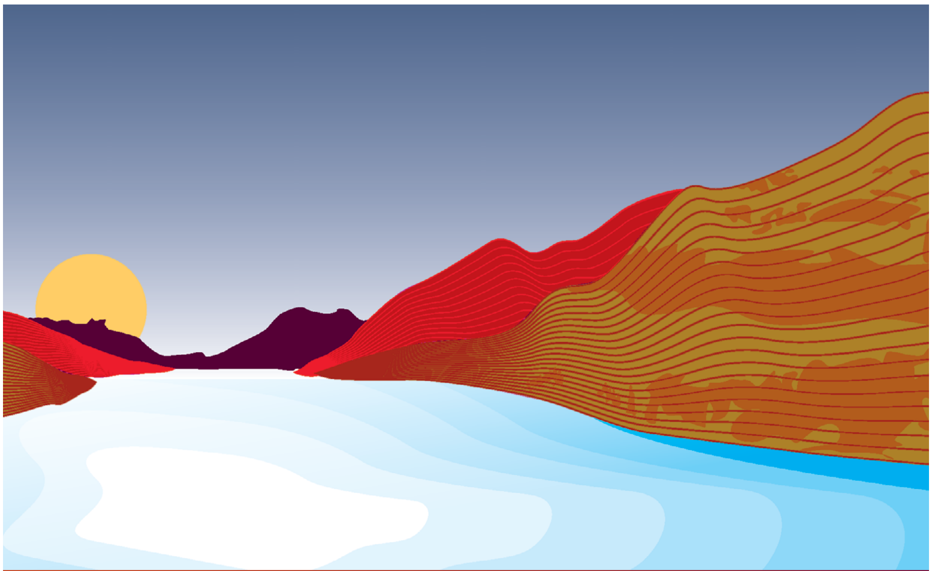
INBO
International Network
of Basin Organizations

Partenariat français pour les déchets PFD
FSWP French solid waste partnership

ISWA
International Solid Waste Association

AFD
AGENCE FRANÇAISE DE DÉVELOPPEMENT



TRANSFER OF WASTE AND PLASTICS IN AQUATIC ENVIRONMENTS

May 2024

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TABLE OF CONTENTS

TABLE OF CASE STUDIES

TABLE OF BOXES

FOREWORD

from the International Network of Basin Organizations

At a time when aquatic ecosystems are under threat from increasing pollution by waste, it is imperative to better understand the phenomenon in order to mitigate its impact. The current situation is alarming: waste, and in particular plastics, is invading lakes and rivers, and therefore the oceans, at a worrying rate, endangering the health of people and ecosystems. Faced with this reality, it is imperative that we take urgent and concerted action to reverse this destructive trend.

In this handbook, which is the result of collaboration between INBO, FSWP, ISWA and AFD, the main sources of pollution and the mechanisms by which waste and plastics are transferred to aquatic environments are identified, and effective strategies for reducing their impact are proposed through a number of case studies. The aim is to raise awareness, inform and equip those involved in protecting aquatic ecosystems and managing waste, by bringing the two communities closer together so that they can make informed decisions and implement concrete actions.

This book is the result of a collaborative effort by experts from around the world in fields as diverse as waste management, environmental policy, water management and scientific research.

This gives decision-makers, managers and those working in the field a comprehensive and accessible tool for tackling this urgent challenge.

By acting in a coordinated way, we can preserve the health of our lakes, rivers and oceans for future generations. This handbook is a call to action, an invitation to work together for a future where aquatic environments are preserved and thrive for all.

