Analysis of Microplastic Fibre Distribution around the Coastal Zones of the Islands of Samos and Lipsi, Greece

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Abstract

Microplastic accumulation is a growing concern within the marine environment. However, little is known about the sources and processes of distribution. This case study focuses on the Greek islands of Samos and Lipsi in the eastern Aegean Sea and assesses the levels of microplastic fibres in beach sediments. Beach sediment samples were processed using filtration and analysed via microscopy. All samples were found to contain microplastic fibres of a variety of colours, with transparent fibres being the most abundant. The synoptic weather state of the sampling days are also presented.

- **Keywords: [Marine] [Pollution] [Aegean Sea] [Plastic Debris]**

1. Introduction

This study examines the distribution of microplastics (MP) as a source of plastic contamination within the eastern Aegean Sea, Greece, and land based sources of both Samos and Lipsi islands, which are presented as case studies. Additionally, the effects of wind direction on the accumulation and translocation of MP's are considered. This type of geophysical approach is necessary in order to properly quantify the pollution of plastic marine debris, enabling the discussion of factors contributing to MP distribution through the sea. Plastic waste has accumulated in the environment through a combination of inefficient waste management and aimless discard where, subject to wind driven transport, it commonly reaches the coast (Kukulka et al, 2012). Defined as a length of <5 mm, MPs can be of either primary (purposefully manufactured to be of microscopic size), or secondary (derived from the fragmentation of macroplastic items) origin (NOAA, 2014). Within the environment these macroplastics degrade via either physical, chemical or biological means (Corcoran et al, 2009). MP's display a variety of forms, from fragments to spherules, but previous studies have found fibrous MP to be the most dominant (Thompson et al, 2004). Therefore, this research will only focus on MP fibres. Plastic debris displays vertical distribution within the upper water column due to wind guided mixing. Total oceanic and coastal land plastic concentrations are considered to be vastly underestimated by traditional practices, requiring a revision of existing plastic marine debris data sets (Kukulka et al, 2012). This research aims to contribute to a more comprehensive understanding of the sources and sinks of MP fibres in the marine environment around the eastern Aegean islands and provide information to stakeholders that will lead to greater awareness and future preventative measures.

2. Materials and Methods

2.1. Sample acquisition: Beach sediments were sampled from the last shoreline at 13 sites in Samos and 10 sites in Lipsi. These locations represented areas of diverse land use; including rural beaches, popular tourist sites and within the vicinity of waste water treatment plants (Fig 3, Fig 4). A 50x50cm quadrat was placed and, using a metal scoop, the top layer of sediment was collected with a maximum depth of 5cm and contained within a glass jar. Care was taken to selectively sample sediment with stones of a size <3cm.

2.2. Preparation of samples: MP fibres were extracted using standard methodology (Thompson *et al*, 2004; Claessens *et al*, 2011). 200g of each sediment sample was mixed with 200ml saturated salt solution and shaken vigorously. Solution was left for at least 12 hours to allow positively buoyant MP fibres to float to the surface. The supernatant was then extracted with a glass syringe and the process was repeated to obtain any residual MP fibres left in the sediment. As the saline solution had a density of 1.2 g cm^{-3}, and with typical MP density ranging from 0.917 (Polyethylene) to 2.3 (Polyester) g cm^{-3}, this method only enabled extraction of the lower density MP fibres. For example PVC, which contributes 19% to the global plastic production, could not be removed with this method

(Hidalgo-Ruz *et al*, 2012). Extracted supernatant was then processed using Whatman 1.2µm GF/F filters and a vacuum filtration apparatus.

2.3. Microscopy: Dried filter papers were analysed through a 10x magnification lens. Identity classification of fibres met the agreed characteristics; being distinctive from the filter paper, a size >5 µm and featuring curvature. Both fibre colour and quantities were recorded and means quantified to an established unit (kg^{-1}) (Claessons, 2011).

2.4 Synoptic Weather: Synoptic Weather parameters for both sampling periods are presented, sourced from HNMS (Fig 1, Fig 2).

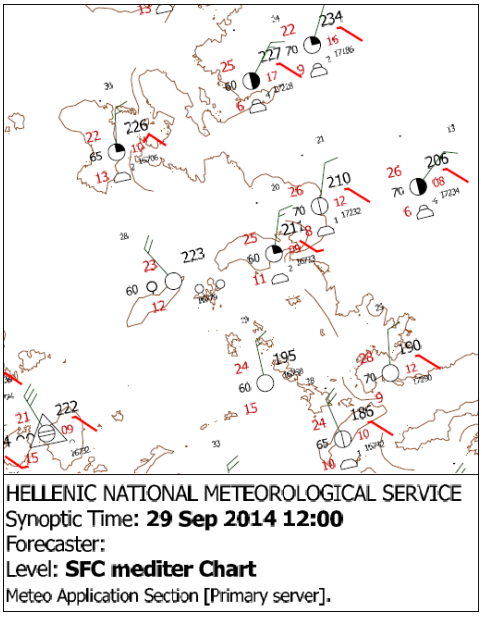

Fig.1. Synoptic weather data around Samos (HNMS, 2014).

