Interreg Danube Region

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AQUATIC PLASTIC

Intervention Methodology for Authorities to Prevent Infiltration into Rivers from High-Risk Waste-Leakage Points

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1. Introduction

Numerous publications have been published in recent years on global waste overview, waste generation, waste management, and riverine litter. Those studies, concept notes, and handbooks form the foundation of this intervention methodology. Furthermore, detailed national surveys and analyses have been published, enabling this study to highlight meaningful experiences, progress, and essential changes in the partner countries. Beyond studies and surveys, we have actively participated in several working groups and EU- and global-level discussions, refining this action plan to be more comprehensive and experience-based.

In some parts of the European Union, fundamental challenges in water and waste management, combined with a transnational influx of riverine litter, significantly exacerbate the issue. In these regions, the root cause of the problem extends far beyond littering, it is driven by massive, industrial-scale, systemic failures in waste management, leading to literal plastic floods.

Massive riverine waste pollution – the so-called plastic flood – is under elimination at the Upper Tisza
Photo: FETIVIZIG

Riverine pollution is not a local inconvenience but a transnational crisis with both visible and invisible consequences across ecosystems, economies, and societies. By integrating lessons from past initiatives, advancing regulatory innovation, and embedding prevention, circularity, and accountability within the legal framework for waste management, we can create a framework capable of addressing the scale and complexity of this challenge. Only then can we move from piecemeal projects and reactive clean-ups to a durable, systemic transformation that safeguards rivers, seas, and communities for generations to come.

Our Aquatic Plastic project and its Consortium worked according to the ocean literacy principles, and during the project we had the opportunity to establish the river literacy principles[1] and fine-tune the global framework into a river basin-related system. The present methodology closely aligns with the following three principles (out of seven), and we hope that the relevant stakeholders and changemakers will use our document to protect rivers more effectively in the future:

"Everything that happens to the river affects the ocean.
Every river is vulnerable and deserves protection.
The river is a shared heritage, not a commodity."

The floating exhibition (FLEX) rests at the Riversaver Centre in Kisköre. Photo: Plastic Cup

2. Scope and objectives

The present action plan aims to help municipalities and authorities prevent waste infiltration into rivers and close open dumpsites by implementing a sustainable, data-driven waste management strategy. Sound waste management is crucial for reducing plastic pollution entering the environment, which poses a threat to both wildlife and human health. Currently, approximately 38% of global waste remains unmanaged, resulting in pollution and health hazards[2]. Waste leakage also imposes considerable social costs through externalities.

Between 2021 and 2027, 95 HORIZON and 34 other projects focusing on litter pollution were funded by various EU sources (LIFE, Interreg, etc.), of which 18 specifically targeted the Danube River Basin[3,4]. Those projects centred on source reduction, mapping, recycling, restoration, education, characterisation, innovation, and exploring alternatives, but very few tackled the question of real-life-based prevention

[1] Molnár et al. (2025)

[2] United Nations Environment Programme. (2024b)

[3] European Commission. (n.d.-b).

[4] European Commission. (n.d.-c).

with a holistic approach to regulation, implementation, and financing. The restoration initiatives encompass all actions that apply technological advancements for mechanical clean-up (e.g. autonomous seabed cleaning of marine litter), as well as ecosystem recovery and remediation through the removal of plastic waste (e.g. abandoned, lost or discarded fishing gear). Most solutions employ an end-of-pipe approach to address the effects of mismanaged processes. It's nothing new; environmental technologies primarily focus on the impact, not on the cause. The factual background of that lies in our economic system, which prefers measurable, innovative, material-based solutions over hard-to-measure and 'steel-free' prevention.

Our action plan fosters discussions on current and innovative strategies[5], possibilities, policies[6], and practices that promote waste reduction. Also, stakeholder involvement in clean-up actions, riversaver education[7], co-creative processes (national roundtables)[8], citizen science for waste monitoring[9], and recycling (how to sustainably finance cleaning riverine waste: secondary raw material certifications[10] and guidance for adaptation[11] and circular economy principles aiming to create a cleaner and healthier environment in the Danube countries.

To achieve those objectives, the following chapters are going to:

- provide **timely data availability** for stakeholders to activate an early warning system and evaluate the validity of collected data through remote sensing technology: this can lower costs and minimise damage to tangible assets, coastal facilities and biodiversity (Chapter 5.1.);
- provide a **tool for assessing the risk** of potential leakage points: this resource will help local governments identify and evaluate where plastic or waste might leak into the environment and its possible effects – so they can take preventive or corrective actions (Chapter 5.3);
- prepare a **list of steps and measures** needed for restoration and recultivation, including the identification of the roles of relevant stakeholders: the herein detailed action plan is going to outline the necessary steps to restore and recultivate a site, and assign specific responsibilities to each stakeholder involved, so that everyone knows their role in the process (Chapter 4);
- share a waste sorting and handling protocol: setting out rules and guidelines for properly separating, collecting, and managing waste to ensure its safe treatment and sustainably (Chapter 6.2);
- finally, we **assess the financial requirements** and the funding possibilities for implementing clean-up activities and successful restoration. Since funding these projects is often problematic, we identify potential funding mechanisms to ensure their financial sustainability and scalability(Chapter 7.).

[5] Interreg Danube Region. (n.d.-c)

[6] Interreg Danube Region. (n.d. -a)

[7] Interreg Danube Region. (n.d. -b)

[8] Interreg Danube Region. (2024)

[9] Interreg Danube Region. *Citizen science campaign*. AQUATIC PLASTIC. Retrieved March 20, 2026, from https://interreg-danube.eu/projects/aquatic-plastic/news/citizen-science-campaign

[10] Interreg Danube Region. (2025 -a.)

[11] Interreg Danube Region.(n.d. -d.)

3. Legislative framework

This chapter outlines the international legal requirements and regulatory framework, focusing on EU and non-EU waste regulations and aspects of the Water Framework Directive (WFD). We summarise the good regulatory practices of individual countries, drawing on updated reports from the Tid(y)Up project's Survey[12] (National Legislative System on Surface Water Quality) and Policy Recommendations[13], the outcomes of the co-creation roundtables and the co-creation policy recommendations. The analysis also encompasses the economic regulatory environment and a presentation of the financing system, including the financial requirements, the full-net-cost coverage and the Polluter Pays Principle, primarily at the EU level.

Although this chapter focuses on existing legal practices, it is important to note that a sustainable response to riverine plastic and waste pollution cannot be achieved through fragmented or voluntary measures alone; it requires the backbone of a comprehensive, **binding, and holistic legal framework**. The findings of this comprehensive action plan and methodological guidance, drawing on years of research, surveys, and international dialogue, make it clear that without harmonised cross-border regulation, coordinated enforcement, and financial responsibility embedded in law, even the most ambitious technical solutions will remain end-of-pipe fixes. In addition to the aforementioned principles of ocean and river literacy and to the Plastic Treaty, which will be elaborated upon later, the other main guiding framework is the studies and assessments of the International Solid Waste Association (ISWA). It is worth starting from the ISWA's "Waste Management to Address the Climate Crisis"[14], which highlights three key elements to policy and regulatory frameworks supporting waste management systems:

1. Assigning roles and responsibilities for waste prevention, collection, treatment, recycling, and disposal , including providing a framework for public/private partnerships to avoid the collectivisation of costs and the privatisation of profits;
2. Defining the administrative, the financial, and the fiscal resources associated with the assigned responsibilities, as well as providing the financial incentive frameworks to drive the change defined in the strategy;
3. Establishing minimum environmental and health protection standards, technical guidelines for implementation, rigorous monitoring and reporting, and an independent regulator to enforce the standards.

3.1 The EU Framework

The EU's waste management directives focus on reducing unsorted waste, increasing recycling rates, and strengthening the application of extended producer responsibility to promote a more circular economy. These regulations aim to minimise landfill use, eliminate waste pollution, and prioritise sustainable resource use across industries. A new wave of legislation is on the horizon, with the **Circular Economy Act** expected in 2026[15]. Council Directive 75/442/EEC, adopted in 1975, was the first major EU waste law,

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[12] Raykov et al. (2021)

[13] Hanko. (2024)

[14] French Solid Waste Partnership. (2024).

[15] European Commission. (2025a)

introducing the Polluter Pays Principle (PPP), which makes waste producers responsible for disposal. Since then, several amendments and replacements have been implemented, and separate regulations have been prepared for specific topics, mainly in EU countries. In non-EU countries, waste management and cross-border waste movement are equally under scrutiny, as reflected in numerous international treaties and agreements. For those in the process of EU accession, ‘Chapter 27 on the environment’ requires the transposition of EU directives. While this is largely completed on paper, implementation remains a persistent challenge across nearly all states.

The EU’s **Waste Framework Directive** 2008/98/EC established the legal framework for waste management within the European Union, outlining the waste hierarchy (Prevention → Reuse → Recycling → Recovery → Disposal). It obliges regulators and nations to put systems in place that prevent the generation of waste and prioritise higher-level treatment of waste, while aiming to reduce the negative impact of waste on human health and the environment. The primary goal is to promote a circular economy and ensure efficient and sustainable resource management. It introduces the **Extended Producer Responsibility (EPR)**, a tool long used to tackle plastic waste collection and treatment, based on the principle that producers of materials and products are responsible for the end-of-life management of their products (detailed in Chapter 4.2.2).

The EU's adoption of the **Packaging and Packaging Waste Regulation** (PPWR – EU 2023/2630) marks a major step in tackling marine and riverine plastic litter. As a Regulation, unlike a Directive, it is immediately binding and applies uniformly across all EU countries, ensuring consistent, high standards. This includes actions on design for recyclability, mandatory recycled content, and waste reduction, with legally binding targets, a ban on certain single-use plastics, and requirements for recyclable packaging of recycled materials. These measures aim to drastically cut plastic waste entering the environment and waterways.

The **Single-Use Plastics Directive (SUP)** 2019/904 on the reduction of the impact of certain plastic products on the environment (particularly on the marine environment) underlines the need to move from measures that manage the effects of our activities on the environment to specific measures aimed at the causes of environmental impact, while promoting innovation and changing consumers’ mentality. It bans certain single-use plastic items and requires a 77% separate collection rate for plastic bottles by 2025.

The **Landfill Directive** (1999/31/EC, amended by 2018/850) obliges nations to put in place systems that ensure a significant reduction in the quantity of landfilled waste.

The Urban Wastewater Treatment Directive (UWWTD, 91/271/EEC, revised proposal in 2022) is also directly linked to waste management by ensuring proper wastewater treatment and encouraging sludge management. In response to current and future water management challenges in Europe, organisations like European Water Association (EWA) are calling for a better place for water and water challenges in mainstream European policies, as well as for the development of a European Blue Deal.

The **Waste Shipment Regulation** (1013/2006, currently under revision) partially controls transboundary waste movements to prevent waste colonialism and illegal dumping in other countries, and to ensure the transparency and accountability of proper waste management.

Despite these efforts, recycled materials accounted for only 11.8% of the materials used in the EU (based on 2023 data). To counterbalance this contradiction, the Commission launched several initiatives (July 2025) to accelerate the EU's transition to a circular economy and prepare the ground for the Circular

Economy Act, expected in 2026.[16] Still, no obligation on the composition or content of the input material is in the pipeline, which would assure recyclability at scale.

The EU also has several objectives to protect and restore freshwater ecosystems and biodiversity, to protect at least 30% of the EU's sea area, and to integrate ecological corridors, as part of a true Trans-European Nature Network in line with the EU Biodiversity Strategy 2030, or to prevent and eliminate pollution of our waters under the EU Action Plan Towards Zero Pollution for Air, Water and Soil.

*In **Bulgaria**, local authorities often enforce stricter pollution controls, particularly in areas with industrial activity or sensitive ecosystems. For example, municipal solid waste management and air quality standards may vary by region.*

Apart from the PPWR, which has a direct effect in Member States, Member States of the European Union shall incorporate EU Directives into their laws and regulations, and establish an implementation system to ensure the specific targets. The following table (in Annex 2) outlines the key regulations in countries closely linked to the areas mentioned above, particularly in waste management, landfills, and illegal dumping.

There are numerous regulatory tools, from which solutions must be selected that can be operated effectively and in a coordinated manner at the national, the regional, and the local levels. Regulations must establish a clear implementation model, including the necessary capacities and finances, specify who is responsible for achieving targets in collection and recycling, and allocate funds to cover the costs of the required actions, including the setup and the operation of waste management systems.

EU directives require more than meeting collection and recycling targets. They mandate a management system that handles all packaging waste, including non-recyclable parts, through environmentally sound disposal methods, such as energy recovery or landfilling. All stakeholders – from producers to waste operators – are legally responsible for the entire packaging lifecycle, ensuring accountability from cradle to grave, and this accountability must be strictly enforced.

The focus of this study is to prevent waste infiltration into rivers; therefore, it is necessary to emphasise that close cooperation between water protection and waste management is essential at all levels. The **Water Framework Directive (2000/60/EC)**, known as the WFD, and **River Basin Management Plans (RBMPs)** are of great importance for water protection and plastic waste management. Since the goal of the WFD is to achieve 'good status' for all EU water bodies, one key element is reducing pollution. The WFD sets out requirements for EU Member States to monitor water quality, including a defined list of priority substances and priority hazardous substances. While some PFAS are covered under this framework, other emerging contaminants, such as microplastics, are not yet fully integrated into its core monitoring requirements. It encourages improvements in waste collection to prevent plastic litter from reaching water bodies. ICPDR's Policy Guidance on Tackling Riverine Plastic Pollution[17] in the Danube River Basin also highlights the importance of the WFD and RBMP plans in water protection in general and in the field of plastic waste pollution. The next table summarises the relationship between waste management regulations and the implementation of the EU WFD in the participant countries.

Table 1: Connection between waste regulations and the WFD

[16] European Commission. (2025a).

[17] Hanko et. al. (2024)

Country	Connection Between Waste Regulations & WFD
Austria	Systemic, indirect connection through AWG 2002; landfill and hazardous waste rules support WFD goals
Bosnia and Herzegovina*	Growing coordination, more in planning than in practice
Bulgaria	Indirect; waste fee policy affects recycling, less tied to WFD
Hungary	Waste regulation aligns with water protection goals; no standalone riverine waste strategy
Montenegro*	Not detailed, but projects often target plastic in rivers/seas
Romania	Strong integration; laws and plans explicitly link WFD and waste
Serbia*	Partial alignment, poor enforcement, and fragmented institutions
Slovakia	Strong legal alignment; challenges in wastewater treatment
Slovenia	Legal alignment exists; weak in practice, esp. for riverine litter

**Candidate European Countries with Accession Plans*

The WFD Reporting Guidance (2022)[18] defines the so-called Key Types of Measures (KTMs)[19], which are **standardised categories** created by the European Commission to ensure that all Member States report their water-management actions consistently. They describe the type of pressure being addressed and the intervention used to achieve the WFD's environmental objectives. The EU guidelines state that KTMs are expected to deliver the bulk of the improvements by reducing pressures to the extent necessary to achieve the WFD Environmental Objectives. KTMs are completed by Member States using national (or planning unit) level measures.

Two of the Key Types of Measures will be detailed in the following chapter (Chapter 6.2.), which are more closely linked to the themes of our Action Plan:

- KTM4: Remediation of contaminated sites – historical, legacy pollution, including sediments, groundwater and soil
- KTM21: Measures to prevent or control the input of pollution from urban areas, transport and built infrastructure

This report also gave us the opportunity to share our experience and knowledge, commenting on the WFD implementation through the European Water Association (EWA) in February 2026.

3.2 Transboundary challenges and negotiations

International collaboration is essential to ensure sustainable water management across borders. For our topic, one of the most important is the International Commission for the Protection of the Danube River (ICPDR), with 14 member countries plus the EU. It coordinates the efforts of the 14 riparian countries to reduce pollution, protect aquatic ecosystems and manage water resources sustainably. The **ICPDR** plays a direct role in tackling riverine waste, especially plastic pollution, in the Danube by coordinating basin-wide surveys of litter. For example, the Joint Danube Survey 4 (JSD4, 2019) included, for the first time, systematic measurements of floating plastic and macrolitter in the river. The most recent, **JDS5**, was

[18] European Commission. (2023, October 26).

[19] Leitner et al. (2021)https://www.eionet.europa.eu/etcs/etc-cca/products/etc-cca-reports/using-key-type-measures-to-report-climate-adaptation-action-in-the-eea-member-countries/@@download/file/ETC-CCA_report_Using_KTM_reporting_CCA_actions_EEA_member_countries.pdf

officially launched on 1st July 2025 in Vienna.[20] As stated in ICPDR's Policy Guidance, any riverine waste management plan should include a data management plan, an emergency plan, an alert notification procedure, joint exercises, and protocols for any further required measures.

In addition to international river commissions, most countries with transboundary riparian areas have multilateral and bilateral agreements, such as the one between Bosnia and Herzegovina and Serbia and Montenegro regarding the Drina River. This river has become emblematic of this issue, turning into a "floating garbage dump" near the Višegrad dam each winter. In response, bilateral and trilateral meetings have been held, including a February 2023 gathering in Višegrad, that brought together ministries from all three countries. Joint clean-up actions were agreed, and Serbia's power utility co-financed an emergency waste removal operation in 2021, demonstrating practical crisis cooperation.

Drina's waste pollution held back at Višegrad, 9 February, 2026
Photo: Dejan Furtula

***Bulgaria** and Greece recently signed a five-year agreement on transboundary waters, under which Bulgaria will supply water from the Arda River to Greece as Greece modernises its dam infrastructure. The agreement follows the expiry of a 60-year bilateral agreement between the two countries and reflects a mutual intent to pursue a permanent water-management solution.*

*In the Transcarpathia region (**Ukraine**), Hungary is financing and supporting the construction of a sanitary landfill in Beregovo (Makkosjánosi) to strengthen the regional waste management system. Next to the landfill is an unused separation plant that has been out of operation for a decade. Owing to the infrastructure development, the separation plant can resume operations after refurbishment. Another best practice is the development of the wastewater treatment system in Beregovo, and the restoration of the Vérke stream, removing the polluted sludge from the streambed[21].*

Within the Transcarpathia region, the dumpsite in Rakhiv (as shown in the attached photo) poses a critical transboundary challenge, continuously polluting groundwater and the Tisza River. Its uncontrolled operation

[20] International Commission for the Protection of the Danube River. (2025)

[21] KEXPORT Környezetipari Klaszter. (2024)

makes it a major pollution hotspot, allowing significant waste to leak into nearby waters. Addressing such sites is complex: closure requires selecting appropriate remediation methods, securing financing, and establishing compliant waste management alternatives, all while overcoming the higher perceived costs of proper environmental solutions.[22]

"The local authorities in charge of waste management are the best positioned to tailor the waste management solutions to their local context. Adequate support mechanisms need to be provided to them along with the necessary leeway to experiment with local solutions, for them to best implement this task."[23]

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

Another good example is the **Danube Riversavers Declaration**[24] – a joint initiative developed through the co-creation approach of the River Literacy workshops within the AQUATIC PLASTIC project. The Declaration is now signed by over 40 entities (individuals and organisations), including key stakeholders such as WWF Hungary, the European Youth Parliament for Water, and the EUSDR PA4 coordination, with further signatures expected.

A niche interview with Peter Kovacs, Water Director of Hungary, responsible for transboundary agreements, allowed us to delve deeper into water negotiations. The dialogue aimed to map practical experiences, with particular regard to the responsibility for costs related to plastic pollution in transboundary rivers, and to identify ways to improve bilateral cooperation. These agreements provide a solid legal framework, but in practice, the quality of cooperation depends largely on the political and economic relations between the countries concerned. Plastic pollution in border waters is a particular

[22] International Solid Waste Association Scientific and Technical Committee. (2016)

[23] International Solid Waste Association. (2024b).

[24] RiverSaver. *RiverSaver groups: Co-creation*. Retrieved March 20, 2026, from https://www.riversaver.eu/en/solutions/innovation/co-creation/riversaver-groups

challenge in the Ukrainian-Romanian context: in Ukraine, waste management infrastructure is weak, and although progress has been made in Romania, such as the introduction of a deposit system and the construction of waste collection facilities, drifting waste remains a problem. Although the EU WFD acts as a guiding framework (even for non-EU countries), municipal and plastic pollution are not included in mandatory water quality testing, and there is no uniformly applicable measurement methodology. Regarding specific pollution prevention, it is important to note that although cost allocation is included in all agreements, it is often addressed through informal solutions (e.g. providing additional water) in practice. However, effective reduction of plastic pollution requires not only better cooperation and stronger political will, but also more advanced laboratory facilities, standardised monitoring, educational and local technical interventions, such as the installation of waste collection facilities or greater involvement of civil society (e.g. Plastic Cup).

In summary, implementing these legal obligations and bi- or multilateral agreements remains complex, given the legal, administrative, financial and infrastructural challenges. While current agreements provide an important legal foundation, they are still insufficient on their own to address the global challenge of waste and macro- and microplastic pollution. Preparing a holistic solution for waste will require a common effort that is not delayed by political short-sightedness and procrastination. We will present our proposed solutions in the Co-creation subsection (Chapter 3.4). However, before we dive into the solutions, let's look at the waste management data for the countries in question, which we analysed further as part of the project, identifying a few more anomalies in the system.

3.3 Waste Gap in the AQUATIC PLASTIC countries

To gain a clearer picture of waste pollution and potential hotspots, we conducted a brief study of waste management data gaps across the 9 project partner countries (AT, MNE, SK, SI, HU, RO, RS, BiH, BG). Building on the previous project's assessment[25], we already knew that publicly available data does not necessarily reflect reality and does not help identify the problem, so we conducted a more in-depth analysis with the help of our project partners. For EU Member States, our primary data source was the EEA's 2025 Waste Management Country Profiles, which contain the most recent, validated 2022 data. For non-EU countries, we conducted a comprehensive review of international statistics, identifying the years with the most complete datasets, typically 2022. Notably, for Serbia, we were able to incorporate 2024 data directly from the Project Partner.

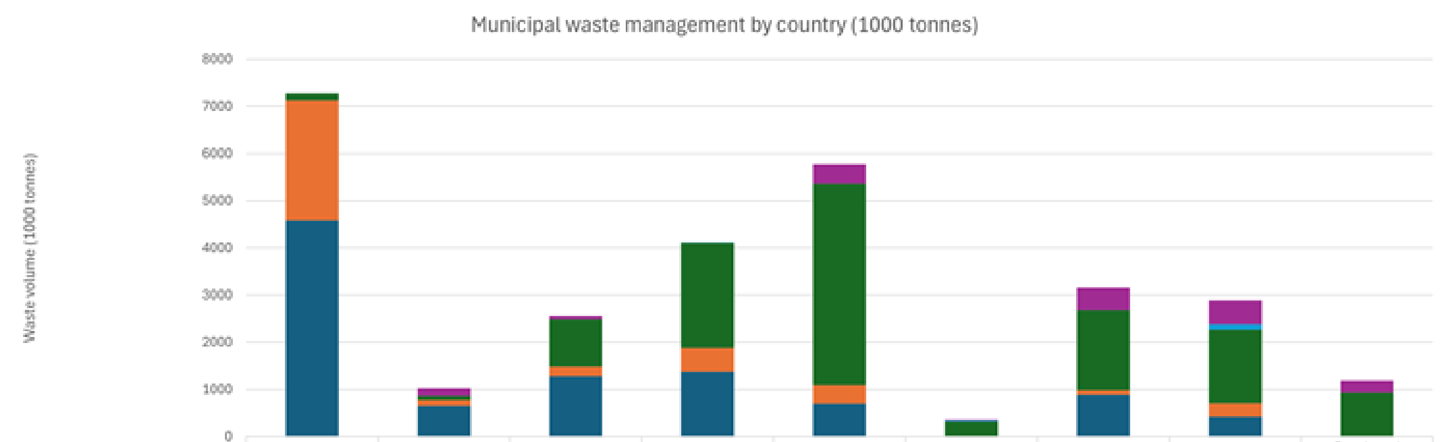
The observed "waste gap" in EU Member States remains minimal, largely due to alignment with EU reporting methodologies. Under this framework, unmanaged waste is typically excluded from the Total Waste Generated figures and treated as an outlier. Consequently, discrepancies in these regions typically stem from technological limitations or systemic inefficiencies rather than illegal disposal. By contrast, non-EU countries often show a significant disparity between generated and treated waste. This gap is frequently attributed to:

- limited service coverage: waste collection systems that do not cover the entire country;
- illegal dumping: waste that bypasses formal management channels entirely.

[25] Raykov et al. (2021)

To ensure data comparability in the future, a unified methodology is essential. For this analysis, the terms should be understood as follows: Untreated Waste[26]; Illegally Placed Waste[27].

Comparison of Municipal Waste Management Methods by Countries



	Austria (2022)	Slovenia (2022)	Slovakia (2022)	Hungary (2023)	Romania (2022)	Montenegro (2023)	Bulgaria (2022)	Serbia (2024)	Bosnia and Herzegovina (2022)
Untreated	0	165	77	0	404	18	474	510	255
Other	0	0	0	4	0	22	0	115	0
Landfilled	146	82	999	2232	4270	319	1705	1559	920
Incineration with Energy Recovery	2546	134	205	504	404	0	95	288	9
Recycling & Composting	4583	648	1280	1375	692	0	884	418	0

Countries

Recycling & Composting, Incineration with Energy Recovery, Landfilled, Other, Untreated

Figure 1: Municipal waste management by countries. Source: HAEE

Please note that this comparative chart shows only officially recorded unmanaged waste and excludes illegally dumped or placed waste. In our opinion, however, it should be incorporated. Detailed estimates of illegal waste disposal will be discussed as follows.