Dr. Eric Tardieu
Secretary General
International Network of Basin Organizations

LIST OF ABBREVIATIONS AND ACRONYMS

- **ADAC** Allgemeiner Deutscher Automobil-Club
- **ADEME** The french ecological transition agency
- **AEC** African Environment and Communities
- **AFD** Agence française de développement // The french agency for development
- **AFP** Agence France Presse // French international news agency
- **AGEC** Loi anti-gaspillage économie circulaire // Anti-waste law for a circular economy
- **ANPER** National Association for the Protection of Water and Rivers
- **ANSES** Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail // French National Agency for Food, Environmental and Occupational Health and Safety
- **CEDRE** Centre de documentation, de recherche et d'expérimentations sur les pollutions accidentelles des eaux // Centre for documentation, research and experimentation on accidental water pollution
- **CEREMA** Centre for Studies on Risks, the Environment,Mobility and Urban Planning
- **CNRS** National Center for Scientific Research in France
- **COP** Conferences of Parties
- **DCSMM** Marine Strategy Framework Directive
- **EMMB** Glossaire Eau, Milieu Marin et Biodiversité // Glossary Water, Marine Environment and Biodiversity
- **EPR** Extended Producer Responsibility
- **FAO** Food and Agriculture Organization of the United Nations
- **FSWP** the French Solid Waste Partnership
- **FWP** The French Water Partnership
- **GDP** Gross Domestic product
- **IFREMER** The French research institute dedicated to understanding the ocean
- **INBO** International Network of Basin Organizations
- **INRAE** The French National Research Institute for Agriculture, Food and Environment
- **ISWA** International Solid Waste Association
- **IWA** International Water Association
- **LEESU** Water - Environment - Urban Systems Laboratory
- **MODECOM** MéthOde DE Caractérisation des Ordures Ménagères // Method for characterising household waste
- **MRCS** The Mekong River Commission Secretariat
- **MTECT** Ministère de la Transition Écologique et de la Cohésion des Territoires // Ministry of Ecological Transition of France
- **NGO** Non-governmental organizations
- **OECD** Organisation for Economic Co-operation and Development

- **ODE DE GUYANE** French Guiana Water Office
- **OFB** Office Français de la Biodiversité // French Biodiversity Office
- **OIEAU** International office for water
- **OSPAR** Convention for the Protection of the Marine Environment of the North-East Atlantic
- **PPSI** Plastic packaging and small non-packaging plastic items
- **PUU** Plastiques à usage unique // Single-use plastics
- **SRF** Solid Recovered Fuel
- **SIAAP** The greater Paris Sanitation Authority
- **UNEP** United Nations Environment Programme
- **UV** (rays) Ultra-violet
- **WHO** World Health Organization

1 - 1. INTRODUCTION

1.1 – PLASTIC WASTE AND POLLUTION

The waste present in the marine environment is increasingly visible and its effects are raising questions in the scientific world and among the general public. It is accepted that around 80% of marine waste comes from land-based activities and reaches the sea via rivers and their catchment areas. The volume of this waste is increasing rapidly, and the amount of plastic waste discharged into aquatic ecosystems could triple in the next twenty years if effective measures are not taken. Beyond the problems of hygiene and cleanliness, this is a major form of diffuse pollution with as yet poorly understood consequences for the economy, biodiversity, ecosystems and human health, exacerbated by global change.

Plastics, which can be transformed into micro and then nano-plastics, are a special category of waste that degrades very slowly in the environment. This ever-increasing pollution is one of the major environmental issues of the century, with estimates of flows into the sea in the order of a million tonnes a year. In March 2022, the United Nations Environment Assembly adopted a resolution to negotiate a global treaty to combat plastic pollution by the end of 2024.

1.2 – OBJECTIVES, TARGET AND SCOPE OF THE MANUAL

The majority of marine litter originates on land and is the result of human activities and imperfections in waste management (production and collection systems). Some of this waste is transported by waterways within catchment areas, ending up in river sediments and the oceans. It has an impact on waterways, particularly when washed down hillsides and valleys by rain. It is essential to look at the problem from the point of view of catchment areas, which are both contaminated by this waste and a source of contamination for the oceans through their transport. The International Network of Basin Organizations (INBO) and its partners the French Solid Waste Partnership (FSWP), the International Solid Waste Association (ISWA) and the Agence Française de Développement (AFD) have therefore joined forces to produce this handbook.

