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Danube Transnational Programme
Tid(y)Up

Policy Guidance on Managing Riverine Plastic Waste in the Danube River Basin

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Authors (in alphabetical order): Ádám Kovács, Attila Dávid Molnár, Gábor Bordós, Gergely Hankó, Imre Király, Orsolya Keményffy
Contributors (in alphabetical order): Gudrun Obersteiner, Csaba Markó, Krisztina Wégner, Miklós Gyalai-Korpos, Sabine Lenz, Zoltán Toronyi

List of abbreviations

AEWS – Accident Emergency Warning System
CEE – Central and Eastern Europe
CfPs – Co-creation for Policy processes
CRCs – Community River Cleanups
CSRD – Corporate Social Responsibility Directive
DRB – Danube River Basin
DRBMP – Danube River Basin Management Plan
DRPC – Danube River Protection Convention
DRS – Deposit Return System
ELV – End-of-Life Vehicles
ENI-UA – European Neighbourhood Instrument – Ukraine
EPR – Extended Producer Responsibility
EPR – Extended Producer Responsibility
EPR – Extended Producer Responsibility
ERDF partner – European Union Regional Development Fund partner
ESPR – Ecodesign for Sustainable Products Regulation
EU WFD – EU Waste Framework Directive
EUSDR – EU Strategy for the Danube Region
HPPs – Hydropower Plants
ICPDR – International Commission for the Protection of the Danube River
INC – Intergovernmental committee
IPA – Integration Partnership Agreement
IPPC Directives – Integrated Pollution Prevention and Control
MPP – Microplastic Pollution
MPs – Microplastics
MS – member state
NFRD – Non-Financial Reporting Directive
NGO – non-governmental organisation
OECD – Organisation for Economic Co-operation and Development
PET – polyethylene
PP – polypropylene
PRCs – Professional River Cleanups
PS – polystyrol
R&D – Research and development
RBMP – River Basin Management Plan
RBMPs – River basin Management Plans
REACH – “Registration, Evaluation, Authorisation and restriction of chemicals” EU Directive
RFID – Radio Frequency Identity
SBR – Styrene-Butadiene Rubber
SMEs – Small and Medium-sized Enterprises
SUP – Directive on single-use plastics
SUP Directive – Single-Use Plastics Directive
THU – Naturefilm.hu Society
TNMN – Transnational Monitoring Network

UWWTD – Urban Wastewater Treatment Directive
WEEE – Waste from Electrical and Electronic Equipment
WFD – Water Framework Directive

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Foreword

The distribution, amounts, and occurrence of marine litter, including its precursor, riverine litter, have become a pressing global issue. The adverse impacts of the aquatic plastic pollution have raised widespread concerns among experts, decision-makers, and the general public. Improper waste management practices, especially those related to plastic waste, have caused significant damage to natural ecosystems. Waterways act as conveyors between landlocked areas and marine environments, but in the process, they become severely polluted.

For far too long, we have ignored the complexity of the environmental and socio-economic crisis posed by marine and riverine litter. However, there is still time for the application of collective and comprehensive solutions. While proper waste management and wastewater treatment facilities are important for achieving good water quality in natural water bodies, they alone are not enough. 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.

This policy paper was prepared as part of the Danube Interreg project Tid(y)Up. The International Commission for the Protection of the Danube River (ICPDR) closely monitored the project's results and requested the elaboration of a list of recommendations for addressing transboundary riverine litter pollution (Resolution of the 25th Ordinary Meeting of the ICPDR, held in Vienna, Austria, on 13–14 December 2022). Based on the findings of Tid(y)Up, this document provides an overview of plastic pollution in rivers within the Danube River Basin (DRB), with a special focus on the causes of this environmental issue, including waste management, water management, and environmental education. This document is primarily intended to:

- **provide** strategic and legislative recommendations to all levels of legislation, including the ICPDR and EUSDR, and to inform stakeholders of the notable achievements and key findings of the Tid(y)Up project;
- **offer** guidance on reducing plastic pollution based on the project partners' extensive practical waste management experience, joint efforts, awareness-raising campaigns, and lobbying of decision makers at the state-level;
- **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. This includes

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.

1 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[1]. Its ultimate goal is to ensure that all water bodies, including rivers, lakes, groundwater and coastal waters, achieve good ecological status by 2027 at 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 programs of measures to implement the RBMPs, and to monitor and report on the ecological status of water bodies.

The Danube River Basin District is one of the largest in Europe, covering an area of over 800,000 km^2 inhabited by around 80 million people[2]. The WFD has played a significant role in improving the water quality of the Danube and its tributaries, through 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 Tid(y)Up project, and the resulting recommendations, aim to address this issue and support the implementation of the WFD in the Danube River Basin.

The cooperation of countries in managing river basins has been recognised as crucial for ensuring the protection and sustainable use of water resources. This need for cooperation was formalised in 1994 with the signing of the Danube River Protection Convention (DRPC), which established the International Commission for the Protection of the Danube River (ICPDR) to implement the Convention. The ICPDR comprises 14 cooperating states[3] and the European Union, and is responsible for the management of the entire Danube River Basin, including its tributaries and groundwater resources. The signing of the DRPC signifies the commitment of participating countries to collaborate on sustainable water management practices, including pollution reduction. In February 2022, the participants of the ICPDR Ministerial Meeting reaffirmed their commitment to these goals by signing the **Danube Declaration**[4]. The declaration serves as a reminder of the importance of cooperation and the need to prioritise sustainable water management practices to protect the Danube River Basin and its valuable resources.

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

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

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

[4] Danube Declaration (download)

As a response, the ICPDR countries, including non-EU member states, agreed to implement the WFD across the entire DRB, under the coordination of the ICPDR. To achieve these objectives, the ICPDR developed its first **Danube River Basin Management Plan** (DRBMP) in 2009, which was updated in 2021. However, to translate this general plan into practical steps and address local-scale challenges, every participating country must prepare a more specific and detailed plan at the national level, called the **River Management Plan** (RMP). Apart from this framework, there is also the **EU Strategy for the Danube Region** (EUSDR), a macro-regional strategy adopted by the European Commission in December 2010 and endorsed by the European Council in 2011. The Strategy was jointly developed by the Commission, Danube Region countries, and stakeholders to address common challenges. The EUSDR aims to create synergies and coordination between existing policies and initiatives across the Danube Region.

Section 2.1.9.3 of the DRBMP highlights plastic pollution as a high-priority issue, which is crucial in light of the repeated waves of plastic pollution - known as plastic floods - and other forms of riverine litter that flow into the Danube from upstream countries, including non-EU Ukraine. The pollution typically takes the form of visible floating plastic bottles, which can be considered as riverine macroplastics. However, microplastics also pose a significant threat to the balance and overall health of freshwater ecosystems, further adding to the list of ways that thermoplastic polymers, or plastics, can cause harm.

Currently, most Danube countries are failing to address the issue of riverine litter, including macro- and microplastic pollution, in its entirety. Typically, the environmental problem is only partially addressed by the national strategy for waste- or water management. The **Tid(y)Up project**[5] consortium[6] initially aimed to reduce plastic pollution along the Tisza River, one of Europe's most heavily plastic-contaminated rivers. The project was led by the Hungarian NGO Naturefilm.hu Society (THU), the parent organisation and organiser of the Plastic Cup initiative[7]. The non-governmental environmental initiative Plastic Cup has already removed over 300 tons of riverine litter from the Tisza River Basin (TRB) and demonstrated that over 60% of the riverine litter can be recycled once properly treated. Tid(y)Up extended the good practices developed by Plastic Cup from the TRB to the lower Danube River Basin (DRB) and implemented international community river cleanup actions in Ukraine, Romania, Serbia, and Bulgaria. In addition to river cleanups, Tid(y)Up placed special emphasis on research and conducted a comprehensive methodological study to compare different methods for monitoring microplastic particles in natural waters. The project partners also developed and launched a set of integrated actions and consultations, providing tools for relevant stakeholders. They also initiated long-term transboundary and intersectional cooperation to monitor and eliminate plastic pollution in rivers, and helped prevent pollution in upstream countries by introducing sound waste management procedures and implementing awareness-raising strategies.

