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The identification of microplastics using density analysis

An Environmentally Friendly Method for the Identification of Microplastics using Density Analysis

Symiah Barnett[a*], Robert Evans[b], Belén Quintana[c], Anastasia Miliou[c], Guido Pietroluongo[c]

[a] Chemical Engineering and Applied Chemistry, College of Engineering and Physical Sciences, Aston University, Birmingham, B4 7ET, United Kingdom

[b] Aston Institute of Materials Research, School of Engineering and Applied Science, Aston University, Birmingham, B4 7ET, United Kingdom

[c] Archipelagos Institute of Marine Conservation, P.O. Box 42, Pythagorio, Samos 83103, Greece

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Abstract: Current methodologies for microplastic polymer identification such as FTIR and DSC are neither cost efficient nor practical in fieldwork. Density analysis is an inexpensive and readily transportable alternative method. However, current density analysis methods use many different hazardous solutions to carry out separation and

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identification of plastics. Here, we demonstrate the use of water, sucrose and ethanol solutions for the density analysis of microplastics. The method developed was able to successfully distinguish between and identify eight polymers commonly found in microplastic pollution.

Keywords: density analysis, microplastics, emerging pollutants, marine plastics, identification, environmentally friendly

*Address correspondence to barnetts@aston.ac.uk

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INTRODUCTION

Over 320 million tons of plastic are produced annually across the world and approximately 5 to 13 million tons of that plastic escapes into the ocean (Santonicola et al 2020). Plastics found in the ocean undergo fragmentation driven by photochemical, physical, and biological degradation to form microplastics (Reisser et al 2013). These are pieces of plastic less than 5 mm in their longest dimension (Lambert and Wagner 2017) and are particularly problematic since they are often ingested by marine biota such as zooplankton, sharks and marine birds (Cole et al 2013). Upon ingestion, contaminants embedded in plastic can be transferred to the organisms (Mato et al 2001). Teuten et al (2009) demonstrated that the uptake and leaching of contaminants are dependent on the polymer type. For example, polyvinyl chloride (PVC) leaches toluene back into the environment quicker than high-density polyethylene (HDPE). Therefore, the identification of microplastics is important to ascertain the potential damage to marine life by any contaminants they contain. In addition, successful identification of

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microplastic composition provides important information for plastic pollution reduction strategies. There are numerous techniques used to identify microplastics. The predominant method used is microscopic analysis (Syakti 2017). This method can be highly inaccurate and, according to Eriksen et al (2013), approximately 20 % of microplastic identified in this way was later recategorized as aluminum silicate when a scanning electron microscope (SEM) was used. Also, it is only suitable for identifying microplastics greater than 500 µm in size (Löder and Gerdts 2015). Unfortunately, electron microscopes are expensive tools, so would be unsuitable for non-profit organisations or small businesses. In addition, as described by Peñalver et al (2020), their use involves extensive sample preparation.

Thermal degradation methods such as thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) can also be used to identify polymers. TGA monitors the weight loss of the plastics whilst the plastic is being heated (Peñalver et al 2020) whereas DSC monitors the melting points of the plastics (Fu et al 2020). Both TGA and DSC are relatively rapid and easy to use. However, these techniques use transition temperatures to identify polymers and the transition temperatures of a polymer depends on the size of the plastic sample. As a result, Peñalver et al (2020) reports the smallest possible size of the plastic sample able to be identified is 0.2 mm. In addition, these techniques are both expensive and necessarily destructive (Peñalver et al 2020).

Microplastics can also be identified on the basis of their chemical structures. Fourier-transform infrared (FTIR) spectroscopy uses the absorbance of infrared light at specific frequencies to produce a spectrum indicating the chemical bonds present in the plastic. From this, the identity of the plastic can be determined (Fu et al 2020). Peñalver et al

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(2020) state that the advantages of this method are its ability to identify plastic as small as 25 µm and the fact that it is non-destructive. Unfortunately, FTIR requires an expensive and immobile piece of equipment and the method can only be used on dry samples.

