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Plastics and climate change: an overview of two connected global problems

Plásticos e mudanças climáticas: uma visão geral de dois problemas globais interligados

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ABSTRACT

This study presents an overview of how plastics and climate change represents two interconnected global problems. Through an interpretive overview of studies retrieved from Scopus, Google Scholar, ScienceDirect, and Web of Science databases, we aimed to identify commonalities among the topics through an integrative approach. Initially, we showed that fossil fuels are the primary raw material for plastic production and that the largest emitters of greenhouse gases (GHG) are also the largest producers of plastics. Projections indicate that plastics will account for 20% of global oil consumption by 2050. However, while their production is still modest, bioplastics and recycled plastics are increasing. Secondly, we examined GHG emissions throughout the lifecycle of the plastic, noting that the initial stages account for more than 60% of emissions. We also explored how plastic pollution, by interfering with ocean dynamics, is related to climate change, as well as the consequences of these two problems for marine ecology, the economy, and human health. Finally, we highlighted the global regulatory aspects of plastic use, often overlooked, and future prospects for ending plastic pollution and reducing GHG emissions. Thus, by integrating these two global problems, we seek to demonstrate that, in order to combat both crises, they can no longer be treated separately.

Keywords: plastics; climate change; greenhouse gas emissions; waste management; marine pollution.

RESUMO

Este estudo apresenta uma visão geral de como os plásticos e as mudanças climáticas representam dois problemas globais interligados. Por meio de uma visão geral interpretativa de estudos recuperados das bases de dados Scopus, Google Scholar, ScienceDirect e Web of Science, buscamos identificar pontos em comum entre os tópicos estudados por meio de uma abordagem integrativa e reflexões sobre o tema. Primeiramente, demonstramos que os combustíveis fósseis são a principal matéria-prima para a produção de plástico e que os maiores emissores de gases de efeito estufa (GEE) também são os maiores produtores de plásticos. As projeções demonstram que os plásticos serão responsáveis por 20% do consumo global de petróleo até 2050. No entanto, embora sua produção ainda seja modesta, os bioplásticos e os plásticos reciclados estão aumentando. Em segundo lugar, examinamos as emissões de GEE ao longo do ciclo de vida dos plásticos, observando que os estágios iniciais são responsáveis por mais de 60% das emissões. Também exploramos como a poluição por plástico, ao interferir na dinâmica dos oceanos, está relacionada às mudanças climáticas, bem como as consequências desses dois problemas para a ecologia marinha, a economia e a saúde humana. Por fim, destacamos os aspectos regulatórios globais do uso do plástico, muitas vezes negligenciados, e as perspectivas futuras para acabar com a poluição por plástico e reduzir as emissões de GEE. Assim, ao integrar esses dois problemas globais, buscamos demonstrar que, para combater ambas as crises, elas não podem mais ser tratadas separadamente.

Palavras-chave: plásticos; mudanças climáticas; emissões de gases de efeito estufa; gestão de resíduos; poluição marinha.

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Introduction

The transportation, energy, and agriculture sectors are often mentioned as the main contributors to climate change. However, emissions resulting from the production of plastics are commonly overlooked (Montenegro et al., 2020). Although plastics and their negative impacts are recurring topics in research, these problems are generally treated separately (Ford et al., 2022). Plastics have surpassed most manmade materials, and their production is ever-growing (Geyer et al., 2017). The manufacture of these materials requires energy-intensive processes that rely heavily on fossil fuels (Bauer et al., 2022) and these processes contribute significantly to global warming (Stegmann et al., 2022). Anthropogenic activities have already caused an increase of 1.25°C in global temperatures, and the current trajectory of emissions suggests that it will exceed 1.5°C in under a decade (Matthews and Wynes, 2022), contrary to the Paris Agreement. Thus, the growing plastics industry is intensifying these problems, creating one of the most pressing environmental challenges today(Sharma et al., 2023).

After being used, plastics are often inadequately managed on a global scale, resulting in what can be referred as mismanaged plastic waste (MPW). This poorly managed waste represents a significant environmental challenge, contributing to the degradation of ecosystems and exacerbating climate change (Ford et al., 2022). It is widely recognized that a large proportion of MPW ends up in the seas and oceans, accumulating in marine sediments, on the water surface, in the water column, and marine biota (Belli et al., 2024). The oceans are crucial for climate regulation, buffering the effects of rising greenhouse gases (GHG) in the atmosphere and global temperatures (Reid et al., 2009). This capacity has a significant impact on the global climate by regulating the concentration of CO_2 in the atmosphere (Heinze et al., 2015). However, the presence of plastics, especially microplastics (<5 mm), in the water column interferes with the balance of natural carbon sequestration, as key organisms (e.g., phytoplankton and zooplankton) in the biological pumping of carbon are affected (Sunil et al., 2024). Furthermore, less than 1% of studies simultaneously link climate change and marine plastic pollution (Ford et al., 2022).

In this context, it is estimated that by 2050, plastic production will represent a significant share of the global carbon budget (CIEL, 2019), with a large portion of this material ending up in the oceans, if the management of these materials remains unchanged (Jambeck et al., 2015). Marine plastic pollution and climate change mitigation are directly linked to the United Nations (UN) Sustainable Development Goals (SDGs): 12 (Sustainable Production and Consumption), 13 (Climate Action Against Global Climate Change), and 14 (Life Below Water), promoting sustainable practices and the preservation of the environment (Sorooshian, 2024). This study focuses on an exploratory approach to the relationship between climate change and increased plastic production and pollution. We seek to compile data from production to consequences (i.e., the complete plastic life cycle), as well as regulatory aspects that are often overlooked (Ford et al., 2022). The discussion will evolve as follows: plastic production (Topic 3), its relationship with climate change (Topic 4) and marine pollution (Topic 5), ecological and socio-economic consequences (Topic 6), regulatory aspects (Topic 7) and, finally, future perspectives (Topic 8). By integrating these issues, the study aims to demonstrate that plastics and climate change can no longer be treated separately.