The Tid(y)Up project achieved significant results, including the removal of tonnes of selective riverine litter, the development of a comprehensive handbook on the implementation of transnational river cleanup actions, and the creation of a zero-waste educational Floating Exhibition. One of the project's

[5] Tid(y)Up Project home page

[6] 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

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

major accomplishments however is the development of this policy paper for the ICPDR, which served as an associated partner in the project. The paper draws on the project partners' vast and joint experience in practical riverine cleanups, waste management, organising collaborative efforts, carrying out awareness-raising campaigns, and lobbying decision-makers at the state level to offer guidance on reducing plastic pollution. This collaborative effort between Tid(y)Up and the ICPDR is a significant contribution to the ongoing efforts to address plastic pollution in the DRB.

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

In late 2021, the Tid(y)Up project partnership conducted a comprehensive assessment[8] (hereafter referred to as the "Study") of the partners' legislative systems for preserving the good quality of surface water bodies. The Study examined the international and national legal frameworks of **environmental protection rules** and the region's water and waste management regulations and practices to better understand the complexity of riverine litter pollution in the Danube River Basin (DRB) and address the recurring plastic flood events. The assessment focused on the relevant legal frameworks of the project partner countries and the international legislation of the Danube region, highlighting potential inefficient regulatory practices and the most critical country-specific circumstances.

The overall assessment revealed that while environmental regulations related to natural waterways in the partner countries are well defined, principles are clear and present - sometimes even at the constitutional level -enforcement however, is generally weak. While sustainability, the protection of natural resources, and the natural heritage of future generations are often expressed as objectives, they are rarely put into practice. This approach does not currently take precedence over other laws. The rights and interests of future generations are not always considered directly by public authorities or judicial decisions. In other cases, the structure of enforcement and the lack of cooperation between the executive bodies involved hinder proper law enforcement. Despite the EU's advanced and comprehensive environmental and sustainability-related legislation, sometimes it still fails to achieve its objectives due to a lack of effective enforcement. Public authorities alone cannot solve this deficiency, and the involvement of active citizens and civil society organisations is crucial to support public authorities in their work and achieve desired goals.

Throughout the implementation of the EU Water Framework Directive (WFD), new integrated, ecosystem-based **water management plans** were introduced in the partner countries, which included the protection of water resources, improvement, and sustainable use of freshwater. The first river basin management plans were published between the end of 2009 and the middle of 2010, outlining measures required to achieve good ecological and chemical status in water bodies 'at risk' of failing to meet these targets. It is worth noting that progress with WFD implementation is reviewed every six years, and the next planning cycle is expected for 2027.

In addition to environmental protection and water management, **waste management** regulations in partner countries were also assessed in the Study. The report presented 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 precautionary and sustainability principles, or **Extended Producer Responsibility** (EPR) are partially applied in some countries, there is still an urgent need to transition towards a circular economy. Although the introduction of EPR increased the demand for recyclable packaging materials, waste landfill rates are still high, except for Austria. Furthermore, illegal or untreated waste disposal is still prevalent in almost

[8] Survey of the National Legislative System on Surface Water Quality, 6th of December 2021 (download)

all partner countries. This issue was particularly relevant in Ukraine, Serbia and Romania, struggling with the illegal deposition of household waste along riverbanks**.**

Transnational cooperation on riverine litter pollution is essential to tackle the problem effectively. Although there have been improvements in bilateral and multilateral agreements since 2020, a small fraction of these agreements deal with the issue comprehensively. The increasing amount of mismanaged waste, especially plastics, in natural waterways generates significant waste collection and elimination costs. Unfortunately, expenses related to mitigation efforts are rarely compensated by the country of origin or the receiver, leaving the water management authorities to bear the cost. In most countries, water management authorities do not have an allocated budget to deal with such emergency cases, making it difficult to respond effectively. However, Hungary has been an exception as it has had a financial allocation for water quality remediation and investments since 2019, which has made a significant difference in water protection, triggering new innovations and cooperation in this area.

The **Danube Declaration**, the latest international development, is a crucial step towards achieving sustainability goals in the Danube River Basin (DRB) through integrated water management. By recognising plastic pollution as a distinct category of surface water pollutants, it commits to maintaining existing measures and implementing additional actions to prevent and reduce waste. The International Commission for the Protection of the Danube River (ICPDR) aims to develop policy recommendations on riverine litter pollution and improve the safety of management facilities at the national level, thereby establishing an enabling regulatory framework for pollution control. Transnational cooperation is crucial to this end, and ICPDR is committed to supporting and updating the Danube Transnational Monitoring Network[9] and the Danube Accident Emergency Warning System[10].

One example of successful cooperation in the region is the common hydrographic **telemetry system** of the Hungarian Upper-Tisza Directorate and the Ukrainian Transcarpathian Water Management Directorate. Established in 2003, this joint Hungarian-Ukrainian system enables partners to access each other's instantaneous measurements and archived datasets. With **152 stations, 104 in Hungary and 48 in Ukraine**, the system serves as a model for effective collaboration. While there are several examples of collaboration between the water and waste management sectors, more must be done to promote industrial symbiosis between water organisations and waste management companies. Additionally, cooperation between NGOs, civil society organisations, and government bodies must be emphasised and supported. However, in some surveyed countries, civil society is still developing and has little weight in decision-making.

1.3. Policy context and related drivers

1.3.1. Global efforts

On March 2, 2022, a historic resolution was endorsed by representatives from 175 nations at the UN Environment Assembly in Nairobi. The resolution established an intergovernmental negotiating committee (INC)[11] with the aim of completing a **legally binding agreement** by the end of 2024 to end plastic pollution. This agreement will address the entire lifecycle of plastics, including the design of reusable and recyclable products and materials, and the need for enhanced international collaboration. Open-ended working groups were organised for stakeholders impacted by the proposed international instrument, and their input will help to ensure faster adaptation of the

[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

instruments in practice. This global-level effort is a significant step towards addressing the issue of plastic pollution.

The **Global Commitment 2022**[12], led by the Ellen MacArthur Foundation in collaboration with the UN Environment Programme. The Global Commitment has united over 500 organisations behind a common vision of a circular economy for plastics. These organisations, representing 20% of all plastic packaging produced globally, have committed to ambitious targets for 2025 aimed at tackling plastic pollution at its source. The Global Commitment is an excellent example of how collective action and collaboration can lead to concrete solutions for a pressing environmental issue.

The **Ocean Literacy**[13] program, which originated in the US in 2002, has been primarily focused on developing STEM education resources, lesson plans, and activities. However, with the adoption of the UN's Sustainable Development Goal 14, there has been a notable shift towards incorporating approaches more closely aligned with the UNESCO framework for Education for Sustainable Development (ESD). The updated approach recognises the importance of engaging learners with the knowledge, skills, and values necessary to contribute to sustainable development, including a greater emphasis on social, economic, and environmental sustainability. This shift in focus acknowledges the interdependence between human activities and ocean health and highlights the need for a holistic approach to ocean literacy education that fosters critical thinking, problem-solving, and action towards a more sustainable future.

1.3.2. EU-level efforts

The **European Green Deal**[14] is a comprehensive plan to make Europe the first carbon-neutral continent by 2030 and to tackle environmental degradation. Among its priorities are reducing water pollution, transitioning to a circular economy, and improving waste management. To support the EU Green Deal, several funding mechanisms are already in place, with over €1 trillion in investments expected to be mobilised over the next decade. To protect European citizens and ecosystems from various forms of water pollution, the EU must 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**[15] 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 produce less waste, and therefore, companies, states, and the EU must invest directly in sustainable projects and activities. However, to achieve this, a common language and clear definition of what constitutes "sustainable" in practice are needed. The **EU Taxonomy**[16] was developed to create a level playing field for stakeholders and provide a classification system for environmentally sustainable activities. The Commission 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. The European Commission has

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

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

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

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

[16] 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

also released a proposal for the new **Corporate Social Responsibility Directive**[17] (CSRD) in conjunction with the introduction of the taxonomy. The CSRD aims to establish a new sustainability reporting framework starting from 2023 and will replace the Non-Financial Reporting Directive (NFRD) which was previously in effect. This new reporting system will serve as 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**[18] (2008/98/EC) establishes the fundamental concepts and definitions related to waste management, serving as a direct legal instrument. It sets out basic waste management principles and introduces the "Polluter Pays Principle" and "Extended Producer Responsibility." These ensure, among other obligations, the financial responsibility of polluters and producers throughout Europe for their end-of-life products, including plastics.