While official national statistics provide a framework for understanding municipal waste flows, they often fail to capture the full extent of environmental leakage. The **Untreated** volumes recorded in formal reporting typically represent waste that is accounted for but was lost during technical processing or due to reporting nuances. However, a significant parallel flow exists: **Estimated Illegally Placed Waste**. This category comprises waste that completely bypasses the formal management system and is **never recorded in official generation statistics**. This category is also the main source of river pollution.

To provide a more comprehensive picture of the environmental challenge, the following table synthesises official untreated figures with citizen science data and regional estimates of illegal dumpsites. This comparison highlights the waste gap, where limited service coverage and illegal dumping create significant disparities between waste generated and waste formally treated.

[26] Refers to volumes that are accounted for within the total generated waste but are lost due to technical residues or process inefficiencies. This does not necessarily equate to illegal activity.
[27] Refers to waste that completely bypasses the formal system and is not recorded in the official generation statistics

Table 2: Estimated Illegal Dumpsites and Unmanaged Waste Metrics. HAEE's compilation

Note: The data compiled in this table are primarily sourced from the European Environmental Agency's (EEA) 'Country profiles on municipal and packaging waste management – 2025'[28], particularly regarding EU Member States. In instances where EEA data were unavailable, information was retrieved from official national statistical documents and local records. For a comprehensive breakdown of specific data sources, please refer to the detailed list provided in **Annex 1**.

Country / Region	Estimated Number of Illegal Dumpsites	Tonnage or Volume of Unmanaged/Untreated Waste
Austria	N/A (system statistically closed)	~15,000 tonnes of annually discarded litter
Slovenia	> 15,000 historical sites	164,500 tonnes (untreated)/92 Olympic pools of legacy volume
Slovakia	10,546 total (6,609 contaminated with plastic)	77,000 tonnes (officially untreated)
Hungary	4,025 plastic-contaminated sites	66,000 tonnes physically removed in 2023
Romania	10,171 plastic-contaminated sites	403,900 tonnes (untreated) + ~3,700 tonnes smuggled annually
Bulgaria	> 280 (identified in Sofia alone)	473,550 tonnes (untreated)
Serbia	2,656 to 3,500 sites	510,000 tonnes (uncollected rural/suburban waste)
Bosnia and Herzegovina	> 1,400 documented sites	255,000 tonnes (uncollected rural waste),
Montenegro	37 (large-scale coastal zones)	18,000 tonnes (untreated)
Zakarpattia (Ukraine)	> 200 (vs. 50 legal landfills)	2,600+ m^3 of floating plastic are intercepted annually

The data above underscore a critical distinction across the AQUATIC PLASTIC project regions: in many EU Member States, the waste gap is driven by technical residues, whereas in non-EU countries, it often reflects the physical reality of incomplete collection coverage. These figures represent more than statistical discrepancies; they reflect localised infrastructural challenges, from rural leakage in Romania and Serbia to the transboundary movement of riverine litter in the Zakarpattia region. To clarify the problems and their interrelationships, we analysed the situation in detail for each country, citing the specific data sources in Annex 1.

3.4 Co-creation findings

The AQUATIC PLASTIC **co-creation process** demonstrated that structured, facilitated dialogue is an effective means of bridging fragmented stakeholder systems and addressing the complex challenges of riverine plastic pollution across the Danube River Basin. This is also closely linked to the issue of abandoned waste.

[28] **European Environment Agency (EEA).** (2025). *Country profiles on municipal and packaging waste management - 2025*.

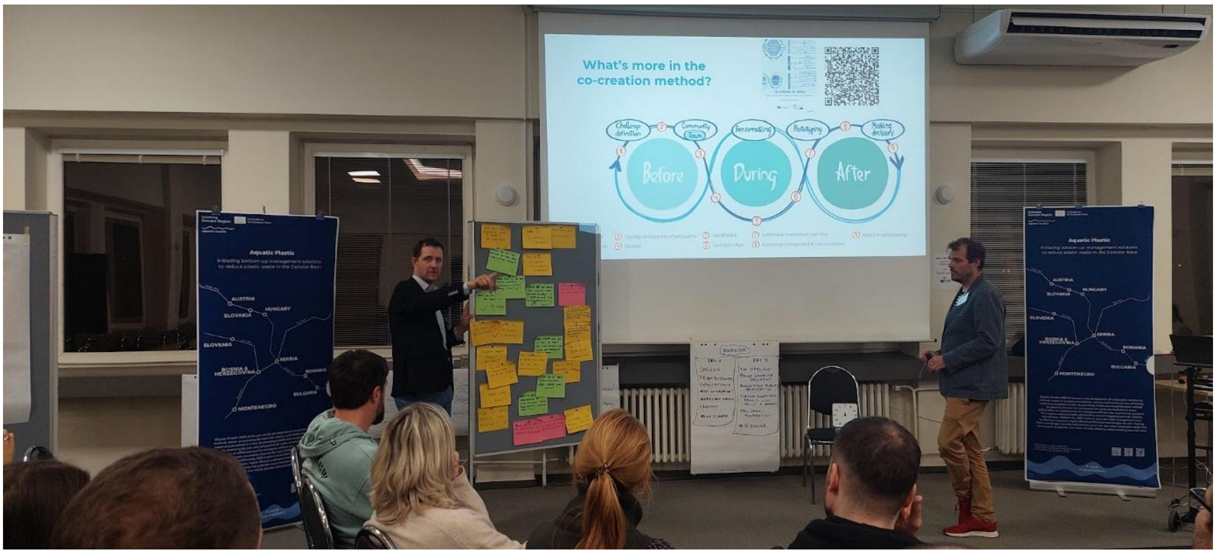
The national co-creation roundtables showed that while cross-border cooperation is essential, tangible progress can already be achieved at the national level by strengthening the collaboration between the water and waste management sectors, including industrial symbiosis. Co-creation methods such as the World Café, GroupExpo, Workshop Canoe, and the OPERA Method enabled inclusive stakeholder participation, mutual learning, and the translation of diverse, jointly identified challenges into actionable proposals, even in highly complex contexts such as riverine plastic pollution, where cooperation is traditionally weak or project-based.

Top 10 Identified issues identified during national roundtables	AT	BIH	BG	HU	MNE	RO	SRB	SK	SI	Total (sum)
Unclear legal responsibility for riverine litter (gaps and/or overlaps between water authorities, municipalities and waste operators)	0	3	3	2	3	3	3	3	3	23
Insufficient financing for sustainable waste management and monitoring (short-term projects, no operational budgets)	0	3	3	2	3	3	3	2	1	20
Weak enforcement of existing legislation (inspection capacity, sanctions, supervision)	0	2	3	1	3	3	3	2	2	19
Insufficient waste collection capacity in rural and river-adjacent areas (service gaps leading to illegal dumping)	0	3	3	1	3	3	3	2	1	19
Weak integration of waste prevention into water management policies (parallel legal and operational systems)	0	2	3	2	3	3	1	2	2	18
Low public - and in some cases institutional - awareness of riverine pollution pathways (no perceived link between dumping and downstream impacts)	0	2	2	2	3	2	2	2	2	17
Lack of long-term monitoring and reliable datasets (project-based, discontinuous data generation)	1	1	2	2	3	3	2	1	2	17
Lack of systematic environmental education on plastics and circular economy (no river-specific content in curricula)	0	2	2	2	3	1	2	2	2	16
Limited cross-border accountability mechanisms (downstream countries cannot prove pollution origin)	1	0	2	3	1	3	1	2	2	15
Absence of harmonised monitoring methodologies (non-comparable MiP/MaP sampling and analysis)	3	0	1	2	0	2	1	3	2	14

Table 3: Top 10 identified issues of national co-creation roundtable discussions

The assessment of the national roundtables concluded that major challenges related to riverine waste are rooted in fragmented legal frameworks, which constitute a central structural barrier. A **lack of environmental liability insurance** for large, potentially hazardous sites, such as non-EU-conforming landfills and mining activities, remains a missing piece of the puzzle. To date, the biggest challenge remains providing real cost coverage for internalising waste-related externalities, as no one wants to pay the full cost of environmental harm caused by products becoming waste.

Responsibilities – especially for riverbanks, floating waste and accumulated riverine litter – are often unclear, particularly at the interface between municipal waste management and water authorities (RO, BG, SK). This ambiguity weakens enforcement and prevents effective penalisation of illegal dumping. In several cases, legislation does not clearly define ownership of floating waste (Chapter 5.2.1) or delineate operational duties for river cleaning. In addition, the operational chain of responsibility from illegal dumping to sanctioning and cost recovery is frequently unclear, with overlapping institutional mandates leading to diffusion of accountability.



Sharing the Tisza Roundtable experience at the AQPLA Project Partner meeting at Bratislava
Photo: ExAnte

A legally defined operational framework for riverine litter is needed to clarify ownership and routine responsibilities for riverbank maintenance, clean-ups, and the installation and maintenance of in-river barriers, supported by clear reporting channels for municipalities. In parallel, stronger legal mandates are required for monitoring and interception at hydropower plants and dams, including formal cooperation agreements with operators to ensure access, data sharing and coordinated action.

At the EU level, major **legal frameworks**, including the WFD and the Danube River Protection Convention, do not explicitly address **microplastics or macroplastic pollution**. Plastic riverine litter is not recognised as a criterion for Good Environmental Status, and national authorities are reluctant to introduce stricter rules without EU-level guidance (SI).

Cross-border governance remains weak. Existing cooperation structures do not ensure structured information exchange, shared priorities or joint interventions, and current frameworks do not provide sufficient clarity on state-level responsibilities (HU, BG, SK). As a result, downstream countries cannot effectively activate cross-border responsibility mechanisms (HU, RO).

Even where legal obligations exist, **enforcement** remains weak. Inspection bodies are understaffed, surveillance is limited, and sanctions are often insufficient (RO, SI, ME, RS). Administrative barriers and poor coordination among local, provincial and national authorities reduce operational effectiveness (RS). Weak **cooperation** between municipalities and water authorities further undermines enforcement in smaller rivers and tributaries (RO). Unregulated sewage systems and legislative limits on upcycling riverine waste further restrict the implementation of circular-economy solutions (SI, SK).

Law enforcement affects hazardous waste management, particularly in contexts where supervision is weak and illegal imports of hazardous materials occur (ME). In some cases, hydropower plants are legally required to collect waste from water structures separately, yet this obligation is not implemented in practice, highlighting enforcement gaps rather than legislative absence (SI).

Weak and uncoordinated **monitoring** and inadequate digital tools worsen enforcement issues. Many countries lack digital monitoring or systematic data support (RS, RO). Monitoring gaps hinder decision-making and cross-border accountability. Several countries report no long-term systems for river waste and microplastics (RO, SI, SK). Existing data are sporadic, limited, or unreliable. Some monitoring is restricted to few points, not capturing basin-wide dynamics (RO).

A recurring governance issue is the **'interest in no data'** phenomenon. Without robust data, public investment cannot be justified, and downstream countries cannot demonstrate the origin of transboundary waste (RO). Limited laboratory capacity and infrastructure further constrain microplastic monitoring and chemical analysis (ME).

Low and uneven **awareness** is a structural barrier across countries. Public understanding of prevention, separation and circular economy principles is limited, particularly in rural and peripheral regions (BG, BiH, ME, RS). Waste is often perceived as a municipal responsibility rather than a shared societal issue (ME). Awareness gaps also affect public authorities and municipalities, with limited technical knowledge of waste prevention, hazardous waste handling and EU regulatory requirements (ME). Sector-specific communication for forestry, agriculture, construction and tourism actors is often missing, despite their relevance to riverine pollution (SI).

Operational weaknesses in waste management directly contribute to river pollution; therefore, **holistic waste management is essential**. Plans must be adapted to local conditions and existing systems to be effective, and financial sustainability and community involvement are critical (waste fees and blended finance models help sustain waste management initiatives). Rural and upstream areas often lack collection coverage, infrastructure, and technical capacity, leading to illegal landfills and overflowing sites near rivers (BG, SK, RO). Waste collection isn't always a municipal service, and water authorities often lack the capacity to remove waste from large reservoirs (SK).

Waste management remains largely reactive with occasional clean-ups, that are not integrated into prevention or monitoring strategies (BiH, BG, RO, ME). Hazardous waste management is risky where supervision is weak, and storage infrastructure is lacking (ME). Recycling capacity is limited, and market demand is low. Even with legal separation requirements, inadequate downstream recycling reduces economic viability (SI, ME). Large-scale riverine litter recycling, including PET bottles, is undeveloped (BG). Cross-border waste displacement occurs, with waste moving downstream, emphasizing the need for basin-level coordination (HU, RO). Illegal tyre dumps in Hungary threaten the environment, contaminating soil and water, affecting multiple settlements.

Nagykölked, Devecser, Zajda, Sorkifalud, Lenti: recurring illegal international trade in waste can severely affect rural areas' natural resources. Photo: 112Press

AQPLA Common Solutions (followed by preventive solution strategies in Chapter 4.1) address the key challenges identified at the co-creation roundtables. **Strengthening legal requirements** for inspection and enforcement in high-risk river zones, supported by monitoring evidence and technological solutions, is particularly important in riverine contexts, where diffuse pollution and flood-driven mobilisation complicate enforcement.

Clarifying **institutional responsibilities** for preventing, monitoring, and cleaning up riverine plastic, particularly in smaller water bodies, is also essential. To enhance **enforcement effectiveness**, investment in institutional and governance capacity should be promoted at both national and river-basin levels, including improved facilitation and cross-sector coordination. In addition, securing **stable**, multi-level **financing** for monitoring, prevention, and infrastructure upgrades is critical at both national and river-basin scales (Chapter 7).

Harmonised **monitoring** of **macro- and microplastics** should be developed and aligned with existing WFD systems, including shared approaches for transboundary rivers to enable comparable upstream–downstream assessments. This requires developing common methodologies, integrating riverine litter monitoring into routine institutional practice, and improving data sharing among public authorities, researchers, infrastructure operators, and civil society.

Using advanced tech is advised, like remote sensing (Chapter 5.1), automated detection, digital tools, and integrated systems (cameras, satellite data, sonar) to improve monitoring coverage and timeliness. It is useful to prioritise small rivers, tributaries, and hotspots for early intervention. Using harmonised data to include river litter indicators in national monitoring, informing planning, enforcement, and WFD measures, with enhanced cross-sector cooperation is also a good practice.

Cross-border cooperation should be strengthened with formal mechanisms such as basin planning, regular transnational and national working groups, and joint pilot projects to test measures. Co-creation can support basin coordination and stakeholder engagement. Additionally, horizontal institutional coordination, vertical alignment across levels, and continuity between local, national, and transboundary efforts are vital.

Several Common Solutions promote a shift from downstream clean-up to upstream, systemic transformation of production, consumption, and material systems, with circular economy approaches at their core. Strengthening **coherence among water, waste and circular economy policies is essential,** including the development of cross-sectoral action plans at national and regional levels.

Economic instruments like incentives, funding, and support for innovation should be expanded to reduce plastic leakage and promote reuse and high-value recovery of riverine litter. Effective implementation requires cooperation among authorities, research, industry, and civil society, supported by co-creation and regional action plans fostering scalable, circular, and cost-effective solutions.

Overall, the **co-creation approach proved** particularly valuable in revealing shared and country-specific challenges and solutions, addressing key obstacles, building trust across sectors, and laying the groundwork for sustained, policy-relevant cooperation. By fostering regional and sectoral partnerships, the initiative aims to develop joint strategies, share resources, and collectively address the shared environmental challenges prevalent in the region (The Assessment of Best Practices for Managing and Removing Large Floating & Flowing Waste Accumulations[29] collects the main parameters of tested large-scale waste removal and monitoring methods to offer solutions for large-scale river clean-up actions). Implementing these solutions would also have a significant positive impact on waste abandonment, as closer cooperation and stricter enforcement of legislation will help ensure waste is managed properly, and abandonment is eliminated.

[29] Molnar et al. (2026).

3.5 Stakeholder management

Effective action against river pollution requires more than technical solutions; it depends on understanding *who* influences, causes, mitigates, and is affected by the problem. Stakeholder mapping and analysis offer a structured approach to identifying these actors, clarifying their roles, interests, responsibilities, and capacities, and revealing how they interact within the river basin system. Without this overview, policies risk fragmentation, poor implementation, or a lack of public legitimacy.

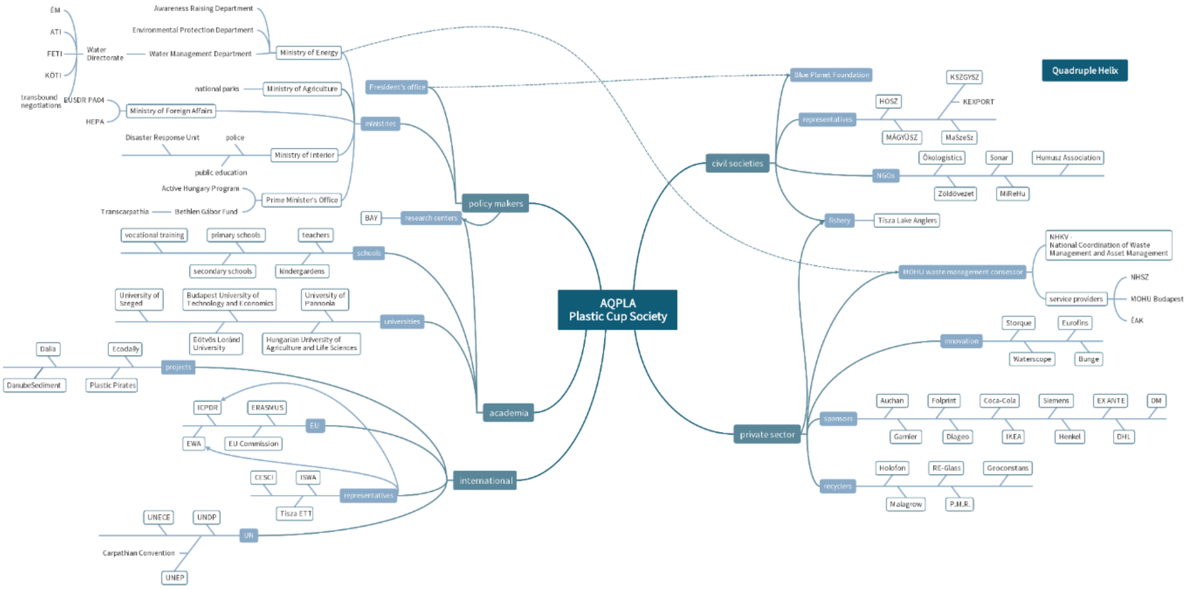
Applying the **Quadruple Helix model** to river pollution emphasises coordinated, cross-sector collaboration. **Policymakers** develop regulations, enforcement, and strategies at various levels. The **private sector** impacts pollution through production, waste management, innovation, and communication. **Civil society** – NGOs, activists, and the public – raises awareness, monitors, and ensures accountability. **Academia** provides scientific evidence, data, and education for decision-making. Often overlooked stakeholders include educational institutions (research and awareness), media outlets (public visibility), religious organisations (community mobilisation), and healthcare institutions (public health risks).

Cooperation among these actors is essential to tackle river pollution and protect aquatic ecosystems. In some cases, barriers include counterparts such as local officials who turn a blind eye, financial actors who underwrite unsustainable operations, and citizens and consumers with low awareness whose demand drives polluting industries. A good way to bring these stakeholders to the table is the co-creation roundtable presented in Chapter 3.3.

By systematically mapping these stakeholders (see the stakeholder map of Plastic Cup below), river pollution management can shift from isolated interventions to integrated, inclusive, and sustainable solutions that reflect both environmental needs and societal realities.

Figure 2: The stakeholder map of the Plastic Cup Initiative[30]

[30] HAEE (2025) - own editing



4. Prevention comes first

Prevention is always at the top of the hierarchy and a top priority, but when it comes to the details, it is usually left until the end or reduced to the bare minimum. In our case, nearly a decade and a half of river clean-up efforts practically compel us to detail prevention prominently and as a main chapter, as we are convinced that only this can bring about meaningful results and changes. So here are the solutions:

4.1 Solutions for preventing pollution

This chapter briefly discusses waste avoidance and outlines an action plan in the next chapter. Preventing illegal waste dumping is the most cost-effective strategy and must occur at multiple, interdependent levels. However, quantifying cost savings is challenging because prevention is hard to measure and valuing ecosystem services, like those of a tree, raises issues of offsetting or paying for pollution.

Figure 3: Strategies to prevent waste pollution

To prevent waste from entering rivers and other water bodies, most countries implement a combination of the following strategies, tailored to their geographical location, economic status and environmental and sustainability considerations:

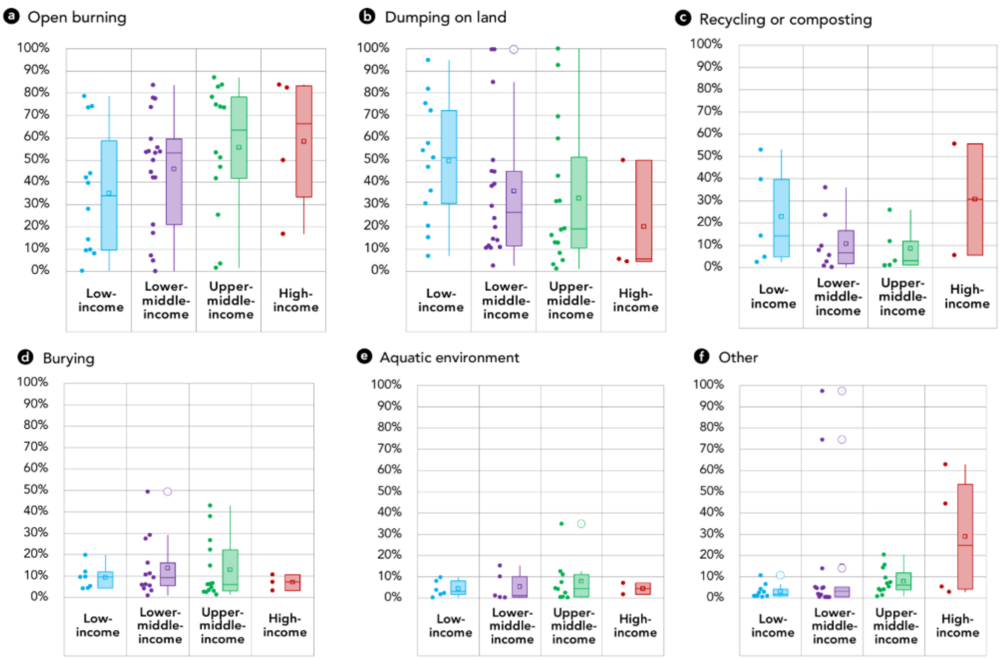
4.1.1 Upstream strategies

Prevention at source – The goal is to prevent waste generation and environmental release.

- **Regulatory measures**
  The primary condition for preventing illegal dumping is the establishment of an appropriate legal and regulatory framework (Chapters 3.1 and 3.2), which must be implemented at the state level. This includes key mechanisms such as PPP, EPR, and DRS systems (Detailed in Annex 2: Key regulations on waste management in the AQPLA project partners' countries).
- **Economic incentives**
  Countries use both positive and negative economic incentives to prevent illegal waste disposal and to remediate waste, as shown in Chapter 7: Table 9. Negative incentives entail the imposition of deterrent fines and legal consequences, supported by adequate regulatory inspections and consistent judicial enforcement (Sanctioning practices listed in Annex 4.).
- **Targeted sectoral measures**
  Specialized guidelines address high-impact sectors, such as agricultural runoff management via Slovakia's Codes of Good Practice and Romania's nutrient management. This also includes construction waste regulations in Slovenia and Romania, as well as tourism waste management strategies in sensitive zones like Slovenia's green tourism and fee-based systems.

- **Environmental liability insurance**
  Insurance coverage is mandated for large, potentially hazardous sites, such as non-EU-conforming landfills and mining activities.
  Construction waste regulations in urban and protected areas: Slovenia, Romania; Tourism waste management strategies in sensitive zones: Slovenia's green tourism and fee-based systems.
- **Waste reduction and eco-design**
  A holistic approach is essential in both packaging and product design, as decisions made during the eco-design phase account for 80% of a manufactured product's total ecological footprint.
- **Awareness raising, education and citizen Involvement**
  We can certainly speak of some form of public engagement, even in the absence of proper collection systems and awareness-raising initiatives. An interesting analysis of this can be found in the World Bank's journal on waste management[31] (although they found reference data for only 49 – unnamed – countries in total, the aggregate results are still telling): In low-income, lower-middle-income, and upper-middle-income countries, the most common methods of managing uncollected waste are incineration and landfilling (dumping). In high-income countries, however, the most common methods of managing waste not collected through centralised systems are open burning and recycling or composting.

Figure 4: The most common methods of managing uncollected waste[32]



[31] World Bank: What a waste? 3.0 https://www.worldbank.org/en/publication/what-a-waste, p 32-33.
[32] World Bank: What a waste? 3.0

Long-term success depends on raising public awareness and shifting attitudes (detailed in Chapter 8: Education, training and awareness-raising)

4.1.2 Midstream strategies

Collection and management – The goal is to efficiently collect and manage generated waste before it escapes.

