Addressing Microplastic Pollution via the Global Plastic Treaty

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Microplastics are small pieces of plastic with their longest dimension ≤ 5 mm [1]. They originate from multiple sources (Fig 1); broadly subdivided as primary (manufactured ≤ 5mm) and secondary (generated by wear or fragmentation of larger items). Recent estimates suggest emissions of 12.7 million tonnes of microplastics to the environment annually [2]. Microplastics are persistent and once in the environment cannot effectively be removed [1], consequently, they have been accumulating in the environment for 70 years [3]. Microplastics contaminate the planet from the deepest oceans to the highest mountains, [4-6] and have been detected in a wide range of organisms with numerous studies demonstrating harmful effects [1,7,8]. To be effective, interventions (Fig 1) must focus on reducing emissions and be applied at global scale.

Primary microplastics include: a) Spillage into the environment during transportation and handling of pellets (nurdles), flakes and powders, from which plastics products are made [2,9]; b) Direct use of small plastic particles, such as glitter, encapsulated fertilizers, blasting media; c) Intentionally added microplastics in cosmetics, cleaning agents and paints. Some products contain 100s of thousands of intentionally added microplastic which are typically ≤ 0.25 mm and can pass to the environment via wastewater [1].

Secondary microplastics include: a) Particles generated by wear of products during normal use e.g. from tyre wear and some food contact materials; b) infill from artificial turf carried to the environment by wind or stormwater; c) Fibres from textiles released to air or water during manufacture, everyday use (laundering, drying, wearing) and disposal [10]; d) Deterioration of products used in agriculture, such as mulch films, poly tunnels, and silage wrap; e) Abrasion of fishing gear, such as dolly ropes on trawling gear; f) Abrasion of surfaces during cleaning or prior to repainting [2]; g) Release of microplastics from waste management, incineration and mechanical recycling [11,12]; h) Fragmentation of larger items of plastic in the environment (including partial degradation of 'biodegradable' or 'compostable' plastics [13]) resulting from chemical and physical deterioration, abrasion and when bitten or chewed by organisms [14,15]. Irrespective of their origin, plastics will degrade over time with microplastics ultimately fragmenting into nanoplastics and increasing the risk of harmful effects [16].

Microplastics have lower density than most natural particles and exist in a wider variety of forms and shapes, including fragments, fibres, films, pellets, flakes, and spheres, that are often weathered and degraded [1]. They can be redistributed by air, water and organisms, however their heterogeneity results in differing transport potential to that of natural particles [17]. While natural particles are a normal component of ecosystem dynamics and cause minimal harm, there is substantial evidence of chemical and particle toxicity resulting from exposure to microplastics [1,7,8,18]. The chemical composition of microplastics varies widely [18], and they can contain mixtures of polymers, unreacted monomers, oligomers, additives, and non-intentionally added substances (NIAS) and can also accumulate harmful chemicals, including heavy metals and organic pollutants from the environment, which may facilitate the uptake of hazardous chemicals by organisms [1]. In addition, microbial surface colonisation can result in transport of pathogens including *Vibrio* spp. and *E. coli*, and antibiotic resistance genes [19,20].

Laboratory studies demonstrate the potential for microplastics to cause harm to a wide range of organisms including invertebrates, fish, birds, mammals and plants (1,7,9), with toxicity increasing as particle size decreases (16). Business-as-usual scenarios indicate the potential for wide scale ecological harm within the next 100 years (1).

Microplastics are widely documented in food and drink including seafood, honey, sugar, beer and tea, as well as in the air we breathe (21). There is evidence that microplastics are ingested by humans (22), and emerging evidence that they can be transferred to a variety of tissues (16,23). As with numerous other substances now known to be harmful to humans, initial evidence of harm comes from experiments with animals. Such evidence already exists for micro-and nanoplastics, and their translocation into the circulatory system has been demonstrated in mammals(23). There are links between microplastic exposure and detrimental changes to gut microbes and their functioning in adults and children (24,25). Given the persistence of microplastics, their potential to form nanoplastics, their ability to carry hazardous chemicals, and the near impossibility of their removal once dispersed in the environment, there is a pressing need for a precautionary approach.

