Agata KOSIERADZKA-FEDERCZYK[1]

Setting the Legal Basis in International Law for Liability for Transboundary Rivers Plastic Pollution[2]

Abstract

This article examines the issue of plastic pollution in rivers, studying various perspectives to provide a comprehensive understanding of the problem. Data on the volume of plastic pollution are presented, including the sources and consequences of this pollution in rivers. This research demonstrates the magnitude of the problem of river plastic pollution, and the challenges associated with conducting reliable research. Furthermore, the various measures adopted by countries to reduce plastic production, use of disposable plastic products, and the sealing of plastic management processes have been identified. Two types of legal acts are identified at the international level: those that address river management issues, the most important being the 1992 and 1997 Conventions. However, these conventions are not global and their geographical application is limited. Conventions with a global dimension, such as the Basel Convention or the Stockholm Convention on Persistent Organic Pollutants (POPs), partially address the issue of plastics.

This article proposes that solving the problem of river plastic pollution requires coherent solutions (at the national and international level) and efficient management of transboundary rivers – at the transboundary level and extended to the global level. The development of legal regulations in these areas will likely contribute towards strengthening the basis for bearing responsibility for plastic pollution. Examples of such responsibility are cited in the article, but they refer to national laws.

Keywords: Plastic Pollution, Transboundary River Protection, River Plastic Pollution, International Law

1 | Prof. UKSW Cardinal Stefan Wyszynski University in Warsaw; ORCID: https://orcid.org/0000-0002-2982-5984; e-mail: a.federczyk@uksw.edu.pl

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1. Introduction

Plastic has played an integral role in the global economy and human life over several years. During these times, positive changes were observed and the problem of increasing pollution was downplayed. However, the issue of environmental plastic pollution, in all its forms and sizes, has recently gained significant attention. Moreover, the abundance of studies on environmental plastic pollution, including river pollution, indicate the level of various entities engagement. These studies, in addition to evidencing the magnitude of the problem, are helping to address the knowledge gaps regarding the sources and effects of pollution. A closer look at research on the presence of plastic in rivers show a strong determination to fully understand the problem, as evidenced by, for example, the latest studies focused on microplastics, which originate from the breakdown of plastic waste.

The following sections present the current state of research on plastic pollution in rivers. The first aspect aims to demonstrate the scale of the problem. The second aspect focuses on plastic pollution in rivers, its sources, and consequences. The subsequent sections summarise the current legal acts (national and international), specifically focusing on their applicability to the problem of river pollution. Additionally, this article presents directions for changes in international law that may contribute to the problem of solving the problem of river plastic pollution – towards strengthening the basis for liability for river pollution under international law.

The structure of the article is designed to achieve its main aim to present a comprehensive overview of the existing research on the extent of river plastic pollution, identify the sources of such pollution, demonstrate the complexity of the measures involved, which constitutes, at the same time, a necessary step towards formulating legal bases to prevent pollution and enforce rules of liability using the polluter pays principle. Regulatory measures should and usually are directed at a defined entity at a specific stage of the product life cycle (e.g. manufacturer, consumer, waste management entity),[3] it is more difficult to determine both the appropriate regulatory measures and subjects for plastics that have already entered the environment.

Various research methods are used in this study. The interdisciplinary method that analyses research on river pollution (e.g. sources, effects of pollution, testing the degree of pollution) is intended to highlight issues that are relevant to legal matters. The dogmatic method was used to address legal issues, focusing on the systematic interpretation and analysis of existing conventions within the international legal system. It emphasises consistency, coherence, and the logical structure of the legal order. It was used to draw attention to possible directions for the

3 | Brennholt et al. 2018, 241.

development of existing international regulations and the adoption of new legal regulations, primarily concerning the use of plastic.

Legal analysis focuses on international law. It does not cover EU legislation and its policy due to the assumption that the issue of river plastic pollution will be presented from a global perspective, and recommendations for further action have been prepared in this regard. However, the EU has introduced several legal measures aimed at improving water quality in rivers and lakes in Member States.[4]

At the outset, it can be observed that the issue of plastic pollution in rivers is being addressed in isolation, that is, from the broader problem encompassing pollution in seas and oceans. Historically, greater emphasis has been placed on addressing the pollution of seas and oceans, with river pollution considered as a secondary matter. Available data indicate that land-based sources contribute highest to plastic pollution in oceans; therefore, it will not be possible to solve the problem of plastic pollution in oceans without first regulating the problem from the perspective of river plastic pollution.

However, it is important to acknowledge that river pollution is not an isolated cause of sea and ocean pollution. Instead, it is a consequence of errors in (broadly meaning) plastic management on land. Consequently, addressing the issue of river plastic pollution requires the implementation of comprehensive solutions at a global level within the context of plastic life-cycle management, supported by appropriate task-setting objectives in water management.

2. The dimension of the problem

The number of studies conducted and results obtained confirm the seriousness of the problem. The extent of the problem of plastic water pollution can also be illustrated with data. It is estimated that 82 million tonnes of plastic waste are mismanaged annually, with 13 million tonnes/year entering the terrestrial environment and 5.8 million tonnes/year in rivers.[5] However, a different study[6] shows that this distribution does not mean that ‘only’ this amount of waste enters water sources, as plastics that are not properly disposed of on land can be transported by runoff and wind.

Other available sources estimate that between 19 and 23 million tonnes, or 11% of total plastic waste generated globally in 2016 entered aquatic ecosystems.[7] Despite the ambitious commitments currently being made by countries and the measures being introduced to reduce the use of plastic, it is estimated that annual emissions into the environment could reach as much as 53 million metric tonnes

4 | An example is Brennholt et al. 2018, 246–251, and the literature cited therein.
5 | OECD 2022, 32.
6 | Ibidem.
7 | Borrelle et al. 2020, 1515.

by 2030.[8] While the forecasts are subject to a certain degree of uncertainty, they indicate that several million tonnes of plastic are likely to enter rivers worldwide every year.

