COMPARISON BETWEEN TWO METHODS FOR MICROPLASTIC SEPARATION FROM SANDY SEDIMENTS

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ABSTRACT

Micro plastics have already entered our food chain and become an inextricably part of it. Their size, mobility, and long-term accumulation and fragmentation processes impair survival of some marine species that mistake them for food or ingest them unintentionally. Once in our food web, negative effects on human health might be possible in the long term due to exposure, ingestion, inhalation, and bio accumulation. Several methods have been developed to isolate micro plastics from water, air, soils and sand to study their distribution and chemical pathways. The most accepted methodology recommended by many authors is based on their physical and chemical properties, e.g. density and size. The present study compares two methods that are applicable to sandy sediments. Finally, we summarize advantages and disadvantages of both methods with the purpose of determining the best suitable method to perform their isolation on site, as part of a large-scale monitoring program.

KEY WORDS: Efficiency, Rate of Yield, Density, Elutriation, Monitoring.

INTRODUCTION

The study of Microplastics has become increasingly important in the last years. Their presence has been reported in marine environments. As far as their toxicity is concerned, they have been compared to harmful persistent organic pollutants (POP). So far, they have been studied in marine, planktonic and benthic species. Their presence and distribution in marine ecosystems are both intrinsically related to macro plastic debris from land-based sources.

This study compares two methods that use density differences of plastics vs. the separating solution. The first one is based on the principle of elutriation. This fluid matrix method allows a faster and easier separation for at least three polymer classes: Polyethylene (PE), Polypropylene (PP) and Polystyrene (PS), when using saturated nontoxic table salt solution as a solvent. The second method consists of dry sieving followed by flotation in a saturated table salt solution.

ELUTRIATION

An adaptation of the Mississippi elutriation system as shown in figure 1 built as a recirculating system that can be used for more than one separation . The method allows the isolation of plastics with a density lower than 1.20 g/cm³ (PE, PP and PS) when used with saturated NaCl.

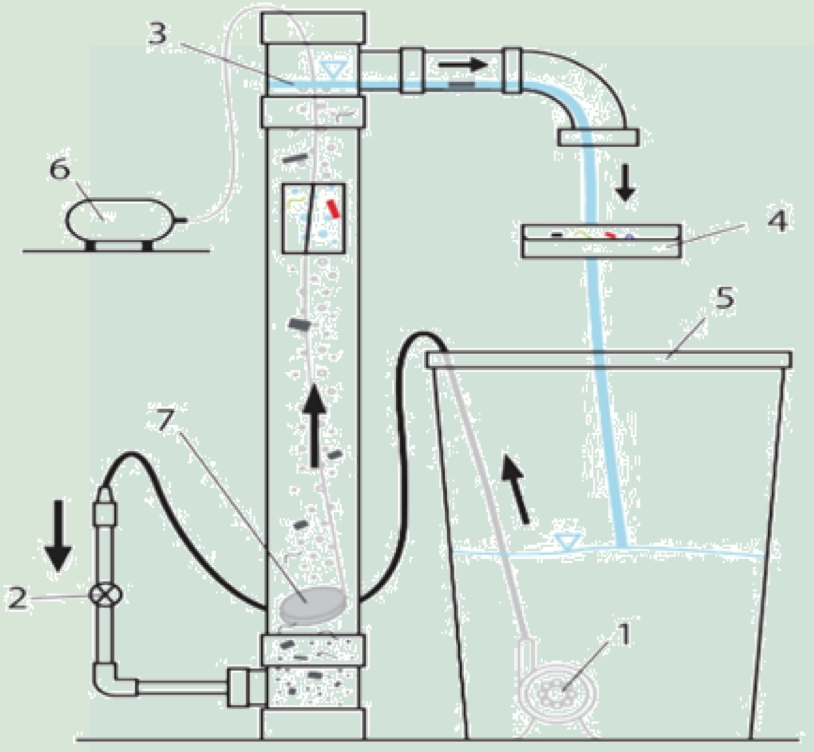

Figure 1. Elutriation system 1) Bilge Pump 2) Ball Valve 3) Water level 4) Sieve 1 mm mesh 5) Saltwater reservoir 6) Aerator pump 7) Porous Air Stone

DATA ANALYSIS

The collected data consisted in recovered microplastic counts from the samples of both methods. The experimental part was repeated 3 times for a total of 6 batches. Each batch was paired into methods (sieving-elutriation) and repetition trials, for a total of 3 paired trials (t1, t2, t3).

