HELCOM BLUES case study: Microplastic concentrations in marine bottom sediments of the German Baltic Sea

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Introduction

Activity 3 "Marine Litter" of the HELCOM BLUES project (HELCOM BLUES 2022) aims to promote the harmonisation of regional work on marine litter indicators and threshold values as well as ensuring alignment with the work of the EU's MSFD Technical Group on Marine Litter (TG Litter). Therefore, guidelines on monitoring microlitter in seabed sediments and surface water have been drafted according to existing approaches and feasibility (HELCOM BLUES Microlitter Group 2022). These draft guidelines are currently applied as a case study to seabed sediments from the southern Baltic Sea.

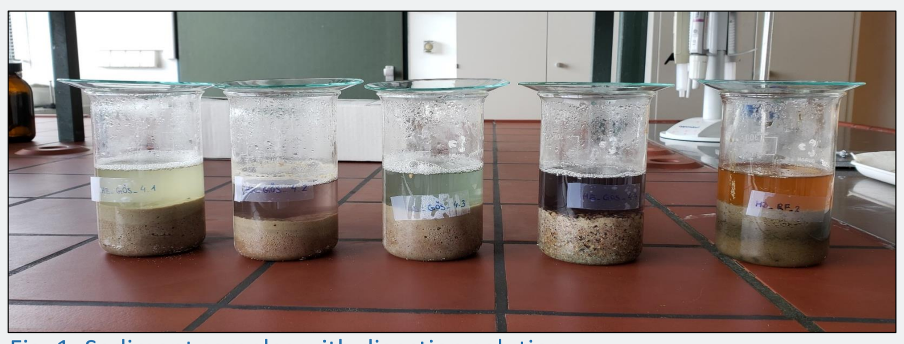

Fig. 1: Sediment samples with digestion solution.

Study Area

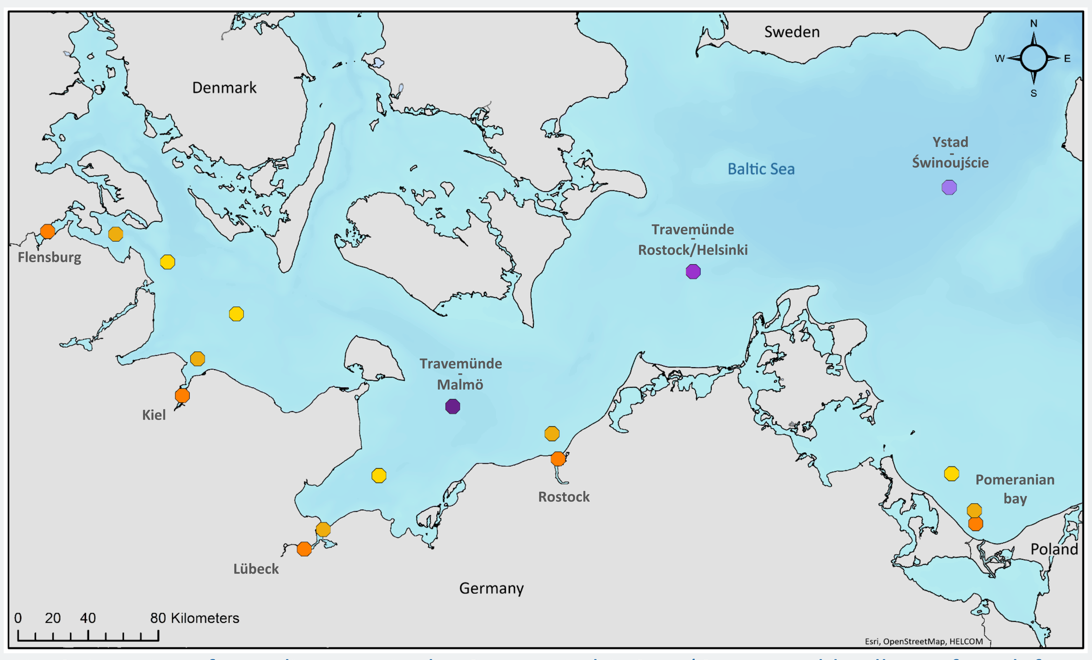

Fig. 2: Location of sampling sites in the German Baltic Sea. (Orange-gold-yellow = from left to right, stations with increasing distance to coastline. Purple = offshore stations).