- **Comprehensive waste collection coverage**
  Opening new waste yards (ensuring public access to legal waste disposal options) or introducing recycling systems (e.g. regular municipal waste collection for special waste) could help prevent illegal dumping (Chapter 7.).
- **Infrastructure development**
  E.g: New BAT (best available techniques) for landfills and the introduction of a fourth purification stage for certain wastewater treatment plants (detailed in Chapter 6.3).

  Repurposing and cleaning up areas exposed to pollution can prevent further illegal dumping (detailed Chapter 5.5.1: prevention of recurrence).
- **Control and enforcement of illegal dumping**
  Fines only have a deterrent effect if the authorities and police have the resources and tools to conduct on-site inspections, carry out checks, and investigate more complex cases (sanctioning systems are detailed in Annex 4: Sanctioning practices in the AQPLA project partners' countries).
- **Data collection and institutional coordination**
  The Hungarian Waste Radar (detailed in Chapter 5.1) has proven to be a good solution for collecting data and automating the authority's clean-ups.

4.1.3 Downstream strategies

Interception and clean-up – The goal is to capture waste that has already escaped or is about to escape[33,34].

- Stormwater and drainage system controls
- Riverine and marine litter capture technologies
- Wastewater treatment improvements[35]
- Hotspot interventions and clean-ups
- Remediation, recultivation and brownfield management[36]
- Monitoring of environmental leakage
  - In the latter case use of permits, monitoring, and polluter registries are necessary: IPPC in Slovakia; Cadastre of Polluters in Serbia; Regional Inspectorates for Environment and Water in Bulgaria; a strict monitoring system and sanctioning for

[33] More effective tools to prevent waste from entering rivers by countries are detailed in Annex 3 and in the 'Documentation of Implemented Professional River Cleanup Pilot Actions'

[34] Interreg Danube Region. (2025b)

[35] Investment in wastewater treatment plants and waste collection systems: Romania's and Hungary's DRS (deposit return system), Serbia's Clean Serbia, and Austria's separation plant at Borealis.

[36] These measures can remove or contain soil contaminants, restore vegetation and wetlands, and prevent contaminated runoff from entering rivers, reducing long-term pollution and protecting aquatic ecosystems.

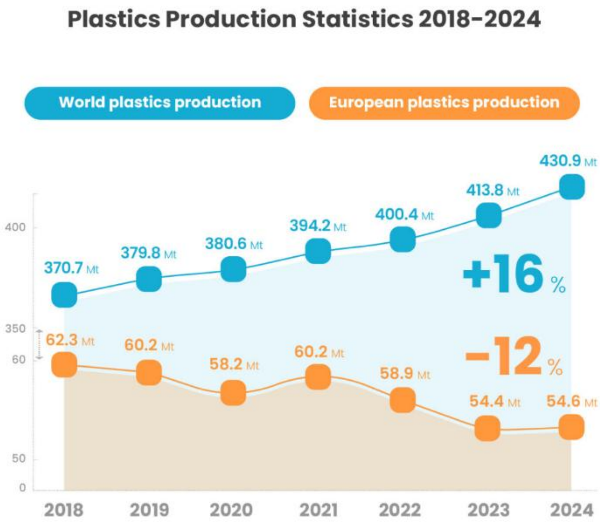
illegal waste disposal. The Polluter Pays Principle is enshrined in legal systems (detailed in Annex 4: Sanctioning practices). Integrated surveillance systems: technical solutions like CCTV cameras can be implemented locally, especially at sites with repeated illegal dumping. However, only large-scale, integrated systems are truly effective; isolated cameras might only displace the problem.

4.2 The Plastic issue

Plastics have become the 'usual suspect' of the waste world – routinely blamed and prosecuted in the court of public opinion – while more harmful offenders quietly evade scrutiny. In our case, plastics can be a good 'indicator species' for identifying polluted sites and making pollution visible.

Plastic waste significantly contributes to the global climate crisis, accounting for approximately 4.5% of global climate impacts. In 2024, Europe's global market share has continued to erode, falling from 22% in 2006 to just 12%. But overall, a general industrial boom is underway in other regions: global plastics production increased by 4.1% in 2024 and by 16.3% since 2018.

Figure 5: The plastics production of the World and Europe (2018–2024)[37]



Despite a global initiative (the UN Plastic Treaty, detailed in Chapter 4.2.2), little progress has been made. Plastic waste generation is rising worldwide, and current recycling systems are insufficient to handle the growing volume. Mismanagement of plastic waste has led to severe environmental consequences, including marine plastic pollution and microplastic contamination in food and water supplies. In Hungary, initiatives to map the occurrence of microplastics in domestic water bodies were launched almost a decade ago. A summary article has been recently published in 'Green Industry 2026'.[38] Over 80% of marine litter consists of plastic, primarily originating from land-based sources such as mismanaged waste, stormwater runoff, and improper disposal.[39] The Danube carries a daily macroplastic load of 4.2 metric tons, amounting to approximately 1,500 tons of plastic transported into the Black Sea annually.

[37] Plastics Europe. (2025)

[38] HAEE. (2026).

[39] United Nations Environment Programme (2024b)

Macroplastic pollution has adverse economic effects across sectors, including conservation of natural protected areas and tourism. It risks compromising natural habitats and their biodiversity, as well as water quality, as plastic-associated invasive or pathogenic species can be transferred to protected areas on their surfaces. When waste enters natural water bodies, the majority (70%) sinks to the bottom, while the remainder either washes ashore (15%) or drifts in the water column[40].

The river debris carried by floods accumulates along the riverbanks, forming layers that resemble tree rings. Photo: Agnes Kiss

Though the risks are well known, no agreement was reached at the Intergovernmental Negotiating Committee (INC-5.2) in Geneva in August 2025 on a new legally binding instrument to tackle plastic pollution, as nations failed to reach consensus on key issues. The process, launched in 2022, again ended without an agreement due to deep divisions between countries pushing for a strong, full-lifecycle treaty and those favouring weaker, waste-focused measures. Although Member States intend to continue, further negotiations are needed to bridge the gaps. The stalemate has also sparked several smaller but more effective initiatives to compensate for the lack of global progress. One of these is the **Position Statement –'Moving into a New Era of Responsible and Holistic Sustainability'**[41] – that sets out a unified vision and a set of strategic, actionable commitments for a sustainable future. Developed within the framework of the Plastics Summit – Global Event 2025, it reflects the contributions of experts, organisations, and thought leaders from across the world, aligning industry transformation with the United Nations Sustainable Development Goals.

Plastics are complex materials made from many substances, including over 13,000 chemicals, of which a quarter are highly hazardous and pose risks to health and ecosystems. Many chemicals lack hazard data, and recycling can reintroduce hazardous substances, risking exposure. Some substances hinder recycling by damaging equipment or reducing product effectiveness. The harmful effects include threats to marine life, microplastics absorbing pollutants and entering the food chain, and health risks to humans[42].

[40] Hanke et al. (2013)

[41] Global Plastics Summit. (2025)

[42] United Nations Environment Programme (2024b)

4.2.1 Preventing plastic waste generation

'Strengthening prevention, the EU Council and the European Parliament provisionally agreed on a regulation to prevent the loss of plastic pellets – the industrial raw materials used to make plastic products – into the environment. The new rules will improve the handling of plastic pellets across the supply chain, both on land and at sea.'[43]

Addressing plastic pollution requires a multifaceted approach, including legal and regulatory frameworks, economic incentives, and the development of technical capacities, monitoring systems, institutional structures and strengthened social awareness, as detailed in Chapters 3.4 and 4.1. The Global Waste Management Outlook[44] highlights that while improvements in recycling and waste collection are crucial, they remain end-of-pipe solutions; therefore, the primary goal should be reducing plastic production and transitioning towards a circular economy. Nevertheless, the Circularity Gap Report 2025 shows a clear picture: global circularity has deteriorated to 6.9% (from 7.2% in 2024), and we could increase circularity to a maximum of 25% with the current growth in material use.[45]

To tackle this issue effectively, several systemic changes are required:

- Reducing overall plastic demand.
- Giving serious consideration to regulating the material composition of plastics.
- Incorporating renewable resources in production.
- Phasing out hazardous chemicals (e.g. PFAS, NMP, etc.).
- Streamlining and harmonising material compositions (e.g. through standards).
- Enhancing transparency across product life cycles (e.g. with digital markers linking to composition information).
- Improving collection, sorting, and waste management systems.

A glimmer of hope at the end of the tunnel

However, the afore-mentioned SUP regulation has delivered its first results. The **EU Coastline Macro Litter Trend report**[46] found that the amount of marine macro litter (items larger than 2.5 cm) in the EU coastline has dropped by 29% between the baseline period (2015-2016) and the assessment period (2020-2021): single-use plastic by 40%; fisheries-related items by 20%, and plastic bags by 20%. This achievement is the result of multilateral, national, regional, and citizen efforts triggered by the Marine Strategy Framework Directive[47].

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[43] Council of the European Union. (2025, April 8)

[44] United Nations Environment Programme (2024b)

[45] Circle Economy. (2025)

[46] Zaldivar et al. (2024)

[47] European Commission. (n.d.-a)

A joint effort by water directorates, HPP operators, and NGOs can be a gamechanger in reducing the influx of riverine waste into the seas. Photo: MTDWD

4.2.2 The Plastic Treaty

Despite partial results, the problem worsens, as shown in the introduction. To address this, an international, legally binding treaty is needed to regulate plastics throughout their lifecycle. In 2022, the UN Environment Assembly in Nairobi launched negotiations for a Global Plastic Treaty. Complex interests shape these regulations, and final results are not yet complete. The treaty draft focuses on waste management, financing, and plastic production, covering three main pillars: product approaches, waste approaches, and financing issues.

The financing mechanism (Chapter 7.) is also worth mentioning, as one of the key elements of a future convention would be to provide for waste management development and capacity building for countries most in need. One idea is to require developed countries to lead funding; another uses the term 'capacity holders' and even suggests that countries with high plastic/polymer production should contribute to the costs. In addition, the involvement of the private sector was discussed, as well as what, how much and with what resources the mechanism should support. Several countries referred to 'common but differentiated responsibilities' (CBDR), which require consideration of the historical contributions of developed countries to pollution through their high consumption rates and the historical export of waste to developing countries. There was also a strong debate on whether to create an existing Global Environment Facility (GEF) or a separate dedicated fund. The former is supported more by developed countries, the latter by the other half of the world.

It is clear from the above that the failure of the negotiating series so far has been due to several reasons. Due to the document's complex structure, significant gaps have emerged between stakeholders' views. In addition, the changed and ever-changing geopolitical landscape has also affected multilateral efforts.

As a result, at the beginning of February 2026, there is still no final, signed document. Although two critical rounds of negotiations have been completed, both have ended in a stalemate:

- INC-5.1 (Busan, December 2024): The text should have been finalised, but member states were unable to agree on the most contentious points.
- INC-5.2 (Geneva, August 2025): This was intended to be the final round, but it also ended in failure.
- And another shorter and more trade-off concentrated summit is upcoming in February 2026.

The countries of the world are divided into two camps: the ambitious coalition (e.g. the EU and less developed countries) would like to reduce the amount of new plastic used globally as a raw material and ban the most dangerous chemicals and single-use plastics.

By contrast, the oil-producing and chemical industry superpowers (e.g. Saudi Arabia, Russia, and China) oppose production restrictions. In their view, the agreement should focus solely on waste management (recycling, collection), while restrictions should remain voluntary commitments within national jurisdiction.

Finding common ground would be possible only if ambitious countries, recognising the geopolitical challenges, adopted a different strategy. Preparatory work needs to be broadly based, with strong involvement from the economic and commercial disciplines. In addition, it is essential that the highest political level is involved in the negotiations, where the 'deal' must be struck. Reasonable common ground must therefore be found where economic and environmental interests intersect. This is not impossible, given the huge potential for product development and recycling as technology advances. Shifting plastics production towards sustainability could reassure economic operators, while significant steps could be taken to protect our environment and our health. It all depends on a common will, strategic thinking and, of course, common sense. Further details in 'Green Economy 2026' (László Uhri: 3.16.5 Plastic pollution as a global problem, p. 249).

Waste management stakeholders were also represented during the negotiations (including ISWA), and it was a good opportunity to focus attention on financing waste management from the end of the waste management process and on bringing waste management in developing countries up to the right level. Owing to our project, we have been able to contribute to this work and develop the 'Guidance on support mechanisms for the implementation of effective municipal waste management systems'" to describe the necessary steps.[48]

5. ACTION PLAN: A step-by-step clean-up guide

Where illegal dumping has already occurred, the waste must be removed. In the following figure, we provide a tool for authorities, municipalities and other stakeholders, a step-by-step guide[49] on dealing with accumulated waste, including monitoring, clean-up, sorting, recycling, and prevention of recurrence. The steps are divided into four main parts:

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[48] International Solid Waste Association. (2024b)

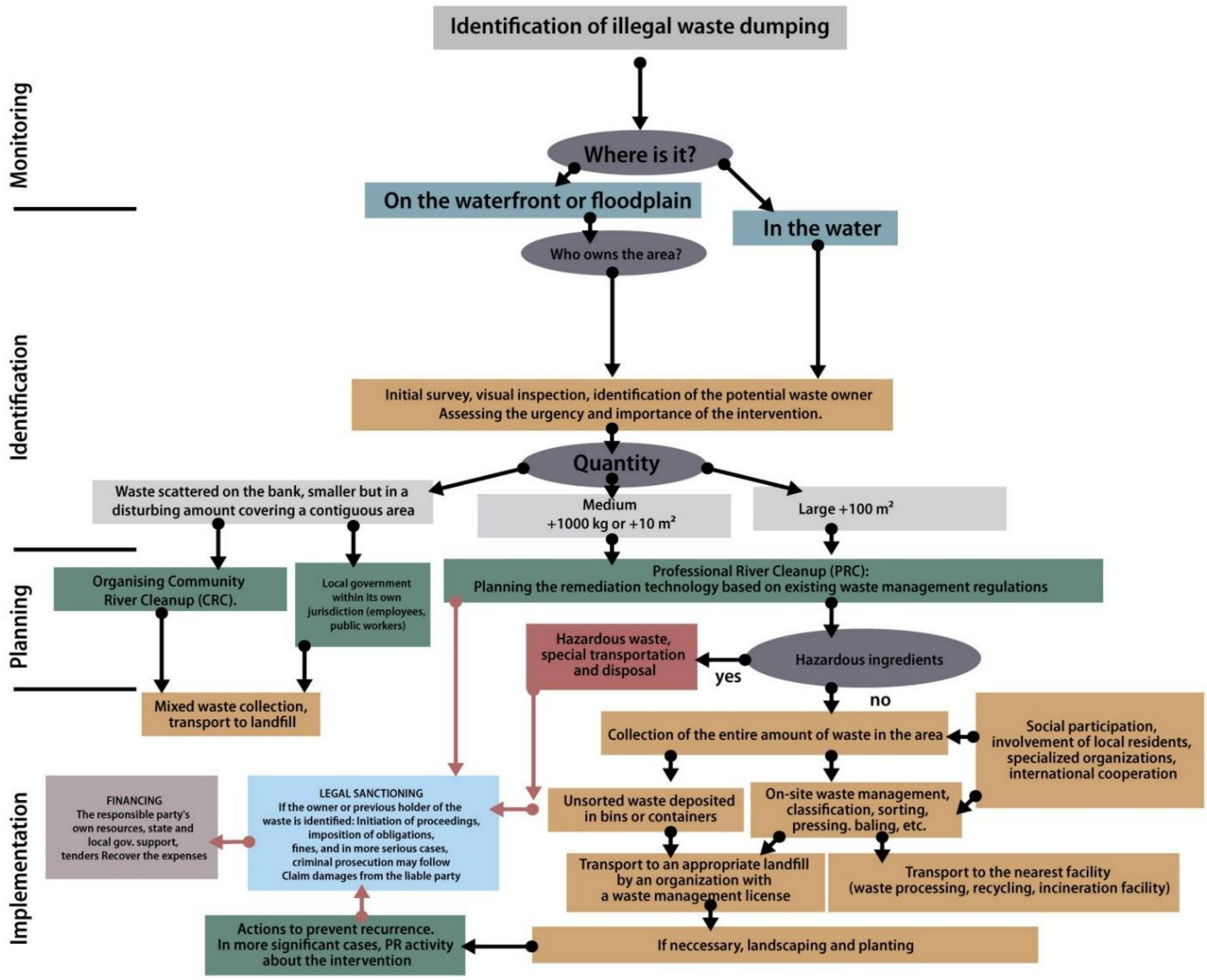
[49] ISWA Scientific and Technical Committee. (2016)

- **Monitoring** – citizen science and digital tools are key catalysts for change, especially remote sensing technologies, which are increasingly influential today. We present their operation in detail, providing key components for their implementation.
- **Identification** – when illegal dumping is identified, responsible institutions are to be notified. The next step is to identify the location and the owner of the waste or the area, and to inspect the quantity of the litter. For this part, we provide a tool for risk assessment and classification of potential leakage points.
- **Planning** – based on the risk assessment, planning waste collection correctly in advance is a crucial part of the process. This is why we offer guidance on the specification of waste clean-up activities.
- **Implementation** – after careful planning, it is time for the different types of clean-up activities. To this end, we provide the AQUATIC PLASTIC Handguide for clean-ups and the Sorting Protocol (Chapter 6.1) to foster effective separation of collected waste and achieve higher recycling rates. The implementation has different aspects, thus we detail good practices both in financing and in the prevention of recurrence.

HAEE's Working Group has developed a flowchart on how to manage the abandoned waste issue[50]:

Figure 6: Flowchart of the whole process to eliminate abandoned waste

[50] HAEE (2026)



5.1 Monitoring

Illegal dumping is mainly reported by residents, inspectors, guards, police, and workers from national parks or water directorates, but remote sensing technology is now increasingly used for detection. A cost-effective, organised approach at the national or regional level involves removing reported dumpsites, which requires accurate mapping of their location and volume. Waste-mapping applications have proven effective in enabling authorities and individuals to report illegal dumpsites. Currently, there are no standard methods or consistent data available on plastic pollution in the rivers of the Danube River Basin, that would help harmonise actions of citizens and other relevant actors. The authority or municipality may learn about an illegal landfill from several sources. On the one hand, waste management inspectors or field guards may work in the field. The public can report illegal landfills by email, phone, or through increasingly widespread applications (like WasteRadar (HU) and TrashOut (SK)). By using the Trashout application and following the video guides[51,52] of Plastic Cup, one can easily leave a mark on the map with this **citizen science** procedure. The map now covers the entire Danube River Basin, including its principal rivers. The database provides the exact GPS locations, size, and other characteristics (such as

51 Plastic Cup Society. (2021b)

52 Plastic Cup Society. (2021a)

composition and accessibility) of the given sites. The CleanTiszaMap[53] summarises the sites and displays the clean-up records, other relevant sites, including riversaver centres, waste yards, riversaver schools, and anchor points.

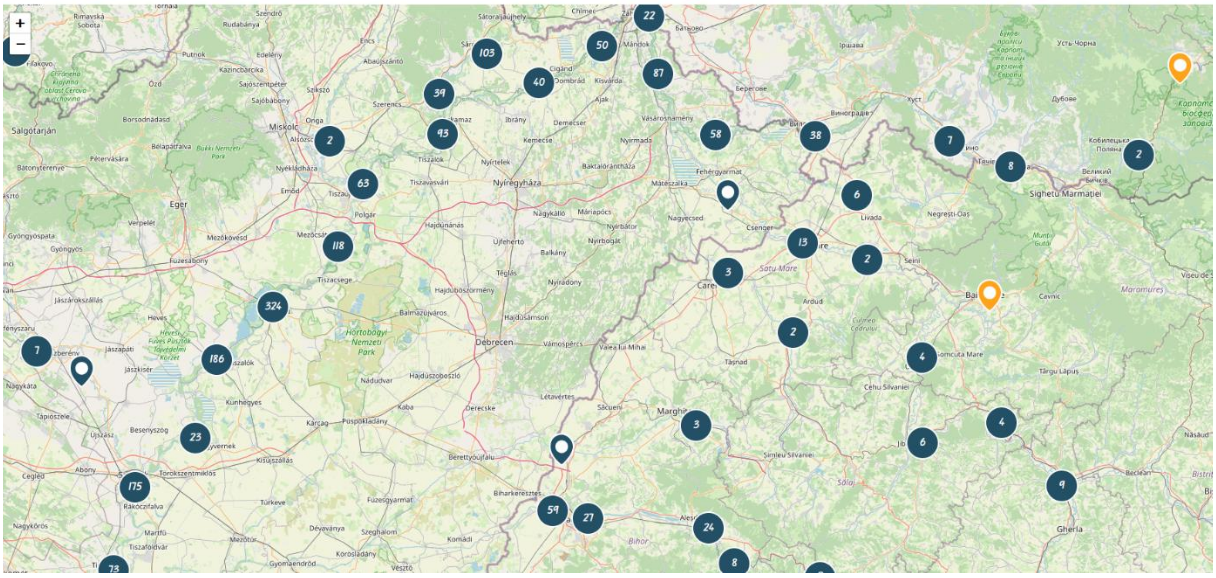


Figure 7: More than 3,500 plastic-polluted sites have been identified along the Tisza's floodplain, and approximately 1,665 tonnes of riverine litter have accumulated in the Tisza River Basin. Source: https://www.riversaver.eu/en/map

It is essential to designate a responsible organisation, institution, or local authority to receive notifications and to be capable of addressing the issue (in terms of resources, personnel, authority, etc.). Online applications typically request access to the device's camera and location (GPS coordinates). In the countries concerned, citizens' willingness to report such issues should also be improved.

The Waste Radar application enables citizens to report illegally dumped waste in ***Hungary****, whether in settlements or outlying areas. Operated by the Governmental Agency for IT Development (KIFÜ), the system allows users to submit photographs along with information on the type, quantity, and accessibility of the waste. This data is forwarded to the* ***competent territorial authority****, ensuring that illegal dumping sites are officially registered and appropriate clean-up actions can be initiated to restore the affected environment.*

Riverbank monitoring[54] is not only an opportunity to monitor waste, but also to build relationships with local people. This activity should also serve as a platform for a representative questionnaire survey to assess local people's attitudes towards the river, their knowledge of river pollution, and their willingness to address it. By evaluating the results, we will also get an idea of areas of deficiency and strengths, which can be used to create community river clean-up activities and build a cross-border riversaver stakeholder management network.

[53] Plastic Cup Society. (n.d.-b)

[54] Molnár et al. (2024)

The **S**patio-temporal quantification of **P**lastic pollution **O**rigins and **T**ransportation (SPOT) model is a fully integrated GIS-based model, that highlights hotspots of plastic pollution worldwide. Written in R, the model has been applied on a global scale (publication to be released shortly) but can also be applied at a higher resolution within any region with dedicated data inputs for enhanced reliability.[55]

5.1.1 The role of timely data in Early Warning Systems (EWS)

Timely and accurate data are crucial for an effective EWS against plastic pollution. Rivers transport debris to larger water bodies, so preventing buildup is vital to break pollution chains. The system aims to provide local authorities, waste management, NGOs, and agencies with real-time or near-real-time information to respond quickly and avoid irreversible damage.

Why data matters: Empowering stakeholders through early warning

To prevent river plastic pollution, relevant stakeholders – local governments, environmental agencies, waste management companies, NGOs, and communities – must have access to timely andaccurate data. These data are vital for creating an EWS for quick, targeted responses to threats. Key data include:

- **Waste generation and disposal patterns**: Real-time or regularly updated data on the amount of plastic waste produced and how it is being managed in a particular area. This helps identify hotspots where mismanaged waste may end up in rivers.
- **Water quality and flow monitoring**: Sensors and monitoring systems can track plastic concentrations, turbidity, and changes in flow that may signal blockages or illegal dumping.
- **Rainfall and weather forecasts**: Heavy rainfall can wash large amounts of waste into rivers (runoff), especially in areas with poor infrastructure. Forecasting models can help predict risk zones in advance.
- **Illegal dumping reports and citizen feedback**: Crowdsourced data from mobile apps or community platforms can alert authorities to plastic waste accumulation in real time.
- **Geospatial and satellite imagery**: Visual data from drones or satellites can help detect larger plastic accumulation zones that may not be visible from the ground.
- **Industrial discharge monitoring**: Tracking plastic pellet losses or other pollutants from manufacturing sites along rivers.

[55] Water, Public Health and Environmental Engineering Group. (n.d. -a).

Massive communal waste influx near Borcea (RO). This site has been cleaned up during the AQPLA project. Photo: KayakCrazyRic

With timely access to these datasets, stakeholders can implement **data-driven prevention strategies**:

- Identify and respond quickly to pollution incidents.
- Prioritise high-risk areas for clean-up and infrastructure improvement.
- Launch targeted public awareness campaigns.
- Strengthen the enforcement of environmental regulations.
- Collaborate across sectors for more effective, coordinated actions.

Key components for implementation:

- **A centralised data-sharing platform**, accessible in real time via a web portal or app, with clearly defined access roles for different users.
- **Automated alerts and notifications:** when sensors or satellite images detect high levels of plastic, the system automatically notifies relevant stakeholders (e.g. municipalities, inspection agencies, NGOs). It is also important that stakeholders alert the relevant partners about the incident to enable joint action.
- **Standardised data formats**: introduction of unified metrics (e.g. plastic density per km^2) to ensure all users interpret the data consistently.
- **Interoperability** with existing environmental protection and emergency response systems.
- **Regular system updates and stakeholder training** to ensure effective use of the data for field-level action.