As part of the EU's circular economy action plan[19], the **European Plastic Strategy**[20] builds on 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. By 2030, all plastic packaging should be recyclable. The **Directive on single-use plastics**[21] (SUP) aims to reduce the volume and impact of plastic products and is a one-of-a-kind regulation that addresses the root of the problem by banning certain products from the EU markets where sustainable alternatives are readily available and affordable. These products include cotton bud sticks, cutlery, plates, straws, stirrers, and bars for balloons, as well as cups, food and beverage containers made of expanded polystyrene, and all products made of oxo-degradable plastic. These measures aim to achieve a "measurable quantitative reduction" by 2026 compared to 2022 through actions such as national consumption reduction targets, promotion of reusable alternatives, and marketing restrictions. Member states must notify the EU of the measures and report on their compliance[22].

For other single-use plastic products, the EU is focusing on limiting their use by reducing consumption through awareness raising, introducing design and labelling requirements, providing information on plastic content and environmental harm, and introducing Extended Producer Responsibility schemes. The European Commission published a **Guideline**[23] (31 May 2021) to facilitate the directive's implementation in national law, and a **Commission Implementing Decision**[24] was issued in 2022 on the calculation, verification, and reporting of reduction in the consumption of specific single-use plastics and the measures taken by Member States to achieve such reduction. By January 1, 2023, all single-use plastic food containers must be purchased (no free lunch), and their prices must be

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

[18] Waste Framework Directive (europa.eu)

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

[20] Eu plastic strategy (europa.eu)

[21] 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)

[22] 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.

[23] (2021/C 216/01) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.C_.2021.216.01.0001.01.ENG&toc=OJ%3AC%3A2021%3A216%3ATOC

[24] Commission Implementing Decision (EU) 2022/162 of 4 February 2022 laying down rules for the application of Directive (EU) 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

indicated on the receipts. While some loopholes have been identified, a comprehensive survey[25] conducted in September 2022 found that a large majority of EU member states are now on track to implement the Single-Use Plastic Directive together with its various measures. The EU also aims to promote the use of recycled materials, including plastics, by setting binding targets[26] for recycled material content for 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 European Commission has also released a communication[27] emphasising the importance of making sustainable products the norm. This communication highlights the proposed Ecodesign for Sustainable Products Regulation (ESPR), which will establish a framework for setting ecodesign and information requirements for specific product categories. The ESPR aims to significantly improve the circularity, energy performance, and other environmental sustainability aspects of products. Although the upcoming **Digital-Product-Passport[28]** regulation in the EU does not specifically address plastics and packaging as separate products, knowing the true environmental impact of a purchase could have a significant impact on customers. This regulatory approach seeks to stimulate more sustainable product designs while offering immense possibilities to educate customers by providing reliable data on their purchases. The adoption of the **Plastic Bags Directive[29]** aimed to address the unsustainable consumption rates of plastic products, with lightweight plastic carrier bags being among Europe's top ten littered items. Member states are required to take measures, including national reduction targets, economic instruments (e.g., fees, taxes), and marketing restrictions (bans), provided that they are 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. As of December 31, 2018, lightweight plastic carrier bags should only 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[30]. The European Commission 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[31].

Filtering has become a leading issue in the home appliance industry in response to microplastic pollution. APPLiA (Home Appliance Europe) is contributing to developing reliable scientific data to understand the extent of microplastic release in the environment, not exclusively originating from

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

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

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

[28] https://www.digitaleurope.org/digital-product-passport/

[29] 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

[30] 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

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

packaging. They supported a literature review on "Microplastics emissions from textile laundry including emission scenarios for the EU.[32]" A **Consortium[33]** of affected companies is also seeking possible solutions, such as filtering microplastics out of the wastewater of laundry machines. These innovations are currently in a testing period. Furthermore, the "Water Quality" Priority Area (PA4) 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[34]. This group of materials includes microplastics (MPs), emphasising the importance of taking action against their release.

The **Ocean Literacy Framework[35]** was originally developed for use in the United States, but its impact has since spread globally. The framework has inspired several significant efforts to promote ocean literacy, including conferences and meetings in countries such as Portugal, Japan, Belgium, Chile, Australia, Fiji, and Italy. In addition, organisations such as the European Marine Science Educators Association have also dedicated themselves to promoting ocean literacy. The European Commission has recognised the importance of ocean literacy and has funded two large H2020 initiatives, Sea Change and ResponSEAble, to spread awareness and understanding of the seas across 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.

In **Slovakia**, Act no. 302/2019 Coll. Disposable Beverage Packaging came into force on 1 January 2022. It deals with the collection of disposable packaging for beverages and the waste from those packages (including cans). The deposit amount is uniform for PET bottles and cans, at 15 Euro Cents, which may be a sufficient incentive to prevent 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 was purchased. An exception is made for packaging of dairy products and drinks for hygiene reasons.

Hungary has adopted legislation to phase out single-use plastics and banned several single-use plastic products and packaging materials from 1 July 2021, in line with EU legislation. Thanks to Greenpeace

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

[33] https://www.applia-europe.eu/images/John/Consortium_PDF-converted.pdf

[34] https://ec.europa.eu/commission/presscorner/detail/en/qanda_22_6281

[35] Unesco Ocean Literacy portal 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/

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

Hungary's campaign, supported by a quarter of a million people, the Hungarian law also includes a restriction on the use of plastic bags. According to a recent announcement, the Hungarian government aims to introduce a PET bottle deposit system in 2024.

In **Bulgaria**, lightweight plastic carrier bags with less than 25-micron-thick walls are prohibited from being placed on the market. A plan to introduce a monetary deposit system for plastic, aluminium, and glass packaging is currently in development in **Romania**. According to the project, consumers will pay an extra 0.5 RON (around 0.10 EUR) for these products, which could be reimbursed if the packaging is returned to specially designated collection areas or any shop that sells these types of products. The legislation is set to be adopted, and the necessary infrastructure is expected to be functioning in 2022.

1.3.4. Non-EU member states

Countries such as **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 and 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 typically dispose of garbage however they can, which typically involves burning, burying, or dumping it in a floodplain forest. 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 is nonexistent 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.

The Russian invasion of Ukraine has made an already dire situation in the region worse. 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, local administrations, and 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 from 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.

EcoBus – Alternative solution for separated collection in UzhgorodRiverine 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 depend 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)

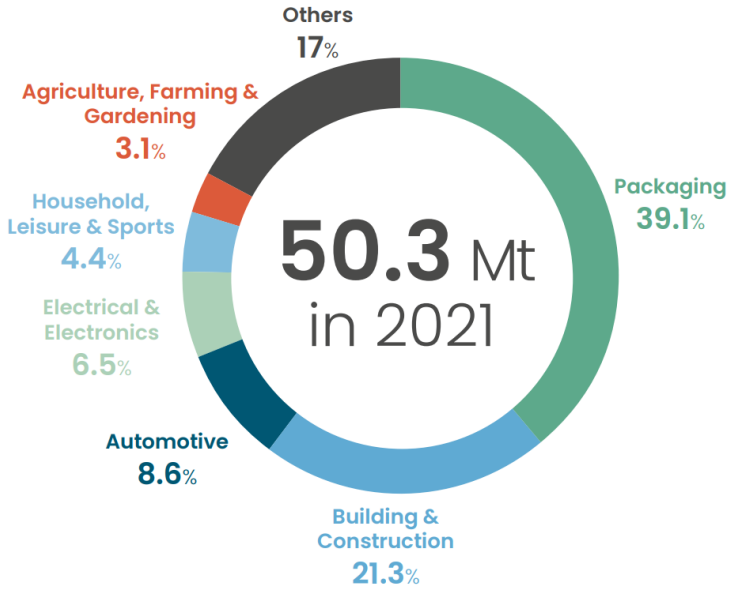
2. Plastic pollution in the rivers of the DRB

2.1. Current status

2.1.1. Plastic production and its impacts on the environment

Global plastic production has continued to rise, after a short stagnation due to the COVID pandemic, and exceeding the 390 million tonnes in 2021, with no signs of slowing down. The European Union (and other three EFTA member states on the continent) alone produced more than 57 million tonnes of plastic in the same year[39]. 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. In the EU, beside the same two leading end-users of the plastics the third largest market is the automotive industry, the fourth are the producers of different electronics and electrical equipment. Together, these sectors consume around three-fourths of all plastic products. Despite the high levels of plastic consumption, only 10.3 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.