Within the Baltic Sea region, a total of 29 grab sediment samples were taken in cooperation with Federal Agencies of Schleswig-Holstein and Mecklenburg Western-Pomerania in 2021 and 2022. Sampling sites (Fig. 2) were located in the region of Flensburg, Kiel, Lübeck, Rostock and Pomeranian bay. Three samples with increasing distance to the coastline were taken within each area. Three offshore stations within the Exclusive Economic Zone (EEZ) were also included in the study. Three parallel samples were taken in Rostock and the offshore stations to determine the variations of different grab samples.

Material & Methods

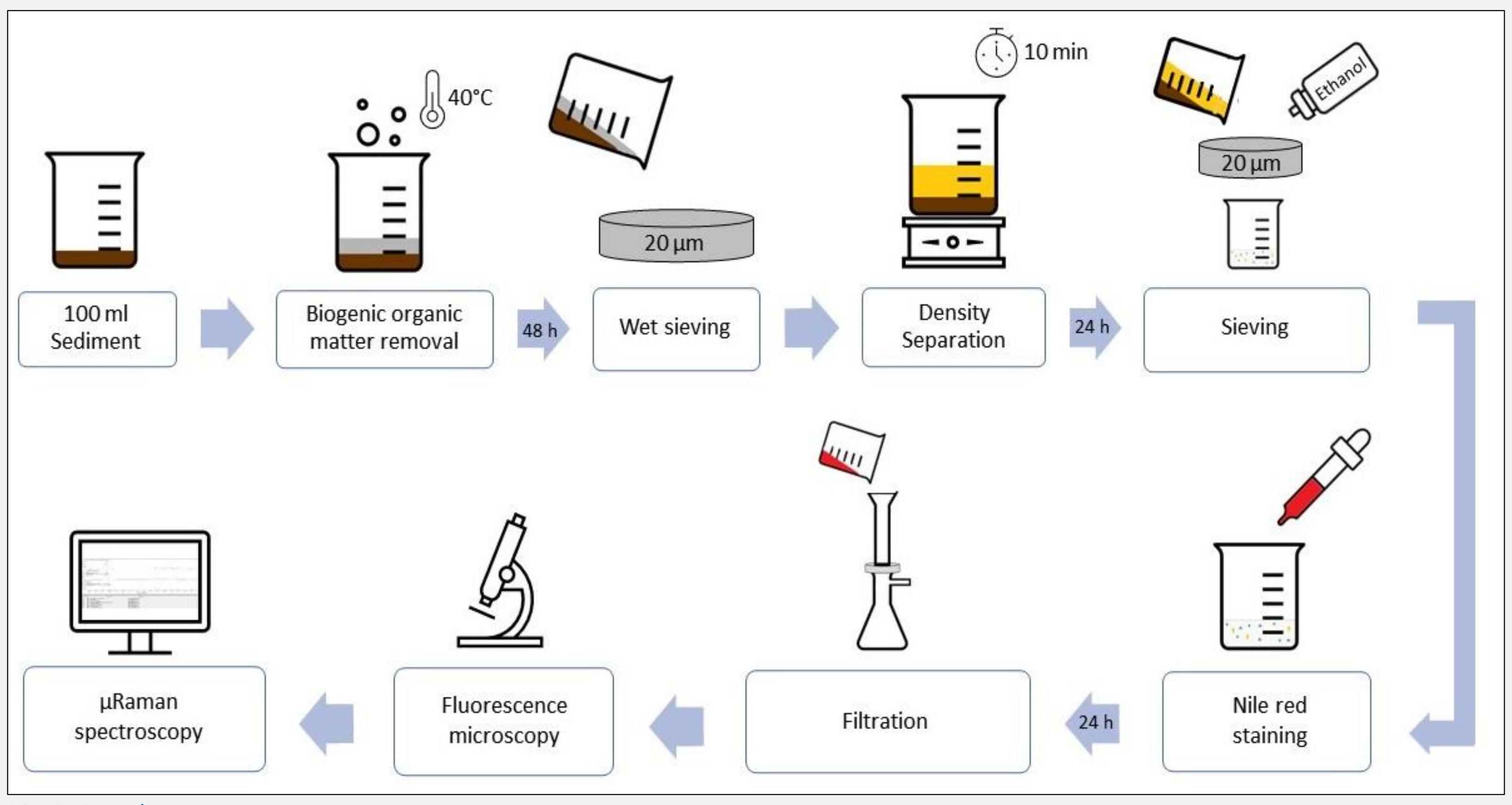

Fig. 3: Sample treatment.

