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Environmental legislation analysis improvement approach of global marine plastic pollution from the perspective of holistic system view

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Marine plastic pollution (MPP) has posed an unavoidable challenge to the conservation of marine ecosystems, escalating at an unprecedented rate. It extends beyond visible pollution, infiltrating the food chain and microcirculation, ultimately affecting the life and health of marine organisms. Of even greater concern is the fact that MPP has been found to penetrate human bloodstreams. The international community increasingly focuses on MPP, and has formulated a series of laws and regulations. This article analyses marine pollution prevention legislation within the context of international environmental resolutions and conventions, including those established by the United Nations, the European Union law and the domestic legislation of sovereign states. It is evident that the current legislation has played a pivotal role in the preventing MPP. However, global legislation on preventing MPP remains fragmented. The problems existing in the current legislation should be reviewed from the holistic systems perspective, and the integrity and systematicness of new plastics convention should be demonstrated. The proposed Marine Plastics Convention should emphasize environmental justice, protect the rights of vulnerable populations, lower the threshold for risk prevention, and focus on addressing residual risks. It must include clear provisions for regulating hydrosphere plastic pollution (HPP) to mitigate land-based pollution and scientifically define fundamental legal concepts to foster coordinated action among States. Moreover, the convention should establish standardized monitoring methodologies and assessment criteria to ensure accurate evaluation of the pollution status.

KEYWORDS

holistic system view, convention on marine plastics, environmental justice, residual risk, monitoring methodologies, evaluation criteria

1 Introduction

Plastic is a necessity for production and daily life, which highlights its positive attributes. However, plastic also lead to pollution, the general consensus is that plastic pollution should not be brought into the ecological environment that people rely on. On June 23rd, 2014, two reports, "UNEP Year Book 2014" and "Valuing Plastic", released at the first United Nations Environment Assembly, both point out that MPP has caused serious damage to marine ecosystems, such as marine biodiversity and offshore aquaculture (UNEP, 2014; UN, 2014a; UN, 2014b). According to conservative estimates, the economic losses caused by marine plastic waste will reach billions of dollars annually, which is shocking. Data from 24 oceanic expeditions suggested that the total amount of MPP was at a minimum of 5.25 trillion pieces weighing over 250,000 tons (Eriksen et al., 2014). However, more recent estimates based on the Great Pacific Garbage Patch suggest that the amount of plastic may be four to 16 times higher than previous estimates (Lebreton et al., 2018). The amount of plastic predicted to enter the ocean by 2025 is expected to increase by an order of magnitude, assuming a stable rate of pollution and accounting for population growth in coastal cities (Jambeck et al., 2015). Over the past 60 years, the global use of plastic products has shown a continuous upward trend, with plastic production soaring from 2 million tons in 1950 to 348 million tons in 2017, becoming a global industry worth $522.6 billion. It is expected that production capacity will double by 2040 (Wang and Li, 2022; Yang and Ding, 2022). In the three environmental crises that have catastrophic impacts on the Earth, namely pollution, climate change, and biodiversity, excessive production, overuse, and non-standard disposal of plastics have made significant contributions and have become important environmental crisis triggers that cannot be ignored.

The increasingly serious issue is the overproduction, overuse, and non-standard disposal of disposable plastic products. The use of disposable medical plastic products in medical protection facilities and equipment (such as masks, cotton swabs, test papers, protective clothing, etc.), especially since the global COVID-19 pandemic, has increased the production and use of disposable plastic products.

The environmental crisis caused by micro-plastics is more considered, but people's understanding of the pollution caused by plastics, especially micro-plastics, is not deep enough. It is a type of micro-plastic pollution with a diameter less than 5 millimeters, characterized by solidity, insolubility, and difficulty in degradation (Zheng and Chen, 2022). More than 70% of the surveyed subjects still hold a negative answer regarding whether they are concerned about the presence of plastic micro-beads in the skincare cosmetics they purchase, and whether they are aware of the harmful effects of plastic micro-beads on the environment (Zheng and Chen, 2022). Micro-plastics mainly come from two sources: primary and secondary. The first type is the original source represented by daily chemical products, such as shampoo, toothpaste, etc.; The second method is to use household garbage bags, beverage bottles, etc. (Conkle et al., 2018). Scientific research has confirmed that micro-plastics, based on ecological cycles, enter the bodies of animals and plants through the marine and terrestrial food chains and pose potential hazards to biological functions (Li J. et al., 2016). For example, if people consume seafood such as fish containing micro-plastics, they can also enter the human body through the food chain, posing potential threats to their health. Several media outlets (People's Daily, 2018), including CNN in the United States and The Guardian in the United Kingdom, reported that at the 2018 European Society of Gastroenterology Gastroenterology Academic Conference, Philipp Schwab and others from the Medical University of Vienna in Austria, reported the first discovery of micro-plastics in human fecal samples, which has attracted public attention. Therefore, "The presence and accumulation of plastic and micro-plastic debris in the natural environment is of increasing concern and has become the focus of attention for many researchers" (Karbalaeis et al., 2018).

It is commendable that most countries globally have recognized the severity of plastic pollution affecting the marine environment and have started to legislate both domestically and internationally to address it. For instance, in October 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development, which addresses ocean plastics in Articles 6, 11, 12, and 14. The Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter has also played a pivotal role in combating MPP. The European Union, through the EU Waste Framework Directive, has established regulations regarding the sources, control measures, and waste management of plastic pollution. In December 2015, the United States passed the Microbead-Free Waters Act, becoming the first country to ban plastic microbeads in cosmetic products (Zhang et al., 2019). In China, specific legal guidance on managing household waste, including plastic waste, is provided through the Solid Waste Pollution Prevention and Control Law. Additionally, China's Marine Environmental Protection Law (2017 Amendment) emphasizes the strict prohibition of dumping any waste, including foreign waste, into Chinese waters (NPC Standing Committee, 2017).

While the aforementioned legislation has made significant contributions to preventing MPP, merely referencing it in a United Nations resolution or addressing it through specific laws represents a fragmented legislative approach that fails to fulfill the systemic function of comprehensive regulation. Therefore, this article seeks to emphasize the need for holistic prevention measures and systematic legal frameworks in the forthcoming global, legally binding instrument aimed at ending MPP. This growing demand for international legal instrument to combat global MPP underscores the urgency of coordinated global action.

Based on this background, the article underscores the importance of adopting a holistic systems approach to analyze the primary legislation aimed at preventing MPP. It provides a comprehensive review of the legislation addressing the three main types of MPP, aiming to enhance understanding of the current regulatory landscape. Additionally, from a systematic perspective, a detailed examination of the legislation for each type of MPP is essential to the overall analysis and ensure a more cohesive legal framework. The strength of the holistic systems approach lies in its comprehensive and systematic perspective. After examining three main types of legal texts, the article identifies four key practical

challenges. First, legislation must fully articulate the recognition of environmental risks. Currently, the understanding of these risks primarily derives from scientific research, which, despite its advancements, has inherent limitations. Second, fundamental legal concepts need to be reevaluated. The delineation of legal concepts directly influences legislative decisions regarding pollution control, including when and how to take action. Third, current enforcement mechanisms do not encompass the entire lifecycle of plastics. Effectively addressing plastic pollution, particularly micro-plastic pollution, necessitating improvements in enforcement mechanisms. Fourth, the lack of uniformity in monitoring methods and assessment standards is a significant issue. This discrepancy not only affects the thorough assessment of MPP but also influences international attitudes and actions toward prevention.

The article initially examines the impact of plastics on marine ecosystems, and then provides a brief review of legislative texts related to the three major categories of MPP prevention. It comprehensively discusses the current issues within the legislation and concludes with specific recommendations for the forthcoming global legally binding instrument aimed at ending MPP.

2 Materials, methods, and analytical frameworks

This paper categorizes the relevant legislation aimed at preventing MPP into three distinct types based on their geographical scope of application. The first category is international environmental resolutions and conventions under the framework of the United Nations. The second category is European Union law, which exhibits a supranational and complex nature, reflecting characteristics of both international and federal law. Thus, the paper classifies it as a unique form of regional international convention. Finally, The third category is the domestic legislation of sovereign states. From the adoption of the London Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Substances by IMO in December 1972 to UNEA-5.2 in February 2022—which aims at establish legally binding measures to combat plastic pollution, the United Nations has played a pivotal role in advancing MPP control over five decades. At the same time, significant contributions have emerged from domestic legislations in major countries such as the United States and China, addressing the regulatory management of land-based activities that contribute to marine pollution. Therefore, both international and domestic legal frameworks are crucial for this study's analysis. In addition to examining these legislative frameworks, this paper undertook a comprehensive review of relevant literature on "MPP" sourced from databases including CNKI, HeinOnline, and Science Direct; thereby laying a solid foundation for its literature review.

The primary methodology employed in this study is legal dogmatics, a normative science that assumes an unwavering commitment to the prevailing legal order as its foundational premise, from which it engages in systematic and interpretative endeavors. Its core activities include the description of existing laws, exploration of the conceptual legal framework underpinning these statutes, and formulation of recommendations to address complex issues (normative practice). MPP distinguishes itself from conventional environmental pollution by impacting not only coastal nations but also non-coastal states through ecological processes such as ocean currents and food chains. Therefore, a thorough examination of legislation related to MPP is crucial. The analysis of literature must be integrated with existing research findings; it should undergo topological analysis to sharpen the research focus and promote innovative developments.

The theoretical framework of this study is based on a novel approach known as the holistic system view. This comprehensive perspective incorporates the cultural concept of "unity of heaven and man" from Chinese classical thought, as well as the epistemological principles of holism found in Western classical philosophy (Qin, 2022a). The holistic system view underscores both integrity and systematicity (Qin, 2022b), calling for an approach that prioritizes wholeness and interconnectedness when analyzing phenomena. It reminds observers of the need to maintain a holistic and systematic viewpoint in order to mitigate potential biases that may arise from focusing on singular viewpoints. Wholeness refers to a comprehensive understanding that considers all dimensions of an entity, examining whether it consists of distinct components or exhibits characteristics of being a unified "whole". Systematicity, on the other hand, highlights the objective laws governing interactions among various elements within entities and delineates the hierarchical logical frameworks established by these components. It stresses whether the importance of each part functioning according to its intrinsic laws and whether their coordinated functioning yields synergistic outcomes where 1 + 1>2. In this context, wholeness represents an essential attribute demanded by the holistic system view, while systematicity emerges is the desired goal aimed at achieving synergies through interrelations between diverse elements.

This study adopts a whole system view analysis framework for two primary reasons. Firstly, extant global legislation aimed at preventing MPP is notably fragmented, with references to this issue often scattered across various resolutions and conventions, lacking a unified approach. Given the urgent need to address MPP comprehensively, it becomes challenging to capture the integrity of such legislation. Thus, examining current laws from a holistic perspective provides valuable insights into their coherence and overall effectiveness. Secondly, The article does not necessarily advocate for a specific legislative model, but the current global legislation to prevent MPP is fragmented, which has compromised the systematic function of the law and cannot achieve the desired synergistic effect of 1 + 1>2. The fundamental principle behind effective legislation lies its capacity to deter polluters through systemic social effects, as law functions as an organized mechanism of social control. Consequently, legislators should prioritize 'systematicness' when crafting laws. Therefore, this methodology is employed as a theoretical framework for analyzing extant legislation on global MPP. It suggests that future international legally binding documents should focus on enhancing both systematization and coherence while mitigating the fragmentation present in current legal frameworks.

