Spatial and seasonal distribution of plastic and zooplankton in a continuous environment: Elbe and Thames Rivers and North Sea

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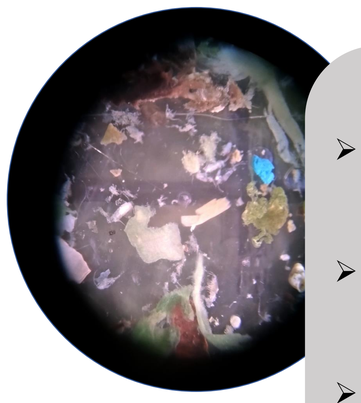
INTRODUCTION

Plastic pollution is present in all aquatic systems studied with concentrations and characteristics varying across different environments, influencing the fate of the particles in each system (Andrady, 2017). In particular, quantification and characterization of plastic particles and zooplankton in the natural environment is the first step to further understand the impact of plastic pollution in planktonic ecosystems (Kosore et al., 2018; Rist et al., 2020).

This study quantify and characterized plastic and zooplankton concentrations in surface water from the Thames River, the Elbe River and the North Sea during different seasons in 2022 and 2023. Plastic and zooplankton were collected along 18 stations with a manta net, scanned using the ZooScan and polymers were identified using infrared hyperspectral imaging.

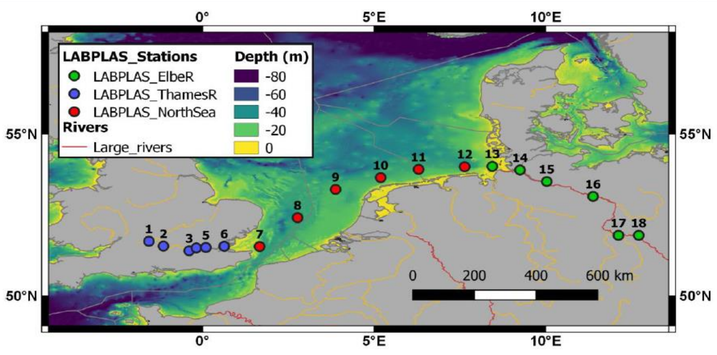


OBJECTIVES

- Quantification and characterization of plastic particles and zooplankton organisms in Elbe River, Thames River and North Sea.
- Examining the spatial and temporal distribution of zooplankton and plastic particles in relation to the hydrodynamics and geographical characteristic of the systems.
- Understanding the exposure of zooplankton to plastic to assess the potential transfer of plastic in marine food webs.

MATERIAL & METHODS

PLANING → SAMPLING → ANALYSIS

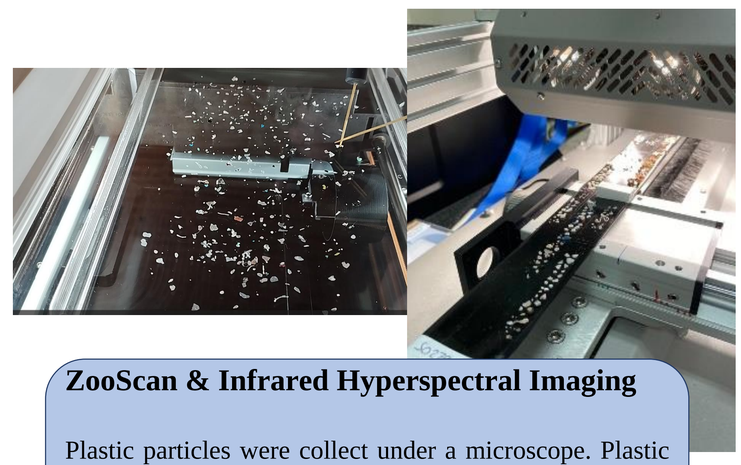


Sampling stations

Thames River (blue dots): 6 stations
North Sea (red dots): 6 stations + (intermediates)
Elbe River (green dots): 6 stations
Seasonal sampling was performed during 2022 and 2023.

Manta net (335 µm)

Plastic and zooplankton were sampled using a manta net in both, rivers and sea. A flowmeter was install for measuring the volume sampled.