While examining the origins of the study of plastic pollution, the problem of marine pollution was frequently the primary focus, while freshwater resources were often overlooked, even though global water systems cannot be protected without considering them. It is crucial to characterise exposure pathways and levels to better understand the risks and impacts of plastics on aquatic ecosystems, including loss of biodiversity. Findings of the research that was conducted at the Helmholtz Centre for Environmental Research (UFZ) should be interpreted as confirming an unequal interest in the problem of plastic pollution in favour of seas and oceans. They show that plastics in the marine environment have been studied the most (9706 publications for microplastics, 1103 for nanoplastics), as microplastic particles were first identified there[9] and nanoplastics have only recently become detectable. It is also emphasised that research about marine plastic pollution has given a corresponding boost to research related o freshwater systems (lakes and rivers, 4370 vs. 492 publications for microplastics vs. nanoplastics).[10]

Marine plastics originate from ships or land-based sources, with the latter being more significant. It is estimated that plastic pollution from land accounts for 80% of the plastic found in marine ecosystems.[11] Of the ten rivers that contribute the most to oceans, eight are located in Asia,[12] and rivers in the top ten watersheds contribute between 88% and 94% (depending on the model used in research) to plastic pollution.[13]

Given that approximately half of the world's population lives within fifty miles of the coast, these plastics have a high potential to enter the marine environment through sewage systems or by being transported by wind from the coast. A substantial proportion of land-based pollution is transported to seas by rivers.[14] However, research in this area remains limited in the academic literature.

Moreover, it is not only about the plastic in rivers leaking into oceans and seas and polluting them but also the problem of river plastic pollution. As studies show, most of the mismanaged plastic waste (>90% studies focused on macroplastics) is retained in rivers and does not reach the sea.[15] Realistic estimates of the flow of plastic from rivers to oceans are very important for raising awareness about the sources of plastic waste and ultimately for taking action to reduce it.[16]

8 | Ibidem.
9 | Thompson et al. 2004.
10 | Schmidt et al. 2024, 3.
11 | Andrady 2011, after Cole et al. 2011, 2592.
12 | Schmidt et al. 2017, 12250.
13 | Ibidem, 12252.
14 | Cole et al. 2011, 2592.
15 | van Emmerik et al. 2022, 1.
16 | Lechner et al. 2014, 177.

Although plastic pollution is common in rivers, seas and oceans, the perception of the problem of plastic pollution in rivers as being the same as plastic pollution in seas and oceans is superficial and requires consideration of several differentiating issues. It is important to note that freshwater resources (lakes and rivers) account for only 0.0091% of the earth's surface water, significantly less than the 0.5% of groundwater and 97.3% of the oceans.[17] Rather than focusing on the surface area occupied, the significance of these water bodies should be determined by their respective functions. The problem of plastic pollution in rivers is part of the overall problem of plastic pollution in the environment and merits separate attention.

Available data indicate that land-based sources contribute highest to plastic pollution in oceans; therefore, it will not be possible to solve the problem of plastic pollution in oceans without first regulating the problem of river plastic pollution.

3. Plastic pollution in rivers – sources and consequences

The sources of plastic pollution have been comprehensively documented. A mounting body of research has also identified the harmful effects of plastics in the environment. Plastic pollution of aquatic ecosystems is caused by macroplastics, microplastics, and nanoplastics. Extant studies show that plastic pollution is extremely persistent in the environment.

Plastics larger than 5 mm are referred to as macroplastics.[18] Larger plastic objects are more visible and, as a result, many types of negative social, economic, and environmental impacts are easier to identify. These deleterious effects encompass, for instance, wild animals getting entangled in fishing nets or the blocking of cooling water intakes on boats, which may require the intervention of rescue services. Research is ongoing into the mechanisms by which large pieces of plastic break down into microplastics, as well as the significance of factors such as temperature, UV radiation, the presence of microorganisms and water flow, all of which accelerate this process.

Microplastics are most often defined as synthetic particles of organic polymers that are <5 mm in size (or more precisely, the largest dimension). Plastic microbeads in the environment are classified as primary or secondary, depending on their source. This classification facilitates the identification of potential sources and the development of mitigation measures to reduce their environmental impact. The concept of microplastic sources can be expanded to include 'primary' sources, where microplastic particles are deliberately manufactured for direct use or

17 | IPCC 2001, 297.
18 | Duis & Coors 2016, 2. Although the article uses a basic division into macro- and microplastics, occasionally it refers to nanoplastics, and the literature introduces a more detailed classification system that includes macro- (>1 cm), meso- (1 to <10 mm), micro- (1 to <1000 lm), nano- (1 to <100 nm), and sub-micro size (100 to <1000 nm), D'Avignon et al. 2021, 229.

incorporation into other products. These are found in cosmetic beads used in scrubs and shampoos, particles used for sandblasting, and as pre-production resin pellets.[19]

Secondary microplastics are defined as fragments of larger plastics that have been degraded based on usage (e.g. fibres released from washing clothes or textiles), waste management or the fragmentation of larger plastics in the natural environment (e.g. plastic bags or bottles).[20]

However, the rate of formation of secondary microplastics is less well understood, as this process is influenced by various factors, including the type of polymer and the environmental exposure conditions.[21] The process of fragmentation can be accelerated by biotic activity, such as microbiological degradation or animal activity. Photodegradation has been shown to cause fragmentation of plastic particles at a variable rate depending on the surrounding environment (e.g. temperature, water depth), and mechanical weathering is also possible.[22] Consequently, the rate of formation of secondary microplastics is challenging to predict. Given the prevalence of large plastic items in the environment, the concentration of smaller microplastic and nanoplastic particles in the environment is expected to increase, at least until the release of plastic into the environment is curbed[23] and plastic is removed. For a more nuanced understanding of the problem, systematic research is required into the breakdown processes of microplastic under realistic conditions.