Sample treatment

Removal of biogenic organic matter from the sediment was performed by adding a digestion solution (NaClO 6-14% and KOH 10M) (Fig. 1) that was allowed to stand at 40 °C for 48 hours with a subsequent wet sieving (20 µm). To extract the microplastic particles, a density separation was carried out. Therefore, NaI was added (density: 1.7 g/cm^3) at a ratio of 1:2, the sample was mixed with glass magnetic stirrers for 10 minutes and then left for settling for 24 hours. Then, 50 % of the supernatant was transferred over a 20 µm sieve and the sieving residue was captured within a beaker with ethanol. This was repeated twice to increase the efficiency. Sample suspensions were stained with Nile red (1 mg/ml in chloroform) and transferred to aluminium oxide filters (Anodisc 25, Whatman, 0.2 µm retention). Potential microplastic particles were detected via fluorescence microscopy (Axioscope 5/7 KMAT, Zeiss). A subset of particles is currently under investigation for polymer composition via µRaman spectroscopy (DXRxi2, Thermo Fisher Scientific) (Fig. 3). Along the microplastic analysis, sediment parameter such as water and organic matter content and grain size of the sediment is analyzed (in processing).

Recovery tests

To assess extraction efficiency, a reference sample was analyzed with each series of samples. For this purpose, a sand matrix was spiked with microplastic reference particles consisting of PET particles (125-200 µm). The recovery rate of a total number of 7 reference samples was > 60 %. Further processing to improve recovery is currently in progress.

QA/QC management

Precautions have been taken in order to reduce background contamination as much as possible. Therefore, glass and stainless-steel materials were used, all chemical solutions were filtered (691, VWR International, 1.6 µm retention) as well as the integration of field and procedural blanks. Between 3 and 8 particles per blank sample were found.

Results & Discussion

Microplastic concentrations and variations

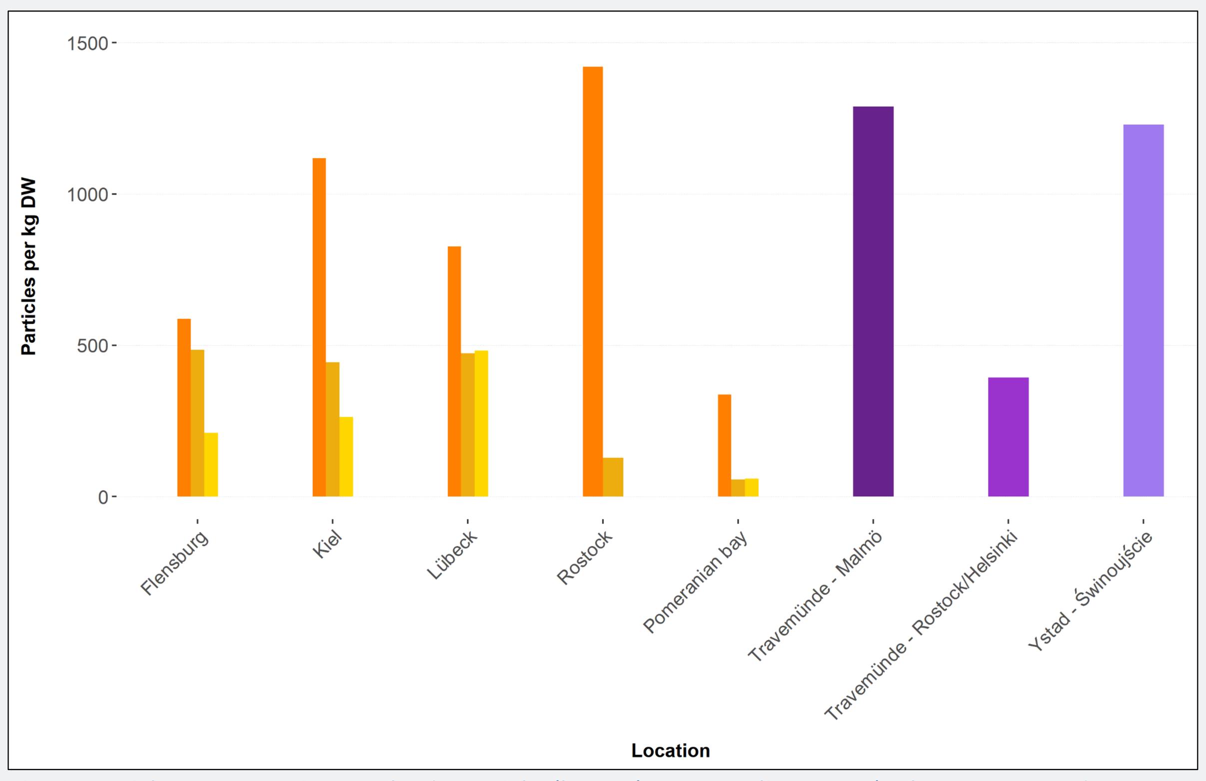

Fig. 4: Particle concentration per kg dry weight (kg DW) per sampling area. (Colors correspond to sampling points in Fig. 2).