Raman spectroscopy uses the scattering of monochromatic light to produce spectra from which the chemical structure can be inferred (Syakti 2017). According to Fu et al (2020) Raman spectroscopy can identify plastic samples as small as 1 µm and can be used on both solid and liquid samples, therefore this method can directly identify microplastics presents in seawater samples. However, Raman spectrometers also tend to be expensive and stationary instruments.

Another method of polymer identification is pyrolysis–gas chromatography-mass spectrometry (Pyr-GC-MS). In this method, the plastic undergoes pyrolysis at 700 °C for 60 seconds and then GC-MS at 350 °C. The thermal decomposition of the sample plastic is compared to a standard to identify the types of plastic present (Syakti 2017). Although this method is destructive, it allows for the accurate identification of both plastic and any organic plastic additives (OPAs) present and no pre-treatment is necessary and it can identify microplastics as small as 50 µm (Peñalver et al 2020). However, similar to SEM, FTIR and Raman spectroscopy, Pyr-GC-MS is neither practical in the field nor in remote locations because it requires stationary instruments and is expensive. Hence, it is not financially viable for non-governmental organizations (NGOs), small institutes and independent researchers. Often these institutions and researchers tackle plastic pollution in remote and inaccessible locations so require instruments and methodologies that can enable them to identify microplastics in the field and, as a result, combat plastic pollution more effectively.

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Density analysis is an inexpensive and mobile way of separating plastics; therefore this paper proposes the use of density to identify microplastics found in the environment. Density is a physical property of a material and is both temperature and pressure dependent. The mass is measured in grams and the volume in cm^3, therefore the unit used in this paper is g /cm^3.

$$\rho = \frac{M}{V}$$

Where density (ρ) is the mass of the material (M) divided by the volume (V). Since different types of plastics have different densities, they will either sink or float depending on the composition of a solution they are suspended in. A considerable amount of literature has been published on the separation and identification of plastics using density analysis. For example, Kolb and Kolb (1991) used monosodium phosphate, ethanol, sodium chloride and chloroform to identify poly-4-methyl-1-pentene, polypropylene (PP), low-density polyethylene (LDPE), high-density polyethylene (HDPE), polystyrene (PS), polymethylmethacrylate (PMMA), and polyethylene terephthalate (PET) based on whether the plastic sample floated or sank in solutions with varying densities. While Kolb and Kolb (1991) were one of the first to demonstrate that it was feasible to identify plastic samples using density analysis, they did not analyze some of the most common polymers. For example, they did not include PVC in the experiment on the basis that PVC is too heavily filled and plasticized to give consistent results. Furthermore, they used many different hazardous solutions to carry out separation and identification of plastics. To illustrate, the authors used a chloroform solution which is harmful to marine life, for example, the EC50 is 2.803 mg/L/48h for *Ostracods* (Khangarot and Das 2009). This is important information to consider when carrying out field work where researchers

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are working alongside marine life that can be easily affected by the experiment. Similarly, Morét-Ferguson et al (2010) used density analysis as a preliminary method to identify plastics in conjunction with subsequent elemental analysis. They concluded that density analysis is a powerful tool for the identification of plastics. Their methodology entailed the placement of a piece of plastic in distilled water. If the plastic sank, concentrated calcium chloride ($CaCl_2$) or strontium chloride ($SrCl_2$) was added until the plastic was neutrally buoyant. However, if the plastic floated, ethanol was added until the plastic was neutrally buoyant. Morét-Ferguson et al (2010) distinguished between only seven types of microplastics using their densities since polystyrene was excluded from this method. The experiment measured the density of the plastic indirectly, and as a result the method was critiqued by Löder and Gerdts (2015), who argued that this technique only allows an approximate identification of microplastic. In addition, the solutions used to carry out identification of the plastics adversely affect aquatic organisms. For example, Watts and Howe (2010) demonstrates that $SrCl_2$ causes reproductive impairment in water fleas and rainbow trout. Nazari et al (2015) draw attention to the ecotoxicity effects of $CaCl_2$ on aquatic life. $CaCl_2$ is toxic to aquatic insects such as mayflies (*Cloeon dipterum*) and small shrimp-like crustaceans (*Gammarus sobaegensis*) because $CaCl_2$ adversely affects osmosis between the aquatic insects and their surrounding environment. This results in EC50s of 6.14 g/L/48h for *Cloeon dipterum* and 3.54g/L/48h for *Gammarus sobaegensis*. Syakti (2017) used sodium chloride (NaCl), sodium iodide (NaI), calcium chloride (CaCl2), zinc chloride (ZnCl2) and lithium metatungstate (Li2WO4), with densities of 1.98 g/mL, 1.46 g/mL, 2.91 g/mL and 3.7 g/mL respectively, to extract polyethylene terephthalate, high density polyethylene, polyvinyl chloride, low density polyethylene,