It has been hypothesised that the smaller the plastic particles, the more likely they are to pass through biological membranes and the greater the risk of adverse effects on organisms. However, studies on aquatic organisms[24] have shown that this relationship may not be as definitive as previously hypothesised, and the toxicity of nanoplastics may not necessarily exceed that of microplastics.[25] Nevertheless, the authors acknowledge the need for more extensive studies to draw broader conclusions.

In addition to health risks, microplastics increase exposure to hazardous substances such as plastic additives and toxic chemicals that are absorbed from the environment. Furthermore, there is a significant risk that pathogenic microorganisms can colonise plastics, which then pass from aquatic ecosystems to plants and animals. The attraction of these particles to water bodies is attributable to their small size and resemblance to food, leading to their unintentional or deliberate ingestion by aquatic species. Research has demonstrated that microplastic

19 | Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection 2015, 18; Arthur 2009, 15–16.
20 | Lassen et al. 2015, 81–82.
21 | Song et al. 2017, 4370–4375.
22 | Pfohl et al. 2025, 2–10.
23 | Duis & Coors 2016, 20.
24 | Yang & Nowack 2020, 2596; Takeshita et al. 2022, 958.
25 | Schmidt et al. 2024, 3.

consumption by aquatic organisms can influence their feeding behaviour, reproduction, and growth. Once ingested, microplastics can be transmitted throughout the food chain.[26]

A significant number of other studies have focused on determining the impact of plastic pollution. To illustrate the intricacy of the research and acknowledge the significance of the problem without centring on the consequences, we can refer to studies that identify the deleterious environmental consequences of microplastic presence in freshwater ecosystems, such as consumption by fish species.[27] Research has also been conducted on the impact of microplastics on vertebrates.[28]

The complexity of aquatic ecosystems, coupled with the extensive range of industrial applications of plastics, poses significant challenges in accurately assessing the impact of microplastics on these ecosystems. Complex environmental conditions cause physicochemical changes in plastics, such as leaching of chemicals, which can alter their properties, inducing surface embrittlement, increasing the surface-to-volume ratio, and thus the leaching rate.[29]

More importantly, certain hazardous bisphenols, alkylphenol ethoxylates, perfluorinated compounds, brominated flame retardants, phthalates, UV stabilisers, and certain metals that are added to modify the properties of plastics are endocrine disrupting chemicals (EDCs). The release of EDCs from plastics is a matter of serious concern, given their proven ability to cause adverse effects on the reproductive, metabolic, thyroid, immune and neurological systems.[30]

Plastic enters the aquatic environment via several routes, including rainfall, sewage from wastewater treatment plants, agricultural, recreational, industrial, and urban run-off, and mismanaged waste.

The latter category is highly extensive as it includes waste that has not been collected and is 'self-managed' by those who produce it – people who dump it on the ground, in rivers and lakes, or burn it in the open, leading to uncontrolled fires. Mismanaged waste can also include waste that has been collected but is later disposed of in landfills that do not have sufficient control to prevent it from interacting with the environment. These practices are predominantly observed in developing countries, although they are also present in more developed economies.[31]

The analysis of river pollution sources is a complex issue. A part of this pollution is undoubtedly attributable to improperly managed waste. However, the sources of primary microplastics, or microplastics produced during the laundering of clothes

26 | These and other negative health effects of microplastics have been cited, for example, in Bouwman et al. 2018, 19–22.
27 | Biginagwa et al. 2016, 146–149; de Souza Petersen et al. 2018, 373–376. The impact of microplastics on invertebrates has been examined by Hurley, Woodward & Rothwell 2017, 12844–12851; Redondo-Hasselerharm et al. 2018, 2278–2286.
28 | Reynolds & Ryan 2018.
29 | Schmidt et al. 2024, 3.
30 | Flaws et al. 2020, 18–19.
31 | OECD 2022, 46.

and textiles, belong to a different category. This underscores the need for establishing legal regulations for addressing this pressing concern.

4. Plastic pollution in rivers – state of research

The extensive use of plastics leads to the accumulation of a substantial amount of primary and secondary microplastics in the environment.

The physical and chemical composition of primary microplastics and the extent of their production have not been catalogued, thus hampering complete estimation of their potential significance. However, research is underway to understand the weathering characteristics of primary microplastics, particularly the release of chemical components.

The presence of plastics in the freshwater environment is now the focus of a growing body of research. Primarily, these studies have examined larger rivers and lakes, while the occurrence of microplastics in smaller streams or lakes requires further research.

In a two-year study, Lechner et al. investigated the occurrence of small plastic objects (0.5–20 mm) in the Danube between Vienna (Austria) and Bratislava (Czech Republic) from 2010 to 2012. The quantitative results of this study indicated that the Danube is contaminated by this particular waste category, and environmental pollution by this category is a significant problem for this river's ecosystem. The significant inter- and intra-annual differences in drift density are explained by the impulsive, accidental release of plastics during processing, packaging, and transport.[32]

Other studies have focused on the prevalence of plastic (microplastic) in European rivers: the Thames,[33] Rhine,[34] and Garonne.[35] Comparative research results are available for the pollution of major European rivers,[36] rivers and lakes on other continents, for instance, Elqui, Maipo, Maule and Bio-Bio (Chile), Saint Lawrence (Canada), Lake Huron, Lake Erie (both belong to the five Great Lakes of North America), Lake Geneva (Switzerland/France), Lake Garda (Italy), Lake Khövsgöl (Monoglia).[37] In the Chinese region, studies on the presence of plastic and microplastics were conducted for the most urbanised area of China, namely Shanghai,[38] and Changsha, which is a port on the Xiang Jiang River.[39] The Shanghai

32 | Lechner et al. 2014, 179.
33 | Horton 2017, 2018–226.
34 | Klein et al. 2015, 6070–6076, https://pubmed.ncbi.nlm.nih.gov/25901760/.
35 | De Carvalho et al. 2021.
36 | Gao et al. 2024.
37 | Dris et al. 2015, 539–550.
38 | Peng et al. 2018, 448–456.
39 | Wen et al. 2018, 414–423, https://pubmed.ncbi.nlm.nih.gov/30509825/.