3 Review: an overview of the current global legislative framework aimed at mitigating MPP

This paper conducts a legal doctrinal analysis of the international environmental resolutions and conventions under the framework of the United Nations, the law of the European Union and the domestic legislation of sovereign states. It is essential to note that while the subsequent investigations are conducted independently, they are not isolated; instead, they are interconnected. This interrelationship highlights the synergy between the application of international treaties and domestic law, which together from the legal foundation for combating MPP. As a result, an integrated systems perspective is necessary.

3.1 International environmental resolutions and international environmental conventions under the framework of the United Nations

3.1.1 International environmental resolutions

The prevention of MPP is primarily addressed through various governance measures established by relevant international conventions under the United Nations. This process is largely facilitated by the collaborative efforts of UN member states and international non-governmental organizations, alongside the gradual execution and enforcement of initiatives from United Nations bodies or specialized agencies.

A range of negative externalities resulting from the Industrial Revolution, including the rapid degradation of ecological systems, accelerated population growth, and the sudden depletion of resources, has compelled nations to reevaluate strategies for humanity's survival and development. It is within this context that the 2030 Agenda for Sustainable Development has been advanced. Indeed, since the 1990s, the United Nations has undertaken the formulation of a series of objectives and initiatives aimed at promoting global sustainable development (Pei, 2018). From Agenda 21 in 1992 to the Millennium Development Goals established in 2000, through multiple negotiation rounds held in Rio de Janeiro in 2012, culminating with the adoption of the 2030 Agenda for Sustainable Development during the 70th session of the United Nations General Assembly in 2015, the overarching objective remains sustainability. This document has been described as a robust framework for universal action aimed at eradicating poverty and protecting our planet (Carpentiera and Braun, 2020). In the pursuit of enhancing the ecological environment through scientific and technological advancements, the resolution adopted during the 71st session of the United Nations General Assembly in 2017 marked a significant milestone by addressing MPP for the first time. This resolution, titled "Our Oceans Our Future: A Call to Action," was highlighted by Fiji's representative, Mr. Daunivalu, who characterized it as a pivotal outcome of the United Nations High-Level Conference on Oceans (UNGA, 2017). From February 2014 to February 2022, the United Nations Environment Program adopted five distinct resolutions addressing marine litter and micro-plastics. Figure 1 lists keywords for the main issues that each resolution addresses. The adoption of these resolutions establishes a crucial policy framework and action plan for tackling issues related to marine plastic waste and micro-plastics. Resolution I/6 on Marine Plastic Debris and Micro-plastics (UNEP, 2016a) underscores the precautionary principle while concentrating on the sources, characteristics, and impacts of micro-plastics. II/11 Marine plastic litter, and micro-plastics (UNEP, 2016b) emphasizes effective management and waste prevention strategies, acknowledging that surface runoff, rivers, and sewage outfalls are significant pathways through which waste is transferred from land to sea. In Resolution III/7 on Marine Litter and Micro-plastics (UNEP, 2016c), priority is given to developing policies and measures at appropriate levels based on the best available knowledge; this includes specific initiatives such as

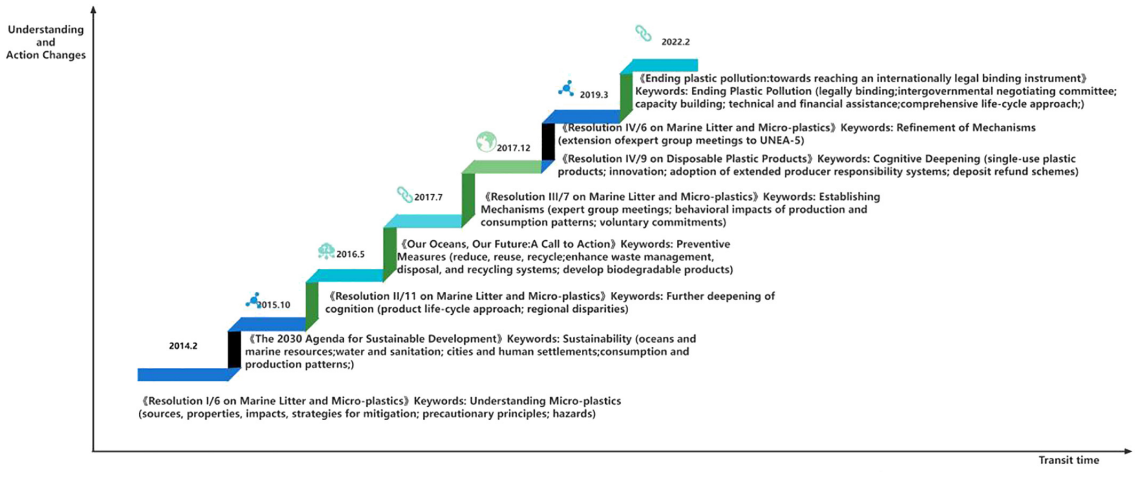

FIGURE 1
Legislative Development of Preventing Plastic Pollution within International Environmental Conventions under the United Nations Framework.

establishing harmonized definitions along with standardized monitoring protocols, as well as enhancing collection efficiency and recycling rates for plastic waste. It also calls for convening an *ad hoc* open-ended expert group meeting to examine barriers to managing marine plastic litter from all sources, particularly those originating from land-based activities. IV/6Marine plastic litter and micro-plastics (UNEP, 2016d) highlights the urgent need to strengthen collaboration between science and policy, promote global coordination in governance, and reiterates the importance of harmonizing testing methodologies and evaluation techniques while introducing life cycle considerations for the first time. Finally, IV/9Marine plastic litter and micro-plastics (UNEP, 2016e) focuses specifically on single-use plastic products by advocating restrictions or prohibitions on their production and sale while encouraging reductions in usage or exploring alternative biodegradable options. In February 2022, Section V of the United Nations Environment Assembly adopted the resolution titled "Ending Plastic Pollution: Towards an International Legally Binding Instrument". This resolution signifies a pivotal transition for nations from mere political declarations to a formal legal framework. It is therefore not surprising that Inger Anderson, Executive Director of the United Nations Environment Program, described the new plastics treaty as the most significant multilateral international agreement since the Paris Agreement (Wang, 2024).

Since the adoption of UNEA-5.2 on "Ending Plastic Pollution: Developing a Legally Binding International Instrument" in March 2022, the intergovernmental negotiating committee's consultations have been proceeding in an orderly manner. After two rounds of negotiations in November 2022 and May 2023, a document called Zero Draft Text of the international legally binding instrument on plastic pollution was formed, including in the marine environment (Zero Draft Text) (UNEP/PP/INC.3/4, 2023); In November 2023, the Zero Draft was revised at the third meeting of the intergovernmental negotiating committee, forming the Revised Draft Text of the international legally binding instrument on plastic pollution, including in the marine environment (Revised Draft Text) (UNEP/PP/INC.4/3, 2024). The Revised Zero Draft Text consists of six parts as a whole: Part One is covered with the Program, including the preamble, objectives, term definitions, principles and application scope; Part Two is the main body of the treaty, including the just transition route, the control method of plastic chemicals and other specific control measures; Party Three refers to financing, capacity building and technology transfer. Party Four deals with national action or implementation plans, implementation and compliance, progress reports and others. Part Five contains the governing bodies and subsidiary bodies of the future treaty and its secretariat; Part Six includes any possible annex to the document.

From the Revised Zero Draft Text, it can be seen that the Revised Zero Draft Text proposes four mechanisms to address the problem of MPP. First, the extended producer responsibility system. The second part of the draft uses 13 summaries for detailed regulations, with the aim of covering the entire lifecycle of plastic products. Second, a common but differentiated international cooperation mechanism. In the fourth part of the draft of the National Action Implementation Plans, it is particularly emphasized to increase the content of action plans based on the capabilities of each country, while also emphasizing that existing relevant data and legislation in each country are prerequisites for action plans, with the aim of taking into account the national conditions of developing countries. Thirdly, a regular reporting mechanism. The fourth part of the draft stipulates provisions on compliance and implementation, progress reporting, regular evaluation, information exchange, etc. Its purpose is to share relevant information and carry out international cooperation. Fourth, safeguard mechanism. The third part of the draft stipulates safeguard provisions such as financing, capacity building, and technology transfer, with the aim of ensuring the implementation of the new plastic convention.

The Revised Zero Draft Text also provides specific regulations for the implementation and compliance of the new Plastics Convention. The second section of Part Four of the Revised Zero Draft Text also states Implementation and compliance specially and offers three alternatives. The first option is to establish a review mechanism (including a committee) as a subsidiary body of the governing body to promote the implementation and compliance of the convention. The nature of this committee is facilitative non-punitive, non-adversarial,expert-based, It should not be used as a mechanism for enforcing or resolving disputes, nor should punishment or sanctions be imposed, and national sovereignty should be respected. The committee can also consider and provide flexibility to developing country contracting parties based on their capabilities. In addition, the plan also provides detailed regulations on the composition of the committee, election of new members, and rules of procedure. The second option is the Bracket entitlement provision. The third option is also to suggest establishing a review mechanism (including a committee). The committee is convenient in nature and operates in a transparent, non confrontational, and non punitive manner.

Figure 1 not only illustrates the keywords of each resolution, but also lists the time when the resolution was passed. Based on the specific content and time of the resolution, the author summarizes three points: First, in terms of timing, the 2030 Agenda for Sustainable Development, adopted at the 70th session of the United Nations General Assembly in 2015, addressed the sustainable development of oceans. However, this does not imply that nations were previously unaware of the dangers of MPP, particularly micro-plastics. As early as 2004, British scholar Richard Thompson introduced the concept of "Micro-plastics", noting that their levels in the ocean significantly increased from the 1960s to the 1990s, posing potential hazards when ingested by marine life. Secondly, awareness is continually evolving. This evolution is primarily manifested in: (1) progressing from conceptual understanding to practical actions and measures. As an example, the shift from individual and national-level scholarly awareness to the subsequent adoption of written resolutions by the United Nations General Assembly. (2) Preventive measures are continuously being refined. For instance, the 2017 United Nations General Assembly's "Our Oceans, Our Future: A Call to Action" emphasized a three-pronged approach of reduction, reuse, and recycling. This strategy includes market-based waste reduction strategies, enhancing eco-friendly waste management, disposal, and recycling systems, and developing substitutes like reusable or

recyclable products or naturally biodegradable items. In relation to disposable plastic products, there's an emphasis on continuous innovation, implementing extended producer responsibility systems, and establishing deposit refund schemes. (3) The focus has shift from plastic pollution to micro-plastic pollution, with a subsequent strong focus on micro-plastics. This shift began with the first United Nations Environment Assembly (UNEA-1) in 2014, Resolution I/6 addressed marine litter and micro-plastics, followed by subsequent resolutions at UNEA-2, UNEA-3, UNEA-4—II/11, III/7, IV/6, and IV/9 on marine litter and micro-plastics, respectively, and disposable plastic products. This underscores the global recognition of the severity of micro-plastic ocean pollution. (4) The development of internationally legally binding instruments. This marks a landmark acknowledgment of marine plastic and micro-plastic pollution. Clearly, governments worldwide now recognize not only the severe risks to water hygiene and the marine environment from MPP but also the potential for marine micro-plastic pollution to enter the human body via ecological cycles such as ocean currents and food chains, thereby presenting significant threats to human health. Consequently, we must resolve to establish an internationally legally binding instrument to bring an end to MPP. Thirdly, the international community has progressively developed a robust framework for implementation. To more effectively examine the barriers and alternatives for managing marine plastic and micro-plastic waste from all sources, especially from land-based ones, the Third United Nations Environment Assembly (UNEA-3) established an open-ended *ad hoc* expert group on marine litter and micro-plastics. In response to the expert group's valuable findings, particularly the need to bolster integration, coordination, and synergies among current mechanisms, the Resolution IV/6 on Marine Litter and Micro-plastics extends the expert group's mandate through UNEA-5 to strengthen cooperation and governance and more effectively tackle the challenges posed by marine litter and micro-plastics at local, national, regional, and global levels (Figure 1). Additionally, the resolution decided to establish a multi-stakeholder platform within the United Nations Environment Program to enhance coordination and cooperation, aiming to promptly implement a life-cycle approach to eradicate the long-term discharge of garbage and micro-plastics into the ocean.