Methodology

This study sought to integrate the links between plastics and climate change. We summarized this complex interaction in an accessible synthesis, prioritizing clarity and the dissemination of knowledge. The research was conducted on the Scopus, Google Scholar, ScienceDirect, and Web of Science platforms, using a combination of the keywords "Plastics," "Climate Change," "Greenhouse Gas Emissions," "Waste Management," "Marine Pollution," and "Regulatory Aspects." With no defined start date, the search extended to May 2025, including only studies in English (e.g., scientific articles, book chapters, and government or non-governmental organization reports). The goal of this research was to conduct an interpretive analysis, identifying points of thematic convergence, rather than a robust systematic review. The process followed three steps: initial screening by title, abstract, and keywords; full reading to confirm suitability to the scope; and removal of duplicates. Thus, we analyzed the results of these studies (>100) and extracted the relevant information.

Plastic production and waste

Plastic production consumes between 5 and 7% of the global oil supply (Mülhaupt, 2013; Rosenboom et al., 2022) and, if current growth trends continue, the projection estimates that plastics will account for 20% of global oil consumption by 2050 (CIEL, 2019). Global plastic production and trends, as well as GHG emissions, are shown in Figure 1. The plastic production process is generally similar for different feedstocks, although there are significant variations. As illustrated in Figure 1B, fossil sources are the primary feedstock for plastic production. In this context, it is no coincidence that the world's biggest emitters of GHG, such as China, USA, India, and European Union (EU) (Figures 1C and 1D), are also the biggest producers of plastics (Figure 1A). In 2023, among these main emitters, China, India, Russia, and Brazil increased their emissions compared to 2022. India had the largest relative increase (6%), while China recorded the largest absolute increase, with 784 Mt CO_2 eq. (Crippa et al., 2024). At the same time, global plastic production has continued to grow, even during the COVID-19 pandemic (Figure 1B).

Asia accounts for the largest share of plastic production in the world, accounting for 33% in China and 22.5% in other Asian countries. North America is the second largest producer (17%), followed by the EU (12%) (Plastics Europe, 2024). The largest market for plastics is packaging (Dokl et al., 2024), which leads to significant environmental concerns.