River was also the focus of a study.[40] A study was conducted on the African continent, focusing on the Vaal River in South Africa.[41] The findings of this study are consistent with other research, revealing the pervasive presence of various types of plastic across the continent. These findings illustrate the extent of the problem.

In addition to the increasing number of rivers being tested for plastic pollution, the methodology for conducting these tests is being improved to reduce the margin of error and provide the most realistic data possible. Examples of significant factors identified in the extant literature include wind, runoff caused by precipitation, river flow velocity, discharge, and the presence of other organisms such as water hyacinth (Eichhornia crassipes).[42] Various hydrometeorological variables have also been correlated with the mobilisation, transport, dispersion, and accumulation of plastics in rivers. Hydrology has been demonstrated to play a pivotal role in not only transporting plastics but also in determining the location and timing of their accumulation in river systems.[43] The interplay between river dynamics and characteristics is crucial in determining if plastics are deposited on banks and floodplains, accumulate in riparian vegetation, settle in sediments, or are transported downstream.[44]

Another study indicates that surface tension also plays a pivotal role in the transport of plastics. The study examined two distinct forms of transport: surface plastics, primarily influenced by surface tension, turbulence, and buoyancy, in contact with a free surface; and suspended plastics, predominantly governed by turbulence and buoyancy. The findings of this study demonstrate that the discrepancy in transport modes serves as the primary source of error in estimating plastic loads, which can be underestimated by as much as 90% using current, well-established monitoring protocols when sampling only the water surface. Consequently, strategies have been proposed for monitoring plastic streams in rivers, thereby achieving a more than tenfold reduction in the error and uncertainty of estimates of river plastic pollution.[45]

Research results are also available on the amount and composition of plastic in rivers. However, the literature indicates that the complexity of microplastics and the lack of harmonisation of sampling methodologies make it difficult to compare different studies[46] and use them for further analyses.[47]

The data cited above indicate a high degree of complexity in the issue of determining plastic pollution in rivers. Available research suggests an alternative optimistic conclusion: the problem of plastic pollution in rivers is increasingly

40 | Haberstroh et al. 2021, 1714–1727.
41 | Saad et al. 2022, 1–5.
42 | Haberstroh et al. 2021, 1714–1727.
43 | Liro et al. 2020.
44 | van Emmerik & Schwarz 2020, 6.
45 | Valero et al. 2022, 1.
46 | Dris et al. 2015, 547.
47 | Koelmans et al. 2019, 417.

recognised and identified. These two elements are crucial for the formulation of effective strategies aimed at addressing the problem of plastic pollution in rivers.

5. National solutions against river plastic pollution

Research results indicating the widespread presence of plastic fractions in rivers and the identified negative effects of this phenomenon have pushed countries to regulate to reduce river pollution. The multi-faceted nature of the causes of plastic pollution in rivers implies that measures to tackle the problem should include general measures to reduce the amount of plastic in the economy, as well as measures that specifically address the presence of plastic in rivers.

The most regulated items were single-use plastic items such as bags, straws, and kitchen utensils (e.g. Kenya, Lesotho, Mozambique, Taiwan, European Union). Regulations have been implemented in several countries, including the United Kingdom, to extend producer responsibility, encompassing proper disposal and recycling. A notable example is the introduction of a deposit system for plastic bottles and containers, which is refunded upon return, a measure that has been adopted in Denmark and Germany. This policy is designed to promote recycling and discourage the use of microplastics in cosmetics, a practice that is prohibited in Canada and South Korea.[48]

Fiscal interventions, such as taxes or levies on plastic products, have also been implemented for discouraging their use and, at the same time, encouraging the use of alternatives and providing financial incentives or subsidies for companies and consumers to switch to environmentally friendly packaging and products.[49]

A ban on the use of microbeads in all washable cosmetics has been introduced in various countries (e.g. in the United States (U.S.) – the Microbead-Free Waters Act of 2015 and in the United Kingdom – the Microbeads Regulations 2017)[50]. In the U.S., production of plastics is subject to industry regulation because of its impact on air and water resources. It is also important to include, the referred to in further sections, the Clean Water Act of 1972, which aims to protect the chemical and biological integrity of water. Among other things, this legislation prohibits the discharge of materials into U.S. waters unless explicit permission has been granted.

Despite several regulatory measures, there is a clear failure to effectively address the issue of plastic waste, including single-use plastic items. Thus, plastics, including single-use plastics, enter the environment, often in locations far

48 | Knoblauch & Mederake 2021, 87–89.
49 | Ibidem, 91–92.
50 | Burns & Boxall 2018, 2776.

removed from their initial use. The magnitude of this environmental problem is evidenced by the findings presented in the preceding section of this article, which details the prevalence of plastic in the environment.

The implementation of specific bans on plastic management has prompted a limited number of legal cases concerning the issue of liability for unlawful behaviour. Given the focus of this article on plastic pollution of rivers, the ensuing examples refer to cases involving liability for river plastic pollution.

For instance, San Antonio Bay Estuarine Waterkeeper, a non-profit organisation that oversees water quality in the bay, in July 2017 initiated legal proceedings against Formosa Plastics Corp., a manufacturer of plastic pellets. Waterkeeper contended that Formosa was in violation of its Texas Pollutant Discharge Elimination System (TPDES) permit, consequently in violation of the Clean Water Act, as it had surpassed the prescribed limits for nurdles – diminutive plastic pellets utilised in plastic manufacturing. The defendant presented data showing compliance violations from January 2016 to March 2019. Following a thorough examination of the case, the court determined.[51]

Another case concerned the defendant Frontier Logistics LP's contamination of the Cooper River and Charleston Harbour, among other places, with plastic. Even in this case, the defendant opted for a settlement, consenting to the implementation of all measures recommended in an audit conducted by a mutually agreed consultant. This is to prevent the release and migration of plastic pellets, flakes and powder off-site Furthermore, the defendant consented to the allocation of $1 million (over a period of four years) for the benefit of beneficial environmental projects selected by the plaintiffs.[52]