Its aim is to provide practical advice on managing and combating the transfer of waste and plastics into aquatic environments, based on examples of achievements in different territories and national or cross-border catchment areas around the world. The aim is to take stock of waste and plastic management in relation to waterways and aquatic environments, to characterise and even attempt to quantify waste and plastics and to measure their impact on aquatic environments. The aim is also to identify the sources of pollution and their points of entry, to understand the fate of discharges into the river system, but also to propose recommendations and solutions, to look at the disposal channels for intercepted waste, and to identify actions to prevent and reduce the transfer of waste and plastics into water.

This handbook is intended for experts concerned with the joint management of waste and water resources, as well as for a wide range of stakeholders interested in these issues: representatives of public authorities, non-governmental stakeholders, river and lake basin managers, as well as water and waste professionals. It is our hope that this handbook will provide decision-support elements for implementing truly operational and effective measures to combat pollution of aquatic environments on land and at sea.

The scope of the handbook covers rivers and lakes and their catchment areas, including the headwaters, mouths, brackish waters and estuaries («From source to sea»), aquatic environments and associated ecosystems, as well as towns and associated stormwater.

The technical scope covers waste and plastics (including micro and nano, see definitions below). Endocrine disrupters and medicines are excluded from this manual.

1.3 – DEFINITIONS

To understand the complexity of the subject covered in this manual, the first step is to define the key concepts.

- WASTE

  Generally speaking, waste is any material, substance or product that has been discarded or abandoned because it no longer has a specific use.

  Naturally occurring elements such as dead trees, algae or animals are not considered to be waste, as they are part of the normal functioning of the ecosystem.

At European level, Directive 2008/851 defines waste as *«any substance or object which the holder discards or intends or is required to discard»*. This implies a notion of responsibility, since all waste producers are responsible for their waste until the end of its treatment.

At international level, article 2 of the Basel Convention states that waste is *«substances or objects which are disposed of, are intended to be disposed of or are required to be disposed of under the provisions of national law»*. Thus, the concept of waste is defined by regulation according to the local context.

Macro-waste is a category of waste that is defined by the RaMoGe agreement (environmental protection treaty signed on 19 May 1976 between France, Monaco and Italy) as *«waste resulting from human activity, floating on the surface or submerged, transported by marine currents or rivers to the coast and deposited on beaches»*. Macro-waste is waste larger than 25mm (RiverSe2).

Anthropogenic waste is *«waste generated by humans and their activities, which ends up polluting the environment, particularly aquatic environments. It may consist wholly or partly of plastics, cardboard, glass, metals, etc. They should therefore be distinguished from waste of natural origin such as plant debris»*. (Cerema, 2020)

■ WASTE CHARACTERISATION
To anticipate, organise and plan waste management, its quantity and nature are essential. In order to define the nature of the waste, different categories need to be established so that it can be sorted and directed towards the appropriate treatment channels, thereby optimising waste management costs.

The categories of waste proposed are mainly taken from the OSPAR guidelines, which can be simplified (EC JRC, 2013).

■ INTERCEPTION DEVICES
Interceptors are devices used to capture waste in waterways, in order to collect the waste stream or to take the samples needed to characterise the waste stream.

There are several types of system: retention net, screen, coarse or fine screen, floating siphon, collection robot....

■ WASTE LANDFILL
A landfill is a place where waste is buried in the ground over several hectares, dug right into the ground (usually clay), equipped with drainage systems and tarpaulins to ensure a passive and active seal.

Depending on the country, regulatory constraints on landfill sites are more or less restrictive. Landfill, also known as burial, is considered to be disposal and not recovery.

When the landfill site is controlled it can be referred to as a sanitary landfill, the term dump or fly-tipping applying more to uncontrolled illegal dumping sites.

