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Distribution and abundance of surface water microlitter in the Baltic Sea: A comparison of two sampling methods

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ABSTRACT

Two methods for marine microlitter sampling were compared in the Gulf of Finland, northern Baltic Sea: manta trawl (333 μm) and a submersible pump (300 or 100 μm). Concentrations of microlitter (microplastics, combustion particles, non-synthetic fibres) in the samples collected with both methods and filter sizes remained <~10 particles m^{-3}. The pump with 100 μm filter gave higher microlitter concentrations compared to manta trawl or pump with 300 μm filter. Manta sampling covers larger areas, but is potentially subjected to contamination during sample processing and does not give precise volumetric values. Using a submerged pump allows method controls, use of different filter sizes and gives exact volumetric measures. Both devices need relatively calm weather for operation. The choice of the method in general depends on the aim of the study. For monitoring environmentally relevant size fractions of microlitter the use of 100 μm or smaller mesh size is recommended for the Baltic Sea.

1. Introduction

Litter is one of the most ubiquitous environmental pressures in both marine and freshwater environments, receiving increasing publicity and causing a lot of concern. Marine litter has most profound negative effects on the ecosystem health, but there are also negative effects on the society coupled to costs for cleaning beaches and loss of tourism (UNEP, 2009). Studies carried out during the last decade have repeatedly pointed out the pervasive occurrence of microscopic litter particles, in particular microplastics in marine environments (GESAMP, 2015). This new knowledge has raised a lot of concern because of the potential risks that different microscopic plastic polymers pose to marine organisms. Microplastics are of concern especially because they can potentially be ingested by a variety of marine organisms (Thompson et al., 2004, Besseling et al., 2014, Watts et al., 2014), and also be transferred along the food web (Eriksson and Burton, 2003, Setälä et al., 2014), and the fact that these items cannot be removed from the marine environment. In contrast: their abundances are supposed to be increasing due to direct discharge as well as the fragmentation of larger litter items with time.

Recommendations for sampling and sample treatment are presented in the monitoring guidance documents for marine litter in European Seas (Galgani et al., 2013, JRC, 2013). However, as noted in the document, all these methods are not yet harmonized. There is still lack of methods for quality assurance/quality control and a need for method development. The need for harmonized sampling methods for marine microlitter, or their optimization and inter calibration has been noted by several researchers, e.g. Magnusson and Norén (2011), Lusher et al. (2015), Syberg et al. (2015) and has also been brought up in the guidance documents. Research on microplastics is proceeding fast with numerous new studies giving more information on these topics. In the Baltic Sea, however, there is presently still relatively little information on the distribution and abundance of microlitter in different habitats (Magnusson and Norén, 2011, Magnusson, 2014, Gorokhova, 2015).

The aim of this study was to produce data for the development of harmonized methods for collecting microlitter on sea surface in the Baltic Sea region. The two methods compared in our study were the commonly used manta trawl, and a prototype of a submersed pump sampler.

The "Manta Net" was originally designed for collecting organisms and flotsam from the sea surface already in the 1980s' (Brown and Cheng, 1981). After that modifications of the early manta trawl have been used for collecting surface floating litter in world's oceans (e.g. Eriksen et al., 2013, 2014). Submerged pumps have been used for microlitter sampling on the Swedish coats since 2010 (Magnusson and Norén, 2011). The use of the submerged pump in this study also allowed us to compare how the filter size used affects the number and type of the collected microlitter.

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2. Material and methods

The study was carried out during the COMBINE 3 monitoring cruise (26.–30. 8. 2013) on board the R/V *Aranda*, in the Gulf of Finland. Samples were collected from 12 sampling stations (Fig. 1.) that represented open sea conditions, except for two sampling sites (Kotka and Helsinki) that situated close to active shipping harbors.

2.1. Manta trawl

In our study we used the suitcase manta trawl (designed and manufactured by Marcus Eriksen, 5 Gyres Institute). This trawl has a rectangular opening of 16 cm (height) × 61 cm (width) and the net mesh size of 333 μm. It has two wings that keep it in balance and at surface during the tow, letting the mouth sink 0.25 m in the water. At the end of the trawl there is a removable collecting bag ("cod end"). The hood of the manta trawl deflects wave crests into the submerged net and captures volumetric measure at the sea surface. The recommended tow speed for the original prototype of manta trawl is 0.26–2.6 m s^{-1} (0.5–5 knots; Brown and Cheng, 1981), while the suitcase manta has been towed successfully with the speed between 0.5 and 1.5 m s^{-1} (Eriksen et al., 2013, 2014).