Source: Plastics - the Facts 2022 • Plastics Europe

The packaging sector has a pivotal role to play in boosting the recycling rates of the EU Member States. This industry is mostly using PE (high and low density also), PP and PET, covering altogether almost 40% of the overall plastic consumption in the EU. These products have the shortest lifespan and give the largest amount of waste (in bulk and in mass, also) from the enumerated industries, but they have the largest potential to be easily collected and easily cleaned before recycling, also.

The longest product lifespan is the characteristic in 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

[39] Plastics - the Facts 2022 • Plastics Europe

can mean additional problems. This also means that 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], followed by PP and PE. 69 % of all PVC produced is used in building and construction industry. Although this sector is usually known for its energy-related effects, the huge amount of generated waste, and the low-level of recycling makes it an important actor also in the field of plastic waste management.

The automotive industry and the electronics usually use more unique plastics beside the well-known PP or PUR. The variety of the plastic materials, the complicated components of a given part or device makes the recycling process difficult.

The textile industry in the EU was not taken into account in the former sections, due to methodological reasons[39]. From other source[41], rough estimations can be done: 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. 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 Ais exported. A minimal part is recycled into fibres.

Promoting sustainable fibre choices and control of microplastic emissions, and 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 European Commission identified textiles as a priority product category with significant potential for circularity. Improved separate collection (which will be eparate collection of textile waste will be obligatory in all Member States by 1 January 2025 due to the EU Waste Framework Directive).

Plastic products undoubtedly have many benefits, including their versatility, durability, and resource-saving capabilities. For example, plastic products can help save fuel in the transportation industry due to their lightweight, reduce CO_2 emissions through the use of plastic foams for thermal insulation, and help prevent food waste with the use of plastic packaging's excellent preservation abilities. 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 this, 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[42].

The EU's Single-Use Plastics 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 production and waste management trends continue, it is estimated that roughly 12 billion tonnes of plastic waste will be in landfills or in the natural environment by 2050.

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

[41] Plastic in textiles: towards a circular economy for synthetic textiles in Europe

[42] www.recyclass.eu

Shockingly, some projections suggest that oceans will carry more plastic mass than fish by that time, and an estimated 99% of seabirds will have ingested plastic[43]. 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 through waste leakage in floodplains, caused by mismanagement and illegal dumping. ii.) Microplastics, on the other hand, are released into the environment through every day and industrial activities, such as using synthetic textiles or car tires that release tiny particles into the waterways[44].

2.1.2. 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. While the most affected by polluted rivers are to be found in Asia and Africa, there is evidence of litter 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[45]. The Danube Region has a diverse population of 83 million people, living in various settings ranging from highly industrialised urban areas to underdeveloped rural locations, leading to various impacts on nature and water quality. The EUSDR recognises the need to address this issue, and one of its 12 Priority Areas is the Water Quality Priority Area, which focuses on studying and preparing for new types of pollution, such as plastic and microplastic.

The collection of data on riverine litter and plastic pollution is hindered by the lack of widely used and officially accepted thresholds, as well as the absence of cost-effective and widely accepted sampling and measurement standards. 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**[46] project; the Plastic Pirates Go Europe! project; the Joint Danube- and Joint Tisza Surveys, the 5 countries 1 river (5in1) Erasmus+ programme and the Danube Transnational Programme (DTP) Tid(y)Up project are all excellent examples to collect data, raise awareness and combat 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.

In addition to environmental education and citizen science activities such as the Riverine Trashlab and the Floating Exhibition (**FLEX**)[47], the DTP Tid(y)Up project has also taken on the crucial task of mapping the most significant coastal macroplastic accumulations. This effort has resulted in the creation of the **Clean Tisza map**[48]. This interactive database provides the public with real-time and open access information about the location of macroplastic deposits within the Tisza River Basin. Compiled through the use of 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 Danube River Basin countries like Bulgaria. The Clean Tisza map is a valuable tool for understanding and addressing the issue of riverine

[43] 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.

[44] Plastic Pollution of Rivers in the Danube Region published by the Ministry of Foreign Affairs and Trade of Hungary

[45] Lechner et al., Danube River releases 530–1,500 tonnes of plastic into the Black Sea annually, 2014

[46] https://plasticfreeconnected.com/

[47] https://www.interreg-danube.eu/news-and-events/programme-news-and-events/7848

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

litter pollution in the region, including the implementation of transboundary, international community river cleanup interventions[49].

When **putting riverine litter pollution into numbers**, water authorities, water management- and engineering companies can provide valuable information about the amount of floating and drifting waste. In Hungary, water authority directorates FETIVIZIG and KÖTIVIZIG have compiled datasets indicating a sudden increase in the annual influx of transboundary riverine litter. Since 2019, FETIVIZIG has successfully removed 80% of the combined riverine litter from the Upper Tisza River and the Szamos (Someș) River, with an average amount of 2605 cubic metres collected per year. Similarly, KÖTIVIZIG has been tracking and researching riverine litter at the Kisköre hydroelectric-power plant (HPP) since 2007, with data showing a nearly doubled annual influx of riverine litter since 2017. Between 2019 and 2021, KÖTIVIZIG removed 8220 m^3 of mixed riverine litter yearly, including 347 cubic metres of solid waste, equivalent to 27 tonnes of riverine waste (mostly aquatic plastic) per year. 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 screenings 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 power plants, 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, 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 about 1500 tonnes of plastic per year into the Black Sea.

2.1.3. Microplastics

Microplastics (MPs), the non-visible fraction of aquatic plastic pollutants, have recently become a prominent focus of scientific research due to their potential hazardous effects on the environment. Recognising their significance, all across the EU projects are launched to gather sufficient data on riverine MP pollution. One such example is **The Act for Tomorrow**[50], 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 DTP Tid(y)Up project[51].

A pioneer study on the Danube River was conducted in spring 2014 in cooperation with the University of Natural Resources and Life Sciences (BOKU), the Austrian waterway company **Viadonau**[52], and the Environmental Agency Austria[53]. 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, and the total plastic load amounts to up to 41 tonnes/year at the same site. The study also

[49] Molnar, A.D. & Hanko, G.: Aquatic Plastic – The transnational River Cleanup Handguide, 2022

[50] Act for Tomorrow Association: Study summary

[51] https://kszgysz.hu/en/interreg/more-new-innovations-and-cooperations-at-the-tisza-roundtable

[52] Danube Watch 3/2016: Plastics and microplastics in the Danube River

[53] https://www.umweltbundesamt.at/fileadmin/site/publikationen/rep0551.pdf

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 R&D project with university partners, **Wessling** Hungary Ltd. conducted the first exploratory microplastic analysis in the Carpathian Basin in 2017. MPs were found to be 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[54].

In 2018, Wessling Hungary Ltd. initiated the **Tiny Plastic Puzzle project**[55] 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, may be a source of microplastic pollution. The project also contributed to developing a more 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[56]. The survey used mass data (in µg/mg) and identified polyethylene (PE) as the most predominant polymer, followed by polystyrene (PS), SBR, and PP. No detailed survey has been conducted yet for the Tisza River. In 2017, Wessling Hungary Ltd. carried out the first microplastic measurement of the Tisza River during the fifth Plastic Cup international community river cleanup action. The sample from Dombrád contained 4.9 plastic particles larger than 300 µm per m^3, and 23.1 particles per m^3 larger than 100 µm. The most common types of plastic particles were polyethylene, polypropylene, and polystyrene. Information on microplastics in other water bodies in the Danube River Basin is also insufficient. In 2018, Wessling Hungary Ltd. measured microplastics from 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 per m^3 detected. In contrast, Rába, which is surrounded by industrial sites in Hungary and Austria, showed higher numbers, with 12.1 particles per m^3 composed of uniquely determined types of plastics and not the commonly used ones.

Inspired and largely influenced by predecessor projects mentioned above, the Tid(y)Up Project in the Danube River and its tributary, the Tisza River, microplastic measurements were conducted at **multiple sampling sites**[57]. During the Tid(y)Up Project, microplastic measurements were conducted in multiple locations along the Danube 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).