■ GREY WATER **(EMMB Glossary)**
Wastewater produced by domestic activities, excluding black water (domestic waste water from toilets, generated when faeces and urine is evacuated). Grey water is intended for reuse after treatment. It is water from showers, baths, washbasins, washing machines, sinks and dishwashers. It is collected by a network and usually directed to a wastewater treatment plant.

■ WASTEWATER **(EMMB Glossary)**
Water that has been used by humans. A general distinction is made between domestic, industrial and agricultural wastewater. This water is discharged into the natural environment either directly or via a collection system, with or without treatment.

■ LEACHATE
A (landfill) **leachate** is «any liquid percolating from landfilled waste and draining from or contained in a landfill (according to European legislation Council Directive 1999/31/EC of 26 April 1999 on waste deposited in landfills).

This residual liquid fraction is generated by the combined action of rainwater and natural fermentation on waste storage. Rich in organic matter and trace elements, leachate cannot be discharged directly into the natural environment and must be carefully collected and treated». (Ademe)

■ ACCUMULATION ZONES
These are areas containing large quantities of waste particles of human origin (anthropic). They are caused by river hydraulics or the remains of a historic landfill site, for example.

Waste is generally stored there on a temporary basis because these areas are subject to erosion and flooding, and therefore generate pollution that can reach the ocean.

■ PLASTICS[1]
The basis of plastic is a polymer, a molecule made up of carbon chains obtained by transforming fossils.

There are different categories of plastics:

- Rigid single-material plastic: article made from a single plastic polymer that retains its shape, such as a bottle or bathtub.
- Flexible single-material plastic: thin article, such as packaging and plastic bags, made from a single plastic polymer.
- Multi-layer plastic: an article, usually packaging, made up of several plastic polymers that cannot be easily and mechanically separated.
- Multiple materials: an item, usually packaging, made up of plastic and non-plastic materials (such as thin metal sheets or layers of cardboard) that cannot be easily and mechanically separated.

Plastic pollution is defined as the negative effects and emissions resulting from the production and consumption of plastic materials and products throughout their life cycle. This definition includes poorly managed plastic waste (e.g. open burning or dumping in uncontrolled landfills) as well as the leakage and accumulation of plastic objects and particles that can have adverse effects on humans and the living and non-living environment (UNEP/PP/INC.1/7).

When plastics break down in the environment, they release micro-plastics, synthetic and cellulosic microfibres, toxic chemicals, metals and micro-pollutants into water and sediments and into food chains. Micro-plastics can carry pathogenic organisms that are harmful to animals and humans. Micro-plastics range in size from 5 millimetres to a few hundred nanometres, i.e. 70 times smaller than the thickness of a human hair (Anses).

More precisely categories for types of plastic are identified by their size:

- meso-plastics with a size between 5 and 25 mm,
- micro-plastics for particles with a size between 1 µm and 5 mm
- nano-plastics for particles with a size smaller than 1 µm

1 Turning off the Tap : How the world can end plastic pollution and create a circular economy - UNEP © 2023 United Nations Environment Programme

2 - WASTE AND AQUATIC ENVIRONMENTS: ANTHROPOGENIC POLLUTION

Waste in freshwater is considered to be the main source of ocean pollution, with rivers and streams as the main transfer vectors (Lebreton et al., 2017; Schmitt et al., 2017, van Emmerik et al., 2020)[2], and therefore through catchments.

Waste found in aquatic environments, known as «macro-waste» (>25mm) in the water sector, comes mainly from land-based and anthropogenic sources (fig.1). It is often accepted that around 80% of waste at sea/oceans comes from poor management of these materials on land.

Waste is made up of a variety of materials: plastic, wood, scrap metal, paper, glass, etc. However, plastic is the predominant material in the aquatic environment. It floats, and therefore travels (contrary to construction waste or glass and metal), does not deteriorate (contrary to organic waste), and does not clump together (contrary to oils and hydrocarbons). It is for this reason that it is particularly studied by the scientific community and that the general elements presented in this chapter most often refer to macro-plastic pollution.

