Macro and microplastic litter in Belgian fishery areas: conclusions and recommendations from the EMFF-funded project MarinePlastics

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Summary

At the end of the project MarinePlastics, research institutes ILVO and RBINS present new and important facts about plastic pollution in the Belgian part of the North Sea. These findings prompted clear and concrete recommendations for plastic pollution management and reduction:

- **Finding and implementing a biodegradable alternative for dolly rope should be on top of the priority list,** as fishing line monofilaments (mainly used s dolly rope in fishing nets) are the main plastic item found throughout our part of the North Sea. They are more evenly distributed than heavier plastics (e.g. crates, bottles and containers), which are mainly found nearby the coast. Depending on sampling method, 77 to 88 % of the macrolitter items are plastic.
- **A detailed study is needed on marine litter hotspots, investigating the impact of different sources and modelling litter transport processes.** During the project, no link was found with sand extraction or offshore windfarms. Neither was a direct link found with fishing distribution, although >50 % of the macrolitter was attributed to fisheries activities. A macrolitter hotspot was identified at one dredge disposal site, although the potential correlation with higher mud content and other hydrodynamic processes need to be further investigated.
- **A national monitoring programme for microplastics needs to be established to comply with European obligations**. **The microplastics pathways in the marine environment, potential hotspots and link with macrolitter distribution need to be investigated**. In this study, the microplastics concentration in coastal sediments (nearby Zeebrugge) was about nine times higher than offshore. In seawater, the difference was even more spectacular: water from the harbour of Zeebrugge and near the coast had respectively a 49 and 10 times higher content compared to more offshore locations. At present, there is no monitoring program that tracks the evolution of this type of pollution in Belgium.
- **The public should/can be informed that seafood from Belgian fishing grounds are currently a safe product in terms of microplastic pollution**. In this study, it was established that microplastics >50 µm do no accumulate in commercial fish and crustaceans sampled on fishing grounds of the Belgian fishing fleet. In almost all fish and crustacean samples (both edible and non-edible parts), microplastics counts were below the limit of quantification. In only 5 out of 42 fish filets, 6 to 2 microplastic particles per 100 g fish filet were found, which is not alarming. However, further research on the occurrence and risks of smaller particles (<10 µm) and nanoplastics is recommended.

Introduction

Up to 80% of the waste in our oceans is plastic, with yearly 4.8 to 12.7 million tons of plastic entering the marine environment (Gesamp, 2019; Jambeck et al., 2015). Although multiple size definitions can be found in literature, marine macrolitter is most commonly defined as litter items >25 mm, followed by mesolitter (25 - 5 mm), microlitter (50 - 1 µm) and nanolitter (<1 µm) (Gesamp, 2019). Several land- and sea-based human activities are sources of marine litter. Micro- and nanoplastics may enter the oceans directly in the form of small particles released from household and industrial products, but can also be formed through degradation of larger waste into smaller pieces (Boucher & Friot, 2017).

Fishery activities are a source of marine litter, e.g. by lost fishing gear or by the wear and tear of dolly rope filaments, whereas the fishing industry can also be affected by marine litter, e.g. damaging of fishing nets by large litter items, and the fact that smaller micro- and nanoplastics may be ingested by seafood (FAO, 2017). A detailed investigation of (macro)litter contamination on the seafloor in Belgian fishery areas will increase our knowledge on sources, sinks and distribution of litter.

As plastics are widespread and highly persistent in the marine environment, several reduction measures and objectives have already been defined at federal[1] and Flemish level[2], within a.o. the Marine Strategy Framework Directive (MSFD) and the Plastic Strategy at European level, and at global level within the UN Environment Programme concerning the 17 defined Sustainable Development Goals for 2030. The Marine Strategy Framework Directive plays a key role in the evaluation and the protection of the European marine environment. Marine litter is defined as one of the eleven descriptors of MSFD, with two primary objectives put forward, stating that the levels of marine macro- (D10C1) and microlitter (D10C2) in the marine environment do not cause any harm. Two other secondary objectives are linked to the impact on marine organisms, stating that the health of species should not be adversely affected by marine litter, either through ingestion, entanglement, or other types of injury.