3.1.2 International environmental conventions

The prevailing consensus is that, through years of practice, countries have come to recognize that concerted actions, the exercise of national jurisdictions, and engaging in normative institutional cooperation are essential for addressing the externality of environmental issues. The voluntary participation and equal consultation among nations, culminating in legally binding international multilateral treaties, positively contribute to preventing the rapid escalation and devastation of MPP. These efforts also serve as exemplary and guiding forces in global environmental protection.

The extant international environmental conventions pertinent to the prevention of MPP encompass the Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Substances, the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, and the Stockholm Convention on Persistent Organic Pollutants.

3.1.2.1 Convention on the prevention of marine pollution by dumping wastes and other substances

As our understanding deepens, nations have increasingly recognized the significance of the marine environment for human survival and development, as well as the detrimental impact of waste discharging into the sea on marine ecosystems. In response, the Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Substances was established. This is one of the 21 international conventions and agreements established by the International Maritime Organization (IMO) aimed at addressing the intentional, negligent, or accidental release of hazardous substances from ships, as well as striving for the complete elimination of intentional pollution in the marine environment (IMO, 1973).The Convention encompasses the definition and scope of,the licensing and regulation of , a comprehensive list of substances prohibited from being dumped into, and the legal liabilities associated with. Consequently, many have regarded Annex V of the MARPOL Convention as a potential solution to the issue of MPP (Maheim and Bruce, 1988). In fact, it is also true that Article 4 (1) (a) and Article 5 (2) of the Convention, as well as the provisions on fishing nets and ropes in Annex I, have played an important role in preventing MPP (Figure 2). The MARPOL Convention and its annexes are applicable solely to pollution originating from vessels at sea. Consequently, the Convention is ill-equipped to address land-based sources of plastic debris, including plastics that enter the ocean via municipal sewage outfalls (Maheim and Bruce, 1988).

The criteria for evaluating wastes or other substances that may be eligible for dumping, as outlined in Annex II of the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Substances, are recognized to involve environmental risks that may surpass current scientific understanding. These criteria may be reassessed in the future if new uncertainties regarding these risks arise.

3.1.2.2 Basel convention on the control of transboundary movements of hazardous wastes and their disposal

In the 1980s, it became increasingly evident that industrialized nations were transferring hazardous waste to developing countries through various means. In March 1989, the United Nations Environment Program adopted the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal. This Convention aims to regulate transnational trade in plastic waste and promote environmentally sound disposal practices. It serves as a robust legal framework for the recovery or treatment of imported and exported hazardous wastes (Gonzalo, 1994). The Convention has significantly contributed to mitigating the ecological damage caused by hazardous wastes through their safe treatment and the regulation of transboundary movements (Iwona Rummel-Bulska, 1994). For example, the clear listing of "hazardous waste" in Article 1 (1) (a) and the definition of "waste" in Article 2 of the Convention provide a basic legal basis for identifying "hazardous waste" and

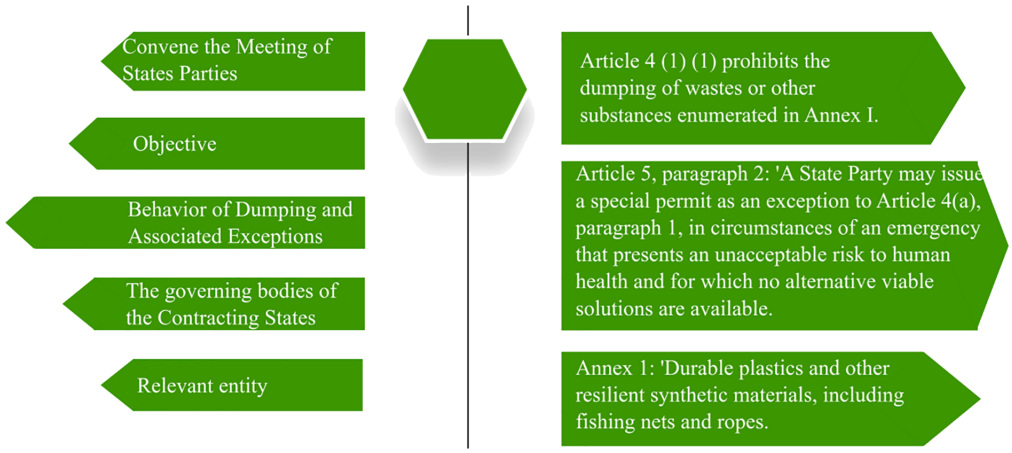

FIGURE 2
The primary stipulations of the Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Substances pertain specifically to plastics.

"waste" related to plastics (Figure 3). In addition, Annex I of the Convention lists many plastic related wastes, which are crucial for limiting the illegal transfer of plastic waste, reducing the degree of environmental injustice, and protecting the "right of everyone to be free from pollution" (Table 1). Nevertheless, the Convention exhibits certain limitations; for instance, the regulatory standards outlined in the amendment to the Basel Convention lack comprehensiveness, making it challenging to quantify indicators and targets aimed at reducing plastic waste production or trade (Liu, 2020). For instance, while the revised Convention delineates concepts such as 'waste', it fails to define the terms 'plastics' or 'micro-plastics', presenting a legal impediment for nations seeking to implement effective measures against MPP.

It is important to note that the Fourteenth Meeting of the Parties to the Basel Convention has revised Annexes II, VIII, and IX of the Convention. Specifically, Annex II introduces a new entry, Y48, related to plastic waste provisions. Annex VIII has added a new entry, A3210, addressing plastic waste, while Annex IX introduces a new entry, B3011, which explicitly specifies plastic raw material polymers such as polyethylene (PE), polypropylene (PP), polystyrene (PS), polycarbonate (PC), acrylonitrile butadiene styrene (ABS), among others.

3.1.2.3 Stockholm convention on persistent organic pollutants

Adopted by the United Nations Environment Program in May 2001, the Stockholm Convention on Persistent Organic Pollutants aims to mitigate or eliminate emissions and releases of persistent organic pollutants, with a particular emphasis on micro-plastics and additives in plastics. The Convention strives to protect human

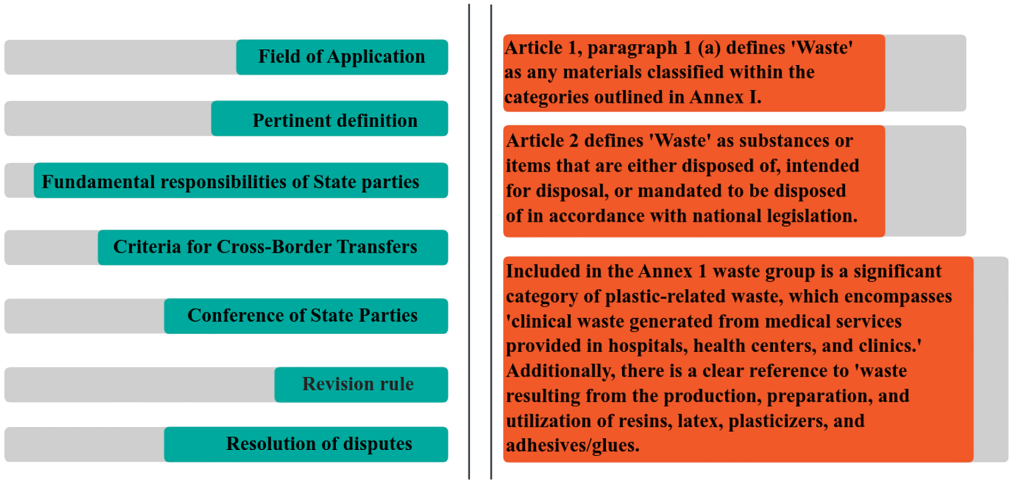

FIGURE 3
The principal stipulations of the Basel Convention concerning the regulation of transboundary movements of hazardous wastes and their disposal are pertinent to plastics.

TABLE 1 Environmental Justice Framework.

Terms	Basics
·Right to protection	Everyone has the right to be free from environmental pollution
·Prevention	Take measures to prevent pollution and eliminate environmental hazards in their early stages
·Inverted burden of proof	Allocate the burden of proof to the infringer, rather than following the traditional principle of who asserts and provides evidence
·Obviating proof of intention	Different data should be allowed to overturn the original qualitative analysis
·Correcting Injustice	From the perspective of pollution hazards, by coordinating resources and taking action to address the most severely polluted areas

health from the dangers associated with plastic products. Comprising 30 articles and two annexes, it marks a significant milestone in international law and has been played a crucial role in advancing global environmental protection efforts (Paul and Michael, 2005). It is also considered a significant milestone in the management of global chemical substances (Sellar and Abdel-Qader, 2021). Since its implementation over two decades ago, 23 chemicals have been added in its annexes. For example, in Annex A, Annex B, and Annex C of the Convention, there are many regulated polymer raw materials related to plastics (Figure 4), which can have adverse effects on the body's blood and respiratory systems. However, the Convention has faced several challenges, including a slow update process for the list of chemical substances (Blicke, 2002),and the ratification process remains notably complex (Mintz, 2001).

While the aforementioned three conventions have significantly contributed to mitigating MPP in recent years, their primary objective is not to directly address the global plastic pollution crisis. Furthermore, there remains a notable absence of international agreements aimed at systematically tackling this issue.