Figure 1: Sources of waste in rivers and aquatic environments.

Figure 2: Example of materials produced by industry that are likely to end up in waterways.

The land – river – sea continuum is the perimeter in which these different types of macro-waste evolve. To take effective preventive action to reduce and combat pollution in aquatic environments, it is necessary to:

1. Identify the public policies implemented for waste management
2. Identify the sources and transfer routes of waste along this continuum, their pathways and implemented management actions. The relevant scale for tackling this issue is the catchment area.
3. Quantify and characterise macro-waste flows, in order to better prevent and manage them.
4. Identify waste management practices, from establishing collection and treatment channels to preventive action to reduce it at source.

2 These studies have estimated that between 0.4 and 4 million tonnes of plastic are discharged into the sea every year worldwide. Other sources of waste in the oceans include maritime and coastal activities (Veiga et al., 2016).

2.1 – HOW DOES WASTE GET INTO WATERWAYS?

2.1.1 Transmission sources and vectors

Waste arrives in waterways and aquatic environments via a multitude of transfer routes and processes: run-off, river run-off, wastewater, grey water and wind, as well as direct deposit in waterways.

More specifically, waste to waterway transfer routes are mainly direct (waste ends up directly in waterways) but also indirect (runoff, wind ...). Extreme weather events, which are becoming more frequent as a result of climate change (storms, floods, etc.), bring large quantities of macro-waste with them. This point is developed in a later section.

Waste in waterways comes from rubbish abandoned on the banks or thrown directly into the waterway. It comes from uncontrolled dumps close to waterways, from former waste dumps eroded by waterways or from rubbish bin overflows.

They can also result from the land application of poor-quality composts made from organic waste that has not been separated at source, and more particularly from the unwanted matter present in this compost.

It is also transferred to water via run-off from sloped terrain or roads. Waste is also often carried by the wind, either to the ground or directly to waterways.

Finally, it also comes from urban drainage systems, which collect rainwater. Waste can accumulate on urban surfaces before being transported by the wind, human activities or water running into sewage systems and then to natural aquatic environments. The flow will vary depending on how it is distributed in the urban area and the activities to which it is linked. The size and nature of the waste elements will vary according to their degradation (L. Ledieu et al., 2023).

Figure 3: Transfer of waste into water and aquatic environments

The transfer routes for macro-waste are being more and more studied in order to better adjust the preventive measures that need to be put in place (see box 1).

Box 1 – Transfer of macro-waste by urban stormwater

A number of European research projects are looking at waste flows, and in particular waste flows from urban stormwater.

Among these projects, the **STRITTER project** (2022-2023) carried out in France was aimed at acquiring knowledge about abandoned waste in urban areas and waste streams transferred to receiving environments.

Macro-waste accumulated at the outlets of two catchment areas was monitored for one year. The waste was collected, characterised and quantified. The results show that the transfer of macro-waste to rainwater outlets is not linear. Various factors come into play: the layout of the public space (areas with vegetation, downspouts, etc.), the configuration of the stormwater network (in particular the morphology of the downspouts), the quantities and types of waste and climatic parameters.

Figure 4: Relief of the Gohards stream (source: OCEAN-SIMON TORLOTIN)

The **PLASTOC project** (2019-2023) was led by the Laboratoire Eau Environnement et Systèmes Urbains (Leesu) and Cerema, and funded by the French Ministry of Ecology.

This project had two objectives:

- Assessing macro-waste discharges from various urban sources,
- Reflecting on an indicator for macro-waste in rivers.

In this study, stormwater was monitored to assess the quantities and typology of macro-waste in stormwater and to *«estimate the **contribution of stormwater and wastewater management systems** to total quantities of macro-waste in the Seine basin»*.

At the same time, a survey and evaluation of the various systems for capturing macro-waste was carried out.