Equally, a proper follow-up of the marine litter levels is necessary to evaluate whether the proposed measures are effective and appropriate to reach the good environmental status with regards to litter. According to the MSFD specifications, the levels of visible litter items at the coastline need to be monitored and may additionally be monitored near the seafloor or in the surface water layer. Microlitter should be monitored both in the seafloor sediment and the water column. However, microlitter analysis involves a completely different approach than macrolitter, and comes with several methodological challenges. As such, the elaboration of a dedicated monitoring programme for microlitter in sediment and seawater in the Belgian Part of the North Sea (BPNS) is required to complement the Belgian set of MSFD monitoring programmes[3].

Within the project MarinePlastics, funded by the European Maritime and Fisheries Fund (EMFF), ILVO and OD Nature-RBINS aimed: (1) to investigate the sources and distribution of macrolitter in Belgian fishery areas in correlation to different human activities at sea; (2) to initiate a national microplastic monitoring programme in Belgian marine water and sediment, (3) to measure the occurrence of

[1] Actieplan marien zwerfvuil (belgium.be)
[2] Vlaams Integraal Actieplan Marien Zwerfvuil (ovam.be)
[3] https://odnature.naturalsciences.be/msfd/nl/monitoring/2020/

microplastics (>50 µm) in several seafood organisms caught in the Belgian fishery areas, and (4) to establish an efficient management of marine litter data.

Main project results

Macrolitter in relation to fisheries and other human activities at sea

Two different datasets were used to assess marine macrolitter concentrations on the seafloor in the Belgian fishery area. The environmental monitoring campaigns of ILVO (EMC; data from 2013-2019) offer a unique dataset with a high number of fish tracks in the BPNS, and many samples in the coastal environment, all sampled with a small-meshed (10 mm) shrimp trawl net. The second dataset, gathered within the ICES international beam trawl survey (BTS; 2011-2019), is sampled with a bigger mesh sized net (40 mm), but has the advantage to cover the wider Belgian fishery area, including the North Sea, the English Channel, the Celtic Sea and the Irish Sea.

On average 12.7 ± 17 macrolitter items per ha were recorded within the 12 nMile zone of BPNS (EMC data). The amount of litter items caught within the BTS fish tracks is much lower, on average 2.2 ± 2.8 items per ha, where the difference is mainly explained by the bigger mesh size of the net.

Seafloor litter largely consists of macroplastics: up to 88% (EMC) or 77% (BTS) of all litter items caught in the net were made of plastic. Clear spatial differences were observed in the distribution pattern of specific litter items. Heavier litter items from land-based sources, such as plastic bottles, crates and containers are mainly found in the coastal area, at least for the BPNS, whereas lighter low density filaments, fishing lines and other types of synthetic ropes are more equally distributed over de BPNS (Fig. 1). In the larger BTS area, fishing line monofilaments were found at higher densities in the Dutch part of the North Sea (Fig. 2).

