Post Graduate Certificate Environment and Sustainability, Birkbeck College, University of London 2024 - 2025

Microplastic pollution in the oceans

Polarisation of the international community, self-interest of the petrochemical industry and difficulty implementing existing regulations have resulted in the failure of the Intergovernmental Negotiating Committee (INC) to negotiate a binding instrument to combat plastic pollution in the marine environment.

Abstract

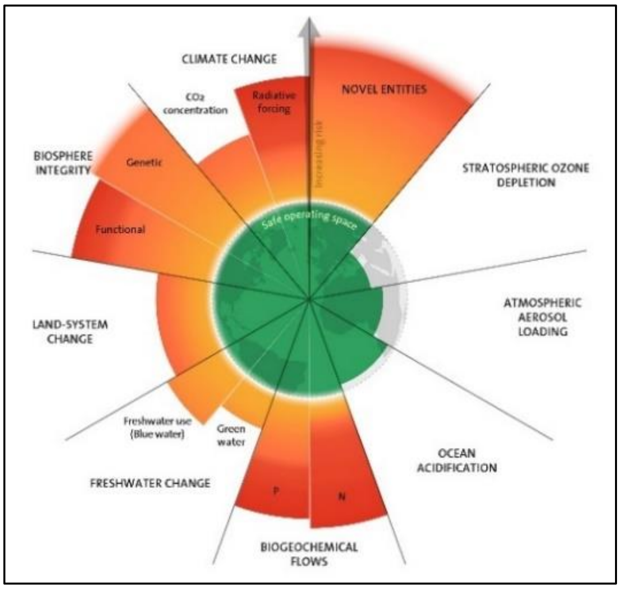
Microplastics particles 5 mm (1 µm to 5 mm) are persistent contaminants found in 1,300 aquatic and terrestrial species, the land, sea and air, across the food chain and in our bodies increasing the likelihood of heart attack, stroke, or death. This essay assesses evidence of microplastic pollution across production, transport, consumption and waste management contributing to plastic pollution outside the safety of the Planetary Boundaries. Polarisation of the international community, self-interest of oil, gas, petrochemical and FMCG companies combined with difficulty implementing existing conflicting regulations has contributed to the failure of the Intergovernmental Negotiating Committee (INC) to negotiate an international legally binding instrument to combat plastic pollution in the marine environment.

Introduction

In 2004 Professor Richard Thompson identified 'microplastics' as particles 5 mm (1 µm to 5 mm) accumulating in the oceans with irreversible effects in the natural environment predicted to cause wide-scale ecological harm over the next 70 - 100 years (YaleEnvironment360, 2024). Intentionally produced primary microplastics are fragments, fibres, pellets, film or spheres for application in synthetic textiles, artificial turf, paint flakes, rubber tires, cleaning products, cosmetics and food packaging. They result from non-intentional production spills, wear and tear. Secondary microplastics result from degradation of larger plastic particles due to UV radiation, waves abrasion and biological degradation. Nanoplastics less than 0.1 µm result from further degradation (Bhattacharjee, Baruah and Shah, 2025; (Jadhav *et al*., 2021; Lots *et al*., 2017; Zhao and You, 2020). There is no end to the impact of plastics within a human lifespan (Wojnowska-Baryła, Bernat and Zaborowska, 2022). Microplastics contribute to permanent pollution of ecosystems and food chains (European Commission, 2023).

Microplastic contamination is in everything: The oceans (Andrady, 2011, Arp *et al*., 2021); marine organisms (Alfaro-Núñez *et al*., 2021); Mediterranean fin whales (Fossi *et al*., 2012); green and leatherback turtles (Schuyler *et al*., 2014); Galápagos giant tortoises (Ramon-Gomez *et al*., 2024); single use carrier bags and discarded fishing equipment (Barnes *et al*., 2009); Arctic and Antarctic (British Antarctic Survey, 2025); Austrian Alps (Materić *et al*., 2021); fresh water sediment (Yang *et al*., 2021); soil (Lakhiar *et al*., 2024); facial cleansers (Fendall and Sewell, 2009); free-range chicken eggs (Petrliket *et al.,* 2024); take-out food and plastic-packaged food (Du *et al*., 2020); bottled water (Qian *et al*., 2024); patients with carotid artery plaque (Marfella *et al*., 2024) and in the human placenta (Ragusa *et al*., 2021).