The last part of this study consisted of proposing a «macro-waste» indicator for rivers, with the *«objective of providing a complementary view of other (bio)indicators for a waterway and should make it possible to measure «a state» but also its evolution in order to compare it with the objectives of good ecological status»*.

On the 4 sites studied, it was shown that the strict rainwater networks are characterised by waste linked to nomadic consumption and tobacco. Combined sewer systems and storm overflows are mainly characterised by wipes and sanitary towels, which are largely derived from wastewater. The combined network in the residential area seems to average between these two types.

2.1.2 Transport of macro-waste in rivers

The transport of macro-waste in rivers is highly complex (Liro et al. 2020). Various factors need to be taken into account:

- hydrological factors such as water height, current speed and discharge,
- geomorphological factors such as the shape of banks and vegetation, which can act as traps for macro-waste,
- physical factors such as the type of waste and its shape (floating versus non-floating, flat, long, round, heavy, light, etc.).

It appears that waste in waterways is mainly locally stored on river banks and is re-mobilised occasionally. Macro-waste therefore moves from upstream to downstream in successive «short hops».

2.1.3 Transport and extreme events

In addition to these identified transfer routes, extreme one-off events play a role in the diffusion of waste in aquatic environments. They make a major contribution to the transport of macro-waste along the land-sea continuum (Van Emmerik et al., 2023).

Floods, storms and tsunamis add to the large flows of waste that are transported, making these new flows even more difficult to manage, or even unmanageable.

For example, flooding can create or displace accumulation zones on river banks or in coastal estuaries (Werbowski et al. 2021) and thus account for the bulk of the flows transported to the sea.

To limit the consequences of these phenomena, which are difficult to predict, preventive action can be taken in the catchment area (see Box 2).

figure 5: extract from a video by Sam Benchegbib co-founder of Sungai Watch (LinkedIn)

figure 6: In a flooded street in Kinshasa, December 2022. Extract from a video by Olga Chera Chibambe (Le Monde)

Box 2 – Waste in the event of natural disasters

In the event of a natural disaster (flood, avalanche, storm, hurricane, etc.), various types of waste are produced: building materials, rubbish, bins, pieces of sheet metal, pipes or cables, cars, etc. They end up in waterways and can cause serious damage. So it's worth thinking ahead and proposing an action plan in the event of natural disasters:

- Identify crisis situations (type of disaster, frequency and intensity)
- Qualify and quantify post-disaster waste by cross-referencing geographic data relating to hazards and those relating to territorial stakes (economic activities, type of land use, etc.).
- Identify potential waste accumulation sites
- Identify storage sites (refer to following chapters)
- Identify the players involved in waste management and prepare post-crisis responses.

These specific phenomena of accumulation caused by natural disasters are increasingly analysed, but are very complex to predict. They must therefore be considered on a case-by-case basis, as each area of the world is specific.

figure 7: Rubbish floating in the River Drina near Visegrad, Bosnia, on Friday 20 January 2023. – Armin Durgut/AP/SIPA

2.2 – HOW CAN WASTE FLOWS AND THEIR IMPACT ON WATERWAYS BE ASSESSED?

Quantifying and characterising waste flows is essential for implementing preventive (awareness-raising, communication, etc.) and/or remedial management measures. This makes it possible to identify the types of waste (materials, uses), their producers (those who generate the waste) and the activities involved.

2.2.1 How is waste quantified?

There are several methods for quantifying and characterising waste: modelling, observation or collection. Observation is particularly important for monitoring rivers, collection for characterising the samples taken and modelling for estimating orders of magnitude (van Emmerik and Schwarz, 2019).

2.2.1.1 Modelling approach

Initial modelling macro-waste flows is performed on the basis of waste production statistics for an area and a rate of leakage into the environment. This approach has produced the first estimates of plastic flows from coastal areas on a global scale.

