Microplastics in the Hamburg port area – An analysis of sediments from the upper tidal Elbe

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MICROPLASTIC RESEARCH AT CEN

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Introduction

Harbors pose a unique environment of increased anthropogenic pressure and artificial river morphology that are of specific interest concerning microplastic release and accumulation. Slowed flow velocity conditions within the harbor estuary could potentially act as important sinks for microplastic particles.

To address the specific situation in the Hamburg port area we conducted a study in cooperation with the Hamburg Port Authority (HPA). This study aims to find similarities in microplastic abundance within the locations as well as to gain a further understanding about microplastic accumulation within the Upper tidal Elbe river.

Study Area & Methods

A total of 31 sediment samples in depth profiles were taken at seven sites with similar flow velocity and underlying morphology. Two of the sampling sites were located upstream and downstream of the port of Hamburg, while four sites were located in the center area of the port. An additional site took the estuary of a receiving stream flowing into the Upper river Elbe into account. For the sampling location Este a Frahm-Lot model with a circumference of 10 cm in diameter was used. The remaining samples were taken using a Frahm-Lot sediment core with a circumference of 15 cm in diameter.

At each sample site one core was extracted resulting in cores up to 50-90 cm below ground level (bgl). Cores were divided by 10-30 cm according to horizon lines on site. For the first 0-2 cm bgl samples, the upper soil depth level was carefully extracted using a stainless steel spoon and placed into amber glass jars. Materials were cleaned with MilliQ-water and blanks were taken for each location to detect the contamination during sampling. All samples were taken at low tide. Additionally, water parameters and flow velocity were conducted at each location using a CTD water sampler (Turner Cyclops-7).