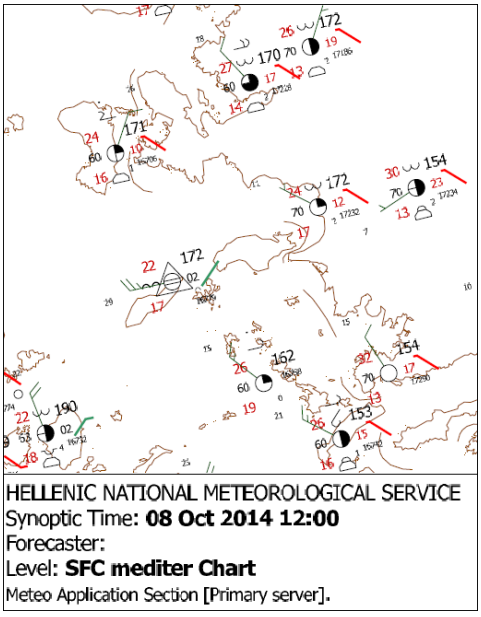

Fig.2. Synoptic weather data for the sampling period (HNMS, 2014).

3. Results

The results presented in Fig 3 and Fig 4 show the quantities of individual coloured and transparent MP fibres in each point surveyed. The greatest abundance of all colours of MP fibres recorded are shown at Samos site 11A (122 fibres kg^{-1}) and Lipsi site 10B (118 fibres kg^{-1}). The lowest amounts were found in Samos site 3 (63 fibres kg^{-1}) and Lipsi site 3 for (50 fibres kg^{-1}). Both islands exhibited greater MP fibre abundance on their southern sites. Sites situated in the near vicinity of local wastewater treatment plants on both islands, located at Lipsi site 1 and Samos site 1, exhibited some of the largest quantities of coloured fibres recorded; 60 fibres kg^{-1} and 67 fibres kg^{-1} respectfully. On the first sampling day of Samos, Fig 1 shows a wind field from the North; a total of 855 kg^{-1} MP fibres were recorded. The second sampling day of Samos, Fig 2 shows the wind direction from the North, North West; 580 MP fibres kg^{-1} were logged.

#	Land use
1	Medium [Tourism; Sewage treatment plant]
2	High [Tourism]
3	Low
4	Medium [Tourism]
5	Low [Tourism]
6	High [Tourism; Port]
7	High [Tourism]
8	High [Tourism; Port]
9	Medium [Agriculture; Tourism]
10	Low
11	Medium [Tourism]
12	Low
13	High [Tourism; Sewage treatment plant; Port]

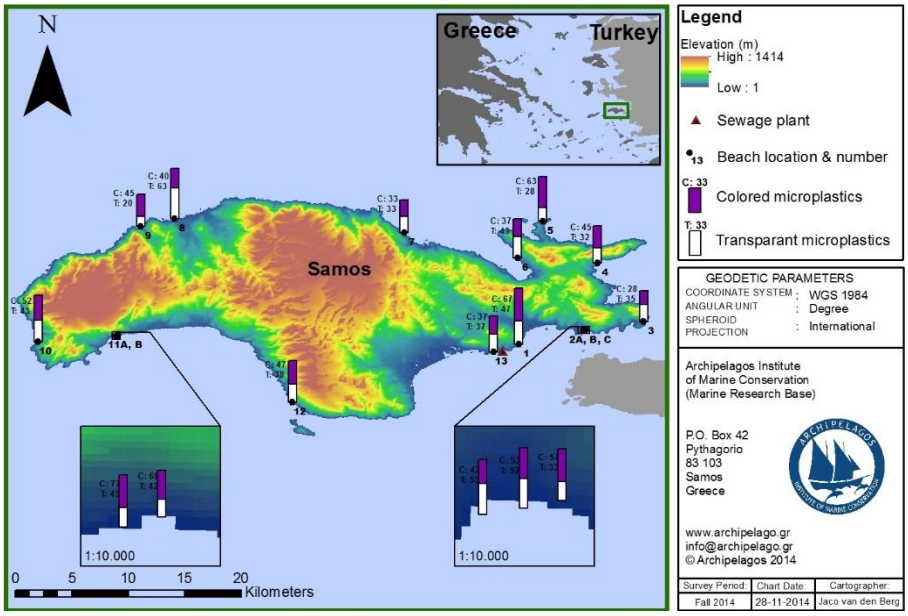

Fig.3. Quantities of transparent and coloured MP fibres found within sediment samples around Samos for the period of September/October 2014. Data is expressed as kg^{-1}. Level and type of land use are also presented