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

[54] https://www.sciencedirect.com/science/article/abs/pii/S0045653518319714

[55] www.mikromuanyag.hu

[56] https://pubs.acs.org/doi/10.1021/acsestwater.1c00439

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

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, while polyethylene was the main cause of pollution, followed by polypropylene, polystyrene, 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, the size range from 50 µm to 1000 µm was 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, as done with the pump method, compared to net sampling on the fraction 500 - 1000µm. Samples collected in the sedimentation box were more integrated 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 MP pollution and also sedimentation or remobilisation.

As part of the EUSDR PA4 activities, Wessling Hungary Ltd. conducted MP analysis in **wastewater treatment plants** (WWTPs) and the recipient Danube River[58]. 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 MPs 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 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 polypropylene and, in effluents and surface water, polystyrene. The influents showed more diverse MPs in terms of polymer type, with polyoxymethylene and polyester detected in several samples.

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

Part B – Strategy

3. Waste management

3.1. Policy tools and recommendations for the DRB countries[59]

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 unnecessary 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[60]

The decision maker has 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**[61]. 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 a circular economy, can also be utilised. For example, specifications for compostable plastics, such as ISO 17088:2021, or a **recyclability certification form** can be used[62]. It has become clear across all product streams that waste prevention cannot be achieved without 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

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

[60] 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.

[61] 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

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

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.

Regularly reviewing the legal regime can ensure that the system can adapt to new challenges, developments, and inventions. For instance, the study suggests that member states should regularly review the measures implemented to enforce the Single-Use Plastics Directive[63] 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 single-use plastic items should be extended. To monitor progress, it is essential to ensure consistency and comparability of 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 more frequently with a more holistic approach, ensuring coordination between implementing bodies in related sectors. This would strengthen regional and transboundary cooperation on micro- and macro-pollutants 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 investments and mining activities. Industrial activities, such as the cyanide pollution of the Tisza River in 2000 and the mine drainage water pollution of the Sajó (Slaná) River in 2022, are among the leading causes of river pollution, but there are no separate budgets to finance compensation for emergency damages or remediation of polluted areas and riverbeds. While EU law requires large, dangerous industrial facilities to have emergency and environmental damage plans and insurance, these are based on the "polluter pays" principle. In

[63] 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.

cases of compulsory liquidation or major pollution, however, the sources of the cause may be insufficient. Similar financial problems exist for **"historical" pollution**, in which case the responsibility falls on the background state[64]. 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.

An excellent example of financial tools is the use of levies, such as the **tax on single-use plastic 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 being 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. Moving away from the end-of-pipe 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 **extended producer responsibility** (EPR) is a good example that holds producers responsible for collecting and recycling specified volumes of plastic that they produce and place into the market. **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 programs. One example is **deposit refund schemes**, 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 that incorporate bans on single-use plastic 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, a combination of financial tools, such as levies, fees, refunds, and incentives, can be employed to drive behaviour change and achieve environmental goals. These tools can be used to 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 ensuring 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 CSR directive 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

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

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 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 among 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 from 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 Tid(y)Up project's **Roundtable discussions**, it is recommended to implement tools like the EU Policy Lab[65] and methodologies like Co-Creation for Policy processes (CfPs)[66]. These steps can help to support democratic advocacy processes in Central and Eastern European 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 in addressing 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 the establishment of 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 from targeted revenues, should also be provided to enable the implementation of these initiatives and to ensure their long-term sustainability.

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

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

3.1.4. Service and Infrastructure

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

The implementation and **optimisation of Extended Producer Responsibility** (EPR) systems is another possible solution to support separate collection of plastic waste. Furthermore, curbing landfilling and preventing illegal dumping play a critical role in the fight against plastic pollution. Even though 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 is still occurring. 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 measuring prioritisation

In the Tid(y)Up 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 of the Study.

3.2.1. Water-management

In this subchapter, only general recommendations will be discussed as the latest update of the **Danube River Basin Management Plan** (2021) provides detailed information on water-management-related issues ("water services" in the Plan) in different countries. In several Danube countries, the water and wastewater networks and 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 wastewater regarding the population, while the Czech Republic, Slovakia, and Hungary are close to that value. Further east, this ratio is getting smaller. 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. One suggestion of the study is to introduce planning and improve water quality monitoring, especially for new kinds of polluters like microplastics. The new proposal for Urban Wastewater Treatment Directive is already addressing this issue. Other effective measures could 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 cannot be entirely discussed as a waste management issue. As reported earlier, riverine litter consisting of various forms of pollutants, such as plastic, glass, metal, communal, toxic waste, requires a combination of tools applied by waste- and water-management sectors.

3.2.2. National waste management practices

According the Survey, In **Serbia**, the lack of proper collection infrastructure has led to large amounts of packaging waste being disposed of in landfills or 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 plastics from packaging waste. One effective solution could be the implementation of a Deposit Refund System (DRS) for single-use beverage containers, which has been successful in reducing 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 cleanup 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 lack of classification of waste according to the Slovakian Waste Catalogue by some organised but illegal and non-supervised waste disposal systems 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, with the installation of 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 being taken by recycling companies is leading to illegal imports disguised as legal ones, 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.

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 to develop and strengthen an efficient and effective collection system. However, a significant step towards a more well-managed and sustainable waste management system is the introduction of a 35-year concession starting in July 2023. The awarded bidder will be responsible for providing municipal waste management services as a single licensor in the country, covering the entire industry value chain, including around 4.5-5 million tonnes per year of municipal solid waste similar to household waste. The Hungarian petrochemical giant company, MOL, has been awarded the concession. The new system will also cover all products falling under extended producer responsibility (EPR) rules, in compliance with EU and specific Hungarian regulations such as ELV, WEEE, batteries and accumulators, packaging, tyres, office and advertising papers, wooden furniture, single-use

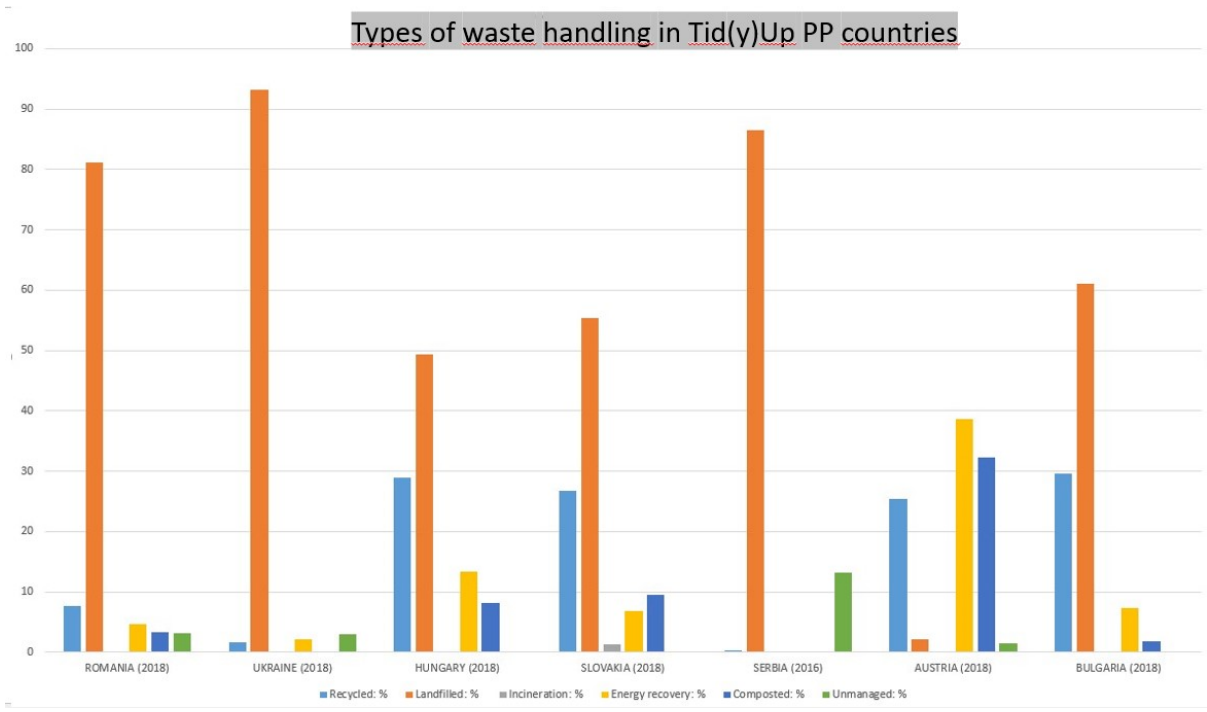
plastics, textiles, and edible oils and fats. An obligatory deposit-refund system will also be introduced from January 1, 2024, for plastic, metal, and glass beverage containers, with similar measures for laminated paper and edible oil packaging to be implemented later. All waste from these products collected by the licensor will be owned by the State, and the licensor will be responsible for arranging 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, landfill, EPR, SUP, and beyond.