By organizing the texts of the three conventions mentioned above, the author examined them from the perspective of time dimension and content regulations (Table 2), and believes that there are three points worth affirming: firstly, the international environmental conventions mentioned above all have legal binding force. This indicates that the international community has recognized the necessity to establish legally binding international environmental conventions to combat MPP, emphasizing that mere publicity and appeals are insufficient. A convention can only be effectively enforced if it is legally binding among the contracting parties. Second, when examining changes over time, the author observes a tightening of international regulations concerning plastic hazardous waste. This is evident from the initial, more general prohibitions on the dumping of hazardous plastic waste, such as the 1972 London Convention's ban on the dumping of "durable plastics and other persistent synthetic materials" as waste or other substances, to the subsequent refinement of these prohibitions through specific listings. For example, Annex I of the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter imposes stricter regulations on substances allowed for dumping, explicitly outlining the permissible waste through a detailed list. Plastic boxes and microplastics are not included in this list, thus prohibiting their dumping. Third, an examination of the specificity in regulations regarding plastic pollution reveals that the international community's provisions on MPP are becoming progressively more detailed. This is evident in the Basel Convention, which broadens its controlled scope to encompass the vast majority of plastic waste, including non-recyclable and contaminated types, as outlined in Annexes II and VIII. The inclusion of a limited amount of pure plastic waste in Annex IX has heightened the requirement for environmentally responsible recycling. The annexes offer comprehensive specifications for plastic wastes, including mixtures such as PE, PP,

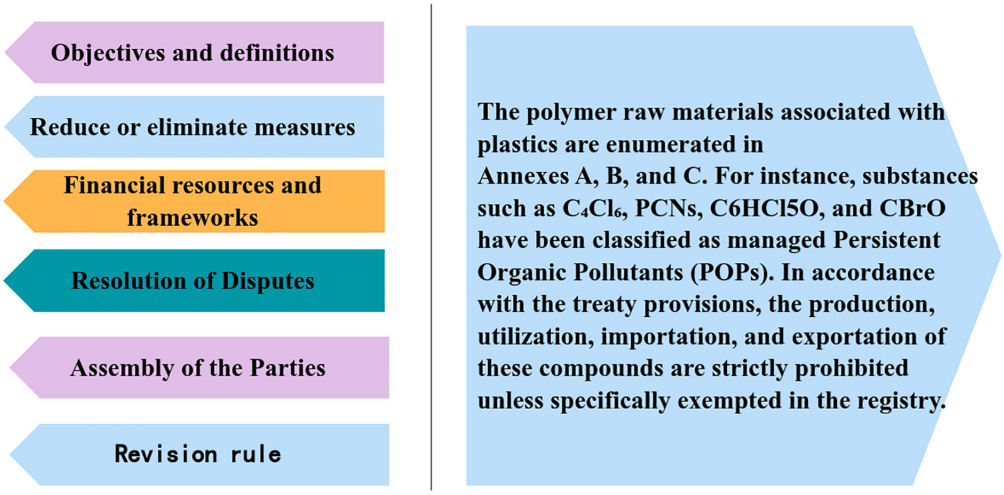

FIGURE 4
The primary stipulations of the Stockholm Convention on Persistent Organic Pollutants pertain to plastics.

TABLE 2 The legislative process in international environmental conventions on the prevention of MPP.

passing time	International Organization	Agreements	Focus
1972.12	International Maritime Organization	Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter (1972 London Convention)	Durable plastics and other durable synthetic materials are included in the list of waste or other substances that should be prohibited from dumping
1989.3	United Nations Environment Program	Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal	Waste generated from metal and plastic surfaces is a category of waste that should be controlled.
1996.11	International Maritime Organization	1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter Basel Convention	Annex I of the protocol specifies the types of waste that can be dumped in a specific manner, and plastic boxes and micro-plastics are not included in the list.
2019.5	United Nations Environment Program	Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal Amendments to Annex 2, Annex 8, and Annex 9	Annex 2 and Annex 9 provide detailed regulations on plastic waste.
2023.10	United Nations Environment Program	Stockholm Convention on Persistent Organic Pollutants	This marks the emergence of specialized control measures for plastic waste through the governance of international law.

or polyethylene terephthalate (PET) plastic waste. Likewise, the more significant Stockholm Convention on Persistent Organic Pollutants has introduced specific regulations for plastic waste through international legal mechanisms.

3.2 Legislative frameworks and policy initiatives within the European Union

In 2019, the EU produced generated an estimated 53 million metric tons of plastic waste. Over the coming decades, this amount is projected to grow, doubling by 2060 to exceed 100 million metric tons annually (Bruna, 2024). To tackle this global pollution issue, the EU has implemented various policies, directives, and laws to combat plastic pollution. The Eu's legislative approach to MPP is primarily divided into regulations targeting both land-based and water source pollution. The author lists the main legislation on preventing plastic pollution in EU law and will analyze it in the following sections (Table 3).

TABLE 3 The main legislation of the European Union on preventing plastic pollution.

passing time	Name of the Bill
2000.11	On port reception facilities for ship-generated waste and cargo residues(2000/59/EC)
2004.2	On packaging and packaging waste - Statement by the Council, the Commission and the European Parliament (2004/12/EC)
2006.12	Regarding the registration, evaluation, licensing, and restriction system for chemicals(REACH, 2006/1907EC)
2008.6	EU Marine Strategy Framework Directive
2008.12	EU Waste Framework Directive(2008/98/EC)
2009.5	Simplifying terms and conditions of transfers of defense-related products within the Community(2009/43/EC)
2009.11	Establishing a Community control system for ensuring compliance with the rules of the common fisheries policy(1224/2009)
2015.4	Amending Directive 94/62/EC as regards reducing the consumption of lightweight plastic carrier bags (2015/720)
2018.1	Plastic Strategy in the Circular Economy
2019.6	On the reduction of the impact of certain plastic products on the environment(2019/904)

The control of land-based pollution is primarily embodied in the regulations for solid plastic waste. In 2018, the EU initiated a revision of regional laws on solid waste, aiming to decrease ocean-bound plastic waste through recycling and reuse. For instance, the EU Waste Framework Directive mandates member states to identify the sources of plastic waste within their territories, establish effective measures to reduce it, and ensure its proper cleaning and collection. Regarding micro-plastic pollution, the EU issued Directive 2004/12/EC on packaging and packaging waste in 2004, setting specific recycling goals for plastic packaging waste. In 2015, the European Union revised the directive and substituted it with Directive 2015/720. The directive further details specific recycling targets for plastic packaging waste, ensuring that the annual consumption of plastic bags per person does not exceed 90 by 2019 and 40 by 2025, with a reduction of 50% by 2019 and 80% by 2025 compared to 2010. In 2015, the European Cosmetics and Personal Skincare Association recommended phasing out the use of plastic frosted micro-beads on cosmetics by 2020 (Cosmetics Europe, 2015). This directly prompted the revision of the six detergent product group standards in the EU echo-label, which incorporated the association's recommendation to ban plastic frosted micro-beads. Additionally, several EU member states have also addressed micro-plastic pollution through legislative measures. For instance, in 2014, five member states—Austria, Belgium, Sweden, the Netherlands, and Luxembourg, jointly declared a ban on the use of plastic micro-beads within the European Union. This

declaration inspired other countries to follow suit. Currently, the European Union is considering the use of the REACH directive to impose the intentional addition of micro-plastics in certain chemicals (European Commission, 2018). In 2018, the European Union released the "Plastic Strategy in the Circular Economy", adopting a holistic approach encompassing the life-cycle of plastics, integrating the design, use, recycling, and reuse of plastic materials. The objective is to ensure all plastic packaging in the EU market is reusable or recyclable by 2030, thereby reducing the consumption of single-use plastics and imposing stricter restrictions on micro-plastics (EU, DIRECTIVE 2019/904). The "Plastic Strategy in the Circular Economy" has yielded positive outcomes, leading scholars to opine that "The adoption of the Plastics Strategy is commendable. It is a farsighted plan for the transformation of economies and societies' relationship to a ubiquitous material that goes beyond just quick fixes" (Penca, 2018).

The control of water source pollution primarily involves the legal regulation of maritime activities. Marine activities that directly discharge plastic waste into the ocean include fishing, aquaculture, shipping, dumping at sea, and other maritime activities (Gilardi et al., 2020). In 2008, the European Union introduced the "Marine Strategy Framework Directive", the first legally binding instrument to tackle marine litter (EU, 2008). It mandates that by 2020, disposal standards for marine litter within the EU must ensure "a satisfactory environmental status", meaning the nature and quantity of marine litter must not harm coastal or broader marine environments. The EU has also established operational mechanisms, including decisions on disposal measures, monitoring, and implementation reporting. Additionally, a marine debris technical group has been created with the authority to provide effective guidance and recommendations to member states on the hazards, origins, and promotion of unified monitoring approaches for marine debris (EU, DIRECTIVE 2008/56/EC). Subsequently, the European Union has issued a series of policy documents, including Directives 2009/43, 2009/1224, 2019/904, and the Port Reception Facilities Directive. The first two directives impose legal obligations on fishing fleets regarding the disposal of plastic waste, the provision of appropriate equipment (Tickler et al., 2018), and notifying registered member states of unrecoverable fishing gear to prevent plastic pollution from lost fishing gear. The third directive further standardizes the management of discarded fishing gear, extending producer responsibility to cover fishing gear containing plastic and those used in aquaculture. This directive further standardizes the management of discarded fishing gear, extending the producer responsibility to cover fishing gear containing plastic and those used in aquaculture. It mandates fishing gear producers to cover the costs of collection, transportation, and disposal of discarded fishing gear, ensuring that discarded plastic fishing gear is fully integrated into the waste recycling system. Currently, the European Union is developing unified standards for the reuse of fishing gear to extend their lifespan (EU, 2019a). The Port Reception Facilities Directive, introduced by the European Union in 2019, broadly restricts the production of plastic waste at sea. This directive focuses especially on managing plastic waste in the shipping industry, encouraging, through economic incentives, the delivery of discarded plastic fishing gear and other plastics from passive fishing to appropriate onshore port facilities for proper treatment as specified in Annex 5 of the International Convention for the Prevention of Pollution from Ships (EU, 2019b).

3.3 Legislative frameworks and policies in China and the United States

3.3.1 Chinese policies and legislative frameworks

On December 31, 2007, the General Office of the State Council of China issued the "Regulations on Restrictions Notice on the Production, Sales, and Use of Plastic Shopping Bags", which requires that from June 1, 2008, the production, sale, and use of ultra-thin plastic bags be prohibited nationwide, and a paid use system for plastic bags be implemented (General Office of the State Council of PRC, 2007). Since then, China has become one of the sponsors in the world to ban plastic. In recent years, China has implemented initiatives such as urban waste sorting, pilot "waste-free cities" projects, and "beautiful countryside" initiatives. It has also launched targeted campaigns against environmental violations related to solid waste, which has played a positive role in reducing land-based solid waste pollution and curbing plastic waste from entering the sea. This has effectively reduced the amount of plastic waste reaching the ocean, contributing to the global effort to combat MPP. In January 2020, China's National Development and Reform Commission and Ministry of Ecology and Environment issued the "Opinions on Further Strengthening the Control of Plastic Pollution", aimed at "establishing a robust long-term management mechanism for plastic products" (National Development and Reform Commission, 2020). China previously imported plastic waste to make products out of recycled plastics, but as of 2017 has permanently banned non-industrial plastic waste from being imported (Brooks et al., 2018).The author has illustrated and listed the relevant legislation on preventing plastic pollution in China (Table 4), and categorized them into three groups based on their respective functions: firstly, regulation of plastic production; secondly, regulation of plastic waste disposal; thirdly, regulation of industry standards for plastic products. From the standpoint of legal logic and semantic interpretation, these laws and regulations can be expanded to address plastic pollution in the marine environment.