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polypropylene, polystyrene polycarbonate, nylon, polyester and polyamide microplastics from seawater and sediment. Again, hazardous solutions were used to carry out the separation. In addition, in this method, density was used only to separate the microplastics, not to identify them. There are numerous papers like Syakti (2017), Morét-Ferguson et al (2010) and Kolb and Kolb (1991) that show that density can be used to separate plastics. This paper takes this concept further and uses density to identify microplastics commonly found in the environment.

In conclusion, there are numerous techniques used to identify microplastics, the techniques discussed in this paper is summarised in **Table 1**.

Table 1. A summary of the advantages and disadvantages current techniques for identifying microplastic.

There is a need for a density analysis methodology that identifies and distinguishes between microplastics that can be easily used in the field. Therefore, the aim of the present study is to identify microplastics' polymer composition in an environmentally friendly, affordable and accessible way using density analysis methodologies. To demonstrate the utility of the method, eight of the most common polymers found in marine microplastics were successfully distinguished from each other using only water, sucrose and ethanol.

MATERIALS AND METHODS

Microplastic selection and collection

Plastic samples were collected from both sea and shorelines of Samos, a Greek island located in the north-eastern Aegean Sea, to give a representative view of the plastic that is typically found in this area. The Aegean Sea is in the eastern Mediterranean Sea, which

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according to Lebreton, Greer and Borrero (2012) contains one the highest amounts of marine litter making this a suitable place for sample collection. Plastics were identified using the resin identification coding system (RIC), in which each number from 1 through 7 corresponds to a different type of plastic (ASTM D7611 / D7611M-20, 2020; Morét-Ferguson et al 2010). The RIC system was used to identify the plastic because it is an ASTM International standard, therefore, it can be used to unequivocally identify the plastic. PS and expanded polystyrene (EPS) have the same RIC, so these plastics were differentiated by other characteristics such as color, plasticity and weight. For this reason, the source of the plastic samples is specified in **Table 2**.

Kolb and Kolb (1991) and Braun (2013) both highlight the fact that plastic density can vary due to modification for a specific function.

After sample collection, density analysis was performed on the eight most common polymers within the sample. These were: PET, HDPE, PVC, LDPE, PP, PS, EPS and PA. In order to carry out density analysis on these eight types of plastic, their typical density needed to be ascertained. The density of PET unfilled is 1.34–1.39 g/cm^3 (Dean and Lange 2001). Polyethylene properties vary with the degree of branching of the polymer chains. Where there are few branches, the chains pack closer together, so the PE is referred to as HDPE. In contrast, where there is a greater degree of branching, the polymer chain is unable to pack together so the PE is known as LDPE. The densities of LDPE, medium-density polyethylene, and HDPE are 0.910–0.925 g/cm^3, 0.926– 0.94 g/cm^3 and 0.941– 0.965 g/cm^3 respectively (Dean and Lange 2001). The density for flexible and unfilled PVC is 1.16– 1.35 g/cm^3 (Dean and Lange 2001).The homopolymer form of PP has the density of 0.90– 0.91 g/cm^3 while the copolymer form has the density

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of 0.89– 0.905 g/cm^3(Dean and Lange2001). Therefore, in the present study the density range given to PP is 0.89–0.91 g/cm^3 and the density of PS is 1.04– 1.07 g/cm3 (Shackelford et al 2015). EPS has a range of densities depending on its use, for example, packaging EPS has a density of 0.015–0.020 g/cm^3 whereas fireproofing and heat-insulation EPS has a density of 0.020–0.050 g/cm^3. As a result, this paper describes the range of EPS as 0.015 –0.050 g/cm^3 (Liu and Chen 2014).