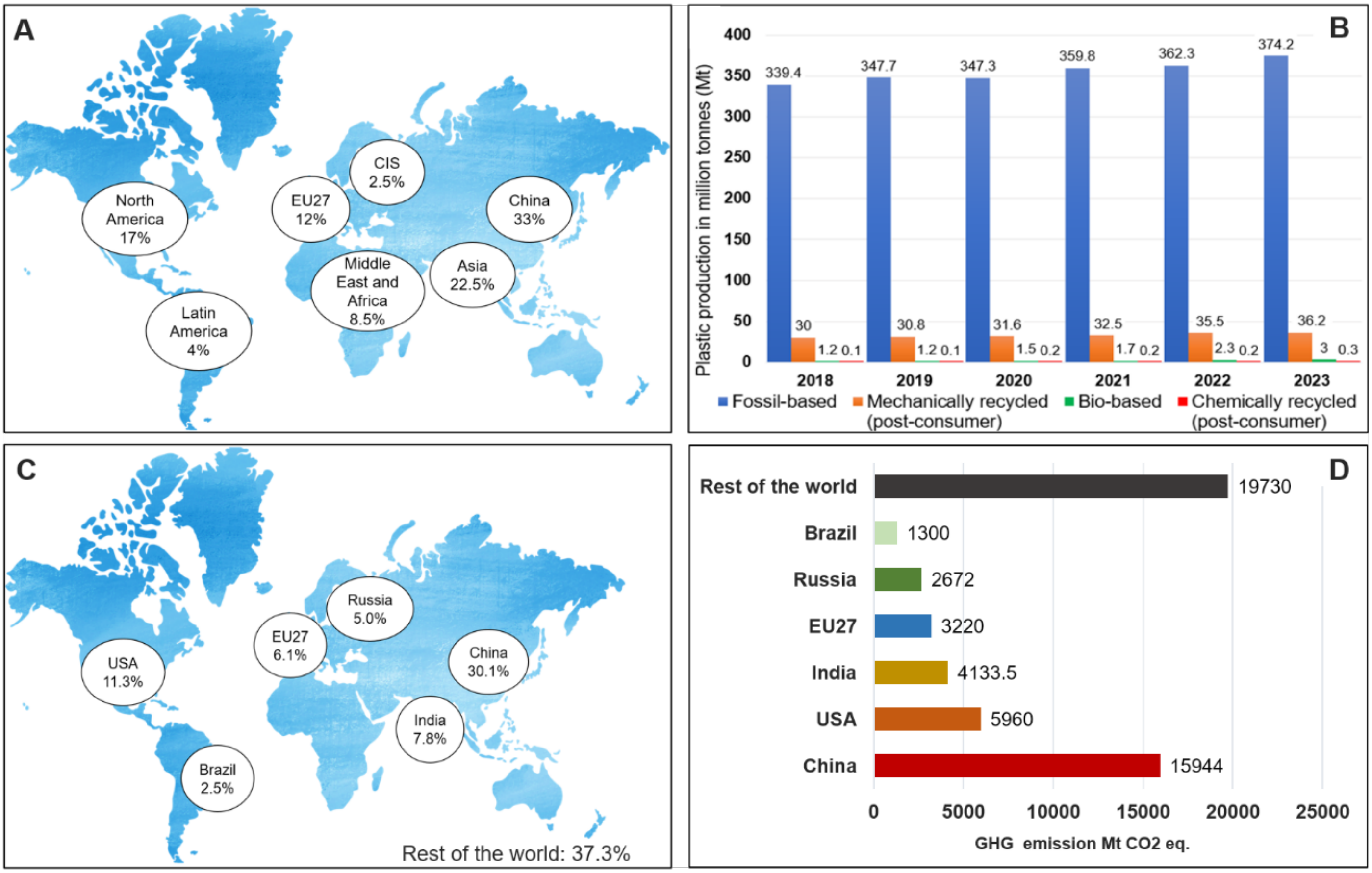

Figure 1 – (a) Global plastics production in 2023, (b) World plastics production trends, (c) GHG emissions in 2023, and (d) the world's 6 largest emitters of GHG in Mt CO_2 eq in 2023.
CIS: Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, and Uzbekistan.
Source: Crippa et al. (2024) and Plastics Europe (2024).

Up to 63% of post-consumer packaging may not be monitored in certain countries, resulting in 0.8 million tons of plastic being disposed of improperly (Pincelli et al., 2021). Households use five to six plastic bags per day, while collection coverage has remained poor in many countries, sustaining persistent leakage (Batcham et al., 2025). In addition, between 1950 and 2015, the total generation of plastic waste reached 6,300 million tons worldwide. Among this total, approximately 12% was incinerated, 9% was recycled, and 79% was deposited in landfills or in the natural environment without control (Geyer et al., 2017).

The production of virgin plastics, derived from oil and natural gas, remains predominant due to low costs and existing infrastructure (Pilapitiya and Ratnayake, 2024; Williams and Rangel-Buitrago, 2022). Recycling efficiency varies between countries, facing logistical and technological challenges (Singh and Walker, 2024), resulting in many recyclable plastics being discarded in landfills or oceans. Chemical recycling, although less widely used, has great potential to mitigate climate impacts and handle plastics that are difficult to recycle (Chen and Hu, 2023). In contrast, mechanical recycling, even in informal settings, generates significant socioeconomic benefits when well coordinated (Gall et al., 2020). In any case, recycling, which is underutilized, can significantly reduce environmental impacts and resource depletion throughout the plastic life cycle (Gabisa et al., 2023).

The promotion of sustainable alternatives such as bioplastics has been an emerging trend in recent years (Figure 1B). Bioplastics production is expected to increase by around 7.5 million tons in 2026 (Ali et al., 2023). These bio-based materials are entirely or partially made from biological resources and they are not necessarily biodegradable. By using renewable or recycled materials, they provide a sustainable alternative within a circular economy (Rosenboom et al., 2022). However, these materials lack international standards, which consequently affect their marketing and pricing (Findrik and Meixner, 2023). The acceptance and promotion of biopolymers such as biofuels could boost their annual growth above 20% (Skoczinski et al., 2024).

Despite recent advances in the production of recycled and bio-based plastics, as illustrated in Figure 1B, it will still be necessary to overcome deeply rooted dependencies and make profound systemic changes in the way plastics are produced (Bauer et al., 2022). About 30% of plastics produced globally are still in use, and a large portion will become waste (Geyer et al., 2017).

Plastic production/consumption linked to climate change

Plastic production from fossil fuels is a significant source of GHG emissions (Figures 1 and 2), accounting for about 3.3% of global emissions (Ritchie, 2023). In 2019, this sector emitted 2.2 billion tons of GHGs, a volume greater than the 1.3 billion tons emitted by aviation and maritime transport combined (Karali et al., 2024). Projections indicate that, if uncontrolled, the contribution of plastics to the global carbon budget is projected to reach 13% or even 21–26% in a conservative growth scenario (2.5%/year), and 25–31% with a 4%/year growth by 2050 (CIEL, 2019; Karali et al., 2024), compromising efforts to keep the global average temperature below 1.5°C in every way. The initial stages of plastic production contribute most to emissions (61%), while the manufacturing of the final product accounts for 30% and the end-of-life stage (e.g., incineration, recycling, and landfilling) represents 9% of the total life-cycle emissions (Zheng and Suh, 2019). Figure 2 illustrates the initial stages along the life cycle of plastics, that can emit up to 10 times more GHG than the end-of-life stage.

About 60% of plastics are produced for single use applications, intended for items such as bags and packaging (Franz et al., 2024). This massive flow of short-lived waste often ends up in air burning sites, a common final disposal practice in low- and middle-income countries (Pathak et al., 2023). However, this practice remains outside most emissions inventories, even though its potential contribution is estimated at 5% of the annual global anthropogenic total (Wiedinmyer et al., 2014). Countries such as China, India, Brazil, Mexico, Pakistan, and Turkey have been identified as the largest emitters and therefore these nations face enormous challenges in waste management due to the high costs of landfills and the lack of effective policies, creating a vicious cycle of pollution and emissions (Lino et al., 2023).

Another way to redirect plastic waste is through international trade. It is estimated that approximately 2% of these materials are traded between countries (Ritchie, 2022), totaling around 255 million tons exported between 1988 and 2022, with the main flows originating from economically developed regions such as Europe, Asia, and North America (Xu et al., 2024). A turning point occurred in 2017 when China, which previously imported more than half of this waste, implemented a ban on plastic waste importation (Wen et al., 2021). This trade, however, has a significant environmental footprint due to CO_2 emissions from maritime transport. Although it is difficult to accurately quantify the share attributable specifically to the transport of plastic waste, commercial shipping overall is responsible for around 1 billion tons of CO_2 annually, equating to 3% of global emissions (Mersin et al., 2019).