In **Austria** the most part of the waste is undergoing thermal recycling, so thus less than 10% goes to landfills. The deposit return system is commonly used, but it can be developed further. Repairing is popular[67].

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 the government 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.

3.2.2.1. Improper waste disposal

The problem of **illegal waste dumping** 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 the human resources and financial capacity to systematically collect, monitor, and analyse relevant data, making capacity building essential.



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

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

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 wastewater treatment plants in small settlements is crucial to prevent pollution from households at the source.

In **Hungary**, stricter penalties are recommended for uncontrolled and illegal disposal of waste, 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 deter illegal dumping. An IT system based on marketing principles would also be essential for effective follow-up.

In **Romania**, the waste collection system needs improvement to address the problem of illegal waste imports. With better rules and 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.

3.2.3. Organisational structure

Austria faces challenges with unified law enforcement due to the lack of federal regulation for nature conservation. A counter-measure against the illegal waste deposition is the “Waste Watchers” system, see section 5.4.

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

In **Hungary**, the absence of a dedicated Ministry for the Environment for many years has led to fragmented administrative bodies and convoluted operational procedures, making it difficult to enforce responsibility for environment protection and nature conservation in a unified manner. This has the potential to 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**, the high level of politicisation in executive bodies and low levels of professional expertise make effective enforcement difficult. To remedy this, it is recommended to form a body of civil servants based on their expertise and merits.

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 are without SWM.

Furthermore, at this point it has to be noted, that the Ukrainian national first level controller (FLC) faced language barriers and lack of competence, and subsequently vetoed the funding of both Ukrainian Tid(y)Up partners, making entering extremely difficult for Ukrainian partners 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

Based on the previous chapter, it is evident that there is sporadic, but continuous, gathering of data 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 program that can develop a comprehensive database. This program 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 part of the **Tid(y)Up** project, three existing 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 require the development of easily applicable and reproducible methods. The three 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 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 delivered in December 2022[68].

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 wastewater treatment plants and other surface water sources such as road dust runoff[69]. 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 DTP's Tid(y)Up project has employed three distinct methods - citizen science, 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** 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 cleanup actions. Hotspots are the primary source of riverine plastic pollution, 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

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

[69] https://www.frontiersin.org/articles/10.3389/fenvs.2022.912323/full

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 Tid(y)Up have effectively monitored macroplastic accumulations in the Tisza River Basin by enlisting volunteers to report on pollution sites via an open-source smartphone application (Trashout)[70]. Volunteers have covered over 4,500 kilometres by foot to survey both shores and floodplains of the 962-kilometre-long Tisza River. The Clean Tisza Map, developed in just two years, has now become a multilingual, responsive, up-to-date online river pollution map that contains more than 5,000 polluted sites. The map can be filtered by composition, size of plastic deposit, river, and country, including Ukraine, Romania, Slovakia, Hungary, Serbia, and preliminary sections of the Lower Danube[71]. 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, 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 precisely represent the natural water bodies. This upgrade has resulted in the pollution map no longer being limited to the TRB, which is significant as 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.

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 Tid(y)Up partner BOKU (Austria)[72] 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 demonstrate that the primary current has a significant impact on the spatial pattern and movement of plastic waste particles[73]. However, the GPS tags have limited battery capacity and provide only a small time window for monitoring purposes.

In the Tisza River Basin, 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 has supported Tid(y)Up by providing trackers for testing. In conclusion, **GPS tagging** was successful in tracking the dynamics of plastic pollution in the Tisza river water 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.

At the end of December 2020, a pilot tracer study was conducted in Freudenau, Vienna to estimate the **riverine litter retention potential** of hydroelectric power plants (HPPs). The study aimed to assess the concentration of floating macroplastics at the right riverbank, directly at the screen of the HPP,

[70] https://www.trashout.ngo/

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

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

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

for discharges below 3000 m³/s. Larger plastic items such as drink bottles, insulation panels, and shipping waste were removed through mechanical screen cleaning ("gondola") or with a separate 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 are overflowed, causing the floating items to be deflected in the direction of the weirs. The tracer test showed that macroplastics can pass the HPP in this way. To prevent litter overflows, floating booms or barriers could be positioned on tributaries to prevent macroplastics from entering the watershed. Further surveys are being conducted in the Tid(y)Up 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 Barriers" will also be delivered[74].

DTP's Tid(y)Up's preliminary **remote sensing research** activities focused on analysing satellite images to identify riverine plastic pollution, by inviting experts from Eötvös Loránd University of Sciences (ELTE) in Budapest, Hungary for a case study. Sentinel-2 and PLANETSCOPE satellite images were examined in multiple locations, including upstream and downstream regions, hotspots, macroplastic deposits, and floating waste accumulations (jams). The initial results indicate that by analysing satellite images captured in the spring and summer months using four distinct wavelengths, it is possible to reliably detect floating plastic accumulations. For example, the debris in front of the Kisköre HEPP 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.

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

Addressing the multifaceted challenge of riverine plastic pollution requires a coordinated effort among various sectors, including those focused on 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 European Union enters Hungary'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.

3.3.1. Roundtable meetings

The stakeholder community of the Tisza river basin benefits from **periodic roundtable meetings**, which provide an open forum for exchanging experiences 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 enhance capacity building in the affected regions.

During these events, participants present their water protection, river management, waste collection and treatment activities, and the results they have achieved. The exchange of knowledge and

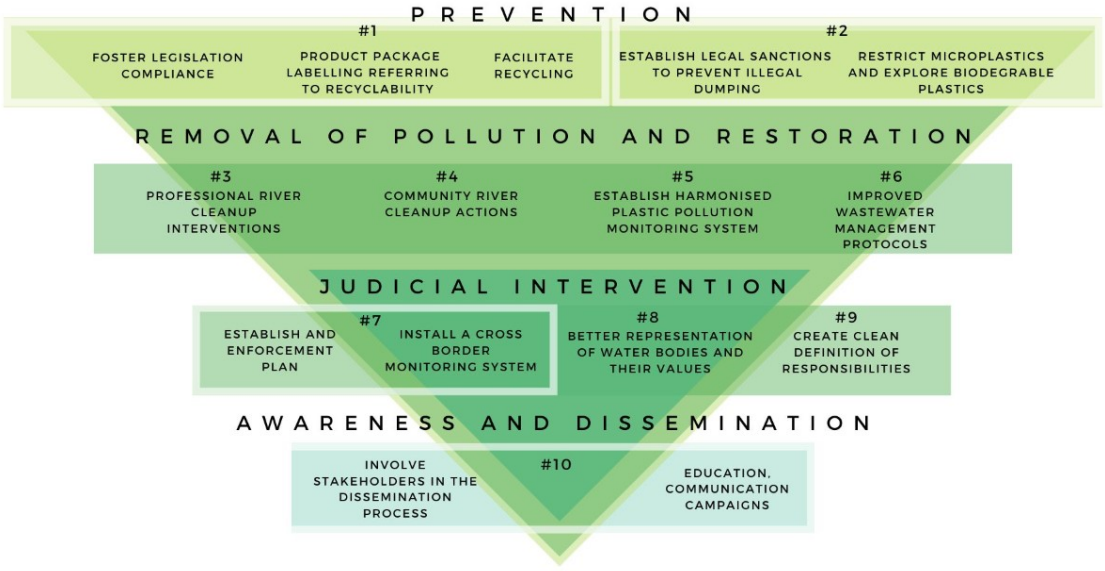
[74] https://www.interreg-danube.eu/approved-projects/tid-y-up/outputs

cooperation among participants allows 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 cafe' and 'opera' methodology are provided. This format has been effective in addressing plastic pollution challenges, including coordinating flood prevention and post-flood cleanup 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 experiences, it is recommended that similar international consultations be held regularly, semi-annually, or annually in a different country or region in the Danube River Basin. Non-governmental organisations could facilitate these events, making them faster and more casual than formal cross-border negotiations, which can facilitate negotiations and make them a valuable complement to official discussions.