In another case, the dispute revolved around the U.S. Environmental Protection Agency's (EPA) failure to recognise certain water bodies as impaired due to plastic pollution. While the case pertained to marine waters, it is noteworthy that the defendant was a public institution, namely the Environmental Protection Agency (EPA). The Center for Biological Diversity (CBD) initiated legal proceedings against the EPA for violating the Clean Water Act, which stipulates, inter alia, the identification of water bodies that do not meet state water quality standards. Prior to the resolution of the legal proceedings, in 2020 the EPA voluntarily included the following water bodies around two beaches in Hawaii in its list of impaired waters after conducting additional analyses: Kamilo Beach and Tern Island in Hawaii. Consequently, these water bodies have now been incorporated into the state's water quality management plans. The inclusion of these water bodies in the state's management plans is intended to enhance water quality in the region, thereby contributing to the broader objective[53]

51 | Morath 2020, 41–42.
52 | https://elaw.org/resource/frontierlogisticssettlement_dsc_3march2021 (accessed: 6.10.2025).
53 | Abate 2023, 615.

6. Research on international cooperation on plastic pollution in water

It is evident that the global environmental consequences of plastic are a considerable challenge to manage,[54] yet this does not excuse the international community from fulfilling its obligations. From the perspective of the conditions described above, the problem of waste pollution is one of water pollution. The problem is entirely anthropocentric in origin, that is, dependent on human activity.

National regulations have long taken precedence in the fight against plastic pollution. While the significance of these measures cannot be underestimated, the data on plastic pollution show that they are inadequate and ineffective. The problem has also been recognised at the global level; however, for many years the problem of environmental pollution has been the focus and, in the case of plastic pollution, wrongly, as highlighted in this article, primarily on the pollution of seas and oceans.

In the context of international law, two primary issues have been addressed in relation to the problem of plastic pollution. First, the transboundary movement of hazardous waste (The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes[55]), which was extended to include selected plastic fractions by the 14th Conference of the Parties (COP) under Decision BC-14/12 amendment. The overarching legal instrument that underpins this convention is the requirement for the prior consent of the receiving country for the transboundary movement of waste covered by the Convention.

The second is to ban or restrict the production and use of some of the most dangerous chemicals known as persistent organic pollutants (POPs) and require the environmentally sound management of waste containing POPs, as introduced by the Stockholm Convention on Persistent Organic Pollutants.[56] Examples of such chemicals include polybrominated diphenyl ethers, which are added to plastics to impart flame resistance and other properties.

The extensive number of parties involved (Basel Convention – 181; Stockholm Convention – 186) ensures the broad applicability of the regulations they contain. Nevertheless, from the perspective of plastic management, their significance is limited and insufficient to solve the problem.

54 | Dauvergne 2018, 29.

55 | The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal Basel, 22 March 1989, United Nations, *Treaty Series*, vol. 1673, 57, as amended.

56 | Stockholm Convention on Persistent Organic Pollutants, Stockholm, 22 May 2001, United Nations, *Treaty Series*, vol. 2256, 119, as amended.

According to Dauvergne,[57] the most cited article on global plastic management worldwide,[58] this management is characterised by: (1) fragmented authority, (2) weak international institutions, (3) uneven regulations, and (4) uncoordinated policies and business-oriented solutions. Consequently, the proliferation of plastic pollution in the marine environment remains unabated.

The need for an international treaty was recognised by the United Nations (UN), which adopted a resolution in March 2022 on the development of an international legally binding instrument on plastic pollution.[59] The adoption of the treaty is intended to address the existing gap in international legal regulations related to plastic management.

The convention's ambitious assumption that the approach will be based on solutions from the perspective of the entire life cycle of plastic products is also controversial for some countries. This has thus far impeded the development of a consensus text for the convention.

The literature identifies seven elements of the convention with the potential to contribute to the establishment of an effective, legally binding international mechanism to prevent plastic marine pollution: a) the principle of common but differentiated responsibility, b) an adequate scope to address the problem by including land-based and sea-based sources, as well as chemical additives and all stages of the plastic life cycle, c) a link to international trade in plastics, d) a financial mechanism to support the necessary implementation measures, e) flexibility to adapt to change, f) effective monitoring, reporting and review procedures, and g) enforcement by encouraging compliance and discouraging non-compliance.[60]

The design of legal solutions for removing plastic from rivers requires a detailed investigation of the sources, origins, and composition of pollution. While the implementation of a more stringent waste management system may serve to reduce pollution from mismanagement, this measure is likely to be ineffective in addressing the contributions of other sources.

There is a broad consensus that plastic is responsible for the unacceptable levels of harm[61]. Addressing the root causes of this harm requires a nuanced and multifaceted approach, as there is no universally applicable solution. In response to the problem of microplastic pollution in water, the Organisation for Economic Co-operation and Development (OECD) has proposed the following solutions:

- Source-oriented approaches, such as the sustainable design and production of textiles, tyres, and complementary products (i.e. washing machines, laundry detergents, road surfaces, and vehicles) to minimise the tendency of products to contribute to microplastic formation.

57 | Dauvergne 2018, 22–31.
58 | According to de Sousa 2024, 4.
59 | UNEA 5.22022.
60 | Tessnow-von Wysocki & Le Billon 2019, 96–102.
61 | Salcido 2024, 73.

