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Editorial: Microplastics in the Marine Environment: Sources, Distribution, Biological Effects and Socio-Economic Impacts

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Editorial on the Research Topic

Microplastics in the Marine Environment: Sources, Distribution, Biological Effects, and Socio-Economic Impacts

INTRODUCTION

From all the synthetic materials ever produced, plastic is the most versatile, overthrowing both glass and metal in many applications, due to its low weight and cost. Global plastic production started shortly after WWII, around the 1950's (PlasticsEurope, 2010), and became a popular household item around the same time (Time, 1955). Since then, global production has been exponentially increasing at a rate of 8% *per annum* (PlasticsEurope, 2020). Notably, it took only 10 (1965) to 17 (1972) years until researchers started noticing the first evidence of plastics in the marine environment (Carpenter and Smith, 1972; Ryan, 2015). Between the 1960's and the 1990's, several studies reported direct consequences of plastic interaction with vessels, particularly entanglement of propellers, and with wildlife, *via* entanglement or ingestion (Ryan, 2015). Consistent findings throughout the world led to calls for action, due to the likelihood that over time the problem would be amplified by fragmentation of larger plastic items into smaller pieces (Carpenter and Smith, 1972). Microplastic research is now a well-established research field, with at least 2,500 papers published so far on this topic (Zhang et al., 2020).

Despite being a relatively recent research field, microplastic pollution has gone beyond the realm of academia into the general public. Several stakeholders with different vested interests are involved in this topic, from standardization bodies to grassroot movements, from national agencies to research institutions. Plastic has become a social issue, due to its economic and environmental consequences, which affect human activities and the natural cycles of the planet. In order to contribute to the debate, this Research Topic (RT) highlights recent research developments in the microplastic field, in a diverse set of topics that cover relevant aspects from methodologies to modeling, and from impacts on fauna to legislation. A total of 23 research papers from 43 primary and partner institutions, in four continents and spread across 15 countries (**Figure 1A**), reveal the prevalence of this global problem, and report on some of the solutions ahead.