3.3.1.1 Plastic production regulations

The Clean Production Promotion Law's legislative intent is clearly stated in its Article 1, aiming to "reduce and prevent pollutant generation, protect and enhance the environment, and ensure human health" (NPC Standing Committee, 2012). Although the law does not directly mention "plastic" or "Micro-plastics", it focuses on the "residual risks" (Banse et al., 2012). Perhaps the most significant contribution of this law to addressing plastic pollution is outlined in Article 2, which established the fundamental principle of clean production: "to reduce pollution at its source, enhance resource efficiency, and minimize or prevent the generation and

TABLE 4 China's legislative measures aimed at mitigating plastic pollution.

passing time	Legal name	Pertinent provision
1984.5	Water Pollution Prevention and Control Law	Article 32
1995.10	Law of the Prevention and Control of Environment Pollution Caused by Solid Wastes	Article 56, Article 69, Article 93, Article 106
2002.6	Cleaner Production Promotion Law	Article 1, Article 2, Article 21
2011.5	Safety Technical Specifications for Washing Products (Under revision)	Article 5
2015.11	Safety and Technical Standards for Cosmetics	Section 3.1.1, Section 3.8.2
2018.8	Soil Pollution Prevention and Control Law	Article 20
2020.6	Regulation on the Supervision and Administration of Cosmetics	Article 55

discharge of pollutants throughout production, service, and product use". This serves as the fundamental legal basis for addressing the root causes of plastic pollution. Additionally, Article 20 sets up product design criteria for items to be "non-toxic, harmless, easily degradable, and recyclable". These regulations establish unyielding boundaries for the selection of materials and characteristics of plastic products, safeguarding against secondary micro-plastic pollution at its source. Furthermore, the "plastic restriction order" policy system provides detailed regulations concerning the pricing, materials, properties, and usage scope of plastic products (General Office of the State Council of PRC, 2007; Ministry of Commerce of PRC, 2008; National Development and Reform Commission et al., 2020).

3.3.1.2 Plastic waste disposal regulations

China has segmented its regulations on plastic waste disposal into two main areas: control of micro-plastic land-based pollution and control of micro-plastic water source pollution. Firstly, the management of micro-plastic land-based pollution primarily focuses on two aspects: preventing and controlling soil pollution as well as solid waste pollution. The Soil Pollution Prevention and Control Law of the People's Republic of China provides the fundamental legal framework for addressing soil pollution caused by micro-plastics. Article 20 of this law stipulates the screening and assessment of soil toxic and harmful substances, as well as the publication of a corresponding catalog. The benefit of establishing such regulations lies in the ability to include micro-plastics within the category of "soil harmful substances" by updating the catalog and expanding interpretations when necessary. This approach saves time on legislative amendments, enhances the efficiency of law enforcement, and enables timely regulation of emerging issues. The Solid Waste Pollution Prevention and Control Law of the People's Republic of China forms the basis for managing solid waste pollution caused by micro-plastics. In the realm of pollution disposal, the law mandates the real-time disclosure of pollution emission data (Article 56) and establishes a large-scale industrial model for pollution prevention and control (Article 93), thereby providing a framework for micro-plastic pollution stakeholders to take responsibility for, monitor, prevent, and manage secondary pollution from plastic waste, as well as implement large-scale remediation strategies. The term 'plastic' is mentioned 10 times in the law, specified in Articles 69 and 106. Article 69 outlines a comprehensive ban and restrictions on the production, sale, and use of disposable plastic items, including non-biodegradable plastic bags. It also sets up a system for the use and recycling of plastic bags by relevant entities, and promotes the use of alternative products. Article 106 mandates imposing fines ranging from 10,000 to 100,000 yuan for violations. Additionally, the management of micro-plastic pollution in water sources primarily encompasses freshwater and marine pollution control. Freshwater pollution control is grounded in the Water Pollution Prevention and Control Law, which, in Article 32, sets forth rules for updating the list of toxic and harmful water pollutants, risk management, and the assessment of environmental risks, as well as the disclosure of water pollutant information. In aquatic environments, micro-plastics have the potential to transform into toxic substances through dissolution and chemical bonding, providing a basis for their inclusion in the category of "toxic and harmful water pollutants". Marine pollution control is based on the Marine Environmental Protection Law, which establishes prohibitive regulations in three key areas: prevention of land-based pollutants, waste dumping, and engineering projects, thereby providing guidance for the prevention and control of micro-plastic pollution in marine environments.

3.3.1.3 Industry standards for plastic products

China regulates the production, use, and disposal of plastic micro-beads through a series of industry standards. From a temporal perspective, Article 5 of the "Technical Specification for Safety of Washing Products" issued in 2011, established the fundamental standard for washing product production: "The environmental impact should be within an acceptable range", This principle served as the basis for restricting the inclusion of plastic microbeads in daily chemical products at the national standard level in China. Currently, China is revising this technical specification by changing the original "General Provisions" to "General Requirements" in the published draft for comment. Under the "General Requirements", "substances in the persistent organic pollutant catalog shall not be used" in the formulation of washing products. Persistent organic pollutants are characterized by their toxicity, recalcitrant degradation, and capacity for bioaccumulation (UNEP, 2001). The "Technical Specification for Safety of Cosmetics," issued in 2015, incorporates in Section 3.1.1 the requirement for "cosmetic safety risk assessment" to ensure that its formulations do not compromise human health under "normal, reasonable, and foreseeable conditions". Additionally, Section 3.8.2 clarifies the dynamic regulation, mandating that the quality and safety of cosmetic raw materials must align with the "level achieved

by production processes and testing technologies". Article 55 of the "Regulations on the Supervision and Administration of Cosmetics", implemented on January 1, 2021, specifies the scenarios for dynamic regulation, namely "advancements in scientific research", "shifts in the understanding of cosmetic raw material safety" or "evidence of existing defects". Although the aforementioned standards and documents do not explicitly mention micro-plastics, those principles and contents of supervision, pollution prevention, and health protection they establish can be applied to the control of micro-plastic pollution. This provides potential solutions for managing new harmful substances such as micro-plastics.

3.3.2 U.S. policies and legislative frameworks

The United States is a major producer of plastics and corresponding waste. It is estimated that the country alone requires 12 million barrels of oil annually to meet the demand for plastic bag production (Clapp and Swanston, 2017). Due to low recycling rates, 100 billion plastic bags are discarded each year, all of which are treated as waste. Improper or inadequate disposal of these bags can lead to plastic pollution.

An overview of the legal regulatory framework for marine plastics in the United States reveals a parallel system of general and specific laws (Table 5). Regarding general law, it is primarily embodied in three legislative acts: the Clean Water Act and Clean Air Act, which address pollution after it occurs, and the Pollution Prevention Act, which focuses on source control. Although micro-plastic pollution was not a concern at the time these laws were enacted, they remain applicable to this type of pollution (Dixon et al., 2017). The CWA explicitly mandates that each state establish water quality standards for all state waters and define maximum allowable concentrations for various pollutants to ensure they do not interfere with designated uses. It also requires states to proactively identify water bodies damaged by pollutants, including household and plastic wastes, and implement appropriate remedial measures, thereby enhancing the environmental governance responsibilities of local authorities. The US Environmental Protection Agency or state governments should establish maximum daily load limits (TMDLs) for pollutants, including plastics, and require states to develop and update non-point source management plans in response to the characteristics of non-point source pollution caused by plastic waste in aquatic environments (National Academies of Sciences, 2022). The Pollution Prevention Act focuses on preventing and regulating pollution emissions from a three-dimensional perspective, enterprising government, enterprises and the public. In terms of special laws, they mainly refer to special provisions made for specific fields. It is mainly included in three laws, namely the Marine Debris Research, Prevention and Reduction Act, Microbead-Free Waters Act, and Save the Ocean Act (Table 5). The purpose of the Marine Debris Research, Prevention and Reduction Act is to identify, assess, prevent, reduce and eliminate marine debris, address the adverse effects of marine debris on the marine economy, environment and navigation safety, and establish the "Prevention and Removal of Marine Litter Plan" to clean up marine debris, including micro-plastics (EPA, 2006). The Micro-bead Free Waters Act was enacted in 2015 to address the issue of different state laws in the United States. Congress deemed it necessary to establish a single federal law applicable nationwide. The bill prohibits the sale or distribution of rinse off cosmetics containing plastic micro-beads, and also amends the Federal Food, Drug, and Cosmetic Act to prohibit interstate trade in cosmetics and toiletries containing intentionally added plastic micro-beads (Wood, 2018). According to the legislation, state and local laws that impose restrictions on the production or distribution of personal care products containing plastic micro-beads and differ from the new federal law shall not be enacted or enforced. The specific details must align with the provisions of the federal law. The enactment of federal legislation has further restricted the management of plastic micro-beads on a national scale (FDA, 2022). Currently, several states including Connecticut, Wisconsin, New Jersey, and Maryland have legislated to ban the sale of products containing micro-beads and have made corresponding changes to comply with federal law. The Save the Ocean Act enacted in 2018 fosters international cooperation in reducing marine debris, engages with other governments, and enhances solid waste management to more effectively address marine debris. In 2020, the legislation underwent further revision and was renamed the "Save the Oceans 2.0 Act", aiming to enhance the U.S. domestic plan for marine debris management, increase international involvement in marine debris control, and establish a national infrastructure for marine debris prevention (NOAA, 2022). Additionally, the legislation mandates and requires NOAA to partner with other federal agencies to develop additional outreach and educational strategies to tackle the sources of marine debris. Regarding emissions reduction, California has enacted a law that not only establishes source reduction goals for plastic and other packaging materials but also holds producers financially accountable for the infrastructure required to manage packaging and waste (Otum et al., 2023).

Beyond federal legislation, following Illinois' 2014 ban on micro-beads in personal care products, eight additional states have introduced similar measures. In its law, Illinois declares micro-beads "present a grave threat to the state's environment" and "concentrate existing harmful pollutants, harming fish and other aquatic species that form the foundation of the aquatic food chain" (Schroeck, 2016). As a result, the law mandates a ban on micro-plastics, and this rationale has been adopted by other states in their subsequent legislation.

TABLE 5 Major US laws aimed at preventing plastic pollution.

passing time	Name of the Bill	Explanation
1972.10	Clean Water Act (CWA)	These three laws possess universal applicability
1970.12	Clean Air Act (CAA)	
1990.10	Pollution Prevention Act (PPA)	
2015.12	Microbead-Free Waters Act (MFWA)	These three principles are applicable to particular domains
2018.10	Save the Ocean Act (SOA)	
2019.2	Marine Debris Research, Prevention, and Reduction Act (MDRPRA)	

4 Commentary: in light of the aforementioned three categories of legal texts

The author needs to make a simple comparison of international environmental resolutions and conventions under the United Nations framework, European Union law, and the domestic legislation of sovereign states (Table 6), in order to find out at a glance the advantages and disadvantages of the current legislation on the prevention of MPP, and to provide a clear direction for the future legislation on the prevention of MPP. This will facilitate a clear understanding of the strengths and weaknesses of current laws on plastic pollution control, thereby providing a definitive direction for future efforts to combat plastic pollution.