Models have now become more and more complex, particularly for macro-plastics, by taking into account transfer dynamics and calibration on the basis of real data, thanks to visual counts. (Meijer et al., 2021).

2.2.1.2 Visual counts

In order to obtain real waste stream data, visual counts from a bridge or a fixed location can be carried out. This makes it possible to estimate a quantity of floating macro-waste per unit of time on a given section, which allows quantifying the waste stream (González-Fernández and Hanke, 2017). This technique has been used extensively, particularly by the Dutch, who combine observations with hydrological data to estimate annual flows in rivers, mainly in Europe and South-East Asia. The large amount of data acquired has helped to calibrate global models (Meijer et al., 2021).

Although this technique is incomplete because it is limited to surface flows, it is easy to implement. It can be used by the general public, for example through participatory science.

Once the waste flows have been observed and identified, waste collections provide a better understanding of the type of waste.

CASE STUDY 1 – Mapping macro-waste on a stretch of the Shkumbin river, Albania Surfrider – Project financed by The Global Environment Facility (GEF)

The BeMed+ project aims to support and accompany the implementation of actions on the field to reduce plastic pollution in the Mediterranean, particularly in the southern and eastern Mediterranean countries, and to initiate sustainable change by involving the private sector.

As part of this component, the protocol for mapping plastic pollution in rivers developed by Surfrider Foundation Europe – Plastic Origins is being implemented on the Shkumbin river, upstream and downstream of the town of Elbasan.

This protocol is used to quantify and qualify plastic pollution throughout the catchment area and to draw up a map of waste accumulation zones and their typology. The method involves geolocating visible waste (i.e. recording its GPS position) on the banks from a kayak-type boat using a mobile application. The data is collected on different sections from 500 m to 4 km spread evenly over the entire river. Once the data has been processed, an indicator (the number of items of waste counted per kilometre of river) will be used to pinpoint the areas of the river most affected and to compare plastic pollution in the river from one year to the next.

https://www.plasticorigins.eu/

Figure 8: Inspection on the Shkumbin river

Figure 9: Plastic bottle in the Shkumbin river

2.2.1.3 Different types of macro-waste collection

Macro-waste collection in aquatic environments can be active (robotic cleaners, manual collection, etc.) or passive (floating booms, nets). These collection actions can be permanent, as part of a cleaning or surveillance plan for example, or one-off, as part of a study or diagnosis.

- **Permanent collections**
  Stranded waste is collected on a regular basis, making it possible to monitor waste streams' evolution and variability (see Naturaul'un box).

Box 3 – Example of Naturaul'un

There is an example of manual collection in the Seine estuary in France. As part of a public contract, the public interest cooperative company Naturaul'un has been commissioned by the Seine Maritime departmental council to actively collect, by hand, waste washed up on the banks and to maintain the banks' natural areas. The regularity and thoroughness of the collections have made it possible to estimate macro-plastic flows on the scale of the Seine basin (100-200 t/year), taking account of estuarine transport dynamics (Tramoy et al., 2021).

According to the authors, these collection operations would make it possible to stop up to 50% of the visible macro-waste stream and 10 to 20% of the total waste stream (which includes smaller macro-waste and/or waste hidden in the banks of the Seine). The macro-waste component is in fact secondary. Other monitoring plans with permanent (but much less frequent) collections exist on the coastline through Cedre. Cedre is a French organisation with expertise in accidental water pollution wwz.cedre.fr.

- **One-off collections**
  Monitoring plans that include permanent collections of macro-waste are still rare, but one-off, active collections are often carried out by citizens and NGOs, such as during «World Clean-up Day», an operation aimed at combating pollution through clean-ups done by citizens.

  The French Zéro Déchet Sauvage (Zero Waste for Nature) platform run by the Muséum d'Histoire Naturelle (Natural History Museum) and Mer Terre (Sea – Earth) also aims to encourage the banking of data from these citizen and community collections.