5.1.2 Assess the validity of collected data using remote sensing technology

To develop a system for detecting illegal dumping and plastic pollution hotspots, data from remote sensing – satellite imagery and drone surveys – must be validated for accuracy before use in warnings, enforcement, or planning. Remote sensing covers large, hard-to-access areas and reveals spatial patterns often missed by ground patrols. However, results can be affected by weather, sensor limitations, and classification uncertainties, risking false alarms or missed risks. Validity assessments should confirm that data meet operational needs. Since early warnings rely on change detection, temporal consistency is vital: images should be captured frequently and under similar conditions to identify sudden pollution events and distinguish persistent from transient deposits. Spatial resolution must match target sizes, especially in high-risk areas with small, fragmented, or obscured dumping sites. Sensor spectral sensitivity influences classification accuracy across seasons and land covers. Coverage and completeness should also be reviewed to prevent missing key areas such as riverbanks, tributaries, urban runoff zones, and industrial discharge points due to gaps or cloud cover.

Ground-truth validation is essential for translating sensors' detections into actual presence. Sampling sites should be selected across different riverbank types, land uses, and dumping locations, then field observations are to be compared with remote-sensing data. When on-site access is difficult, high-res drone images can serve as references. This helps measure accuracy, identify failure modes (like mistaking plastic waste for bright surfaces), and estimate false positive/negative rates, impacting alert credibility. QC must be embedded to make data uncertainty visible to decision-makers. Reliable remote sensing improves early-warning thresholds, predictive models, reducing false alarms and missed events. Quality-reviewed spatial data reveals monitoring gaps, guiding survey frequency, additional sensors, and clean-up actions. Embedding validation as a feedback loop allows the system to evolve, increasing trust and performance with changing data and conditions.

5.1.3 AQPLA software development for remote sensing

The AQPLA remote sensing software was developed as a practical, Python-based solution for the automated detection of macroplastic waste and waste-related change patterns from multispectral satellite imagery. The implementation comprises two complementary user-facing products:

• a desktop application supporting model training and batch classification workflows, and

• a web-based prototype for continuous monitoring that periodically retrieves new imagery, runs inference with pre-trained models, and visualises results for predefined and user-defined locations.

The system uses medium- to high-resolution multispectral satellite imagery from configurable sources, primarily Sentinel-2 and PlanetScope. At a minimum, the imagery includes four spectral bands (Blue, Green, Red, and Near-Infrared). After data acquisition, the software applies standard preprocessing and generates additional features, with a focus on spectral indices that help distinguish plastics and waste-related materials from water, shadows, and natural surfaces.

Two types of machine-learning approaches are implemented in the system: 1) Random Forest classifiers, which operate on pixel-level features and spectral indices, and 2) Convolutional Neural Network (CNN) segmentation models, specifically U-NET and U-NET++, which are trained to produce spatially consistent, pixel-wise classification maps.

Model selection and performance depend strongly on the characteristics of the satellite sensor, including available spectral bands and spatial resolution, as well as on which plastic-related spectral indices can be calculated. For example, the Adjusted Plastic Index (API) improves the ability to distinguish plastics but requires shortwave infrared (SWIR) bands, which are available in Sentinel-2 but not in PlanetScope. As a result, PlanetScope-based workflows rely on the Plastic Index (PI) and other related features. The desktop tool targets operational users (waste management organisations, researchers, and technical staff), who need repeatable workflows for developing and applying models across sites and seasons. It supports preparing training datasets, training new models from defined inputs, and classifying imagery with selected trained models. The application addresses three monitoring use cases:

1) hot-spot detection for illegal dumps in upper catchments that contribute to downstream leakage during flood events,

2) floating waste detection for river-surface accumulations (e.g. near dams and hydraulic structures), and

3) detection of washed-up waste in floodplains using higher-resolution imagery where available.

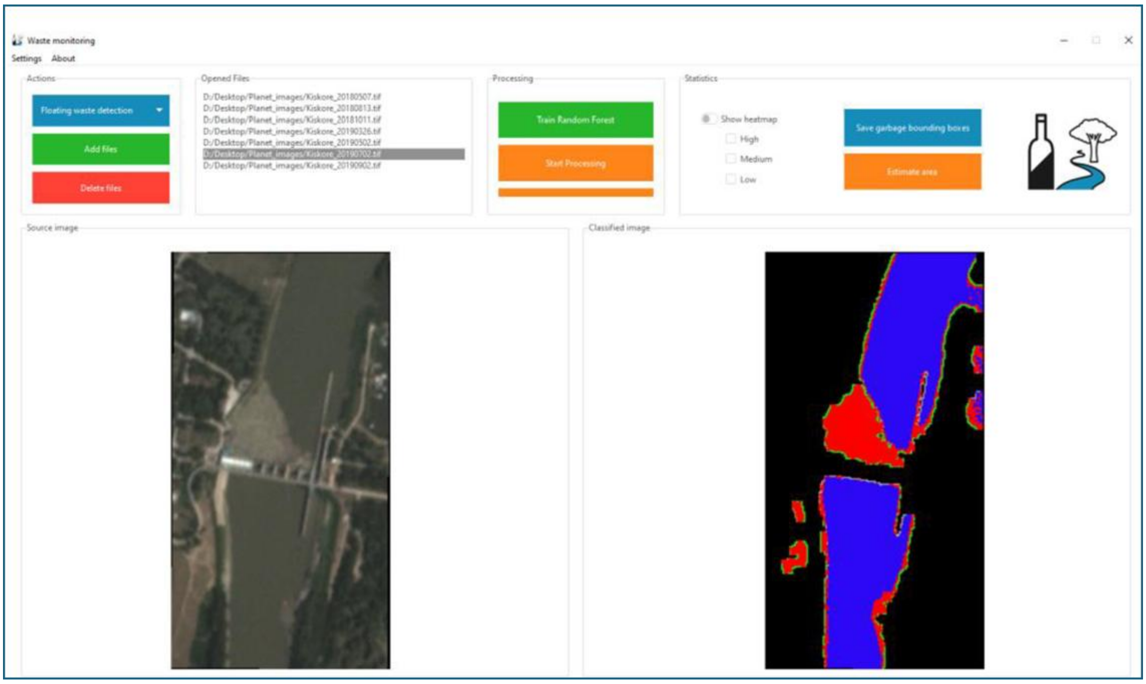


Figure 8: Desktop interface

Web application (continuous monitoring + visual analytics). The web prototype operationalises the monitoring concept; it automatically searches for newly acquired satellite images, downloads them on a frequent schedule (daily in the prototype), classifies them using the selected pre-trained model (Random Forest or U-NET++), and displays outputs in an interactive map interface. Practical constraints are handled explicitly: the viewer prioritises the most recent usable acquisitions for each location by filtering on cloud cover (prototype threshold: 15%) and provides a short rolling window (last five suitable dates) for rapid trend review. Visualisation layers include a classified mask and confidence-driven heatmaps (high/medium/low confidence ranges), enabling users to triage detections and focus field verification on the most credible areas. The prototype also integrates hydrological context (measurement point locations, current/predicted water levels, and flood hazard mapping) to support interpretation of whether detected waste areas may be submerged, mobilised, or redistributed by high-water events; in the demonstrated implementation, this functionality is available where national data services are integrated (prototype coverage includes Hungary)[56].

[56] ELTE Geoinformatics Laboratory. (n.d. -b)

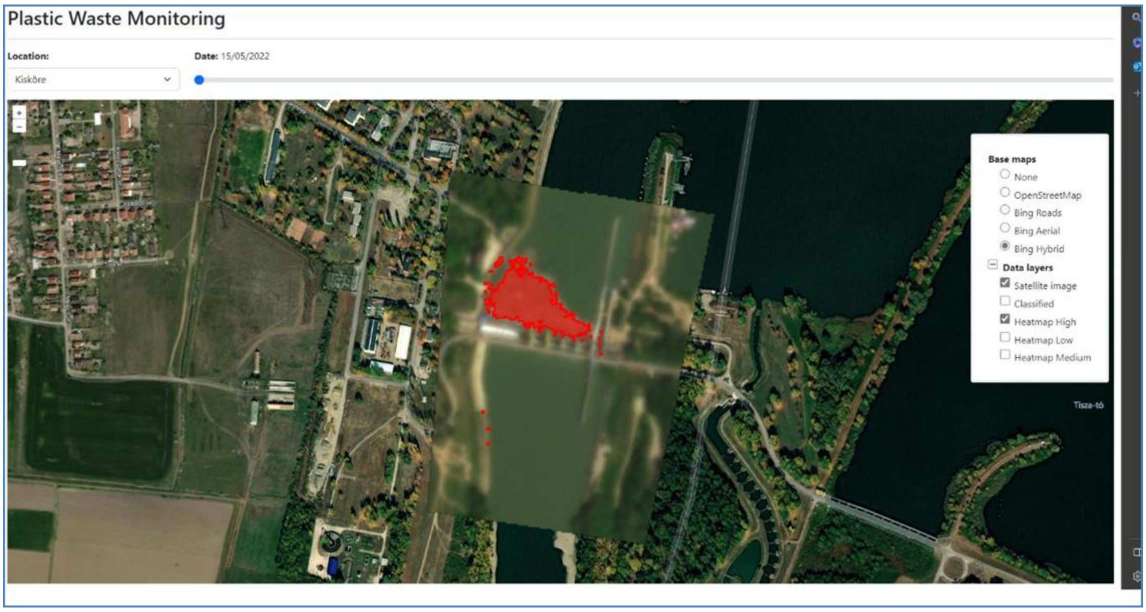


Figure 9: Web application

The solution provides a complete, end-to-end workflow – from data collection to map visualisation – enabling systematic monitoring rather than ad hoc analysis. Its sensor-agnostic design, with minimal spectral requirements (Blue, Green, Red, and NIR), enables easy expansion beyond the initial data sources. A dual modelling approach combines the efficiency of Random Forest classifiers with the spatial coherence of U-NET architectures, where data and resources permit. Confidence heatmaps enhance decision support by highlighting high-probability detections and reducing manual effort. Hydrology-aware interpretation links detections to water levels and flood risk, better addressing submergence and transport in rivers. Fully transparent, with publicly available source code, it supports auditability and adaptation.

The approach is subject to several limitations, primarily related to data availability and transferability. Cloud cover and satellite revisit cycles reduce the number of usable acquisitions, leaving small rivers and narrow riverbanks unobserved during critical periods. Sensor-specific spectral constraints further degrade performance, as the API relies on SWIR bands and therefore cannot be applied to PlanetScope imagery, limiting robustness when using higher-resolution, spectrally constrained data. Detection capability is also influenced by spatial resolution: Sentinel-2's 10 m resolution restricts the identification of narrow river features and small accumulations, while higher-resolution imagery – although mitigating this limitation – often entails subscription costs and increased processing demands. Model performance is highly dependent on the availability of representative training data across seasons, substrates, and geographic regions, and transfer to new sites without local calibration may lead to increased false positives or negatives. Finally, the integration of the hydrological context depends on sustained access to external national services for water-level and flood data, with prototype coverage not being basin-wide by default. An online demo is available[57].

[57] ELTE Geoinformatics Laboratory. (n.d. a-)

AQPLA's remote sensing workflow is strengthened when combined with systems that quantify and spatially prioritise plastic leakage using independent evidence streams:

- SPOT[58] (University of Leeds): a macroplastic emissions inventory combining probabilistic material flow analysis with temporal geospatial modelling, designed for baselining, hotspotting, and action-plan support at local-to-global scales.
- ISWA Plastic Pollution Calculator[59] (University of Leeds/ISWA): a decision-support toolkit to map plastic waste flows through complex waste management systems (including informal recycling and leakage pathways) to support targeted interventions.
- Waste Detection/Plastic Waste Monitoring web app[60] (ELTE GISLab): an operational example of automated satellite-image retrieval and model-based classification with web visualisation, aligned with the type of monitoring logic implemented in AQPLA.

5.2 Identification

As we have already indicated, the starting point for clean-up is that the obligation to remove and manage waste deposited on a given property lies with the former owner of the waste. Since, in most cases, the identity of the person who deposited the waste is unknown – especially if it's drifted, riverine waste – **the need for a clear legal status** is essential.

5.2.1 Legal status: ownership and responsibility

The question of legal status is a fundamental yet often overlooked aspect of tackling illegal dumping and riverine pollution. Waste ownership determines responsibility, legal standing, and liability for clean-up and remediation, but current regulations are inconsistent and would benefit from a harmonised EU-level approach.

*In some countries, such as **Hungary**, waste ownership is transferred to private entities. While this may function under normal waste collection systems, it creates serious complications once waste is mismanaged or illegally dumped. Even when such waste is later collected by municipalities or voluntary initiatives, legal uncertainty remains due to the original ownership structure.*

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[58] Water, Public Health and Environmental Engineering Group. (n.d. -a)

[59] Water, Public Health and Environmental Engineering Group. (n.d. -b)

[60] ELTE Geoinformatics Laboratory. (n.d. -b)

Waste storage and off-grid sites can be potential hotspots with a high potential to be transported by surface runoff. Csepel-island, Budapest, cleaned up by authority. Photo: Green Collect Ltd.

These issues are particularly acute in transboundary cases. Waste transported by rivers is not covered by the Basel Convention, leaving responsibility for cross-border waste undefined. As a result, disputes and delays frequently arise, undermining effective clean-up and remediation. Establishing **direct responsibility** is extremely difficult unless the perpetrator is caught in the act or identified through clear evidence. Since illegal dumping is typically motivated by a desire to avoid disposal costs, waste is often deliberately made untraceable. Nevertheless, if the former holder can be identified through documents found in the waste, that person remains responsible for its removal. Regulations must therefore clearly assign responsibility when waste crosses borders, preventing accountability from being lost between jurisdictions or hidden behind ownership structures. A dedicated, harmonised EU legal instrument could provide binding principles for transboundary waste responsibility and enforcement.

The property owner usually bears waste removal costs and can avoid liability by identifying the previous holder or proving preventive measures. This is often hard for public landowners like municipalities or parks, unfairly burdening innocent public actors. A solution could be higher fines, with the money reserved for cleaning unidentified waste.

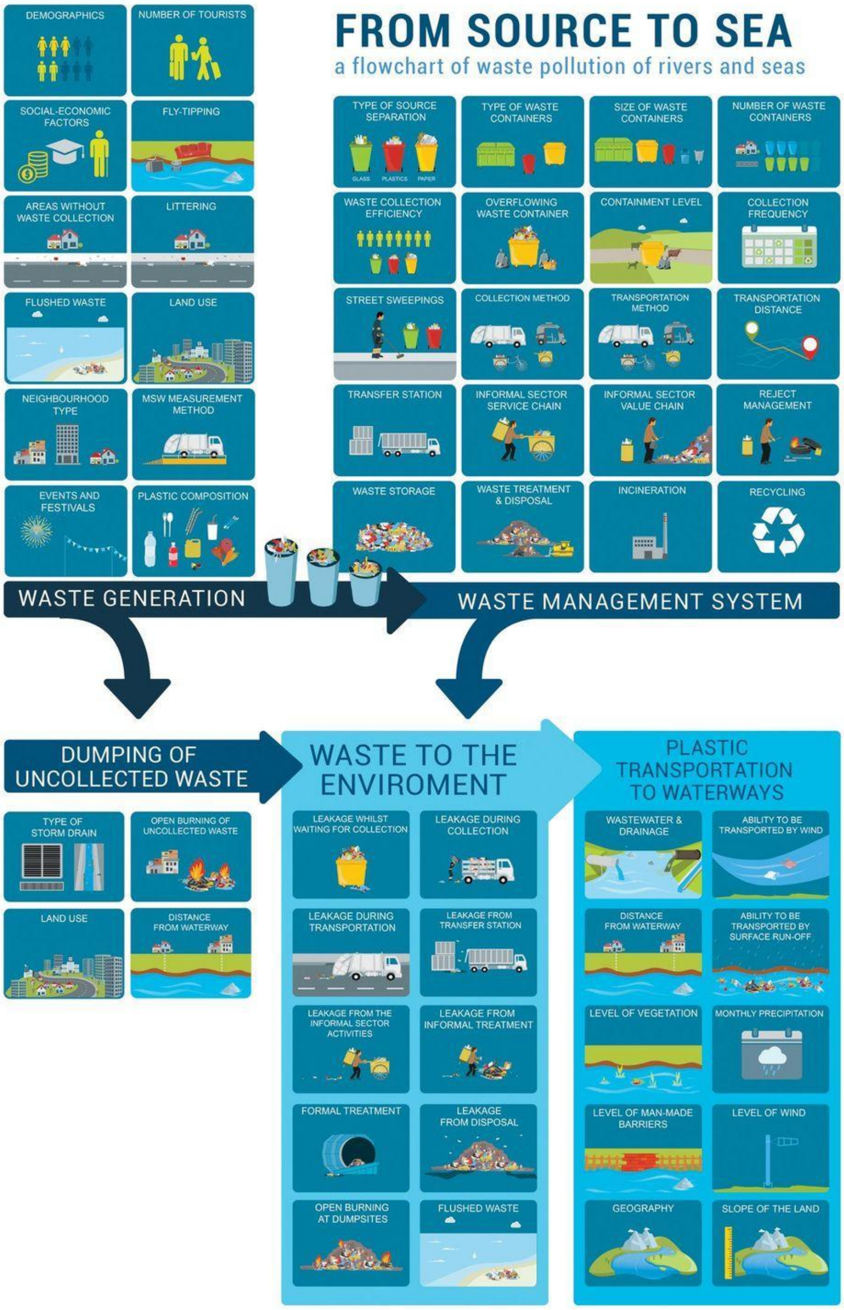
*In **Bulgaria**, enforcement is carried out by governmental entities such as the Regional Inspectorates for Environment and Water. Inspections and monitoring are crucial for identifying infractions and ensuring compliance. For instance, in cases of river pollution, authorities investigate incidents, impose fines, and require remedial actions. A recent example involved the pollution of the Devinska River, where emergency wastewater discharges led to administrative penalties and commitments to restore the affected ecosystem.*

5.2.2 Potential sources of pollution – HOTSPOTS

The next figure shows a flowchart of the different types and hotspots of waste pollution:

Figure 10: Flowchart of waste pollution of rivers and seas[61]

[61] University of Leeds, ISWA Marine Litter Task Force: Plastic Pollution Calculator, Graphically redesigned by HAEE, 2024.



Most countries **have identified types of potential polluters**; these include both point and diffuse sources, which typically fall into the following categories (the examples are from the national surveys of the AQPLA project and the GreenEconomy 2026 study book in Table 4):

Source of pollution (by sector)	Cause and/or types of pollution	Potential source of pollution (by group)	mentioned in the AQPLA national survey	Solution (detailed in Chapter 4.1)
Industrial sources	Mainly point sources of air, water, biota and soil pollution due to non-compliance with environmental standards	production and manufacturing: factories and plants, especially those near major rivers	chemical industry pollution in Austria, Serbia, Romania, and Slovakia. Plastic raw material is discharged into the Danube in Austria.	adequate environmental standards, stricter inspections and deterrent penalties
	Agricultural runoff: A source of diffuse pollution and specific wastes	farmers and entrepreneurs engaged in intensive farming	fertilisers, pesticides in Slovakia, Romania, Montenegro	appropriate environmental standards, phasing outcertain substances, stricter inspections and deterrent penalties
	Construction and demolition sector: inadequate management of building materials and waste	construction sites, abandoned industrial areas and residential neighbourhoods	waste left near rivers in Slovenia, Slovakia, and Austria	brownfield management, selective demolition, waste management plan and control
	Tourism sector: disturbance of protected areas, wave damage, pollution by fuel, and packaging waste	travel agencies, tour guides, waterfront facilities, beaches	fishing waste left behind at Lake Tisza; tourism-related waste, primarily packaging waste, on the riverbank	introducing river-friendly catering and tourism; Informing anglers, enforcement, and penalties
Municipal sources	untreated wastewater and poorly managed waste	municipalities without sound wastewater treatment, waste	untreated sewage, poorly managed waste in Serbia,	Proper use of the sewage system (no waste), sound

		management	Montenegro, Ukraine, Romania	waste management practices
Illegal landfills or informal dumpers	unmanaged waste, illegal dumping, open burning	unofficial waste handlers, companies, municipalities	reported in many countries, including Serbia, Montenegro, Ukraine, and Slovakia	introducing the EPR system and waste fees; establishing landfills with environmental protection
General public and househol ds	a diffuse source of littering and small-scale waste abandonment (fly-tipping), and untreated wastewater	citizens, shops, markets	widespread issues of littering, cigarette butts, and single-use plastics in every country	education, awareness-raising campaigns, enforcement, and penalties

Decades of industrial activity have left a legacy of contaminated sites and brownfield areas across Europe. To tackle this, the Soil Monitoring Law (SML)[62], entered into force 16th December 2025. It represents the first European soil-specific policy initiative, with the overarching aspirational goal of achieving healthy soils across Europe by 2050.

The SML requires Member States to establish harmonised monitoring systems to assess soil functions and identify contaminated sites using a unified EU methodology. It introduces an indicative list of soil contaminants, including per- and polyfluoroalkyl substances (PFAS) and pesticides, and allows consideration of micro- and nanoplastics. These measures respond to growing concern over emerging pollutants and will significantly shape soil assessment, data collection and analysis across the EU, with implications for Eastern Europe as well. Industrial pollution is still a major issue in the Central-Eastern and the Southeast-European region.

*Just to get a sense of the quantities, **Serbia,** for example, produces 8-10 million tonnes of power plant fly ash annually, and the country has 1.4-1.7 billion tonnes of mining waste. Most of the currently produced hazardous waste is not disposed of properly, and the only viable solution is export, for which only 13 companies have a licence.*

*In **Bosnia and Herzegovina**, a total of 331 tonnes of electronic equipment containing PCB-contaminated oil has been identified, of which only 30 tonnes are not in use, and 130 tonnes of hazardous waste is recorded in abandoned industrial areas. In the Republic of Serbia alone, there are two oil refineries and two large 'oil pits', each containing 30-50 thousand m^3 of hazardous waste stored in earthen basins.*

Further details in The GreenEconomy 2026 study book (Balázs Morvai: 2.11.: Opportunities for hazardous waste management (...), p. 69.).[63]

[62] European Commission. (2025b)

[63] HAEE (2026)

Oil gate next to a refinery in Bosnia and Herzegovina. Photo: Balázs Morvai

Classification and systematisation of the affected areas (size, waste composition, brownfields, etc.) with indicators such as the types of affected areas and their vulnerability, and the composition and origin of the waste, need to be carried out in this phase. We will provide a tool for this in the next section.

5.3 A tool for risk assessment and classification

Establishing a priority list of interventions is advisable, considering the large number of potential leakage sites and the limited nature of resources (labour, machinery, finances). Intervention and clean-up priorities should be determined based on the risk they pose to the river and the environment, specifically on the volume of plastic transferred from the land. In the present chapter we are introducing a risk assessment technique, focusing on the critical factors influencing the transfer of macroplastics from land to rivers.

The advantages of risk assessment

Risk assessment may offer the following advantages:

- **Efficient resource utilisation**: Governments, NGOs, national parks, water and waste management organisations operate with limited resources. Prioritising high-risk leakage points enables a more strategic allocation of funds, manpower, and technology, ensuring interventions have the most significant impact on reducing plastic waste.
- **Targeted interventions:** Not all leakage points require the same approach. High-priority sites might need immediate remediation, such as clean-up, installation of barriers and waste traps, or stricter waste management policies, whereas lower-priority areas might benefit from long-term educational programmes and community involvement.
- **Data-driven decision-making:** Creating a priority list based on scientific risk assessments ensures that actions are evidence-based. This leads to better planning and measurable outcomes.
- **Prevention of downstream accumulation:** Addressing high-risk leakage points upstream can prevent the accumulation of plastic waste further down the river, reducing the impact on ecosystems, fisheries, and human settlements that rely on these water sources. It also has a positive effect on transboundary cooperation.

- **Regulatory and policy support:** A well-documented priority list can support policymaking and regulatory enforcement, helping authorities focus on critical areas where stricter waste-disposal laws and compliance measures are needed.
- **Encouraging stakeholder collaboration:** Prioritisation fosters better collaboration among local communities, industries, NGOs, and government bodies by identifying key areas where collective action can have the greatest impact.
- **Risk assessment methodology for plastic waste leakage points:** A comprehensive risk assessment may integrate a wide range of factors, including waste management data, hydrological and spatial data, and socio-economic indicators, to develop a comprehensive understanding of the sources, transport pathways, and potential risks associated with plastic pollution. However, including an excessive number of variables may hinder the prioritisation process, particularly in contexts with limited data availability.