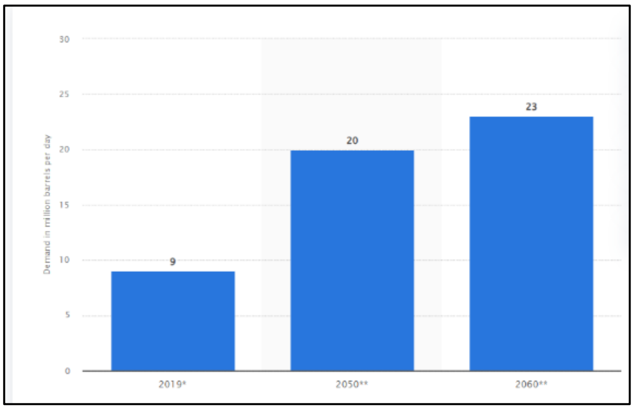
There is no centrally recognized global scientific or political authority tasked with addressing the plastic problem (Nielsen *et al*., 2020). The EU is restricting intentionally added microplastics to detergents, fabric softeners, glitter, fertilisers, plant protection products, toys, medicines and medical devices (European Commission, 2023). Adoption is up to each Member State. There was an increase of 7% - 9% in microplastic releases between 2016 - 2022 (European Coatings, 2024) with no progress in reducing microplastic releases against the European Environment Agency's 30% reduction target. The outlook for 2030: Off track. (European Environment Agency, 2025).



(**Fig 1**. Azote, for Stockholm Resilience Centre, based on analysis in Richardson *et al*. 2023)

Nine Planetary Boundaries define where humanity operates safely (Rockström *et al*., 2009). Six have been transgressed with increasing risk from Novel Entities including microplastics (Stockholm Resilience Centre, 2024). Lack of data on chemicals in plastics risks product safety (Planetary Health Check, 2024). Plastic in the oceans is a planetary boundary threat (UN Environment Programme, 2023). Weathering marine plastic litter fulfils two of three criteria to impose a Planetary Boundary threat (Arp *et al*., 2021). The plastic life cycle contributes to climate change and biodiversity loss outside the safe operating space of the Planetary Boundaries (Walker and Fequet, 2023).

Production



(**Fig. 2**. Statista (2025). Oil demand for plastics production in 2019, 2050 and 2060 (millions of barrels per day

Plastics are vital for construction, medicine, consumer products, transportation and food packaging (Rogers *et al*, 2024). Every day 9 million barrels of oil go into making plastics (Gohd, 2023). This will account for 20% of global oil and gas consumption by 2050 (Anderson and Fletcher, 2022). Global production accounted for 415 million metric tonnes in 2023 (Statista, 2025). Global market value 712 billion U.S .dollars in 2023 and projected at 1,050 billion U.S. dollars by 2033 (Statista, 2025). Ugwu, Herrera and Gómez (2021) report worldwide microplastic production according to polymers: 36% polyethylene (PE), 21% poly propylene (PP), 12% polyvinyl chloride (PVC), <10% polyethylene terephthalate (PET), <10% polyurethane (PUR) and <10% polystyrene (PS). The plastic supply chain creates pollution and harm at every step from extraction to production, use, and disposal (Center for Environmental Law, 2024).