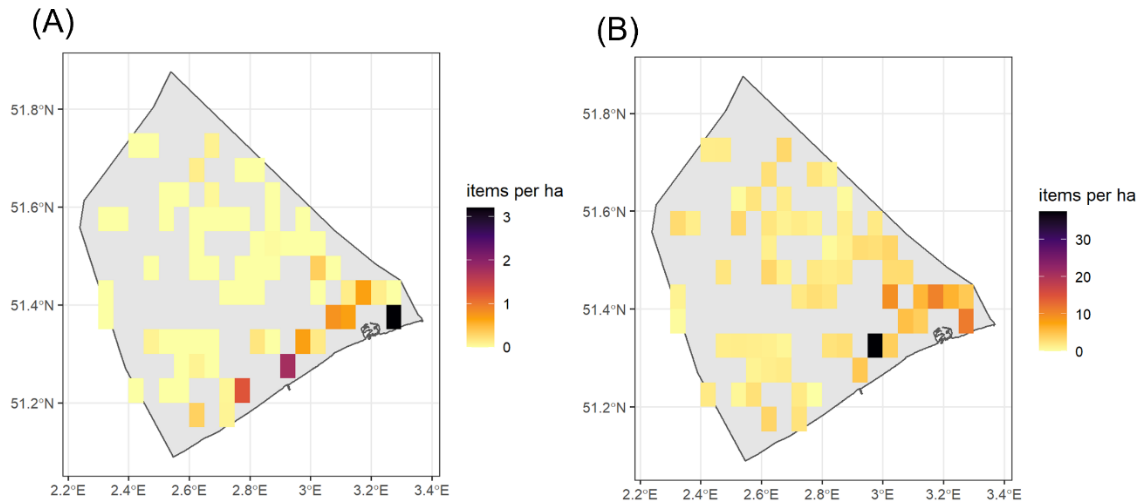

Figure 1. Average number of litter items per ha for the different categories (BPNS, pooled data, 2013-2019). (A) plastic bottles, crates and containers and (B) fishing line monofilaments, fishing line entangled and ropes.

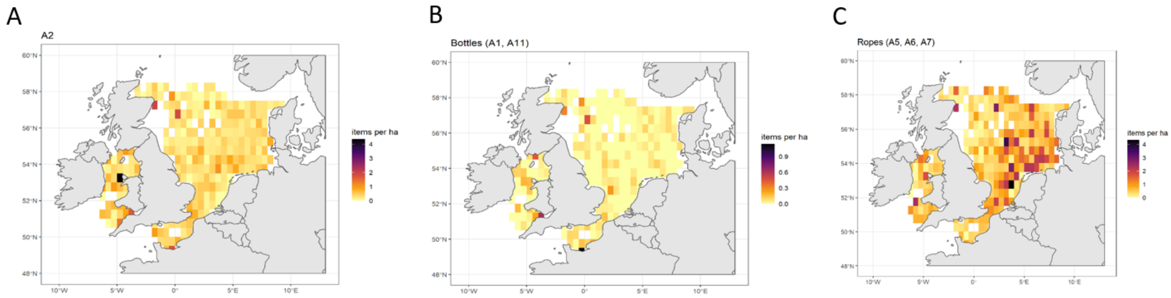

Figure 2: Average number of litter items per ha for the different categories (BTS, pooled data, 2011-2019). (A) plastic sheets (B) plastic bottles, crates and containers and (C) fishing line monofilaments, fishing line entangled and ropes.

Correlations between the distribution of marine macrolitter and the presence of human activities are difficult to make. Different environmental factors, including hydrodynamic and geomorphological characteristics, have an impact on the distribution patterns of marine macrolitter, but also the human activities themselves may have moved or displaced the marine litter. Anyhow, no increased amount of litter items was noted at the sand extraction areas nor the offshore windfarm areas in the BPNS, and also no clear links could be made between the spatial distribution of fishery activities and fisheries-related litter items. Nevertheless, fisheries are an important source of marine litter: up to 52% of all macrolitter items collected in the offshore area of the BPNS can be linked to fisheries.

Concerning dredge disposal, a hotspot marine litter location was identified in dredge disposal site BR&WZE at the eastern coastal zone of the BPNS. On average 61 ± 79 macrolitter items per ha were caught in the net on the dredge disposal site, compared to 15 ± 15 litter items per ha in the nearby zone and 12 ± 14 litter items per ha in more remote reference zones. It remains unclear if the high amount of litter items at this site is solely related to the high intensity of dredge disposal activities in this area or a combined result from dredge disposal with hydrodynamic processes such as sedimentation. Therefore, we recommend a detailed investigation on the sources and the processes affecting litter accumulation in this area to efficiently remediate hotspot areas.