#	Land use
1	Medium [Sewage treatment plant]
2	Medium [Agriculture; Tourism]
3	Low [Agriculture; Tourism]
4	Low [Agriculture]
5	Medium [Waste site]
6	Medium [Tourism]
7	Medium [Former Aquaculture; Port]
8	Low [Tourism; Agriculture]
9	Low [Tourism]
10	Medium [Tourism; Port]

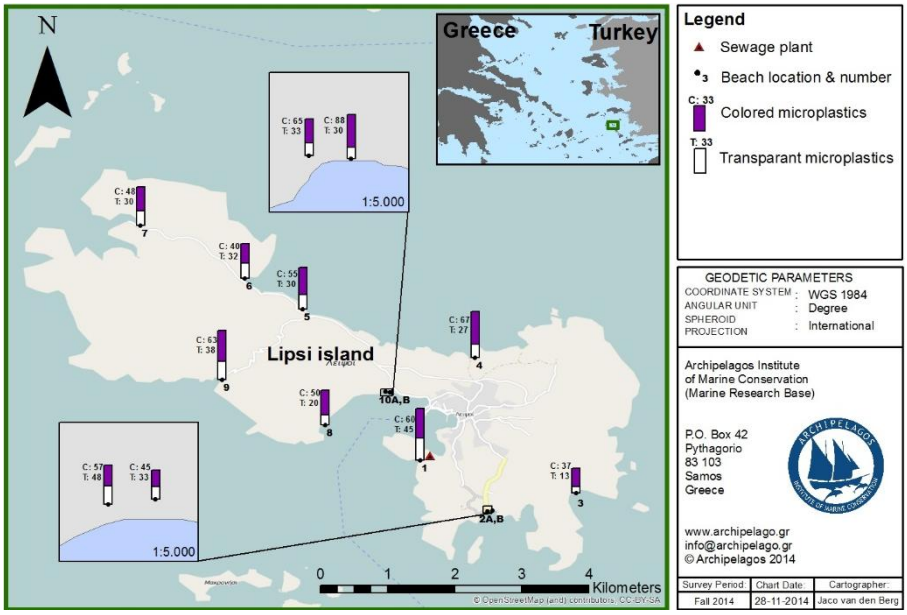

Fig.4. Quantities of transparent and coloured MP fibres found within sediment samples around Lipsi for the period of late October 2014. Data is expressed as kg^{-1}. Level and type of land use are also presented

4. Conclusions/Discussion

Presented are the first results of a larger scale research currently taking place across Samos and Lipsi islands. MP fibres were recorded at each of the 23 sampling sites, providing further evidence for the widely accepted concept that MP fibres are ubiquitous in the marine environment (Thompson et al, 2004). Quantities of transparent MP fibres prevailed above all other colours observed on both islands. In Samos transparent MP fibres were almost double the amount than of any other colour found so it is safe to assume that the origin of these

transparent MP's corresponds to the dominance of transparent plastic used in packaging, clothing and fishing lines (Cole et al, 2014).

Previous studies have suggested that coloured MP's originate from synthetic fishing lines and nets, but also from cloth fibres that enter the marine environment through wastewater effluent (Browne et al, 2011; Free et al, 2014). Large abundances of coloured fibres located in the area of wastewater treatment effluent on both islands, in conjunction with previous studies, provides further evidence that household waste is a key source of coloured MP pollution (Browne et al, 2011).

Densely populated and common tourist regions displayed equivalent levels of MP fibres in comparison to less populated areas, suggesting no correlation between land use and quantity of MP fibres. Surface velocity fields created by the currents, Ekman transport, affects the MP's distribution and can enable increased frequency of MP's in remote areas due to greater transport availability (Kukulka, 2012; Francois, 2004; Hidalgo-Ruz et al, 2012). The second phase of the study will continue analysis of beach sediments and concentrate on the effects of seasonal changes of the weather. Finally, this study aims to focus attention on the fine balance required between preventative measures and management of plastic waste.

5. Acknowledgements

We would like to thank E. Kardasi from HNMS for their invaluable help in collecting wind data.

6. References

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