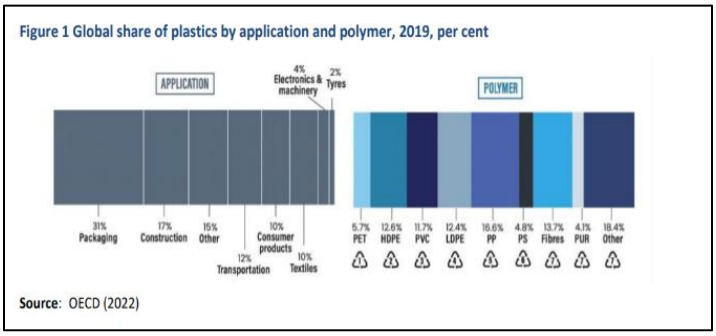


Fig 3. OECD (2022)

Polymer definitions: Polyethylene (PE) low-density poly ethylene (LDPE): homopolymer of ethylene with a densely branched structure; linear low-density polyethylene (LLDPE): copolymer of ethylene and longer-chain olefins, linear structure with short branches; high-density polyethylene (HDPE): homopolymer of ethylene with linear structure], polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC), poly(ethylene terephthalate) (PET) and polyurethane (PUR) (Bodor *et al*., 2024).

Plastics are 99% derived from crude oil or gas processed into monomers and polymerized with chemical additives enhancing ultraviolet light (UV) stability, heat resistance and flexibility (Rogers and Jaspers, 2024; Bodor *et al*., 2024; Anderson and Fletcher, 2022). Seven classifications of long-chain plastic polymers include natural (cellulose) and synthetic (nylon) (UNEP, 2023; Plastics Europe, 2024; Broda, Yelle and Serwańska-Leja, 2024).
Biobased plastics account for 2% of plastics (Walker and Fequet, 2023). Not all are biodegradable (Fredi and Dorigato, 2021). Biobased plastics require additional land and emit more GHGs due to deforestation (Halkos *et al*., 2025). Companies developing sustainable packaging are backtracking. In 2023, Unilever revised its goal to halve virgin plastic consumption to 30% by 2026 and 40% by 2028 (BloombergNEF, 2024).

Transporting nurdles

Fig. 4. Nurdles at North Queensferry, Firth of Forth, Scotland. © Alasdair Neilson

Microplastic nurdle pellets are the raw material of manufacture. 445,970 tonnes of 2-5 mm in diameter pellets are lost from the supply chain into the environment annually (Fidra, 2021; Mehrotra-Varma and Tunnell, 2023; Penn Environment, 2023). Nurdles are hydrophobic and carry toxic chemicals into oceans (Mato *et al*.,2001). The view of the Center for International Environmental Law (2024) is that resin producers are the ultimate genesis of the plastics crisis integrated into oil, gas, and petrochemical companies such as ExxonMobil Chemical and SABIC.

A spillage of 87 containers released billions of nurdles along Sri Lanka’s coastline (The Guardian, 2021), The International Maritime Organization issued MEPC.1/Circ.909 on recognising plastic pellets in packaged form as a “harmful substance”. Saudi Arabia and the United Arab Emirates responded that plastic pellets are not harmful substances/dangerous goods (Declan, Lloyds List, 2025). However, the European Council and the European Parliament have announced new rules on handling of plastic pellets on land and sea placing the obligation on operators, EU and non-EU carriers. (European Council, 2025).

Consumption

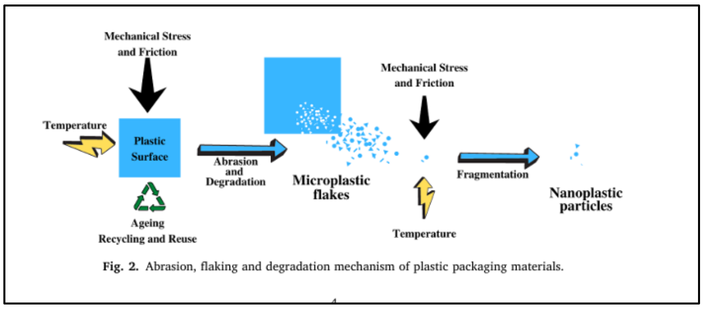


Fig 5. Jadhav, Sankhla, Bhat, and Bhagat 2021, p 4.

