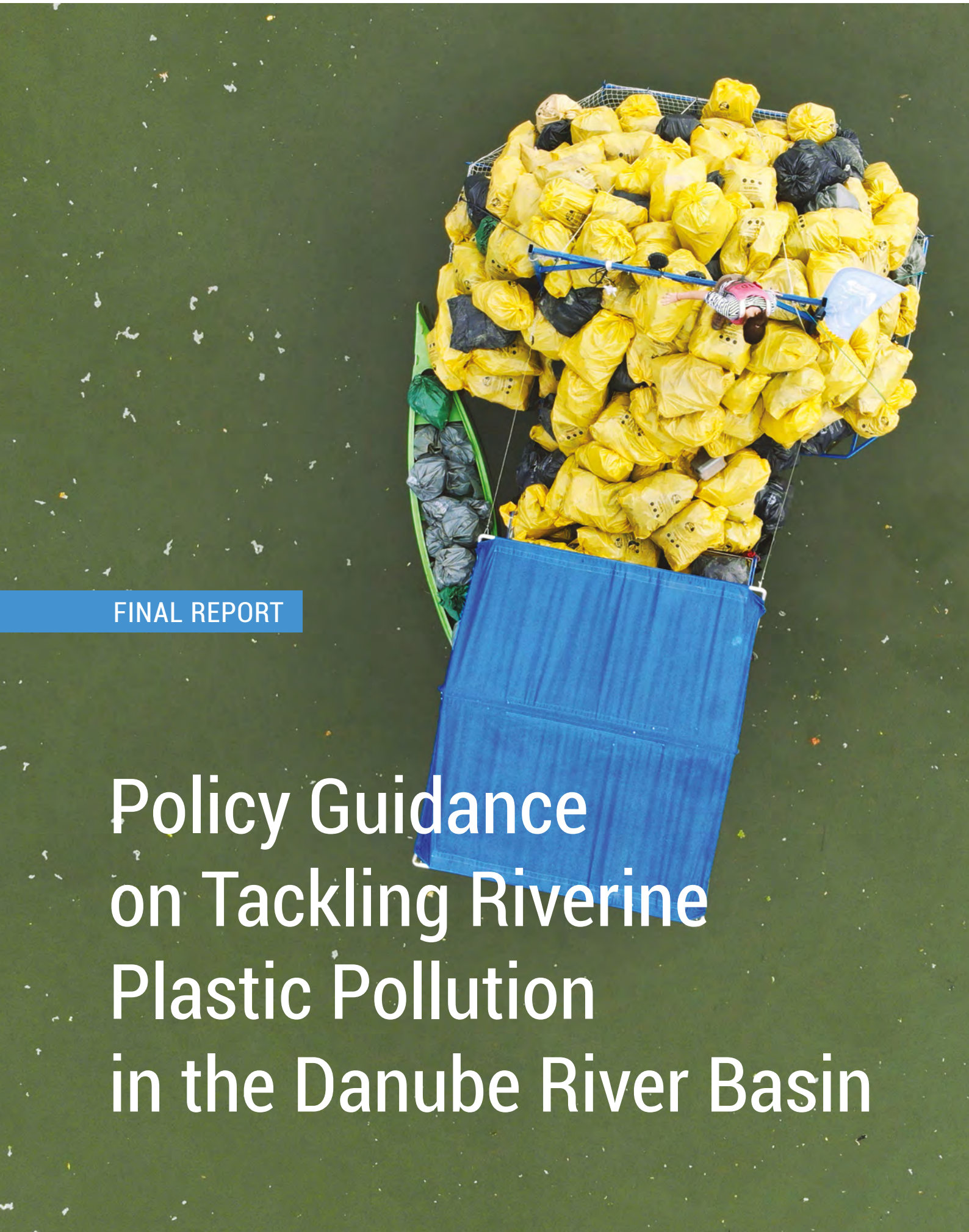
Interreg
Danube Transnational Programme
Tid(y)Up

ICPDR IKSD
International Commission for the Protection of the Danube River

Hungarian Association of Environmental Enterprises

PLASTIC CUP



FINAL REPORT

Policy Guidance on Tackling Riverine Plastic Pollution in the Danube River Basin

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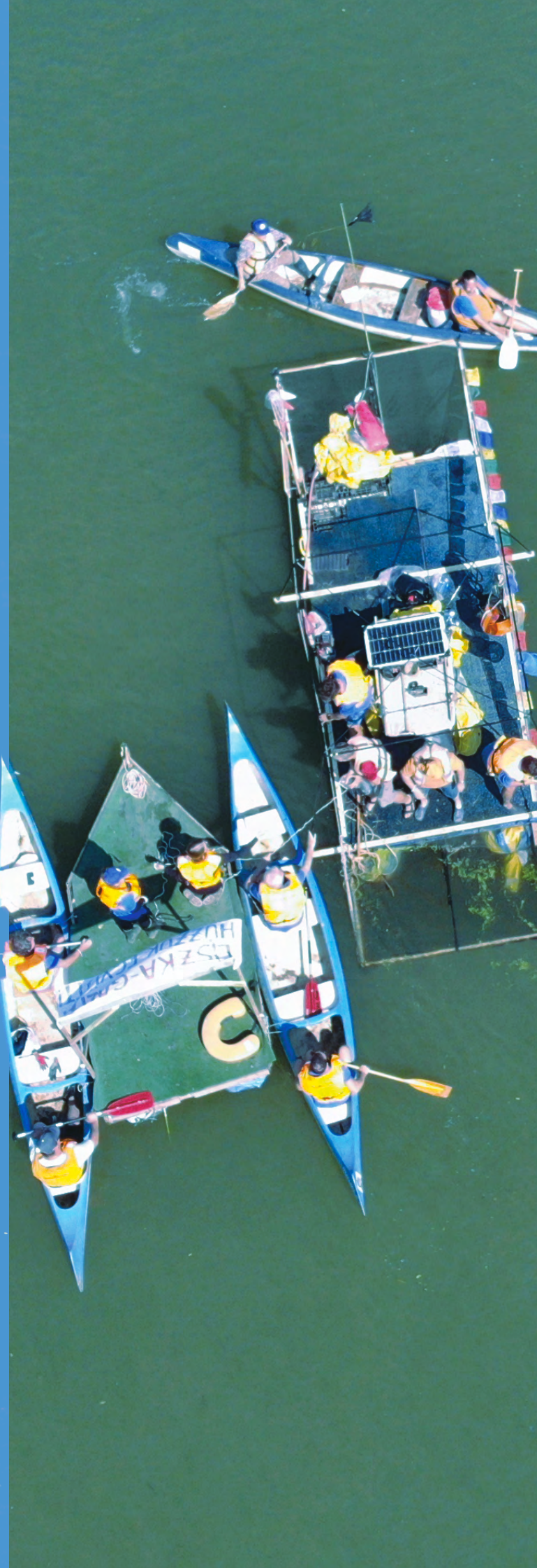

Foreword

Effective transboundary water and river basin management in the Danube River Basin (DRB) needs close cooperation and strong partnership among Danube countries, rooted in mutual respect, understanding and cooperation. The International Commission for the Protection of the Danube River (ICPDR) has been coordinating basin-wide collaboration on key water management issues in the DRB since 1998. Among other management objectives, reducing pollution and monitoring and controlling water emissions have always been high on the ICPDR's agenda. While Danube countries have made significant efforts in managing "regular" pollutants (e.g. organic materials, nutrients) and certain micropollutants, plastic pollution is an emerging issue, for which no basin-wide management strategy has been developed yet.

While current investigations are now focused on riverine systems, extensive evidence of plastic pollution has already been collected from studies conducted in the marine environment – including the Black Sea – over recent decades. Scientific investigations have revealed compelling connections between marine pollution and terrestrial areas linked to land-based activities. Factors, such as incorrect waste disposal, inadequate waste management, littering, plastic industry facilities, the utilization of textile and cosmetic products in households, or tire abrasion, collectively contribute to river pollution. The plastic litter is subsequently discharged from rivers into receiving seas, exacerbating plastic litter contamination in marine ecosystems.

The significance of plastic pollution has also received recognition at the EU level, where it has gained political momentum towards more ambitious environmental objectives. The EU adopted its Plastic Strategy on the sustainable and safe use of plastics alongside the EU Green Deal, which champions a zero-pollution objective.

These developments, coupled with several pilot studies quantifying the microplastic pollution of the Danube River and its tributaries, have laid the foundation for the ICPDR to embark on activities aimed to better understand plastic pollution and its potential basin-wide adverse impacts. Initial investigations were undertaken in 2019 during the ICPDR's Fourth Joint Danube Survey (JDS 4), regarded as one of the world's most comprehensive surface water monitoring campaigns. For the first time ever, consistent sampling and analytical methods for microplastic pollution were employed, providing comparable datasets for the entire Danube River. The results were eye-opening, and microplastics were detected in nearly all JDS 4 samples, including fine-grained suspended solids and sentinel mussel species.

Besides microplastics, macroplastic pollution remains a persistent issue in several sub-basins of the Danube River Basin. Notably, observations of the Upper Tisza Basin and recently of the Drina catchment area have shown that severe plastic pollution occurs periodically during flood events, originating from litter illegally dumped in floodplains. The Plastic Cup initiative, initiated in Hungary in response, has attracted considerable public attention. This community-driven, bottom-up, non-governmental and non-profit initiative aims to raise awareness and contribute to the clean-up of the Upper Tisza River. The Plastic Cup initiative brings together local residents, environmentalists, artists, volunteers, companies, students, families and friends in a shared mission to protect the aquatic environment, while enjoying the beauty of riverside nature.

A significant step towards managing plastic pollution in the Tisza Basin was taken with the implementation of the Tid(y)Up Project, generously funded by the Danube Transnational Programme. The project's key outcomes have been warmly welcomed as they provide valuable tools to help Danube countries tackle and overcome the plastic challenge. The project has delivered important technical advancements, including harmonized microplastic monitoring methods and an online hot-spot map that shows major plastic accumulation sites along and in the Tisza River and its main tributaries. Additionally, a professional clean-up activity was launched in cooperation with the Hungarian water authorities, complemented by numerous voluntary, community-led actions undertaken by concerned citizens. Furthermore, the project has produced valuable dissemination and awareness-raising materials, including policy recommendations, a clean-up handbook, a floating exhibition, and a waste reduction toolkit.

This policy paper draws upon the findings of the Tid(y)Up project and is a collaborative effort between the project team and ICPDR experts. It relies on a comprehensive legislative survey conducted across the Danube countries and offers recommendations on implementing regulatory measures, financial instruments, and advisory tools to manage plastic pollution effectively. This document highlights the most important strategic interventions in line with the waste hierarchy, a framework that prioritizes waste management options based on environmental benefits. It emphasises the necessity of establishing a proper waste management system to curtail illegal and uncontrolled waste deposits. The proposed system needs to be accompanied by an enabling regulatory framework, support for innovation and recycling, effective plastic pollution monitoring, and river clean-up activities. In addition, behavioural change, education and public awareness are essential components for fostering a more responsible and sustainable use of plastics.

The Policy Guidance should be viewed as a strategic framework offering guiding principles on tackling plastic pollution in the Danube River Basin. Danube countries are encouraged to incorporate those principles into their national efforts. That collaborative approach will contribute to a more effective and coordinated response to the plastic pollution challenge.

Birgit Vogel

Executive Secretary

International Commission for the Protection of the Danube River

List of abbreviations

AEWS	Accident Emergency Warning System
BOKU	University of Natural Resources and Life Sciences
CEE	Central and Eastern Europe
CfP	Co-creation for Policy Process
CRC	Community River Clean-up
CSRD	Corporate Social Responsibility Directive
DRB	Danube River Basin
DRBMP	Danube River Basin Management Plan
DRPC	Danube River Protection Convention
DRS	Deposit Refund System
DTP	Danube Transnational Programme
EC	European Commission
ELTE	Eötvös Loránd University
ELV	End-of-Life Vehicles
ENI-UA	European Neighbourhood Instrument – Ukraine
EPR	Extended Producer Responsibility
ERDF	European Regional Development Fund
ESPR	Ecodesign for Sustainable Products Regulation
EU	European Union
EUSDR	EU Strategy for the Danube Region
FETIVIZIG	Upper Tisza District Water Directorate
FLEX	Floating Exhibition
GIZ	German Development Agency
GPS	Global Positioning System
GWP	Global Water Partnership
HAEE	Hungarian Association of Environmental Enterprises
HPP	Hydropower Plant
ICPDR	International Commission for the Protection of the Danube River
INC	Intergovernmental Negotiating Committee
IPA	Integration Partnership Agreement
KÖTIVIZIG	Middle Tisza District Water Directorate
NFRD	Non-Financial Reporting Directive
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Co-operation and Development
PE	Polyethylene
PET	Polyethylene terephthalate
PP	Polypropylene
PRC	Professional River Clean-up
PS	Polystyrene
PVC	Polyvinyl Chloride
RBMP	River Basin Management Plan
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RFID	Radio Frequency Identity
R&D	Research and Development
SBR	Styrene-Butadiene Rubber
SME	Small and Medium-sized Enterprise
STEM	Science, Technology, Engineering, and Mathematics
SUP	Single-use Plastics
THU	Plastic Cup Society
TNMN	Transnational Monitoring Network
TRB	Tisza River Basin
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UWWTD	Urban Wastewater Treatment Directive
WEEE	Waste from Electrical and Electronic Equipment
WFD	Water Framework Directive
WWTP	Wastewater Treatment Plant

Table of Contents

Introduction

This policy paper is a product of the Danube Interreg project Tid(y)Up[1] (referred to as "Project" in the text) and draws extensively from the findings of the Project, the insights contributed by Project partners, and the outcomes of a survey on national legislative systems concerning surface water quality in the Danube River Basin (DRB)[2] conducted within the project's framework. The International Commission for the Protection of the Danube River (ICPDR) closely monitored the results of the project and subsequently requested the elaboration of a set of recommendations for addressing transboundary riverine litter pollution. This request was formalized through a resolution adopted at the 25th Ordinary Meeting of the ICPDR, held in Vienna, Austria, on 13–14 December 2022. This document is based on the findings of the Project and presents an insightful overview of plastic pollution in rivers within the DRB. It places a special emphasis on understanding the underlying causes of this environmental issue, including a number of areas, such as waste management, water management, and environmental education. However, we believe that this document is not limited to the DRB context. It offers a universally applicable, best-practice based methodology, which can be valuable for other rivers suffering from this kind of pollution and can help tackle this pervasive issue in various river ecosystems worldwide.

The widespread occurrence and escalating volume of marine litter (and its source, the riverine litter) have become pressing global issues. The adverse impacts of plastic pollution in aquatic environments have raised widespread concerns among experts, policy-makers, and the general public. Inadequate waste management practices, particularly those related to plastic waste, have caused significant damage to natural ecosystems. Waterways serve as conduits connecting landlocked areas to marine environments; however, they undergo severe pollution in the process.

We have been ignoring the complexity of the environmental and socio-economic crisis posed by marine and riverine litter for far too long. However, there is still time to apply collective and comprehensive solutions. While proper waste management and wastewater treatment facilities are important for achieving good water quality in natural water bodies, they are insufficient. Each country has unique characteristics and economic conditions, which are reflected in the way they handle their waste. Every little piece of floating plastic in mid-oceanic garbage patches begins its journey as a piece of household or industrial waste that was mistreated and found its way into the environment, usually through rivers. The challenge posed by transboundary riverine litter pollution is complex and requires a comprehensive solution. This includes harmonised actions, standardised measurements, modern waste management techniques, and awareness-raising efforts, which should be carried out on a transboundary basis. It is essential to keep in mind that the most effective approach is to prioritise prevention by reducing waste generation and preventing the pollution of natural water bodies.

From single-use plastics (SUP) to legacy pollution: stranded riverine litter overgrown by vegetation and covered with layers of sediment. Tisza River near Zsurk, Photo: Gergely Hankó

[1] Tid(y)Up - Interreg Danube (interreg-danube.eu)

[2] Survey: National Legislative System on Surface Water Quality (interreg-danube.eu)

This document is primarily intended to:

- **provide** strategic and legislative recommendations to all levels of legislation, including the ICPDR and the European Union (EU) Strategy for the Danube Region (EUSDR);
- **offer** guidance on reducing plastic pollution based on the Project partners' extensive practical waste management experience, joint efforts, awareness-raising campaigns, and lobbying at decision makers;
- **raise awareness** among key actors about plastic litter pollution in rivers, improve cooperation among stakeholders, develop innovative tools for better water and waste management;
- **facilitate** harmonised actions of water management authorities/directorates and encourage communities and decision makers to organise transnational actions;
- **assist** non-EU members with knowledge and technology transfer to prevent major contaminations.

The target groups of this document are defined by the Quadruple Helix model approach and include policymakers, civil society, business/entrepreneurs, and academic circles. These include representatives of national and regional bodies and authorities responsible for environmental issues, particularly water quality and waste management in the countries concerned, waste collection and treatment service providers, municipalities, companies and chambers of commerce, educational institutions ranging from kindergartens to universities, as well as public and non-governmental organisations.

Part A

Context

1.Scope

1.1. Rationale and objectives

In the EU, the Water Framework Directive (WFD) sets out a comprehensive approach to water management based on the principles of integrated river basin management and the precautionary principle[3]. Its ultimate goal is to ensure that all water bodies, including rivers, lakes, groundwater and coastal waters, achieve good ecological status by 2027 the latest. The WFD requires member states to adopt river basin management plans (RBMPs) for each river basin district, which include measures to improve water quality and reduce pollution. The RBMPs must be reviewed and updated every six years and must be based on extensive public consultation and stakeholder involvement. The WFD also requires member states to establish programmes of measures to implement the RBMPs and to monitor and report on the ecological status of water bodies.

The DRB District is one of the largest in Europe, covering an area of over 800,000 km^2, and it is home to 79 million people[4]. The WFD has played a significant role in improving the water quality of the Danube and its tributaries through various measures, such as the reduction of point source pollution from industrial and municipal wastewater, the promotion of sustainable agriculture practices, and the reduction of diffuse pollution from urban runoff and agricultural sources. However, challenges still remain, particularly in the area of non-point source pollution from litter and microplastics. The Project, and the resulting recommendations, aim to address this issue and support the implementation of the WFD in the DRB.

The overview of the Danube River Basin (DRB). Source: ICPDR

[3] The EU Water Framework Directive - integrated river basin management for Europe

[4] https://www.icpdr.org/main/publications/danube-river-basin-management-plan-drbmp-update-2021

The importance of countries working together to manage river basins and ensure the protection and sustainable use of water resources has long been recognised as crucial. In 1994, the need for cooperation was formalised with the signing of the Danube River Protection Convention (DRPC), which established the International Commission for the Protection of the Danube River (ICPDR) as its implementing body. The ICPDR comprises 14 co-operating states[5] along with the European Union (EU) and holds responsibility for the management of the entire Danube River Basin (DRB), including its tributaries and groundwater resources. The signing of the DRPC signifies the commitment of participating countries to collaborate on practices promoting sustainable water management, including pollution reduction. In February 2022, during the ICPDR Ministerial Meeting, participants reaffirmed their commitment to these objectives by endorsing the **Danube Declaration**[6]. This declaration not only reinforces the importance of international cooperation, but also underscores the political commitment and urgency of prioritising sustainable water management practices to protect the DRB and its invaluable resources.

In response, the ICPDR countries, including non-EU member states, collectively committed to implementing the Water Framework Directive (WFD) across the entire DRB, with the ICPDR serving as its coordinating body. To effectively work towards these objectives, the ICPDR developed its first **DRB Management Plan** (DRBMP) in 2009, subsequently updating it in 2015 and 2021. However, to translate this general strategic plan into actionable measures that can address local-scale challenges, each participating country is tasked with developing a more specific and detailed plan at the national level, known as national **River Basin Management Plans** (RBMPs). In addition to this framework, there exists a **European Union Strategy for the Danube Region** (EUSDR), a macro-regional strategy adopted by the European Commission (EC) in December 2010 and endorsed by the European Council in 2011. Collectively developed by the EC, Danube Region countries, and stakeholders, the EUSDR addresses and tackles shared challenges. Its primary aim is to foster synergies and coordination among existing policies and initiatives throughout the Danube Region.