4. Recommendations

4.1. Principles for Targeted and Hierarchical Implementation of Measures

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



4.2. TOP 10 findings

4.2.1. 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 establishing 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 in order to prevent the generation of waste 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 Single-Use Plastics (SUP) Directive by extending plastic collection, increasing recycling rates, and enforcing producer 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 single-use plastic products.
- Updating and improving cross-sectoral policies to achieve a comprehensive ban on single-use plastics.
- Implementing a deposit scheme for PET bottles with a focus on achieving the EU's target of 90% collection 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.

Policy measures should prioritise prevention by reducing the overall use of plastic products and promoting the reuse of manufactured products to support resource conservation and the circular economy. To address **microplastic** challenges, the Study recommends enforcing EU-wide ECO labels for a wide range of products (e.g., household and cosmetic products) and financing 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 (e.g., mining and chemical production), 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 the need for “Right to repair” legislation. In 22nd November 2023, the European Commission adopted a new proposal on common rules promoting the repair of goods[75].

2. Enhancing the legal framework for 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 3.2.2.1). Despite a well-developed legal framework that aligns with EU rules, there is a need to increase enforcement to achieve the set objectives. Strengthening enforcement is critical for more efficient prevention, not only through improving administrative processes and organisational structures, but

[75] Proposal for a Directive on common rules promoting the repair of goods

also by promoting cooperation among executive bodies and encouraging citizens to participate actively in enforcing the law[76].

4.2.2. Recommendations for Proper Treatment of Plastic Waste in Rivers

3. Professional river cleanup interventions. One of the main findings of the Tid(y)Up 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[77]. In developed countries with functional waste management systems, we 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-South-Eastern part of the Danube River Basin, where waterways transport orders of magnitude more plastic into the Black Sea.

To effectively address riverine plastic pollution, it's 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 macro-plastic particles/minute). In contrast, plastic floods are periodic events that result from fundamental waste management problems in upstream regions. In the Danube River Basin, for example, we see 2-4 floods per year, 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 (5-10 days) leads to unnecessary construction and maintenance costs, as well as environmental damage. To prevent these unwanted expenses and minimise environmental stress, we propose the application of mobile, versatile and temporary litter traps. Permanent structures have a negative impact on the environment both above and below the water surface[78]. At the same time, cost-effective, permanent and continuously working monitoring and **professional river cleanup**[79] (PRC) solutions can manage plastic leakage and waste accumulations attached to existing water engineering structures such as HEPPs. For managing plastic floods during high waters, we recommend using temporary and efficient installations and applications to ensure easy transferability and comprehensiveness. These proposed solutions are based on best practices and innovative methods and do not require complete river closures. 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. Community river cleanup 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 community river cleanup actions[80] (CRCs), which have become increasingly important mitigation measures in recent years. Tid(y)Up partners - along with Plastic Cup volunteers - have significant experience in large-scale transnational CRCs in the Danube River Basin and have been actively involved in the implementation of river cleanup

[76] https://emla.hu/en/improving-access-to-justice/

[77] Winter plastic floods in the TRB video - https://youtu.be/gghjvbu3F3A

[78] https://wwfcee.org/pdf_collections/9/WWF-Potential%20of%20barrier%20removal%20report.pdf

[79] Professional river cleanup operation, illustration

[80] Community river cleanup action, illustration

actions in six countries. Over the past ten years, we have cleaned 743 coastal riverine litter accumulations, managed approximately 300 tons of riverine waste (most of which has been recycled), mainly through CRCs, and provided continuous support for large-scale professional river cleanups on four sites in two countries. By combining the professional and community approach, we can ensure that cleanup activities are ongoing all year round. 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 is able to form accumulations or reach marine ecosystems. The partners have also published a handguide on transnational river cleanup to share their expertise and knowledge. 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 cleanups. Their solutions build on best practices and innovative ideas and have proven effective in managing riverine waste on a large scale while minimising the impact on the environment.

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, as demonstrated in the microplastic chapter (see 3.2.4.1). To this end, the Tid(y)Up Study has formulated recommendations for improving the legal environment and policy framework, presented in a similar form to the waste hierarchy. One of the key recommendations is the establishment of a monitoring system for plastic pollution, which 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 Danube River Basin (DBR).
- The standardisation of definitions and sampling, testing, 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 wastewater plants 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 reports and infographics should also be accessible and easy to understand.

6. Improved wastewater management protocols. When constructing or upgrading a wastewater treatment plant, it is crucial to establish clear guidelines for the safe and effective disposal of wastewater, including removing and treating micro- and macro-pollutants. This is particularly important in non-EU member states, where regulations may be less stringent. The **Urban Wastewater Treatment Directive** (UWWTD) sets standards for proper treatment in EU member states, but 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 sewage sludge to detect the presence of microplastics. This can help identify areas that need improvement and ensure that the treatment plant is effectively removing microplastics. It is also essential to consider the proper disposal of the removed pollutants, as improper disposal 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 macro-pollutants from wastewater. This includes incorporating filtration, activated carbon, or membrane bioreactors, among others. The use of these technologies will not only ensure the safe disposal of wastewater but also help reduce the impact of pollution on the environment. Finally, the guidelines should emphasise the need for ongoing monitoring and evaluation of the wastewater treatment plant's effectiveness. This can include regular water quality testing and inspections to identify any issues that may arise and to ensure that the treatment plant is operating at maximum efficiency. By implementing these guidelines, we can ensure that wastewater treatment plants are effectively and safely disposing of wastewater and protecting our environment from harmful pollutants.

4.2.3. 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 river water pollution, including plastic, other municipal, and hazardous waste. This cooperation agreement should include a data management plan, emergency plan sharing, joint exercises, and protocols. Currently, in the DRB, such a system exists, but it focuses solely on chemical pollution. Therefore, broadening the scope to plastic pollution is recommended. To monitor cross-border pollution more effectively, camera surveillance systems shall be installed. This way, authorities can better prepare for and promptly remediate any pollution incidents.

8. Legal representation of natural entities. It can 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[81] due to its decreasing touristic value caused by pollution. These measures can strengthen the legal protection of natural resources and promote sustainable management practices.

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 Extended Producer Responsibility (EPR) regulations were harmonised to provide

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

financial support for cleaning rivers from the remnants of products under EPR. Producers should be held financially responsible for the cleanup and collection of their products.

4.2.4. Awareness-raising and dissemination

10. Environmental education programmes. Raising awareness, educating, and communicating with citizens to change their behaviour and mindset are crucial in 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. Integrating awareness-raising campaigns into school curricula and teaching children about waste prevention, zero-waste culture, and reducing consumption is advised. 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 selective waste collection and treatment. As the result of DTP Tid(y)Up and the Erasmus+ 5in1 projects, we propose the application and adaptation of Ocean Literacy principles to natural waterways like streams, rivers and lakes.

Part C – Implementation

5. Best practice examples

5.1. 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. ~~As a result, 71% of plastics waste in Austria was incinerated, 28% was recycled, and only 1% was landfilled in 2015.~~ Currently, about 40% of the municipal waste undergoes thermal recovery in 11 waste incineration plants and in 51 co-incineration plants. And almost the 60 % of the municipal waste is recycled.

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 cleanup and collection of the waste. Additionally, the regulation[82] 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.

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 deposit return system (DRS) in 2022, already achieving high collection rates and expecting to reach over 90% within 2-3 years. Hungary, Romania, and Serbia are also working on implementing a DRS system.

In **Romania**, there is a legislative proposal for the creation of a particular prosecutorial body under the General Prosecutor's Office, with a focus on illegal logging, non-compliance with pollution prevention rules, and killing protected species. Although the law was adopted by Parliament last year, the Constitutional Court found it to breach the Constitution, so it is currently back in parliamentary procedure and not yet in force.