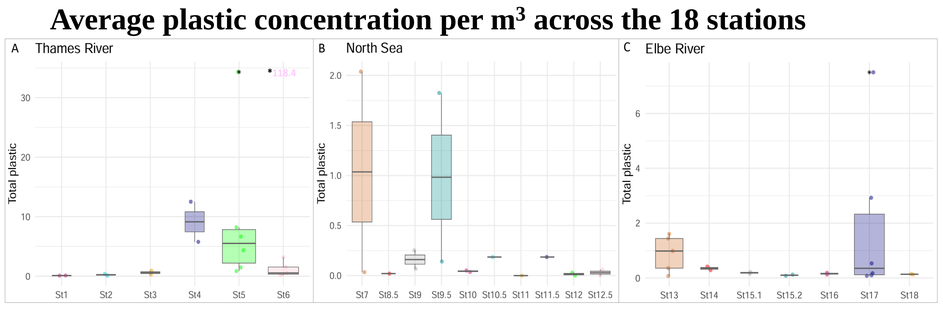


ZooScan & Infrared Hyperspectral Imaging

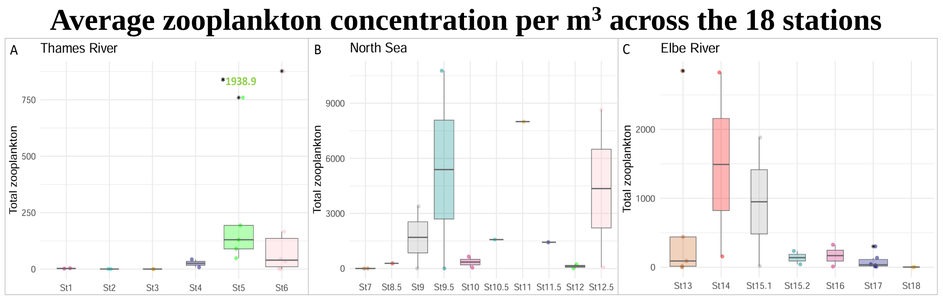
Plastic particles were collect under a microscope. Plastic particles and zooplankton were analyzed using ZooScan scanner and ZooProcess software.
Infrared Hyperspectral Imaging was used for polymer identification.