Section 2.1.9.3 of the DRBMP Update 2021 highlights the critical state of plastic pollution, given the recurring occurrences of aquatic plastic – often termed plastic floods – and other forms of riverine litter entering the Danube from upstream countries, including from non-EU Ukraine. This pollution typically manifests as visible floating plastic bottles, categorized as riverine macroplastics. However, the menace further extends , encompassing microplastics that pose a significant threat to the balance and overall health of freshwater ecosystems, further adding to the spectrum of plastic-induced harm.

Unfortunately, most Danube countries are failing to address the issue of riverine litter pollution, including macro- and microplastic pollution, in its entirety. Typically, national strategies for waste or water management only partially address this environmental challenge. The Project consortium[7] initially set out to reduce plastic pollution along the Tisza River, recognized as one of Europe's most heavily plastic-contaminated rivers. The Project was led by the Hungarian Non-Governmental Organisation (NGO)[8]. Over the past decade, the Plastic Cup, a non-governmental environmental initiative, has performed exceptional work, cleaning up more than 900 coastal riverine litter accumulations and removing over 370 tons of riverine litter from the Tisza River Basin (TRB). It has demonstrated that over 60% of riverine litter can be recycled once properly treated. The Project partners, together with Plastic Cup volunteers, have amassed invaluable experience in large-scale transnational community river clean-up (CRC) initiatives within the Danube River Basin. They have extended the good practices developed by the Plastic Cup from the TRB to the lower DRB and actively participated in the implementation of international CRC efforts in Ukraine, Romania, Serbia, and Bulgaria.

[5] Germany, Czech Republic, Austria, Slovakia, Hungary, Slovenia, Croatia, Serbia, Montenegro, Bosnia-Herzegovina, Bulgaria, Romania, Moldova and Ukraine

[6] Danube Declaration (download)

[7] Partners: Naturefilm.hu Society (Lead partner), Hungary / Association of Environmental Enterprises (ERDF partner), Hungary / Institute of Oceanology – Bulgarian Academy of Science (ERDF partner), Bulgaria / Multisalva Association (ERDF partner), Romania / University of Life Sciences and Natural Resources, Vienna (ERDF partner), Austria / Agency for the Support of Regional Development Košice n.o. (ERDF partner), Slovakia / General Directorate of Water Management (ERDF partner), Hungary / Faculty of Technical Sciences Novi Sad (IPA partner), Serbia / For the nature- and environmental protection – PAPILIO (ENI-UA partner), Ukraine / Agency of Regional Development Cross Border Cooperation "Transcarpathia" of Zakarpatska Oblast Council (ENI-UA partner), Ukraine

[8] Plastic Cup webpage, Plastic Cup (in Hungarian: PET Kupa) is a registered and protected trademark

Lifeguards secure the TidyUp river clean-up action in Tutrakan, Bulgaria in May 2022. Photo: Attila D. Molnar

Furthermore, the Project offered continuous support for large-scale professional river clean-up (PRC) actions at four locations in two countries. In addition to river clean-up operations, special emphasis was placed on research. A comprehensive methodological study was conducted to compare different methods for monitoring microplastic particles in natural water environments. The Project partners also developed and launched a set of integrated actions and consultations, providing essential tools for relevant stakeholders. The Project partners also initiated long-term transboundary and intersectional cooperation actions to monitor and eliminate plastic pollution in rivers. That has contributed to preventing pollution in upstream countries by introducing sound waste management practices and implementing awareness-raising strategies.

The collaboration yielded significant results, including the removal of tons of targeted riverine litter, the formulation of a comprehensive handbook delineating the implementation of transnational river clean-up actions, and the creation of an educational platform with zero-waste principles, known as the Floating Exhibition (FLEX). One of the Project's major achievements was the development of this policy paper for the ICPDR, which played an important role as an associated partner. Drawing from the extensive experience of the Project partners in the practical aspects of river clean-ups, the management of retrieved riverine litter, the coordination of collaborative efforts, the implementation of awareness-raising campaigns, and the advocacy with state level decision-makers, this paper offers guidance on mitigating plastic pollution. This collaborative effort between the Project and the ICPDR makes a significant contribution to the ongoing efforts to address and combat plastic pollution in the DRB.

Comparative survey showcasing the most prominent methods used to monitor microplastic particles in the water column. From left to right: pump method, drift or manta net, sedimentation box. Photo: Tid(y)Up

1.2. Interconnected challenges of the Water Sector: a multisectoral approach

In late 2021, the Project partnership conducted a comprehensive assessment of the partner countries' legislative systems aimed at preserving the good quality of surface water bodies. The study examined both the international and the national legal frameworks governing **environmental protection rules** and the region's water and waste management regulations and practices. The primary goal was to gain a deeper understanding of the complexity of riverine litter pollution in the DRB and address recurring plastic flood events. The assessment focused on evaluating the relevant legal frameworks of the Project partner countries and the international legislation of the Danube region, highlighting potential inefficiencies in regulatory practices and underscore the most critical country-specific circumstances.

The overall assessment revealed a striking contrast. While partner countries all had well-defined environmental regulations related to natural waterways, – sometimes even at constitutional level – the enforcement is generally weak. Although sustainability, the protection of natural resources, and the natural heritage of future generations are often expressed as objectives, they are rarely put into practice. These goals currently do not take precedence over competing laws, and the rights and interests of future generations are not always considered directly by public authorities' decisions or judicial rulings. In some cases, deficiencies in enforcement structures and the lack of coordination between executive bodies even hinder proper law enforcement. Despite the EU's advanced and comprehensive environmental and sustainability-related legislation, achieving its objectives is sometimes obstructed by the lack of effective enforcement. Recognizing that public authorities alone cannot address these challenges, the involvement of active citizens and civil society organisations was identified as crucial to supporting public authorities in their work and achieving the desired goals.

Throughout the implementation of the WFD, partner countries introduced new integrated, ecosystem-based **water management plans, known as RBMPs**. These plans also addressed the protection of water resources as well as the improvement and sustainable use of freshwater. The first RBMPs were published between late 2009 and mid-2010, outlining a series of measures required to achieve good ecological and chemical status in water bodies at risk of failing to meet these targets. It is important to note that progress in implementing the WFD undergoes review every six years, with the next planning cycle scheduled for 2027. In addition to assessing environmental protection and water management aspects, the study also assessed **waste management** regulations in partner countries. It provided insights into the main aspects of industrial and municipal waste collection systems, along with the problem of illegal deposition of household and industrial waste, as well as legal sanctions against polluting activities. While some countries have adopted precautionary and sustainability principles such as the **Extended Producer Responsibility** (EPR), there is still an urgent need for a transition towards a circular economy. Despite the introduction of EPR, which has increased the demand for recyclable packaging materials, waste landfill rates remain persistently high, with the exception of Austria. Furthermore, the problem of illegal or untreated waste disposal continues to be prevalent in almost all partner countries. Notably, this issue was particularly relevant in Ukraine, Serbia and Romania, where challenges related to the illegal deposition of household waste along riverbanks is especially acute.

Coastal landfills serve as high-risk leakage points, where dissolved and solid waste can contribute to transnational riverine pollution. Rakhiv, Transcarpathia, Ukraine. Photo: Plastic Cup

Effective **transnational cooperation** is essential to address the issue of riverine litter pollution. Although there have been improvements in bilateral and multilateral agreements since 2020, only a small fraction of these agreements deal with the issue comprehensively. The increasing amount of mismanaged waste, especially

plastics, in natural waterways results in substantial costs for waste collection and disposal. Unfortunately, the expenses incurred in mitigation efforts are rarely compensated by the country of origin or the receiver, leaving the water management authorities to bear the financial load. In most countries, water management authorities lack allocated budgets to respond effectively. Hungary stands out as the exception, having a designated financial allocation for water quality remediation and investments since 2019. This allocation has made a significant difference in water protection, triggering new innovations and cooperation in this area.

The **Danube Declaration** represents a crucial international development towards achieving sustainability goals in the DRB through integrated water management. By recognising plastic pollution as a distinct category of surface water pollutants, this declaration commits to maintaining existing measures and implementing additional actions to prevent and reduce waste. ICPDR is actively working towards developing policy recommendations on riverine litter pollution for implementation at the national level. This effort thereby contributes to establish an enabling regulatory framework for pollution control. Transnational cooperation is pivotal in this process, and the ICPDR is committed to supporting and enhancing the Danube Transnational Monitoring Network (TNMN)[9] and the Danube Accident Emergency Warning System (AEWS)[10] along with other relevant assessment tools. These key technical instruments play a crucial role in protecting water quality in the region.

One notable example of successful cooperation in the region is the common hydrographic telemetry system of the Hungarian Upper Tisza District Water Directorate and the Ukrainian Transcarpathian Water Management Directorate. This cooperative effort, established in 2003, has enabled partners to share instantaneous measurements and archived datasets. With 152 stations, 104 in Hungary and 48 in Ukraine, the system stands as an exemplary model of effective collaboration. It is important to highlight that this successful example of cooperation between Ukraine and Hungary primarily focuses on flood alert and contributes significantly to flood management. However, when it comes to addressing transnational riverine litter pollution, instances of best practices remain relatively scarce, despite the evident connection between flood events and plastic floods. For an in-depth description of plastic floods in the DRB, please refer to chapter 2.2. below. While there are several examples of collaboration between the water and waste management sectors, there is a pressing need to promote industrial symbiosis between water organisations and waste management companies. Additionally, emphasis and support should be placed on fostering cooperation between NGOs, civil society organisations, and government bodies. However, it is essential to recognize that in some of the surveyed countries, civil society is still in the developmental stages and may have limited influence in decision-making processes.

1.3. Policy context and related drivers

1.3.1. Global efforts

On 2 March 2022, a historic resolution was endorsed by representatives from 175 nations during the United Nations (UN) Environment Assembly in Nairobi. This resolution marked the establishment of an Intergovernmental Negotiating Committee (INC)[11] with a compelling mission: to finalize a **legally binding agreement** by the end of 2024 to end plastic pollution. The scope of this agreement encompasses the entire lifecycle of plastics, including the design of reusable and recyclable products and materials, as well as the imperative for enhanced international collaboration. Open-ended working groups have been organised to engage stakeholders impacted by the proposed international instrument, and their input will help to ensure a faster practical implementation of the measures. During the final review of this policy paper, the UN Environment Programme (UNEP) issued a roadmap that outlines solutions to curtail global plastic pollution. This UNEP-endorsed system change scenario, developed by a team of renowned experts and scientists, holds a particular significance in the context of global efforts to reduce plastic pollution in natural water bodies, including seas, oceans, lakes, and rivers.[12]

[9] TNMN - TransNational Monitoring Network | ICPDR - International Commission for the Protection of the Danube River
[10] AEWS - Accident Emergency Warning System | ICPDR - International Commission for the Protection of the Danube River
[11] https://www.unep.org/about-un-environment/inc-plastic-pollution
[12] https://www.unep.org/resources/turning-off-tap-end-plastic-pollution-create-circular-economy

The Global Commitment 2022[13], led by the Ellen MacArthur Foundation in collaboration with UNEP, has rallied over 500 organisations around a shared vision of a circular economy for plastics. These organisations, representing 20% of total plastic packaging production, have pledged to pursue ambitious targets for 2025, aimed at tackling plastic pollution at its source. The Global Commitment serves as an excellent example of how collective action and collaboration can yield concrete solutions to a pressing environmental concern.

Furthermore, the Ocean Literacy[14] programme, initially established in the United States in 2002, has primarily focused on the development of education resources, lesson plans, and activities in the areas of Science, Technology, Engineering, and Mathematics (STEM). However, with the adoption of UN Sustainable Development Goal 14, there has been a notable shift towards incorporating approaches more closely aligned with the UN Educational, Scientific and Cultural Organization (UNESCO) framework for Education for Sustainable Development. This evolved approach recognises the critical importance of engaging learners in acquiring the knowledge, skills, and values necessary for contributing to sustainable development. It places great emphasis on social, economic, and environmental sustainability. This shift in focus acknowledges the interdependence between human activities and the health of our oceans, emphasizing the need for a holistic approach to ocean literacy education that fosters critical thinking, problem-solving, and actionable engagement towards a more sustainable future.

1.3.2. EU-level efforts

In the area of environmental sustainability, the **European Green Deal**[15] stands as a comprehensive plan to make Europe the first carbon-neutral continent by 2030, while addressing the issue of environmental degradation. Among its key priorities are the reduction of water pollution, the transition to a circular economy, and the improvement of waste management practices. To support the EU Green Deal, several funding mechanisms are already in place, with the ambitious objective of mobilizing over €1 trillion in investments over the next decade. In protecting European citizens and ecosystems from various forms of water pollution, the EU recognises the need to improve its prevention, monitoring, and reporting practices, as well as rehabilitation efforts for contaminated natural habitats. A more systematic approach is needed to achieve the ambitious targets set out in detailed legislation, regulations, and actions. To coordinate these efforts, the **Zero Pollution Action Plan**[16] for air, water, and soil was adopted in 2021.

A key aspect of the EU Green Deal is moving beyond the end-of-pipe approach and focusing on prevention. Sustainable processes inherently generate less waste, necessitating direct investment by companies, states, and the EU into sustainable projects and activities. To achieve this vision, there is a need for a common language and clear definition of what constitutes "sustainable" in practical terms. The **EU Taxonomy**[17] was developed to create a level playing field for stakeholders and provide a classification system for environmentally sustainable activities. The EC has created lists of environmentally sustainable activities by defining technical screening criteria for each environmental objective through delegated acts. The Taxonomy can play a crucial role in redirecting investments towards sustainability and help implement the European Green Deal. In conjunction with the Taxonomy, the EC has also proposed the new **Corporate Social Responsibility Directive**[18] (CSRD), which will establish a new sustainability reporting framework starting from 2023. This will replace the Non-Financial Reporting Directive (NFRD), offering an additional driving force in the transition towards a green economy by providing a means of making sustainable efforts comparable and transparent.

The **Waste Framework Directive**[19] (2008/98/EC) serves as a legal instrument establishing fundamental concepts and definitions related to waste management. It sets out essential waste management principles and introduces the Polluter Pays Principle and the EPR, which

[12] https://www.unep.org/resources/turning-off-tap-end-plastic-pollution-create-circular-economy

[13] https://ellenmacarthurfoundation.org/global-commitment-2022/overview

[14] Ocean literacy for all: a toolkit https://unesdoc.unesco.org/ark:/48223/pf0000260721

[15] The European Green Deal, presented by the Commission on 11 December 2019

[16] On 12 May 2021, the European Commission adopted the EU Action Plan: "Towards a Zero Pollution for Air, Water and Soil"

[17] Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088

[18] In April 2021, by the European Parliament and the Council (press release)

[19] Waste Framework Directive (europa.eu)

hold polluters and producers financially accountable for end-of-life products, including plastics, across Europe.

As part of the EU's circular economy action plan[20], the **European Plastic Strategy**[21] builds upon existing measures to reduce plastic waste, contributing to the objectives of the 2030 Sustainable Development Goals and the Paris Climate Agreement. The Plastic Strategy aims to transform the design, production, use, and recycling of plastic products in the EU, setting a target for all plastic packaging to be recyclable by 2030. The **Directive on single-use plastics**[22] (SUP) represents a groundbreaking regulation towards reducing the volume and impact of plastic products. It is one-of-a-kind, since it tackles the root causes of the problem by banning specific products from the EU markets where sustainable alternatives are available and affordable. These banned products include items like cotton bud sticks, cutlery, plates, straws, stirrers, bars for balloons, cups, certain food and beverage containers made of expanded polystyrene (PS), and all products made of oxo-degradable plastic. These measures aim to achieve a measurable quantitative reduction by 2026 compared to 2022 through national consumption reduction targets, promotion of reusable alternatives, and marketing restrictions. Member states must notify the EU of their measures and report on their compliance[23].

For other SUP products, the EU focusses on reducing consumption through awareness-raising, design and labelling requirements, information on plastic content and environmental harm, and introducing EPR schemes. The EC has issued a **Guideline**[24] (31 May 2021) to facilitate the directive's implementation in national law, and a **Commission Implementing Decision**[25] was issued in 2022 on the calculation, verification, and reporting of reduction in the consumption of specific SUPs and the measures taken by member states to achieve such reduction. Since 1 January 2023, all SUP food containers must be purchased ("no free lunch"). While some loopholes have been identified,[26] conducted in September 2022, found that a large majority of EU member states are now on track to implement the SUP[27] for recycled material content concerning producers of plastic packaging. These targets will create a real market for secondary materials, significantly increase the need for such high-quality recyclates, decrease the need for primary raw materials, and encourage the use of secondary, circular raw materials.

The EC has also released a communication[28] underscoring the importance of making sustainable products the norm. This communication highlights the proposed Ecodesign for Sustainable Products Regulation (ESPR), which is set to establish a comprehensive framework for defining ecodesign and information requirements specific to various product categories. The ESPR aims at achieving significant improvements in product circularity, energy performance, and other dimensions of the environmental performance of products. It represents a pivotal step in advancing the circular economy and promoting more eco-friendly product designs. Although the upcoming **Digital Product Passport**[29] regulation in the EU does not specifically target plastics and packaging as separate products, it still carries a significant impact for customers who become acquainted with the true environmental impact of their purchase. This regulatory approach seeks to incentivise more sustainable product designs while offering immense substantial educational opportunities for consumers. By providing reliable data on the environmental impact of their purchases, it has the potential to raise awareness and empower consumers to make environmentally conscious choices. The adoption of the **Plastic Bags Directive**[30] serves as another vital instrument in the EU's efforts to combat plastic pollution. It addresses the

[20] Circular economy action plan (europa.eu)

[21] Eu plastic strategy (europa.eu)

[22] Directive (EU) 2019/904 of the European Parliament and of the Council on the reduction of the impact of certain plastic products on the environment (5 June 2019)

[23] Some MS opt for levies on single-use cups, such as Ireland with its planned "Latte levy", others, like Germany for example, want to promote reusable containers and initiatives for deposit-based to-go-systems. Belgium is discussing to ban single-use cups and food packaging altogether in 2022.

[24] Commission guidelines on single-use plastic products in accordance with Directive (EU) 2019/904 of the European Parliament and of the Council on the reduction of the impact of certain plastic products on the environment

[25] 24 2019/904 of the European Parliament and of the Council as regards the calculation, verification and reporting on the reduction in the consumption of certain single-use plastic products and the measures taken by Member States to achieve such reduction

[26] https://rethinkplasticalliance.eu/wp-content/uploads/2022/09/SUP-Implemetation-Assessment-Report.pdf

[27] https://www.euractiv.com/section/energy-environment/news/eu-set-to-adopt-mandatory-recycled-content-targets-in-new-packaging-law/

[28] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0140&qid=1649112555090

[29] https://hadea.ec.europa.eu/calls-proposals/digital-product-passport_en

[30] Directive (EU) 2015/720 of the European Parliament and of the Council of 29 April 2015 amending Directive 94/62/EC as regards reducing the consumption of lightweight plastic carrier bags

unsustainable consumption rates of lightweight plastic carrier bags, which rank among Europe's top ten littered items. Member states are required to implement measures, including setting national reduction targets, introducing economic instruments (e.g. fees, taxes), and enforcing marketing restrictions, including bans. These measures must be proportionate and non-discriminatory, to ensure that the annual consumption level of lightweight plastic carrier bags does not exceed 40 per person by the end of 2025. Since 31 December 2018, lightweight plastic carrier bags are only permitted to be provided for a fee at the point of sale.

While legislation tends to lag behind production and pollution, measures are being prepared to address the increasing release of microplastic particles into natural water bodies and other habitats[31]. The EC is announcing new initiatives to address the unintentional release of microplastics in the environment, such as developing labelling, standardisation, certification, and regulatory measures, delivering harmonised data on microplastics concentrations in seawater, and closing gaps in scientific knowledge related to the risk and presence of microplastics in the environment, drinking water, and food[32].