Nylon is a type of polyamide and there are many different types of Nylon. These include Nylon 6 (1.12– 1.14 g/cm^3), Nylon 6/6 (1.15– 1.17 g/cm^3 when it is filled with molybdenum disulfide), Nylon 6/9 (1.08– 1.10 g/cm^3 when it is molded and extruded), Nylon 6/12 (1.06– 1.08 g/cm^3 when it is molded), Nylon 11 (1.03– 1.05 g/cm^3 when it is molded and extrude) and Nylon (1.01– 1.02 g/cm^3 when it is molded and extruded) (Dean and Lange 2001). In addition, Radhalekshmy and Gopalan Nayar (1973) state that the density of polyamide fishing equipment is 1.14 g/cm^3. The literature presents a wide range of densities for polyamides, but for the purpose of the present study, the range assigned to polyamide is 1.01-1.14 g/cm^3 because the polyamide used in fishing gear is 1.14 g/cm^3 and, according to Dean and Lange (2001), Nylon 6/6 is typically found outside of this range but is also often highly modified with molybdenum disulfide filler. The density data listed in this section is summarised in **Table 2**.

Table 2. Description of the plastic types considered in the present study and their resin code. Data obtained for Moret-Ferguson et al (2010). In addition, the table contain the density ranges, in g/cm^3, of PET, HDPE, PVC, LDPE, PP, PS, EPS and PA with common modification. The data was obtained from Dean and Lange 2001; Liu and Chen 2014; and Shackelford et al 2015.

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The plastics were converted to microplastic samples by being cut into pieces, of at least 5 mm in their longest dimension, with a scalpel or scissors. Then the pieces were placed in containers labelled A-H by a member of a research team. Another member of the research team carried out the experiment therefore the method was validated by a blind test.

Preparation of the solutions

Solutions of 8 different known densities were prepared following protocols laid out in **Table 3**.

Table 3. Solutions used in this experiment, their densities, and which polymer type floats in each solution. The desired density of the solution was selected using plastic density data. The ethanol and water solutions were made using data from Kolb and Kolb (1991) and Scott (1946).

The appropriate concentrations of the sugar-water solutions were calculated using the °Brix and prepared using the following equation (James, Usher, Campbell and Bond 2008).

$$\text{Specific gravity} = 1 + \left(\frac{°Brix}{258.6 – \left(°Brix \left(\frac{227.1}{258.2} \right) \right)} \right)$$

Where the °Brix $\left(\frac{g}{100g}\right)$ is defined as mass (g) of sucrose dissolved in 100 g of water.

Since 100 g of water is approximately equal to 100ml, the specific gravity $\left(\frac{\mathrm{g}}{\mathrm{ml}}\right)$ of a solution is approximately equal to its density (Millero et al 1976). Therefore, the amounts of sucrose needed to obtain the desired densities of the sugar-water solutions were calculated.

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Sugar-water solutions were prepared by weighing 18 g, 38 g, 70 g and 80 g of sucrose and pouring approximately 60 ml of hot water into each Erlenmeyer flask. Water was added to obtain a final volume of 100 ml then the flasks were gently swirled until the sucrose was dissolved completely. All solutions were kept at a constant temperature of 25º C, after cooling down, since density is temperature dependent.

Ethanol-water solutions of 10:7 and 7:11 were prepared adding the corresponding volumes of each liquid. The volume ratio was obtained from Scott (1946) and Kolb and Kolb (1991). The temperatures of the ethanol-water solutions were also kept constant at 25° C.

Density-separation experiment

For each polymer type, 8 test tubes were placed in a rack and one microplastic piece placed in each tube. Then, 5 mL of the different solutions were poured into each test tube and gently swirled. This was left to rest for one minute to ensure no ambiguity on whether the plastics sank or floated. The buoyancy of the plastics was observed either by the eye, compound light microscope or magnifying glass depending on the visibility of the plastics. The buoyancy, identified by whether the microplastic sank or floated, was recorded. It was ensured that no air bubbles were present since air bubbles would decrease the density of the solution and cause the plastic to float, resulting in a false reading. This methodology was repeated three times per polymer type, to ensure reliability of the data collected and to reduce experimental mistakes and human errors in handling the plastics.