In **Ukraine** the Law "On Restricting the Circulation of Plastic Bags on the Territory of Ukraine" is a good example (see in Chapter 1.3.4)

5.2. 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 eliminating microplastics.

Hungary has implemented door-to-door 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 and 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. In Hungary, producers of beverage goods will be held

[82] I. Act of 1988 About road trafficking

accountable for the post-consumer stage of the waste generated from their products, including organisational and financial responsibilities, in line with the EU packaging directive. This measure will be implemented in the middle of 2023 by a single country-wide licensor.

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[83] to improve waste management operations in Austria. This technology includes waste volume measuring tools based on ultrasound and 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.

According the Study, in **Serbia**, during 2018-2020, 17 towns and municipalities were supported through the German Development Agency (GIZ) Climate Sensitive Waste Management Project, a revision 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 the introduction of waste separation at source, home composting, and construction of two central composting plants.

5.3. Cleanup actions and reuse/recycling

Community and professional river cleanup actions help rivers in multiple ways, one of which is the practical value and awareness-changing potential of riverine litter itself. The proposed solutions of this Study enable the selection and separation of riverine litter (light, heavy fraction) right on the water level, 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 cleanup operation. Based on DTP Tid(y)Up members' HAEE and THU experience, the rate of recycled and upcycled materials can exceed 65% out of the 100% mixed riverine litter collected, thanks to their social innovation called Plastic CUP[84]. We have internationally recognised procedures and experience in product development made from 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 active and eco-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[85] - Transnational River Cleanup Handguide, developed as part of the Tid(y)Up project, serves as a comprehensive guide for organising river cleanup 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 effectively manage the collected waste. With numerous challenges and obstacles associated with river cleanups, the handbook provides valuable insights on how to address these challenges and improve the efficiency of these initiatives.

5.4. Awareness-raising, workshops and capacity-building events

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

[84] THU and HAEE have unrivaled experience in the selection of riverine litter, illustration

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

The Tid(y)Up 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 **Floating Exhibition**, which has already visited five countries in the Danube basin. The exhibition, constructed of 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.

One of the remarkable features of Plastic CUP is its extensive awareness-raising infrastructure, which includes the mobile and container-based **Riverine Trashlab**[86]. 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 on a journey, 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 Tid(y)Up project offers a comprehensive **Waste Reduction Toolkit**[87] 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 free posters and infographics that can be easily disseminated.

Another exciting initiative within the toolkit is the **RiverSaver qualification** system, designed to promote sustainability in restaurants and buffets along waterways. This system - extended in the Erasmus+ 5in1 project to 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, the River Friendly 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. The Tid(y)Up project recognises the need for collective action to address this issue and is taking 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, having carried out around 19,000 consultations last year. In 2020, they went a step further and produced portable ashtrays from PET blanks, which they distributed for free to smokers.

The **Slovakian**-developed, free, and 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 through TrashOut; in 2019, 500 illegal landfills were reported, and they

[86] https://petkupa.hu/hu_HU/muanyagmuhely

[87] https://kszgysz.hu/en/knowledge

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 3.3.1). In **Serbia**, a project to strengthen the Aarhus Centres[88] from eight countries is being implemented to 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, including PET, aluminium cans, and glass, brought to the collection machines. This initiative is an excellent example of synergetic event organisation.

6. 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 Tid(y)Up project and to show the afterlife of this initiative.

The **Aquatic Plastic** submission under the Interreg programme builds upon the successful experience of Tid(y)Up and the decade-long project development in the CEE region to propose a comprehensive approach to reducing plastic pollution in the Danube Basin. The consortium aims to implement on-site cleanup 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 Tid(y)Up project and demonstrates the potential for impactful collaboration between international organisations and local stakeholders.

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. This will be achieved by intercepting floating riverine litter particles while in motion and retrieving them from the environment. Additionally, the initiative aims 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, and validation of innovative technologies, along with existing and new river cleanup 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 program (2020-1.1.2-PIACI-KFI-2021-00239), is a 4-year research initiative led by WESSLING 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 wastewater treatment plants and atmospheric deposition. The project takes a comprehensive approach, considering not only the microplastic particles themselves, but also their potential role as vectors for the transport of microbiological and chemical pollutants. The goal of the

[88] https://aarhus.osce.org/

RISK MP project is to develop multiparametric investigation systems that can accurately analyse the environmental risks associated with microplastics and inform effective mitigation strategies.

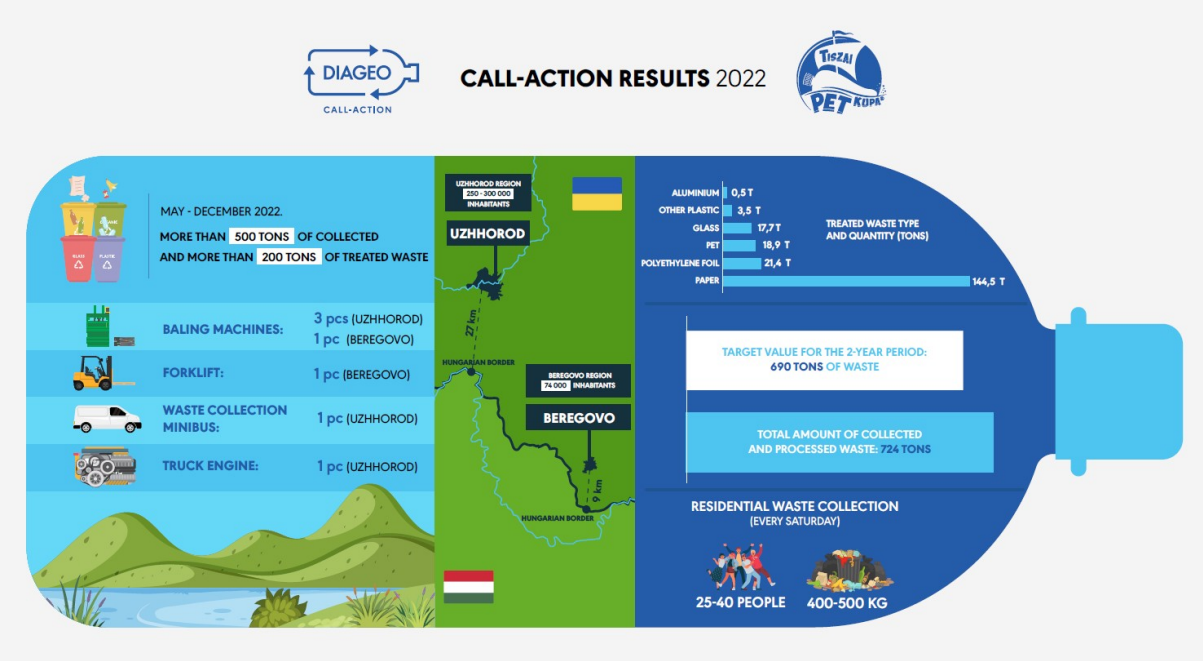
The **DALIA (Danube Region Water Lighthouse Action)** project is a collaboration of 22 expert organisations, including universities, authorities, SMEs and NGOs, from 8 different Danube and Associated countries. Together, we possess an outstanding set of knowledge, covering not only the basin geographically, 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 decision-making 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.

Plastic CUP is a grassroots social innovation led by Naturefilm.hu Society, which organises annual international river cleanup 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.

River Lit(t)eracy is a continuation of the 5 countries 1 river Erasmus+ project that was implemented in the Tisza River Basin. 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 of individuals who are literate in these matters and are actively engaged in combating plastic pollution in their local communities.

The **Call-Action**[89] 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 separate waste back into the recycle loop and creating employment opportunities in the region. The project plans to collect, select, and manage at least 690 tonnes of waste during its lifetime, and in the first seven months, approximately 280 tonnes of waste were collected. The initiative has increased waste collection capacity in Uzhhorod and Beregovo, and in the next period, more waste collection points will be set up and installed in schools and community institutions, involving over 21 municipalities, 29 schools, and 61,800 residents and students.

[89] https://petkupa.hu/hu_HU/?cikkId=970



In 2019, Coca-Cola Foundation began supporting the cleaning of the Tisza River, as they view reducing, collecting, and recycling packaging materials as a matter of great concern. The **Zero Waste Tisza Project**[90] 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 third phase of the Zero Waste Tisza Project will be launched at the beginning of 2023.

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