Filtering has become a leading challenge in the home appliance industry in response to microplastic pollution. APPLiA (Home Appliance Europe) is actively contributing to the generation of reliable scientific data to help understand the scope of microplastic release in the environment, which is not exclusively attributed to packaging materials. Their work includes a literature review on "Microplastics emissions from textile laundry including emission scenarios for the EU.[33]" Additionally, a **Consortium[34]** of affected companies is exploring possible solutions, such as developing systems to filter microplastics from wastewater generated by laundry machines. These innovations are currently undergoing testing. Furthermore, the Priority Area 4 (Water Quality) of the EUSDR, operating under the coordination of Hungary and Slovakia, aims to encourage the monitoring, prevention, and reduction of water pollution caused by hazardous and emerging substances. This group of materials includes microplastics, emphasising the importance of taking action against their release.

The Ocean **Literacy Framework[35],** originally developed for use in the United States, has had a global impact, inspiring numerous efforts to promote ocean literacy across the world. These initiatives include conferences and meetings in countries such as, Portugal, Japan, Belgium, Chile, Australia, Fiji, and Italy. Organisations such as the European Marine Science Educators Association have also committed to promoting ocean literacy. The EC has recognised the importance of ocean literacy and has funded two Horizon projects – Sea Change and ResponSEAble – to raise awareness and enhance understanding of marine environments throughout Europe. These efforts align with the EU's Action Plan to protect and restore marine ecosystems, which includes the elaboration of Marine Litter Action Plans in regions, such as the Mediterranean, the Black Sea, and the Baltic Sea[36].

1.3.3. Country-level efforts

It is a pressing matter for **all EU countries** to implement the following regulations: a comprehensive and consistent curriculum to raise awareness about reducing consumption, preferably integrated into the national education system and plan; an EPR system; a deposit-refund system (although this is already being introduced in several member states, particularly for single-use beverage containers); reuse and refill systems; and separated waste (and wastewater) collection from ships in harbours.

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[31] Specific laws with partial objectives: Marine Strategy Framework Directive, Fertilising Products Regulation, REACH restriction proposal – which addresses intentionally added microplastics. Unintentionally formed microplastics fall outside of the scope of the new initiative and are addressed by the Plastics strategy, Waste Framework Directive, Marine Strategy Framework Directive, and EU Drinking Water Directive. Several EU laws affect the production of microplastics, or their release into the environment, both directly and indirectly, e.g. Ecodesign Directive, Waste Framework Directive, Urban Waste Water Treatment Directive, Directive on air quality, Industrial Emissions Directive

[32] https://environment.ec.europa.eu/topics/plastics/microplastics_en

[33] https://www.applia-europe.eu/images/studies/2020-10-28_APPLiA-RISE_Literature_Review_Final_for_release-3.pdf

[34] https://www.applia-europe.eu/images/studies/2023-03-24_Consortium_final_report_for_webpage_Approved.pdf

[35] https://oceanliteracy.unesco.org/?post-types=all&sort=popular

[36] https://helcom.fi/action-areas/marine-litter-and-noise/marine-litter/marine-litter-action-plan/

In **Slovakia**, Act no. 302/2019 Coll. Disposable Beverage Packaging came into force on 1 January 2022. It addresses the collection of disposable packaging for beverages and handling the waste from those packages (including cans). The deposit amount is consistent for Polyethylene terephthalate (PET) bottles and cans, 15 euro cents, which may be a sufficient incentive to prevent the littering of PET bottles. In the first ten months, this system performed well above expectations, with a collection rate of approximately 67%, instead of the originally planned 60% for the first year. The long-term goal is to recycle and reuse 90% of beverage packaging sold by 2025[37].

In **Austria**, a ban on plastic bags has been in effect since 2020, and the separate collection of plastics has been standardised since 1 January 2023, with the aim of recycling more plastic waste. In addition to plastic bottles, food packaging is now collected separately throughout the country. A deposit fee system for aluminium cans and plastic bottles will be introduced from 2025, with the deposit fee reimbursed upon return to the same shop where the product would have been purchased. An exception is made for packaging of dairy products and drinks for hygiene reasons.

Hungary has adopted legislation to phase out SUP and banned several SUP products and packaging materials from 1 July 2021, in line with EU legislation. Thanks to Greenpeace Hungary's campaign, supported by a quarter of a million people, the Hungarian law also includes a restriction on the use of plastic bags. Furthermore, the Hungarian government will introduce DRS in 2024. In Bulgaria, lightweight plastic carrier bags with less than 25-micron-thick walls are prohibited from being placed on the market.

In **Romania**, a monetary deposit system for plastic, aluminium, and glass was introduced by the Governmental Decision 1074/2021 regarding the establishment of the guarantee-return system (GRS) for non-reusable primary packaging. According to the decision, consumers will pay an extra fee for these products, which could be reimbursed if the packaging is returned. Starting from 30 November 2023, the GRS, unique at the national level, has been mandatory for all producers and traders under the terms of the decision. The decision applies both to products manufactured in Romania and to those imported or purchased intra-community, including regarding the possibility of effective participation of economic operators in the functioning of the system and the tariffs imposed on them by the GRS administrator.

Also, from 2021, the 9 product categories mentioned by Directive 904/2019 regarding the reduction of the impact of certain plastic products on the environment were banned. Economic operators who introduce drinking glasses and food containers to the national market are obliged to progressively reduce the introduced quantities (from 5% for the year 2023 to 20% for the year 2026, compared to the year 2022).

A procedure for registering with the Environment Fund Administration will be approved for the economic operators that introduce sustainable reusable alternatives to the national market or that replace the SUP and PET bottles with plastic-free alternatives, including those that introduce recycled plastic to the market to be incorporated into PET bottles.

1.3.4. Non-EU member states

Non-EU countries, such as Serbia, Montenegro, Bosnia-Herzegovina, and **Ukraine** contribute significantly to the riverine litter pollution load of the DRB, and ultimately, the Black Sea. The source of the Tisza River, the longest, heavily polluted tributary of the Danube River, lies in Transcarpathia, the westernmost region of Ukraine. The natural conditions of this area make it challenging to develop and maintain appropriate waste management systems. A wide variety of factors, such as economic and geographical constraints, hinder the collection, transportation, and disposal of waste. Consequently, waste collection and processing measures have never met European standards, further deteriorating river ecosystem services along the lower DRB. Moreover, the conditions under which waste is disposed of are far below European standards. In villages, people still dispose of garbage however they can, which typically involves burning, burying, or dumping it in a floodplain forest.

[37] https://sensoneo.com/drs-slovakia-sensoneo-rwm/

Addressing this complex environmental problem requires a better understanding of the situation. Not only does the waste management system require an overall survey, but also the distribution and quantity of mistreated and illegally deposited waste should be monitored both on a temporal and a spatial scale. For instance, data collected by the volunteers of the Plastic Cup initiative suggests that waste collection and transportation are non-existent in about 196 municipalities, which translates to a minimum of 10,000 tonnes of untreated waste per year in addition to the above figures. However, this only covers a fraction of the sources of waste pollution.

Tid(y)Up partner PAPILIO's field coordinator standing on a macroplastic accumulation in April 2022 in Ukraine on river Latorice, tributary of the Tisza. The organic waste (driftwood) is mixed with a lot of inorganic waste (plastics, metal, glass). Photo: Papilio, Ukraine

Typical hotspot site in Ukraine, Transcarpathia. Along the shores of the Black Tisza, there are hundreds of places in similar condition where the household waste gets released into the environment. Photo: Plastic Cup

The Russian invasion of Ukraine has made an already dire situation worse in the region. Waste management companies are struggling more than ever, with the added challenge of dealing with an influx of refugees. The population of Transcarpathia has increased by around 25%, and the war economy has further depleted the resources of the state, the local administrations, and the residents. Although economic activity has increased due to the region's distance from the war zone, power outages, energy crises, and the uncertain operation of large waste processors have hindered waste collection and processing capacities. As a result, the amount of riverine waste coming from Ukraine is **expected to increase**. However, various projects initiated by the Plastic Cup in 2022 and onwards will help to collect an additional 700 tonnes of waste per year, resulting in 700 fewer tonnes of waste being dumped in rivers or burnt into toxic smoke, diverted from the natural environment back to the circular economy.

Small scale preventive measures – like the EcoBus application – help to redirect the flow of waste away from the river. Uzhhorod, Transcarpathia, Ukraine. Photo: Ruslan Shvarts

Riverine litter pollution is a global issue that transcends national boundaries, affecting ecosystems and communities across borders. Recognising the transnational nature of the problem, Ukraine has taken steps to address it, including the development of the Transcarpathian Waste Management Strategy 2030, which was supported by the Ministry of Foreign Affairs and Trade of Hungary in 2019[38]. Despite facing significant challenges, Ukraine has shown a commitment to aligning with European legislation and regulations. For instance, during the **all-Ukrainian forum Ukraine 30. Ecology**, the president signed the Law on Restricting the Circulation of Plastic Bags on the Territory of Ukraine № 1489-IX, which prohibits the sale of plastic bags in shops, pharmacies, catering, and service outlets. The ban on using thin, oxo-decomposable, and ultra-thin plastic bags was also enacted in March 2022, and from 1 January 2023 only biodegradable packages should be used in Ukraine. While the legislative framework is moving in the right direction, implementation remains a challenge, particularly given the ongoing war efforts. The success of these directives and legislative steps depends on the government's ability to allocate sufficient resources and prioritise waste management initiatives despite competing demands. Nonetheless, such initiatives offer a glimmer of hope in the face of an urgent and complex environmental issue.

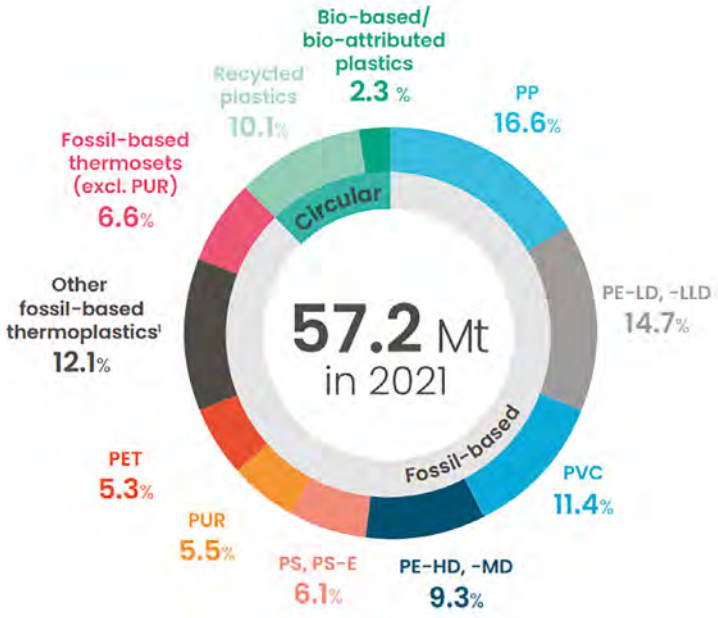
[38] Waste management plan in Zakarpattia Oblast until 2030 | EGTC-monitor (cesci-net.eu)

2. Plastic pollution in the rivers of the DRB

2.1. Plastic production and its environmental impacts

Global plastic production has continued to rise after a short stagnation due to the COVID pandemic and exceeded 390 million tonnes in 2021, with no signs of slowing down. The EU (and the other three EFTA member states on the continent) alone produced more than 57 million tonnes of plastic in the same year. Shockingly, over 40% of the plastic used in the EU is packaging material, which typically has a short lifespan. Plastic bottles make up a significant portion of this packaging waste, with a staggering one million sold worldwide every minute.

On a global scale, packaging is the largest consumer of plastic, followed by the building and construction sector, and then the textile industry. Besides the same two leading end-users of plastics, the third largest market is the automotive industry in the EU, and the fourth is the producers of different electronics and electrical equipment. These sectors together consume around three-fourths of all plastic products. Despite the high levels of plastic consumption, only 14.5 million tonnes of post-consumer plastic waste were collected separately in the EU in 2020[39], highlighting the need for more effective recycling and waste management practices.



European plastic production by type (2021)
Source: Plastics - the Facts 2022 • Plastics Europe[39]

The packaging sector has a pivotal role to play in boosting the recycling rates of the EU member states. This industry is mostly using polyethylene (PE, both high and low density), polypropylene (PP), and PET, covering altogether almost 40% of the overall plastic consumption in the EU. These products have the shortest lifespan and account for the largest amount of waste (both in bulk and in mass) from the aforementioned industries, but they also have the largest potential to be collected and cleaned easily before recycling (see Chapter 4 – Recommendations).

The best product longevity is a characteristic of the building and construction sector. It has special requirements (especially durability and strength) for the plastics it uses. Since the plastics from buildings today are often 30–50 years old, they contain substances that are no longer permitted, which can entail additional problems. This also means that the new plastic products we use today have to be designed to be recyclable in 30–50 years' time. The most commonly used plastic is polyvinyl chloride (PVC), accounting for 43% of plastic used in the sector[40]. 69% of all PVC produced is used in the building and construction industry. Although this sector is usually known for its energy-related effects, the huge amount of generated waste, and the low amount of recycling makes it an important actor also in the field of plastic waste management.

[39] Plastics - the Facts 2022 • Plastics Europe
[40] Plastics, the circular economy and Europe's environment — A priority for action (EEA)

The automotive industry and the electronics usually use more unique plastics beside the well-known PP or Polyurethane. The multiple industrial requirements, from safety to durability, from quality assurance to costumer demands, result in a variety of plastic materials and additives. These sophisticated components of a unit or device complicate the recycling process.

It is desirable to improve the durability and increase the proportion of secondary raw materials, reducing the number of material types. But two key components, necessary for the automotive industry to take those measures, are enhancing consumer awareness and shifting their expectations regarding these kinds of products.

The Directive on end-of-life vehicles (ELV)[41] in the EU (ELV Directive) and the Directive on the type-approval of motor vehicles with regard to their reusability, recyclability and recoverability[42] (RRR Directive) set clear targets for ELV and their components within the concept of EPR. Motor vehicles that have reached the end of their useful lives create between 8 and 9 million tonnes of waste in the EU annually[43]. (A typical car contains around 20% of plastic.) These directives, among others, set requirements for choosing product codes and/or distributing information on parts and components, ensuring the availability of information for consumers and treatment organisations. This practice furthers achieving reuse, recycling and recovery performance targets, preventing and limiting waste from ELV and their components while improving the environmental performance of all economic operators involved in the life cycle of vehicles.

The textile industry in the EU was not considered in the former sections, due to methodological reasons[39]. However, rough estimates can be made[44]: in 2017, European households consumed about 13 million tonnes of textile products – clothing, footwear, and household textiles. Synthetic fibres, such as polyester and nylon (PA), make up about 60% of clothing and 70% of household textiles. The global trends – e.g. clothing production roughly doubled worldwide between 2000 and 2015, while the average number of wears is decreasing[45] – can also be observed in Europe. EU consumers discard about 5.8 million tonnes of textiles, of which about two thirds consist of synthetic fibres. In Europe, about one third of textile waste is collected separately, and a large part of it is exported. A minimal part is recycled into fibres.

Promoting sustainable fibre choices and control of microplastic emissions, together with improving separate collection, reuse, and recycling, have the potential to improve the sustainability and circularity of synthetic textiles in a circular economy. In the 2020 circular economy action plan, the EC identified textiles as a priority product category with significant potential for circularity. (Improved separate collection will be obligatory in all member states by 1 January 2025 due to the EU Waste Framework Directive).

Plastic products offer numerous benefits, including versatility, durability, and resource-saving capabilities. For example, plastic products can help save fuel in the transportation industry due to their light weight, reduce CO2 emissions through the use of plastic foams for thermal insulation, and help prevent food waste with the use of the excellent preservation abilities of plastic packaging. However, addressing plastic pollution requires moving away from the end-of-the-pipe approach and towards a focus on sustainable materials and eco-design. To achieve that, we need to consider environmental factors at all stages of the product development process, from the choice of basic materials to the disposal of the finished product. New developments in **Eco-Design** can help balance ecological and economic requirements, enabling the creation of products with the lowest possible environmental impact throughout their lifecycle. For example, initiatives like RecyClass work on developing scientific testing methods for innovative materials and incorporating the results into guidelines and databases, such as the Design for Recycling Guidelines and the free RecyClass Online Tool[46].

The EU's SUP Directive, which became mandatory from the beginning of July 2021, aims to implement strict regulations for numerous plastic products until 2030, thereby reducing the amount of plastic waste in the environment. However, if current trends in production and waste management persist, it is estimated that roughly 12 billion tonnes of plastic waste will be in landfills or in the natural environment by 2050.

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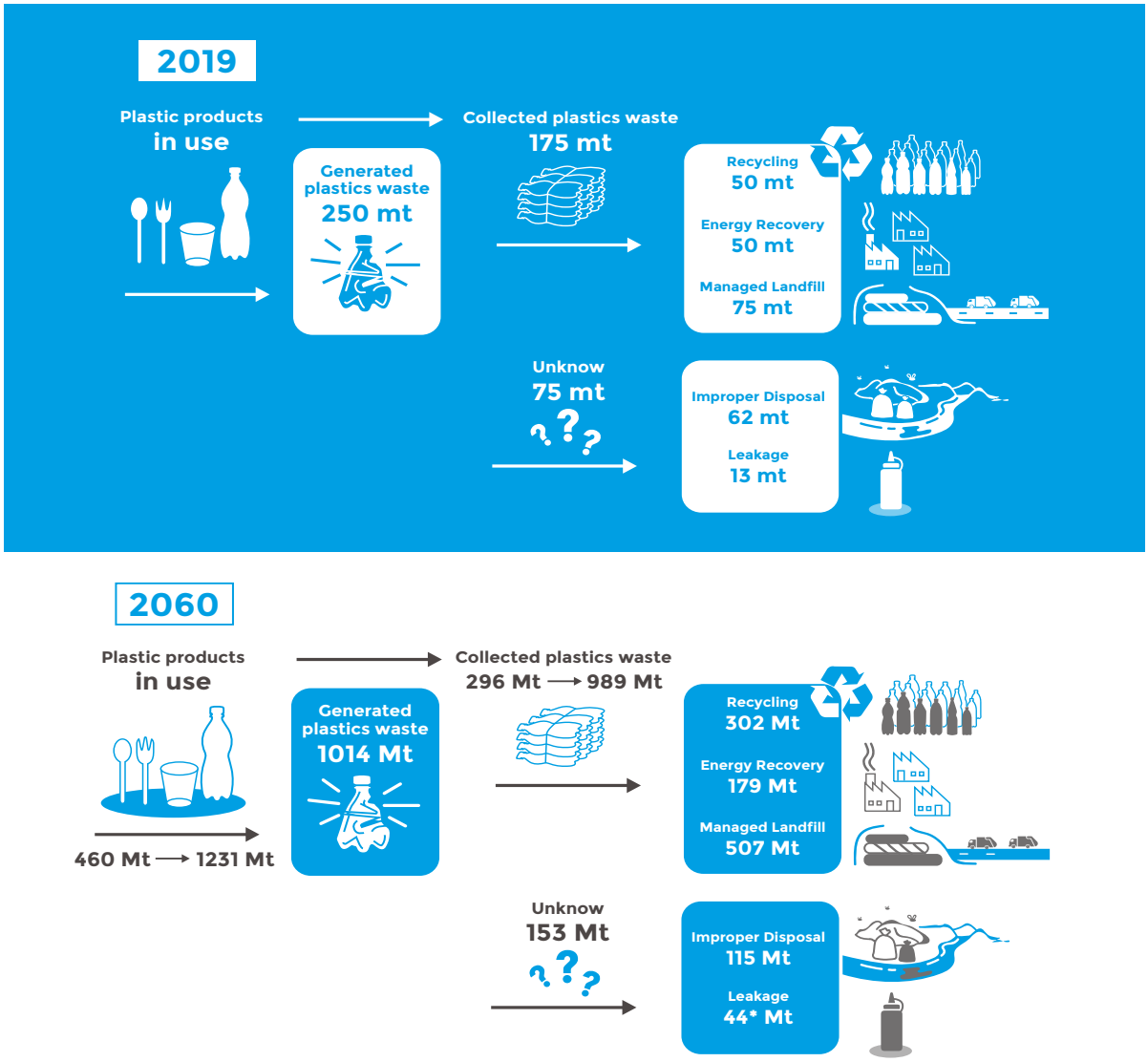
[41] EUR-Lex - 32000L0053 - EN - EUR-Lex (europa.eu): "ELV Directive"
[42] EUR-Lex - 32005L0064 - EN - EUR-Lex (europa.eu): "RRR Directive"
[43] https://en.wikipedia.org/wiki/End_of_Life_Vehicles_Directive
[44] Plastic in textiles: towards a circular economy for synthetic textiles in Europe
[45] Textile waste and recycling (in Hungarian, hard copy), by Interreg Central Europe
[46] www.recyclass.eu



