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Editorial: Microplastics and nanoplastics in polar areas: Arctic, Antarctica, and the world's glaciers

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Editorial on the Research Topic
Microplastics and nanoplastics in polar areas: Arctic, Antarctica, and the world's glaciers

Introduction

Despite their apparent remoteness from human activities, polar regions and glaciers worldwide are becoming silent witnesses to the dramatic global impact of plastic pollution (Bergmann et al., 2022; De-la-Torre et al., 2024; Jones-Williams et al., 2025; Rosso et al., 2024). As a matter of fact, plastic pollution has no borders and reaches even these most remote places; it is emerging as a major environmental threat with potential consequences for the environment and in particular for fragile ecosystems such as the polar areas. However, several gaps of knowledge about the occurrence, the transport pathways and fate of micro- and nanoplastics (MNPs) in polar areas and on glaciers still need to be filled. MNPs form through the breakdown of larger plastic materials; in relation with their sizes, these particles can be transported over long distances via atmospheric and oceanic pathways (Bucci et al., 2024; Rosso et al., 2024; Yang et al., 2024).

Additionally, MNPs can release toxic additives into the environment, being able to cause significant impacts on biota, impacting organisms throughout the food chain (Corami et al., 2022; Da Costa et al., 2023), and endangering the ecosystems. Besides, MNPs can interfere with sea ice formation, contribute to glacier melting and amplify climate change effects such as permafrost thaw. Therefore, understanding the pathways and impacts of MNPs in polar regions is crucial for developing strategies to mitigate their effects and protect these vulnerable ecosystems. From this perspective, identifying bioindicators is crucial for evaluating the ecological and biological impacts of plastic pollution, particularly in fragile polar ecosystems (Iannilli et al., 2019; Lusher et al., 2022). A deeper understanding of this escalating threat is essential to fully assess its global implications and implement effective solutions.

The Research Topic "Microplastics and Nanoplastics in Polar Areas: Arctic, Antarctica, and the World's Glaciers" focuses on the pollution caused by MNPs in these peculiar ecosystems, aiming at a better understanding of the occurrence, distribution and transport pathways, including ocean currents, local rivers, and atmospheric transport, emphasizing the global nature of microplastic pollution, and potential biological implications.

The studies focus on MNPs pollution in both Arctic and Antarctic polar regions, increasingly exposed to plastic contamination, albeit in different ways. Marine currents can significantly contribute to the transport of MNPs in the Arctic, as observed in the study on the Barents Sea (Emberson-Marl et al.) and in that on Kara Sea (Berezina et al.). However, Arctic rivers can be a relevant transport pathway for MNPs (Pakhomova et al.) towards the sea, taking into account that glacier melting and atmospheric transport can greatly enrich the plastic load of rivers and, consequently, of the sea. Besides, it should be underlined that multiple factors, including shipping traffic from fishing and the growing tourism ship, can greatly contribute to the transport pathways of MNPs in the Arctic. Multiple transportation processes can deeply affect the plastic load in Antarctica, as well (Cunningham et al.). In particular, synthetic fibers in the Antartic air and seawater samples were predominant, highlighting that MNPs can originate from diffuse sources. Besides, the atmospheric transport can also play a key role in introducing synthetic fibers and other MNPs to Antarctica, further complicating pollution management.

Bioindicators allow in-depth understanding of the changes of organism's physiological responses and/or population dynamics due to presence of pollutants, e.g., MNPs. Among the various bioindicators are seabirds that primarily feed at sea, which can be employed as bioindicators for MNPs pollution (Taurozzi and Scalici) in view of the urge to both quantify and monitor MP ingestion by marine wildlife. Due to their role of top predators in the polar food webs, birds can be considered early indicators of plastic pollution. By studying their ingestion of MNPs it is possible to assess the broader ecological impact of plastic pollution in these remote regions.

All the studies stress the need a) for systematic monitoring of microplastic pollution to assess its ecological impact, and b) of standardized protocols in order to plan appropriate actions and strategies to mitigate the effects of microplastics on marine and terrestrial organisms in polar regions.

Perspectives

The studies collected in this Research Topic reveal that MNPs' pollution is already endangering these fragile environments, with several concerns about its origins, pathways, fate and ecological impact. This growing research effort emphasizes the need for a monitoring network at a global scale, standardized methods and a stronger focus on the ecological impacts of microplastics using bioindicator species, which can provide useful information on the contamination of the food web and biological effects.

In conclusion, although polar regions are often regarded as pristine environments, there is ever increasing evidence of microplastic contamination, highlighting the need for a global approach to address this pollution. Further studies are also needed to gain an in-depth understanding of how plastic pollution can enhance and hasten the processes of ongoing global climate change. Therefore, expanding research, standardizing methods, and integrating local and global knowledge are essential to mitigate the impacts of microplastics, requiring collective action to protect these vulnerable ecosystems for future generations.

Author contributions

FC: Conceptualization, Supervision, Validation, Writing – original draft, Writing – review & editing. VI: Conceptualization, Visualization, Writing – original draft, Writing – review & editing. IH: Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

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