Marigomez *Anthropocene Coasts* (2023) 6:12
https://doi.org/10.1007/s44218-023-00027-5

Anthropocene Coasts

EDITORIAL

Open Access

Coastal and marine pollution in the Anthropocene

Ionan Marigomez[1]*

Keywords Metals, Oil, Microplaspics, Sources, Fate, Biological effects, Risk assessment

In the Anthropocene, land-based activities, maritime traffic, accidental spills and offshore mining result in a variety of pollutants in coastal and marine ecosystems including e.g. metals, persistent organic pollutants (POPs), pharmaceuticals, nanomaterials (NMs), microplastics (MPs) and other contaminants of emerging concern (CECs). Moreover, these pollutants occur in combination and their occurrence, fate and biological impact depend on environmental and oceanographic variables driven by global change patterns and trends exacerbated in the Anthropocene. Studies dealing with emerging issues in coastal and marine pollution, as well as with regional and large-scale monitoring, long-term trends, and risk and impact assessment are pivotal to provide scientifically based support to environmental policy makers and managers.

Marine MPs are widely distributed in the world and include small plastic particles (<5 mm) that exhibit wide ranges of densities, sizes, and shapes resulting in diverse dynamical properties, such as sinking or rising velocity, critical shear stress, and re-suspension threshold (Khatmullina and Chubarenko 2019). Moreover, these properties vary significantly with the time spent in marine environment, where the MPs may persist for decades to centuries. Modelling the transport and fate of MPs is crucial to deal with this global environmental challenge. Due to the their heterogeneous nature and to their persistence, movability and mutability in the marine environment, modelling of the transport and fate of MPs should include coupling of different models including ensemble modelling, chaos theory approaches, machine learning, etc. Overall, the complex processes of MPs transport in the ocean include surface drifting, vertical mixing, beaching, and settling (Li et al. 2020). For buoyant MPs, a Lagrange track model may simulate the surface drift process, considering current, windage effect, and Stokes drift. Modelling of vertical mixing is more limited because the processes of vertical mixing are less known due to the small size of the MPs. Modelling includes settling rate because MPs accumulate in sediments as a result of settlement and entrainment. Yet, it must be taken into account that settling may be enhanced by biofilm formation on the MPs surface resulting in an increase in their density and include biofouling rate as a modelling parameter.

Research on MPs in freshwater systems, estuaries, coasts, open sea and polar regions is progressing rapidly in China (Li et al. 2019), which has provided records of their spatial and temporal distribution as well as new data on their toxicity and risk assessment. Yet, the methodology for collecting and quantifying the MPs and for assessing their ecotoxicity and biodegradability is diverse. The management and control of MP pollution demand extensive international cooperation, unified methodologies and a better knowledge on flux, life cycle, global distribution and ecotoxicology of the MPs. Bai and Li (2020) used a material flow analysis (MFA) method to understand the contribution of China in global marine plastic waste input. The MFA method includes lifecycle assessment (from primary plastic to waste including intermediate plastic products) and combines statistical data (Governmental and provided by non-profit organizations)

---

*Correspondence:
Ionan Marigomez
ionan.marigomez@ehu.eus
[1] Plentzia Marine Station (PiE-UPV/EHU), University of the Basque Country, Autonomus Community of the Basque Country, Plentzia, Bizkaia, Spain

to establish an MFA model. On this basis, the annual amount of plastic waste entering the ocean from China was estimated to be of 0.65 million tonnes in 2011, with a slight increasing trend until 2016 and a decline since 2018 after governmental management actions. In the Yellow Sea, most recent research on MPs includes studies on surface water, the seawater column, sediments, and marine organisms (Li and Sun 2020). MPs are found throughout the west Yellow Sea (surrounded by China and the Korean Peninsula), being more abundant in the North than in the South region. Fibres, films and fragment of diverse size from 0,025 to 5 mm were frequent in the seawater, whilst pellets and foams were the main shapes in intertidal sediments and fibres in seabed sediments. Ingested MPs were identified in a wide variety of marine organisms (zooplankton, shellfish, and fish), especially in sea cucumbers, in which the dominant MPs were fibres (<1 mm) and transparent-coloured MPs made of polyethylene, polypropylene, and cellophane.

Li and Sun (2020) identified main challenges for research on MP pollution in coastal and marine environments, say: standardize MP sampling methods, understand MP-biota interactions (e.g., food web transfer, MPs as vectors for POPs), and specific strategies for MP risk assessment and for reducing MP emissions. Nerheim and Lushe (2020) used opportunistic non-disruptive sampling to investigate MPs in subsurface waters in Norwegian fjords including the analysis of distribution effects. Sampling was carried out on-board of research and recreational vessels, commercial freight and transport covering 250 km from Bergen to Masfjorden. Thus, they succeeded in identifying MPs in 89% of samples, with an average abundance estimated to be 1.9 particles m^{-3}. The validated opportunistic non-disruptive sampling methods were shown to provide a feasible toolbox for sampling, chemical characterisation, and long-term monitoring of MPs that might be suitable for worldwide implementation. Ward et al. (2019) dealt with the interactions of MPs with feeding and digestion in suspension-feeding bivalve molluscs. Bivalves have the ability to select among particles both pre- and post-ingestively; this may be relevant to understand internal exposure, toxic effects, and trophic transfer of MPs in these target marine organisms. Particle size, shape, and surface properties have effect on capture, preferential ingestion, post-ingestive sorting, and egestion of the MPs, which has implications for the use of bivalves as bioindicators of MPs pollution in the marine environment.