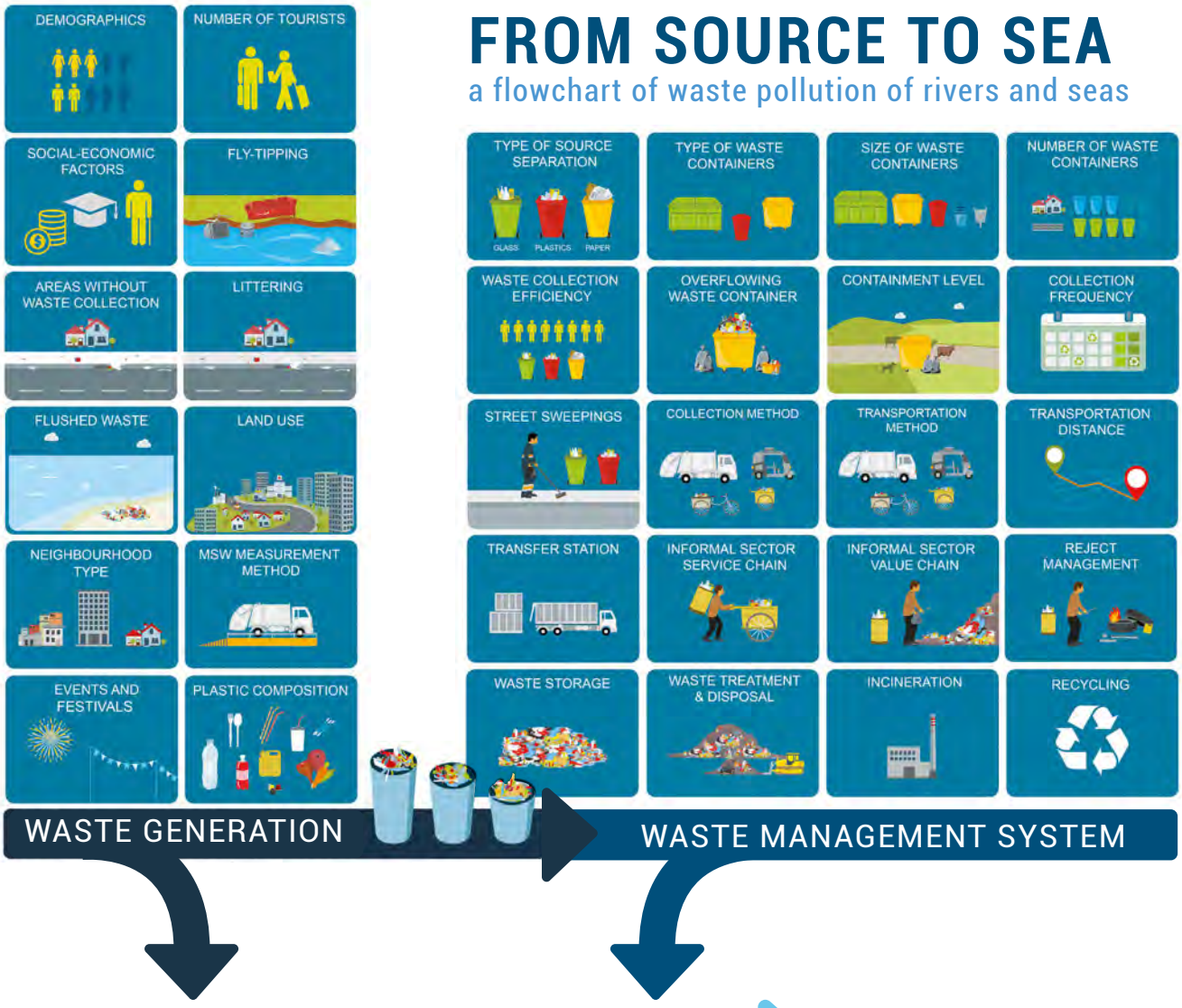
Global plastic production and the multidirectional flow of plastic waste.
Source: Projections on the amount of plastic and plastic waste based on OECD Global Plastics Outlook (Source: HAEE)

Shockingly, some projections suggest that oceans will carry more plastic mass than fish by 2050, and an estimated 99% of seabirds will have ingested plastic[47]. Despite the advanced waste management in Europe and the related ambitious recycling objectives, plastic and microplastic pollution still finds its way into the Danube and its tributaries. Even though the data are scattered and fragmented, two main forms of plastic pollution in the Danube basin have been identified. i.) Macroplastics enter natural waterways[48] through waste leakage in floodplains, caused by littering and systematic failures in the waste management industry, ii.) Microplastics, on the other hand, are released into the environment through communal and industrial activities, such as using synthetic textiles or car tires that release tiny particles into the waterways. It is worth mentioning that the two primary categories of aquatic plastic pollution, namely macroplastics and microplastics, may initially appear as distinct entities. In reality, macroplastics, once released into the environment, tend to undergo degradation processes such as photodegradation, oxidation, and abrasion. This degradation leads to the formation of secondary microplastics. However, we will continue to discuss macroplastics and microplastics in separate sections for practical reasons. A good graphical summary was made by the International Solid Waste Association (ISWA) and the University of Leeds (member of the ISWA Task Force on Marine Litter) for their Plastic Pollution Calculator (PPC)[49] tool, developed in a joint effort. This figure shows the link between solid waste sources, composition, management, and emission mechanisms, and enumerates the pathways to macroplastic pollution at a local level (cities).

[47] Wilcox, C., Van Sebille, E., & Hardesty, B. D. (2015). Threat of plastic pollution to seabirds is global, pervasive, and increasing. Proceedings of the National Academy of Sciences, 112(38), 11899-11904.
[48] Plastic Pollution of Rivers in the Danube Region published by the Ministry of Foreign Affairs and Trade of Hungary
[49] https://plasticpollution.leeds.ac.uk/home/toolkits/calculator/

FROM SOURCE TO SEA

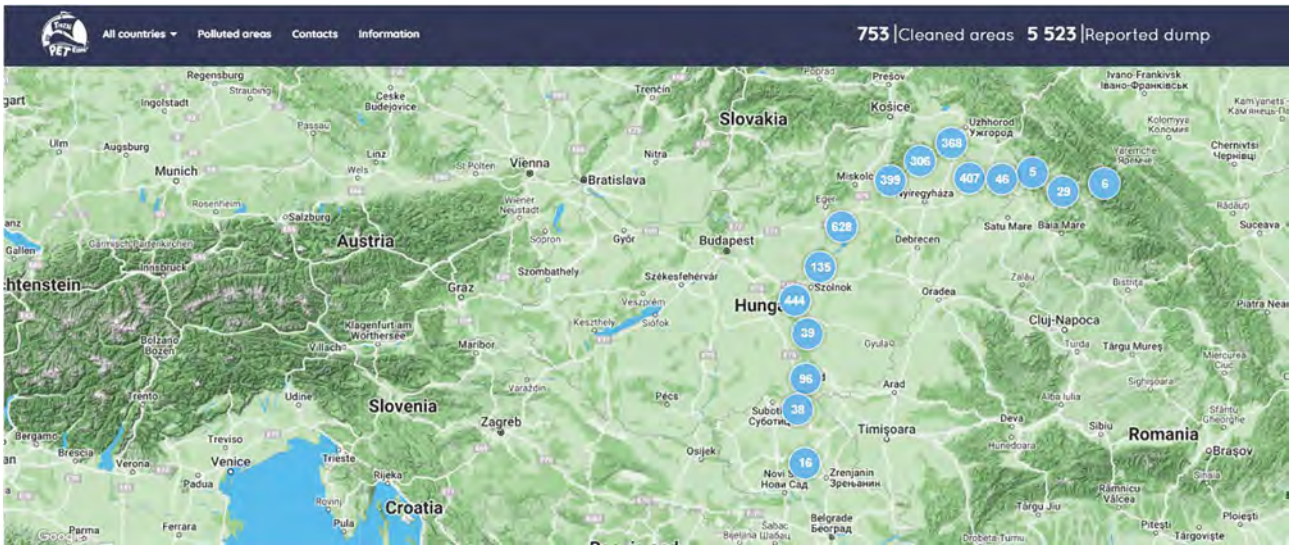
a flowchart of waste pollution of rivers and seas



Source: University of Leeds, ISWA Marine Litter Task Force: Plastic Pollution Calculator, 2019
Graphically redesigned by HAEE, 2024

2.2. Riverine Litter Pollution: macroplastics

According to research, approximately **80%** of marine litter originates from land-based sources, with rivers being the primary transporters of this pollution into our seas and oceans. Although it is in Asia and Africa where polluted rivers have the most detrimental effect, there is evidence of litter also in European rivers, including the Danube. It is estimated that the Danube carries almost 1,500 tonnes of waste to the Black Sea each year[50]. Nevertheless, there is no reliable quantification of the plastic load of the Danube since the collection of data on riverine litter and plastic pollution is hindered by the lack of widely used and officially accepted methods, as well as the absence of cost-effective and widely accepted sampling and measurement standards and protocols. However, there are several good practices and exemplary initiatives implemented in the EU to fill in the gaps in our knowledge concerning riverine litter pollution. For instance, the **Plastic Cup initiative**, the **PlasticFreeDanube**[51] project, the **Plastic Pirates Go Europe!** project, the Joint Danube and **Joint Tisza Surveys**, the **5 countries 1 river (5in1) Erasmus+ programme**, and the Project are all excellent examples of collecting data, raising awareness, and combating plastic pollution in rivers. These projects have implemented various innovative and effective methods for monitoring and mitigating plastic pollution in rivers, including the use of citizen science and community engagement, the implementation of sustainable waste management practices, and the development of innovative monitoring technologies.



The experimental online pollution map highlighting the largest coastal riverine litter accumulations along the Tisza River and its tributaries.
Source: www.tisztatiszaterkep.hu

In addition to environmental education and citizen science activities, such as the **Riverine TrashLab** and the **FLEX**[52], the Project has also taken on the crucial task of mapping the most significant coastal m29icroplastic accumulations. This effort has resulted in the creation of the **Clean Tisza map**[53]. This interactive database provides the public with real-time and open-access information about the location of m29icroplastic deposits within the TRB. Compiled using citizen science, the dataset behind the online map now boasts over 5000 identified polluted areas, with the majority situated within the floodplain forest area that spans across all Tisza countries (Ukraine, Romania, Slovakia, Hungary, and Serbia) and some other DRB countries like Bulgaria. The Clean Tisza map is a valuable tool for understanding and addressing the issue of riverine litter pollution in the region, including the implementation of transboundary, international CRC interventions[54].

When **putting riverine litter pollution into numbers**, not only water authorities, water management and engineering companies but also NGOs can provide valuable information about the amount of floating and drifting waste. In Hungary, water authority directorates Upper Tisza District Water Directorate (FETIVIZIG) and Middle Tisza District Water Directorate (KÖTIVIZIG) have compiled

[50] Lechner et al., Danube River releases 530–1,500 tonnes of plastic into the Black Sea annually, 2014
[51] https://plasticfreeconnected.com/
[52] https://www.interreg-danube.eu/news-and-events/programme-news-and-events/7848
[53] https://www.tisztatiszaterkep.hu/#/en/
[54] Molnar, A.D. & Hanko, G.: Aquatic Plastic – The transnational River Cleanup Handguide, 2022

comprehensive datasets indicating an increasing trend in the annual influx of transboundary riverine litter. Since 2019, FETIVIZIG intercepted and removed about 80% of the transnational riverine litter pollution from the Upper Tisza River and the Szamos (Someș) River. According to water-authority data, each flood is associated with a so-called plastic flood event, when an average amount of 750 m^3 of floating waste arrives in Hungary from the direction of Romania and Ukraine. From these two countries, about 2605 m^3 of floating riverine litter is collected anually, as there are 2-3 **plastic flood** events registered per year. The data indicates that the Somes and Upper Tisza rivers transport over 3000 m^3 of floating riverine litter into downstream countries each year. Affluent rivers like the Bodrog, Crisul and Mures further aggravate the problem. In the Middle Tisza Valley, KÖTIVIZIG has been blocking and retrieving floating riverine litter at the Kisköre Hydropower Plant (HPP) since 2007, with data showing a nearly doubled annual influx of riverine litter since 2017. Between 2019 and 2021, KÖTIVIZIG removed 8220 m3 of mixed riverine litter yearly, including 347 cubic metres of solid waste, equivalent to 27 tonnes of riverine waste (mostly aquatic plastic).

Plastic and driftwood accumulation after a flood in downstream Hungary, at the Kisköre hydropower plant (HPP). The temporary structure can be 3 meters thick and reach more than a hectare in overall size. Photo: Plastic Cup

It is crucial to emphasize that in the previous paragraph we specifically referred to the **floating fraction** of riverine litter. When the waste enters natural bodies of water, the majority of mismanaged waste sinks to the bottom (70%), while the remaining amounts either wash up on shores (15%) or drift in the water column (15%)[55]. In essence, floating riverine litter serves as a mere indicator or the visible portion of a larger problem, similarly to the tip of an iceberg. As for stranded plastics, volunteers of an international citizen science survey registered more than 3000 large coastal riverine litter accumulations along the river Tisza, suggesting that at least 1665 tons of plastic and other environmental solid waste are accumulated in the floodplains of the Tisza, turning into legacy pollution if effective mitigation measures are not applied. Additionally, it is important to note that these figures represent conservative estimates and do not account for the stranded or deposited riverine litter found in the tributaries of the Tisza. For instance, the floodplain forests of the Bodrog alone are estimated to retain at least 60 tons of riverine litter. Considering these figures, even the most conservative estimates suggest that the natural waterways of the TRB, the longest tributary of the Danube, contain over 10,000 tons of riverine litter accumulated over the years. This substantial amount is dispersed in the riverbed and the floodplains and significantly contributes to the overall plastic load of the Danube.

Studies conducted in Austria have confirmed the great waste retention capacity of HPPs and have shown that the amount of organic and inorganic litter varies with the flow rate, and there is no evident correlation between average annual discharge and screening volume. The amount of transboundary river litter pollution has increased in the past years. While precise data on the composition of riverine litter is not available for all HPPs, screening analyses have been carried out at Danube HPPs in Austria, with estimates suggesting that the share of waste in the screenings amounts to approximately 2.5%, of which 0.9% is plastic. Between 23 and 95 tons of plastic waste have been removed from the Danube each year since 2011, according to these estimates. From the water catchment area of the TRB, the Tisza River transfers an average of 100–150 tonnes of floating riverine litter to the Danube annually. However, the overall plastic load is likely higher, as a considerable amount of high-density riverine litter and submerged objects contribute to the overall riverine litter load of the Danube. The combined amount of floating, drifting,

[55] Hanke, Georg, et al.: Guidance on Monitoring of Marine Litter in European Seas: a guidance document within the Common Implementation Strategy for the Marine Strategy Framework Directive. (2013)

and submerged riverine litter particles flowing from the Tisza into the Danube is estimated to be 250 tonnes per year. Therefore, even with the most moderate estimates, the Tisza is responsible for at least 15% of the total plastic load of the Danube, which ultimately transports roughly about 1500 tonnes of plastic per year into the Black Sea. Unfortunately, although these data are based on actual measurements, this kind of estimations can vary in a wide range due to the small number of local measurements, made with non-comparable techniques, carried out at random intervals. A regular, systematic and standardised measurement regime is needed to procure accurate data.

Water authorities intercept transnational riverine litter coming from Romania and Ukraine in the framework of a professional River Clean-up action near Vásárosnamény Hungary. Photo: FETIVIZIG

2.3. Riverine Litter Pollution: microplastics

Microplastics, the fraction of small-sized (<5mm) aquatic plastic pollutants, have recently become a prominent focus of scientific research due to their potential hazardous effects on the environment. Recognising their significance, projects are launched all across the EU to gather sufficient data on riverine microplastic pollution. One such example is[56], a Romanian NGO that recently partnered with the British Embassy to release a report on microplastic pollution in the country's freshwater sources. Significant datasets are being compiled through international initiatives, like the **Danube Watch**, the **Plastic Pirates Go Europe!**, the **Joint Danube and the Joint Tisza Surveys**, the **Plastic Cup initiative**, as well as the methodological survey conducted as part of the Project[57].

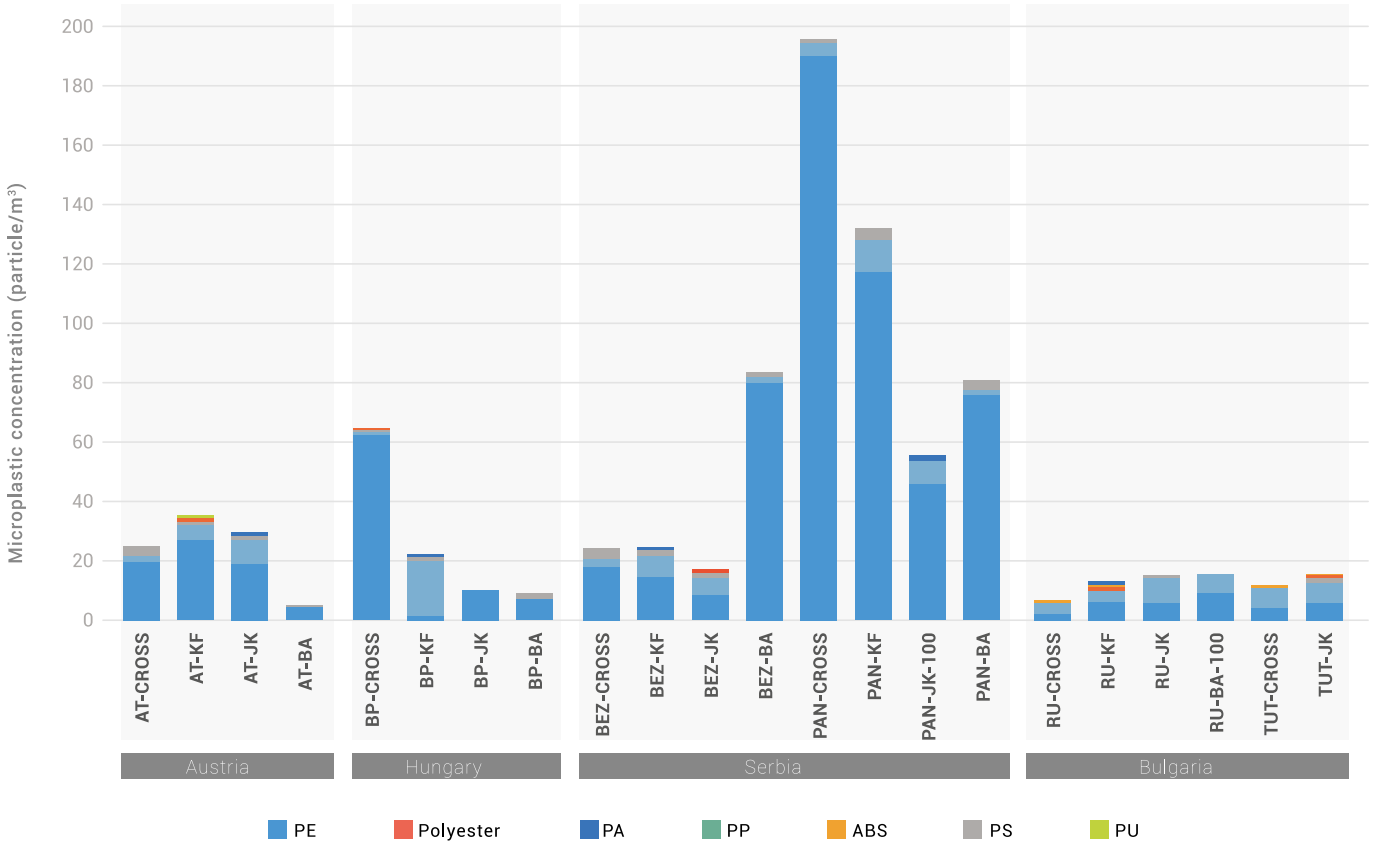
A pioneer study on the Danube River was conducted in spring 2014 with the cooperation of the University of Natural Resources and Life Sciences (BOKU), the Austrian waterway company **Viadonau**[58], and the Environmental Agency Austria[59]. The survey aimed to categorise and quantify drifting plastic items. The measurement results showed that the annual load of microplastics can reach up to 17 tonnes at Hainburg an der Donau, and the total plastic load amounts to up to 41 tonnes/year at the same site. The study also revealed that it is crucial to address the entire river when sampling a cross-section, as plastic fragments have the properties of suspended particles rather than floating ones. As part of a national research and development (R&D) project in cooperation with university partners, **Wessling Hungary Ltd.** (legal predecessor of current: **Eurofins Analytical Services Hungary Ltd.**) conducted the first exploratory microplastic analysis in the Carpathian Basin in 2017. Microplastics were present in nearly all water samples, in quantities similar to international results (5–20 particles/1000 litres of water sample). Additionally, microplastics were found in sediments of fish farms, but their concentrations were significantly lower than the available related international data[60].