- Use-oriented approaches, such as the use of best usage practices (e.g. washing parameters, eco-driving) and mitigating technologies (e.g. microfibre filters) to reduce avoidable releases.
- End-of-life approaches, such as improved waste management practices, to prevent waste from entering the environment and potentially contributing to microplastics.
- 'End-of-pipe' approaches, such as improved management of wastewater, storm water and road runoff and treatment, to stop emitted microplastics before they reach water bodies.[62]

While it is acknowledged that current international legal instruments do not comprehensively address the full life cycle of plastics, nor all the aspects involved, it is equally important to recognise the existing legal solutions that offer responses to the plastics crisis. Compared to international regulations on plastics, those relating to cross-border cooperation in river management are much more extensive. The management of transboundary water resources is established by the Convention on the Protection and Use of Transboundary Watercourses and International Lakes[63] and the Convention on the Law of the Non-Navigational Use of International Watercourses.[64]

Importantly, the 1997 Convention does not have global scope. Ghana ratified the 1997 Convention in 2020, while Kazakhstan and Zimbabwe ratified it in 2024. The Convention is currently in force in several European, African, and Asian countries, comprising a total of 40 countries. The right to equitable use (Articles 5, 6) is balanced by the obligation of the watercourse state to take all appropriate measures to prevent any significant harm to other watercourse states. Furthermore, the responsible state is obligated to undertake all requisite measures, in consultation with the affected state, to either eliminate or mitigate the damage, and "where appropriate, to discuss the question of compensation".[65] The 1997 Convention also regulates the protection, conservation, and management of ecosystems. The riparian states are obliged to protect and conserve watercourses either collectively or individually.

The 1992 Convention was originally established as a regional convention for the member states of the United Nations Economic Commission for Europe (UNECE). However, since 2013, it has been open to all UN member states. Several countries outside of the European region have evinced interest in acceding to the 1997 Convention, including Jordan, Tunisia, among others. In 2023, Nigeria, Namibia, Iraq,

62 | OECD 2022, 11.

63 | Convention on the Protection and Use of Transboundary Watercourses and International Lakes, Helsinki, 17 March 1992, United Nations, *Treaty Series*, vol. 1936, 269, referred to as: the 1992 Convention.

64 | The Convention on the Law of the Non-Navigational Uses of International Watercourses, New York, 21 May 1997, United Nations, *Treaty Series*, vol. 2999, 77, referred to as the 1997 Convention.

65 | Article 7, in conjunction with Article 21, which introduces the principle of prevention; Sands, et al. 2003, 467.

and Gambia acceded to the Convention, followed by Zimbabwe and Zambia in 2024. This demonstrates the need to extend the solutions regulated by the Convention to other regions. The Convention is currently being enforced in 55 countries.

The 1992 Convention introduced even more far-reaching regulations for protecting transboundary watercourses. Adopting a preventative approach, underpinned by the principles of no harm, polluter pays, the Convention proposed a series of concrete instruments to limit pollution, such as prior authorisation and subsequent monitoring of discharges (with limits based on best available technology for discharge of hazardous substances), application of stricter requirements where the ecosystem so requires, and environmental impact assessment.

The Convention regulates and reinforces the application of the abovementioned principles, in addition to the establishment of control mechanisms, monitoring activities and the identification of mutual obligations in the context of cross-border cooperation. These conventions signify a substantial advancement by establishing principles that have the potential for implementation on a global scale. These conventions are a foundational starting point, providing a framework upon which countries can establish cooperation agreements with their neighbours concerning the utilisation of shared freshwater resources. However, the scope of the conventions is limited and, as a result, their impact is also circumscribed.

Conversely, other multilateral environmental agreements, such as the Convention to Combat Desertification[66] and its subregional action programmes, the Ramsar Convention on Wetlands[67] and the Convention on Biological Diversity,[68] are concerned with the conservation of natural resources and are global in nature. However, these instruments have little relevance to the problem of plastic pollution in rivers.

The issue of cooperation regarding freshwater pollution is also the subject of soft law documents. During the 1980s, the UNECE alone produced the Declaration of the European Economic Commission on the policy of preventing and reducing water pollution, including cross-border pollution (1980), Declaration on the policy of rational use of water resources (1982), Principles of cooperation in the field of transboundary waters (1984), 'Charter on the Rational Use of Groundwater', and Code of Conduct on Emergency Pollution of Transboundary Inland Waters (1990).

River pollution has long been a topic of interest in international environmental law. A mounting body of research has confirmed the presence of plastic particles of all sizes even in the pristine regions of the earth, thereby highlighting the need for more effective regulation.

66 | United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa, Paris, 14 October 1994, United Nations, *Treaty Series*, vol. 1954, 3.
67 | Convention on Wetlands of International Importance Especially as Waterfowl Habitat, Concluded at Ramsar, Iran, on 2 February 1971, United Nations, *Treaty Series,* registration no. 14583.
68 | Convention on Biological Diversity, Rio de Janeiro, 5 June 1992, United Nations, *Treaty Series*, vol. 1760, 79.

While it is acknowledged that current international legal instruments do not comprehensively address the full life cycle of plastics, nor all the aspects involved, it is equally important to recognise the existing legal solutions that offer responses to the plastics crisis.

The existing legal and political framework is intricate, ranging from the general obligations to prevent pollution arising from the conventions mentioned above to the policy directions outlined in the Sustainable Development Goals agenda. The normative landscape is particularly intricate, corresponding to the complexity of the factors that constitute the problem: rivers, biodiversity, waste and plastics, river management, international cooperation, which are the basic elements.

7. Existing principles and curbing river plastic pollution

The principles of environmental protection developed in international law are and should be widely used to solve the problem of river plastic pollution. The open nature of these principles is considered to facilitate the smooth adaptation of international law as new threats emerge.[69] Fundamentally, the principle of prevention, based on the assumption that it is better to avoid environmental damage than to repair it, is one of these principles. Since its international recognition in the 1972 Stockholm Declaration on the Human Environment, the principle of prevention has rightfully gained an influential place. This principle should guide the response of states to the plastics crisis. The significance of this principle is underscored by the conventions previously referenced in this article, including the 1992 Convention, which emphasises pollution prevention. In accordance with the stipulations of this convention, states are obligated to implement a range of measures, including legal, administrative, economic, financial, and technical interventions, with the aim of reducing pollution of waters and associated ecosystems that traverse national boundaries.[70]

At the national level, this principle is operationalised through the implementation of bans on various single-use plastic items and the marketing of products containing primary plastic. At the international level, it should be a fundamental pillar of the negotiated plastic convention.