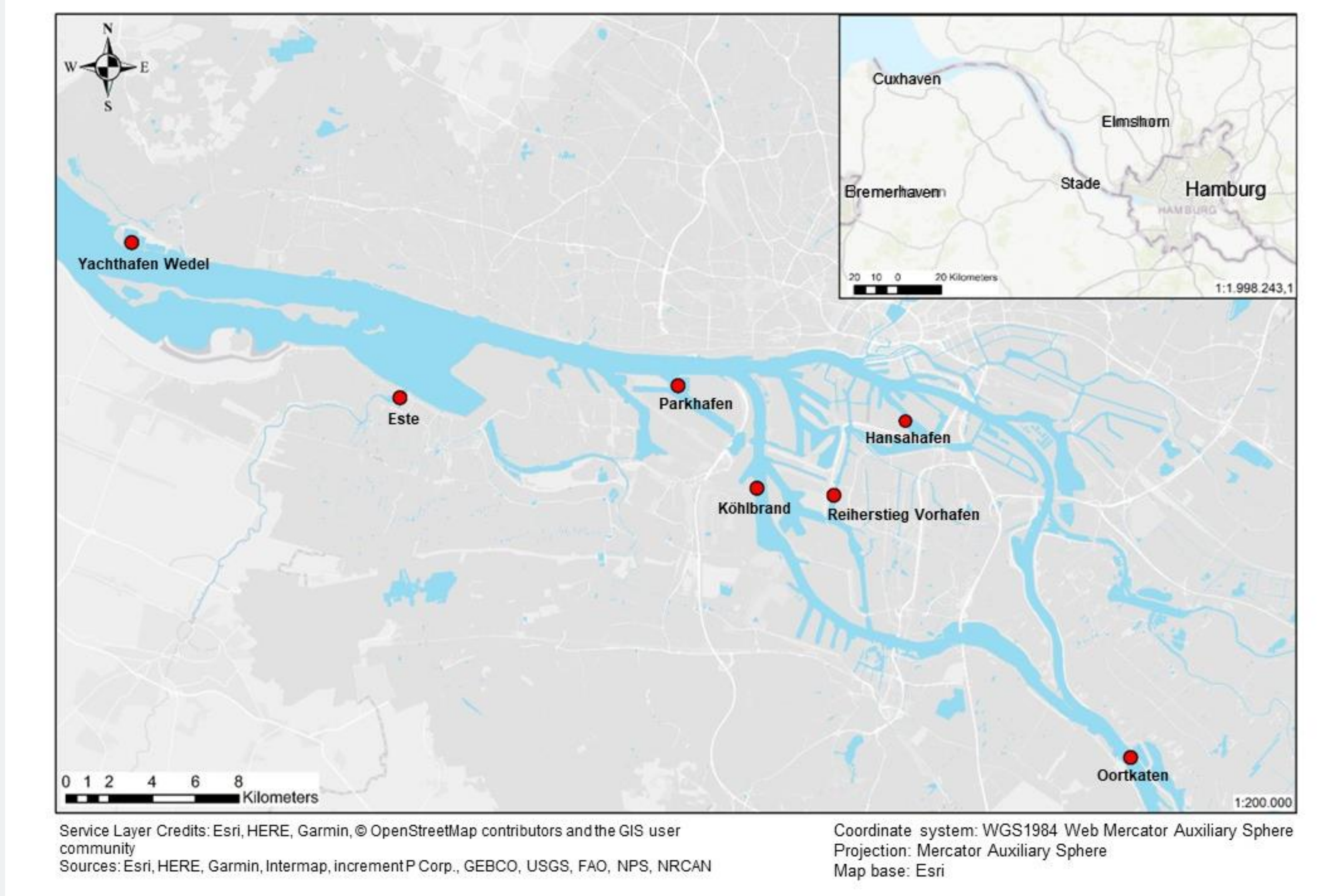

Fig. 1: Study area at the Elbe river within the wider area of the port of Hamburg. Red points mark the sampling sites.

Material & Methods

For the analysis of microplastic concentrations in the samples, the biogenic organic matter was removed by digestion (H_2O_2 10 %, NaClO 6-14 %) followed by wet sieving and density separation with NaI (density: 1.5 - 1.6 g/cm³). For this step, the sample was given into a 1 L glass column which was subsequently filled with NaI solution (Fig. 2). The column was shaken twelve times and left for a sedimentation period of 10 min before the remaining sediment material on the bottom of the column was slowly removed via the tap at the base. The supernatant left in the column was filtered onto a paper filter (413, VWR International, 5-13 µm retention) using vacuum filtration. For identification the Nile red staining method in combination with fluorescence microscopy (AxioLab A.1, Zeiss, TRITC HC Filterset (AHF), 2.5x) was applied. A random subset of 101 identified synthetic polymers was investigated for polymer composition via µRaman spectroscopy (DXR2xi Raman Imaging Microscope, Thermo Fisher Scientific). During every laboratory step, blank samples were taken and subtracted from the sample results. Parallel to the microplastic analysis, soil parameters such as water and organic matter content and grain sizes were determined.

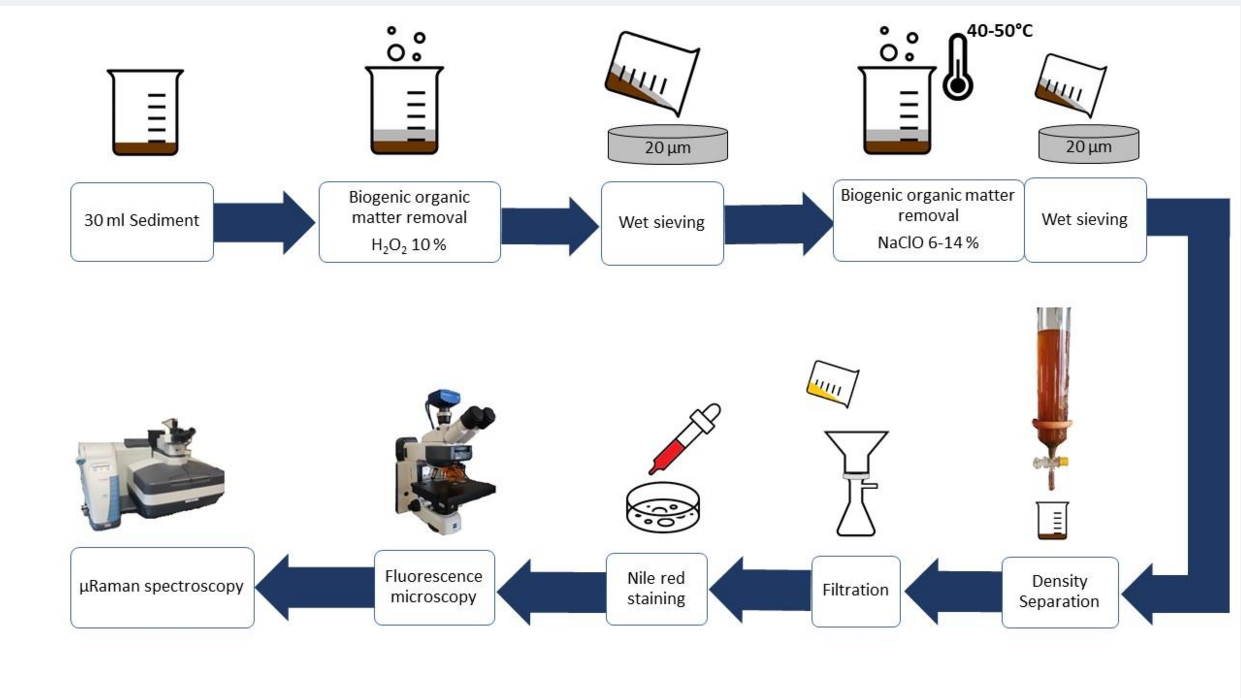

Fig. 2: Flowchart of the laboratory analysis

Results & Discussion

Fig. 3: Particle concentration and shape distribution at all locations (different scales at Hansahafen, Parkhafen and Reiherstieg Vorhafen).