Recovered microplastic fraction (RF) was a variable used to calculate the amount of microplastic particles recovered from the samples during trials. This value was expressed in a ratio scale (or percentage, if multiplied by 100) and calculated as follows:

$$RF = MP_R / MP_T * 100 \quad [1]$$

The Mean value, standard deviation, and standard error of the RF were calculated for each type of microplastic within the trials of each method. Then, the average recovered fractions of different types of microplastics were studied and compared using graphical analytic methods. (Table 1).

Paired t-test was used to identify the presence of statistical differences between both methods. Each paired trial was compared using the test but also the mean values of the paired trials. The variable used for the tests was the recovered microplastic fraction. The results were considered non statistically significant when the p-value was greater than a=0.05. Data analysis was conducted using R programming (R Core Team, 2013).

Microplastic	Sieving				Elutriation			
	T1	T2	T3	Mean ± SD	T1	T2	T3	Mean ± SD
Sponge PUR	0.70	1.00	1.00	0.90 ± 0.17	0.90	1.00	1.00	0.97 ± 0.06
Green Fiber PP	1.00	1.00	1.00	1.00 ± 0.00	1.00	1.00	1.00	1.00 ± 0.00
Blue Film PE	0.90	0.40	1.00	0.77 ± 0.32	0.90	0.40	1.00	0.77 ± 0.32
Colorless Film PP	1.00	1.00	1.00	1.00 ± 0.00	0.00	1.00	0.80	0.60 ± 0.53
Colorless PE Pellets	1.00	1.00	1.00	1.00 ± 0.00	1.00	1.00	1.00	1.00 ± 0.00
White PP Pellets	1.00	1.00	1.00	1.00 ± 0.00	0.98	1.00	1.00	0.99 ± 0.01
Colorless PET	1.00	1.00	1.00	1.00 ± 0.00	0.00	0.00	0.50	0.17 ± 0.29
White PS	0.90	1.00	1.00	0.97 ± 0.06	1.00	1.00	1.00	1.00 ± 0.00

Table 1 Statistic mean and standard deviation results for recovered MPs.

MATERIAL AND METHODS

SAMPLE PREPARATION

The samples used in the trials were prepared using a combination of sand (grain sizes between 500 and 125 mm), organic and mineral debris, in similar sizes and proportions as they are commonly found at some Panamanian beaches. The beach sand combined as follows: 20-gram (g) of mixed organic matter (twigs, leaves, seeds, and dried flowers); <500 µm (180g); <250µm (200g) and <125µm (600g) totalizing 1 Kg of dry sand. The samples were then spiked with known quantities of six types of polymers (PET, PP, PE, PS, PUR and PC) of known origin (reference substances) in different shapes (pellets, fragments, fibers, films, sponges and foams).