2.2. Submersed pump sampler

An electrically driven impeller pump (MEI standard 2.2 kW motor, 3 phase @ 400 V) was mounted inside a stainless steel box with 2.5″ PVC and stainless steel tubes and fittings (ASME-BPE standard, vendor www.gpa.se). The pump model was chosen due to its good suction capability and the impeller was made of silicone rubber. At the inlet side a 4″ (diam. 108 mm) stainless steel clamp holds the sampling filter between the clamp flanges. No gasket was used. This ensures that the sampled water passes through the filter before being in contact with any part of the pump, pipes or hose, which minimizes contamination from airborne particles. The pump rate was electronically controlled using an adjustable speed drive (ABB ACS355). The flow rate was measured using a ×3 flow meter mounted 700 mm downstream a straight ø50 mm PCV pipe with a total length 1000 mm. This placement ensured a more laminar flow for the flow meter impeller. The pump was attached to a flexible drainage hose (PVC coated rubber) with ø50 mm. All couplings in the systems were 2″ Camlock couplings. In this study the pump was equipped with 300 μm or 100 μm mesh size filters during sampling (referred to pump 300 and pump 100 in this study). The filters were mounted from nylon plankton net and kept clean in Petri dishes until use.

2.3. Sampling and sample treatment

The manta trawl was towed on the port side of the research vessel, the towing point situated approximately 4 m away from the hull (Fig. 2.). Care was taken not to steer the trawl close to turbulent flow coming from the ship's side propellers. Manta trawl was always deployed directly after the pumping was conducted on a station when ship was moving with the wanted speed. The calm weather conditions during the cruise were optimal for using the trawl. The manta trawl was always towed at a low speed since estimations of the sampled water volumes became inaccurate with increasing speed due to the bouncing actions of the trawl on the crests of the waves. Different towing times were tested, and for most of the times a tow lasted for 10 min at a speed of 2.5 knots. The trawl was equipped with a water flow meter (Tsurumi-Seiki 3567, Tsurumi Seiki Co Ltd) to calculate the volume of the inflowing water. After the trawl was taken up from the water it was rinsed with sea water. The sample in the collecting bag was washed thoroughly under a hood into a clean jar. Large organic particles were removed from the sample by hand with tweezers, rinsed above the jar and after that the jar lid was closed. The sample was consecutively concentrated by filtering onto a 300 μm nylon mesh, each filter placed in a pre-cleaned Petri dish and stored in an oven until dry (60 °C). One manta tow resulted in several sub-samples depending on the amount of organic material in the sample. No protocol blanks for manta were used.

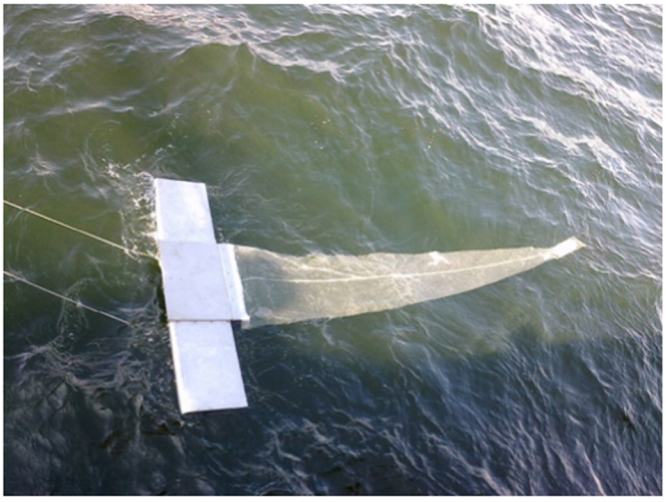

Fig. 2. Manta trawl deployed for sampling on the vessel side.

The pump was deployed from the back of the vessel using the ship winch. It was lowered until the opening of the filtering manifold was just below the surface (Fig. 3). This depth varied between

Fig. 1. Sampling sites in the Gulf of Finland.

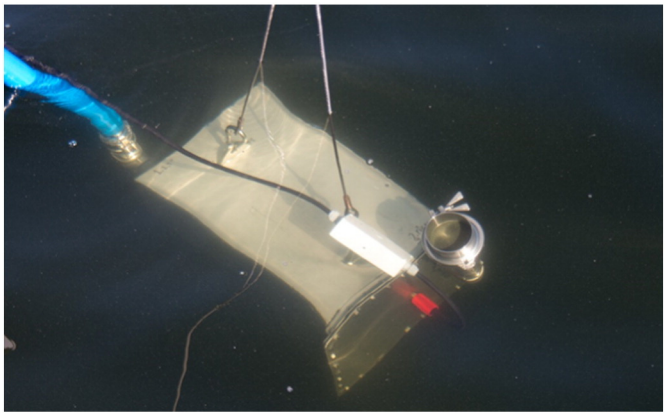

Fig. 3. The submerged pump.

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