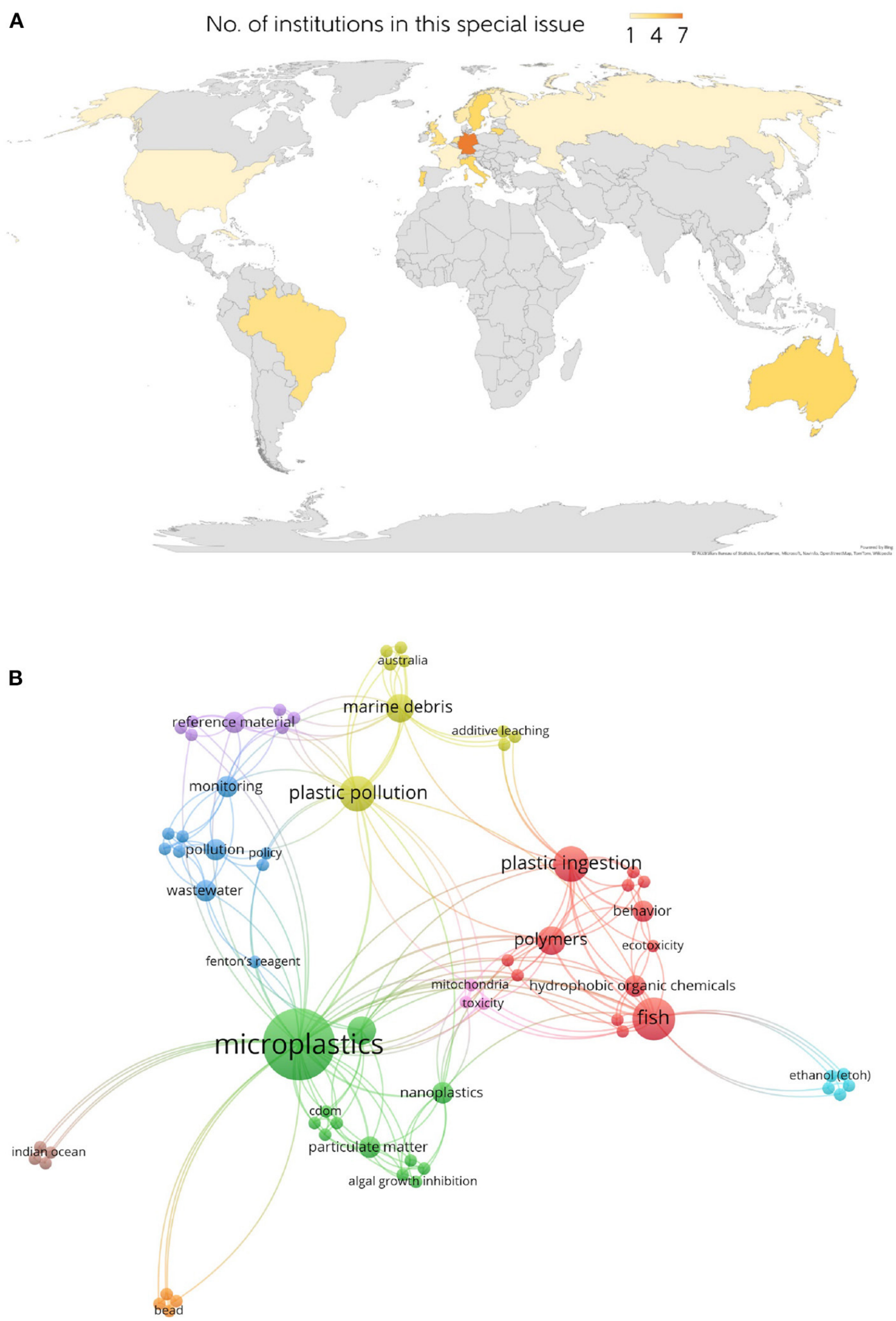

FIGURE 1 | (A) Number of institutions primary and partner institutions per manuscript ($N = 43$) contributing to this RT. **(B)** Distance-base map (based on association strength) of a set of 67 keywords retrieved from 21 papers. Keywords are grouped into 9 clusters of different colors.

A SHORT BIBLIOMETRIC ANALYSIS OF PAPERS PUBLISHED IN THIS RT

The author's keywords from each paper were compiled and analyzed in the software VOS viewer to illustrate the diversity of topics explored here (Van Eck and Waltman, 2010). The set of 21 papers (with their final versions published by 01.03.2021) in this RT had a total of 152 keywords. To standardize keywords describing the same concept, a thesaurus was created (**Table 1**). For example, polyethylene, polypropylene and other polymer types were all grouped under the keyword "polymers." As such, a total of 67 keywords are presented in the final set. The

TABLE 1 | Thesaurus of alphabetical ordered author's keywords ("Label") and standardized concepts.

Label	Replace by
Anthropogenic litter	Marine debris
Atlantic chub mackerel	Fish
Atlantic salmon (*Salmo salar* L.)	Fish
Benzo(a)pyrene	Hydrophobic organic chemicals
Chlorpyrifos	Hydrophobic organic chemicals
Combined sewer overflow	Wastewater
Cost-effective marine litter monitoring method	Monitoring
EE2	Hydrophobic organic chemicals
Extraction techniques	Methods
FT-IR spectroscopy	Spectroscopy
GIT analysis	Plastic ingestion
Horse mackerel	Fish
Hydrodynamic dispersion model	Model
Hydrodynamic model	Model
Infrared imaging	Spectroscopy
Ingestion	Plastic ingestion
Lates calcarifer	Fish
Long-term monitoring	Monitoring
Lutjanus argentimaculatus	Fish
Marine litter	Marine debris
Microplastic	Microplastics
Microplastic (MP)	Microplastics
Microplastic pollution	Microplastics
pe	Polymers
Peppery furrow shell	Bivalve
Pet	Polymers
Plastic and plastics	Plastic pollution
Plastic polymers	Polymers
Plectropomus leopardus	Fish
Polyethylene	Polymers
Polyethylene terephthalate	Polymers
Polyethylene(PE)	Polymers
Polypropylene	Polymers
Polystyrene	Polymers
Polystyrene(PS)	Polymers
pp	Polymers
Reflectance micro-FTIR	Spectroscopy
Sand	Reference material
Selachians	Fish
Silica	Reference material
Sodium iodide	Density separation solution
SPM	Particulate matter
Stickleback	Fish
Storage	Methods
Suspended matter	Particulate matter
Three-spined stickleback (*Gasterosteus aculeatus*)	Fish
Top marine beach litter items	Marine debris
Uptake	Plastic ingestion
Wastewater treatment plant (WWTP)	Wastewater
Wastewater treatment plants	Wastewater
Zebrafish	Fish

Authors keywords are listed in alphabetical order.

most popular keyword is "microplastics" ($N = 10$ occurrences), followed by "fish" ($N = 5$), "plastic pollution" and "plastic ingestion" ($N = 4$). The keywords "polymers," "spectroscopy," and "marine debris" appeared in three papers each ($N = 3$). All other keywords appeared in one or two publications only, indicating a generally very low frequency of used keywords and therefore a variety of studied topics (**Figure 1B**).