4.1 The comprehension of environmental risks must be continually enhanced in legislation

Plastic pollution, particularly the advent of micro-plastics, has significantly surpassed people's comprehension of environmental risks. In January 2018, researchers from China's 34th Antarctic Expedition discovered micro-plastics smaller than 0.3 millimeters in the Powell Basin of Antarctica (People's Daily, 2018). In October 2022, the Global Daily reported that micro-plastics were found in human breast milk for the first time in a study. It was reported that breast milk samples from 34 healthy mothers contained microplastics in 75% of the cases (Global Times, 2022). This finding surpasses traditional understanding of plastic pollution and highlights how emerging forms of environmental contamination are expanding the boundaries of your risk perception. Indeed, the emergence of various new types of environmental pollution is progressively pushing the boundaries of our risk perception. This necessitates a reevaluation of environmental risks from a holistic systems perspective. The advent of new environmental risks highlights two notable aspects: firstly, the occurrence of new environmental risks indicates a pervasive and systematic degradation of the ecological environment in a particular domain, impeding the ecosystem's ability to self-repair; secondly, the legal norms governing environmental infringements show gaps and inadequacies in the legal system's comprehensiveness. Consequently, it is imperative for the author to continuously deepen their understanding of environmental risks and to translate this understanding into legislative terms.

We have always lived in the polymer age. Humans are essentially polymeric, from the deoxyribo nucleic acid (DNA)that encodes our human traits to the protein that covers our body (skin)

TABLE 6 Overall comparison of three types of legislation.

Type Contend	Relevant legal concepts	Monitoring Techniques and Assessment Criteria	Implementation mechanism
International Environmental Resolutions and International Environmental Conventions under the framework of the United Nations	International environmental resolutions are not clearly defined; International environmental conventions have provided preliminary definitions of relevant concepts, but are not very clear about plastics and microplastics.	International environmental resolutions are not clearly defined; Some international environmental conventions exist, but they are inconsistent. For example, the provisions of the Stockholm Convention and the 1972 London Convention are inconsistent	Resolution III/7 concerning marine litter and micro-plastics has established an expert group meeting; Establish appropriate mechanisms, for example, the Stockholm Convention mandates that contracting parties establish registers for the emission and transfer of pollutants. The Basel Convention (1996 Protocol) requires contracting parties to establish action plans.
Law of European Union	The EU Chemicals regulation REACH defines the concept of microplastics.	The EU has adopted decisions on disposal measures, monitoring and implementation reporting within the Maritime Strategic Framework Directive.	The EU established a technical group on Marine litter in the Maritime Strategic Framework Directive
Domestic legislation of sovereign states	The Micro-bead-Free Waters Act in the US offers a definition of plastic micro-beads; China has not provided a specific definition, but has outlined basic characteristics. Waste plastics are defined in the "Technical Specifications for Pollution Control of Waste Plastics" (HJ 364—2022).	The United States advocates for a comprehensive life cycle management strategy in the report titled Mobilizing Federal Action on Plastic Pollution: Progress, Principles, and Priorities. The Chinese Clean Promotion Law mentions evaluation, but does not provide specific evaluation methods	China has established operational mechanisms for "screening and assessing toxic and hazardous substances in soil" as well as "publishing a directory of such substances" in the Soil Pollution Prevention and Control Law; The United States has created a Marine Waste Coordination Committee under the Marine Waste Research, Prevention, and Reduction Act, comprised of eight agencies, including the National Oceanic and Atmospheric Administration and the Environmental Protection Agency.

and our keratin-laden hair (Iroegbu et al., 2021). Therefore, ever since its invention, plastic has been an integral part of people's lives. However, pollution caused by plastics soon followed. One could argue that plastic pollution closely follows its introduction into people's lives. While the initial forms of pollution went unnoticed, visible pollution soon become apparent, such as the "white pollution" caused by white plastic bags discarded carelessly or suspended in the air during strong winds. Surprisingly, the discoveries do not end here. The ingestion of plastic pollution poses another critical threat to marine life. Plastic can break down into micro-plastics (less than 4.75 millimeters) and disappear from the ocean's surface (Eriksen et al., 2014). This not only makes them harder to quantify but also intensifies their infiltration of the marine food web. Ultimately, most micro-plastics settle into the deep sea, where their impact on the biota of deep-sea sediments remains uncertain (Woodall et al., 2014). Experts consider the ingestion of plastic utensils and bags discarded at sea by large marine animals such as seabirds, turtles, and marine mammals to be a significant risk (Wilcox et al., 2016). As it turns out, in the Northeast Atlantic, 74% of seabird species have been found to ingest plastic (Wilcox et al., 2016), and Marine mammals, turtles, seabirds, and invertebrates have been found to die from ingesting plastic (Rochman et al., 2016). After these microplastics are ingested, organisms will also be exposed to toxic, bioaccumulated, persistent organic pollutants that are concentrated in plastics (Li W. C et al., 2016).

The United States Environmental Protection Agency defines environmental risk as the likelihood that adverse effects resulting from an environmental factor will inflict harm on human beings or the ecosystem (EPA, 2024). In other words, the entities responsible for this damage probability are either human beings or the ecosystem itself. Article 4 of the General Provisions of the Estonian Environmental Code articulates the concept of environmental risk in terms of both the likelihood of its occurrence and the severity of potential adverse consequences. The realization of risk pertains to the probability that a specific environmental risk transitions from being classified as "risk" to resulting in "damage". The severity of an adverse outcome is determined by the extent to which an environmental risk can manifest and cause harm (Veinla, 2018). China has explicitly articulated the concept of environmental risk in the Technical Guidelines for Environmental Risk Assessment of Construction Projects. The definition of environmental risk in China has evolved through two distinct phases. In 2004, China promulgated the Technical Guidelines for Environmental Risk Assessment of Construction Projects (HJ/T169-2004), which not only established the notion of "environmental risk" but also delineated the fundamental formula for calculating the probability of environmental risk occurrence: R[hazard/unit time] = P[accident/unit time] × C[hazard/accident] (Ministry of Ecology and Environment of the PRC, 2004). However, this concept was revised in the Technical Guidelines for Environmental Risk Assessment of Construction Projects (HJ169-2018), released in 2019, to define environmental risk as the extent and possibility of environmental harm resulting from unforeseen accidents. A significant aspect of this revision is the removal of the formula previously used to calculate environmental risks. This change primarily reflects a shift away from assessing an acceptable level of risk represented by the R value, recognizing that risk evaluation is influenced by a multitude of factors. Simultaneously, the new guideline (HJ169-2018) has introduced the concept of "environmental risk potential", which denotes a generalized analytical expression of the degree of potential environmental harm associated with construction projects. This revision has progressively refined and enhanced the scientific and rational definition of this concept. The detrimental effects of MPP represent a significant environmental risk, particularly concerning the risks associated with micro-plastics.

As previously noted, plastic pollution has transitioned from visible "white pollution" to an insidious form that often goes unnoticed. Without advancements in scientific monitoring, it would be challenging to comprehend how micro-plastics infiltrate human blood and impact marine life. These observations underscore the urgent need for a paradigm shift in our understanding of environmental risks linked to MPP, especially within legislative frameworks; thus, enhanced regulatory measures are imperative.

4.2 The definition of fundamental concepts requires further elaboration

The enforcement power and regulation degree of the legal system depend on the general social understanding of a particular hazard. However, the current level of scientific and technological understanding is not the final of scientific inquiry (Ulrich, 2003), and its limitations are self-evident. The legal regulation of plastics or micro-plastics is not the final end of such pollution control, let alone the best choice.

The concept of plastic or micro-plastics is not clearly defined in the four types of legal texts mentioned above, making it challenging to legally categorize these materials as pollutants. For instance, the US Plastic Free Beads Act uses the scientific physical characteristic of "diameter less than 5 millimeters" to define micro-plastics. However, the bill lacks clarity in defining and standardizing plastic micro-beads, making it difficult to establish a comprehensive regulatory framework for their production and sale. In contrast to the Plastic Free Beads Act, California's legal definition of micro-plastics is more explicit. It characterizes micro-plastics in drinking water as solid polymer materials that may have been produced with chemical additives or other substances, and are defined as two-dimensional particles larger than 1 micrometer and smaller than 5000 micrometers (California State Water Resources Control Board, 2020). But whether this definition method conforms to legal logic and has operability remains to be discussed, at least this effort deserves recognition. The biggest potential loophole in many state bans in the United States is the definition of micro-plastic beads (Nicholas, 2016). China's domestic laws also do not define plastics or micro-plastics at the legal level. However, in the "Notice on Solidly Promoting Plastic Pollution Control Work" released in 2020, "intentionally adding solid plastic particles with a particle size less than 5 millimeters" was excluded from the addition materials of daily

chemical products. But the existing framework cannot explain whether micro-plastics are "legal pollutants" and lacks confirmation of environmental laws. According to Article 42 of China's Environmental Protection Law, which specifies the types of pollutants that should be prevented and controlled by law, micro-plastics cannot be included in the category of "statutory pollutants". In addition, the legal concept of plastic or micro-plastics is not clearly defined in international conventions, only the term plastic or micro-plastics is mentioned.

The definition of plastic pollution should be explicitly articulated in the forthcoming plastics convention. Neither the Zero Draft Text nor the Revised Draft Text explicitly specifies the terms of this definition. The third clause concerning definitions in Part I of the Zero Draft remains unfilled; it is noted in a footnote that specific term instructions may be provided as footnotes within particular clauses. In contrast, Article 3 of Part I in the Revised Draft suggests that a precise definition could either be established as an independent clause or integrated into the substantive provisions of the instrument.

However, as a globally binding convention on plastics, it is essential to uphold legislative uniformity. Legislation should incorporate standardized provisions addressing plastic pollution. This approach aims to avert the pitfalls of legislative fragmentation observed in existing relevant conventions.

4.3 Implementation mechanisms are inadequate to cover the complete life cycle of plastics

Addressing marine plastics necessitates assistance from various disciplines to gain a precise understanding of marine plastics. Once this foundational information is grasped, comprehensive regulation of the entire life cycle of plastic design, production, use, recycling, and disposal becomes essential, requiring effective legal enforcement mechanisms. Regrettably, existing international environmental resolutions and conventions have not yet established an implementation mechanism system that covers the entire lifecycle of plastic pollution control. While some implementation mechanisms exist within existing international conventions, they fail to cover the whole life cycle of plastics. The cornerstone of marine plastic waste management is to reduce waste at the source over the long term.

However, most current international regulations primarily focus on downstream control and waste management of plastics to prevent pollution. For instance, the Basel Convention addresses the trans-boundary movement of plastic waste, but it lacks jurisdiction over actions countries take within their own borders. While it is possible to develop an international regulatory system for both upstream and downstream plastics through amending existing conventions, this approach is hindered by challenges such as coordinating internal regulations, lengthy procedural time-frames, and regulations that inadequately address marine waste, as outlined in the amendment processes and practices of each convention. The US Plastic Free Micro-beads Act is similarly limited, as it only regulates the inclusion of plastic micro-beads in personal care products and the trade of related items, failing to adequately address the broad range of sources of micro-plastics. A literature review and analysis of convention provisions reveal that the enforcement mechanisms of current international agreements have only limited success in addressing marine litter concerns and are incapable of achieving comprehensive life cycle pollution management for plastics.

