating MPs of various sizes with known and reproducible recovery efficiencies
- Our results show that the recovery efficiency of particles spiked decreases with decreasing particle size → we are one of the few groups that are spiking and evaluating the recovery efficiencies of smaller particle sizes (<300 µm)
- We are currently in the process of library enhancement and method development for the LDIR and are working towards higher sample throughput