Microplastics in marine sediments and surface waters in the BPNS

Microplastics were assessed in both marine sediments and surface waters of the BPNS. An accurate and reliable methodological protocol has been elaborated, based on a thorough literature review (including project reports such as from the JPI Ocean project BASEMAN), exchange of information via expert groups and several tests. The lower size limit was set at 100 µm, based on international guidelines and harmonization efforts.

Figure 3 Generalized overview of methodological protocol for microplastic analysis

The concentration of microplastic particles in coastal sediments nearby Zeebrugge is about 9 times higher (182.3 ± 128.7 per kg dry weight sediment) than at the offshore location (20.8 ± 4.2 per kg dry weight) (Fig. 4). More than 60% of the microplastic particles had sizes between 100 and 350 µm, which is the smallest size class considered. Part of the variation between sediment core replicates can be attributed to differences in sediment composition, with more plastic particles present when the organic matter content and the amount of mud are higher. This was also recorded in other studies and attributed to the influence of hydrodynamic forces on the grainsize of the sediment and the distribution and migration of microplastics in intertidal zones (Maes et al. 2017; Wang et al. 2018). Subsampling within one sediment core showed uniform results, indicating the methodology is reliable and repeatable.

Similar to the results in sediment, the concentration of microplastics in seawater is much higher in the harbour of Zeebrugge and the nearby coast (1475 and 300 ± 177 particles/m^3, respectively) compared to the more offshore locations in the BPNS (30 ± 14 particles/m^3) (Fig. 4). These results are based on samples taken via the continuous vessel inlet system, except for the harbour where the amount of suspended matter is too high and only Niskin bottles were used. Additionally, a relatively high variability was observed by repeated measurements in coastal seawater. This is most probably related to the fact that floating microplastics are highly mobile and hence influenced by meteorological and hydrodynamical conditions (Maes, 2017).

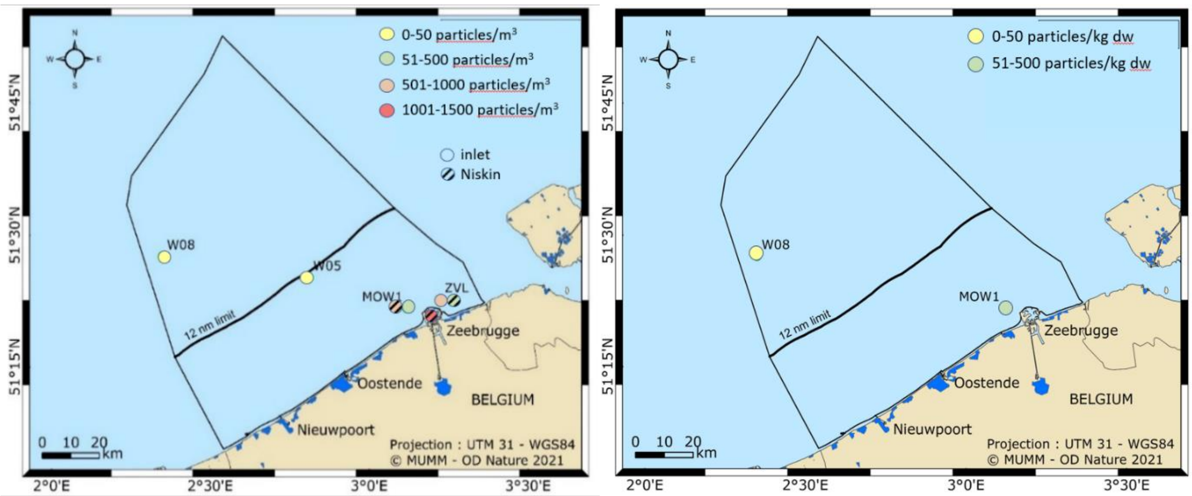

Figure 4: Microplastics particle number in seawater (left) and sediment (right) in the Belgian Part of the North Sea

Differences in the shape of microplastics were observed between sediment and water samples, with more fragments or pieces (60%) found in sediment samples, whereas fibers were dominant in seawater samples (74%) (Fig. 5).