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RESULTS

The buoyancy of the microplastic was qualitatively determined, if the microplastic either sank or floated. If the microplastic dropped to the bottom of the test tube, then the microplastic were considered to have sunk. Plastic samples that were either floating on the surface or in the middle of the test tube were considered to be floating. The results of the identification of polymers are shown in **Table 4**. The recorded behavior of each polymer type in each solution was the same for each replicate. The point at which the plastic started to float within that solution is highlighted in bold.

Table 4. Recorded buoyancies of the different polymer types alongside the solution composition and the source of the polymer. This data was obtained from this experiment.

The data in **Table 4** indicate that different types of plastics have different densities and will sink or float depending on the solution they are in. Their different buoyancies can be used to discriminate between the type of microplastic. A flow diagram, **Figure 1,** was constructed to simplify the identification process.

Starting with water, an unknown piece of plastic is placed in the solution, shaken and then left to sink or float. The next solution that the plastic is placed in is dependent on whether the plastic previously sank or floated. The flow diagram in **Figure 1** illustrates the sequence in which the solutions should be used based on the buoyancy observed. As the flow diagram illustrates, these steps are repeated until the identity of the plastic sample is determined.

Figure 1. A flow diagram showing the steps to identify PET, HDPE, PVC, LDPE, PP, PS, EPS and PA microplastics starting from immersion in pure water.

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DISCUSSION

The idea of identifying plastics via density analysis is consistent with the separation and identification experiments described by Morét-Ferguson et al (2010), Syakti (2017), and Kolb and Kolb (1991) which confirmed that solutions with different densities can be used to identify different plastics. Although they all support using density analysis as a method for identifying microplastics, there are some differences in their methods and materials. For example, Kolb and Kolb (1991) recommend 1:1 EtOH/H_2O to differentiate between HDPE and LDPE, whereas, the present study used 7:11 EtOH/H_2O. This discrepancy between the dilution ratio for ethanol and water could be due to differences in experimental conditions, since Kolb and Kolb (1991) do not describe the conditions under which the experiment was done. The 7:11 EtOH/H_2O mixture ratio is supported by Scott (1946) who states that an ethanol and water with a density of 0.93g/cm^3 is comprised of 61% water by weight, consistent with a 7:11 mix of EtOH and H_2O.

The methodology developed in the present study successfully distinguished between microplastic polymer type on the basis of their buoyancies. This is a suitable method for inexpensive identification of the most prominent plastics found in coastal areas and waters, which are PET, HDPE, PVC, LDPE, PP, PS, EPS and PA with common modification, only using water, sucrose and ethanol.

However, a limitation of the present study is that it only focuses on eight polymer types, whilst there are numerous types of plastics found in marine microplastics, some with similar densities to the polymers studied in this work (Dean and Lange 2001). In addition, the samples analysed in this work were collected from only a single source. For instance, a piece of fishing net was used to represent PA; however, PA can also be found in clothes

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and toothbrush bristles. A wider range of sources is recommended to further develop this methodology.

In addition, modification, such as molding and extrusion, can change the density of the plastic (Dean and Lange 2001), which then affects the buoyancy of the microplastic pieces. For example, EPS is foam used in packaging while PS is a rigid solid used for Petri dishes. A similar situation occurs with regard to HDPE and LDPE. A way to develop this experiment would be to study the effects that any modification has on the densities which would help to make identification of the sources more precise.