In 2018, Wessling Hungary Ltd. (legal predecessor of current **Eurofins Analytical Services Hungary Ltd.**) initiated the **Tiny Plastic Puzzle project**[61] to measure microplastics in Budapest. The concentration of microplastics at the Megyeri Bridge was found to be 45 particles per cubic metre, while the Csepel Freeport had a concentration of 55 particles per cubic metre. These results suggested that the capital, with its high population, surface runoff, and sewage treatment plants, could be a source of microplastic pollution. The project also contributed to developing an improved sampling method for microplastics by expanding the lower size limits of the sampling and measurement. Following the prioritisation of the issue of plastic pollution by the ICPDR, measuring microplastics was included in the **4th Joint Danube Survey**, which began in 2019 and was organised by the Commission[62].

[56] Act for Tomorrow Association: Study summary
[57] https://kszgysz.hu/en/interreg/more-new-innovations-and-cooperations-at-the-tisza-roundtable
[58] Danube Watch 3/2016: Plastics and microplastics in the Danube River
[59] https://www.umweltbundesamt.at/fileadmin/site/publikationen/rep0551.pdf
[60] https://www.sciencedirect.com/science/article/abs/pii/S0045653518319714
[61] mikromuanyag.hu
[62] https://pubs.acs.org/doi/10.1021/acsestwater.1c00439

The comprehensive survey investigated the microplastic content in the Danube River at 18 sampling sites using sedimentation boxes, and identified polyethylene (PE) as the most predominant polymer, followed by PS, styrene-butadiene rubber (SBR), and PP. No detailed survey has been conducted yet for the Tisza River. In 2017, Wessling Hungary Ltd. (legal predecessor of current: Eurofins Analytical Services Hungary Ltd.). carried out the first microplastic measurement of the Tisza River during the fifth Plastic Cup international CRC action. The sample from Dombrád contained 4.9 plastic particles larger than 300 µm/m^3, and 23.1 particles/m^3 larger than 100 µm. The most common types of plastic particles were polyethylene, PP, and PS. Information on microplastics in other water bodies in the DRB is also insufficient. In 2018, Wessling Hungary Ltd. (legal predecessor of current: Eurofins Analytical Services Hungary Ltd.) measured microplastics in the Ipoly (Ipeľ) and Rába (Raab) rivers. The Ipoly, which flows mainly through a national park without industrial and urban influences, had a low concentration of microplastics, with only 1.7 particles/m^3 detected. In contrast, Rába, which is surrounded by industrial sites in Hungary and Austria, showed higher numbers, with 12.1 particles/m^3 composed of uniquely determined types of plastics and not the commonly used ones.

Inspired and largely influenced by predecessor initiatives mentioned above, microplastic measurements were conducted in the framework of the Project at **multiple sampling sites**[63] in the Danube River and its tributary, the Tisza River, including Hainburg (AT), Mannswörth (AT), Korneuburg (AT), Budapest (HU), Bezdan (RS), Pancevo (RS), Ruse (RO/BG), and Tutrakan (RO/BG). Measurements were also taken in the upper course of the Tisza River, specifically in Kisköre (HU), Tuzsér (HU), Tokaj (HU), and Tiszasziget (HU), as well as close to its estuary in Titel (RS), from March to July 2021. Additionally, pump measurements were taken in Tuzsér (HU), Tokaj (HU), and Tiszasziget (HU), and sedimentation box measurements were recorded in Mannswörth (AT) and Korneuburg (AT).



Microplastic particles in water samples from the Danube (Tid(y)Up DT1.1.1 Microplastic Measurement Report, 09.2022)[64]

[63] On the hunt for microplastics, video https://youtu.be/nK-dzYqCQaw

[64] Tid(y)Up DT1.1.1 Microplastic Measurement Report, 2022.09

Three methods were tested and evaluated to compare the measurements carried out by different countries as a basis for monitoring microplastic pollution and to help fight transboundary plastic pollution. These included simultaneous net sampling with mesh sizes of 500 µm and 250 µm at three different depths of the water column, sampling with a 1 mm pre-filter followed by cascade filtration of 300µm, 100µm, and 50 µm (pump method), and the sedimentation box, as already used during JDS4. Best practice options for sampling and analysis under varying boundary conditions were derived. From the results of samples taken with nets, the number of microplastics in the size range from 500 to 5000 µm was similar at all locations and counted up to 4 microplastic particles per m^3 in the Danube River and over 8 particles/m^3 in the Tisza River (Titel). No increase in downstream microplastic concentration was detected when considering all evaluated fractions. Fibres were found to be a significant source of pollution, whereas polyethylene was the main cause of pollution, followed by PP, PS, and other plastics. As the particle size decreases, their number increases, but differences in plastic-type distribution depending on the size were not observed. With the pump method, size ranges from 50 µm to 1000 µm were analysed, and results ranged from 4.7 to 196 particles per m^3. Only at one point in Serbia was the number of microplastic particles per m^3 found to exceed the mark of 50 particles/m^3 for all sample points (surface, middle, bottom, and cross-section measurement). It was observed that the number of particles was about ten times higher when including fractions less than 500µm, with the pump method, compared to net sampling on the fraction 500 – 1000µm. Samples collected in the sedimentation box were more extended in time (14 days exposure) than the net and the pump samples. However, due to the lack of sample volume (water flow) measurements, results cannot be projected on sample volume. Overall, none of the methods could detect a continuous accumulation of microplastic particles along the flow of the Danube from Austria to the Black Sea. Inflows can increase or decrease microplastic pollution and also sedimentation or remobilisation.

As part of the EUSDR Priority Area 4 activities, the former Wessling Hungary Ltd. (legal predecessor of current: **Eurofins Analytical Services Hungary Ltd.**) conducted microplastic analysis in **wastewater treatment plants** (WWTPs) and the recipient Danube River. The analysis concluded that these plants reduce the microplastic content of the influent raw wastewater, but the treated effluent wastewater that is released to the environment still contains more microplastics than the receiver river water. This means that WWTPs are a source of environmentally occurring microplastics. The microplastics in influents ranged from 800 to 4400 particles/m^3, while in effluents the amount was 11.7 to 84.6 particles/m^3, and in the Danube River[65] samples varied from 9.4 to 27.9 particles/m^3. Sewage sludge as a potential sink was also analysed, and 3 to 94 particles/kg were detected. This could be an issue later in agricultural use, so further investigation is needed. Polyethylene was the most abundant polymer type in all samples, followed by PP and, in effluents and surface water, PS. The influents showed more diverse microplastics in terms of polymer type, with polyoxymethylene and polyester detected in several samples.

In conclusion, there are convenient and widely accepted monitoring methods available to detect and report microplastic particles floating in the water column. However, significant gaps exist in the datasets concerning microplastic particles accumulated in sediment and biota, highlighting the need for standardised and harmonised methods. Monitoring the ingestion or deposition of microplastic particles is crucial, as preliminary data suggests that not all microplastic particles remain floating or drifting; some sink (e.g. tyre abrasion particles), accumulate along the riverbed, and enter the food chain. Future studies should encompass all major types of riverine microplastics, including floating, deposited, and ingested particles, as well as secondary microplastics. Photodegradation, abrasion, and oxidation can transform riverine litter accumulations, whether floating, stranded, or sunk, into a source of new, secondary microplastic particles also to be included in the calculations.

The first microplastic sampling on the Tisza River in 2017. Photo: Gergely Hankó

[63] https://waterquality.danube-region.eu/analysis-of-wastewater-treatment-plants-along-the-hungarian-stretch-of-the-danube-river/

Part **B**

Strategy

3. Recommendations

3.1. Policy tools and recommendations for the DRB countries[66]

Plastic pollution is a significant issue that requires action at all levels of the waste hierarchy. The best approach is to take measures that address the problem at its source, such as preventing waste generation. This includes reducing the amount of often problematic and avoidable plastics on the market.

Once we have reduced plastic waste generation, we can then focus on ensuring that plastic items in use are designed sustainably. The design stage plays a crucial role, as it determines the recyclability, reusability, and repairability of plastic items, as well as their lifespan, end-of-life treatment, and potential secondary uses.

By using policy tools to encourage sustainable design, we can better manage plastic waste at the end of its lifecycle, ultimately reducing the amount of plastic waste that ends up in lower levels of the waste hierarchy and minimising the risk of environmental leakage. Policy approaches can take various forms, including regulatory measures, market-based tools, information and voluntary schemes, and financing and investment strategies.

It is very important that the regulatory instruments shall not stand alone but shall be linked with economic instruments and awareness-raising tools to create a robust policy mix, using the synergy effect to reach the goals.

3.1.1. Regulatory tools[67]

Decision makers have a range of tools at their disposal to regulate plastic pollution. The traditional legal framework can be established at the **municipal, national, or international** level, including **intergovernmental treaties**[68]. In addition to the regulatory system, an adequate enforcement infrastructure is necessary at the appropriate governmental level, which consists of legal requirements, including authorisations, licences, or permits. Other tools, such as product standards or certifications that support recycling and circular economy schemes, can also be utilised. For example, specifications for compostable plastics, such as ISO 17088:2021, or a **recyclability certification form** can be used[69]. It has become clear across all product streams that waste prevention can only be achieved by regulating the design and production, which determines a product's lifecycle environmental impact. Ideally, authorities should ensure that waste management facilities operate using the best available techniques and consistently improve their environmental performance. This can be achieved through the implementation of various environmental and quality management systems.

To ensure environmental protection and prevent damage, a **liability regime** must be established for facilities engaged in risky or potentially risky activities. These regulations should be developed in a systematic and harmonious manner, taking into account present practices and future objectives to enable quick implementation. This systematic approach also requires collaboration between water and waste management regulatory systems at the policy-making level, to align their policies and initiate joint actions. It is crucial to establish practices and tools that assist authorities in **monitoring facility performance** in compliance with regulations, controlling waste management activities, and enforcing regulations. Facilities that meet specific performance indicators may be eligible for incentives or relief measures.

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[66] Based on: PLASTIC SMART CITIES INITIATIVE materials (www.plasticsmartcities.org)

[67] Based on: OECD (2019), Waste Management and the Circular Economy in Selected OECD Countries: Evidence from Environmental Performance Reviews, OECD Environmental Performance Reviews, OECD Publishing, Paris, https://doi.org/10.1787/9789264309395-en.

[68] Like e.g.: Commission decision on establishing the identification system for packaging materials pursuant to European Parliament and Council Directive 94/62/EC on packaging and packaging waste

[69] https://recyclass.eu/get-certified/recyclability

Regularly reviewing the legal regime can ensure that the system can adapt to new challenges, developments, and inventions. For instance, member states should regularly review the measures implemented to enforce the SUP Directive[70] and propose further measures if necessary. The directive allows member states a wide margin when it comes to reducing the use of food and drink containers, and it is crucial to review and strengthen the instruments used to achieve the objectives. The directive does not set an EU-wide target, instead it requires member states to achieve ambitious and sustained reductions for these products by 2026, which is too vague and makes compliance measurement difficult. Moreover, the ban on SUP items should be extended. To monitor progress, it is essential to build consistency and comparability of the data on standards. All technology-driven, source-based monitoring should consider microplastics as a pollutant, and emissions and limit values should be reviewed frequently. Financial support should be provided for upgrading existing water treatment facilities and installing new ones. It is recommended that ex-ante policy impact assessments be conducted in a participatory manner before making decisions on policy interventions.

The waste framework directive and waste stream directives, including the packaging directive, are subject to **constant change**. They set increasingly ambitious targets and regulate the use of instruments based on practical experience. For instance, the EPR system has been widely adopted in the EU, despite only being regulated in 2018, and more detailed regulation would support harmonious implementation and ensure better results. While a 6-year cycle is mandatory for updating legal acts in the EU, it is recommended to review river basin management plans and related waste legislation with a more holistic approach, ensuring coordination between implementing bodies in related sectors. This would strengthen regional and transboundary cooperation on micro- and macropollutants in water and improve the biological status of water bodies. International agreements should define and facilitate the implementation of roundtable cooperation, inviting all relevant stakeholders of the DRB and ensuring frequent transnational meetings across sectors.

3.1.2. Financial tools

Financial tools are not limited to levies, but also include incentives, fees, and refunds (such as deposits), which can incentivise stakeholders, particularly producers and end-users, to achieve environmental goals. Depending on the system in place, these tools can generate extra financial resources to support necessary measures. However, one of the biggest challenges facing us today is the lack of **environmental liability insurance** for large, potentially dangerous sites, e.g. non-EU conform landfills and mining activities. The ways transnational river pollution cases are managed are applicable to riverine litter management: 1. ultimately, plastics can be indicators of more serious pollutants arriving with the solid waste pollution; 2. not only best but also worse practices exist, which should be evaluated and conclusions should be drawn from them; 3. coastal plastic deposits are turning into legacy pollution, because most stranded plastics are built into the sediment in want of intervention.

While EU law requires that the large, dangerous facilities have emergency and environmental damage plans and insurance, this is based on the "polluter pays" principle. In cases of compulsory liquidation or major pollution, however, the financial resources of the polluter may be insufficient. Similar financial problems exist for **legacy pollution**, in which case the responsibility falls on the state[71]. The Hungarian ombudsman has conducted a comprehensive study and legislative proposal in the interest of future generations on the enforcement of environmental liability, suggesting the establishment of a central state fund financed by risky activities to support the remediation of abandoned pollution sources. Such analysis could also be carried out basin-wide (not targeting solely the plastic pollution).

An excellent example of financial tools is the use of levies, such as the **tax on SUP items** like plastic bags, bottles, and food packaging, to discourage their use. Another approach is to use **non-refundable fees levied on individual products** at the point of purchase, with the fee incorporated into the product price based on the estimated collection and processing costs. **Landfill or incinerator taxes** are also charged to private landfill/incinerator operators to encourage environmentally preferable treatment alternatives, such as reuse, recycling, and composting.

[70] In this regard, Member States are required/have to collect data and set a baseline on the consumption by 2022, so that they can use it to assess if they have achieved their national target, that they should set by 2026.

[71] (https://www.ajbh.hu/documents/10180/2776705/JNBH_jogszabalyi_javaslat.pdf/61968154-4a75-bf07-0479-10a667263033) (in Hungarian)

Moving from end-of-pipe mindset to preventive thinking, **packaging material fees** can be an effective tool that requires manufacturers to pay fees based on the amount of packaging material they put on the market. Following the circular economy-based approach, the **EPR** is a good example that holds producers responsible for collecting and recycling the specified volumes of plastic they produce and distribute. **Plastic credit systems** can also be a sophisticated way to reach circularity, as they require manufacturers to purchase recycling certificates issued by accredited re-processors or recyclers based on the amount of plastic waste recycled.

An effective way to incentivise waste reduction is through reward schemes that encourage users to actively participate in separate waste collection, reuse, and preventive programmes. One example is **deposit refund systems (DRS)**, which offer a small refund to consumers when they return items to authorised collection points. Another innovative approach is the **Plastic Bank**, which provides above-market rates for plastic waste, incentivising plastic collection in exchange for money, items, or services. Public procurement standards incorporating bans on SUP items, as well as targets and incentives for reusable and plastic-free alternatives, can also be effective methods. **Blended finance** is a financing approach that blends scarce public concessional funds with private sector commercial capital to realise innovative, high-impact infrastructure projects that do not yet have a commercial track record. **Municipal bonds** are a commonly used long-term debt instrument issued by governments, companies, municipalities, commercial and development banks to finance or refinance assets or activities that can have environmental benefits, including waste management. In summary, financial tools, such as levies, fees, refunds, and incentives, can be employed to drive behaviour change and achieve environmental goals. These tools can create financial incentives for producers and end users to achieve waste reduction targets, finance compensation for emergency damages, remediate polluted areas, and encourage the adoption of circular economy practices.

Using **financially viable solutions** for environmental challenges is an effective approach to ensure the success of such projects. However, it is important to note that bankable solutions may not always be readily available. In most cases, waste collection and recycling systems cannot be compiled solely from profitable parts. Nevertheless, the EU has established systems, such as the EU Taxonomy and the CSRD, to support green investments, which can be helpful in promoting sustainable projects. In addition, **recovery funds** offer future opportunities to restore and rehabilitate living and built infrastructures in regions such as Ukraine, affected by military activities. This presents an opportunity to address long-standing landfill constructions and expand waste processing capacity in the affected areas.

3.1.3. Capacity building

Capacity-building measures are crucial to ensure that organisations, including key legal bodies, have the necessary skills, knowledge, and resources (including digitalisation) to carry out their tasks effectively. However, solving the problem of riverine plastic waste requires a more comprehensive approach that goes beyond regulatory tools. This involves fostering **collaboration and partnerships across different sectors**, such as the water and waste management industries, to address the problem in a more efficient and timely manner. While legal mandates can facilitate such collaborations, they may not be enough to ensure effective cooperation. A more organic approach that fosters a symbiotic relationship based on shared capacities and services can be more effective in minimising costs and damages. Therefore, the legal system should encourage and incentivise such collaboration through the financial instruments discussed earlier and by updating the regulatory environment to keep pace with the changing environmental challenges.

Encouraging and supporting eco-innovation start-ups is a crucial step towards building a pool of knowledge and solutions to address the problem of riverine plastic waste. In particular, areas such as illegal dumping require a multifaceted approach. While strengthening the enforcement of environmental rules is necessary, the capacity of executive bodies may be insufficient to mitigate the problem effectively. Therefore, raising **public awareness** and involving citizens and civil society organisations is essential to achieving better enforcement outcomes. Institutionalising and supporting such initiatives could be the key to solving the problem in the long term. Efficient financial assistance, such as Eco Funds based on targeted revenues, should be made available to adequately support initiatives and NGOs

in filling the capacity gap of governmental bodies and coordinating actions between stakeholders to achieve better enforcement. Additional funds should be earmarked for capacity building and coordination efforts to discover, eliminate, and prevent illegal dumping.