Microplastic Abundance

A total number of 11,280 microplastic particles were detected. The results were all converted into particles per kilogram dry sediment (per kg DS). The highest concentration of microplastics was found at Reiherstieg Vorhafen (473 min – 21,799 max particles per kg DS). This site also displayed the highest level of contamination at depth level three (20-40 cm depth bgl). In contrast, the lowest number of particles found was at Hansahafen (60 min – 526 max particles per kg DS). Note worthy about this study site is the fact that the most frequent particle shape found were microbeads. The most common shape in all the other locations analyzed were fragments (Fig. 3). In addition, microplastic particles in the 20-100 µm size range were the most frequent as seen in Fig. 5.

Polymer composition

For the µRaman spectroscopy analysis a random subsample of 101 particles were analyzed for polymer composition. The most common compositions found were PVC (34 %) and PET (28 %). Other materials found include, PE (11 %), PS (11 %), VA (8 %), PA (6 %), Rubber (2 %) and PR (1 %) (Fig. 4). Results indicate, that microplastics with a higher density such as PVC and PET sink to the river sediment compared to those with lower density.

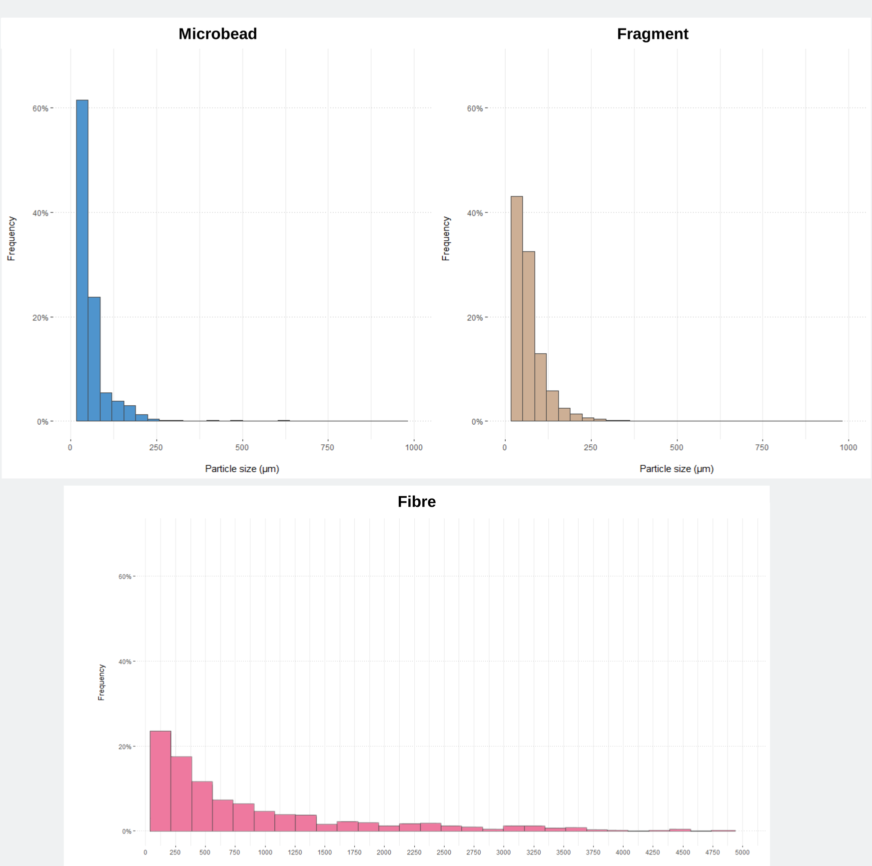

Fig. 5: Frequency distribution of particle sizes (µm) of microbeads, fragments and fibres.