Finally, in this experiment, the microplastic samples were collected from marine plastic litter found in the sea and on the shorelines of Samos, a Greek island located in the North-Eastern Aegean Sea. To give a better representative view of the plastic typically found in the sea and shorelines, the samples could be expanded to include those found in the digestive systems of fish, invertebrates and marine animals and also in sediment. Using the protocol described by Kaiser et al (2017), the sample should be filtered and treated with hydrogen peroxide to remove all the organic material so that only the non-biological material remains for testing. Furthermore, a hot needle test could be used to distinguish between plastics and other non-biodegradable materials. This is a common protocol for extracting and identifying microplastics obtained from the digestive systems of fish, invertebrates and marine animals and also from seawater and sediment (Lusher, Welden, Sobral and Cole 2017), (Wagner et al 2017) and (Zobkov and Esiukova 2018). The hot needle test could be validated using Raman spectroscopy, pyrolysis–gas chromatography-mass spectrometry or a scanning electron microscope.

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The identification of microplastics is important to ascertain the potential damage to marine life by the contaminants they contain. In the density analysis process, the contaminants may remain adsorbed on the surface of the plastics or leach out into the solutions, depending on the type of contaminant. Nonetheless, contaminants can be identified. If they remain adsorbed on the surface of the plastics, contaminants such as inorganic plastic additives can be identified using scanning electron microscopy as described in Fries et al (2013). If contaminants leach out into the solutions, a coupled plasma mass spectrometry could be run on the solution to detect contaminants such metals or ion chromatography to detect persistent organic pollutants (POPs).

To summarize, future research could be conducted in more authentic settings to resemble the plastics found in marine environments and seawater samples. In addition, further research is needed to extend this methodology, to include modification of the same plastics and other polymer types. Nevertheless, this provides a good starting point for discussion and further research into more environmentally friendly and inexpensive way of identifying microplastics.

CONCLUSION

The results of the present study confirm that microplastics can be identified by density analysis using solutions containing only water, sucrose and ethanol. Based on the buoyancy data obtained, **Figure 1**, a flow diagram for the identification of microplastic samples using the methodology developed here, was devised. This flow diagram summarises both the method and required data analysis in a clear manner, allowing for wide use of the inexpensive, environmentally friendly methodology in microplastic sample determination.

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This methodology can assist other researchers in identifying the main sources of microplastic pollutants in the environment when working in the field, in an inexpensive and more environmentally friendly way. The present study differs from others in that less hazardous solutions than previous density analysis research are used, therefore, the methodology is in line with the European Chemicals Agency substitution initiative, as described in their Strategic Plan 2019-2023 (ECHA 2019). In addition, the present paper provides a protocol for the preparation of the solutions and a flowchart that enables the identification of microplastics. In summary, this procedure offers a quick and inexpensive way of distinguishing between eight plastics commonly found as microplastic pollutants in marine environments.

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Author contributions statement—A. Miliou, B. Quintana, S. Barnett and G. Pietroluongo conceived and designed experiments. S. Barnett performed experiments. S. Barnett wrote manuscript. R. Evans, B. Quintana and G. Pietroluongo provided technical and editorial assistance.

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FIGURE CAPTION

Figure 1. A flow diagram showing the steps to identify PET, HDPE, PVC, LDPE, PP, PS, EPS and PA microplastics starting from water.

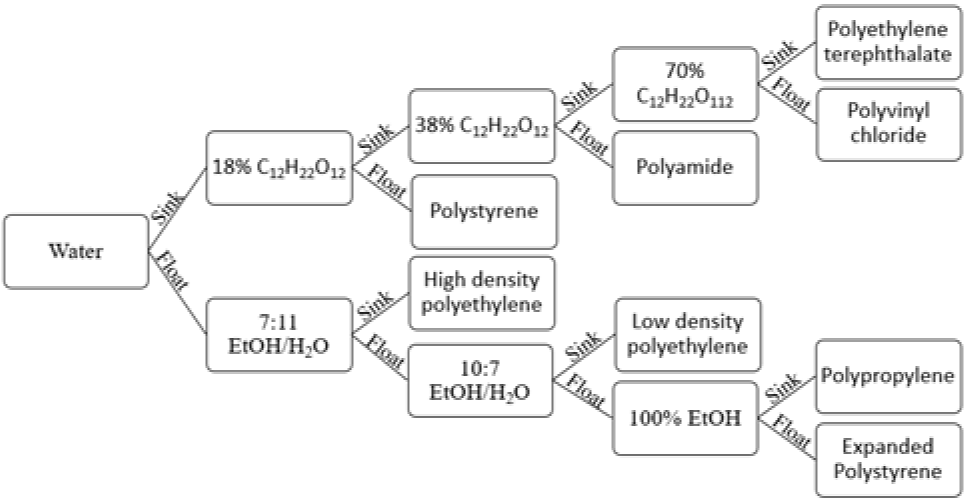

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Table 1. A summary of the major advantages and disadvantages of current techniques for identifying microplastic.