4.4 Monitoring methods and evaluation standards lack uniformity

Legal governance across various domains must leverage the intrinsic mechanisms of each field. Likewise, employing environmental laws to tackle MPP requires us to first clarify the quantity, types, hazards, and growth of marine plastic waste, a task that these environmental laws alone cannot fulfill. This necessitates the support of environmental science. Global scale data for plastic waste generation, collection, and disposal are often incomplete or unreliable due to inconsistencies in reporting among countries, differences in methodologies and units used in reporting, and omitted values (Kaza et al., 2018). Therefore, it is imperative to address the lack of standardization in monitoring methods and assessment criteria for marine plastics. Currently, there are no globally unified methods and standards for monitoring and assessing marine plastic waste. According to a review report by UNEP on current governance, the 37 reported monitoring activities cited more than 25 different monitoring protocols (Yang and Ding, 2022).

Despite the issuance of several research methodologies and analytical guides both domestically and internationally, the absence of uniform technical standards has rendered monitoring data collected in various locations and environments unusable for global comparative analyses, and has complicated accurate environmental and ecological risk assessments. Without knowing all the populations or species affected, it is hard to scale up even further to ecological effects. For instance, one review found no significant ecological effects from plastic ingestion studies, something they attributed to studies not using systematic data (Browne et al., 2015). Without knowing all the populations or species affected, it is hard to scale up even further to ecological effects. For instance, one review found no ecological effects from plastic ingestion studies, something they attributed to studies not using systematic data (Browne et al., 2015).Additionally, the absence of globally standardized statistical data within the plastic value chain hampers the ability to comprehensively represent and compare the situations of plastic production, trade, consumption, and disposal across different countries, thereby complicating the establishment of global objectives and whole life cycle management. Relevant UNEA resolutions consistently emphasize that enhancing scientific comprehension is essential for tackling the challenges of marine debris and micro-plastics, underscoring the pressing requirement to enhance the integration of science and policy, along with bolstering global coordination, cooperation, and governance (UNEP, 2016d, e).

5 Solution: the environmental law approach to a global agreement for ending plastic pollution

There is a consensus to develop a globally legally binding agreement that covers the entire life cycle of plastics. This study suggests that five environmental legal considerations need to be taken into account when formulating a global plastic agreement.

5.1 The new plastic convention should clearly outline the principles of environmental justice

Justice is an enduring theme, particularly in the realm of the environment. The concepts of environmental justice and marine environmental justice originated in the United States in the 1980s, deriving from concerns about the disproportionate pollution burden borne and experienced by black communities and socioeconomically disadvantaged populations (Cutter, 1995). Broadly, environmental justice encompasses the equal and effective participation of all in the distribution of environmental benefits and risks, as well as in environmental decision-making and legal frameworks. In its 2021 resolution, the United Nations Human Rights Council recognized that everyone has the right to live in a clean, healthy and sustainable environment (United Nations Human Rights Council, 2021).

It is worth noting that people need to analyze the meaning of "Global conventions" in order to facilitate the negotiation and formulation of "Global conventions". In this context, the term "global" here should not refer to the geographical level of the world, but rather to the global pollution caused by ecological cycles such as ocean currents and marine plastics, and the measures taken to protect the global ecological environment. Therefore, when formulating a global plastic agreement, not every country should be required to participate, and of course, only some countries should be determined to participate. The author aims to refute a viewpoint called "key action countries", which argues that these countries (China, Indonesia, Philippines, Vietnam, Sri Lanka, Thailand, Malaysia, Bangladesh, India, and Pakistan) have poor management of plastic waste and contribute 50% of the value of land-based plastic waste flowing into the ocean. Hence, they are required to take immediate action to establish consensus, demonstrate urgently needed commitment, political will, and support for the negotiation process of the new plastic treaty, in order to achieve the proposed treaty's goal of "ending plastic" as adopted in the resolution (Hussain et al., 2023). This viewpoint is disturbing, particularly because of the challenges in quantifying the aforementioned countries' contribution to plastic pollution. As highlighted above, there is currently no unified global monitoring method or evaluation standard. Assuming the "50%" figure is based on a specific monitoring method in a particular country, the validity of this data remains to be substantiated. It is also important to recognize that countries not part of the "key action nations" may have different models for prevention and control obligations, which clearly undermines the goal of establishing consistent monitoring and evaluation standards. As a result, this viewpoint fails to achieve logical consistency within the legal framework.

Plastic pollution is intricately linked to environmental justice. Plastic pollution frequently affects vulnerable populations disproportionately and varies across regions, necessitating tailored solutions that account for local conditions. Tens of thousands of individuals involved in the plastic waste recycling continue to face systemic environmental injustice (International Alliance of Waste Pickers, 2023).The majority of plastic pollution issues are disproportionately located in the Global South, especially in South and Southeast Asia (Jambeck et al., 2015; Lebreton et al., 2017), leading to environmental injustice and "slow violence" (Nixon, 2011). For example, the Philippines, a country in the Northern Hemisphere, generates 163 million plastic bags, 48 million shopping bags and 45 million film bags every day (GAIA, 2019). However, this plastic waste lacks proper disposal methods and is often discarded on the streets, eventually making its way through waterways to the oceans and impacting countries in the Southern Hemisphere (Conlon, 2020).In the United States, approximately 79 percent of municipal incinerators are situated in communities that possess the least economic and political influence (Baptista and Perovich, 2019).

Despite the global prevalence of plastic pollution, its negative externalities are specially severe in impoverished regions where plastic waste is not originally produced. These externalities manifest in issues such as clogged sewer systems, increased disease transmission, and reduced tourism (Giacovelli, 2018; Godfrey, 2019). A significant factor is the legal or illegal transport of plastic waste from developed nations to developing ones (Blettler and Wantzen, 2019; McCormick et al., 2019). On the surface, these countries seem to bear the brunt of plastic pollution, with the responsibility of managing the waste falling disproportionately on them However, it is precisely these nations that contribute the least to global plastic waste (Conlon, 2020).From this perspective, nations that generate lower levels of plastic waste have taken on the responsibilities typically borne by those countries that manage plastic waste disposal, exemplifying a prevalent form of environmental injustice. Hence, environmental justice considerations must be integrated into policy-making to ensure fairness, legitimacy, and efficacy of these policies.

Although the newly revised draft of the plastics convention identifies "the protection of vulnerable communities" as a fundamental principle, it lacks detailed specifications. Nevertheless, the need for environmental justice is unmistakable. This section outlines the framework for environmental justice and proposes specific measures to reinforce its role within the new plastics Convention. The imperative of environmental justice is undeniable. Yet, explicit frameworks for environmental justice are relatively scarce (Nathan et al., 2022). It is essential to explore how environmental justice can be incorporated into this new global agreement on plastics. For instance, from the standpoint of environmental benefits and responsibility, upstream producers, not downstream victims and local governments already suffering from pollution, should bear the primary responsibility for preventing plastic pollution. Additionally, the environmental justice framework

proposed by Bullard can be applied to assess whether the new global plastics agreement embodies environmental justice (Table 1).

The new plastic convention should reflect contents such as "Right to protection", "Prevention", and "Correcting Injustice". Equally important for the treaty's legitimacy and credibility is the recognition of environmental justice as a fundamental component of human rights within this ambitious international framework.

In the new plastic convention, distributive justice should be considered as the overall action plan to address environmental inequality, which is also a manifestation of the "Right to protection" concept in Bullard's theory of environmental justice(Table 1). Firstly, the stipulations of this convention should address the inequitable distribution of plastic waste impacting low-income and marginalized communities (Adeola, 2000; Bullard, 2021; Davies and Mah., 2020). Secondly, it should also highlight that individuals exposed to higher levels of plastic pollution tend to receive fewer benefits (Clapp and Swanston, 2009; Conlon, 2020). As previously stated, the widespread environmental injustice of illegal plastic waste disposal by developed nations in developing countries underscores the need for stricter regulations within the relevant provisions.

In addition, specific action plans should also be developed. For example, the principle of environmental justice must be integrated into financial and technical assistance initiatives. Such support is crucial for developing countries to effectively mitigate plastic pollution (Stoett, 2022; Environmental Investigation Agency, 2022). Environmental justice should not only be addressed in the preamble or introduction but must also be reflected through concrete countermeasures. The provisions of the new plastics convention should include financial mechanisms such as finance, taxation, and funding to assist developing countries with governance costs. Additionally, support for technology governance in these nations should be strengthened through measures like technology transfer and promotion. Furthermore, international or national compensation mechanisms can be established to address the needs of regions most adversely affected by plastic pollution (Orellana, 2021).

Emphasizing the elements of environmental justice within the new plastics convention is likely to yield a beneficial impact on societal development. Once implemented, this convention can further safeguard the legitimate rights of indigenous peoples, women, and marginalized communities, including their rights to clean water and a healthy environment (Orellana, 2021). It also strengthens and promotes the fundamental rights of children and adolescents (Children and Youth Major Group to UNEP, 2023), exemplifying the principle of intergenerational equity. Furthermore, it was recognized that adopting a human rights framework could effectively fulfill the objectives of the new plastics Convention, particularly concerning the health rights of vulnerable populations (The Government of Peru, 2022).From an economic perspective, the adoption of environmental justice principles may elevate the costs associated with plastic management; however, it is likely to yield significant long-term benefits for human health and the ecological environment. Furthermore, data from the United Nations Conference on Trade and Development (UNCTAD) indicate that global international trade in plastic waste amounts to approximately 3.3 billion US dollars, underscoring the necessity for collaborative efforts within the international community to address waste recycling challenges (Barrowclough et al., 2020).

5.2 The new plastic convention should lower the risk prevention threshold

The principle of risk prevention is the cornerstone of modern environmental protection. This status is dictated by the uncertainty inherent in risks and is intimately linked to environmental issues themselves. The continual emergence of new environmental risks necessitates a reevaluation of risk management. As discussed earlier, the emergence of environmental issues indicates irreparable harm to ecosystems and underscores the need to lower or raise the threshold for risk prevention. Accordingly, international legal instruments aiming to decisively tackle plastic pollution must embody the primacy of risk prevention principles, with a focus on the presence of "residual risks". Ulrich K. Preuss exhibits a forward-looking perspective on "residual risk" which can be considered a fundamental criterion for establishing the threshold of the risk prevention principle. He posits that the three distinct forms of danger, risk, and residual risk can be broadly delineated based on linear determinism: Danger is the belief that there is a "sufficient likelihood" between the current cause and future harmful effects, as perceived by the average person; risk is met when this "sufficient likelihood" is partially achieved; both can be regulated and adjusted once the respective criteria are met. As in the case of environmental pollution, legal regulation can be determined by general causal principles. However, the necessity for regulatory intervention in relation to potential risks, particularly "minimal possible dangers", presents a challenge in applying the precautionary principle. Although it is now possible to demonstrate that marine animals are poisoned and even killed by the ingestion of plastic, the danger of micro-plastics may be limited to this. Hence, the "residual risk" needs to be reconsidered in people's cognition. For example, while individual animals have died or been injured due to plastic pollution, it is unclear how this scales to population-level effects (Wilcox et al., 2016).