The majority of 8 million tonnes of plastics leaking into oceans yearly is from plastic packaging (Ellen MacArthur Foundation, 2016). Packaging uses 36% of all plastics produced (United Nations environmental programme, 2025). Packaging by FMCG companies generates primary and secondary microplastics (Center for Environmental Law, 2024). No single publicly available information source identifies chemicals associated with packaging. Available information is incomplete (Groh *et al.*,2019). Non-intentionally added substances (NIAS) may account for over half the chemicals in plastic manufacture (UN environment programme, 2023). It is impossible to detect and identify all NIAS in products due to a lack of comprehensive analyses (Geueke *et al*., 2022). The European Commission introduced stricter food contact materials regulations (EUR-Lex, 2025). UK REACH prioritises intentionally added microplastics but says risks are not fully understood (GOV.UK, 2024).

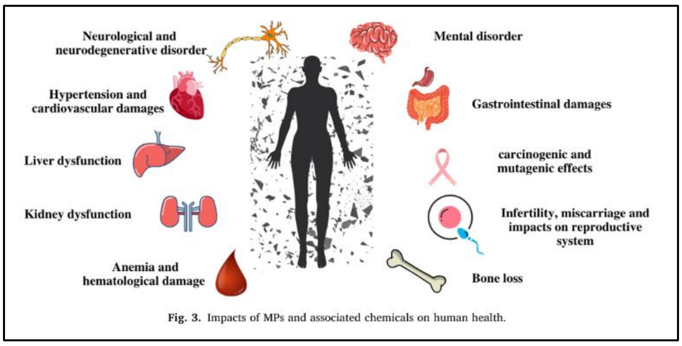


Fig.6. Jadhav, Sankhla, Bhat, and Bhagat 2021,p 7.

Microplastics enter the human body through inhalation and ingestion (Vethaak and Legler, 2021). Wu *et al*. (2024) show microplastics in salt, sardines, beer, fish, honey, sugar, tea bags, mineral water and drinking water. Li *et al*. (2020) estimate 12-month-old infants are exposed to 1,580,000 PP MPs/capita/day average daily consumption in feeding bottles. Microplastics are in lung tissue (Jenner *et al*., 2022); in patients undergoing carotid endarterectomy for asymptomatic carotid artery disease (Marfella *et al.*, 2024) and in the human placenta (Ragusa *et al*.,2021). When informed that microplastics may affect human health, 75% of survey respondents are concerned (Deng *et al.,* 2024). They might be even more concerned about microplastics in Recirculating Aquaculture Systems land-based indoor fish farming (Wei *et al*., 2024). As a nation of pet lovers, the British may shudder that sheep's heads with plastic tags on their ears are ground up in pet food (Earth Day, 2025) and concentrations of PET and PC are found in dry cat and dog food (Zhang, Wang and Kannan, 2019). The EU officially permits zero plastic in animal feed. However, some EU countries operate a 0.15% limit on residual plastic from packaging in animal feed (*The Guardian*, 2018).

Waste management

The rise in plastic waste poses constraints on achieving the United Nations Sustainable Development Goals (Stoett *et al.*, 2024). Environmental justice addresses waste disposal as landfills, incinerators, dumps, and burn facilities are located near low-income marginalised communities (Zero Waste Europe, 2022). Landfill is expected to continue as the leading global plastic waste management method with over 300 metric tonnes disposed of annually (Statista, 2025). Landfill is a source of microplastics. He *et al.* (2019) identified 17 plastic types in landfill leachate with 99.36% derived from buried fragments. Polyethylene and polypropylene predominated. Globally, plastic leakage will double to 44 Mt a year. Build-up of plastics in lakes, rivers and oceans will triple as plastic waste balloons from to 1,014 Mt in 2060 (OECD, 2022). Plastic production and incineration of plastic waste annually generate 400 million tonnes of CO_2 (Nielsen *et al.,*2020). Post incineration bottom ash is a source of microplastics (Yang *et al*., 2021).