The key aspects

Below is a structured methodology based on these key groups of aspects:

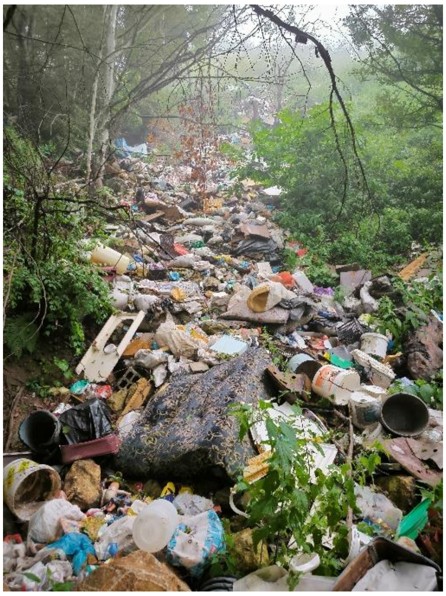
- **Hydrological Aspects:** Hydrological factors are critical for predicting plastic waste mobilisation, transport, and accumulation in riverine systems. Key dynamics include: the increased probability of waste leakage near water bodies (rivers, canals, and stormwater infrastructure); the direct effect of river flow characteristics (velocity, seasonal discharge, and tidal influences) on downstream transport; and the increased influx of waste caused by hydrometeorological events, such as heavy rainfall and flooding. Integrating these parameters into plastic pollution models is crucial for identifying high-risk areas and informing effective mitigation strategies.
- **Waste Management Aspects:** Waste generation and composition (volume and type) are primary factors determining potential pollution loads. System efficiency is equally crucial, encompassing municipal service coverage, recycling infrastructure, and the prevention of illegal dumping practices. While **informal collectors** often contribute to material recovery, their improper handling and unregulated disposal (e.g. open burning) can significantly elevate the risk of plastic leakage. Additionally, the quality and enforcement of waste management policies are critical indicators of a region's capacity to prevent environmental release. Assessing these comprehensive factors is essential for identifying high-leakage risk areas and guiding targeted waste governance strategies.
- **Spatial Aspects:** Spatial and geographic factors determine a landscape's vulnerability to plastic waste leaking into aquatic environments. Land use and urbanisation shape waste generation profiles across urban, industrial, agricultural, and rural settings. Identifying and mapping disposal hotspots – such as open dumps, unregulated landfills, and industrial zones near riverbanks or drainage – is essential for pinpointing leakage sources. Topography (elevation and slope) influences runoff and debris transport during rainfall or floods. Drainage networks and tributaries serve as pathways for debris entering rivers. GIS and geospatial analysis help visualise high-risk areas, analyse routes, and support predictive modelling for targeted interventions and watershed planning.
- **Socio-Economic and Behavioural Aspects:** Socio-economic and behavioural factors strongly shape the dynamics of plastic waste generation, management, and potential environmental leakage. Population density is a critical factor, as densely populated areas typically generate higher volumes of plastic waste, increasing the risk of mismanaged disposal and leakage into natural systems. Consumption patterns, closely linked to urbanisation and income levels, further influence the types and quantities of packaging and materials used. Public awareness and community engagement also play pivotal roles – levels of environmental literacy, attitudes towards recycling, and participation in waste management initiatives can either mitigate or exacerbate plastic pollution. Economic activities,

including those in manufacturing, tourism, and fisheries, often contribute directly to local plastic waste streams and, in some cases, are significant sources of environmental leakage.

5.3.1 The Risk Quantification Model

In this subchapter, we will analyse the leakage risk from typical waste accumulations, leakage areas, or waste already collected in the water, located on the open floodplain, the foreshore of a watercourse, or in the water body itself. From an affected leakage area, floods can carry waste (typically plastic, such as packaging material, or wood) and deposit it in other areas, which can then become leakage points themselves. Plastic waste is usually the main component of this process; however, leakage points where only plastic waste has accumulated are quite rare.

To conduct risk assessments, a georeferenced database of known plastic waste leakage points within a defined distance of riverbanks is needed. All potential leakage points located up to 1 kilometre from riverbanks need to be analysed using data such as distance to river, elevation related to water level, estimated total volume of waste, and estimated share of plastic or hazardous waste content. To enhance the efficiency and practical applicability of **plastic waste risk assessment**, it is essential to quantify risk using the probability of occurrence and **potential consequences**. This approach – originally developed in previous research on environmental risk assessment for ranking landfills by environmental impact[64], and subsequently adapted and enhanced for this project in the context of plastic pollution in rivers – enables the objective ranking of leakage points and their categorisation by intervention urgency.



A highly polluted area with high probability of leakage in the Sar Planina National Park (NM). Photo: Gergely Hankó

[64]*Ubavin, D. 2008, Selection of a remediation model for illegal dumpsites based on environmental risk assessment (Master's thesis). University of Novi Sad, Faculty of Technical Sciences.*

Risk Quantification Model

Risk (R) can be expressed using the following formula: ***R = P x C;*** where: **P (Probability)** – the likelihood that a specific plastic waste leakage point will contribute to river pollution, and **C (Consequence)** – the potential impacts of such pollution, including the amount and type of waste that ends up in the river. Each of these components will be quantified using predefined criteria and scoring.

Probability of Risk Occurrence (P): The likelihood of a given location containing plastic can be assessed by analysing the following factors: proximity to water bodies, site elevation, hydrological factors and vulnerability of the area.

Table 5: Probability

Factors/Probability	Very Low (1)	Low (2)	Medium (3)	High (4)	Very High (5)
Proximity to water bodies (m)	>1000	500-1000	100-500	50-100	<50
Site elevation (m)	>4	3-4	2-3	1-2	0-1
Flood frequency	HQ100	HQ50	HQ10	HQ5	HQ2
Vulnerability	Not vulnerable Industrial area	Floodplain, agricultural area	Floodplain, forest area*	Touristic- and water management area	Sensitive from a conservation and ecological point of view**

**it it's not Natura2000 or under protection*
***i.e. Natura2000 area*

Probability Scaling (P): Very low probability: 4-6; Low probability: 7-9; Medium probability: 10-12; High probability: 13-16; Very high probability: 17-20.

PET bottles accumulated on the riverbank of the Tisza. Photo: Gergely Hankó

Consequences of Risk©: The consequences of plastic waste leakage points near rivers are reflected in the potential amount of plastic waste that ends up in the rivers.

These are evaluated based on the following factors:

- Total amount of waste at the leakage point
- % of plastic waste
- Mobilisation potential

Table 6: Consequences

Factors/ Consequences	Minimal (1)	Low (2)	Moderate (3)	High (4)	Catastrophic (5)
Total amount of waste	<5m^3	5-10 m^3	10-50 m^3	50-100m^3	>100m^3
% of plastic waste	<5%	5-10%	10-15%	15-20%	>20%
Mobilization potential	100% covered waste	Regularly compacted and partially covered waste	Regularly compacted and not covered waste	Occasionally compacted and not covered waste	Not compacted and not covered waste

Consequence Scaling (C): Minimal consequences: 3-4; Low consequences: 5-7; Moderate consequences: 8-10; High consequences: 11-13; Severe consequences: 14-15.

Managing hazardous waste is particularly challenging. It is therefore crucial to assess the overall environmental and public health risks posed by the entire volume of waste to determine whether it qualifies as hazardous. A special case involves hazardous waste that originates directly from industrial processes and is illegally dumped. In such instances, identifying the responsible party and enforcing strict penalties is a key priority.

Table 7: Risk assessment based on the results of probability and consequences

Probability (P)\ Consequences (C)	Very low C (1)	Low C (2)	Medium C (3)	High C (4)	Severe C (5)
Very Low P (1)	1	2	3	4	5
Low P (2)	2	4	6	8	10
Medium P (3)	3	6	9	12	15
High P (4)	4	8	12	16	20
Very High P (5)	5	10	15	20	25

- The risk score (**R = P x C**) ranges from **1 to 25**.

Table 8. Categorisation of leakage points by risk level

Risk (R)	Category	Recommended Action	Recommended preventive action
1–5	Low risk	Monitoring	Long-term preventive measures
6–11	Medium risk	Mitigation measures with community engagement	Lectures, training, information campaigns, and the importance of raising awareness of prevention
12–17	High risk	Urgent remediation measures	Improved waste management Measures taken to prevent recurrence: i.e. cameras, barriers, and inspection

18–25	Critical risk	Immediate intervention	Strict regulatory measures to prevent recurrence

Conclusion

Risk quantification using the **probability-consequence model** provides a clear and systematic approach to assessing plastic waste leakage points. This method facilitates **more efficient planning, faster decision-making, and improved resource allocation**, significantly reducing the risk of plastic accumulation in rivers and their long-term environmental consequences.

5.4 Planning

Once the presence of illegal waste has been reported to the relevant organisations, and the site type, the owner, and the quantity of waste have been identified, it is necessary to develop a detailed removal plan and, if required, to restore the affected area. Key questions to be addressed include whether the local government can resolve the problem within its own jurisdiction. Additionally, the requirements for mobile machinery, transport capacity, size, and sensitivity of the affected area, accessibility, and scheduling should be determined. If necessary and feasible, an appointed expert may be involved to assess potential hazards.

Collecting such waste requires significant manual labour, often lacking in capacity among state-owned enterprises. Volunteers from civil society, NGOs, and local councils can be vital in combating this type of pollution. Formal cooperation or regular clean-up campaigns can institutionalise volunteer efforts. Meanwhile, the EU promotes blue jobs in water and marine sectors to address labour shortages, supported by its 'Restore our Ocean and Waters by 2030' mission and blue economy agenda, which focuses on skills, training, and employment in aquatic environmental management via dedicated blue economy job platforms connecting employers with qualified conservation professionals.

Beyond the key ingredients of clean-ups, an adequately dense infrastructure is vital for receiving and processing the removed waste, including provisions for recovery and reuse (see Chapter 6.1 Sorting Protocol), as well as an institutional and civil organisational network that supports the process. It is also essential to have dedicated individuals, and those involved should have access to a list of organisations and companies equipped to handle and transport waste.

Planning a large and complex action requires a roadmap. To support these initiatives, we have already published a handbook for small-scale community river clean-ups (CRCs). The 'Aquatic Plastic Transnational River Cleanup Handguide'[65] provides a step-by-step roadmap for organising a community event, covering awareness-raising, safety, equipment, calculations and waste handling (see Handguide, pages 44-96).

Here is a full list of essential steps to support the planning phase of the large-scale, professional clean-up (PRC) action:

Site assessment and risk classification

Accurate assessment of the location, volume, composition (including hazardous fractions), and environmental sensitivity of the site, supported by the risk classification tool to determine urgency and the appropriate intervention level (as discussed earlier in Chapters 5.1 and 5.3).

Legal status and permits

[65] Molnar et al. (2022)

Clarification of land and waste ownership as well as liability was provided in Chapter 5.2.1, but obtaining all necessary permits is also a key requirement. Depending on the size and complexity of the project, the required permits can vary, as evidenced by the Plastic Cup initiative and the previous Interreg Tid(y)Up project's international clean-up actions (Annex 5).

Technical feasibility and access

Evaluation of site accessibility for heavy machinery and transport vehicles, including terrain conditions, seasonal constraints (e.g. flooding), and potential impacts on surrounding ecosystems.

Machinery, equipment, and workforce capacity

Planning for suitable heavy machinery (excavators, loaders, crushers, boats, barges), transport capacity, and qualified operators, complemented by trained personnel for manual tasks, sorting, and supervision. A detailed table is provided below (Chapter 5.4.1).

Waste handling, sorting, and downstream capacity

Identification of available waste treatment, recycling, and disposal facilities with sufficient capacity to handle large volumes, including temporary storage, pre-sorting, and hazardous waste handling options.

Health and safety measures

Health and safety during field operations are maintained through task-specific control measures derived from the risk assessment, such as PPE, safe work procedures, hazard communication, and ongoing on-site monitoring, to ensure compliance with safety standards.

Stakeholder coordination and roles

Clear responsibilities among project partners – municipalities, authorities, contractors, NGOs, land managers – supported by formal agreements and a coordinating body.

Financing and cost estimation

Detailed budgeting for machinery, labour, transport, treatment, permits, monitoring, contingency reserves, and funding sources like public budgets, environmental funds, EU funds, fines, or private contributions (Chapter 7).

Scheduling and logistics

Realistic timelines that account for permitting, procurement, ecological constraints, communication, volunteer recruitment, planning, implementation and follow-up activities.

Communication and public involvement

Transparent communication with local communities and the media to manage expectations, ensure public safety, and strengthen legitimacy, while clearly distinguishing professional clean-up tasks from possible volunteer activities (Chapter 8).

Prevention of recurrence

Integration of follow-up measures like access control, surveillance, better legal disposal (Subchapter 5.5.1), and awareness efforts to prevent re-pollution.

Therefore, in the next section, we will specify the required capacities for waste clean-up activities.

5.4.1 Key figures for planning clean-up activities

This specification outlines procedures, resources, and personnel for clean-up in flood-prone zones, categorising activities by dump size and access. Standardising methods and equipment aims to streamline operations and improve coordination, especially for projects combining fieldwork, citizen science, monitoring, or infrastructure.

Table 9: Key figures for planning clean-up activities

Location Type	**Illegal Dump**			**Riverbank**	
	≤ 5 m³	**5–20 m³**	**> 20 m³**	**(Shore Access)**	**(Boat Access)**
Collection Method	Manual collection	Front-end loader/excavator + manual work	Front-end loader/excavator	Manual collection	Manual collection
Type of required waste transport vehicle	Light-duty tipper truck or skip loader truck	Light-duty tipper truck or skip loader truck	Garbage truck (closed bed)	Light-duty tipper truck or skip loader truck. A boat or larger ship suitable for transport may be necessary here as well, as it may be accessible from shore, but not with larger transport vehicles. It may be easier to transport by water and deposit elsewhere.	
Bag requirement	20 bags/m³	20 bags/m³	-	20 bags/m³	20 bags/m³
Number of volunteers required for clean-up activities	2-3	2-5	4-10	1 person per 50 m²/hour	1 person per 50 m²/hour
Estimated clean-up time	5 m³/hour	5-10 m³/hour	5-10 m³/hour	50 m²/hour per person	50 m²/hour per person
Waste collection equipment	Shovels, pickaxe, wheelbarrow, PPE	PPE (boots, gloves, suit) Shovels, pickaxe, wheelbarrow	Shovels, pickaxe, wheelbarrow, PPE	PPE	PPE
Waste sorting equipment	PPE, sorting table, plastic sheet, jumbo bags	PPE, sorting table, plastic sheet, jumbo bags	Sorting at a dedicated facility only	PPE, sorting table, plastic sheet, jumbo bags	PPE, sorting table, plastic sheet, jumbo bags
Number of volunteers required for waste sorting	4 per m³/hour	4 per m³/hour	-	4 per m³/hour	4 per m³/hour

Location Type	Illegal Dump			Riverbank	
	≤ 5 m³	5–20 m³	> 20 m³	(Shore Access)	(Boat Access)
Estimated sorting time	1 m³/hour	1-2 m³/hour	1-3 m³/hour	1 m³/hour	1 m³/hour

For above 10-20 m^3, machinery is unavoidable. Photo: Green Collect

5.5 Implementation

Field implementation involves task-sequenced modules that start with **site prep and hazard isolation**, during which access routes are secured, vegetation is selectively cleared, unstable surfaces are reinforced, and hazards such as sharp objects, waste piles, and contaminated zones are cordoned off. Before activities, personnel attend a **mandatory briefing** covering the day's workflow, responsibilities, and key Health and Safety protocols, including PPE use, safe procedures, communication signals, and emergency responses from the risk assessment.

The handling of illegally dumped waste also presents a secondary issue: how to treat and dispose of the collected waste. The most traditional method is **landfill disposal**. However, this merely postpones the problem, furthermore, in cases where there is no landfill and collection system (e.g. where the system is incomplete and there is no sanitary landfill nearby), the waste we collect may be returned to the environment. To avoid this, it is important to choose the right partners and to account for and report on the waste collected. Another key step to prevent re-pollution is the on-site selection of the waste (if it's feasible).

Selective waste extraction and segregation, using material-specific handling techniques, are transformative tools for raising awareness, preventing cross-contamination, and optimising downstream treatment. To support this process, a dedicated sorting area is established on site, enabling the systematic separation of recoverable materials (as detailed in Chapter 6).

Quality assurance involves real-time documentation, GPS-referenced data collection, and photographic evidence, ensuring full traceability and reporting. The operation ends with site restoration, such as soil stabilisation, vegetation protection, or erosion control interventions, followed by a **post-clean-up**

evaluation to verify that environmental and regulatory goals are met. Waste scattered around the landfill should also be collected. The final step is a technical report summarising waste, treatment, safety, and monitoring recommendations.

*A Professional River Cleanup (PRC)[66] action in **Bosnia and Herzegovina** was completed on the Radimlja River, approximately 300 metres upstream of the confluence with the Bregava River, near the city of Stolac, Herzegovina-Neretva Canton, in November 2025. The size of the illegal landfill was approx. 1200 m^2. The site represents a long-standing illegal landfill used for the uncontrolled disposal of mixed municipal waste. Due to the seasonal and karst nature of the Radimlja River, accumulated waste remains exposed along the riverbanks during dry periods, while during floods, nearly all of it is remobilised and transported downstream into the Bregava River and larger river systems, and ultimately into the sea. During a one-day clean-up event in the framework of the AQPLA project, approximately 20 local volunteers collected and separated 2.5 tonnes of municipal waste into three main fractions (plastic, metal, and communal waste) despite its contamination with organic matter and degradation.*

The Aquatic Plastic project will implement several clean-up actions in South-Eastern Europe: The Regional Education and Information Centre for Sustainable Development in South-East Europe (REIC) collected more than 2500 kilograms of waste from the Radimlja River. Source: REIC

Cooperation was established with the public utility company, which collected and took over the waste after the clean-up action. Further AQPLA[67] clean-up actions will be implemented in Montenegro, Romania, Bulgaria and Bosnia and Herzegovina.

5.5.1 Prevention of recurrence

The following section addresses how to prevent the recurrence of specific instances of illegal dumping, rather than focusing on general waste management regulation or the role of prevention. It's worth noting

[66] Molnar et al. (2022) p. 34.

[67] https://interreg-danube.eu/projects/aquatic-plastic

that the issue of illegal waste is highly complex, as evidenced by the failure of past solutions to achieve significant improvement in the overall situation or a noticeable reduction in waste pollution. One contradiction: while it would be better for waste collection fees to be based on the amount of waste generated, this could easily lead some people to choose illegal disposal methods to avoid paying, ultimately worsening the problem. Furthermore, in our case, there are regions where waste collection fees have never been introduced before.

Prevention is a paramount concern and manifests in numerous forms and methods, akin to the diverse shades of blue found in rivers. While these measures may appear costly in the short term, they prove to be the most efficient and cost-effective solutions over the long term. The broader the application of preventive practices - encompassing entire regions and engaging a wide spectrum of stakeholders - the greater will be their effectiveness. Consider this: merely cleaning up a contaminated site independently and subsequently closing it does not deter notorious polluters. However, if potential landfill sites become increasingly scarce in your area and reports or observations highlight a series of penalties, these measures are more likely to incentivise polluters to cease harmful activities and to manage their waste responsibly.

Possible steps and methods to prevent recurrence.

- **Blocking access**, especially to vehicles. This measure is most effective at sites with limited access routes (e.g. a single road), where recurrence can be prevented by installing a physical barrier and posting warning signage.
- **Presence on-site**, including patrols or guardianship, can retain polluters.
- **Monitoring systems**: Surveillance systems (CCTV), motion-activated lighting, etc., at well-known illegal dumping hotspots.
- **Improved detection** and encouraged citizens to report illegal dumping.
- **Switching function:** Changing the function of the polluted site can also be a long-term solution. Although redefining a frequented site as a playground, educational trail, or leisure park is an expensive option, it surely has a deterrent effect against dumping and fly-tipping.
- **Raising awareness and environmental education,** involving NGOs that work to combat illegal dumping and pollution.
- **Naming offenders:** The community has a right to know who is responsible for pollution. A simple, honest conversation can solve the problem if we explain why it is important to stop this harmful activity and what the more convenient solutions are.
- **Consistent and targeted penalties,** including the introduction of tailored sanctions.

Additionally, it should be made easier to dispose of waste legally and at no cost, especially for construction, hazardous, or potentially harmful waste. This should be combined with:

- stricter penalties,
- simplified evidence-gathering procedures,
- faster enforcement (e.g. within 3 days),
- improved tools, human resources and procedures for authorities,
- and overall simplification of enforcement systems.

*In **Montenegro**'s Aquatic Plastic project, the Ministry of Ecology placed a 5 m³ container at Gradac clean-up site, an illegal dumping area with bulky waste. This location lacks a container, making regular service vital for residents. The utility company will maintain it to prevent waste buildup.*

6. Circular economy

This chapter covers recycling opportunities and the role of circular economy in preventing waste from entering rivers. For macroplastics, prevention is key, and the recyclability of waste is crucial.

'Recycling is not the ultimate goal of waste management: it is always better to reduce waste by preventing it in the first place.'[68]

All the more so, since recycling does not seem to be developing sufficiently in the countries of the CEE region (short country reports are available in Annex 6), and developing a circular economy requires extensive innovation and product development. For example, problematic and difficult-to-handle plastics must be replaced, and test programs for reuse must be implemented.

In our case, our vision is a future without unnecessary plastic production or consumption, where all plastic is recycled and responsibly managed throughout its life cycle.[69]

Until the end of Aquatic Plastic's Activity 2.5, there were, in fact two certification schemes selected for quotation by the management of the Plastic Cup: the OBP certification and the RecyClass system. Each has its own advantages and disadvantages (e.g. the first is a standalone system developed for a community-based plastic waste collection system in Asia, while the other refers to several international standards created by a European initiative, focusing on plastic converters). Still, both seem suitable for this NGO's needs.

At the final evaluation, in addition to pricing (which is sometimes difficult to compare), other factors are taken into account to select the better certification scheme, such as which standard aligns better with the organisation's usual operations and subjective factors, for instances the difficulty of contacting the organisation and response times from the authorised authority.[70]

The next stage is attempting to obtain certification (and documenting findings to provide background material for other NGOs about the certification process).

As the certification process continues, riverine upcycling best practices are emerging. In ***Hungary****, the Plastic Cup initiative collects 10–20 tonnes of riverine glass waste each year. Committed volunteers were the first to recognise the value in what others had discarded. Through careful selection, the recovered glass travels from Kisköre to Orosháza, where ReGlass further sorts the material, and O-I Glass – the town's historic glass factory – gives it new life using an old mould to remelt the transparent waste into soda bottles once again. This rebirth is sustained by a living network: traditional soda-water makers along the Tisza, who continue their craft despite the dominance of disposable plastic bottles, restaurants that help restore glass bottle's place on the table, and determined PET Pirates working to free Hungarian rivers from waste. From riverbank to flame, the tradition lives on.*[71]

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[68] United Nations Environment Programme (2024b)

[69] Magyar Tudományos Akadémia. (2024)

[70] Interreg Danube Region. (2025, November 4). *Assessment of secondary raw material certification schemes for plastics* (Deliverable D 2.5.1). AQUATIC PLASTIC. https://interreg-danube.eu/projects/aquatic-plastic/library

[71] Plastic Cup Society. (2024.b)

Figure 11: Movie graphics: Sparkling water – the delicious Hungaricum, 2025[72]

6.1 The Sorting Protocol

Accumulated waste has great potential if we can demonstrate its value. It is essential to recognise that many waste components can be reused and, with appropriate preparation, converted into valuable industrial raw materials. This requires thorough sorting and innovative upcycling. During this process, specific fractions – defined by their material characteristics – are separated from the mixed waste for further treatment or utilisation.[73] Once appropriately prepared, these sorted fractions can be used as industrial feedstock, thereby generating economic value. A well-developed waste infrastructure can **offset the costs of illegal dump removal** by generating recovered material value.

Most waste types already have established recycling technologies, despite lingering uncertainty regarding the economic viability of some. Nonetheless, paper, various plastics (e.g. PE, PET, PP), metals, and glass are directly recyclable in their original form. Scrap metal has long been an integral part of a well-established recycling system and is regularly purchased by waste management facilities. Other fractions – such as plastic and paper – are also widely collected: small amounts can generally be deposited for free at recycling points, while larger volumes of well-sorted, high-quality material may even receive financial compensation.

An excellent example of waste processing carried out by the Plastic Cup initiative makes this bottom-up clean-up action a European flagship. The organisation primarily focuses on cleaning riverbanks and collecting waste transported and deposited by water, which has been left lying there for a long time. This significantly influences the composition of the waste they handle: it consists predominantly of persistent, buoyant waste – lighter than water – mostly made of plastic, as well as glass and metal cans. As a result, typical waste types found in illegal dumpsites on the outskirts of towns, such as paper, construction debris, and organic material, are generally absent in this context.