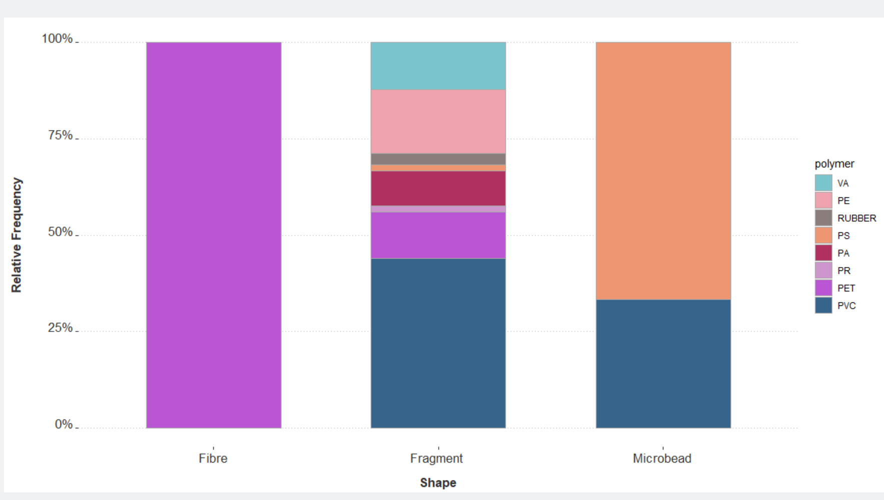

Fig. 4: Comparison of the relative frequency of polymer types by shape

Microbeads

Microbeads could be detected at all locations. Since mostly PS and PVC microbeads were found, an industrial source of pollution can be assumed, as they can be used in cleaning products, printer toners and industrial products such as abrasive media (Sundt et al. 2014). As for PS microbeads in specific, they are also frequently used as ion-exchange resin beads (Scherer et al. 2020, Mani et al. 2018). As Fig. 6 depicts, PS and PVC microbeads display morphological differences thus multiple sources of origin seem likely.

Conclusion

- Microplastics were identified in all samples
- The lowest amount of microplastic contamination, across all locations, was found at the first depth level
- A substantial amount of PS as well as PVC microbeads were found
- Most common polymer type detected is PVC

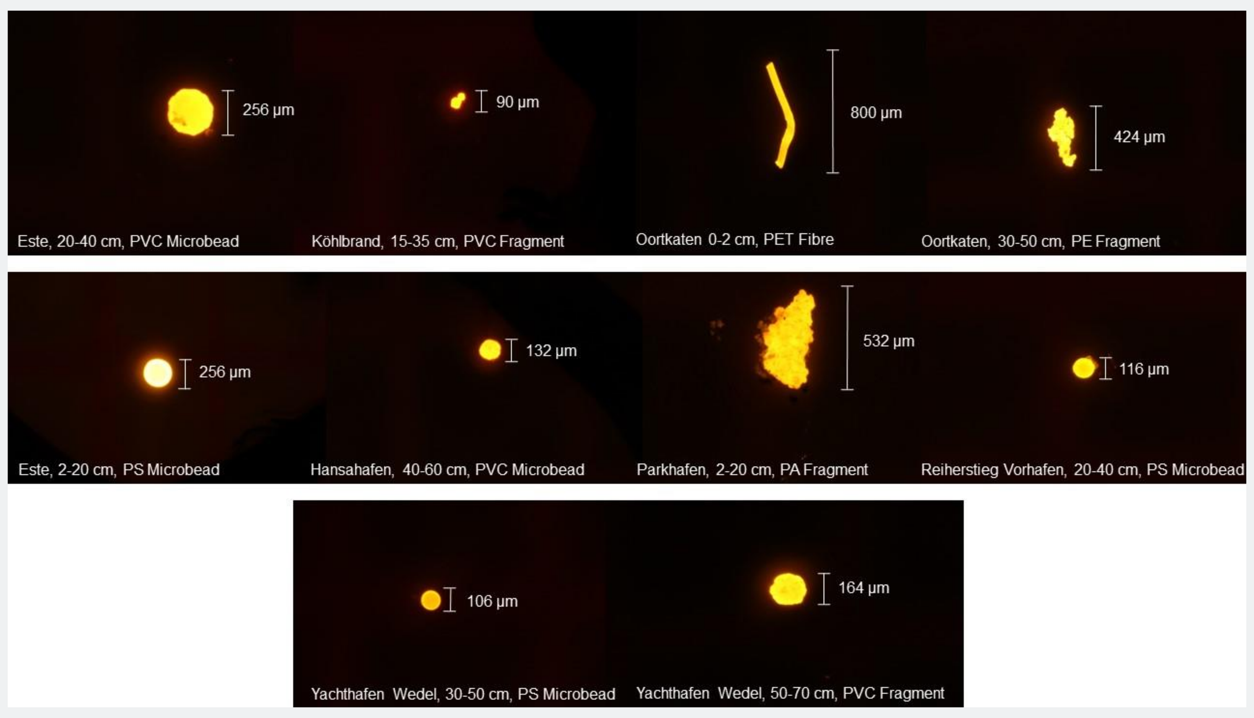

Fig. 6: Microplastic Particles comparision under the fluoresence microscopy

References

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