In fact, the regulation and adjustment of danger and risk encompass not only objective linear and deterministic factors but also include people's subjective judgments about these factors. In other words, judgments of danger and risk encompass both objective and subjective aspects, with residual risk representing a distinct scenario. UIrich K. Preuβ defines it as a threshold that indicates the possibility of a certain type of damage occurring. Below this threshold, considering resource lack, protective measures are no longer provided because the probability of this potential damage materializing is very low. As a consequence, while the existence of damage cannot be theoretically excluded, it is dismissed based on "the standard of practical rationality". In essence, this represents a trade-off among potential cognitive errors, regulatory adjustments, and technological advancements. However, people today can no longer afford to engage in such trade-offs and should aspire to the Eu's ambition in fulfilling its treaty obligations (Article 21 (2) (f) TEU (EU, 1991a) and Article 191 (1) of the EU Treaty (EU, 1991b), with the EU resolved to "lead by example" (EEAS, 2016). Individuals likewise require this courage and

spirit of inquiry to confront the "residual risks" beyond the known hazards of microplastics. With this cognitive foundation, it can achieve Goal 14 of the 2030 Agenda for Sustainable Development.

5.3 The new plastic convention should clearly address the regulatory issue of HPP

Although already mentioned in the revised draft, the goal is "to end plastic pollution, including in the Marine environment [and other aquatic and terrestrial ecosystems]" (UNEP/PP/INC.4/3, 2023). However, there is a lack of explicit reference to HPP. As a new comprehensive convention addressing plastic pollution, HPP should not be broadly categorized under other aquatic and terrestrial ecosystems. Clear provisions for HPP are necessary. Because, HPP has become an increasingly significant challenge in managing MPP.

Studies have shown that plastic waste on land accounts for about 80% of MPP (Jambeck et al., 2015), indicating that rivers are important carriers of MPP (Schmidt et al., 2017). Therefore, labeling plastic pollution as a marine issue has limited the full understanding of the problem (Hartley et al., 2018). People must re-examine the relationship between river plastic pollution and MPP.

For instance, a study on marine MPP in European waters suggests that limiting MPP requires considering the role of rivers and land-based activities in plastic accumulation in the marine environment (Black et al., 2019). This study on land-based plastic pollution provides favorable evidence for this result, with 10 rivers accounting for 88% to 95% of the world's marine plastic load (Schmidt et al., 2017). Another study estimates that approximately 1.15 million to 2.41 million tons of plastic waste flow from inland rivers to the marine environment worldwide each year (Lebreton et al., 2017). These rivers cover approximately 2.2% of the land area and 21% of the global population. However, the shocking data is that they account for about 67% of the total input of plastic waste into the world's oceans (Hussain et al., 2023).

Recent research suggests that approximately 3-19% of plastic emissions in coastal areas come from land-based river sources such as rivers (Lebreton et al., 2017). The production activities in coastal regions are directly linked to inadequate management of plastic waste [MMPH], while the role of rivers in this issue is often underemphasized (Small and Nicholls, 2003). Rivers create networks that enable the long-distance transport of plastic waste to the ocean, similar to the transport of terrestrial sediments (Ludwig et al., 1996). This indicates that the riverine transport of plastic waste has emerged as a significant pathway for marine ecological pollution. Although people believe that this matter is related to the direction of controlling MPP, their understanding of plastic pollution control in river systems lags behind their understanding of MPP control (Wagner and Scott, 2018). People must understand the environmental mechanism behind the qualitative transformation of river systems into carriers of plastic waste transportation, namely the natural flow principle of river networks, in order to develop a good and targeted legal framework for global response to MPP.

From this perspective, the natural flow principle of river networks should be given due attention, especially in the treatment of marine environmental pollution. Therefore, the focus of a legally binding international instrument to end MPP should not only be on the issue of marine plastic, but equally important should also be on plastic pollution in inland rivers. This kind of attention may seem to interfere with some domestic legislation on the surface, but the fact is that it is through data investigation of the source and through the phenomenon to see the essence. At the legislative level, how to avoid appearing as "interference" in domestic legislation can be achieved entirely through legislative techniques, such as the selection of legislative models. Research shows that the current fragmented freshwater legislation in Europe lacks a deep understanding of plastic sources and transportation carriers, which poses a significant challenge for the development and implementation of effective plastic laws and regulations (Black et al., 2019). Consequently, it is imperative to explicitly outline the regulations governing HPP within the forthcoming plastics convention.

5.4 The new plastic convention must elucidate fundamental legal concepts

Concepts are the logical foundation of law, and both domestic and international law need to be developed from these foundational concepts of the book. Bodenheimer once pointed out: "Concepts are necessary and essential tools for solving legal problems. Without strict and specialized concepts, people cannot think clearly and rationally about legal issues. If people completely reject concepts, the entire legal building will be reduced to ashes" (Bodenheimer, 1999). The definition of legal concepts will directly affect the application of law. To sum up, legal concepts are the foundation of the legal system and play an important role in regulating behavior, interpreting laws, constructing systems, safeguarding rights, and achieving fairness and justice. This is essential for a thorough understanding and grasp of legal concepts in order to correctly understand and apply the law.

Introducing certain concepts from other environmental fields into the legal domain can facilitate the regulation of social relations through legal means. This is interdisciplinary communication and necessary, but after all, there are still significant differences between the two and cannot be completely borrowed directly. Concepts in other environmental fields possess their unique physical and chemical characteristics. In law, the basic elements that define concepts are the basic points of legal concepts such as adjustment objects, adjustment scope, adjustment methods, and adjustment objectives.

Taking the concept of micro-plastics as an example, the current approach mainly adopts the viewpoint of Thompson et al. from Plymouth University in the UK in 2004, which refers to plastic fragments and particles smaller than 5 millimeters. But some scholars define micro-plastics as those with a diameter less than (<4.75 millimeters) and can disappear from the ocean surface (Eriksen et al., 2014). There are also scholars who believe that

"Micro-plastics are those plastics that are less than one millimeter in diameter" (National Geographic, 2024).

This illustrates the following two points: Firstly, people's understanding of "micro" is not unified; secondly, the scientific validity of defining plastic beads with a diameter less than 5 millimeters as micro-plastics needs further validation.

This discrepancy in definition gives rise to at least three negative implications.

(1) From a legal standpoint, differently characterized pollutants are subject to inconsistent regulatory measures and legal applications.

(2) In the context of environmental law, the categorization of pollutants essentially embodies the threshold of the precautionary principle and influences future pollution prevention efforts.

(3) In the realm of international law, it represents a form of disguised application or non-application of international treaties to the diverse interests of the international community (disguised application might arise from trade barriers; disguised non-application might stem from the significant economic costs of controlling microplastic sources domestically). This is also among the reasons why the international community is ambitiously working to establish an international agreement with universal binding force for contracting parties.

In the absence of a legal definition, substances that take decades or even centuries to degrade might still be considered biodegradable. Therefore, at this historic juncture, a universally binding international instrument must first address fundamental legal concepts. These concepts cannot be individually detailed in this text, but they must at least encompass the fundamental elements of degradability (basic scientific understanding), regulatory targets, scope, and environmental impact.

While the authors find it challenging to finalize the definition of plastic pollution within the new plastics convention, These concepts must include at least two fundamental elements. First, It must demonstrate certain typical characteristics of the environment and offer quantitative criteria for the formulation of specific legal measures. Second, there is a legal dimension; ultimately, plastic pollution is fundamentally a legal construct. Within this framework, it is crucial to emphasize its detrimental impact on social or ecological environments to underscore the necessity of legal regulation concerning plastic pollution.

5.5 The new plastics convention must delineate standardized monitoring methodologies and evaluation criteria

The development of unified plastic testing methods and evaluation standards is a formal justice for the unified application of the upcoming international treaty. On the basis of unified monitoring and evaluation, what measures should countries take to address domestic land-based plastic pollution is convincing. Various research methods and analytical techniques are currently available. For instance, surface monitoring is carried out through aerial imaging and remote sensing technology (such as satellites and drones), water column monitoring is carried out through autonomous underwater vehicles (AUVs) and remotely operated underwater vehicles (ROVs), seabed detection is carried out through bottom trawl and grab sampling and underwater imaging (ROVs, AUVs), biological monitoring is carried out by examining the intestinal contents and feces of marine organisms, biological accumulation in biological tissues, feeding and entanglement of marine organisms, and public science and community monitoring are conducted through beach cleaning surveys and data collection. Due to various reasons, the National Oceanic and Atmospheric Administration (NOAA) of the United States has been unable to take satellite photos of the garbage patch (Goldberg, 2012). Resolutions 20/86 and 274/00 of the Brazilian National Environmental Protection Commission have established criteria for saltwater used for recreational purposes, including floating materials, oil and grease, odorous or turbid substances, artificial dyes, and substances that form harmful sediments; Fecal coliforms, DBO-5 and other indicators. Despite various indicators, the "foamability" of Brazilian beaches (determining the parameters suitable for bathing) has always been determined by the number of bacteria (Escherichia coli and/or Enterococcus) in the water's coliform community (Diogenes et al., 2020). The description of the size of the ocean plastic problem varies greatly, as a clear scientific method for measuring debris has not yet been established (Goldberg, 2012). This is a very serious issue.

Consequently, it is urgent to develop unified monitoring methods and evaluation standards in the new global plastic agreement to determine more accurate data on current seabed plastic waste. Because this is a prerequisite for taking unified action. Regardless of the legislative model used for this monitoring method and evaluation criteria. Of course, the author tends to favor a specific convention model. Because it, firstly, can ensure the simplicity and clarity of the convention documents, which also meets the requirements of streamlining and seriousness in formulating laws; Secondly, the formulation and modification of annexes are more flexible compared to the main text of the convention. The variability of pollution forms and scientific uncertainties necessitate that the convention allows for flexible modifications; Thirdly, incorporating core obligations directly into the main text of the convention will further encourage contracting parties to accelerate their transformation efforts.

6 Conclusion

This paper adopts a holistic systems perspective. The strength of this framework lies in its ability to assess only the coherence and systematic nature of extant legislation but also to propose recommendations for a new plastics convention from an integrated viewpoint. In response to the fragmented legislative landscape addressing MPP, the paper presents targeted strategies to tackle legislative fragmentation. These strategies include emphasizing environmental justice within the new Marine

Plastics Convention, lowering the threshold for risk prevention, clearly defining legal regulations concerning HPP, scientifically elucidating fundamental legal concepts, and standardizing monitoring methodologies and evaluation criteria on a global scale.

The global issue of MPP is no longer just a matter of international environmental law. It also spills over issues such as environmental justice and provides a renewed understanding of environmental risks. As for the issue of environmental justice, it includes two aspects. On the one hand, countries or regions with high emissions of pollution make regions with low emissions bear more environmental externalities. On the other hand, when formulating a global plastic agreement, it is important not to overly criticize economically countries or regions. The recent discovery of micro-plastics in marine animals and human blood has renewed awareness of environmental risks. This phenomenon needs to be reminded that people should not only focus on causal relationships based on determinism in classical physics, but also pay attention to the existence of "residual risk". At a time when there is a strong global call for the development of a legally binding international document, including the above-mentioned spillover issues requires a holistic and systematic approach. In this agreement, a comprehensive approach to the global issue of plastic pollution should be adopted, along with systematic measures to address it. For example, determining the overall goals of governance, the main measures taken, and supporting measures.

Of course, the discussion in this paper is an analysis based on the existing legal situation and scientific knowledge. With the continuous improvement of international regulations and national laws for the prevention of MPP, as well as the interaction between the two, some of the views in this paper will also change and be subject to further review, but given the systemic nature of the ecological environment, the study of this issue from a holistic systemic perspective will continue to be of great practical importance in terms of methodology.

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