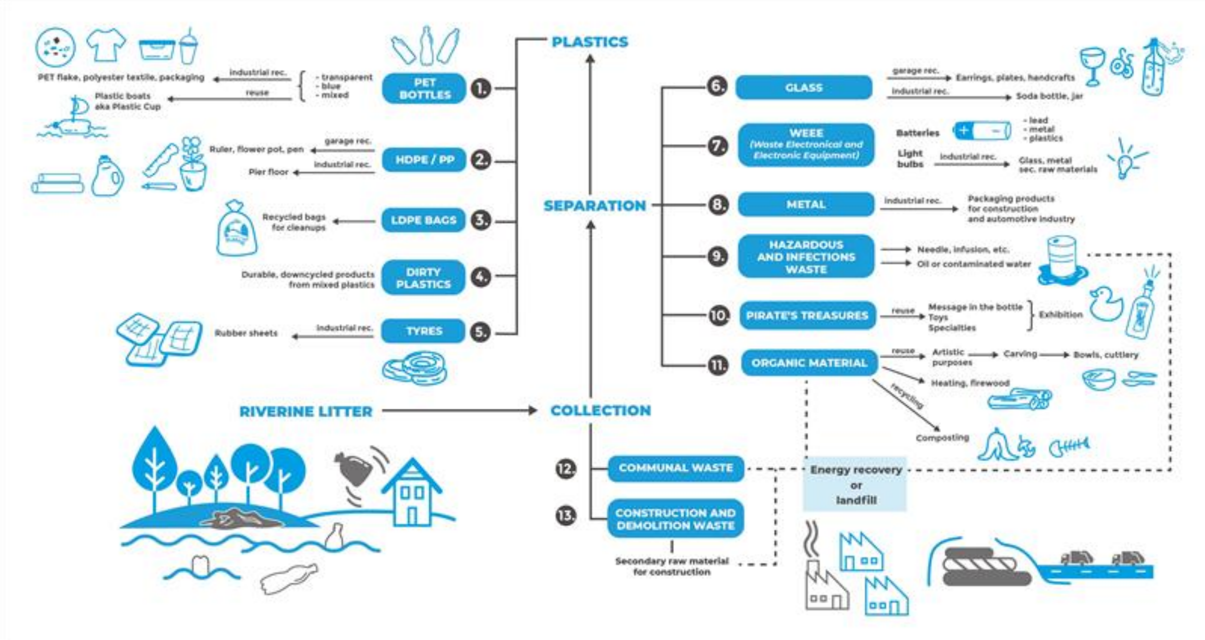
Volunteers collect riverine waste along hundreds of kilometres of riverbank each year. Basic sorting, or pre-sorting, begins during collection, separating three main fractions: glass, recyclable waste suitable for

[72] Plastic Cup Society. (2024a)

[73] Molnar et al. (2022)

detailed sorting, and non-recyclable waste for landfill. When possible, these are collected in recycled bags. Pre-sorting simplifies later sorting by removing glass (green bags) and non-recyclables (black bags), leaving the so-called 'selective' fraction in yellow bags for further processing. This fraction includes lightly contaminated PET, PE, and PP plastics, metals, and light bulbs. The municipal fraction contains contaminated plastics such as oily and painted items, composites, and textiles. Curiosities such as 'pirates' treasures' – toys, utensils, messages in bottles – are collected separately and displayed during educational activities.

Figure 12: The sorting protocol of the Plastic Cup[74]



The composition of the 'selective' waste obtained through pre-sorting meets the standard requirements for household selective waste collection. Therefore, if the clean-up site is too far from the central base of the clean-up activity for transport to be cost-effective, the 'selective' fraction is handed over to the local waste management provider for further sorting.

The waste we continue to process undergoes detailed sorting to recover the cleanest, most recyclable raw materials. 'Adequate cleanliness' in this context means that the sorted material is free from contaminants that are difficult or impossible to remove (such as oil, paint, or protein fibres from zebra mussels) and contains only the target material type.

The sorting process results in various waste fractions separated by material type, plus a mixed municipal residue destined for landfill. Proper pre-sorting prevents most municipal waste from reaching the sorting table. Sorting occurs on a permanent or temporary table, with waste collected in large bags. Volunteers sort by hand, wearing gloves. Plastic types are identified by material codes, but large quantities make inspection difficult. With practice, types can be distinguished by colour and texture.

[74] Molnar et al (2022)

Figure 13: The types of plastics

Tyres – although they do not reach the sorting table – are also collected separately. They are transferred to a certified waste processor, where they are shredded and used to produce rubber mats. **Glass** is the easiest waste to separate. With proper pre-sorting in the field, it never reaches the sorting table. Glass is a raw material that can be 100% recycled in its original form. Light bulbs are also treated separately. Incandescent bulbs are passed on for the recovery of the rare metals they contain. Although less common, metals also represent a valuable waste fraction. In rivers, they typically sink quickly and therefore do not travel far. The most frequently collected forms of **metal** waste include aluminium drinks cans and aerosol deodorant containers. These are either recycled without sorting or separated into aluminium cans, magnetic metals, and non-magnetic metals.

The most common type of river waste is **plastic**. Particular emphasis should be placed on collecting polyethylene terephthalate (PET), polyethylene (PE – including HDPE and LDPE) and polypropylene (PP). These are the plastics that can be reintroduced into industrial use with partners' help. Although **PET** is slightly denser than water, it typically enters the river in a sealed form, allowing it to float on the surface. Its disadvantage is its high volume, which makes storage and transportation inefficient unless compacted. Therefore, baling PET waste makes transportation more efficient for delivering it to industrial partners. The goal is to begin producing PET filament for 3D printing from river-collected PET bottles in the near future, although the technology is still under development.

PE and **PP** are the easiest plastics to recycle, owing to their low melting points and mutual compatibility. These are stored in big bags and transported to our partners for granulate production. In small amounts, PE and PP are upcycled during educational activity in the Mobile Plastic Lab, where they are shredded and melted to produce rulers, carabiners, and small gadgets for visitors[75]. Collection and storage bags are also sorted and recycled. Of the **LDPE** bags used for field collection, usable ones are reused, while worn-out ones are baled and sent to recyclers. Larger collection bags and FIBCs can be used for an extended period, run multiple cycles, and when they become waste, are baled and transferred to a processor.

Unfortunately, **hazardous waste** forms a separate category. Each year, several dozen litres of oil or chemical-like liquids arrive in various-sized containers. These are collected into larger canisters and delivered to an authorised handler for further processing and disposal.

Beyond common waste fractions, rarer types are also managed in an environmentally friendly manner. A significant amount of cell batteries, classified as hazardous waste, are collected each year. These are typically disposed of by dropping them into collection boxes at supermarkets. On one occasion, a **lead-acid battery** was found and consequently submitted for recycling, along with the other metal waste. When an intact electronic device arrives, it is transported to the appropriate partner for dismantling.

[75] Plastic Cup (n.d. -c)

Occasionally, jars of preserves, jams, or other **preserved food**s appear; their contents are composted locally. Although driftwood transported by water isn't considered waste, usually water directorates or the gestors of remediation activities on water collect it in large quantities. Most of the harvested wood is sold as firewood after drying. Smaller amounts can be used to create decorative items and small gifts.

Pirates' treasures can bring joy and inspiration to sorting activities. Toys, messages in bottles, specialities, indefinable objects, and strange everyday objects can be found in the dirt. A well-balanced mix of these objects can serve as a baseline for an awareness-raising exhibition[76].

A toy from the debris brings up many thoughts and questions. Photo and design: Zsófia Kabarcz

Every year, a few Ytong block fragments also turn up; they can be used locally for road filling.

At *Plastic Cup*, selective sorting is driven by principle, but it also has significant cost-reduction benefits (detailed in Chapter 7.).

[76] https://petkupa.hu/eng/?cikkId=exhibition

Mobile sorting after a floodplain forest clean-up, photo: Plastic Cup Society

Mechanisation is playing an increasingly important role in sound waste management. While manual sorting still has its place, it is labour-intensive and often imprecise when handling large volumes of mixed waste. Contemporary waste treatment plants utilise advanced technologies that can identify and separate materials with exceptional precision and speed. These include magnetic separators for metals, infrared and optical sensors for plastics, and AI-assisted shape recognition systems. Machine learning algorithms continue to enhance performance by adapting to the specific characteristics of incoming waste streams.

Despite their effectiveness, such advanced systems require significant investment and are only financially viable when there is a steady and substantial inflow of recyclable materials. This underscores the importance of a robust and well-organised collection infrastructure.

A fully equipped, mechanised waste processing plant can deliver substantial environmental and economic benefits. It can recover significant quantities of valuable materials – including plastics, metals, and glass – which can be reintegrated into industrial production as secondary raw materials, after appropriate treatment. This helps conserve natural resources, reduce reliance on landfills, and through the sale of recovered materials, can potentially cover operating costs, contributing to the long-term sustainability of the waste management sector.

6.2 Remediation of contaminated sites

As mentioned in the Legislation Chapter, the WFD Reporting Guidance (2022) defines the Key Types of Measures (KTMs), and KTM4 is about remediation of contaminated sites and historical, legacy pollution[77], including sediments, groundwater, and soil.

Contaminated sediment in still waters or watercourses threatens organisms and aquatic life through interactions with water. Recommended actions include disposing of sludge and plant residues,

[77] Hanko et. al. (2024) page 29.

recultivating remaining sediment, and removing silt to reduce lake volume or river flow capacity. Pollution usually doesn't remain confined to the water, especially after floods, and can significantly affect the surrounding soil. Macro- and microplastic particles left on the ground can embed in the soil without proper measures, altering the soil's physical properties, such as porosity and water retention, which in turn affects plant growth and soil stability. Toxic additives, such as plasticisers or metals, can leach into the soil, harming microscopic organisms vital for soil health. These chemicals can eventually move up the food chain, affecting livestock and humans.

Soil remediation for plastics, particularly microplastics, is a rapidly evolving but still new scientific field. Because plastic particles are often physically and chemically integrated into the soil matrix, traditional 'dig and dump' methods or mechanically based separation techniques (such as using screens or salt solutions to float plastics out of excavated soil), are being replaced by more sustainable, on-site technologies. The new directions in remediation lean on biological solutions such as bioaugmentation (in situ growth of plastic-eating organisms and fungi), phytoremediation (especially to hold the soil in place and, in addition, to enhance the activity of plastic-degrading microbes), or nanotechnology (such as nano-catalyst particles, which use sunlight to speed up the chemical breakdown).[78]

The relationship with hazardous substances is a crucial consideration in planning and implementing measures. Internal loading from sediments may also contribute to exceeding the EQS (at least locally), particularly in sedimentation areas, lakes, and reservoirs. Dredging removes sediment-dwelling organisms, which can cause significant ecological problems. If dredging is justified for other reasons, it can have a positive effect, e.g. by improving the poor condition caused by hazardous substances. It should be emphasised that the dredged sludge must be disposed of with appropriate care. In the case of river and standing-water sediment dredging, attention must be paid to contamination with cadmium, fluoranthene and lead.

*In **Hungary's** current River Basin Management Plan, this measure is divided into three parts: remediation under state responsibility; remediation under farmers' responsibility; reduction and elimination of sediment pollution in watercourses and standing waters, and disposal in accordance with environmental considerations.*

6.3 Landfills

For landfills that are still in operation, operators must ensure the recultivation, maintenance and monitoring of the landfill. This requires preparing an environmental assessment of the landfill, followed by a recultivation plan. A recultivation plan is crucial for landfills to ensure their safe and environmentally sound integration into the landscape after closure, preventing long-term pollution and restoring ecological value. Its content typically includes the technical steps for capping and sealing the waste, strategies for soil restoration and landscaping, and a long-term monitoring and maintenance plan for groundwater and gas emissions. Based on these documents, the environmental protection authority prescribes the environmental requirements for recultivation and aftercare in the form of a decree. Experience has shown that improperly sealed landfills are hotspots for illegal waste dumping and sources of solid waste, groundwater and air pollution. The owner of the landfill is ultimately responsible for the recultivation of these areas even after 30 years of closure.

[78] NICOLE

The European Union is striving to reduce waste disposal by moving towards the reuse and recycling of waste that is inevitably generated, thereby reducing the amount of waste sent to landfill, extending the operational life of existing landfills, and hopefully reducing the need to build new ones. **Illegally dumped waste is generated every year** (as detailed in Chapter 3.3), and, without proper supervision and enforcement, is increasingly dumped in increasing quantities, typically on the outskirts of settlements. Even the smaller dumpsites pose environmental risks, as they can contain hazardous waste that increases the risk to human health, water, and the geological environment, and also distort the market by offering seemingly free solutions for dumping unwanted waste.

How can the CEE region meet the ambitious target numbers? Join the discussion in October in Budapest.

For landfills currently in operation or to be established in the future, technical protection in accordance with legal requirements ensures the maximum possible protection of the environment. The bottom and sides of the landfill basin and their insulation must be designed so that the geological insulation layer complies with the requirements for the landfill category. A seepage system must be built to collect, drain and control leachate. Separate treatment systems must be established for the collection and treatment of leachate and rainwater. The removal of waste by wind must be prevented by fencing and protective forests. Gas capture shall ensure that the maximum amount of methane is captured, treated and used, avoiding climate implications. A monitoring system must be operated during the operation of the landfill and throughout the aftercare period. The landfill operator must ensure the future reclamation of the landfill and its aftercare.

6.3.1 Leachate treatment

Proper **leachate treatment** must be ensured at all municipal landfills, including those that have already been recultivated. Even when a landfill is closed and covered, precipitation infiltrating the waste body can generate contaminated leachate for decades, posing a significant long-term risk to groundwater and surface waters. Without proper treatment, this leachate often contains high concentrations of ammonia, heavy metals, organic pollutants, and persistent micropollutants, which can migrate into aquifers and rivers. Ensuring leachate treatment at landfills would greatly reduce diffuse pollution from waste disposal sites (e.g. Hungary). It would also align national practice with the principles of the EU Water Framework Directive, which requires member states to prevent further deterioration of water bodies. Moreover, following the Romanian model, presented below, would demonstrate a clear commitment to applying BAT and safeguarding water resources for future generations.

***Romania** provides a useful example in this regard, as it has made leachate treatment mandatory at municipal landfills, whether active or recultivated. This regulatory approach ensures that all sites are equipped with appropriate collection and treatment systems, thereby reducing the risk of transboundary pollution and protecting shared water resources. The best available technology (BAT) for leachate treatment is reverse osmosis (RO), which is highly effective because it physically separates dissolved contaminants from water using semi-permeable membranes under high pressure. This process can remove a wide range of pollutants – from salts, ammonium, and heavy metals to organic micropollutants and pathogens – resulting in a purified water stream that can be safely discharged or reused.*

Inside a leachate treatment facility – RO-equipped mobile container by Klarwin

Another key advantage of RO is its modularity and mobility: containerised RO systems can be installed directly at landfill sites, including smaller or remote ones, and can be scaled according to the volume of leachate produced. RO also delivers reliable, predictable performance, which is critical for ensuring compliance with stringent water quality standards and preventing environmental incidents. While reverse osmosis generates a concentrated reject stream that requires further management or can be reinjected into the landfill body, this is typically a much smaller volume than the untreated leachate, making downstream handling more feasible.

The environmental hazard of an old, closed landfill – or area used for waste disposal – built with inadequate technical protection is reduced by disposal (transfer to another landfill with technical protection), assessment and measurement of the dumpsite and its contents, the subsequent construction of technical protection, then integrating the area into the landscape, and eventually its aftercare of variable duration (approx. 20 years) (environmental monitoring, data provision, maintenance). If the waste remains in place, groundwater pollution from the landfills must be eliminated by installing a surface **sealing layer and drainage** during recultivation, preventing rainwater from entering the body of waste. If groundwater or even surface water reaches the waste body, then, depending on the age of the disposed waste, collection is mostly unavoidable (unless the decomposition and dissolution processes have completely ended).

Since illegal dumping most frequently occurs in peri-urban or rural areas – typically on state- or municipally-owned land – the task of removal generally lies with public bodies.

In the next chapter, we will take a step-by-step look at the process of eliminating waste, from finding it to restoring it. These steps partially overlap with the sequence that prevents abandoned waste from entering rivers, since both processes can be divided into discovery, exploration, planning, and implementation phases. Therefore, we recommend that the steps outlined in the following figure be considered for prevention as well.

6.3.2 Landfill mining

Landfill mining presents a viable remediation and resource recovery strategy for older sanitary landfills, established before modern waste separation obligations, as well as for landfills still in operation but lacking the necessary environmental protection, which should be transferred to EU-compatible landfills. This option can be particularly significant at a time of increased demand for rare earth minerals. At such sites, significant quantities of recoverable materials, such as metals, certain plastics, glass, and clean soil, were often buried indiscriminately. By excavating and processing this historic waste through a series of mechanical screens, shredders, and separators, these materials can be recovered for recycling, thereby freeing up valuable landfill space, mitigating long-term pollution risks, and rehabilitating the land for future use. While not universally applicable, this approach can also be a strategic option for certain uncontrolled dumpsites, provided specific conditions are met – such as a known waste composition with sufficient recoverable materials, the financial viability of the operation, and the availability of suitable processing technologies to ensure it is conducted safely and effectively.

7. Financing

Financing the prevention of illegal dumping and the remediation itself is not just about covering clean-up costs – it is about investing in infrastructure, surveillance, education, and community engagement that can reduce the incentive and opportunity for unlawful disposal practices. This requires a shift in perspective: from reactive spending on remediation to proactive, long-term investment in prevention. These measures are largely embedded in legislation (such as the Polluter Pays Principle (PPP) and the Extended Producer Responsibility (EPR), which are key mechanisms for addressing plastic waste). These tools – if regulated and implemented well – can ensure proper, transparent, and financed mechanisms for separate collections and help avoid future landfilling, but cannot solve the issues of existing landfills, dumpsites, and pollution.

The PPP principle ensures that those responsible for pollution bear the costs of managing it. Under EPR, producers are responsible for the end-of-life management of their products. Among participating countries, Austria and Romania demonstrate the most comprehensive and structured systems. In these countries, PPP is embedded across multiple instruments, including packaging fees, a landfill ban on recyclable plastics, and even a carbon tax on virgin plastic production. EPR is applied broadly through mandatory participation in Producer Responsibility Organisations (PROs), covering packaging, electronics, batteries, and more. It has been shown to be an effective mechanism when properly set up and operated, with clear responsibilities, targets, and incentives. Limited financial and human resources can delay progress, and international funding often comes with conditions that may not align with national priorities.

Financial constraints underpin many structural weaknesses. Municipalities, particularly in rural areas, lack sufficient resources to ensure quality waste collection and the removal of illegal deposits (BG, SK, ME). Furthermore, some municipalities lack waste collection and have not introduced waste management fees (UA). Waste management projects are often short-lived, and funding does not cover long-term operation or maintenance (ME, SK). Access to international funds remains limited due to administrative barriers, a lack of co-financing capacity, and insufficient project preparation support (RS, ME, BG). Inconsistent waste collection fees and economically non-viable service models undermine sustainability (ME, SI). Insufficient business incentives limit industry participation in EPR schemes (ME). Fragmented financing results in occasional monitoring and innovation projects without systemic continuity (HU). Weak inspection systems are also linked to limited financial support (SI). Positive and negative economic incentives are used in the countries to prevent illegal waste disposal and support remediation, as shown in the next table.

Table 10: Economic incentives

Positive	**Negative**
● national grants from environmental funds (for example, direct grants for remediation; tenders for the purchase of property protection equipment (cameras, barriers, drones)) ● international grants and programs ● free disposal services ● subsidies for recycling & waste treatment ● tax benefits & discounts ● low-interest loans ● Deposit-Return System (DRS) for Beverage Packaging ● pilot reward schemes ● corporate support ● 'pay-as-you-throw' system	● environmental taxes and fees (for example, on businesses that fail to comply with waste disposal regulations) ● environmental liability insurance for large, potentially hazardous sites, such as non-EU-conforming landfills and mining activities ● landfill fees, taxes and levies ● fees imposed on producers and importers of products that become waste ● pollution charges – PPP ● fines for illegal dumping (in Austria, depending on the severity, fines can be up to €41,200) ● regulatory compliance costs ● sanctions for non-compliance with waste management obligations ● EPR schemes ● criminal penalties

Whereas economic incentives encompass both rewards and penalties to address waste pollution, countries' sanctioning practices focus specifically on the implementation of punitive measures, including penalties and fines. We summarise each country's sanctioning practices in Annex 4.

Barge barriers consist of floating barriers attached to barges or pontoons. They are suitable for large rivers with high litter loads. Hungary deployed their system in 2021. Photo: FETIVIZIG

On the positive side, some countries have state funds for research into the environmental impact of plastic waste in rivers and for tackling abandoned waste (for example, through environmental protection funds). However, these funds are often limited and highly competitive. Research may also be funded indirectly through academic grants and the budgets of scientific institutions, complemented by EU funds or fully international projects with local participation.

*For example, **Montenegro** is a partner in the AdriPlast initiative, which addresses plastic and microplastic pollution from freshwater sources into the Adriatic Sea. The Institute of Public Health of Montenegro is contributing to this project, which is funded by the Interreg IPA ADRION programme. **Slovakia** also utilises small-grant schemes with open calls for NGOs, schools, and municipalities. Typical projects include river clean-ups, environmental trails near rivers, and anti-litter campaigns.*

In many countries, municipalities charge and collect waste fees (from residents and businesses), manage waste disposal systems, and balance financial sustainability with public acceptance. The fees are used to finance municipal waste management, including collection, recycling, and disposal. The various aspects of waste management can include:

- Partially or fully covering the operational costs of sanitation services, especially when fees collected from citizens or businesses are insufficient or when tariffs have a social component.
- Investing in local waste management infrastructure, such as purchasing collection bins, developing small transfer stations, or establishing separate collection points (e.g. "eco-islands").
- Co-financing larger waste management infrastructure projects (such as integrated waste management systems, sorting stations, and composting plants) that are primarily funded by EU grants or national programmes.

The charges can vary. Waste disposal fees may be based on the number of household bins, the size of waste containers, the frequency of emptying, etc.

*In **Serbia**, household fees are generally low, and revenue often falls short of covering the full costs of waste management services, placing financial strain on municipal budgets. To address these challenges, some municipalities are exploring implementing pay-as-you-throw schemes (already used in other countries), where fees are based on the actual amount of waste generated by a household or business. This approach aims to encourage waste reduction and proper sorting by making users more accountable for their waste generation.*

*In **Slovakia**, PROs, such as ENVI - PAK, manage and finance separate waste collection for packaging and non-packaging materials. They cover the costs of collection, transport, recycling, and the purchase of recycling bins, thereby relieving municipalities of these financial burdens.*

*There are, however, exceptions: in **Hungary**, local governments play no role in financing waste management, and state-run waste management services are provided nationwide by the concessionaire. The municipal waste collection fee has been part of the government's utility cost reduction programme since 2013 and has therefore been frozen. On average, the fee for emptying a 120-litre bin is about 2 euros per month, which falls far short of covering actual costs. All of this, combined with the low landfill tax (approximately 16 euros per tonne), makes it impossible to achieve waste reduction targets and comply with the waste hierarchy.*

'The EU's Growth Plan can enhance the green transition in the region. The Instrument for Pre-Accession Assistance (IPA) remains the backbone of EU support for governance, competitiveness and sustainability in the region. The Economic and Investment Plan (EIP) for the Western Balkans significantly increased the scale and sector-focus of infrastructure and green investments. The Western Balkans Investment Framework (WBIF) acts as a blending mechanism, combining grants, loans and guarantees to prepare and de-risk infrastructure and private-sector projects. More recently, competitive EU programme windows – such as the LIFE programme (for environment and climate action) and Interreg cross-border cooperation – have become increasingly accessible to Western-Balkan actors, enabling NGOs, universities, municipalities, and SMEs from the region to apply directly or via partnerships to EU-wide calls.' (HAEE (2026): Green Economy 2026: dr. Krisztina Wégner: 2.10.: The Western Balkans (…), p. 63.)[79]

7.1 Corporate-funded actions

Usually, privately funded clean-up initiatives are smaller, mostly local, and carried out through CSR activities or sponsorships. Many companies organise corporate volunteering clean-ups along rivers: e.g. Coca-Cola, Henkel, IKEA, bank99 in Austria, the Clean Up Montenegro campaign, supported by private companies and embassies, and the Act for Tomorrow in Romania, dedicated to combating plastic pollution in the Danube and its tributaries, has been supported by various private sector partners, including retailers like Lidl Romania (a key strategic partner for this programme) and other companies from the FMCG, banking, or industrial sectors. Support includes funding for clean-up activities, installing waste-collection devices on rivers, and educational campaigns. Henkel Serbia has organised river and lake clean-up campaigns, mobilising employees and volunteers to remove waste from water bodies.

*In **Ukraine**, the Call-Action project has delivered tangible, system-level improvements to waste management and water protection in Transcarpathia by combining infrastructure development, community engagement,*

[79] HAEE (2026)

*and cross-sector cooperation. Launched in 2022 through a collaboration between Plastic Cup and **Diageo**, the initiative significantly exceeded its original targets by diverting far more waste from the environment than planned: by 2026, more than 2,500 tonnes of riverine and municipal waste had been intercepted before reaching the Tisza and its tributaries. This overperformance directly strengthened local waste management capacity in Uzhhorod, Berehove, and surrounding settlements through expanded collection, sorting, and transport infrastructure, including the introduction of regular Ecobus collection routes that enable households to hand over pre-sorted PET, paper, and glass at urban hubs. Beyond environmental outcomes, the project contributed to social and economic resilience in a war-affected region by creating local jobs, stabilising waste services, and fostering community participation, while extensive awareness-raising and education activities reached thousands of participants and embedded practical, long-term waste-conscious behaviour.*[80]

Viktor Buchinskyy, one of the pioneers of Transcarpathia's circular economy. Source: Кольорові Баки

With the introduction of ESG regulations throughout the EU, such initiatives are expected to become more prevalent soon. It remains true, despite the famous Omnibus amendments to the legislation, which tightened the affected target groups on the one hand and recently loosened the required deadlines on the other, without withdrawing these regulations.

7.2 Cost Savings through Separation

The Plastic Cup initiative reduces costs across the water management, energy, and waste sectors by intervening at multiple points along the waste pathway and transforming diffuse pollution into a managed material flow. For **hydro power plants (HPPs)**, the systematic interception of floating waste upstream and along rivers significantly lowers operating and maintenance costs by reducing the frequency of emergency debris removal, minimising unplanned turbine shutdowns, and preventing damage to intake screens, gates and mechanical components caused by plastic and mixed floating waste.