Policy Interventions: The numerous pathways to the environment and the challenges of removal emphasise the need to address sources, but proposed interventions must be evaluated to ensure their efficacy and safety (26). Reduction in primary polymer production will reduce all sources listed above. Legislation on intentionally added microplastics has successfully been implemented in multiple countries, e.g. bans on microbeads in cosmetics and REACH legislation (27). Additional measures are outlined in Fig 1.

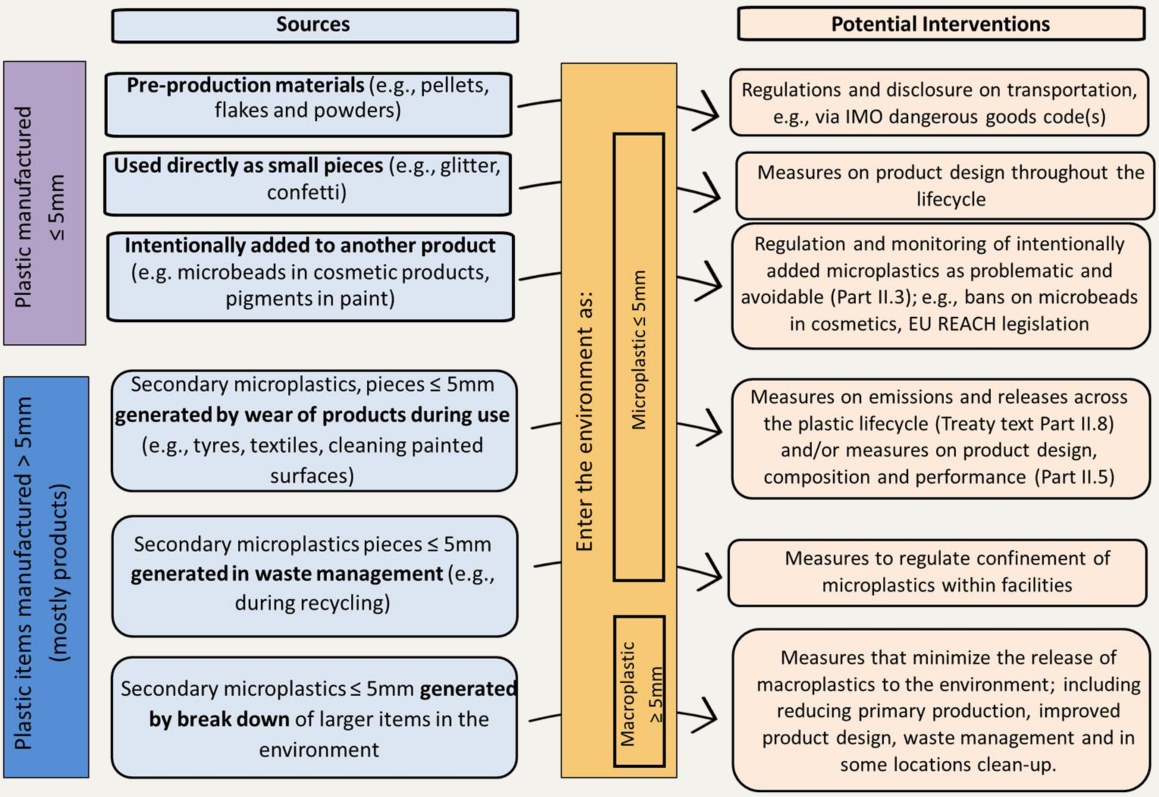

Fig 1. Categorisation of microplastic sources according to size at time of manufacture / mode of generation together with examples of potential policy interventions.