The transition to a low-carbon economy in the plastics sector depends mainly on two strategies: bio-based polymers and recycling (Titone et al., 2022). The impact of conventional plastics on the climate is significant: the production of 1 kg of virgin fossil-based plastic emits at least 2.9 kg of GHG. At the end of their useful life, their disposal or incineration adds another 2.7 kg of emissions. Recycling breaks this cycle, as recycled material replaces new plastic, avoiding the extraction of further resources and virgin production. This substitution can prevent the emission of 1.91 to 5.70 kg of CO_2 eq. for each kilogram of recycled polymer that is reintroduced into the market (Tenhunen-Lunkka et al., 2023). Other initiatives are also mentioned in Topics 7 and 8.

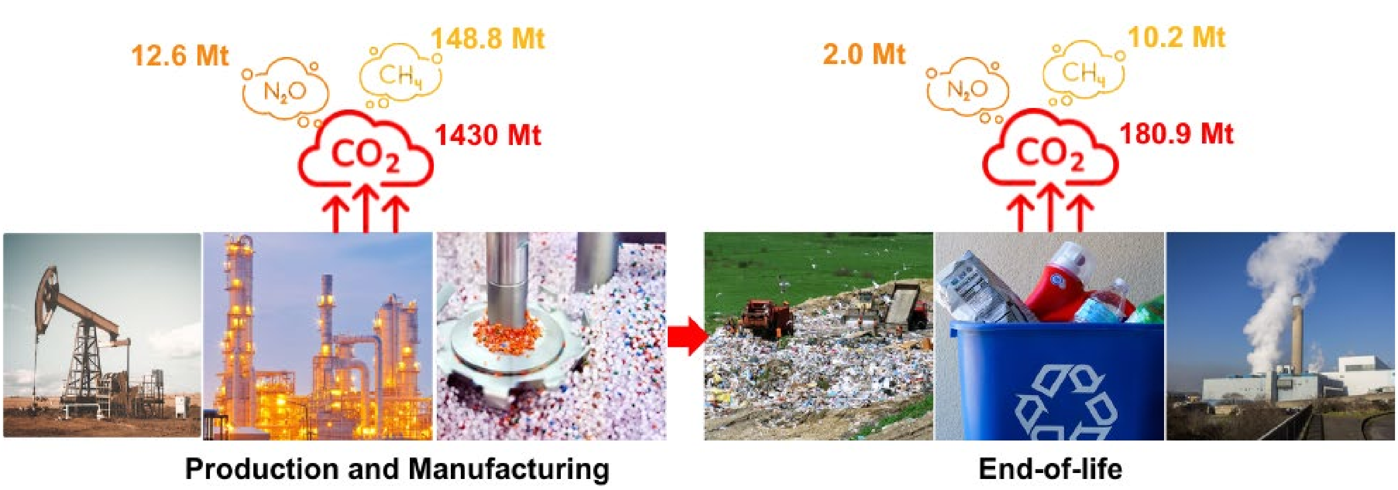

Figure 2 – Greenhouse gas emissions (GHG) from the life cycle of plastics in 2019. Emissions are measured in tons of CO_2 eq.
End-of-life: landfill, recycling or incineration. Carbon Dioxide (CO_2), Nitrous Oxide (N_2O), and Methane (CH_4).
Source: Ritchie (2023).

Marine plastic pollution linked to climate change

The presence of plastics in the oceans is no longer an emerging threat, but a globally recognized environmental problem. Approximately 13 Mt ofplastic waste can be| found in terrestrial environments, while 6 Mt accumulates in rivers or coastlines. Of this total, 1.7 Mt ends up in the oceans (1.5 Mt remaining close to the coast, 0.2 Mt sinking to the bottom, and <0.1 Mt dispersed on the ocean surface), with rivers being the main transport routes (OECD, 2022). The oceans play a crucial role in regulating life on Earth (Grégoire et al., 2023). They are the largest reservoir of CO_2, having absorbed approximately 40% of anthropogenic CO_2 (Reid et al., 2009). Moreover, the oceans act as a heat pump, moving large volumes of warm water and air, and helping to regulate the climate (Galland et al., 2012). However, continuous emissions, mainly from the burning of fossil fuels, are overloading the oceans and weakening their absorption capacity (Heinze et al., 2015). This massive absorption of carbon and heat modifies the temperature, pH, and carbonate ion concentration of the ocean (Caldeira and Wickett, 2003; Levitus et al., 2005). Figure 3 illustrates the possible consequences of marine plastics in association with climate change.

The presence of plastics in marine environments also warns to the fact that they contribute to intensifying climate change. As temperatures rise, the properties of the polymers begin to change, resulting in the deterioration of plastics in both the short and long term. Plastics can increase diurnal temperature extremes in beach sediments. The accumulation of debris poses a significant warming risk to coastal regions, with temperatures exceeding 2°C (Lavers et al., 2021). In parallel, the release of chemicals from plastics intensifies, increasing the leaching of these substances into the water (Wei et al., 2024). Based on a series of laboratory experiments with new and aged plastics, exposed to sunlight (with a solar simulator) or kept in the dark, Romera-Castillo et al. (2023) demonstrated that abiotic degradation of plastics induces a decrease in seawater pH. The authors highlighted that this process is accelerated by solar radiation, which intensifies the release of dissolved organic carbon (DOC) from plastics. The decrease in pH is mainly attributed to the release of organic acids and the production of CO_2.