Technique	Minimum size of plastic that method requires	Advantage	Disadvantage
SEM	500 µm	More accurate than microscopy	Involves lengthy sample preparation Expensive Stationary instrument
TGA and DSC	20 µm	Relatively rapid and easy	Sample size dependent Destructive Expensive
FTIR	25 µm	Non-destructive	Suitable for solids only Expensive Stationary instrument
Raman spectroscopy	1 µm	Identifies microplastics in liquid and solid samples Non-destructive	Expensive Stationary instrument
Pyr-GC-MS	50 µm	Identify OPAs No pre-treatment is necessary	Expensive Destructive Stationary instrument

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Density analysis	Independent of size	Inexpensive and transportable	Use of hazardous salts Modifications of the plastic changes its density

Table 2. Description of the plastic types considered in this study and their resin code. Data obtained for Moret-Ferguson et al (2010). In addition, the table contain the densities ranges, in g/cm^3, of PET, HDPE, PVC, LDPE, PP, PS, EPS and PA with common modification. The data was obtained from Dean and Lange 2001; Liu and Chen 2014; and Shackelford et al 2015.

Plastic type	Source	Resin Code	Density range (g /cm^3)
PET	Water bottle	1	1.34–1.39
HDPE	Shopping bag	2	0.941– 0.965
PVC	Garden hose pipe	3	1.16– 1.35
LDPE	Bottle cap	4	0.910–0.925
PP	Cup	5	0.89–0.91
PS	Petri dish	6	1.04– 1.07
EPS	Packaging	6	0.015 –0.050
PA	Fishing net	7	1.01-1.14

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Table 3. A Summary of solutions used in this experiment, their densities. The desired density of the solution was selected using plastic density data. The ethanol and water solutions were made using data from the Kolb and Kolb (1991) and Scott (1946) whereas the sugar and water compositions were calculated using the Brix equation from Millero et al (1976)

Solutions	Composition of the solution	Density g/cm^3
Ethanol	100% EtOH	0.79
Low density ethanol-water solution	10:7 EtOH/H_2O	0.91
High density ethanol-water solution	7:11 EtOH/H_2O	0.93
Distilled water	100% H_2O	0.999
Low density sugar-water solution	18% $C_{12}H_{22}O_{11}$ in H_2O	1.07
Medium density sugar-water solution	38% $C_{12}H_{22}O_{11}$ in H_2O	1.17
High density sugar-water solution	70% $C_{12}H_{22}O_{11}$ in H_2O	1.36
Very high-density	80% $C_{12}H_{22}O_{11}$ in H_2O	1.42

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sugar-water solution

Table 4. Recorded buoyancies of the different polymer types alongside the solution composition and the source of the polymer.

Plastic type	Source	Solution							
		99% Ethanol	10:7 Ethanol	7:11 Ethanol	100 % Water	18% Sucrose	38% Sucrose	70% Sucrose	80% Sucrose
PET	Water bottles	Sink	Sink	Sink	Sink	Sink	Sink	Sink	**Float**
HDPE	Shopping bag	Sink	Sink	Sink	**Float**	Float	Float	Float	Float
PVC	Garden hose pipe	Sink	Sink	Sink	Sink	Sink	Sink	**Float**	Float
LDPE	Bottle cap	Sink	Sink	**Float**	Float	Float	Float	Float	Float
PP	Cup	Sink	**Float**	Float	Float	Float	Float	Float	Float
EPS	Packagin	**Float**	Float	Float	Float	Float	Float	Float	Float

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	g								
PS	Petri dish	Sink	Sink	Sink	Sink	Sink	**Float**	Float	Float
PA	Fishing nets	Sink	Sink	Sink	Sink	**Float**	Float	Float	Float

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