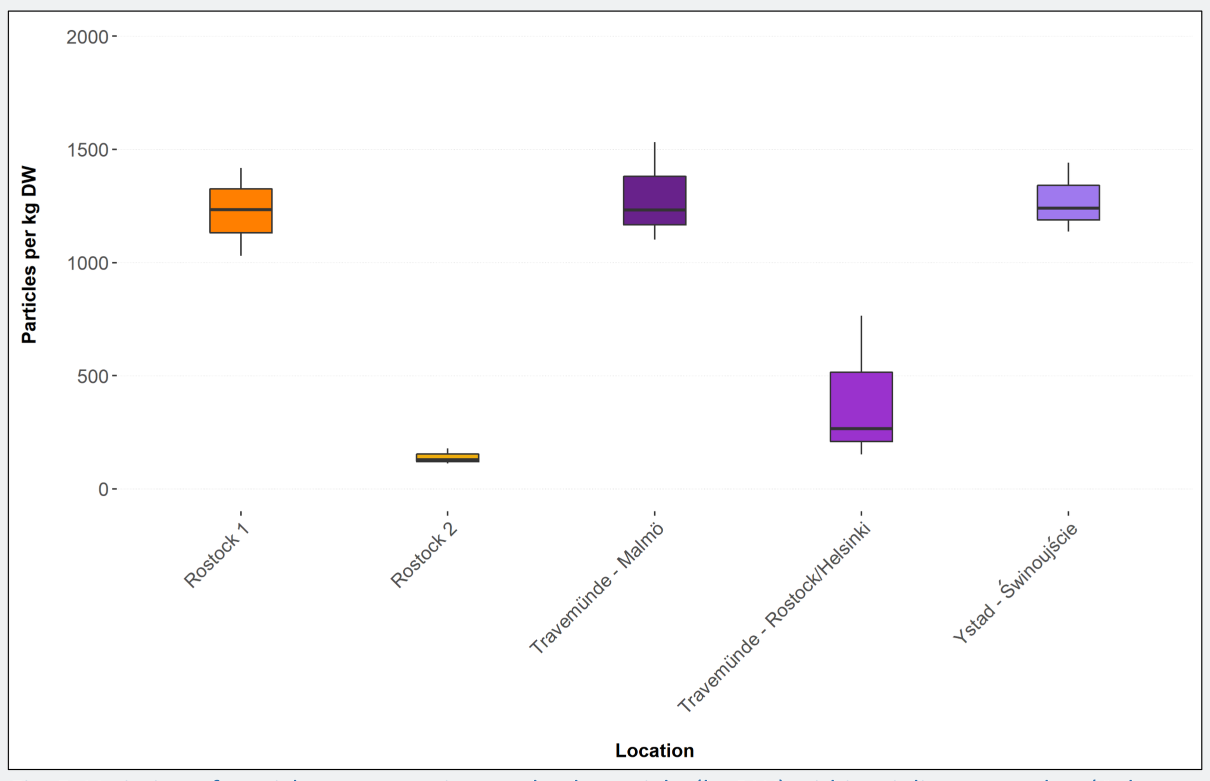

Fig. 5: Variation of particle concentration per kg dry weight (kg DW) within triplicate samples. (Colors correspond to sampling points in Fig. 2).