Sunlight is also crucial in the degradation of plastics, making them more vulnerable to fragmentation into micro and nanoplastics (Andrady et al., 2022; Dimassi et al., 2022). By absorbing light in the aquatic environment, they raise the water temperature and alter its density, an effect that can be intensified by future changes in the ozone and climate, further accelerating global warming and degradation (Andrady et al., 2022; Oliveri Conti et al., 2024). In addition, the ocean's surface microlayer, vital for biochemical processes and gas exchanges, is affected when bacteria colonize microplastics: through biofouling, they increase the production of organic matter and consume more oxygen, reducing the availability of this gas for other forms of life (Galgani and Loiselle, 2019; Wurl et al., 2017); and, although based on a pilot laboratory study, research suggests that high concentrations of microplastics and organic matter can reduce CO_2 absorption by the ocean.

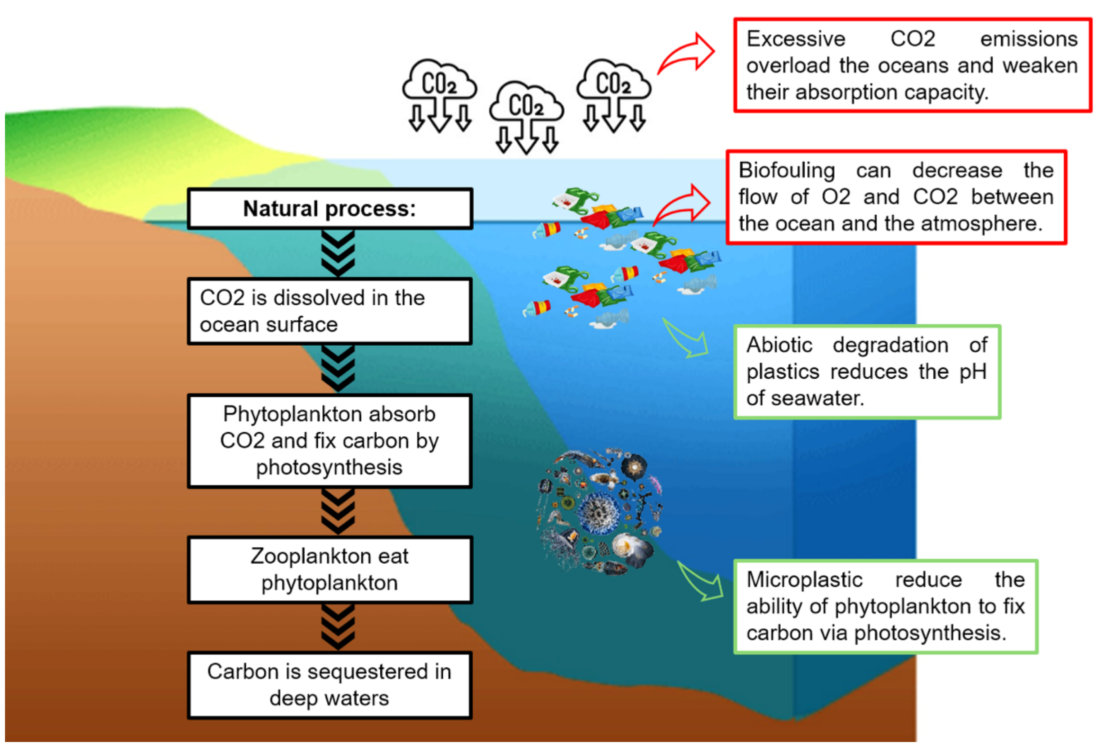

Figure 3 – Potential consequences of marine plastics associated with climate change.

These microplastics found on the surface also have the ability to be transported over long distances (Belli et al., 2026), reaching remote polar regions, where their presence in ecosystems sensitive to climate change poses a significant threat. Due to their varied physical and chemical characteristics, these microplastics can absorb sunlight and decrease the albedo of snow and ice surfaces (Evangeliou et al., 2020).

Mangroves also play a vital role in blue carbon sequestration, storing four times more carbon than tropical forests and accounting for 10 to 15% of the global coastal total (Choudhary et al., 2024). However, plastic pollution, especially microplastics, threatens this balance. He et al. (2025) identified a positive correlation between the presence of microplastics in the surface layer and the ratio between methanogenic and methanotrophic functional genes. This microbial imbalance increases methane (CH_4) production (by favoring methanogenic archaea) and, consequently, reduces the net carbon storage capacity of these ecosystems. Although initial research has previously shown that plastic debris can alter water characteristics and affect carbon sequestration capacity, the issue requires further investigation. It is imperative to improve plastic waste management on land, promote the transition to a circular economy, and implement policies that combat marine pollution and climate change simultaneously.

Consequences for the marine ecology, economy, and human health

The accumulation of plastic fractions not only damages the aesthetics of the environment but also poses risks to human health and ecosystem integrity (Seewoo et al., 2023; Alijagic et al., 2024). The discovery of "plastic-rock complexes" confirms that plastic has become part of the earth's geological cycle, generating microplastics at rates tens to hundreds of thousands of times higher than in typical environments (Wang et al., 2023). Flooding is one explanation for the formation of these complexes, as plastic debris is crushed into the rocks. Due to increased flooding caused by global warming (Alifu et al., 2022), new "complexes" may be detected. Some of these plastic fractions persist in the aquatic ecosystem for long periods, as they are resilient to natural decomposition mechanisms. Thus, organisms face the dual threat of plastic pollution and climate stressors (e.g., warming, acidification, and deoxygenation of the oceans) acting in concert (IPCC, 2023). For instance, marine organisms may ingest microplastics, leading to reduced feeding efficiency, respiratory impairment, and increased susceptibility to disease (Muñiz and Rahman, 2025). Coral reefs are experiencing significant degradation of their biological and physical functions due to the combination of climate change, overfishing, and plastic pollution (Pinheiro et al., 2023).