Externalising their waste problem to other countries by using the waste recipient's land for disposal is a form of colonialism (#BreakFreeFromPlastic, 2024). In 2017, China implemented the 'National Sword' policy designed to ban the import of recyclable wastes, including plastics. This was followed with the 2021-2025 Plastic Pollution Control Action Plan.

Thailand, Malaysia, and Vietnam were overwhelmed with imported plastic waste before they too put in place restrictions (Ng *et al.* 2023; YaleEnvironent360,2019). Now Indonesia is one of the largest contributors to ocean plastic pollution with 620,000 to 1.29 million metric tons of plastic waste entering its marine ecosystems annually (Jambeck *et al*., 2015). The Netherlands was the largest exporter of plastic waste to Indonesia in 2023 at 120 thousand metric tonnes. Germany was second with 38,800 metric tonnes. Indonesians face a microplastic crisis consuming 15 grams of microplastics per month with 80% of fish consumed contaminated with microplastics (International Pollutants Elimination Network, 2024).

Africa ranks second after Asia as a consumer of plastics that break down into microplastic. Over 80% of microplastics waste is inadequately disposed of with 1.53 metric tons of plastic waste and 0.13 metric tonnes of primary microplastics released into the ocean annually through polluted rivers (Okeke *et al*.,2022). Small Island Developing States (SIDS) may account for <3 % of microplastics on their beaches. Lack of technical waste management expertise creates barriers to effective management of plastic pollution (Ambrose and Walker (2023). Back to Blue (2023) reported the frustration of SIDS delegates at INC-2 in June 2023. Recycling represents less than 10% of plastic waste management worldwide (Statista, 2025; GlobalSouthHub,2024). The supply chain of recycled plastic and production systems is not robust (Omair, Stingl and Wæhrens, 2025).

Pollution

Microplastics enter soil and plants causing drastic changes in physicochemical characteristics (pH, water retention, nutrient content), microbial community and fertility impeding a plant's performance and response (Lalrinfela *et al*., 2024; Allouzi *et al*., 2021; Bodor et al**.,** 2024; Bhattacharjee, Narayan and Shah, 2025). Compost, sewage sludge, irrigation with plastic-contaminated water and flooding cause unintentional contamination (Guo *et al*, 2024).

Rivers transport 70% - 80% weight of ocean plastic to the ocean (Ritchie, 2021). Stratification and mixing at the interface of riverine freshwater and saline seawater affects movement of debris (Zhang, 2017). Microplastics are more ecotoxic than bulk plastic debris in freshwater (Zhao, Richardson and You, 2024). Water companies in the UK are responsible for untreated wastewater and raw sewage as the main source of microplastic pollution in the UK's rivers (The University of Manchester, 2021).