This RT included a relatively high number of papers using fish as a model organism (see "fish" in **Figure 1B**), either by exploring combined effects of (nano-micro) plastics and organic pollutants in teleost (Trevisan et al.; Bour et al.; Ašmonaite et al.; Abihssira-García et al.) or by improving extraction and analysis methods for predicting plastic ingestion in fish (Dawson et al.; Pedà et al.; Pequeno et al.). In the same cluster, the keyword "plastic ingestion" included papers that explored the transfer of microplastics particles among successive levels in marine trophic webs or potential transfer of plastic additives and chemicals from plastics to biota when ingested (Costa et al.; Kühn et al.). Also grouped together are papers using the keyword "polymers" showing works that explore polymer-specific effects of particles in model-animals (Santana et al.).

Papers with more general approaches are clustered around keywords such as "plastic pollution" and "marine debris" (**Figure 1B**, in yellow). These are papers related to legislations to mitigate plastic (marine) pollution (Da Costa et al.; Galaiduk et al.), potential bioindicators of (micro)plastic pollution (Reichelt and Gorokhova; Fossi et al.), but also to method development with potential to be used over large geographical areas (Enders et al.; Haseler et al.; Rodrigues et al.; Tagg et al.) and modeling of microplastic sources into the environment (Balthazar-Silva et al.; Gorman et al.; Schernewski et al.; Piehl, Atwood et al.; Piehl, Hauk et al.).

CONCLUSION

We considered this special issue to be very successful both in terms of number of papers published and variety of studies targeting several microplastic pollution issues. Notorious research advancements and science breakthroughs, as well as technological developments, are highlighted here based on the efforts of the microplastic scientific community over recent years. Manuscripts in this RT aim at fulfilling knowledge gaps while creating new research questions to fully understand the ubiquitousness of plastics in the environment. Although there is still a long way to go within this research extensive knowledge gathered so far [see for example Galgani et al. (2021)] will allow decision makers to make better decisions surrounding this global problem, while consolidating microplastic pollution as a permanent research field.

Plastic pollution is intrinsically linked to consumption habits and waste management practices globally. Therefore, recommendations need to be aligned with regulations and with the adequate use of market-based instruments, so that solving this problem is addressed holistically. One thing that the global pandemic brought to sight is that behavior change is possible, and when we work together reduction and prevention can be achieved. For example, understanding how to tackle losses and emission throughout the entire supply-chain will effectively reduce the abundances of plastic marine litter in the environment. That is an excellent way to start to flatten the current plastic pollution scenario worldwide.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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REFERENCES

Carpenter, E., and Smith, K. (1972). Plastics on the sargasso sea surface. *Science* 175, 1240–1241. doi: 10.1126/science.175.4027.1240

Galgani, F., Brien, A., So., Weis, J., Ioakeimidis, C., Schuyler, Q., Makarenko, I., et al. (2021). Are litter, plastic and microplastic quantities increasing in the ocean? *Micropl. Nanopl.* 1:2. doi: 10.1186/s43591-020-00002-8

PlasticsEurope (2010). *The Facts - An Analysis of European Plastics Production, Demand and Recovery for 2009*. Available online at: https://www.plasticseurope.org/en/resources/publications/171-plastics-facts-2010 (accessed February 06, 2021).

PlasticsEurope (2020). *The Facts-An Analysis of European Plastics Production, Demand and Waste Data*. Avaialble online at: https://www.plasticseurope.org/en/resources/publications/4312-plastics-facts-2020 (accessed February 06, 2021).

Ryan, P. G. (2015). "A brief history of marine litter research," in *Marine Anthropogenic Litter*, eds M. Bergmann, L. Gutow, M. Klages (Cham: Springer), 1–25. doi: 10.1007/978-3-319-16510-3_1

Time (1955). *Throwaway Living: Disposable Items Cut Down Household Chores, Vol. LXVI No. 5*. Available online at: http://content.time.com/time/magazine/0,9263,7601550801,00.html

Van Eck, N., and Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics* 84, 523–538. doi: 10.1007/s11192-009-0146-3

Zhang, Y., Pu, S., Lv, X., Gao, Y., Ge, L. (2020) Global trends and prospects in microplastics research: a bibliometric analysis. *J. Hazard. Mater*. 400:123110. doi: 10.1016/j.jhazmat.2020.123110

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.

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