The precautionary principle asserts that governments should act even in the absence of scientific certainty if there is a risk of irreversible damage to the environment or human health.[71] Notably, the precautionary principle does not supersede the scientific approach; rather, it serves to enhance it, particularly in circumstances where scientific knowledge is limited.[72] The utilisation of the precautionary principle in legal frameworks serves to focus attention on the

69 | Duvic-Paoli 2020, 195.
70 | Szilagyi 1993, 41.
71 | Perez et al. 2023, 123.
72 | Holdway 2008, 38.

unrecognised negative impacts of pollutants on the environment, including human life and health. While the negative impact of plastics on the environment is well recognised, much work remains to be done to determine the negative impact on human health and life. The absence of recognised harmful effects in this area cannot be a reason to abandon measures to prevent pollution.

The precautionary principle is associated with other environmental standards, including intra- and intergenerational equity, which are now integral components of the evolving nature of environmental management. The challenge of constraining the actions of present generations to preserve future resources is a contentious issue.[73] This is further compounded by the fact that, while in the past human activities could impact only small areas and within short time frames, new technologies have the potential to harm vast areas and all of humanity, including future generations.[74]

The polluter pays principle (PPP) is far from the economic dimension proposed by the OECD in the early 1970s. At that time, the OECD asserted that the responsibility for implementing pollution control measures undertaken by public authorities to ensure an acceptable state of the environment should fall upon the polluter.[75] However, in the context of PPP, legal scholars interpreted the economic principle as an obligation that polluters should assume all the social and economic costs of their actions.[76] In the context of PPP, a polluter's responsibility has expanded gradually to encompass the costs of pollution prevention and control, along with other associated expenses such as fees, taxes, clean-up costs, and compensation.[77]

The PPP principle has been incorporated into several environmental conventions. For instance, the 1992 Convention stipulates that the 'polluter should pay', thereby obliging plants or business organisations responsible for the pollution to cover the costs of preventing, controlling, and limiting pollution.[78]

The body of international law relevant to the plastic management crisis also includes the well-established prohibition of causing transboundary harm (also known as the principle of non-harm), which aims to protect the territorial integrity of states. This principle, which is now codified in several legal instruments, derives from customary law. States are obliged to ensure that plastics do not cause significant damage outside their jurisdiction or control.[79] While some scholars argue that the principle of non-harm is overly focused on protecting territorial integrity to the point of adequately addressing the problems of plastic pollution in oceans,[80] it is more applicable to the pollution of transboundary rivers and lakes.

73 | Salcido 2024, 79.
74 | Holdway 2008, 38; Andorno 2004, 12.
75 | OECD 1972, 1.
76 | Gaines 1991, 470.
77 | OECD 2022, 14; Grossman 2006, 10; Zhu & Zhao 2015, 34.
78 | Szilagyi 1993, 41.
79 | Duvic-Paoli 2020, 195.
80 | Ibidem, 197.

A river's plastic pollution limits can be used to implement this principle. However, the establishment of equitable pollution limits for transboundary rivers remains a challenging task. Monitoring river pollution will likely facilitate to determine the extent of pollution and establish the basis for potential national liability for exceeding the agreed-upon pollution limits.

The Rio Declaration stipulates that countries have common but differentiated responsibilities about plastic marine pollution, given their different contributions to global environmental degradation. Consequently, developed countries, endowed with advanced technologies and sufficient financial resources, bear a substantial responsibility for global plastic waste management, and they should assume a greater share of the responsibility for pursuing international sustainable development. However, the implementation of this principle requires detailed analysis. Nevertheless, it appears that the most significant scope lies in the establishment of regulations for plastic management at the global level. This principle may be implemented through activities undertaken as part of technological cooperation, comprising the development and exchange of experiences in the application of technologies that are plastic-free, or the removal of plastic from rivers.

The principle of fair and reasonable use is the most important principle of the international water law. This principle entails the right of a state to use the benefits of a watercourse reasonably and to protect it from violations by other states.[81] It is important to note that this principle does not imply that all states with access to a given watercourse share it equally or proportionally. The objective of achieving optimal utilisation and benefits does not entail the pursuit of 'maximum' utilisation, the most technologically efficient utilisation or utilisation with the highest monetary value. It is also not concerned with the maximisation of short-term profit at the expense of long-term losses.[82]

8. Measures that must be adopted at an international level to strengthen water resilience and cooperation in the protection of water resources

The following summary reflects the initial state of the problem: around 40% of the world's population lives in river and lake basins that span two or more countries; even more importantly, over 90% live in countries that share river basins. The 263 transboundary lakes and rivers that have been identified cover almost half of the Earth's land area and account for an estimated 60 percent of global freshwater flow. A total of 145 countries hold territory within such river basins, and

81 | ILC 1994, 98.
82 | Ibidem, 97.

30 countries lie entirely within them. As of 2008, approximately 2 billion people worldwide were dependent on groundwater, which includes 300 transboundary aquifer systems.[83]

According to available data, about 295 international water agreements have been adopted since 1945,[84] including the 1994 Convention on the Cooperation for the Protection and Sustainable Use of the Danube River, the 1960 Indus Water Treaty, the 1978 Great Lakes Water Quality Agreement, the 1991 Pakistan Water Apportionment Accord, the 1995 Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin, the 1995 Protocol on Shared Watercourse Systems in the Southern African Development Community Region (revised and extended in 2000), and the 1996 Mahakali and Ganges treaties. In this context, the Rhine is worthy of attention, as it is subject to five different international regulations aimed at protecting its environment.[85]

Despite the proliferation of agreements on transboundary water resources management, there are many watercourses, not to mention aquifers, without an adequate legal framework for cooperation. A notable example is the 2008 report by UN Water, which highlighted that 158 of the 263 international river basins and transboundary aquifer systems lacked any form of cooperative management framework.[86]

Several measures must be undertaken to urgently address the problem of plastic pollution. These actions include the establishment of a global legal framework for cooperation between nations on transboundary watercourses. The 1992 and 1997 conventions, which are based on the principles of international environmental law, have potential in this regard.