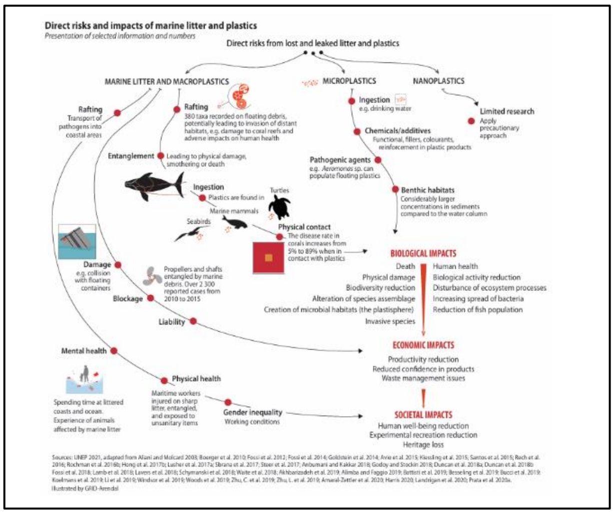


Fig. 7.UNEP, 2021, p7

Polyethylene (PE), polypropylene (PP), polystyrene (PS), polyamide (PA, nylon), polyester (PES) and acrylic (AC) microplastic particles are the most common plastics in oceans (Pollution Tracker, 2025) gathering in gyres that are hotspots for microplastic accumulation (Wright, Thompson and Galloway, 2013). UN Ocean Conference (2022) identifies six gyres circulating ocean waters. Garbage patches inside gyres draw in marine debris. Mass concentrations of new microplastic fragments are in the North Pacific Subtropical Gyre due to the break-down of decades old plastics (The Ocean Cleanup, 2024). Plastic marine debris migrates from Eastern Seaboard locations 1000 km to the interior of the North Atlantic Subtropical Gyre in less than 60 days (Zettler, Mincer and Amaral-Zettler, 2013). Garbage patches are expected to grow to 34 billion metric tons by 2050 (UN Ocean Conference, 2022). No single party is responsible for mitigation as accumulation zones are outside national territories (The Ocean Cleanup, 2024).

Up to a million seabirds and 100,000 marine mammals die ingesting plastic fragments or become entangled in the Great Pacific Garbage Patch (Geographical, 2024). Microplastics are found in 1300 aquatic and terrestrial species, from invertebrates to apex predators (Thompson *et al*., 2024). Wilcox, Van Sebille and Hardesty (2015) predict 99% of all seabird species will suffer plastic ingestion by 2050. Mediterranean fin whales Balaenoptera physalus are exposed to harmful chemicals (Fossi *et al*., 2012). Oceanic life-stage sea turtles are at the highest risk of debris ingestion and olive ridley turtles are the most at-risk species (Schuyler *et al*., 2014).

The density of microplastics affects distribution in the water column (Thushari and Senevirathna, 2020). Microplastics and leached toxins entering marine food webs depends on whether debris is buried on the seafloor, on a hard bottom, in shallow, coastal habitat or floating (Gilman *et al*. 2021).The plastisphere constitutes hotspots of antibiotic-resistant bacteria (Amaneesh *et al*., 2022). European Food Safety Authority (2024*)* warned of an increase in the risk of Vibrio bacteria in seafood due to climate change and antimicrobial resistance.

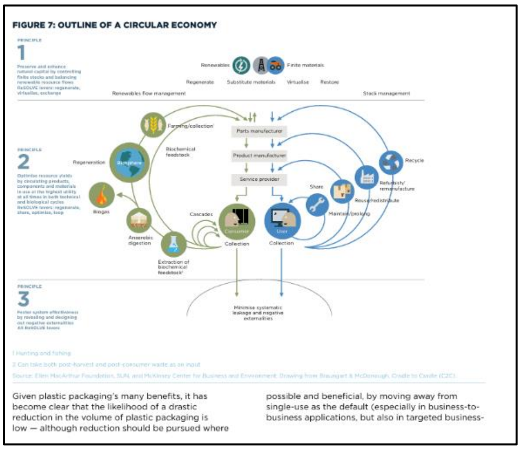
However, microbial communities of heterotrophs, autotrophs, predators, symbionts and harmful algal species hitch hike on plastic fragments less than 5 mm (Zettler, Mincer and Amaral-Zettler, 2013). Colonies of anemones, barnacles and brittle stars survive long trips to thrive in the Great Pacific Garbage Patch (Williams and Rangel-Buitrago, 2022). After the 2011 Japanese tsunami millions of plastic fragments supporting communities of marine life were colonized by marine organisms and transported to the Central and Eastern Pacific Ocean with 289 invertebrate and fish species arriving from Japan (Carlton *et al*.,2017).

Fig 8. Marine debris at Kochi on the banks of the Periyar River joining the Arabian Sea, Kerala, India © Sarah Woodgate.