Particle size and morphology

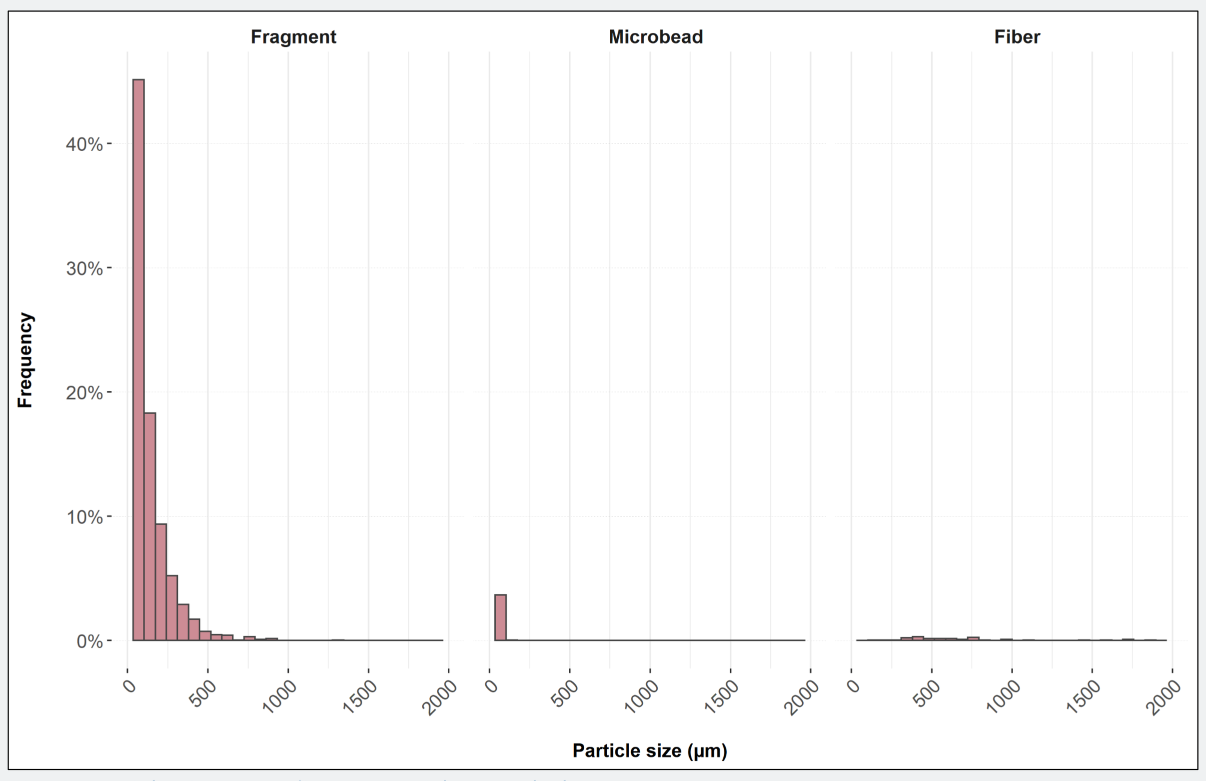

Fig. 6: Particle size according to particle morphology.

Figure 4 shows the microplastic particle concentration per kilogram dry weight (kg DW) of the different sampling sites. Within all samples, a total of 9,847 microplastics per kg DW are recorded. Regarding the coastal locations, the highest amount was found in the Rostock Warnow estuary with 1,420 microplastics per kg DW. Particle concentrations in the inner fjord and estuary area show the highest concentrations with decreasing particle numbers with increasing distance from the coastline for the stations Flensburg, Kiel and Rostock. In contrast, the two more remote sites of Lübeck bay and Pomerania bay show similar results. The higher amount of microplastic particles in fjords and estuaries has already been demonstrated in other studies (Harris 2020). For the offshore area, the Travemünde-Malmö site with 1,289 microplastics per kg DW shows the highest concentration. The sites are expected to be influenced by river inputs (Schmidt et al. 2017) or show distinct reduced flow velocities (Chubarenko et al. 2022). However, due to single sampling no significant differences can be calculated for the sampling sites and within the respective transect.

Particle concentrations of the triplicate sampling are shown in Figure 5. With 217 particles, the samples of the Travemünde-Rostock/Helsinki site have the highest variation. The Rostock samples have the lowest variation with 35 particles. Small-scale variations in sediment grain size and organic matter that are currently processed will be taken into account for further analysis of influencing factors.

Concerning the morphology of the particles, predominately fragments (92 %), followed by microbeads (6 %) and fibers (2 %) were found. The size frequency of the particles are shown in Figure 6. The fragments measure between 20 µm and 1316 µm (131 ± 121) with an increasing frequency at a decreasing particle size across all sites. The highest abundance of fragments are in the size class 20-100 µm.

Regarding microbeads, the measurements vary between 20 µm and 114 µm (43 ± 17). The highest concentration with 152 microbeads per kg DW were counted in the estuary area of Lübeck.

Conclusion

The sediment of the German Baltic Sea is contaminated with microplastics, with a tendency of decreasing microplastic concentration with increasing distance from the coast. Furthermore, higher concentrations are found again at the offshore stations. Triplicate samples show that different grab samples could result in different concentration amounts. Further analysis regarding the grain size and organic matter of the sediment need to be finalized to determine the influence on the particle concentration.

References

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