[80] CallAction

This improves operational reliability, extends asset lifetimes, and lowers both labour and repair expenditures, while also reducing the risk of regulatory non-compliance linked to pollution incidents. At the level of **water directorates**, the initiative introduces organised collection and compaction of waste (detailed in Chapter 6), which dramatically decreases transport volumes and logistics costs by increasing load density and reducing the number of required haulage trips. Compaction and pre-sorting also lower downstream treatment costs, as less contaminated, better-separated waste streams are easier and cheaper to handle, store, and transfer within existing waste management systems. From a circular economy perspective, the Plastic Cup model prioritises manual and semi-mechanised sorting of collected river waste, enabling the recovery of PET bottles, PE-PP waste, glass, metals and other recyclable fractions that would otherwise be landfilled or incinerated, thereby retaining secondary raw materials within the economic cycle and generating offsetting revenues or avoided disposal fees. These recovered materials reduce demand for virgin raw materials in a small way, while residual, non-recyclable fractions are reduced in volume and cost through prior segregation. Taken together, these mechanisms create a **cumulative cost-reduction effect**: fewer emergency interventions for HPPs, lower logistics and treatment expenses for water directorates, improved material efficiency for the waste sector and potential income through the OBP certification for the NGOs – all achieved through a prevention-oriented, cooperative system that converts environmental pressure into measurable economic savings (more details in Chapter 4.4.1. and 4.4.2. in the Assessment of Best Practices for Managing and Removing Large Floating & Flowing Waste Accumulations)[81].

Accumulated waste visible from the air at Kisköre HPP. Source: Google Earth

8. Education, training and raising awareness

This chapter analyses existing and experimental methods that offer opportunities to strengthen conscious information and attitude formation regarding waste's impact on nature, and to expand them as widely as possible from this action plan’s perspective. In this way, we seek to raise awareness,

[81] Molnar et al. (2026).

understanding, and accountability for preventing waste generation and its entry into rivers, not only from a specialised or economic perspective, but also from a social perspective. Countries typically integrate waste pollution, river protection, and environmental education into the formal education system at various levels, but implementation varies in scope and depth across these levels.

Primary Education – Environmental topics are introduced in a basic form through General Studies, Environment or Science and Nature, and through practical activities (e.g. collecting and separating waste, recycling). Field trips and eco-days are organised by schools.

Lower Secondary Education – More in-depth coverage in subjects such as Biology, Geography, Chemistry and Physics (water cycles, ecosystems, pollution impacts); Civic Education and Ethics (personal responsibility, laws related to waste); Technology/Practical subjects (waste types, sorting, reuse).

Upper Secondary Education – Topics become more scientific and policy-oriented, such as Environmental Sciences (in natural science streams); Biology, Geography and Chemistry courses explore the effects of soil and water pollution, water analysis, and waste management systems; Optional electives or school projects (waste audits, river clean-ups, eco-initiatives).

Universities and research institutions offer programmes in fields such as Ecology, Geography, Natural Sciences, Forestry, Sustainable Development, or Water Engineering that address waste pollution in detail, including its impacts on rivers.

Exhibition from trash? By all means. Photo and design: Zsófia Kabarcz

Behaviour change always requires investment; initial subsidies and incentives can help communities transition to new waste management practices, although in the case of plastics, deposit-refund systems have long proven to be efficient tools for collecting high-quality materials. Collaboration among governments, industries, NGOs, and communities to implement sound waste management strategies is also a must.[82] Key responsible actors for environmental education and raising awareness include educational authorities (e.g. responsible ministries) and schools which integrate environmental topics in

[82]International Solid Waste Association. (2024a)

formal education, environmental NGOs and movements which drive public campaigns, volunteer engagement, and informal education (workshops, clean-ups, materials), media and international organisations that support outreach, fund education projects, and disseminate information widely.

EU-level action plans and campaigns (such as the European Week for Waste Reduction (EWWR)) can drive and provide a framework for national or regional awareness and clean-up campaigns. Here is a list of good practices from the AQPLA countries:

- In **Austria**, there is a special programme called ÖKOLOG-Schulen, initiated by the Ministry of Education. For 25 years, ÖKOLOG schools have been implementing the teaching principle of 'environmental education for sustainable development' and equipping students with the skills they need to shape a future worth living. Several action-based campaigns exist, such as Austria's 'Throw it in instead of throwing it away' and the citizen-science-based Plastic Pirates.
- In **Bosnia and Herzegovina**, one notable coordinated initiative was the Think Nature! project (Misli o prirodi!) – funded by Sweden and implemented by CPCD – which brought together ministries, NGOs, and schools to strengthen environmental education from 2019 to 2022. The initiative provided training for dozens of teachers, whereas schools received Eco-School certifications – illustrating multi-actor cooperation: ministry approvals, NGO training, school execution, and company (Coca-Cola, Tetra Pak) support. Volunteer mobilisation is paramount regarding the Usora River.
- The Changing with Climate initiative trained 183 educators in seven **Bulgarian** cities to integrate environmental education into their teaching. The programme focused on climate change, natural disasters, and human health, using interactive games, simulations, and discussions to engage students.
- In **Romania**, the Green Week National Program was launched in the 2022-2023 school year. Schools have the flexibility to select specific themes and activities that can directly address waste management, recycling, pollution prevention (including river pollution), and clean-ups. This program allows for more hands-on, project-based learning. Romania's Cu Apele Curate programme is a well-known national-level clean-up initiative.
- Community events and international collaborations are key. The Supernatural Festival in **Serbia** combines ecology, art, and music to raise environmental awareness. Cross-border initiatives, such as the TARGET project under Interreg IPA Hungary-Serbia, educate youth on urban greenery via schools and civil programs. Serbia's Trash Challenge is another notable achievement.
- Let's Do It **Slovakia** combines clean-up actions with awareness on waste prevention and ecosystem health. The Danube Day events are part of the international ICPDR effort, which includes public outreach and youth education. Slovakia developed the TrashOut application to get data on abandoned waste globally.
- **Montenegro**'s Plastic-Free Rivers and Let's Clean Montenegro campaigns are forming the framework for environmental initiatives in the country.

Join the best environmental exhibition in Central and Eastern Europe and meet AQPLA team in person. Source: HAEE

- Proficiency in environmental education has recently become a criterion in the evaluation of teachers in **Hungary**. Another niche initiative is Sustainability Week, featuring guest speakers, a sustainability challenge, and field trips. A Green Earth textbook was also integrated into secondary schools, and sustainability has become an elective subject on the high school graduation exam. Pick It Up! (Teszedd!) is a national-level clean-up action. Riversaver School Network and Clean Tisza Map, Plastic Cup[83] became global best practices, mentioned in the 'Global Initiatives to Beat Plastic Pollution'[84] report. Citizen science is also very popular, the Message in the Bottle campaign is well-known, with bottles tagged in the AQPLA project[85].
- NGO-led awareness and watchdog roles: notably active in Hungary, Austria, Romania, and Slovenia.

Green Earth Textbook Series. Source: Alapértékek Nonprofit Ltd.

The Community River Cleanup Coordinator Training (*under the umbrella of AQPLA project: AT3.1*) is strengthening environmental cooperation between the countries along the Danube. The training gives an opportunity to help the next generation of riversavers and to establish a continent-wide network of future colleagues, strengthening the Blue-Jobs initiatives. During the training, participants will learn the

[83] Plastic Cup Society (Official Website) https://petkupa.hu/eng/

[84] International Solid Waste Association. (2024a)

[85] Interreg Danube Region. *Citizen science campaign*. AQUATIC PLASTIC. https://interreg-danube.eu/projects/aquatic-plastic/news/citizen-science-campaign

basics of river lit(t)eracy and the achievements of river protection to date, as well as opportunities for further development. The participants took part in a community river clean-up (CRC) action by boat and canoes as a field exercise, got acquainted with the professional river clean-up (PRC) tools used by water authorities, and also learned the community waste collection and riverine waste sorting methodology.[86]

The first university student group at the River Clean-up Coordinator Training. Photo: Plastic Cup

Municipalities have key roles in education and awareness on river waste; they are usually responsible for informing residents about proper waste disposal, environmental protection, and the consequences of littering. Local governments often support environmental education in schools through funding eco-activities, organising river-related contests or excursions, and connecting schools with NGOs or environmental educators. Many municipalities initiate or support volunteer clean-up events near rivers, often in cooperation with other associations. They also install warning and educational signs near rivers.

However, the effectiveness and reach of these educational efforts vary greatly depending on the municipality’s resources, political will, and staff capacity. In many smaller or rural municipalities, local governments often lack funding or trained personnel to sustain awareness campaigns.

Whether awareness on the topic is high or low in the country, responsible actors face several obstacles in implementing effective public awareness campaigns, based on reports from the countries concerned. Some challenges are combating apathy and ingrained habits, funding constraints, ensuring consistent support and enforcement, and securing resources to maintain long-term public engagement. A fragmented approach, with many organisations working separately, sometimes leads to overlapping efforts or gaps in coverage, reducing overall effectiveness.

Explaining the broader environmental, social, and economic impacts of river pollution in simple, relatable terms remains a challenge for educators and communicators. Sometimes messages are too technical, abstract, or not locally relevant, making it hard for people to relate. Different educational and age groups require different communication strategies. Reaching remote or disadvantaged communities remains difficult due to limited access to information channels and lower levels of environmental education. Young people are more accessible online, while older people tend to use traditional media. There are still knowledge and behaviour gaps, especially among certain age groups and sections of the population.

[86] Plastic Cup Society (2025)

Knowledge alone does not automatically lead to environmentally friendly behaviour. Campaigns must appeal to emotions and offer concrete incentives for action.

Changing long-standing waste-disposal habits requires sustained effort and practical alternatives, such as accessible recycling infrastructure. Enhancing coordination, investing in education, and improving waste management infrastructure are key to overcoming these obstacles.

9. Summary, Conclusion

The findings of the Aquatic Plastic project confirm that riverine plastic pollution is not an isolated environmental issue but a systemic governance challenge, rooted in gaps in regulation, enforcement, infrastructure, and cross-border coordination. As highlighted throughout the study, the scale and persistence of waste leakage demand a shift from fragmented, reactive measures towards integrated, prevention-oriented, and data-driven management.

The analysis demonstrates that implementation remains uneven despite significant progress in EU legislation and national waste frameworks and many local systems still struggle with inadequate waste management, unclear responsibilities, and limited financial and technical capacity. At the same time, global waste generation continues to rise, recycling systems remain underperforming, and the lack of a binding global treaty further delays systemic change. These trends underscore the urgency of equipping authorities with robust tools that can be applied immediately and effectively at the local and the regional levels.

The showcased early-warning monitoring systems, remote sensing validation, risk-based prioritisation, stakeholder-specific responsibilities, and structured planning and implementation steps help authorities identify leakage hotspots, assess their severity, plan targeted interventions, and prevent recurrence. The approach is adaptable to diverse local contexts while remaining aligned with EU policy objectives and transnational cooperation principles.

The project also demonstrates that successful river protection depends on more than technical solutions. It requires a **cultural shift** towards shared responsibility, transparency, and long-term stewardship of water bodies. This took shape in the **River Literacy** framework, which helps communities better understand and protect their rivers.

Looking ahead, the challenge is to ensure that the methodologies and tools developed within the Aquatic Plastic project become embedded in everyday institutional practice. This means integrating risk-based monitoring into routine inspections, strengthening enforcement capacities, ensuring stable funding for remediation and prevention, and maintaining active cooperation across borders and sectors. As the Danube and its tributaries connect countries, communities, and ecosystems, their protection must also be a shared and continuous effort.

The condition of our rivers reflects the condition of our societies. Preventing waste from entering water bodies is not only an environmental obligation but also an investment in public health, economic resilience, and regional stability. By adopting the approaches outlined in this implementation methodology, authorities can move from reactive clean-ups to proactive, systemic solutions that safeguard freshwater ecosystems for future generations.

The tide is turning. The momentum created by the Aquatic Plastic project shows that meaningful change is within reach. The question now is whether institutions across the region will seize this opportunity and translate the presented methodology into lasting, operational practice – ensuring that the rivers of the Danube River Basin remain living, resilient, and protected.

If you enjoyed our study, please explore the other resources from the Aquatic Plastic project and the Riversaver Platform: https://www.riversaver.eu/en/document-library (QR-kód)

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11. Annexes

11.1 Annex 1: Analysis of Municipal Waste Management by Country[87]

The following analysis details the municipal waste management landscape across AQUATIC PLASTIC project partner countries, highlighting the distinction between officially recorded untreated waste and estimated illegal disposal.

[87] **CEWEP (2025).** *Municipal Waste Treatment 2022.* [Online] Available at: https://www.cewep.eu/wp-content/uploads/2025/02/MW-treatment-2022.pdf.

Austria (2022)[88]

Austria represents a highly efficient waste management system, where **7,275,000 tonnes** of municipal solid waste (MSW) were generated in 2022.[89] The vast majority of this volume is managed through high-recovery methods, with **4,583,250 tonnes** recycled or composted and **2,546,250 tonnes** utilised for energy recovery. While official statistics show **zero untreated waste** within the formal system, it is important to note the presence of **Estimated Illegally Placed Waste**. According to the *1st Austrian Littering Report*, approximately **15,000 tonnes** of waste are carelessly discarded annually in public spaces and nature.[90] This volume skips the formal reporting system entirely.

Slovenia (2022)[91]

Slovenia presents a unique case within the EU framework, with a population of **2,112,076** and a relatively low per-capita waste generation of **487 kg**. Out of the **1,028,000 tonnes** of municipal solid waste generated, the country achieves a strong recovery rate, with **647,500 tonnes** directed toward recycling and composting and **134,000 tonnes** utilised for energy recovery.

A notable aspect of the Slovenian data is the **164,500 tonnes** categorised as **untreated**. While this waste gap appears significant on the chart, the provided explanation clarifies that this discrepancy is primarily a **reporting and industrial side effect** rather than an indication of illegal dumping.[92] Unlike the littering estimates seen in other regions, this volume is accounted for within the formal system but lost during processing or due to specific industrial reporting methodologies.[93] Consequently, there is currently **no applicable data (N/A)** for estimated illegally placed waste outside the formal system. However, the country still contends with a legacy network of **over 15,000 historical illegal dumpsites** (according to Let's Clean Slovenia civic campaign), which in 2018 were estimated to hold a volume of waste equivalent to **92 Olympic swimming pools**, including significant amounts of construction debris (41%) and hazardous materials (10%).[94]

Slovakia (2022)[95]

Slovakia, with a population of **5,428,792**, generated a total of **2,561,000 tonnes** of municipal solid waste in 2022, averaging **472 kg per capita**. The country's management strategy shows a balanced distribution between recovery and disposal: **1,280,000 tonnes** were successfully recycled or composted, while **205,000 tonnes** were

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88 **European Environment Agency (EEA) (2025).** *Municipal Waste Management Country Profiles: Austria Factsheet.* [Online] Available at: https://www.eea.europa.eu/en/topics/in-depth/waste-and-recycling/municipal-and-packaging-waste-management-country-profiles-2025/at-municipal-waste-factsheet.pdf.

89 **CEIC Data (2022).** *Austria Environmental: Waste Management: Municipal Waste Generated.* [Online] Available at: https://www.ceicdata.com/en/austria/environmental-waste-management-oecd-member-annual.

90 **Umweltbundesamt (2021).** *1. Österreichischer Littering-Bericht (1st Austrian Littering Report).* Report REP-0730. [Online] Available at: https://www.umweltbundesamt.at/fileadmin/site/publikationen/rep0730.pdf

91 **European Environment Agency (EEA) (2025).** *Municipal Waste Management Country Profiles: Slovenia Factsheet.* [Online] Available at: https://www.eea.europa.eu/en/topics/in-depth/waste-and-recycling/municipal-and-packaging-waste-management-country-profiles-2025/si-municipal-waste-factsheet.pdf.

92 Statistical Office of the Republic of Slovenia (SURS) (2024). *More municipal waste generated, its recovery rate higher.* [Online] Available at: https://www.stat.si/StatWeb/en/news/Index/12770.

93 Statistical Office of the Republic of Slovenia (SURS) (2024). *Waste, Slovenia, 2023.* [Online] Available at: https://www.stat.si/StatWeb/en/news/Index/13215.

94 Interreg Italy-Slovenia. (2024, February 15). *Illegal dumps: Help us report them!* https://www.ita-slo.eu/en/news-and-events/news/illegal-dumps-help-us-report-them

95 European Environment Agency (EEA) (2025). *Municipal Waste Management Country Profiles: Slovakia Factsheet.* [Online] Available at: https://www.eea.europa.eu/en/topics/in-depth/waste-and-recycling/municipal-and-packaging-waste-management-country-profiles-2025/sk-municipal-waste-factsheet.pdf.

processed through incineration with energy recovery. However, landfilling remains a significant component of the system, accounting for **999,000 tonnes**.

The **untreated** waste in Slovakia is recorded at **77,000 tonnes**, representing approximately **3%** of total generation. Interestingly, data discrepancies between Eurostat and the Statistical Office of the Slovak Republic (ŠÚ SR) are minimal and often stem from the classification of specific streams, such as small construction waste.

Regarding the waste gap, the unmanaged portion is frequently linked to **rural infrastructure challenges**. In areas where bulky waste collection is less frequent, localized illegal dumping becomes more prevalent. While a specific tonnage for **estimated illegally placed waste** is not officially provided (N/A), the scale of the issue is highlighted by citizen science data from the TrashOut application, which reveals a significant challenge, identifying **10,546 illegal dumpsites** across the nation in 2023, with **6,609 of those locations** heavily contaminated with persistent plastics. This unmanaged waste crisis is tied to spatial inequality, as thousands of individuals in marginalized rural communities live within 100 metres of major, hazardous dumpsites that bypass the formal management system.[96] This suggests that while the formal reporting gap is small, physical illegal disposal remains a persistent environmental challenge.

Hungary (2022 and 2023 data)[97,98]

Hungary, with a population of **9,599,744**, generated a total of **4,115,000 tonnes** of municipal solid waste in 2023, which equates to **429 kg per capita**. The waste management landscape is characterised by a high reliance on landfilling, which accounts for **2,232,000 tonnes**. Recovery efforts include **1,375,000 tonnes** through recycling and composting, and **504,000 tonnes** via incineration with energy recovery and **4000** tonnes via incineration without energy recovery.

In the official reporting for 2023[99], Hungary recorded **zero untreated waste** within the formal 100% of generated MSW. However, the data reveals a significant volume of **unmanaged waste** that exists entirely outside the formal reporting system. In 2022, authorities removed approximately **67,000 tonnes[100]** of illegal waste-material that escaped the primary collection and treatment infrastructure (according to HulladékRadar).

Illegal waste dumping remains a persistent challenge in Hungary, although monitoring and reporting have significantly improved through digital tools. The **HulladékRadar (WasteRadar)** mobile application has become the primary tool for tracking these discrepancies. The more than **79,000[101]** reports made through the app indicate that while formal waste streams appear "closed" in official statistics, a significant parallel illegal waste flow exists, requiring further government intervention.

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96 Circular Economy: Municipal Solid Waste and Landfilling Analyses in Slovakia - MDPI, hozzáférés dátuma: március 16, 2026, https://www.mdpi.com/2227-7099/12/11/289

97 European Environment Agency (EEA) (2025). *Waste Generation: Hungary Country Data.* [Online] Available at: https://www.eea.europa.eu/en/europe-environment-2025/countries/hungary/waste-generation.

98 European Environment Agency (EEA) (2025). *Municipal Waste Management Country Profiles: Hungary Factsheet.* [Online] Available at: https://www.eea.europa.eu/en/topics/in-depth/waste-and-recycling/municipal-and-packaging-waste-management-country-profiles-2025/hu-municipal-waste-factsheet.pdf.

99 Hungarian Central Statistical Office. *Quantity of specific waste types by treatment method [thousand tonnes]*. Retrieved March 20, 2026, from https://www.ksh.hu/stadat_files/kor/hu/kor0029.html

100 Direct data request from the Ministry of Energy, Hungary

101 Direct data request from the Ministry of Energy, Hungary

Following the measures of the Tisztítsuk meg az országot! (Let's Clean Up the Country) project announced under the Climate and Nature Protection Action Plan, more than **724,000**[102] tonnes of illegally discarded waste have been eliminated since 2020.

Romania (2022)[103]

Romania, with a population of **19,042,455**, presents a waste management profile characterised by significant reliance on landfilling and notable data inconsistencies. While official figures report a total generation of **5,770,000 tonnes**-averaging a relatively low **303 kg per capita**, regional experts widely question these numbers. They suggest that the low per-capita figure reflects a failure to capture waste flows in rural areas, where collection services are often incomplete or entirely non-existent.

The treatment breakdown is dominated by landfilling, which accounts for **4,269,800 tonnes**. Recovery efforts remain modest, with **692,400 tonnes** recycled or composted and **403,900 tonnes** utilised for energy recovery.

The **untreated** volume is recorded at **403,900 tonnes**, but this figure is the subject of considerable scrutiny. A comparison between Eurostat data[104] and the National Agency for Environmental Protection (ANPM) reports reveals significant discrepancies:

- **Inconsistent Tracking:** The gap between the reported recycling rate for packaging waste (38% in 2021) and municipal waste (12%) indicates a breakdown in data tracking across different streams.
- **Systemic Leakage:** The unmanaged waste – calculated as the difference between generation and treatment – suggests that several hundred thousand tonnes go unrecorded annually.
- **Rural Infrastructure Gaps:** Because rural collection coverage is significantly lower than the national average, there is a systemic 'leakage' of waste into illegal dumpsites in the countryside.

This statistical discrepancy is underscored by a physical crisis, as citizen science platforms (TrashOut) have identified at least **10,171 illegal dumpsites** containing plastic waste. Additionally, the country has become a central nexus for transnational waste trafficking; in 2021 alone, environmental authorities intercepted over **3,700 tonnes of smuggled waste**[105] that was falsely declared as recyclables to exploit black-market disposal fees, which are significantly lower than legitimate rates in Western Europe.

Montenegro (2023)[106]

Montenegro, with a population of **623,633**, generated an estimated **360,000 tonnes** of municipal solid waste in 2023, averaging **549 kg per capita**. The data reveals a system heavily reliant on disposal, with **319,000 tonnes** sent to landfills and **zero** recorded volumes for recycling, composting, or incineration with energy recovery. A

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102 Direct data request from the Ministry of Energy, Hungary

103 European Environment Agency (EEA) (2025). *Municipal Waste Management Country Profiles: Romania Factsheet.* [Online] Available at: https://www.eea.europa.eu/en/topics/in-depth/waste-and-recycling/municipal-and-packaging-waste-management-country-profiles-2025/ro-municipal-waste-factsheet.pdf.

104 Municipal waste statistics - Statistics Explained - Eurostat - European Commission, hozzáférés dátuma: március 16, 2026, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Municipal_waste_statistics

105 Waste Management World. (2021, August 30). *Romania to face up to illegal waste trafficking problem*. Available at: https://waste-management-world.com/collection-and-handling/romania-to-face-up-to-illegal-waste-trafficking-problem/

106 Statistical Office of Montenegro (MONSTAT) (2024). *Generated and treated waste 2023.* [Online] Available at: https://www.monstat.org/uploads/files/otpad/2023/Generated%20and%20treated%20waste_2023.pdf.

portion of the waste, specifically **22,000 tonnes**, is categorised as ‘other’, primarily consisting of exported materials.

A critical aspect of Montenegro’s waste profile is the gap between generated and collected waste. Out of the 360,000 tonnes generated, only **342,000 tonnes** were officially collected. This leaves an **untreated"** volume of **18,000 tonnes**. The fate of this **18,000 tonnes** is complex. While it is likely subject to **illegal management practices** – authorities have identified at least **37 large-scale illegal disposal sites** in immediate coastal zones, which threaten both marine ecosystems and the region's porous karst landscapes[107] – it also points to a significant **systemic problem**. This discrepancy reflects a lack of comprehensive collection infrastructure, where the formal network simply fails to reach certain areas or populations.

Bulgaria (2022)[108]

Bulgaria, with a population of **6,447,710**, generated a total of **3,157,000 tonnes** of municipal solid waste in 2022, averaging **489 kg per capita**. The management of this waste is heavily centred on landfilling, which accounts for **1,704,780 tonnes**, while recovery efforts include **883,960 tonnes** through recycling and composting and **94,710 tonnes** via incineration with energy recovery.

A significant feature of the Bulgarian data is the substantial **untreated** volume, recorded at **473,550 tonnes**. This represents a large gap in the national statistics, where the final fate of a considerable portion of municipal waste remains officially unknown.

The explanation for this discrepancy points to two primary possibilities:

- **Reporting Failures:** It is highly probable that this gap reflects a failure to report the final disposal of residues that remain after pre-treatment processes.
- **Unmanaged Waste:** Alternatively, it may suggest an increase in unmanaged waste that bypasses formal treatment.

While there is **no official estimate (N/A)** for illegally placed waste outside the system, investigative data reveals that Producer Responsibility Organizations (PROs) systematically underreport plastic packaging placed on the market by margins of **30% to 78%**, which allows hundreds of thousands of tonnes to bypass formal channels.[109] This unmanaged waste often ends up in illicit locations, such as the **nearly 280 illegal landfills identified around Sofia alone.**

Serbia (2024)[110]

Serbia, with a population of **6,586,476**, has a municipal waste profile that reflects a transition toward more structured management, yet still faces significant infrastructural gaps. Based on 2024 data, the country generated **2,380,000 tonnes** of waste, averaging **361 kg per capita**. Treatment methods include **418,000 tonnes** recycled or composted and **288,000 tonnes** utilised for energy recovery. Landfilling remains the primary

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[107] Development of the project documentation and remediation of 37 illegal non-equipped solid waste disposal sites in coastal area, defined in the National Action Plan of Montenegro (NAP) for the implementation of the LBS Protocol and its Regional Plans in th | Department of Economic and Social Affairs.https://sdgs.un.org/partnerships/development-project-documentation-and-remediation-37-illegal-non-equipped-solid-waste

[108] European Environment Agency (EEA) (2025). *Municipal Waste Management Country Profiles: Bulgaria Factsheet.* [Online] Available at: https://www.eea.europa.eu/en/topics/in-depth/waste-and-recycling/municipal-and-packaging-waste-management-country-profiles-2025/bg-municipal-waste-factsheet.pdf.