Resolution UNEA-4/RES.6 stresses the importance of the preventing and reducing marine litter including microplastics from land and sea-based sources in support of the 2030 Agenda for Sustainable Development and the Sustainable Development Goals (UNEP, 2019). However, The Pew Charitable Trusts (2020) estimate 10% - 30% of total microplastic leakage is from maritime sources including Abandoned, Lost, or otherwise Discarded Fishing Gear (ALDFG). ALDFG plastics smother benthic organism habitats, hinder gas exchange and alter the composition of benthic biota (Apete, Martin and Lacovidou, 2024). Bottom thermohaline currents concentrate microplastics in benthic habitats coinciding with biodiversity hotspots (Gilman, *et al.* 2021). Highest levels of microplastics recorded are in seafloor sediments in the Mediterranean (*BBC*, 2020).

Annex V of the International Convention for the Prevention of Pollution from Ships (MARPOL) overlooks ancillary polystyrene containers, ice bags and carrier bags (Apete, Martin and Lacovidou, 2024). Deliberate dumping of general plastic waste from seagoing vessels is illegal with exemptions (The Pew Charitable Trusts, 2020). However, marine vessels, intentionally or unintentionally, dump plastic litter in the ocean, with an accumulation rate of some 6.5 million tons per year (Thushari and Senevirathna, 2020). There are 31 signatories to The Single-Use Plastic Charter 2019 banning the use of non-essential single-use plastics (UK Chamber of Shipping, 2025). The European Environment Agency (2025) reported marine macro litter declined 29% along EU coastlines between 2015-2016 and 2020-2021 and the EU is likely to meet the target by 2030. Outlook: Likely.

Overcoming barriers



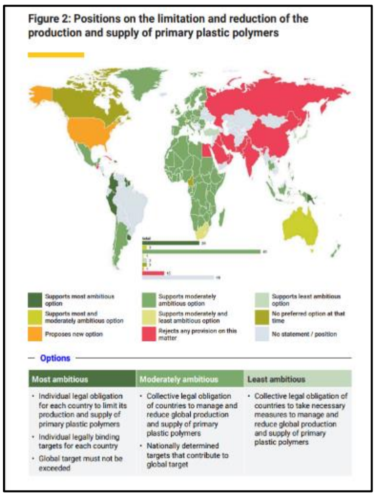
(**Fig.9.** Ellen MacArthur Foundation (2016) 2016, fig 7, p. 32).

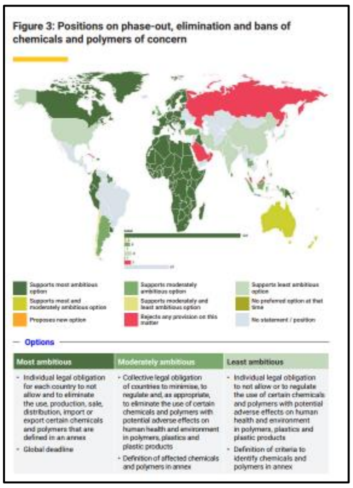
The shift to a circular economy is essential to address plastics' impact on the triple planetary crisis - climate change, biodiversity loss and pollution and waste crisis (Halkos *et al*, 2025). The cornerstone of the Ellen McArthur Foundation's New Plastics Economy is creating an effective after-use plastics economy by improving the economics and uptake of recycling, reuse and controlled biodegradation for targeted applications (Ellen MacArthur Foundation, 2025). A successful independent initiative is the Global Partners for Plastics Circularity multinational collaboration of associations and companies that make, use and recycle plastics with an $18 billion Investment in 128 projects that are operational, under construction, or planned projects**.** (https://plasticscircularity.org/our-progress/, 2025). It is questionable whether this can be replicated and scaled up without intergovernmental engagement.

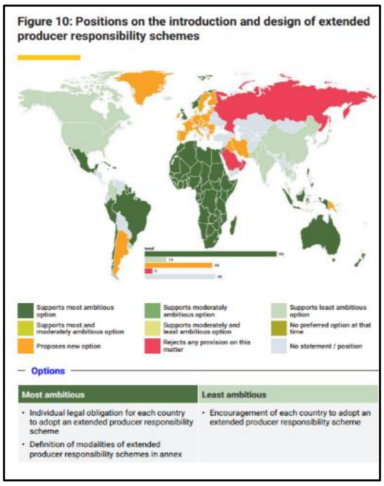
However, the European Parliament (2017) acknowledges challenges to adopting a circular economy due to current weak economic incentives, technical issues and finance (European Environment Agency, 2025). Hossain, Park, Suchek and Pansera (2024) found no systematic engagement with debates on democratic planning including the role of citizens and communities in decision-making about transition toward circularity.