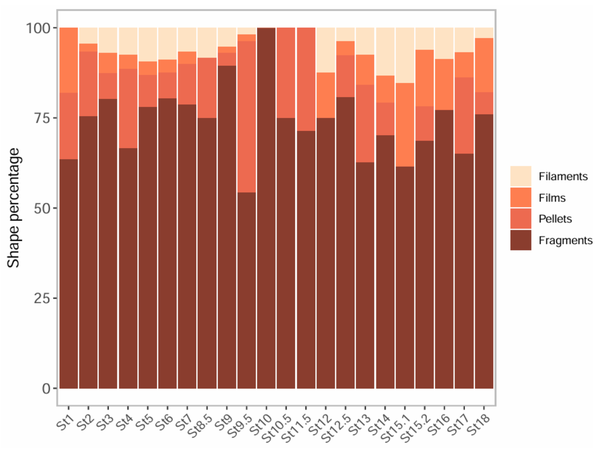
RESULTS AND DISCUSSION

Average plastic concentration per m^3 across the 18 stations

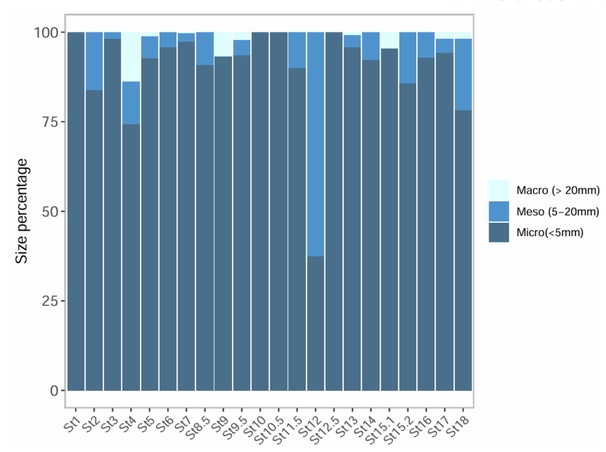


Average zooplankton concentration per m^3 across the 18 stations

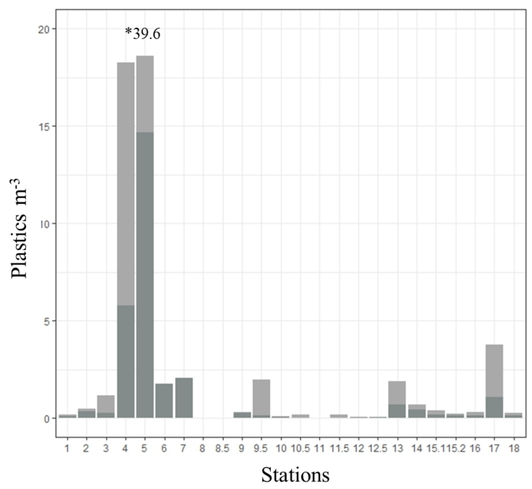




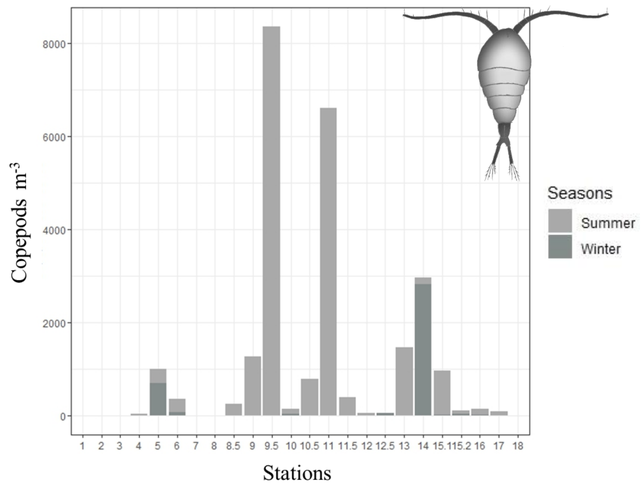
Fragments is the most abundant plastic shape in all stations, followed by pellets, filaments and films. Overall, fragments constitute 72.4%, pellets 14.6%, filaments 7.9%, and films 5.1%.



Plastic and zooplankton concentrations in summer and winter across the 18 stations



Microplastic concentrations range from 0 to 39.6 MPs m^3 in station 6, (Thames River) in summer. Thames River presents the highest plastic concentration with an average of 12.40 plastics m^{-3}, followed by Elbe River (0.88 plastics m^{-3}) and North Sea (0.30 plastics m^{-3}). In Thames, the highest concentrations are found in the stations closest to London, whereas, in Elbe River plastic is more abundant in the areas influenced by the tide.



Zooplankton concentrations in the North Sea (average 2194.03 ind. m^{-3}) are higher than those in the Elbe River (471.5 ind. m^{-3}) and the Thames River (228.8 ind. m^{-3}). Copepods, in particular, were found in the North Sea during the summer of 2023, with 1783 ind. m^{-3}, while the lowest concentration was recorded in the winter of the same area, with 16.3 ind. m^{-3}.

Dimensions of the plastic particles found in the three aquatic

	Thames River			North Sea			Elbe River		
	Area (mm^2)	Feret (mm)	ESD (mm)	Area (mm^2)	Feret (mm)	ESD (mm)	Area (mm^2)	Feret (mm)	ESD (mm)
Average	4.24	2.44	1.49	1.56	1.68	0.96	3.28	1.95	1.21
SD	31.48	3.46	1.78	9.76	3.58	1.03	46.22	2.98	1.65
Median	0.78	1.51	0.99	0.35	0.89	0.66	0.61	1.30	0.88
Min	0.07	0.35	0.30	0.07	0.36	0.30	0.07	0.36	0.30
Max	1608.44	72.34	45.25	319.56	65.91	20.17	2150.17	71.31	52.32

As shown in other regions, the smallest plastic sizes predominate (Cui et al., 2022). Microplastics (<5 mm) were the most abundant particles with 91% in the rivers and 80% in North Sea. However, in terms of mass, macroplastics (>20 mm) present the highest weight despite being present in only 8 stations.

CONCLUSIONS

- Plastic concentrations in rivers are higher than in the sea. Fragments, (<5mm), are the most common particle shape, with polyethylene being the most prevalent polymer.
- Microplastic concentrations in rivers vary significantly across different seasons and locations.
- Zooplankton concentrations are higher in the North Sea than in the rivers, potentially indicating a lower risk of plastic ingestion by zooplankton.
- To compare plastic mass fluxes from rivers to the sea further analysis is needed.
- Temporal variability in the hydrographic conditions, such as tidal regime, could explain the high variability in distribution and concentrations of plastics.

REFERENCES: **Andrady, A. L**. (2017). The plastic in microplastics: A review. *Marine Pollution Bulletin*, *119*(1), 12–22. **Kosore, C.** et al. (2018). Occurrence and ingestion of microplastics by zooplankton in Kenya's marine environment: First documented evidence. *African Journal of Marine Science*, *40*, 225–234. **Rist, S.** et al. (2020). Quantification of plankton-sized microplastics in a productive coastal Arctic marine ecosystem. *Environmental Pollution*, *266*, 115248. **Cui, Y.** et al. (2022). Microplastics in the surface waters of the South China sea and the western Pacific Ocean: Different size classes reflecting various sources and transport. *Chemosphere*, *299*, 134456.

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