Ocean acidification changes the carbonate chemistry of seawater and exacerbates the impacts of plastics on marine organisms (Grabb et al., 2024; Huang et al., 2022). Simultaneously, rising ocean temperatures are dramatically altering ecosystems, facilitating the migration of species to higher latitudes due to a 1.05°C increase in sea surface temperature (e.g., the microalgae *Penicillus capitatos* in the Azores) (Gabriel et al., 2024). This reorganization is global: cetaceans are adjusting their migratory routes (van Weelden et al., 2021), colonies of northern gannets (*Morus bassanus*) are moving toward the Arctic due to the warming of the Barents Sea (Barrett et al., 2017), and phytoplankton diversity is projected to increase by more than 16% in many regions (Benedetti et al., 2021). However, this scenario is not balanced, with a decline in zooplankton diversity to be expected in tropical regions, which could destabilize food webs and signal a comprehensive and complex transformation in the composition and functioning of marine communities (Benedetti et al., 2021).

Even though plastic fractions affect marine organisms, as previously reported, it is impossible to directly correlate this impact to human health (Paparella et al., 2021), even though there is already evidence of plastics being detected in the human body (Roslan et al., 2024). However, the effects of consuming food contaminated with MPs have already been reported, including cancer, digestive problems, and cardiovascular diseases (Allouzi et al., 2021). The *One Health* approach considers health management in response to rapidly accelerating environmental change, recognizing that the health of humans, animals, plants and the environment overall are closely linked and interdependent (Bustamante, 2024).

Climate change and pollution pose growing threats to human well-being and socioeconomic systems, particularly in countries with high levels of social inequality. This vulnerability is reflected in the fact that countries with the greatest disparity between the rich and the poor have recorded a flood mortality rate 26 times higher than that of more egalitarian nations, especially in Africa, Asia, and America (Lindersson et al., 2023). The problem is exacerbated by the strong links between the increase in MPW and the growing incidence of urban flooding (MacAfee and Löhr, 2024). In agriculture, global warming compromises food security, with the production of six essential crops decreasing by 5.5×10^{14} kcal for every 1°C increase in temperature (Hultgren et al., 2025). The oceans also suffer twice: marine fisheries face massive reorganization, with 23% of the transboundary stocks projected to change by 2030, leading to an average change of 59% in the proportion of catches in global Exclusive Economic Zones (EEZs) (Palacios-Abrantes et al., 2022), and plastic pollution, which dumped between 4.8 and 12.7 million tons into the oceans in 2010 alone, also degrading ecosystems at an estimated cost of $ 3,300 to $ 33,000 per ton/year (Beaumont et al., 2019).

Furthermore, covering approximately 1.7 million hectares in more than 118 countries, mangroves are on the front line of climate impacts, including rising temperatures, sea level rise, extreme weather events, changes in ocean circulation, and precipitation patterns (Wang and Gu, 2021). Sea level rise will be a critical factor driving future mangrove changes, with a critical threshold of approximately 6 mm per year. Projections indicate increased mangrove mortality in regions with higher temperatures and lower rainfall, with extreme weather events resulting in significant losses in areas such as the Gulf of Mexico, the Caribbean, Asia, and oceanic islands (Alongi, 2022; Friess et al., 2022). Finally, it should not be ignored that rising temperatures and heatwaves increase the consumption of plastic materials. For example, an increase of just 1°C in the average temperature is associated with an increase of almost one-fifth in water bottle comsumption (Zapata, 2021). This phenomenon creates a paradox where climate change increases the demand for plastics, intensifying plastic pollution, while their growing production of plastics exacerbates climate change (Wei et al., 2024). The world has reached a stage where it is necessary to drastically mitigate these effects.

Global regulatory aspects of plastics use

The linear relationship between plastic production and plastic pollution, irrespective of region or waste management system, indicates that reducing plastic production is crucial to minimizing pollution (Cowger et al., 2024). Single-use plastics (e.g., plates, bags, cups, straws and packaging, etc.) are considered the most problematic due to their short lifespan and widespread commercialization (Rabiu and Jaeger-Erben, 2024). Global regulatory approaches to combat climate change through plastic control reveal a diverse and fragmented landscape. The linear relationship between plastic production and pollution indicates that reducing production is key, leading many countries to focus on bans on specific items. Notably, 127 countries have implemented national legislation to address plastic bags, and 27 countries have instituted some form of ban on single-use plastics, excluding bags (Figure 4). However, actions against MPs in personal care products are less common, with only eight countries, including Canada, France, and the United States, implementing national bans (UNEP, 2018). This sectoral and incremental approach demonstrates global recognition of the problem, but a coordinated and comprehensive strategy for the entire plastic life cycle remains absent.