Based on the success of initiatives such as the Plastic Cup and the Project's Tisza **Roundtable** series, it is recommended to implement tools like the EU Policy Lab[72] and methodologies like the Co-creation for Policy Process (CfP)[73]. These steps can help support democratic advocacy processes in Central and Eastern Europe (CEE) countries and facilitate policy co-creation with multiple stakeholders in partner countries and beyond. By fostering **collaboration and collective intelligence** at various levels of governance, tangible outcomes can be generated to inform decision-making. In addition to these measures, collective unions formed by neighbouring municipalities to jointly tackle waste management activities – including the development of collection and processing facilities, as well as communal interventions along shared waterways – can also be effective. This approach is especially relevant in cases where the central regulatory system is not supportive enough to address these issues. Moreover, it is important to ensure that efficient communication and information-sharing platforms are in place to facilitate collaboration and knowledge-sharing among stakeholders. This can include establishing digital platforms that enable stakeholders to exchange best practices, as well as the organisation of training sessions and workshops to build capacity and enhance skills among relevant actors. Adequate financial support, such as Eco Funds based on targeted revenues, should also be provided to enable the implementation of these initiatives and to ensure their long-term sustainability.

3.1.4. Services and Infrastructure

Proper **separate waste collection** is a critical prerequisite for high-quality recycling and must be prioritised. Expanding the collection and separation of waste streams can also create new job opportunities. Moreover, an improved plastic waste collection system will help reduce the leakage of plastics into the environment.

To achieve this, the **expansion of collection infrastructure** should be encouraged, with a particular focus on door-to-door collection systems, which have been shown to result in the highest capture rates and yields of recyclables. However, it is important to note that existing collection systems can only achieve high collection rates if citizens are adequately informed, educated, and motivated, and if they trust the system. Therefore, raising awareness and building trust among the population is crucial to the success of separate waste collection.

Implementing and optimising **EPR** systems is another possible solution to support the separate collection of plastic waste. Furthermore, curbing landfilling and preventing illegal dumping and littering -play a critical role in the fight against plastic pollution. Whereas incineration can at least recover the energy content of plastic waste, landfilling results in the loss of any further use of the plastic. Although the EU Landfill Directive has already been transposed into national law by all countries, plastics are still being landfilled and illegal dumping still occurrs (see Chapter 3.2.2.1.). Therefore, the implementation of landfill restrictions, bans, control systems, and where appropriate, sanctions must be enforced to address these issues

3.2. Knowledge-based development for prioritising measuring

In the Project, partners collaborated to develop recommendations aimed at improving the legal environment and policy framework to combat plastic pollution in the Danube Region. This section discusses recommendations based on the main findings in the partner countries. Later on, Chapter 4 presents the top 10 general recommendations.

[72] https://blogs.ec.europa.eu/eupolicylab/

[73] Co-creation for Policy Process (CfP): participatory problem-solving processes. see more: JRC Publications Repository - Co-creation for policy: Participatory methodologies to structure multi-stakeholder policymaking processes (europa.eu)

3.2.1. Water management

The socio-economic significance of rivers is unquestionable. However, accurately estimating the true costs of transnational plastic pollution in rivers is challenging. Riverine litter adversely affects communities along rivers in various countries and industries, such as fishing, shipping, tourism, and water engineering, resulting in economic losses. Moreover, there are additional costs involved, including the decline of ecosystem services, loss of species, habitats, and environmental values. Therefore, any river clean-up initiative that improves water quality has beneficial effects on multiple stakeholders, including riverside communities, wildlife, and the aforementioned industries. The Project was implemented in a macro region of the EU known for its notorious history of river pollution disasters. From the cyanide catastrophe in 2000 (Somes and Tisza rivers) to the red sludge disaster in 2010 (Marcal, Rába, and Danube rivers) and the mine drainage catastrophe in 2022 (Slana and Tisza rivers), the list of incidents is extensive. These events are further exacerbated by recurring waves of plastic pollution, transporting hundreds of tons of riverine litter, predominantly plastics, into the DRB from Eastern regions of the EU and Ukraine as well as Bosnia-Herzegovina and Serbia.

Slana river pollution wave in 2022 from Slovakia. Photo: Marton Mohos

Due to the limitations of this document's scope, we are unable to comprehensively discuss the range of opportunities water management practices offer in mitigating the consequences of solid waste pollution from industrial or communal sources. However, it is crucial to emphasize that riverine litter, in general, is closely linked to certain pollutants that jeopardize water quality. The presence of plastic bottles floating on the surface should serve as an indicator, signalling the need for further monitoring activities that are not limited to solid waste particles but also include dissolved pollutants.

Hereby only general recommendations are discussed, as the latest update of the DRBMP (2021) provides detailed information on water management related issues ("water services" in the Plan) in different countries. In several Danube countries, the water networks, wastewater sewage systems, and treatment plants are in poor condition due to a lack of long-term funding possibilities, proper maintenance, and effective operation. Only Germany and Austria are collecting and treating nearly 100% of the domestic wastewater, while Slovakia, the Czech Republic, and Hungary are behind (in descending order, ending with the Hungarian value of 52%, in terms of compliance rate)[74]. Further east, this ratio decreases. In Serbia, just over half of households are currently connected to the sewage network. Only a small percentage of the infrastructure has wastewater

[74] Country profiles on urban wastewater treatment, WISE Freshwater information system for Europe: https://water.europa.eu/freshwater/countries/uwwt

treatment to some degree. The largest cities – e.g. Belgrade or Novi Sad – still discharge wastewater directly into rivers. The good news is that in recent years, the number of wastewater treatment facilities with tertiary treatment has become more common, indicating more efficient pollutant removal from the treated waters, such as microplastics. Moreover, it is suggested to introduce and improve specific water quality and sludge monitoring, especially for new kinds of polluters like microplastics. The new proposal for the EU Urban Wastewater Treatment Directive (UWWTD) is already addressing these issues. Other effective measures include creating specific strategies to enhance investment in wastewater treatment facilities and designing strategies and models for knowledge transfer on wastewater treatment technologies. Before discussing waste management issues, it is worth noting that once mistreated communal or industrial waste enters the environment, its treatment surpasses the scope of waste management. As reported earlier, riverine litter consisting of various forms of pollutants, such as plastic, glass, metal, and communal and toxic waste, requires a combination of tools applied by the waste and water management sectors, the municipalities, and the authorities.

3.2.2. National waste management practices

According to the Survey, the lack of proper collection infrastructure in **Serbia** has led to large amounts of packaging waste being disposed of in landfills or at other inadequate locations. This has had a significant impact on water pollution, as some of these locations are situated near water bodies. To address this issue, a strategic plan must be developed and implemented to ensure the proper collection of packaging plastic waste. One effective solution could be the implementation of a Deposit Refund Scheme for single-use beverage containers, which has successfully reduced littering in other countries. Without a well-functioning collection network, it is economically unviable to carry out other waste-related activities. Therefore, the development of treatment capacities must also be considered once the collection of relevant waste streams is done, either at the national or regional level. Defining clear responsibilities for the clean-up of rivers and streams, especially in remote areas, is also crucial. Currently, Serbia's recycling rate is only 5%, highlighting the urgent need for adequate penalties for illegal waste disposal, penalties for public utility companies that underperform in waste collection, and increased targets and financial incentives for packaging waste collection. Effective supervision and enforcement are key to successful implementation, and therefore actors involved in waste management should be trained and equipped to operate efficiently.

In **Slovakia**, the issue of illegal landfills operating without permits and closure plans is a serious concern. The fact that some organised but illegal and non-supervised waste disposal systems fail to apply the classification of waste as defined in the Slovakian Waste Catalogue only exacerbates the issue. A comprehensive legislation and enforcement framework for landfill operations is urgently needed to address this problem.

In **Romania**, progress has been made in controlling waste abandonment by transferring control and sanctioning to local authorities and installing camera systems along water bodies to deter illegal dumping. However, a nationwide system for separate waste disposal and ecological storage is needed to effectively combat the problem. The insufficient amount of waste received by recycling companies is stimulating illegal imports disguised as legal ones while hindering the growth of domestic recycling businesses. Furthermore, microplastic pollution is a major issue in all of the country's major rivers, and immediate action is needed to measure its concentration in surface waters and adopt effective measures to prevent and combat it.

Romanian authorities organize actions in each county to verify the way rivers have been cleaned up and ditches and channels have been maintained to protect the drainage sections of large waters. Following these inspections, remediation measures and sanctions are established for the local authorities regarding the areas with uncontrolled deposits of household or other waste. In addition, measurements were taken at intervention points to collect data on floaters and specialised equipment was purchased for their removal. In the first stage of that action, those measures were implemented along the Someșul Mare watercourses (3 sections), Lăpuș, Ier, Crișul Repede and Barcău, under the jurisdicton of the Someș-Tisa, Crișuri Water Basin Administrations. In 2022, Romanian authorities also installed five collection systems on Dâmbovița, Jiu, Argeş, Ialomița, and Mureş rivers, as well as five barriers to block floaters on Jiu, Cerna, Olt, Buzău, and Siret rivers.

In **Ukraine**, local communities need to be empowered to implement effective waste management systems that consider environmental, public health, economic, and other aspects of waste management. Despite having appropriate legal frameworks in place, the lack of monitoring systems, state capacity, and failures in law enforcement contribute to the autonomous and ineffective waste management practices. The government must work to strengthen its monitoring and enforcement capacities to ensure that waste management practices are implemented correctly.

Hungary has been undergoing a series of waste management system reorganisations in recent years, which has not helped develop and strengthen an efficient and effective collection system. However, the introduction of a 35-year concession started in July 2023 is a significant step towards a better-managed and more sustainable waste management system. The awarded bidder is responsible for providing municipal waste management services as a single licensor in the country, covering the entire industry value chain, including approximately 4.5–5 million tonnes of municipal solid waste per year. The Hungarian petrochemical company MOL has been awarded the concession, and its affiliate company, MOHU MOL Waste Management Ltd. is responsible for achieving the national and the EU target numbers. The new system will also cover all products falling under EPR rules, in compliance with EU and specific Hungarian regulations, such as ELV, waste from electrical and electronic equipment (WEEE), batteries and accumulators, packaging, tyres, office and advertising papers, wooden furniture, SUP, textiles, and edible oils and fats. An obligatory DRS will also be introduced from 1 January 2024 (with a 6-months transition period) for plastic, metal, and glass beverage containers. Similar measures for laminated paper and edible oil packaging are to be implemented later. All waste from these products collected by the licensor will be owned by the state, and the licensor will be responsible for handling the full management of waste on behalf of the state through subcontractors. While the state's influence on waste management may seem excessive, it is intended to satisfy all EU waste management obligations, including directives on municipal waste, landfills, EPR, SUP, and beyond.

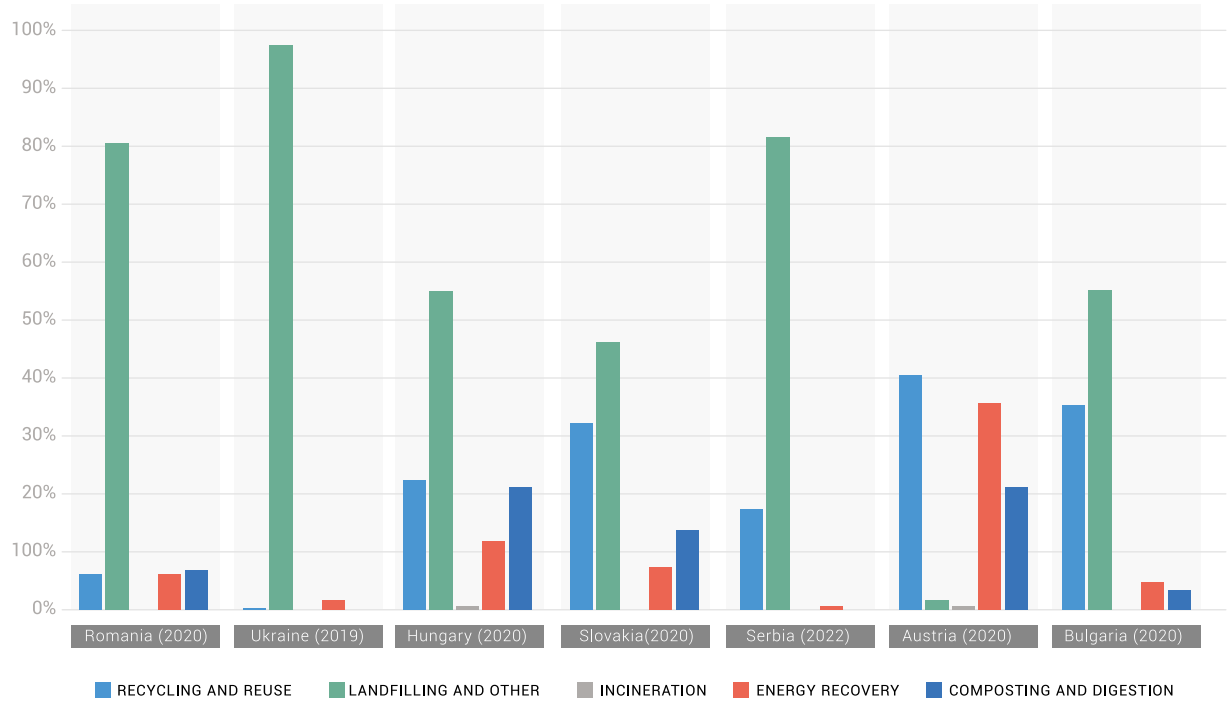
In **Austria**, the bigger part of the waste is undergoing thermal recycling, so less than 10% goes to landfills. The DRS is commonly used but can be developed further. Repairing is popular[75] and widely-spread.

In some Eastern European countries, media centralisation and political influence limit the opportunities for awareness-raising and dissemination of environmental issues and sustainable solutions. The media must be free to cover environmental issues, and governments should encourage media outlets to prioritise reporting on these issues. Education and awareness-raising campaigns could also be developed to inform the public about the importance of proper waste management practices and the negative effects of pollution on the environment and public health.

[75] A good initiative for promoting repair: Repair Voucher In Wien

3.2.2.1. Improper waste disposal

The problem of **illegal waste dumping** and littering poses a significant challenge to many countries. In general, there is insufficient data on this issue due to the lack of monitoring and control mechanisms. In many cases, the state lacks human resources and financial capacity to systematically collect, monitor, and analyse relevant data, making capacity building essential.



Percentage distribution of waste processing methods in relation to the total amount of treated waste in the Danube Countries[76,77]

In **Slovakia**, the issue of illegal dumping is further complicated by land ownership. Some contaminated lands were privatised in the 1990s, making it difficult for environmental law enforcement officials to identify the responsible party by tracing the history of land ownership. Sanctioning unknown perpetrators is a recurring problem in all partner countries, and a conceptual solution is needed. It can be concluded that current legislation is ineffective in deterring illegal waste dumping activities. The problem must be addressed holistically, and stakeholders should be incentivised. Although restrictions and rules are included in the legal framework, implementation has not been successful, and key elements of success, like prevention, need to be promoted at all levels. Investment in the maintenance and repair of WWTPs in small settlements is crucial to prevent household waste pollution at the source.

In **Hungary**, stricter penalties are recommended for uncontrolled and illegal waste disposal , particularly for construction and hazardous household waste. To achieve more effective and rapid enforcement, evidence protocols should be simplified, and measures and requirements for authorities should be streamlined. The immense amount of waste generated by construction and demolition activities needs to be regulated not only through building legislation but also through a separate regulation to encourage separate collection and recycling and to deter illegal dumping. An IT system based on marketing principles would also be essential for effective follow-up.

[76] Municipal waste by waste management, Eurostat (2023)

[77] data about Ukraine: DLF ATTORNEYS-AT-LAW UKRAINE (2021). Ukrainian National Waste Management Strategy

In **Romania**, the waste collection system needs improvement to address the problem of illegal waste imports, even though the legislation imposes rules on imported wastes to tackle pollution. Importing waste of any kind into the territory of Romania for the purpose of its elimination is prohibited. Importing waste for the purpose of recovery is allowed and practiced within specific regulations in the field, with the approval of the government, in accordance with the provisions of the Treaty on Romania's accession to the EU. Waste recovery is carried out only in specialised facilities, using processes or activities authorized by the competent public authorities. With better enforcement, domestic recycling businesses could thrive, reducing the demand for legal waste imports and increasing compliance with the Basel Convention and EU Shipments of Waste Regulation.

In **Serbia** huge amounts of waste are dumped in illegal dumpsites, outside the control of municipalities and local/regional public utility companies. According to the data from the Environmental Protection Agency, there are 3,059 illegal landfills in Serbia. Based on information provided by 142 local self-governments and citizens through the "Remove the Landfill" application, in most cases, illegal dumps are located in rural areas, but they can also be found on the outskirts of large cities, and even in central urban areas. In the "Report on Waste Management for the Period 2011–2021" by the Environmental Protection Agency, it is noted that illegal landfills are formed not only in cities and villages throughout Serbia but also along roads, where waste is simply dumped from trucks or discarded by citizens from their cars. The large amounts of garbage from illegal dumpsites near riverbanks and from flood-prone areas, carried by rivers complicates the flood defens measures, as was the case in Prijepolje, Priboj, Sjenica, Novi Pazar, and Kraljevo during recent (2023) river floods.

3.2.3. Organisational structure

Austria faces challenges with the inadequacy of unified law enforcement, due to the lack of federal regulation for nature conservation. Their countermeasure against illegal waste deposition is the Waste Watchers system (see Chapter 4.4.).

In Serbia this problem is not resolved at all. There are plenty of illegal landfills, dumps, and a high rate of waste abandonment.

In **Hungary**, the long-standing absence of a dedicated Ministry for the Environment has led to fragmented administrative bodies and convoluted operational procedures. As a result, it is difficult to enforce responsibility for environmental protection and nature conservation in a unified manner, which might hinder cooperation among stakeholders during instances of pollution where urgent action is necessary to prevent further damage to nature. To effectively address this complex issue, the recommendation is to consolidate existing powers, simplify procedural processes, and apply the subsidiarity principle to environmental protection tasks, leading to more structured and efficient long-term planning, prevention, and enforcement capabilities. A more stable regulatory environment would also improve operational efficiency.

In **Romania**, effective enforcement needs to improve the control activity and the application of sanctions regarding waste dumping by increasing the capacities of the local Environmental Guards.

In **Ukraine**, strengthening institutional and administrative capacity at the local level is crucial to achieving the objectives set for the sector at the national level. In the Transcarpathian region, there are at least 200 settlements without solid waste management.

Furthermore, it has to be noted at this point, that the Ukrainian national first-level controller faced language barriers and lack of competence, and subsequently vetoed the funding of both Ukrainian Project partners, making it extremely difficult for other Ukrainian partners to enter into such projects.

In **Slovakia**, the judicial decision-making process needs to be improved by reducing the time required to reach a decision and ensuring transparent communication between the different enforcement bodies. Local authorities should also be more involved in the control of pollution and polluters.

3.2.4. Monitoring

3.2.4.1. Microplastics

Detailed in the previous chapter (2.3), it is evident that there is sporadic, but continuous data collection on the distribution and dynamics of riverine litter pollution, including **microplastic particles** in the water column. However, it is currently impossible to draw any generally valid conclusions or identify any trends from the results. Therefore, it is essential to establish a regular and consistent monitoring programme that can develop a comprehensive database. This programme is necessary to conduct the required research, develop practical strategies, and create the necessary tools. These tools range from hardware, such as proper sampling equipment, to technology, such as the best removal techniques for given circumstances, to software, such as predictive analysis of plastic debris movement and deposition in river bodies and on shores.

As detailed before (chapter 2.3.), different microplastic monitoring methods were tested under varying conditions to determine their suitability for field application, ease of use, error-proneness, and cost-efficiency. The future and regular monitoring of microplastics requires the development of easily applicable and reproducible methods. The test methods were trialled in parallel, and the results were assessed to obtain meaningful data about microplastic pollution and to compare the individual advantages that may compensate for the disadvantages of the other methods. To consider the depth variance and spatial distribution of microplastics, sampling was performed all across the river cross-section and at different depths.