[109] Parallel realities: managing plastic packaging waste in Bulgaria ..., hozzáférés dátuma: március 16, 2026, https://zerowasteeurope.eu/wp-content/uploads/2025/03/ZWE_Mar25_Report_Parallel-realities_-managing-plastic-packaging-waste-in-Bulgaria-beyond-official-statistics.pdf

[110] Environmental Protection Agency of Serbia (SEPA) (2024). *Izveštaj o upravljanju otpadom u Republici Srbiji za 2024. godinu (Report on Waste Management in the Republic of Serbia for 2024).* [Online] Available at: https://sepa.gov.rs/wp-content/uploads/2025/12/Izvestaj-2024.pdf.

disposal route at **1,559,000 tonnes**, though it is worth noting that a significant portion (**1,110,000 tonnes**) is now handled via sanitary landfills. Additionally, **115,000 tonnes** of waste are exported.

The most critical challenge in the Serbian system is the **untreated** volume of **510,000 tonnes**. Unlike in EU member states, where untreated waste often stems from reporting nuances, in Serbia, this gap is primarily a physical reality caused by **incomplete waste collection coverage**. This infrastructural divide forces residents to dispose of waste in the natural environment, leading to the estimated existence of over **3,500 illegal dumpsites** and 135 non-compliant landfills.[111] Consequently, roughly **20% of all municipal waste** in the country is dumped illegally, contributing to severe plastic contamination in transboundary rivers like the Lim and Drina[112] and an air pollution crisis linked to **6,592 premature deaths** annually.[113]

Consequently, the half a million tonnes of untreated waste represent a volume that sits entirely outside the formal collection system, posing a continuous environmental and logistical challenge for the national authorities.

Bosnia and Herzegovina (2022)[114]

Bosnia and Herzegovina, with a population of **3,430,891**, generated **1,184,000 tonnes** of municipal solid waste in 2022, averaging **345 kg per capita**. The waste management infrastructure is almost entirely centred on disposal, with **919,710 tonnes** sent to landfills and a minimal **9,290 tonnes** processed through incineration with energy recovery. Currently, there are no recorded volumes for recycling or composting.

The most striking feature of the data is the **untreated** volume of **255,000 tonnes**, which represents the gap between the waste generated and the **929,000 tonnes** actually collected. This discrepancy is a direct result of the **lack of universal waste collection coverage** across the country. While urban collection reaches approximately 90% of the population, coverage plummets to **40%–45% in rural regions**, leaving roughly one-quarter of the national population entirely outside the formal waste management grid. Consequently, an estimated **25% of all disposed waste** ends up in the natural environment, contributing to more than **1,400 documented illegal dumpsites** across the country. The scale of the issue is highlighted in Republika Srpska, which contains nearly **590 illegal landfills** compared to only 43 registered legal ones.[115]

Estimation of uncollected waste quantities in Zakarpattia

In analysing the waste management situation in the Zakarpattia region, a critical factor is determining the volume of illegally abandoned waste or waste entering the environment. For this estimation, demographic data and specific waste generation indicators provided by the **Tisza European Grouping of Territorial Cooperation (Tisza EGTC)[116]** were used.

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111 Situational Analysis - Municipal Waste Management in Serbia - The World Bank, hozzáférés dátuma: március 16, 2026, https://thedocs.worldbank.org/en/doc/8c0c355b685476cdcc2154a3ecf42768-0080012024/original/Situational-Analysis-Municipal-Waste-Management-in-Serbia.pdf

112 Illegal Landfill Sites in the Balkans Affecting Water Pollution - Eurasian Research Institute, hozzáférés dátuma: március 16, 2026, https://www.eurasian-research.org/publication/illegal-landfill-sites-in-the-balkans-affecting-water-pollution/

113 Mandić, V. et al. (2023). *Informal recycling sector in Serbia through a health perspective.* ResearchGate. [Online] Available at: https://www.researchgate.net/publication/372733985_Informal_recycling_sector_in_Serbia_through_a_health_perspective.

114 European Environment Agency (EEA) (2025). *Country profiles on waste prevention 2025: Bosnia and Herzegovina Factsheet.* [Online] Available at: https://www.eea.europa.eu/en/topics/in-depth/waste-and-recycling/country-profiles-on-waste-prevention-2025/ba-waste-prevention-factsheet-final.pdf/@@download/file

115 The Hidden Cost of Waste: What Happens to Waste in Bosnia and Herzegovina? - CETAP, hozzáférés dátuma: március 16, 2026, https://cetap.ba/en/the-hidden-cost-of-waste-what-happens-to-waste-in-bosnia-and-herzegovina/

116 Szabóné Cap, A. (2025.) *Környezetszennyezés a Tisza forrásvidékén – Kárpátaljai helyzetkép* [Presentation]. Tisza European Grouping of Territorial Cooperation (Tisza EGTC).

The estimation methodology is based on the theoretical waste generation of the population, not covered by organized waste collection services. The calculation considers the region's base population of 1,816,684, supplemented by approximately 600,000 internally migrating persons due to the war, totalling 2,416,684 potential waste generators. The average specific waste generation rate for the region is 470 kg/person/year.

Considering that 62% of the population lives in rural areas where organized public services and solid municipal waste collection are currently not established, the estimation was projected onto this underserved population (approximately 1,498,344 people). **Under a worst-case scenario – assuming that in the absence of services, the entirety of the generated waste remains untreated or ends up in illegal dumpsites – the annual volume of abandoned waste may reach 704,222 tons.**

This quantity represents an extraordinary environmental burden on the headwaters of the Tisza River. **This systemic failure transforms the Tisza River into a waste conveyor, transporting an estimated 2,600 to over 3,000 cubic metres of floating plastic across international borders into Hungary and Romania every year.**[117] This continuous annual influx further exacerbates the problem of the estimated 3 million tons of untreated waste, already accumulated in the region, a significant portion of which enters riverbeds directly during flood events.

11.2 Annex 2: Key regulations on waste management in the AQPLA project partners' countries

Country	Key regulations on waste management
Austria	Waste Management Act (Abfallwirtschaftsgesetz) (AWG 2002); Landfill Ordinance, (1997, latest amendment in 2016); Packaging Coordination Ordinance (2014), Criminal Code (StGB, section 181b), The Austrian Core Water Act (Wasserrechtsgesetz, WRG)
Bosnia and Herzegovina*	Law on Waste Management in the Federation of BiH, Law on Waste Management in Republika Srpska, corresponding law in Brcko District, Law on Water
Bulgaria	Waste Management Act (2012); Prevention and Remedying of Environmental Damage Act (ELPRED), National Waste Management Plan 2021-2028
Hungary	The Environmental Protection Act; Act CLXXXV of 2012 on Waste; The Water Management Act; 20/2006. (IV.5.) Decree on the Requirements for the Disposal of Waste in Landfills; the National Waste Management Plan; Waste Prevention Program 2021-2027
Montenegro*	Law on Waste Management; Water Law; National Waste Management Plan
Romania	Law No. 17/2023 (replaced Law no. 211/2011) on the Waste Regime; GEO No. 195/2005 on Environmental Protection; OUG 92/2021 on the waste regime; Law 101/2006 on sanitation services; Water Law no. 107/1996
Serbia*	Law on Waste Management; Law on Water; Law on Environmental Protection; Rulebook on Packaging and Packaging Waste Management; National Waste Management Strategy for the Period 2020–2030; Law on Integrated Pollution Prevention and Control

[117] Hanko et al. (2024).

Country	Key regulations on waste management
Slovakia	Act No. 79/2015 Coll. on Waste and on Amendments to Certain Acts (latest version from the 1st of April 2025); Act on Fees for Waste Disposal; Waste Prevention Program
Slovenia	Law on Waste Management (OJ RS, No 77/22, 113/23 and 13/25); Water Act (ZV-1); The Marine Strategy Framework Directive; The SUP Directive

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11.3 Annex 3: Effective technical tools to prevent waste from entering rivers

Country	Effective technical tools to prevent waste from entering rivers
Austria	traps within the sewage system and stormwater systems; retention barriers fences, noise barriers or windbreaks; clean-up measures;
Bosnia and Herzegovina*	floating booms at Višegrad Hydro Power Plant on the Drina River and on the Lim River; warning signs such as 'No Dumping – 250 BAM Fine' and surveillance cameras in hotspots like near Sarajevo's Miljacka River; Digital tools like the Green Alarm app allow citizens to report illegal dumping; public hotlines and eco-police inspectors; Education: Nature parks like Una National Park and eco-trails at Vrelo Bosne use info boards to raise awareness.
Bulgaria	advanced wastewater management systems use real-time data and sensors to detect sewer blockages and optimize system capacity, reducing spills; Interactive Recycling Apps: Platforms; Crowdsourced Waste Reporting Apps; E-Waste Collection Services (Digital scheduling tools); Construction Waste Management Platforms;
Hungary	**PET remover system** in Upper Tisza: Partial closure of the river during floodtime with barges, deriving the floating waste to the shore. Four intervention sites have been developed in 2021, where the accumulated waste can be excavated and transported to a processing area for further separation and treatment. The **PETII** is a lightweight fast-response riverine litter collector boat developed by the Plastic Cup, which runs mainly on renewable energy (such as the river flow), and instead of setting up a complete closure of the river, it uses the special hydrodynamic characteristics of the floating litter for its separation and collection with its extendable arms, swing out from both sides, making the PETII one of the most capable litter removal machines on smaller affluent rivers like the Bodrog, since it targets the mean line of flow, where most of the buoyant riverine plastics are drifting. Other innovative and cost-effective equipment also available, such as the **HYDR** or the **KRKN** river litter skimmer solutions of the Plastic Cup, which, working like a vacuum cleaner, is suitable for picking up the plastic debris floating on the water surface (detailed in 'Documentation of Implemented Professional River Cleanup Pilot Actions'[118]) VALYO, 'Valyo! Beach and other projects'[119] are an association working for the valorisation of the banks of the Danube in Budapest.
Montenegro*	garbage bins at certain places
Romania	Strategically placed bins near riverbanks; ANAR; floating booms or barriers on rivers like the Olt; organized clean-up campaigns; grates and screens on storm drains; CapChEA (Automated Catcher of Floating Waste on Water); TrashOut App[120]; Placing signs near rivers prohibiting littering; Environmental education in schools; Deposit-Return System (DRS) for beverage packaging
Slovakia	Riverbank Trash Barriers and Nets; Trash Bins and Sorting Containers Near Water Bodies; Warning and Prohibition Signs; Educational and Nature Trails;

118 Interreg Danube Region. (2025b)

119 Valyo – City and River Association. (n.d.)

120 Trash Out. (n.d.)

Country	Effective technical tools to prevent waste from entering rivers
	TrashOut App[121] (Developed in Slovakia); Online Monitoring Portals – managed by SIŽP (Slovak Environmental Inspectorate) or water authorities; School & Youth River Programs; Eco-Certification for Campsites and Recreation Sites

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11.4 Annex 4: Sanctioning practices in the AQPLA project partners' countries

Country	Sanctioning practices
Austria	Penalties for illegal waste dumping are a joint responsibility of the federal and provincial governments. While the federal law (AWG 2002) forms the basis, the federal states regulate the details and implement the penalties. The level of penalties and responsibilities can therefore vary from province to province. In Vienna for example, the Vienna Clean Air Act (Wiener Reinhaltegesetz) came into force in 2008. It bans littering in public spaces, enables controls and regulates the power of the Waste Watchers, who are authorised to issue warnings, impose fines, or file a complaint with the competent authority. The Waste Watchers have the option of issuing an administrative fine in the current amount of 50 euros, in serious cases up to 90 euros and the right to report to the authorities (criminal authority: MA 58 - Water Law, fines of up to 2,000 euros). For waste that is thrown out of the car (e.g. cigarettes, take-away packaging, plastic bottles, etc.), the fine is at least 75 euros. The revenue from the fines is used for cleanliness measures: A large number of checks and penalised violations of the cleanliness rules lead to a significant decrease of littering and over 128 million properly disposed of cigarette butts per year since the beginning of their deployment.
Bosnia and Herzegovina *	Bosnia and Herzegovina's sanctioning system for abandoned waste and river pollution is legally in place but historically very weak in enforcement. Laws at entity and local levels prescribe penalties for illegal waste dumping, littering, and pollution of watercourses. For instance, under FBiH's waste law, individuals dumping waste in the environment (including near rivers) can be fined several hundred BAM, and companies face higher fines (thousands of BAM). Republika Srpska's law similarly outlines punitive fines and even criminal charges for large-scale pollution. Now, with Article 33a added, inspectors have clear authority to fine those who dispose of waste in unapproved sites, including riversides, and fine amounts have been scaled by offense severity. Enforcement also extends to polluter pays clean-up orders: authorities can order the polluter to remove waste at their expense. While rarely used before, there is new intent to apply this.

[121] detailed later

Country	Sanctioning practices
Bulgaria	Regarding penalties for environmental violations, Bulgaria has a legal framework that includes national laws, EU directives, and international agreements. Violations such as illegal dumping, excessive emissions, and pollution of protected habitats can lead to administrative and penal sanctions. Enforcement is carried out by governmental entities, such as the Ministry of Environment and Waters, Regional Inspectorates for Environment and Water and local authorities. Inspections and monitoring play a crucial role in identifying infractions and ensuring compliance with regulations. For instance, in cases of river pollution, authorities investigate incidents, impose fines, and require remedial actions to be taken. Some violations, such as illegal dumping and industrial pollution, persist despite regulations. The European Commission has previously initiated infringement procedures against Bulgaria for failing to meet environmental standards. Since then, key advancements have included stricter penalties for environmental violations, such as increased fines for pollution and illegal waste disposal, upgraded wastewater treatment plants, enhanced monitoring and emergency response systems, and integration with EU climate policies.
Hungary	Illegal waste disposal is criminalised in the Criminal Code. Those who place waste in a location not officially approved for that purpose, without a permit or exceeding the scope of their license, shall be penalised by up to 3 years in prison, in severe cases, up to 8 years. The investigating authority often automatically assigns an expert, even if it is not necessary (i.e., the nature of the waste can be identified through visual inspection). The Act on Waste provides an additional option for sanctioning the illegal disposal or abandonment of waste.
Montenegro *	The Law on Waste Management provides for penal provisions ranging from 1,000 to 40,000 euros. The new law also provides for better inspection oversight.

Country	Sanctioning practices
Romania	Key enforcement authorities: National Environmental Guard is the main control and sanctioning body. It performs inspections and issues fines for illegal waste disposal in or near rivers. Local authorities (e.g. municipalities) are responsible for identifying and removing abandoned waste and can apply local sanctions. ANAR monitors river pollution and collaborates with other institutions to report and address cases of uncontrolled waste accumulation in rivers and on banks. According to the Water Law, both individuals and legal entities (including public authorities and private operators) may be sanctioned if they allow or cause waste to reach water bodies. In cases where local authorities fail to clean rivers or prevent waste accumulation, ANAR has the legal right to act on their behalf, and the cost of intervention is charged to the non-compliant local administration. Fines for individuals: Can range from a few thousand RON (e.g. 5,000 to 15,000 RON for abandoning waste by individuals) up to higher amounts for more severe breaches. Fines for legal entities (companies) re significantly higher, ranging from tens of thousands to hundreds of thousands of RON (e.g. 50,000 to 70,000 RON for abandoning waste or uncontrolled disposal by legal entities, and even higher for hazardous waste). Besides fines, sanctions can include the obligation to clean up the affected site and restore it, confiscation of vehicles used in committing the offense, and suspension or cancellation of permits/authorizations for businesses. Criminal Offenses: Law 17/2023 amending OUG 92/2021 introduced or clarified criminal liability for more severe waste offenses, such as managing significant quantities of waste in a way that causes substantial environmental damage, including pollution of water bodies. Penalties can include larger fines and imprisonment.
Serbia*	Under the Act on Fees for the Use of Public Goods, companies are required to pay environmental protection fees. However, these fees have lost their earmarked purpose since 2012, meaning the funds collected are no longer exclusively used for environmental protection. This undermines the Polluter Pays Principle, rendering the economic incentive system largely ineffective. Fees are calculated based on company size and activity rather than on actual quantities or toxicity of pollutants released into soil or water. This approach fails to incentivize pollution reduction or investment in cleaner technologies. In addition, product-based charges have been introduced for plastic bags, car tyres, batteries, oils, electrical equipment, and similar waste-generating goods. However, water pollution charges remain extremely low and are not based on the real discharge of pollutants, which fails to encourage industrial or municipal investment in wastewater treatment infrastructure. From a criminal law perspective, Serbia's Criminal Code provides for prison sentences ranging from six months to eight years and fines for serious environmental offences.

Country	Sanctioning practices
Slovakia	The sanctioning and enforcement system in Slovakia for dealing with abandoned waste and river pollution is structured under environmental legislation, particularly the Waste Act and the Water Act. It is overseen primarily by the Slovak Environmental Inspectorate (SIŽP), in cooperation with other state and local authorities. Administrative sanctions: Fines: For individuals: typically €50 to €1,500. For legal entities: can range from €500 to €350,000, depending on severity, volume, and recurrence. Orders to remove waste: Offenders can be legally required to clean up the site. Temporary suspension of operations for companies causing repeated environmental violations. Compensation for environmental damage: The state can claim costs for remediation. In more serious cases (e.g. large-scale pollution, hazardous waste, threats to public health or ecosystems), the offense may qualify as an environmental crime, resulting in imprisonment (typically 1 to 8 years depending on damage and intent), asset forfeiture, ban on activities for legal persons.
Slovenia	The Environmental and Nature Protection Inspectorate (IRSOP), which works within the Ministry of the Environment, is responsible for enforcing laws to river pollution and abandoned waste in Slovenia. Local waste problems are also handled by municipal inspectors. Individuals may be fined between €200 and €1,000, while legal entities may be fined up to €40,000. Forced execution may be used if violators disregard directives to clear waste or clean up contaminated areas.

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11.5 Annex 5: Potentially needed permits regarding large-scale clean-up actions

Land access and landowner consent: Formal written consent from the landowner (municipality, state authority, water directorate, forestry service, national park, or private owner), defining access rights, duration of works, and restoration obligations.
Waste management permit/notification: Authorisation for the collection, temporary storage, transport, and treatment of waste, including the designation of licensed waste operators and facilities in accordance with national and EU waste legislation.
Hazardous waste handling permit (if applicable): Special permits for the identification, packaging, transport, and treatment of hazardous waste fractions (e.g. oils, chemicals, asbestos, batteries, contaminated soils), including mandatory documentation and traceability.
Environmental protection permit or screening decision: Environmental authority approval confirming that the planned activity does not cause unacceptable environmental impacts, or requiring a simplified environmental assessment for large volumes or sensitive locations.
Nature conservation permit: Mandatory authorisation when activities take place in protected areas (e.g. Natura 2000 sites, national parks, floodplain forests), specifying allowed machinery, seasonal restrictions (i.e.: nesting season), and mitigation measures.
Water management permit: Required for operations affecting riverbanks, floodplains, riverbeds, or surface waters, including the use of floating equipment, temporary crossings, or bank stabilisation

measures.

Forestry permit (where applicable): Approval for access and operations on forest land, including temporary road use, vegetation removal, or soil disturbance in managed or protected forests.

Construction or earthworks permit: Needed if the clean-up involves excavation, regrading, removal of large waste bodies, construction of temporary access roads, or installation of technical protection measures.

Transport and traffic permits: Authorisation for the movement of heavy machinery and waste transport vehicles, including oversized loads, temporary traffic regulation, or use of restricted roads.

Temporary storage and transfer station approval: Permit for establishing temporary waste storage, sorting, or consolidation areas, ensuring compliance with safety, environmental, and fire protection requirements.

Occupational health and safety approvals: Compliance with labour safety regulations, including risk assessments, protective equipment requirements, and emergency response plans for workers and contractors.

Cultural heritage clearance (if relevant): Required if the site is located near or within areas of archaeological or cultural significance, ensuring that clean-up works do not damage protected heritage assets.

11.6 Annex 6: Recycling effectiveness in AQPLA project partner's countries

Country	Effectiveness of recycling
AU	Since 2025, all the lightweight packaging (plastic and metal packaging) are collected together in the Yellow Bin or Yellow Sack in all Austrian federal states. In addition, one-way deposit system was introduced throughout Austria. The switch to joint collection of plastic and metal packaging in 2023 increased collection volumes in Vienna, Lower Austria, Carinthia and Salzburg by an average of 21% in the first year. In the federal states where the changeover will take place on 1 January 2025, ARA also expects a significant increase in packaging not affected by the one-way deposit.
BIH*	Over the past five years, both the collection and recycling of plastics have increased modestly. Estimates from the FBiH Environmental Protection Fund indicated that around 15% of packaging waste (much of which is plastic) was being recovered in the Federation by the late 2010s. Recycling containers for plastic bottles have been installed in cities in the past five years. Sarajevo, Banja Luka, Mostar, and Tuzla have started placing color-coded bins or cages for PET bottles in public areas. Despite these efforts, most plastic still ends up in landfills or dumps. A significant portion of the collected plastic is exported for recycling abroad.
BU	Bulgaria's plastic waste recycling programs have faced challenges despite efforts to align with EU regulations. While the country has transposed waste management legislation, the effectiveness of recycling programs remains questionable due to structural weaknesses. Over the past five years, plastic waste management has seen mixed trends. On one hand, Bulgaria has implemented a National Waste Prevention Program (2021-2028) aimed at reducing waste generation and promoting reuse. On the other, discrepancies in waste data and issues with waste incineration have

Country	Effectiveness of recycling
	hindered progress. Bulgaria has reported a significant rise in plastic recycling rates, with over 52% of scrap plastic now being recycled, and several initiatives have been introduced to enhance recycling and waste management: circular economy programs, EPR, separate collection system, green innovation hubs.
HU	As of 01/07/2023, the collection and treatment of most plastic waste (including packaging waste) is centralised through a concession. MOHU Zrt. organises the collection, transport and pre-treatment of waste covered by the concession, collects EPR fees, and finances the collection and treatment of products that have become waste and are subject to EPR regulations. On 01/01/2024, the deposit return scheme (DRS) came into force, including a number of plastic and plastic-containing beverage containers. The infrastructure for bottle returns has been in place since mid-2024. Over the past five years, PS, PP, PE and EPS capacities have stagnated. PVC capacity has increased. PET recovery has been phased out, with only one plant producing waste-derived products. There is no regranulate production in the country; the recovered baled PET is recycled abroad. Meanwhile, engineering plastics are thriving owing to market-based collection and recovery. Big bag and strapping processing plants have been established.
MO*	In Montenegro, recycling as such is insignificant. Plastics as well as other recyclable materials are prepared for reuse and recycling. They are mostly exported. The degree of prepared materials for reuse and recycling increases year by year, and the latest report on the implementation of the State Waste Management Plan indicates a figure of 18%. However, our Statistical agency points to a very low percentage (1%), which stems from using different methodologies.
RO	Romania's journey with plastic waste recycling has been fraught with challenges, resulting in generally low effectiveness and a slow pace of improvement over the past five years. However, recent significant initiatives, most notably the introduction of a Deposit-Return System (DRS), are poised to potentially reshape the landscape for specific types of plastic packaging. While the past five years saw Romania struggling with low plastic collection and recycling rates despite some efforts, the recent implementation of the DRS marks a pivotal moment. This system is anticipated to substantially increase the collection of targeted plastic packaging, which should in turn provide a cleaner and more abundant feedstock for recyclers, potentially leading to an increase in recycling rates for those items in the coming years. Plastic waste recycling programs in Romania are not very effective, consistently placing the country among the lowest performers in the EU. For instance, the recycling rate for plastic packaging waste was approximately 30.05% in 2020 and saw a slight increase to 31.59% in 2021. Some reports from mid-2023 still cite a general plastic recycling rate of around 30%.
SB*	Serbia has made progress in the recycling of packaging waste, notably plastics; however, the overall effectiveness of plastic waste recycling programs is still limited.

Country	Effectiveness of recycling
	Significant obstacles remain, particularly in household waste collection and recycling as well as the implementation of comprehensive collection and processing.
SK	In 2022: Slovakia achieved a plastic packaging recycling rate of 60%, the highest among EU countries. Deposit Return System (DRS): Launched on 1 January 2022, Slovakia's DRS has been highly effective, with over 820 million plastic bottles and cans returned in its first year, achieving a return rate exceeding 70%. Separate Collection: The introduction of separate collection for biodegradable kitchen waste in 2021 aims to reduce contamination and improve recycling rates.
SLO	In the past, most municipal waste ended up in landfills. This trend has been reversed with amendments to legislation, through policy instruments and by establishing municipal waste management centres, and the proportion of separately collected waste and the recycling rate both increasing. This has made Slovenia one of the European countries with the highest recycling rate for municipal waste (59%).

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