Figure 4: Microplastic particle shapes (%) in seawater samples (left) and in sediment samples (right).

Microplastics in seafood from Belgian fishery areas

The occurrence of microplastics was measured in both edible and non-edible parts of five commercially important fish species (sole, plaice, brill, turbot and cod) and two crustacean species (brown shrimp and edible crab) from the wider Belgian fishery areas. We used a validated method for microplastic analysis, allowing to determine colored microplastics >50 µm and colorless microplastics >200 µm. In almost all fish and crustacean samples (both edible and non-edible parts), microplastics counts were low, in most cases even below the limit of quantification (LOQ). Only 5 out of 42 fish filets had a value above LOQ, ranging between 6.0 and 12.1 microplastic particles per 100 g fish filet. These results indicate that microplastics do no bioaccumulate in commercial fish and crustaceans, at least not from the Belgian fishery areas. This is in clear contrast to earlier research worldwide where extremely high numbers of microplastics in seafood have been reported. In the meantime it has been shown that such high values for microplastics in seafood were most probably incorrect and must have been caused by laboratory background contamination rather than environmental contamination (Hermsen et al., 2017; 2018). Moreover, most microplastics are too large to cross the gastro-intestinal wall into the blood or meat (Lusher et al., 2017), meaning that no significant amounts of microplastics are to be expected in fish filets or crustacean meat. Based on our results, we suggest that microplastic ingestion (particles >50 µm) will be limited when consuming seafood from the Belgian fishery areas.

Microlitter data management

Fully documented data and secure data archival is a requirement for long term data comparison and interpretation. While a well-established regional data format exists for macrolitter, this is not yet the case for microplastics. Based on the currently existing formats proposed by ICES and EMODnet Chemistry, items for further consideration have been shared within the OSPAR expert group and a excel data template has been prepared. The project results together with a wide range of meta information are stored and archived in this format and will be reported in regional and EU context by the Belgian Marine Data Centre (BMDC).

Conclusion

More macrolitter was recorded in the nearby coastal area of the Belgian part of the North Sea (BPNS) compared to the more offshore area or the larger Belgian fishery areas (North Sea, English Channel, Irish and Celtic Seas). Up to 77 to 88 % (dependent on the used sampling gear) of the macrolitter consists of plastic. Heavier plastics (e.g. boxes and bottles) were mainly found in the nearby coastal zone (at least of the BPNS); fishing line monofilaments (mainly pieces of dolly rope) were most frequently found and distributed more or less evenly over the study area, although higher concentrations were noted in the Dutch part of the North Sea.

A spatial correlation between human activities and presence of macrolitter is hard to make. We did not find a link with sand extraction nor offshore windfarms in the BPNS. Also no direct link was found with fisheries, although >50% of the marine macrolitter can be attributed to fisheries activities. Furthermore, we found a hotspot of macrolitter at the dredge disposal site in the eastern coastal part of the BPNS, which should be further investigated.

Within the EMFF MarinePlastics project, we elaborated an accurate and reliable methodological protocol for the analysis of microplastics in marine sediments and seawater. Considerably higher microplastic concentrations were recorded in the coastal zone of the BPNS compared to the more offshore locations, both in the sediment and seawater. According to the shape of the microplastics, more fibers were found in seawater, whereas in marine sediments more plastic fragments were recorded. A high variability was observed in seawater at the coastal location which is related to hydrodynamical and meteorological conditions. Since microplastics tend to accumulate in sediment, and in particular in sediments containing a lot of organic matter, the focus for monitoring should be put on these areas.