As a result of the Project, **user-friendly protocols** for sample preparation and analysis have been developed, which enable inter-laboratory comparisons for each sample type. These protocols were applied to roughly assess the microplastic pollution situation along the Danube and Tisza Rivers. In addition, a guideline on multiple-net methods for measuring plastic transport in medium and large-sized rivers was developed and presented in December 2022[78].

While this research aimed to identify the best methods for sampling and measuring microplastics for a specific purpose, it is equally important to establish a standardised and systematic monitoring system for microplastic sources, including WWTPs and other surface water sources such as road dust runoff[79]. Identifying the primary sources of pollution, such as highways, factories, and rainwater drainage, is crucial. However, it can be challenging to survey the number, size, spatial distribution, and composition of waste deposit sites and other diffuse sources of pollution along riverbanks due to the accumulation of plastic litter on the surface and in river sediments. Nonetheless, this information is essential for developing effective strategies to tackle microplastic pollution in water bodies.

3.2.4.2. Macroplastics

The Project has employed three distinct methods – citizen science, Global Positioning System (GPS) tagging, and remote sensing – to monitor the entry points, deposition, migration, and accumulation sites of plastic pollution in rivers. The aim of the **citizen science approach** is to create an accessible **online riverine plastic pollution map** (see Chapter 2.2.) that is free to use and open to all Danube countries. The map's software is able to expand in size and functionality and serve as a tool for research activities, habitat restoration, prevention measures, and clean-up actions. Hotspots are the primary source of aquatic plastics, and Ukraine alone has thousands of illegal waste deposit sites where residents dispose of their household waste. During floods, these hotspots release their contents into the river, causing pollution that drifts downstream for hundreds of kilometres before washing up on the shores and forming coastal macroplastic accumulations. In the past four years, projects such as 5 countries 1 river and the Project have effectively monitored macroplastic47 accumulations in the TRB by enlisting volunteers to report on pollution sites via an open-source smartphone application (Trashout)[80]. Volunteers have covered over 4,500 kilometres by foot to survey both shores and floodplains of the 962-kilometre-long Tisza River. The Clean

[78] https://www.interreg-danube.eu/approved-projects/tid-y-up/outputs
[79] https://www.frontiersin.org/articles/10.3389/fenvs.2022.912323/full
[80] https://www.trashout.ngo/

Tisza Map, developed in just two years, has now become a multilingual, responsive, up-to-date online river pollution map that contains more than 6100 polluted sites. The map can be filtered by composition and size of plastic deposit, river, and country, including Ukraine, Romania, Slovakia, Hungary, Serbia, and preliminary sections of the Lower Danube[81]. The contribution to the development of the pollution map has been significant, particularly in terms of expanding the database to cover other countries and rivers. The pollution map now covers a much broader range of waterways, from small tributaries to the Danube itself, resulting in a five-fold increase in the length of represented rivers. To ensure the accuracy of the map, developers utilised **geographical, hydrographical, and morphological data** provided by water authorities to represent the natural water bodies precisely. This upgrade has resulted in the pollution map no longer being limited to the TRB, which is significant because pollution, like rivers, does not recognise borders. As a result, this development represents a significant step forward in addressing riverine plastic pollution on a larger scale. Further ongoing research and publications are working on localising the accumulation points and the most polluted protected areas.[82]

Alternative methods for collecting reliable data on macroplastic pollution include remote sensing. The benefits of observing pollution dynamics from a safe distance, in real time, and possibly online, are evident. However, putting theory into practice is more challenging than it may seem. The list of remote sensing technologies for waste monitoring includes methods such as **tagging and tracking plastic items** in the environment, as well as analysing high-resolution aerial photographs or satellite images. The PlasticFreeDanube project by BOKU[83] has successfully applied GPS tagging to track riverine plastic waste. The survey, conducted on the Austrian section of the Danube, tagged plastic waste items of different sizes, and the preliminary results demonstrated that the primary current had a significant impact on the spatial pattern and movement of plastic waste particles[84]. However, the GPS tags have limited battery capacity and provide only a small window of time for monitoring purposes.

In the TRB, experts working on the Zero Waste Tisza project, funded by the Coca-Cola Foundation, have been able to tag multiple plastic bottles successfully. After initial setbacks, they found technical solutions to track the movement patterns of tagged bottles for months over hundreds of kilometres. According to their experience, the migration of plastic bottles is primarily driven by the main current. However, their large surface and small weight make them susceptible to the effects of wind, ice, and floating debris. The Zero Waste Tisza project supported the Project by providing trackers for testing. In conclusion, **GPS tagging** was successful in tracking the dynamics of plastic pollution in the Tisza River catchment area in both Romanian and Hungarian waters. The method revealed both new and previously identified coastal macroplastic accumulations. The data collected confirms the high waste retention capacity of HPPs.

Third generation of GPS-tracked bottles developed by Plastic Cup and Waterscope Inc. Photo: Plastic Cup

At the end of December 2020, a pilot tracer study was conducted in Freudenau, Vienna to estimate the **riverine litter retention potential** of HPPs. The study aimed to assess the concentration of floating macroplastics at the right riverbank, directly at the screen of the HPP, in discharges below 3000 m³/s. Larger plastic items, such as drink bottles, insulation panels, and waste from shipping were removed via mechanical screen cleaning ("gondola") or with a specialized gripper/crane. However, smaller plastic items like foils and fragments flow through the turbines. When the discharge is above 3000 m³/s, the weirs of the HPP overflow, diverting the floating items in the direction of the weirs. The tracer test showed that macroplastics can pass the HPP in this way.

[81] https://www.tisztatiszaterkep.hu/#/en/

[82] Molnar, A.D. et al. (2023): Monitoring coastal riverine litter accumulations in the Tisza River Basin

[83] https://www.viadonau.org/unternehmen/projektdatenbank/aktiv/plasticfreedanube/

[84] https://infothek.bmk.gv.at/gegen-die-plastikflut-in-der-donau/

To prevent litter overflows and macroplastics from entering the watershed, floating booms or barriers could be positioned on tributaries. Further surveys were conducted in the Project to characterise the litter stream captured by the HPPs. As an output, a "Handbook on the Introduction of Standard Procedures for the Assessment of Macroplastic in Fluvial Systems, including the Retention Capacity of Hydropower Plants and Other Barrier" was also compiled[85].

The **remote sensing** research activities from the aforementioned surveys focused on analysing satellite images to identify riverine plastic pollution, by inviting experts from Eötvös Loránd University (ELTE) in Budapest, Hungary for a case study. Sentinel-2 and PLANETSCOPE satellite images of multiple locations were examined, including upstream and downstream regions, hotspots, macroplastic deposits, and floating waste accumulations (jams). The initial results indicated that by analysing satellite images captured in the spring and summer months using four distinct wavelengths, it was possible to reliably detect floating plastic accumulations. For example, the debris in front of the Kisköre HPP could be separated from its surroundings using remote sensing. However, detecting coastal macroplastic accumulations in areas covered with vegetation requires further research, time, and a significantly greater number of satellite images[86].

3.3. Coordinated approach and planning (RBMPs and other policies & strategic plans)

Addressing the multifaceted challenge of riverine plastic pollution requires a coordinated effort of various sectors, including environmental protection, nature conservation, water management, waste management, disaster response, agricultural law, chemical safety, spatial planning, and construction law. A comprehensive, integrated, and cross-sectoral approach is essential to effectively tackle this complex issue. In particular, the challenges associated with transboundary rivers, such as the Tisza, underscore the need for decision-making processes that transcend national borders. When plastic waste originating from outside the EU enters a country's waterways, a lack of cooperation with neighbouring countries can hinder urgent efforts to address the problem. Without coordinated action, downstream countries such as Hungary may bear the brunt of the pollution and be left to deal with the problem alone. It is therefore crucial to foster international collaboration and engage in constructive dialogue to find lasting solutions to this pressing environmental issue.

Return to camp after a cold winter cleanup. Photo: Plastic Cup

[85] https://www.interreg-danube.eu/approved-projects/tid-y-up/outputs

[86] Molnar, A.D. (2023): Coupled Field and Numerical Analysis of Riverine Macroplastic (40th IAHR World Congress)

3.3.1. Roundtable meetings

The stakeholder community of the TRB benefits from **periodic roundtable meetings**, which provide an open forum for exchanging experience and coordinating river protection activities. Since 2016, these meetings have been held annually in Hungary, and in 2022, each country along the Tisza hosted such an event to involve local stakeholders with the capacity to act for cleaner rivers. The roundtables aim to eliminate gaps in cooperation between key players and high-level decision makers and enhance capacity building and cooperation in the affected regions (see Chapter 3.1.3.).

During these events, participants present their water protection, river management, and waste collection and treatment activities, and the results they have achieved. The exchange of knowledge and the cooperation among participants allow for better use of human and financial resources, making river protection efforts more effective through coordinated action. To facilitate participation and generate ideas, discussion topics and special facilitation methods like 'world café' and 'opera' methodology are employed. This format has effectively addressed plastic pollution challenges, including coordinating flood prevention and post-flood clean-up tasks, standardising detection and measurement techniques for sources and components of pollutants, and linking individual sub-basin management plans. Moreover, organisations that cooperate at these events can quickly apply for financing or solve cross-border challenges and tasks. For example, the Plastic Cup found sponsors for some of its activities at these events. Based on these successes, it is recommended that similar international consultations be held regularly, semi-annually or annually, in a different country or region in the DRB. Non-governmental organisations could facilitate these events, making them faster and more casual than formal cross-border negotiations, so they can facilitate collaborations and make them a valuable complement to official discussions.

<< Daily heavy load of the PETII waste collector ship during the IV. Bodrog Plastic Cup. Photo: Plastic Cup

3.4. Principles for Targeted and Hierarchical Implementation of Measures

The primary objectives of these recommendations are to implement a legislative system that enhances preventive measures, fosters circular economy, and prevents illegal dumping more effectively. These measures aim to facilitate the collection and disposal of river waste while considering the potential environmental impacts of the intervention.

Summary of the proposed measures (own graphic design)

3.5. TOP 10 findings

3.5.1. Recommendations proposed regarding prevention

Implementing a system for separated collection of plastic waste, as well as other waste streams, at both household and industrial levels, is just the beginning. Establishing waste management facilities that can handle larger amounts of plastic waste from citizens and industries, organising transport to larger facilities for sorting and storage, and developing infrastructure for reuse/recycling and safe disposal of communal waste are essential steps to address the issue of plastic pollution. However, education, communication, and awareness-raising efforts must also be implemented to prevent waste generation and tackle further pollution. While these measures may be in place in EU countries, they may be lacking, at least in part, in non-EU countries. Furthermore, these efforts must be supported by a regulatory framework that clearly outlines responsibilities and requirements.

1. To foster compliance with existing legislation, specific actions are required, with a particular focus on **preventing the production and release** of macro- and microplastics into the environment. This includes the transposition of the SUP Directive by extending plastic collection, increasing recycling rates, and enforcing producers' responsibility. To achieve this goal, the following measures should be implemented to strengthen the existing legal frameworks:

- Setting additional requirements for product design to promote the reuse of plastic products.
- Expanding the scope of regulations that prohibit the manufacturing and use of SUP products.
- Updating and improving cross-sectoral policies to achieve a comprehensive ban on SUP.
- Implementing DRS for PET bottles with a focus on achieving the 90% collection EU target by 2029 and reducing the use of PET bottles by developing a system of returnable glass bottles.
- Increasing the reuse quotas to reduce the overall amount of plastic waste.

- Imposing stricter penalties for improper disposal of plastic waste.
- Introducing mandatory labelling of products with the type of plastic used, to promote separate collection and recycling, and shifting the packaging industry towards mono-materials.
- Exploring and providing financial support for the development of biodegradable plastics in product segments where emissions to the environment cannot be avoided.
- Informing consumers and incentivising responsible consumer behaviour, in order to reduce litter from plastic products.

Policy measures should prioritise prevention by reducing the overall use of plastic products and promoting the reuse of manufactured products, in order to support resource conservation and the circular economy. To address **microplastic** challenges, it is recommended to enforce EU-wide ECO labels for a wide range of products (e.g. household and cosmetic products) and to finance legal initiatives that incorporate proven technological solutions to prevent primary and secondary microplastics from entering rivers. Stricter emission limits should be implemented and enforced for polluting sectors, including industrial activities, wastewater treatment, the energy sector, and agriculture. Leading countries that have successfully managed microplastic waste should share their technological solutions, and patent patterns should be unlocked for implementation.

A good initiative from the European Parliament is identifying the need for "right to repair" legislation. On 22 March 2023, the EC adopted a new proposal on common rules promoting the repair of goods[87].

2. **Enhancing the legal framework against environmental violations** and establishing effective mechanisms and tools to identify, sanction and prevent illegal dumping. Illegal dumping presents a complex challenge, as different countries face unique environmental and specific issues (see Chapter 3.2.2.1). Despite a well-developed legal framework that aligns with EU rules, there is still a need to increase enforcement to achieve the set objectives. Strengthening enforcement is critical for more efficient prevention, not only by improving administrative processes and organisational structures, but also by promoting cooperation among executive bodies and encouraging citizens to participate actively in enforcing the law[88].

3.5.2. Recommendations for Proper Treatment of Plastic Waste in Rivers

3. **PRC interventions:** One of the main findings of the Project is that it is no longer enough to prepare for future **plastic floods**, as these pollution waves are already overwhelming the biggest ecological corridors and floodplains in Central-Eastern Europe[89]. Developed countries with functional waste management systems are accustomed to the consequences of littering and occasional malfunctions in waste management, such as those caused by strong winds, floods, or low-level pollution. These plastic leakage events result in a relatively small but constant solid waste load in natural waterways, with up to 5 macro-plastic particles per minute contributing to the plastic pollution of rivers like the Seine, Rhein, or Elbe. However, plastic floods are a sign of fundamental and persistent issues in waste management in upstream regions. This is true not only in Asia, but also in the Eastern and the South-Eastern part of the DRB, where waterways transport orders of magnitude more plastic into the Black Sea (see Chapter 2.2.).

To effectively address riverine plastic pollution, it is important to understand its complex nature, which ranges from small-scale leakage to larger plastic floods. Leakage typically results from littering or temporary waste management malfunctions and constitutes a relatively small load of pollution (max. 5 macroplastic particles/minute). In contrast, plastic floods are periodic events that result from fundamental waste management problems in upstream regions. In the DRB, for example, 2–4 floods per year can occur, with the pollution wave lasting only a few days. Building permanent water engineering structures solely for the purpose of operating for a few days per year leads to unnecessary construction

[87] Proposal for a Directive on common rules promoting the repair of goods
[88] https://emla.hu/en/improving-access-to-justice/
[89] Winter plastic floods in the TRB video - https://youtu.be/gghjvbu3F3A
[90] https://wwfcee.org/pdf_collections/9/WWF-Potential%20of%20barrier%20removal%20report.pdf

and maintenance costs, as well as environmental, biodiversity damage both above and below the water surface[90].
To prevent these unwanted expenses and minimise environmental stress, mobile, versatile, and temporary litter traps are recommended to ensure easy transferability and comprehensiveness. These proposed solutions are based on best practices and innovative methods and do not require complete river closures. At the same time, cost-effective, permanent and continuously working monitoring and **PRC**[91] solutions can manage plastic leakage and waste accumulations attached to existing water engineering structures such as HPPs. Through these measures, we can manage plastic floods on a large scale and in motion, preventing contamination from accumulating and potentially reaching marine ecosystems.

4. CRC actions: Another way to manage transnational riverine litter pollution cases is to involve a wide range of stakeholders (NGOs, local communities, independent environmental initiatives, companies, and individual volunteers). By bringing together representatives from different sectors and disciplines, we can harness the power of CRC actions[92], which have become increasingly important mitigation measures in recent years. The Project published a handguide on transnational river clean-up to share expertise and knowledge[93]. The proposed solutions build on best practices and innovative ideas and require no complete river closures, enabling efficient management of plastic floods on a large scale well before contamination can form accumulations or reach marine ecosystems. In summary, this approach to riverine litter and pollution management is innovative and sustainable, involving a wide range of stakeholders and leveraging the power of community river clean-ups. By combining the professional and community approach, we can ensure that clean-up activities are ongoing all year round.

Joint pilot community river clean-up (CRC) action on the Slovakian Bodrog. Photo: Attila D. Molnar

5. Establish a harmonised monitoring system for macro- and microplastic pollution: To effectively target plastic pollution in the DRB, it is essential to establish a harmonised monitoring system for both macro- and microplastic pollution. Such a system should include the standardisation of definitions and sampling, testing, and assessment procedures (see Chapter 3.2.4.1). The monitoring system should be based on the following policy requirements:

- A standardised measurement method should be adopted to ensure that a shared database, based on comparable data, can be built and maintained, including data from all countries in the DRB.
- The standardisation of definitions and sampling, testing, analysing, and assessment procedures is crucial to ensure consistency and comparability of data across the region.
- Sampling measures should be easily applicable and reproducible, while also accurate and precise, to ensure reliable and representative data.
- Sample preparation and analysis protocols should be practical and user-friendly, enabling inter-laboratory comparisons.
- A unified, regular monitoring system for microplastic emitters, including WWTPs and other surface water sources (such as surface runoff from road dust), should be established.
- Initiatives and technologies to locate the sources and pathways of litter into national riverine systems should be supported by making the physical location of mapped plastic waste available to all.

The monitoring system should be aligned with the EU principles of open access to science, including establishing a publicly available and open portal with a database of data and measurements. This will enable researchers, policymakers, and the general public to access and download data describing the situation of the rivers. In addition to detailed datasets, periodic, short and easily comprehensible reports and infographics should also be accessible.

[91] PRC operation, https://drive.google.com/file/d/1FkddfXS_ndgOaPN9pp3xGW4W3goCO5vU/view
[92] Community river cleanup action, https://drive.google.com/file/d/1Ce9SNOX8SNTJqhM7da8VaEwj4bsZfrIb/view
[93] Molnár, A.D. et al. (2022), Aquatic Plastic I. - The Transnational River Cleanup Handguide, HAEE

6. **Improved wastewater management protocols.** When constructing or upgrading a WWTP, it is crucial to establish clear guidelines for the safe and effective treatment of wastewaters, including removing and treating micro- and macropollutants. This is particularly important in non-EU member states, where regulations may be less stringent. The **UWWTD** sets standards for proper treatment in EU member states, but the draft of the revised directive now proposes even stricter rules, such as the removal of micropollutants. Requirements for specific reduction targets or effluent limits on plastics can also be included in the guidelines. To begin, it is recommended to include monitoring requirements for urban wastewater and for the sludge and runoff waters from the treatment process to detect the presence of microplastics. This can help identify areas that need improvement and ensure that the WWTP is effectively removing microplastics. It is also essential to consider the proper disposal/adequate treatment of the removed pollutants, as improper disposal/treatment can lead to further contamination of the environment. In addition, the guidelines should emphasise the importance of using advanced treatment technologies that can effectively remove micro- and macropollutants from wastewater. This includes incorporating ozonisation and filtration with activated carbon, or other advanced techniques, like nano-filtration or membranes. Finally, the guidelines should emphasise the need for ongoing monitoring and evaluation of the WWTP's effectiveness. This can include regular water quality monitoring and inspections to identify any issues that may arise and to ensure that the WWTP is operating at maximum efficiency. By implementing these guidelines, we can ensure that WWTPs are effectively and safely treating wastewater and protecting our environment from harmful pollutants.