Aligning global climate and plastics treaties is crucial for effective environmental action as plastic pollution and climate change are intertwined, with production, use, and waste management contributing to GHG emissions (Halkos *et al*., 2025). Failure by the INC to negotiate an international legally binding instrument by 2024 to combat plastic pollution, including in the marine environment as mandated by the United Nations Environment Assembly (UNEA) 2022 reflects polarising national self-interest. At INC-1 the American Chemistry Council representing ExxonMobil, Shell and Dow did not support overall caps on resin (Geddie and Brock, 2022). At INC-3 the SWITCH-Asia Programme (2024) collated data on the positions of all countries showing polarisation on objectives, core obligations and financing (UNEP, 2025). Resistance from sanctions-hit Iran was not unexpected. The plastics industry contributed 2% of GDP in 2022 (Climate Home News, 2024). Polymers were the second biggest source of export revenue for Iran in 2023 (Mahoozi, S.(2024).

Fig.10. Figure 2: Positions on the limitation and reduction of the production and supply of primary plastic polymers. **Figure 3**: Position on phase-out, elimination and bans of chemicals and polymers of concern. **Figure 10**: Positions on the introduction and design of extended producer responsibility schemes.







INC-5.1 registered 220 fossil fuel and chemical industry lobbyists and 17 national lobbying delegations including China, the Dominican Republic, Egypt, Finland, Iran, Kazakhstan, Malaysia and Peru (Center for Environmental Law, 2024). 175 countries failed to agree on how much to limit new plastic production (Dias and Wholf, 2024). The only agreement was to hold INC-5.2.

The World Bank (2024) states the private sector has a key role to play in terms of finance, technology, and circular business models. Mah (2021) addresses weaknesses of privately-led sustainability governance arguing that transnational corporations in contested industries lobby against environmental legislation. Unearthed (2024) reports Alliance to End Plastic Waste pledged $1.5 billion to eradicate millions of tonnes of plastic waste yet the companies on the executive committee – Shell, ExxonMobil, TotalEnergies, Chevron Phillips and Dow produce more plastic in two days than the Alliance's projects have cleaned up over five years. ZeroWasteEurope (2022) and WWF (2024) advocate for making Extended Producer Responsibility a mandatory practice creating a system where corporations are held responsible for the entire lifecycle of their products.

Ahead of INC-2 the 59 Ministers in the High Ambition Coalition to End Plastic Pollution by 2040 reiterated their deep concern about the continuous release and accumulation of microplastics and the degradation of plastic waste that may pose risks to human health and contribute to degradation of ecosystems and biodiversity (High Ambition Coalition, 2023). Ahead of INC-5 the 69 Ministers in the High Ambition Coalition to End Plastic Pollution by 2040 emphasize the principle that polluters should be held responsible for their activities and products including extended producer responsibility schemes (High Ambition Coalition, 2025). The importance of their influence at INC-5.2 in Geneva from 5-14 August 2025 cannot be overestimated.

Conclusion
Aligning global climate and plastics treaties that will push huge corporations to cut plastic production is crucial. Plastic pollution and climate change are intertwined with production, consumption, transport and waste management contributing to pollution and greenhouse gas emissions. The rise in plastic waste poses constraints on achieving the United Nations Sustainable Development Goals. The public is ahead of the politicians in concerns over

impacts of microplastics on human health. INC-5.2 is the global forum in which diverse stakeholders must advocate for making Extended Producer Responsibility a mandatory practice with corporations held responsible for the entire lifecycle of their products.

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