Faced with the global plastic crisis, economic blocs and nations are adopting regulatory strategies of varying scopes. The European Union is at the forefront with Directive 2019/904, imposing mandatory targets such as the collection of 90% of plastic bottles by 2029 and the incorporation of 25% recycled material by 2025, combined with extended producer responsibility (European Union, 2019). At the same time, China, the world's largest producer and polluter, implemented an ambitious plan in 2020 to drastically ban items such as disposable cutlery and non-biodegradable straws (Liu et al., 2022). In contrast, other regions exhibit more fragmented approaches: the African continent's legislation is often restricted to waste management, even though Rwanda has been a success story since 2008 (Adebiyi-Abiola et al., 2019); the USA lacks federal legislation, resulting in a patchwork of state rules, such as bans on plastic bags in California and New York (Wang et al., 2022); and Mercosur operates without a common standard. Argentina and Uruguay advance national regulations, including a ban on personal care products containing microplastics (Belli et al., 2024). Meanwhile, Brazil, through Decree No. 12,688/2025, establishes rules, targets, and implementation phases focused exclusively on plastic packaging, with direct impacts on manufacturers, importers, distributors, and retailers (Brasil, 2025).

Despite the global movement to curb plastic pollution, policy effectiveness is uneven and shaped by local contexts. In the United States, regulatory fragmentation is compounded by preemption laws in 19 states, blocking municipal regulations and creating an inconsistent landscape (Wang et al., 2022). In Africa, where nearly half of the countries have bans in place, however implementation is hampered by poor enforcement and a lack of viable alternatives for populations that depend on plastic in contexts of poverty (Knoblauch and Mederake, 2021). The European Union faces internal resistance in the transition to a circular economy, with common goals that generate conflicts between Member States (Beghetto et al., 2023). China saw its pioneering 2008 policy become ineffective due to symbolic fees and the rapid rise of unregulated e-commerce (Liu et al., 2022). In Brazil, operational inefficiency keeps formal selective collection low, reflecting the disconnect between legal frameworks and the necessary infrastructure and financing (Gonçalves-Dias et al., 2024). Thus, building a circular system requires not only political will, but also the overcoming of sectoral vetoes, adapting to socioeconomic realities, and robust investments in enforcement and infrastructure.

Given this fragmented scenario, it is imperative to move toward an international treaty that establishes common global standards. A key objective of such an agreement should be the coordinated reduction of plastic pollution, promoting the collaboration between countries, aligning national policies and encouraging the development of alternative materials and recycling technologies. A unified legal framework is crucial for ensuring an effective global commitment, addressing the problem at its root, i.e., namely production.

Future prospects and challenges

Reducing the production and use of single-use plastics represents an important challenge for the future, and it is fundamental not only to minimize pollution, but also to create new economic opportunities (Chen et al., 2021; Kasznik and Łapniewska, 2023). For the elimination of single-use plastics to be effective, it is crucial that it should be accompanied by complementary public policies and initiatives. The EU has adopted the Single-Use Plastics Directive (EU 2019/904) (European Union, 2019), which bans many single-use plastic products and includes measures such as extended producer responsibility. If implemented effectively, these actions could significantly reduce plastic waste, with estimated reductions of 13 to 25% in general waste and 22 to 30% in plastic waste, depending on moderate improvements scenarios (Kiessling et al., 2023).

There is a great deal of research on the subject, but as mentioned previously, few have found the correlation between the two issues.