3.5.3. Recommendation regarding legal consequences

7. **Cross-border monitoring and alert system:** An organised and documented cooperation agreement between the two sides of the border is crucial to establish an enforcement plan and cross-border monitoring system (early-warning system) for flood prevention and river pollution (including plastic, municipal, and hazardous waste). Any **riverine waste management plan** should include a data management plan, an emergency plan, an alert notification procedure, joint exercises, and protocols for further required measures. Currently, a similar system exists in the DRB, but it focuses mainly on flood management and dissolved pollutants. To monitor cross-border riverine litter pollution more effectively, innovation and transnational cooperation is required. All river clean-up interventions – preventive or mitigative actions alike – have a carbon footprint and can cause various forms of environmental stress, such as damage to native vegetation, noise pollution, visual pollution, dust, etc. The negative side effects of these actions should not be underestimated, but rather balanced against the positive impacts they can achieve. To serve as an effective tool in the implementation of future riverine waste management plans, monitoring methods (such as GPS tagging or satellite imagery analysis) must be capable of providing continuous, up-to-date, and cost-effective data regarding the size, composition, and behaviour of riverine litter. This enables authorities, local communities, and other stakeholders to gain a clear understanding of the environmental challenges they face. Once this knowledge is available, they can proactively prepare and undertake preventive or mitigative actions for the future.

8. **Legal representation of natural entities:** It may be beneficial to provide adequate legal protection for rivers and the natural resources they hold. This can be achieved by involving specialised experts in law and natural sciences to provide effective legal representation for natural resources. Such measures can enhance the enforcement of environmental protection regulations. A remarkable example of granting legal representation to a river is the case of the Whanganui River in New Zealand, which has been recognised as a legal entity with rights. Similar initiatives have been implemented in other countries like Colombia, Ecuador, and India, where water bodies or ecosystems have been granted rights based on traditional and religious beliefs. In Europe, the Spanish lagoon Mar Menor was also granted legal personality in July 2022[94] due to its decreasing touristic value caused by pollution. These measures can strengthen the legal protection of natural resources and promote sustainable management practices.

Tour guiding at the River Rescue Center at Kisköre. Photo: Plastic Cup >>

[94] https://www.euronews.com/green/2022/09/22/spain-gives-personhood-status-to-mar-menor-salt-water-lagoon-in-european-first

9. Defining the problem: It is essential to have a precise definition of responsibilities for eliminating water pollution and managing collected waste at both national and international levels. Regulations must be established to clearly identify who is responsible for recycling and covering the costs of safe removal and disposal. Adequate financial resources and human power must be allocated to establish and operate such a system. Cooperation between public control and other enforcement bodies should be strengthened by defining the legal obligations in this regard. A good example of such a system would be if national EPR regulations were harmonised to provide financial support for cleaning rivers from the remnants of products under EPR. Producers should be held financially responsible for the clean-up and collection of their products.

3.5.4. Awareness raising and dissemination

10. Environmental education programmes: Raising awareness, educating, and communicating with citizens to change their behaviour and mindset are crucial for improving plastic waste prevention, recovery, recycling, and zero-waste implementation. It is essential to involve all stakeholders, such as decision makers, producers, citizens, NGOs, etc. and disseminate information about methods, results, and available infrastructure, such as community composting sites, recycling points, etc. Legislation, both at EU and national levels, should ensure that the third sector (e.g. voluntary and community organisations or social enterprises and cooperatives) and the general public are involved in preparing strategic or legislative documents. To tackle the complex problem of plastic pollution, legal and financial support must be provided to create platforms that link public authorities with the private sector and citizens. It is advised to integrate awareness-raising campaigns into school curricula and to teach children about waste prevention, zero-waste culture, and reducing consumption[95]. They should also learn about the impact of their lifestyle choices on waste generation and pollution. Society must understand the problem and act accordingly, using strategies ranging from less consumption and no littering to separate waste collection and treatment. It is proposed to apply and adapt the Ocean Literacy principles to natural waterways like streams, rivers, and lakes.

Part C

Implementation

4. Best practice examples

4.1. Policy making

Austria has demonstrated success in the rapid and consistent implementation of European laws, particularly in the implementation of the Landfill Directive. Landfill waste disposal in Austria is regulated by limit values, particularly the total organic carbon value of the waste, and the introduction of landfill taxes, which have made landfilling more expensive than incineration. Currently, about 35% of the municipal waste is separately collected, and more than 60% of the municipal waste undergoes thermal recovery in 11 waste incineration plants and in 51 co-incineration plants. Only a small amount ends its life in landfills.[96,97]

Slovakia's introduction of bulk collection in certain municipalities is an excellent example of how to reduce mixed municipal waste. Additionally, Slovakia, along with other EU countries, has established its DRS in 2022, already achieving high collection rates and expecting to reach over 90% within 2–3 years.

In **Hungary,** the sanctioning system imposes liability on the property owner if the act of waste abandoning does not constitute a criminal offence or the perpetrator cannot be identified. This regulation makes the property owner financially responsible for the clean-up and collection of the waste. Additionally, the regulation[98] allows road managers to use data recording systems to keep public roads clean. Road managers are obliged by law to ensure the application of the principles of personal data protection, particularly concerning data storage, purpose limitation, limited retention, and usability. Hungary will introduce DRS from 1 January 2024 (with a 6-months transition period).

Romania and Serbia are also working on implementing a DRS.

In **Romania**, an extensive information and education campaign launched in 2022, carried out by the environment authorities at the national level, aims to make the population responsible for the management and separate collection of waste ("Recycling in Romania"[99]). Romania aims to prevent the generation of waste and to improve waste management. Consequently, in the autumn of 2023[100] was introduced into the students' curriculum. In addition, the education and environmental authorities are developing a strategy on environmental education, implemented in school curriculum starting in the 2023–2024 school[101] Romania has developed a National Strategy[102] on Circular Economy and is currently finalizing its Action Plan for the Implementations of the National Strategy for Circular Economy[103]. A series of investments will be funded in waste infrastructure under the National Recovery and Resilience Plan.

In **Ukraine**, the Law on Restricting the Circulation of Plastic Bags on the Territory of Ukraine sets a good example (see Chapter 1.3.4).

[96] SecureFileAccess.aspx (oewav.at)
[97] https://www.bmk.gv.at/themen/klima_umwelt/abfall/aws/bundes_awp/bawp2023.html
[98] I. Act of 1988 About road trafficking (in Hungarian)
[99] https://reciclaminromania.ro/ ; https://www.youtube.com/watch?v=EwiqR5fDpB8; https://www.youtube.com/watch?v=ZOy1tewetOw
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4.2. Measure implementation

In the cosmetics industry, some manufacturers have voluntarily ceased using microplastics in their products, while others use the EU eco-label on rinse-off cosmetic products (2014/893/EU) to commit to removing microplastics.

Hungary has implemented door-to-door separate waste collection systems in several municipalities since 2018. Although the system is not yet well-supervised and enforced, it has been effective in channelling waste into a controlled mechanism instead of ending up in landfills. In 2021, the government introduced new measures for waste disposal, including stricter rules to tackle illegal dumping and the introduction of returnable glass, plastic bottles, and metal cans. These changes are expected to create a legal basis for the transition to a circular economy and to help eliminate domestic and imported illegal waste by strictly sanctioning those responsible. Hungary introduced the EPR system with a 35-year concession on 1 July 2023 (see Chapter 3.2.2.).

In **Austria**, the Packaging Coordination Agency has played a key role in successfully coordinating the separate collection of packaging waste. As the interface between recycling and collection systems, producers, end consumers, and disposal companies, it ensures the effective organisation of packaging waste collection. Additionally, **Sensoneo**, a waste management technology company, has introduced innovative hardware[104] to improve waste management operations in Austria. This technology includes waste volume measuring tools based on ultrasound and Radio Frequency Identity (RFID) chip technology installed in garbage cans or trucks. This has resulted in more efficient logistics and improved waste management operations, leading to better overall waste reduction and recycling efforts.

In **Serbia**, between 2018 and 2020, 17 towns and municipalities received support from the German Development Agency (GIZ) via the Climate Sensitive Waste Management project. It entailed a number of improvements, such asrevision of local waste management plans in line with circular economy principles; development/revision of regional waste management plans in the context of the circular economy; development and promotion of regional value chains in the waste sector; and introduction of waste separation at source, home composting, and construction of two central composting plants.

The government's goal is to provide 80% of the population with sewage infrastructure in the next five years, as well as to build more WWTPs. As part of the cooperation with Hungary, it has been announced that 10 new WWTPs and 351 kilometres of sewage network are to be built at 12 locations in Serbia. With similar goals in mind, cooperation with Germany's KfW Development Bank has also been started.[105]

In **Romania**, integrated municipal waste management systems have been developed, modernised and implemented as a model at the county level and at the city/municipal level. The financial support is extended to 2026 under the Recovery and Resilience Mechanism and as part of that, digitalised "ecological islands" (sets of containers) and collection centres are to be built through voluntary contribution. Their goal is to further separate collection of waste streams, including plastics.

In **PlasticFreeDanube** project, the Clear Waters' Romania Programme has been implemented by the Global Water Partnership (GWP) Association (GWP-ROMANIA) in partnership with the Lower Danube University in Galati, with the support of LIDL Romania. The programme represents a call for involvement in combating and preventing plastic pollution of the waters of the Danube and its tributaries, addressing members of the communities and public authorities in the targeted localities. In the project, the "GREEN CAT", a remote-controlled autonomous floating unit (drone type) was designed and operated to collect waste, mainly plastic and other types of small, discarded items, floating along the Romanian stretch of the Danube within the area of the towns Braila, Galati, and Tulcea. The Green Cat project got the Bronze award at the 2021 Innovation and Research Forum organized by the Lower Danube University in Galati, Romania.

[104] https://sensoneo.com/smart-waste-monitoring/

[105] Serbia invests billions of euros in wastewater treatment (balkangreenenergynews.com)

4.3. Clean-up actions and reuse/recycling

CRC and PRC actions help rivers in multiple ways, one of which is their awareness-raising potential about the practical value of riverine litter. It is highly recommended to enable the selection and separation of riverine litter (light, heavy fractions) already in the water, even before containment and collection. This approach ensures that organic waste, such as driftwood and organic debris, is not mixed with recyclable materials like plastics, glass, and metal during the clean-up operation. Based on the observations of the Hungarian Association of Environmental Enterprises (HAEE) and THU during their community initiative called Plastic Cup[106], the rate of recycled and upcycled materials can exceed 65% out of the 100% mixed riverine litter collected. They have internationally recognised procedures and experience in making products out of circular raw materials. Besides their practical value, products made from recycled riverine litter have a significant awareness-raising effect. Kayaks, canoes, traditional fishing boats, and textiles made from riverine litter attract special attention from all sides, including shipping, fishing, sports, industry, and eco- and active tourism. This approach not only addresses the issue of litter in our rivers but also showcases the value of sustainable materials and raises awareness among the public about the importance of responsible waste management.

Toolkit for everyone. The Aquatic Plastic Clean-up[107], developed as part of the Tid(y)Up Project, serves as a comprehensive guide for organising river clean-up events at various scales. Whether it's a small local initiative or a large-scale international intervention, the handbook offers practical advice, tips, and guidelines on how to conduct these activities and manage the collected waste efficiently. With numerous challenges and obstacles associated with river clean-ups, the handbook provides valuable insights on how to address these challenges and improve the efficiency of these initiatives.

4.4. Awareness raising, workshops and capacity-building events

The Project aims to raise awareness among the general public about transnational river pollution and to encourage changes in consumption habits and household waste management. One of the primary outcomes of this effort is the **FLEX**, which has already visited five countries in the Danube basin. The exhibition, constructed from recycled and reclaimed materials, is housed on a renewed ferry boat and features videos and installations that demonstrate the origin, magnitude, and distribution of plastic pollution in rivers, as well as potential solutions through innovative recycling. The exhibition is multilingual, making it accessible to a broad audience, and it aims to generate closer connections between people and their rivers.

The zero waste Floating Exhibition (FLEX) Photo: Plastic Cup

[106] THU and HAEE have unrivaled experience in the selection of riverine litter, https://drive.google.com/file/d/1J6E_SKIxMQAoxZGDjkv-FMAW6D4NeH9A/view

[107] Molnár, A.D. et al. (2022), Aquatic Plastic I. - The Transnational River Cleanup Handguide, HAEE

One of the remarkable features of the Plastic Cup is its extensive awareness-raising infrastructure, which includes the mobile and container-based **Riverine Trash-lab**[108]. This innovative platform offers a unique opportunity for schoolchildren to witness and participate in the enchanting transformation of plastic waste into new, useful items, such as pens, carabiners, rulers, and more. Since its launch in May 2021, the Plastic Lab has been continuously travelling, reaching out to numerous pupils in Hungary, Slovakia, Romania, Bulgaria, and Transcarpathia. This mobile platform plays a crucial role in educating the younger generation about plastic pollution, promoting sustainable practices and encouraging creativity and innovation to turn waste into resources.

The Project offers a comprehensive **Waste Reduction Toolkit**[109], that provides guidance to local municipalities, schools, residents, and businesses on how to prevent waste and manage it efficiently. The toolkit offers practical tips and advice on reducing waste generation, optimising resource use, and saving money. To promote best practices, the toolkit includes a guide[110] free posters, and infographics that can be easily disseminated.

Another exciting initiative within the toolkit is the **RiverSaver qualification** system, designed to promote sustainability among NGOs dealing with riverine litter as well as restaurants and buffets along waterways. This system – originally developed in the Erasmus+ 5in1 project for RiverSaver schools – will encourage businesses to adopt environmentally responsible practices that minimise their impact on the riverine environment. By recognising and promoting establishments that adhere to these standards, this qualification system will help to shift the catering industry towards more sustainable practices. This initiative is particularly relevant, as experience has shown that shoreline buffets and restaurants can be a significant source of riverine plastic pollution. It was recognised that there is a need for collective action to address this issue and to take proactive steps towards promoting responsible practices among businesses operating along waterways.

In **Austria**, Waste Watchers are empowered to issue warnings and fines to violators, and they have been submitting reports to the Water Law Department since 2017. The funds collected from fines are designated for further cleaning operations in Vienna. Waste Watchers also serve an informative role: they provided around 19,000 consultations last year. In 2020, they produced portable ashtrays from PET blanks, which they distributed to smokers, free of charge.

The Slovakian-developed, free, open-source smartphone application TrashOut provides a platform for mapping illegal dumpsites. Since its launch in 2021, over 8,731 illegal sites have been reported through the app. Municipalities can incorporate customised widgets to inform citizens about the current state of landfills in their area. The western regions of Slovakia have been particularly active in combating illegal dumping via TrashOut; in 2019, 500 illegal landfills were reported, and they have all since been cleaned up. Additionally, TrashOut facilitates communication between citizens and municipal governments.

In **Hungary**, the regular Tisza Roundtable has become an international best practice, with its practical and beneficial approach (see Chapter 3.3.1).

In **Serbia**, a project to strengthen the Aarhus Centres[111], operating in 14 countries, is being implemented to help the transition to a circular economy and more efficient use of natural resources. The aim is to increase capacity, exchange experience, redistribute smaller donations to local activities, and develop strategies, plans, and laws, using tools developed within the Aarhus and Espoo Conventions.

Another noteworthy initiative took place in September 2022 in **Romania**, where residents of 65 cities could ride public transport for free in exchange for waste in the Romania Change PET campaign. Kaufland Romania and the Ministry of Environment organised the action on the occasion of European Mobility Week. In every Kaufland store, residents received free public transport tickets in exchange for every five pieces of waste brought to the collection machines, including PET, aluminium cans, and glass. This initiative is an excellent example of synergetic event organisation.

[108] https://petkupa.hu/hu_HU/muanyagmuhely
[109] Hungarian Association of Environmental Enterprises (2022): Waste Reduction Toolkit - downloadable here: https://kszgysz.hu/en/knowledge
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5. Follow-up activities

The following part is a non-exhaustive but illustrative list to explore what other projects have been created in the wake of the Project and to show the afterlife of this initiative.

In the framework of the Interreg programme, the application of **Aquatic Plastic** has been positively evaluated and will present a comprehensive action plan to reduce plastic pollution in the Danube basin, building on the experience of the flagship Tid(y)Up project. The consortium aims to implement on-site clean-up actions in heavily polluted floodplains, set up a remote-sensing macroplastic monitoring system, extend the microplastic assessment to the Balkans, and engage stakeholders to improve legislation and raise awareness in all partner countries. This ambitious proposal highlights the ripple effects of the Project and demonstrates the potential for impactful collaboration between international organisations and local stakeholders. The project will be launched 1 January 2024.

The **Styx Initiative** is a promising project application, currently under assessment in the Horizon Europe programme. Its main strategic objectives are to prevent the formation of riverine litter accumulations through effective monitoring of macroplastics and microplastics in European rivers. They aim to achieve it by intercepting floating riverine litter particles while in motion and retrieving them from the environment. Additionally, the initiative plans to turn the recovered aquatic plastic into circular raw material to keep waste streams in the loop. The Styx Initiative also aims to provide support for the development, testing, analysis and validation of innovative technologies, along with existing and new river clean-up protocols and procedures. This will be achieved through technology, knowledge, and data sharing. Overall, the project aims to contribute to the reduction of plastic pollution in Europe's rivers and oceans, and to promote a more sustainable use of resources.

The **RISK MP project**, funded by the PIACI KFI programme (2020-1.1.2-PIACI-KFI-2021-00239), is a 4-year research initiative led by Eurofins Analytical Services Hungary Ltd. in collaboration with the Hungarian University of Agriculture and Life Sciences and the University of Pannonia. The project, which began in 2021, aims to investigate microplastics in freshwater systems, with a focus on identifying sources of contamination from WWTPs and atmospheric deposition. The project takes a comprehensive approach, considering not only the microplastic particles, but also their potential role as vectors for the transport of microbiological and chemical pollutants. The goal of the RISK MP project is to develop multiparametric investigation systems that can accurately analyse the environmental risks associated with microplastics and inform effective mitigation strategies.

The **DALIA (Danube Region Water Lighthouse Action)** project is a collaboration of 22 expert organisations, including universities, authorities, small- and medium-sized enterprises (SMEs) and NGOs, from 8 different Danube and associated countries. Together, they possess an outstanding set of knowledge, covering not only the basin geographically, but also all the different fields of expertise necessary to deal with the multidisciplinary issues from source to sea. The project aims to bring an integrated DALIA tool to the DRB, which will be integrated into the Danube Mission Hub for better decisionmaking and to improve the restoration of fresh and transitional water ecosystems. The tool will provide options for strategies and policies that concern freshwater ecosystem protection and ecosystem connectivity in the DRB, as well as improve the security of local communities and ecosystems from extreme events and pollution threats.

The **Plastic Cup** is a grassroots social innovation led by Plastic Cup Society, which organises annual international river clean-up events, team-building activities, and awareness-raising initiatives. The active involvement of volunteers has been instrumental in the success of the Plastic Cup initiative and the sustained motivation of regional communities.

The **River Lit(t)eracy** is a continuation of the 5 countries 1 river Erasmus+ project that was implemented in the TRB. The project's goal is to adapt best practices from around the world, such as the Ocean Literacy principles, to educate and raise awareness among the public about river and plastic pollution. The aim is to cultivate a new generation who are literate in these matters and are actively engaged in combating plastic pollution in their local communities.

The closing ceremony of the IV. Tisza-Lake Plastic Cup. Photo: Plastic Cup

The **Call-Action**[112] project, funded by Diageo company in 2022, aims to support separate waste collection and improve waste management in Transcarpathia, Ukraine. The 2-year initiative seeks to improve the living conditions of at least 120,000 people living along the Tisza by bringing tonnes of valuable sorted waste back into the recycle loop and creating employment opportunities in the region. The project planned to collect, select, and manage at least 690 tonnes of waste during its lifetime, but until November 2023 more than 1100 tonnes of waste were collected. The initiative has increased waste collection capacity in Uzhhorod, Berehove and the surrounding region.[113]

In 2019, Coca-Cola Foundation began supporting the cleaning of the Tisza River, as they regard reducing, collecting, and recycling packaging materials as a matter of great concern. The Zero **Waste Tisza project**[114] allowed them to expand their participation and spread their activities to other areas. Their financial support provides an opportunity for Plastic Cup and water authority experts to organise more frequent and diverse actions. Due to the project's remarkable success, the fourth phase of the Zero Waste Tisza project will be launched in the beginning of 2024.

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