Recent Advances on Density Separation Techniques for Microplastic Recovery from Sediments

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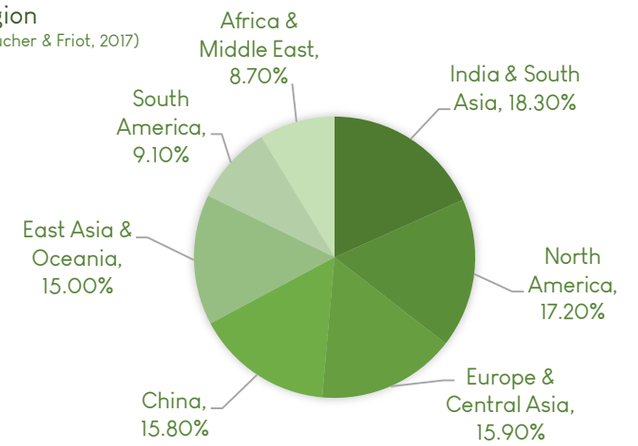
ABSTRACT

Microplastics are small plastic fragments commonly less than 5 mm in size, making up about 92% of the total plastic pollution. Since it is transparent, it causes invisible plastic pollution, and due to its adsorptive properties, it can potentially harm both marine and human life if ingested. Microplastic extraction is the isolation of microplastics from its original matrix using various methods and instruments to ease the process. Density separation utilizing salt solutions of different densities is a widely used method due to its accessibility and versatility. Electrostatic separation, magnetic extraction, and pressurized fluid extraction are established microplastic extraction methods but require more effort. However, the influence of the nature of salts on the efficacy of salt-assisted density separation of microplastics is not yet well understood. This review carefully surveys reported different salt solutions used in microplastic extraction via density separation in the last five years.

INTRODUCTION

Microplastics is any plastic debris measuring less than 5mm in length, with about 1.5 million tons released into the ocean per region every year (Figure 1). Several approaches have been developed to extract microplastics from the environment due to its harmful consequences when ingested. The most common approach, salt-assisted density separation, allows low-density microplastics to float in the solution while other particles sink to the bottom.

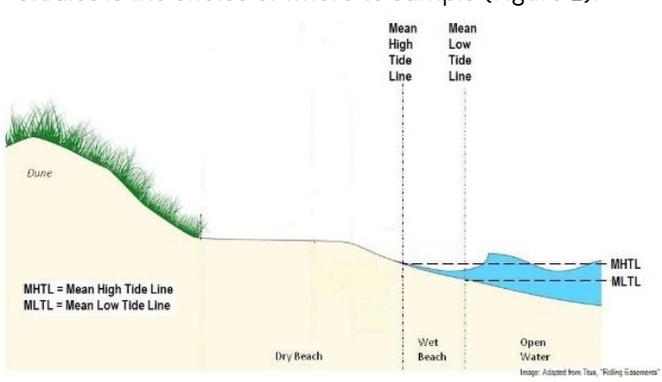
Distribution of primary microplastics in the ocean per region
(Boucher & Friot, 2017)



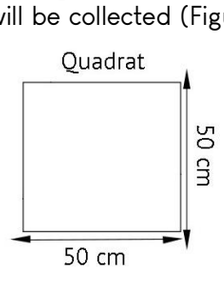
This review focuses on the efficiency of different salt solutions used in microplastic extraction via density separation in the last five years.

SAMPLING AND MICROPLASTIC EXTRACTION

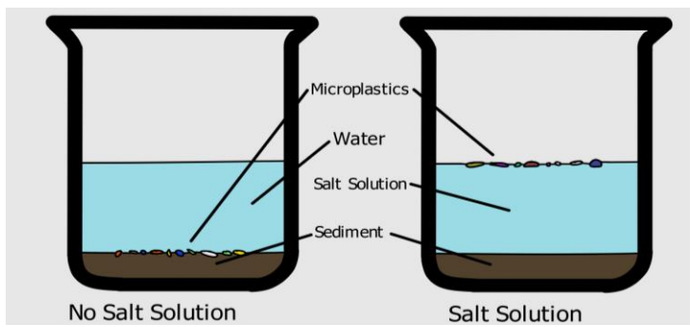
- The basis for representative results of microplastic studies is the choice of where to sample (Figure 2).



- The procedure requires a wrack along the beach to be selected, wherein the samples will be collected (Figure 3).



DENSITY FLOTATION MEDIUM



- Salt solutions facilitate extraction of microplastics from the sample matrix by altering the sample's density (Figure 4).

Table 1. Summary of microplastic quantification and extraction efficiency of various studies.

Flotation medium	Density (g/cm³)	Mean extraction efficiency	Identified polymers	Author
NaCl	1.17	<90.0%	PP, LDPE, PE, HDPE, PS, nylon, PVC P, PVC UP, PET	Quinn et al. (2017)
CaCl2	1.46	69.0%	EPS, PVC, ABS, PA, PES	Crichton et al. (2017)
NaH2PO4	1.40	>93.0%	PE, PP PMMA, PS, PVC, POM, PET	Zhang et al. (2020)
NaI	1.57	91.0% - 98.0%	PP, LDPE, PE, HDPE, PS, nylon, PVC P, PVC UP, PET	Quinn et al. (2017)
ZnBr2	1.71	99.0%	PA, PE, PVC, PC HDPE, PET, PP	Quinn et al. (2017)

- High-density salt solutions tend to have higher extraction efficiency rates when compared to those with low densities (Table 1).
- NaCl fails to extract microplastics denser than the salt; nevertheless, it is commonly used because it is environmental and cost-friendly.
- NaI and $ZnBr_2$ can extract heavy polymers but are expensive and hazardous to the environment.
- $CaCl_2$ is harmless and cost-effective. However, it tends to flocculate to organic matter, which interferes with microplastic identification.
- NaH_2PO_4 density can be increased by heating. It is also regarded as a high-density, low-cost, and non-toxic salt.

CONCLUSION & RECOMMENDATIONS

Salts that are safe, cheap, available, and high-density are preferable as higher density salts were reported to have higher extraction efficiency rates. However, the currently used salts have limitations that may hinder the extraction efficiency. With this, using a high-density salt after using a low-density salt may address these limitations. Additional research on the properties and interactions between salts and microplastics from the environment is needed. Furthermore, a standardized methodology is recommended for reliable comparison of results.