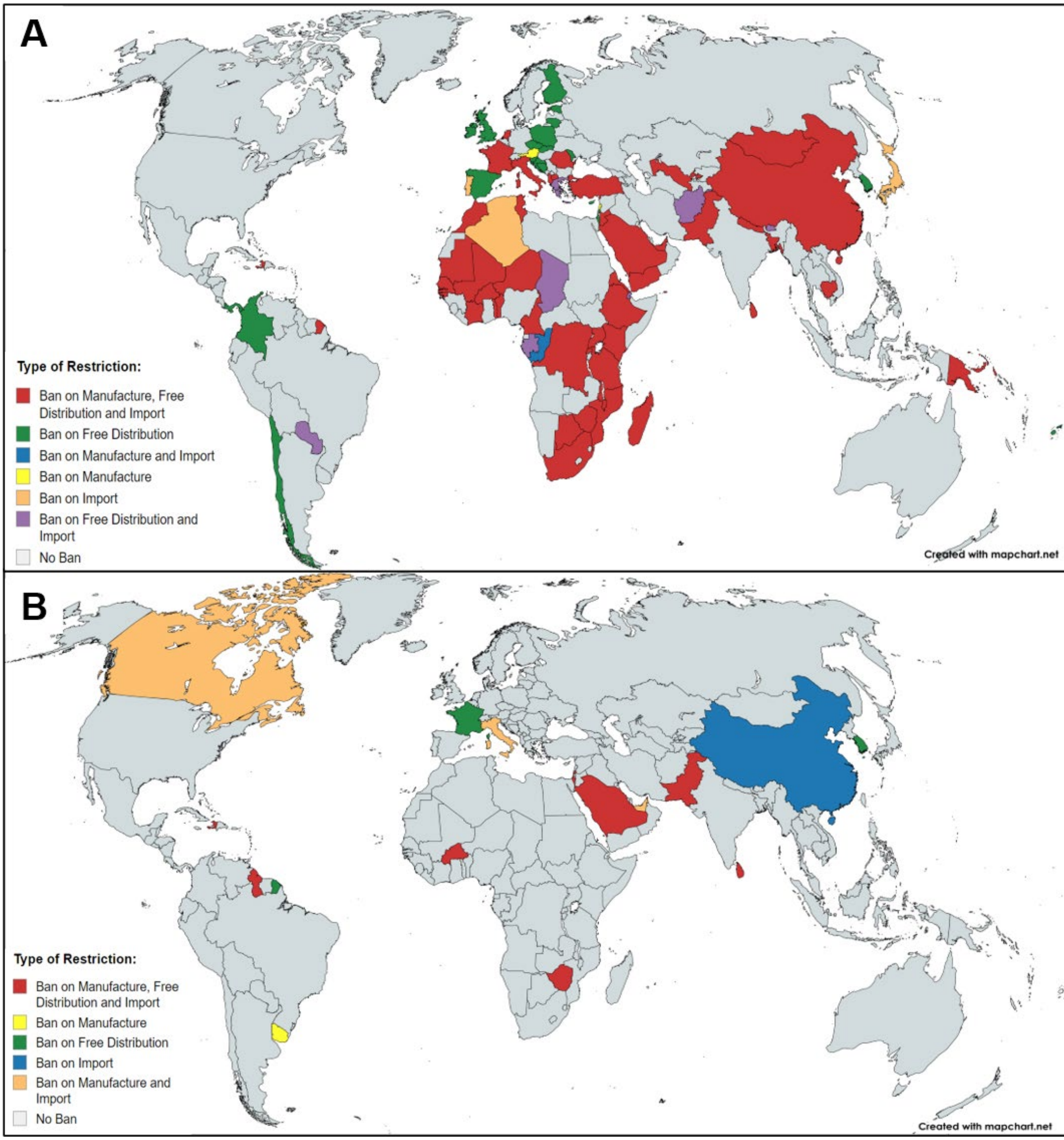

Figure 4 – (a) Countries with plastic bag bans. (b) Countries with a ban on single-use plastics, except plastic bags.
Source: UNEP (2018).

Since 2022, it has been reported that there is an increasing co-occurrence of these global issues, along with other stressors that threaten the resilience of species and habitats sensitive to both climate change and plastic pollution (Ford et al., 2022); however, since then, little has changed in terms of research on the subject. The impact of plastic pollution on climate change represents the most urgent need for decision-makers, who must draw up mitigation policies to address this threat (Sharma et al., 2023). Another important tool to minimize climate change is comprehensive plastic waste management, which strengthens efforts to prevent its spread, protects the health of the planet, especially human health, combatting plastic pollution by limiting the production of new plastics. It is important to highlight the lack of proper regulations and a worldwide policy framework that could regulate the green production of plastics and the recovery of plastic waste from the environment.

Since 2022, the UN has been working towards a historic global agreement to address the entire plastic life cycle and, consequently, reduce plastic pollution.. However, the negotiations have failed to reach a consensus. It has become clear that there are persistent disagreements over critical aspects of the plastic life cycle, especially regarding the production stages, which account for the highest percentage of emissions. The global effort to stop plastic pollution is evident, with negotiations moving toward a legally binding treaty. This treaty will be essential to protect both health and the environment. Despite the challenges, progress is promising and reflects global determination.

Although the UN treaty on plastics did not result in a consensus among member states, there are still opportunities to review and adjust these results, as multiple policies can be adopted to tackle the plastics issue. According to Pottinger et al. (2024), a combination of four policies, taken together, stands out for reducing MPW by 91% and plastic-related GHG emissions by one-third. These key policies include: requiring a minimum of 40% of global plastic waste to be recycled; limiting virgin plastic production to the 2020 levels; investing US$ 50 billion in expanding waste management infrastructure (e.g., improving formal waste collection and constructing landfills), especially in low-income regions; as well as implementing a high tax on plastic packaging consumption. These actions could virtually eliminate plastic pollution, reducing it to around 11 million tons by 2050, while also cutting plastic-related GHG emissions to 2.09 Gt CO_2 eq. during the same period. This highlights the relevance of robust and comprehensive policies to tackle the problem of plastic waste and its environmental consequences, underlining the importance of well-structured and coordinated policies to achieve significant results (Pottinger et al., 2024).

Conclusion

This paper explores the relationship between plastics and climate change, demonstrating their adverse effects on ecosystems and human health. The discussion emphasizes the urgency of integrating these issues into future studies to protect planetary health and minimize plastic pollution by promoting the reduction of virgin plastic production and greater recycling efforts. The importance of an effective global agreement to ensure proper disposal of plastics is highlighted. To achieve the Paris Agreement target of limiting global warming, this study shows that success depends on reducing the use of fossil fuels and, consequently, decreasing plastic production. Therefore, it is imperative that developed countries take the lead in meeting the targets set out in current global agreements by promoting sustainable policies and practices.

This overview emphasizes that these problems can no longer be treated separately and that an integrated approach is beneficial for mitigation strategies. Public policies should combine efforts to reduce plastic pollution and mitigate climate change through supporting the decarbonization of the plastic life cycle; fostering innovations in plastic production; and developing strategies to reduce and mitigate plastic pollution. It also suggests mitigation strategies, such as biodegradable alternatives (e.g., biodegradable polymers), by promoting a circular economy, and strengthening recycling initiatives. Future studies must be coordinated with public policies adressing both issues, as only through coordinated actions and international cooperation will it be possible to minimize the damage and preserve environmental and human health.

Authors' Contributions

Belli, I. M.: conceptualization; methodology; formal analysis; writing — original draft; writing — review & editing; visualization. **Leite**, A. R. B.: conceptualization; methodology; formal analysis; writing — original draft; writing — review & editing; visualization. **Andrade**, A. G. B.: writing — review & editing; visualization. **Waskow**, L.B.: writing — review & editing; visualization. **Bezerra**, M. E.: writing — review & editing; visualization. **Nadaleti**, W. C.: conceptualization, writing — review & editing. **Belli Filho**, P.: conceptualization; writing — review & editing. **Castilhos Junior**, A.B.: conceptualization; resources; writing — review & editing; supervision; project administration.

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