Regardless of the relevant legal framework, and irrespective of the need to solve the problem of river plastic pollution discussed in this article, a closer look at the management of water resources itself is necessary. The existing literature argues that water management solutions cannot be simple, global and, above all, technical or governmental. Instead, inequalities should be embedded in specific histories, reflecting the character of a place, its boundaries, and conflicts.[87] These and several associated factors have contributed to the ongoing discourse concerning the relative merits and potential applications of various management options, with attention centred on the comparative effectiveness of multi-level management in contrast to the bottom-up or top-down approaches.[88]

83 | UN WATER 2008, 1.
84 | Ibidem, 3.
85 | Sands, et al. 2003, 479.
86 | UN Water 2008, 3.
87 | Crow 2014, 249.
88 | Gupta & Pahl-Wostl 2013, 3.

Historically, the management of water resources has centred on the local, national, and transboundary levels.[89] However, Dellapenna[90] argues that a global dimension should be incorporated into these levels. It is crucial to emphasise two reservations in this regard: first, the approach must remain highly adaptable to current challenges; and second, it must be sensitive to regional conditions that influence river management.

While effective cross-border water management begins at the national level,[91] the global scale of the problem of plastic water pollution indicates that coherent solutions must be developed to enable cooperation between countries for protecting shared water resources. The enhancement of the competence of UN-Water, which is a constituent of the UN for coordinating work on water, could represent a step towards addressing existing deficiencies. Currently, water resources management is loosely institutionalised at the global level.[92]

The issue of river plastic pollution, including transboundary rivers, is multi-faceted and interlinked with other areas, entangled in a mosaic of intertwined problems and policies attempting to address them. The two primary challenges and their corresponding measures are plastic management and water management. Achieving effective management of these problems requires action at multiple levels. However, both issues should be addressed through the establishment of international legal instruments. The primary solution to the problem of plastic pollution is the regulation of plastic management itself, including the prohibition of plastic-based ingredients in products. The sealing of the process of managing larger plastic waste should also be included in these solutions, with packaging waste management being used as an example.

Further research is required to determine an effective framework for this cooperation, the precise details to be incorporated into the regulations on plastic pollution, and the flexibility to be granted to national governments at lower levels of governance, whether in the form of bilateral cooperation or national regulations.

- The adoption of regulations on plastic management, focused on the management of plastic-containing waste, is recommended. Given that the main sources of plastic pollution are located on land, it is necessary to first adopt instruments that implement the principle of prevention.
- Standards for monitoring and assessing water quality must be adopted. This is not merely an endeavour to obtain data that is globally comparable; it is also about establishing a methodology for measurement that provides reliable data.
- Institutions responsible for water management should be strengthened through the establishment of international agreements. It is particularly

89 | Examples of such bilateral cooperation on river protection from Hungary's perspective are presented in article Marinkás 2019, 96–112.
90 | Dellapenna 2013, 3.
91 | UN Water 2008, 6.
92 | Dellapena et al. 2013, 1.

important to strengthen the area of investigating responsibility for water pollution, including plastic pollution.

- Promotion of technology transfer and best practices in water management is imperative. In the context of plastic pollution, this encompasses both measurements and methods, including biological methods, for river remediation.
- Another aspect that must be addressed is the provision of support for scientific research on plastic pollution and its impact on water resources.
- Another important aspect is public education to reduce the use of plastic products and raise awareness of the consequences of plastic pollution. As this topic is not analysed in the article, it is highlighted as an important area requiring improvement.

9. Conclusions

The first approach proposed in this article involves presenting various data describing the problem of transboundary plastic pollution of rivers (regardless of size); second, the efforts made to solve the problem, mainly legal and to a less extent management, allows to draw the following conclusions.

The problem of plastic in rivers is part of overall plastic pollution. As argued in the academic literature, and rightly so, we have failed or underestimated the damage caused by plastic, thus allowing it to evade rational control within existing environmental standards. Furthermore, it is evident that the plastics industry has been operating with a certain degree of impunity. In response, governments have initiated efforts to address the inadequacies in waste management systems.[93]. Nevertheless, it is necessary to recognise that the scale of the problem has long since transcended national borders and appropriate global regulations on plastics are needed, and these measures require international consensus. As evidenced by the course of negotiations, achieving such a compromise is not straightforward.

While the problem of plastic in rivers forms part of the problem of plastic pollution, it also has its own specific features. This is characterised by transboundary rivers.[94] Consequently, the solution demands an individual approach. Legally, this must be grounded in international law, encompassing relevant accords between coastal nations, supplemented by domestic instruments (e.g. restrictions on microplastic discharges).

Contrary to the existing regulations on plastics management, there are several regulations on river management, both bilateral and regional.[95] These regulations,

93 | Salcido 2024, 75.
94 | For special problems of transboundary rivers see more: Marinkás 2019, 96–111.
95 | For research on water management in Central Europe see Szilágyi 2019, 182–194.

while diverse in respective particulars, collectively provide a foundation for addressing the issue of river contamination, including that caused by plastic.

The data cited in this article demonstrate that several rivers have not yet been subject to the adoption of any agreements. However, even the adoption of such agreements does not guarantee that the measures implemented under them will effectively address the issue of river pollution, including plastic pollution. The data on plastic pollution indicates that this is not the case.

This raises the question of why plastic pollution is so heavy. The underlying reasons are complex – in addition to any lack of adequate international regulation of plastic itself, the solution lies in water management, as demonstrated by the selected directions of changes proposed in this article, specifically in the previous subsection. The numerous and varied consequences of plastic pollution require equally diverse solutions. A concerted effort is imperative from all stakeholders, including governments, scientific communities, and the private sector.

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