Together with contaminants of emerging concern, oil spills and long-term pollution in estuarine sediments and coastal landfills also pose important risks for coastal and marine environments. During oil spill events, oil slicks cover changes the surface roughness by suppressing multi-scale ocean surface waves and the drag coefficient. Shen et al. (2019), using SAR satellite remote sensing to quantify these changes, found that the oil slick cover after the Deepwater Horizon oil spill could result in over- estimates by 75~100% in the wind driven Ekman current. The authors conclude that overlooking this bias could jeopardise oil trajectory prediction, especially for large-scale oil spill situations. As discussed by Alyazichi et al. (2021), trace element pollutants accumulate within surface sediments of estuaries for decades and constitute a potential environmental challenge as they may enter the water column by re-suspension, changes in pH and redox potential, bioturbation and organic degradation, aggravated by global climate change. Sediment metal levels depend on the composition and granulometry of the sediment, but they are sensitive indicators of the relevance and proximity of pollution sources such as urban and industrial discharges and storm water outlets, as shown by Alyazichi et al. (2021) in the relatively unpolluted and healthy estuary of Port Hacking (Sydney, Australia). In this case study, metals (Ni, Cr, Cu, Zn, Pb, and As) in the sediments were below the ANZECC/ARMCANZ guideline low trigger value (ISQG-low) and posed little risk; however, a hot spot was identified in Gunnamatta Bay, where Zn and Cu concentrations exceeded the high trigger value (ISQG-high). Brand and Spencer (2018) recognise that historic coastal landfills are a global environmental problem. These landfills are eroding and releasing waste to nearby ecosystems, and erosion is likely to become more common with the anticipated effects of climate change. Their impact may be counteracted by implementing regionally targeted mitigation actions but these are expensive and hence environmental managers must define priorities. Brand and Spencer (2018) propose an overall risk index to identify historic coastal landfills that pose high pollution risk. The index includes a "waste release" component and a "pollution" component and provides support to decide which sites pose the greatest pollution risk to prioritise management resources.

These contributions are exemplary of the many that will provide scientifically based support to advance towards a better management of coastal and marine pollution. In future papers in *Anthropocene Coasts*, we look forward to consolidating this scope as well as to extending its coverage with contributions dealing with ecosystem and human health, sustainability and additional threats linked to coastal and marine pollution (e.g. other CECs, antibiotic resistance genes).

Acknowledgements

The author would like to gratefully acknowledge financial support from the Basque Government through Consolidated Research Group GIC IT1743-22.

Author's contributions

Not applicable.

Funding

Basque Government; Consolidated Research Group GIC IT1743-22.

Availability of data and materials

Not applicable.

Declarations

Competing interests

Not applicable.

Received: 7 June 2023 Revised: 7 June 2023 Accepted: 14 June 2023

References

Alyazichi YM, Qasim AK, Jones BG, McLean E, Murad J, Aljawi A (2021) Geochemistry, spatial distribution, and sources of trace element pollution in the surface sediments of Port Hacking, southern Sydney, Australia. Anthropocene Coasts 4:1–16. https://doi.org/10.1139/anc-2020-0005

Bai M, Li D (2020) Quantity of plastic waste input into the ocean from China based on a material flow analysis model. Anthropocene Coasts 3:1–5. https://doi.org/10.1139/anc-2018-0028

Brand JH, Spencer KL (2018) Risk screening assessment for ranking historic coastal landfills by pollution risk. Anthropocene Coasts 1:44–61. https://doi.org/10.1139/anc-2018-0001

Khatmullina L, Chubarenko I (2019) Transport of marine microplastic particles: why is it so difficult to predict? Anthropocene Coasts 2:293–305. https://doi.org/10.1139/anc-2018-0024

Li Q, Sun X (2020) Progress on microplastics research in the Yellow Sea, China. Anthropocene Coasts 3:43–52. https://doi.org/10.1139/anc-2018-0033

Li D, Peng G, Zhu L (2019) Progress and prospects of marine microplastic research in China. Anthropocene Coasts 2:330–339. https://doi.org/10.1139/anc-2018-0014

Li Y, Zhang H, Tang C (2020) A review of possible pathways of marine microplastics transport in the ocean. Anthropocene Coasts 3:6–13. https://doi.org/10.1139/anc-2018-0030

Nerheim MS, Lushe AL (2020) Investigating microsized anthropogenic particles in Norwegian fjords using opportunistic non-disruptive sampling. Anthropocene Coasts 3:76–85. https://doi.org/10.1139/anc-2020-0002

Shen H, Perrie W, Wu Y (2019) Wind drag in oil spilled ocean surface and its impact on wind-driven circulation. Anthropocene Coasts 2:244–260. https://doi.org/10.1139/anc-2018-0019

Ward JE, Rosa M, Shumway SE (2019) Capture, ingestion, and egestion of microplastics by suspension-feeding bivalves: a 40-year history. Anthropocene Coasts 2:39–49. https://doi.org/10.1139/anc-2018-0027