References and Notes

1. SAPEA, A Scientific Perspective on Microplastics in Nature and Society (2019).
2. Earth Action, Leakage of microplastics into oceans and land, (2023).
3. R. C. Thompson, *et al*., Lost at sea: Where is all the plastic? Science 304, (2004).
4. I. E. Napper, *et al*., Reaching New Heights in Plastic Pollution—Preliminary Findings of Microplastics on Mount Everest, One Earth, (2020).
5. M. Bergmann, *et al*., High quantities of microplastic in Arctic deep-sea sediments from the HAUSGARTEN observatory. Environ Sci Technol 51, (2017).
6. X. Peng *et al.* Microplastics contaminate the deepest part of the world's ocean. Geochem. Persp. Let. 9, (2018)
7. T. Gomes, *et al*., Ecotoxicological Impacts of Micro- and Nanoplastics in Terrestrial and Aquatic Environments in Microplastic in the Environment: Pattern and Process, (2022).
8. L.M Thornton Hampton *et al.,* A living tool for the continued exploration of microplastic toxicity, Micropl.&Nanopl. 2 (2022)
9. *Note - pellets, powders and flakes are predominantly <5mm and fall within the definition of microplastics; some are larger however and measures to prevent spillage into the environment should be applied irrespective of size*': Fauna and Flora, A global opportunity to end plastic pellet pollution (2024)
10. F. De Falco, *et al.,* Microfiber Release to Water, Via Laundering, and to Air, via Everyday Use: A Comparison between Polyester Clothing with Differing Textile Parameters, Environ. Sci. Tech. 54 (2020)
11. G. Suzuki, N. *et al*., Global discharge of microplastics from mechanical recycling of plastic waste. Environ. Pollut. 348, (2024).
12. M. Shen *et al.,* Can incineration completely eliminate plastic wastes? An investigation of microplastics and heavy metals in the bottom ash and fly ash from an incineration plant, STOTEN 779 (2021)
13. Scientists' Coalition for an Effective Plastics Treaty (2023) Policy Brief: The global plastics treaty: What is the role of bio-based plastic, biodegradable plastic and bioplastic? (possible core obligation 8)
14. D. J. Hodgson, A. L. Bréchon, R. C. Thompson, Ingestion and fragmentation of plastic carrier bags by the amphipod *Orchestia gammarellus*: Effects of plastic type and fouling load. Mar Pollut Bull 127, (2018).
15. SAPEA, Biodegradability of plastics in the open environment, Publications Office of the European Union, (2021)
16. P. J. Landrigan, *et al*., The Minderoo-Monaco Commission on Plastics and Human Health. Ann Glob Health 89 (2023).
17. K. Waldschläger *et al*. Learning from natural sediments to tackle microplastics challenges: A multidisciplinary perspective, Earth Sci. Res 228 (2022).
18. M. Wagner, *et al*., State of the science on plastic chemicals - Identifying and addressing chemicals and polymers of concern (2024)
19. M. Junaid, *et al*., Wang, Enrichment and dissemination of bacterial pathogens by microplastics in the aquatic environment. STOTEN 830, (2022).
20. E. M. Stevenson, *et al*., Selection for antimicrobial resistance in the plastisphere. STOTEN 908, (2024).
21. World Health Organization, "Dietary and inhalation exposure to nano- and microplastic particles and potential implications for human health" (2022).
22. P. Schwabl, *et al*., Detection of Various Microplastics in Human Stool. Ann Intern Med 171, (2019).
23. A. F. R. M. Ramsperger, *et al.*, Nano- and microplastics: a comprehensive review on their exposure routes, translocation, and fate in humans. NanoImpact 29, (2023).
24. A. Tamargo, *et al*., PET microplastics affect human gut microbiota communities during simulated gastrointestinal digestion, first evidence of plausible polymer biodegradation during human digestion. Sci Rep 12, 528 (2022).
25. E. Fournier, *et al.*, Exposure to polyethylene microplastics alters immature gut microbiome in an infant in vitro gut model. J Hazard Mater 443, (2023).
26. I. E. Napper, A. C. Barrett, R. C. Thompson, The efficiency of devices intended to reduce microfibre release during clothes washing. STOTEN 738, (2020).
27. European Commission, amending Annex XVII to Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) as regards synthetic polymer microparticles. (2023).

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