The microlitter results are stored in a consistent and well documented data format taking into account currently existing international guidelines.

Based on the results for five important fish species and 2 crustacean species, we found that microplastics >50 µm are almost not present in both edible and non-edible parts and in most cases even below the limit of quantification. We conclude that microplastics do no bioaccumulate in commercial fish and crustaceans, at least not from the Belgian fishery areas. Public awareness should be restored on the fact that seafood from the Belgian fishery areas can be seen as a qualitative and safe product.

Recommendations

Based on the results of the EMFF MarinePlastics project, following recommendations are put forward:

Recommendation 1*: Alternative fishing line monofilaments*

Although spatial correlations between fisheries activities and fishery-related litter items are difficult to make, the MarinePlastics project showed that fisheries largely contribute (>50 %) to the total amount of litter items on the seafloor in the Belgian part of the North Sea (BPNS) and the wider Belgian fishery areas. The largest contribution came from fishing line monofilaments (up to 30 items per ha), which are commonly used as dolly rope to protect the fishing nets. Non-plastic and degradable alternatives for dolly rope do exist or should be developed. It is highly recommended to force the implementation of such alternatives for dolly rope, but also for monofilament fishing lines.

Recommendation 2*: Detailed source investigation on macro and microlitter hot spots in the Belgian Part of the North Sea.*

The project results indicate the presence of at least one marine litter hot spot in the BPNS. However, the marine litter source is not yet unambiguously identified, and the impact of processes altering litter distribution, such as water currents, sedimentation processes or litter delocalization by fisheries, are not yet fully understood. A detailed study on marine litter hotspots, investigating the impact of different sources and modelling litter transport processes is advised. Additionally, both macrolitter and microplastics concentrations were much higher in the nearby coastal zone. The correlation between the distribution of both macrolitter and (degraded) microplastics should be investigated as well.

Recommendation 3*: To validate quality-assured, cost-efficient and harmonised monitoring methodologies for microplastics analysis*

For routine long-term monitoring, a validated methodology for the determination of microplastics is of primary importance. The methodology elaborated in the frame of the MarinePlastics project needs further validation and improvement, taking into account evolving analytical possibilities, new knowledge, cost-efficiency and harmonisation efforts at the regional and EU level. Laboratory intercomparison exercises need to be developed and implemented to assess the quality of the analysis method.

Recommendation 4*: To establish a long-term monitoring programme for microplastics in the Belgian Part of the North Sea*

A monitoring network needs to be defined with annual sampling, at least in the nearby coast, allowing us to follow-up the evolution of microplastics contamination in the BPNS. As the type of microparticles differs in seawater and sediment (fibers vs. fragments), both matrices should be monitored, although it is recommended to focus especially on the seabed, since microplastics tend to accumulate in the sediment. A detailed study on the behaviour and distribution of microplastics in the marine environment, including a modelling approach, is essential to localise potential microplastic hotspots (e.g. muddy areas) in the Belgian marine waters and the elaboration of risk-based monitoring approach in the frame of the MSFD.

This monitoring programme needs to be accompanied by a secure, long-term and well-documented data management to allow the evaluation of differences between locations and evolution over time.

Recommendation 5*: To communicate that Belgian fisheries products are a safe food source with regard to microplastics*

The project results clearly revealed that microplastics >50 µm are almost not found in the edible parts of fish and crustaceans from the Belgian fishery areas. As the concentrations of microplastics were also low in the non-edible parts, we conclude that microplastics do not accumulate in seafood from the Belgian fishery. Therefore, it is important to restore or increase the public awareness that concentrations of microplastics in seafood from the Belgian fishery areas are very low, thereby ensuring a qualitative product. Additionally, further research on the occurrence and risks of smaller particles (<10 µm) and nanoplastics, which can potentially pass the gastro-intestinal wall into the blood and filets, is recommended.

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