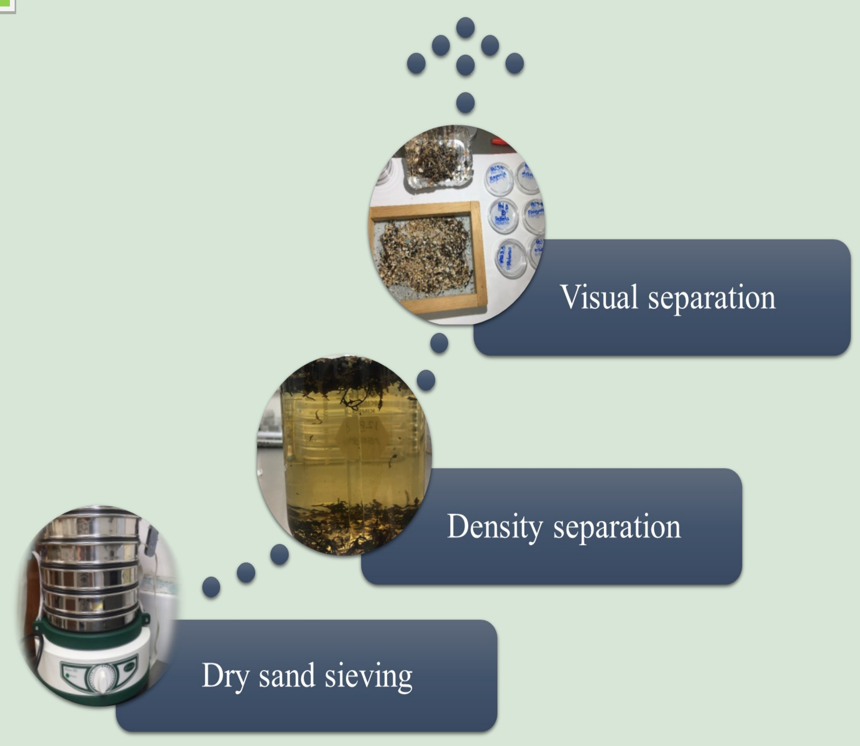

Figure 2. Usual sample and MP isolation scheme

DENSITY SEPARATION METHOD

The process involves three major steps: 1) dry sand sieving, 2) density separation and 3) visual separation. Density separation was carried out with saturated NaCl.

TRIAL RESULTS

Both methods showed high recovery ratios for almost all types of microplastic with exception of PET, when using elutriation.

The recovery rate of reference materials was 100% for PE pellets, which were recovered from samples, regardless of the methodology employed. The results for the paired t-test applied to each paired trial (t1, t2, and t3) presented in Table 1 showed no statistical significance with p-values of 0.2546, 0.3506, 0.2133, respectively. Since all p-values are smaller than the statistical significance value (α=0.05), both methods can be used just as well for the recovery of the three different most common types (PP, PE, PS) and almost all shapes of microplastics from sand samples. Although there is no statistically significant difference between the used methods, we found that sieving is a better method to recover PET.

DISCUSSION

Plastic contamination found in all compartments (air, soil and water) has increased at a speed that has never seen before. Due to its growing importance, several authors have studied, validated, and proposed various microplastic separation techniques. The importance of marine environments for trophic webs and economies has been highlighted. Galgani et al. emphasize the need for a consolidated knowledge on microplastics isolation methodologies used by researchers. However, the chosen method depends on the composition of beach sand, which may vary from location to location.

By means of statistics, around 65% of the methods used for extracting microplastic from sand samples are based on density differences between the solution used for flotation and plastics. As already mentioned, flotation requires longer processing times and expertise from the technician selecting the plastics. In addition, NaCl (1.2g/cm³) density separation will have a negative recovery rate for plastics with higher density, as they will sink to the bottom with other debris, making their recovery difficult. Therefore, their presence in water and sand may be underestimated.

Nevertheless, some considerations such as the method being time consuming, training of technicians for an accurate visual separation, costs, special equipment, energy and manpower are clearly a disadvantage.

On the other hand, the main advantage of the elutriation column is the shorter separation times needed for each sample.

Furthermore, the sample does not need a previous drying step which results in less damaged plastics during the separation process. The whole system is portable, allowing on-site separations when plugged to a 12 Volt car battery.

Perhaps the most important caveat is the fact that NaCl saturated solution will only recover plastics with a maximum density of 1.2 g/cm³. In contrast, granulometric sieving followed by a macroscopic optical separation has the advantage that denser plastic types might be picked from the bulk sample. One disadvantage might be the drying times of the samples (60 °C for at least 24 hours).

The evaluation of different methods to isolate denser materials is necessary to determine their presence in different matrices. Our results indicate that elutriation proves to have a higher efficiency in terms of processing times. The addition of denser solutions to the reservoir is possible. However, the high cost of the required reagent makes the studies often non-viable.

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