Collections, this time more passive, are sometimes carried out as part of scientific studies during sampling campaigns, in order, for example, to gain a better understanding of the distribution of macro-waste in a river.

Schöneich-Argent et al. (2020, 2021) collected waste in the following compartments of the aquatic environment:

- The banks, at the interface between the land and the aquatic environment (illegal dumping of waste or washed-up waste)
- Surface water (floating waste)
- The water column
- The bottom/bed of the aquatic environment (lake, river, sea, etc.)

The authors have shown that the distribution of macro-waste depends on the compartment investigated, with maximum abundance and diversity on the banks and minimum on the bottom. Various collection techniques can be used for such sampling.

2.2.1.4 Collection techniques

Once the location has been determined, diffuse waste can be collected from the waterway either manually or mechanically, using retention devices. Different techniques exist depending on the quantity of waste to be collected, and the following is a non-exhaustive list.

- **Eco-barriers or booms (passive collection)**
  The aim is to channel floating waste onto the waterway and direct it to a buffer zone where it accumulates. The waste is then collected, sorted where possible and treated.

Figure 10: The interception barrier in Guatemala – Ocean Cleanup© NGO website

The "River whale» waste collector or robot collector (passive/active collection)
Floating waste collection is targeted and can be combined with hydrocarbon collection by absorption.

Figure 11: Principle of the waste collector – River Whale

■ Retention nets (passive collection)
To retain waste before it is discharged into waterways, anti-waste nets are installed at the outlets of stormwater networks, at the outlets of outfalls or between the outfall and the receiving environment. They can vary in size (from a few decimetres up to several metres) and mesh size (from a few mm to several centimetres).

Figure 12: Retention nets in place in Brest Métropole in waterways, rainwater outlets and downspouts (Photos OiEau)

■ Harvesters or bank bins (active/passive collection)
These bins are placed along waterways so that walkers, fishermen, etc. can pick up litter and deposit it in the bins, which are then collected (either by a dedicated service or by an association).

Figure 13: An example of a riverside waste collector (ANPER)

■ Float traps (passive collection)
Float traps (siphonic walls) are used to reduce waste in storm water reservoirs.

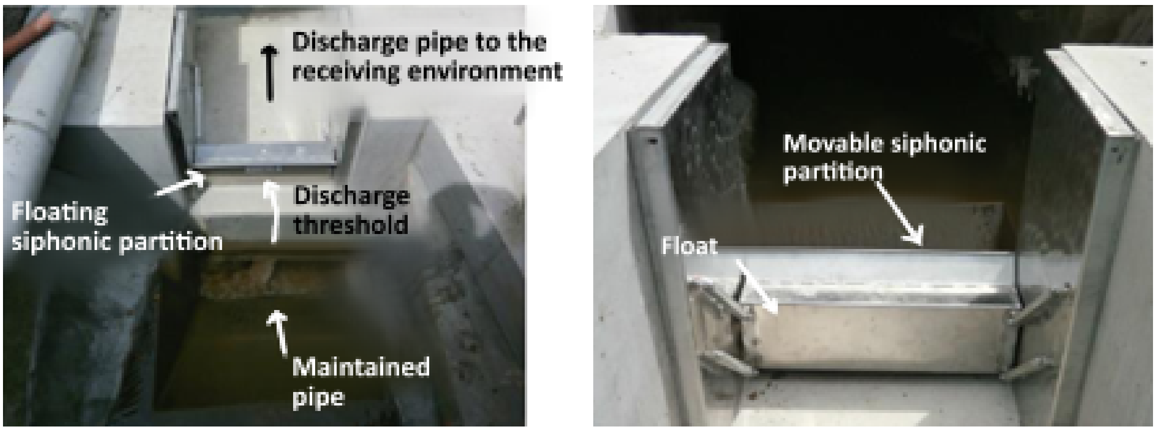


Figure 14: Example of a movable siphonic partition to retain floating waste (Source: HYDRASS-3D water)

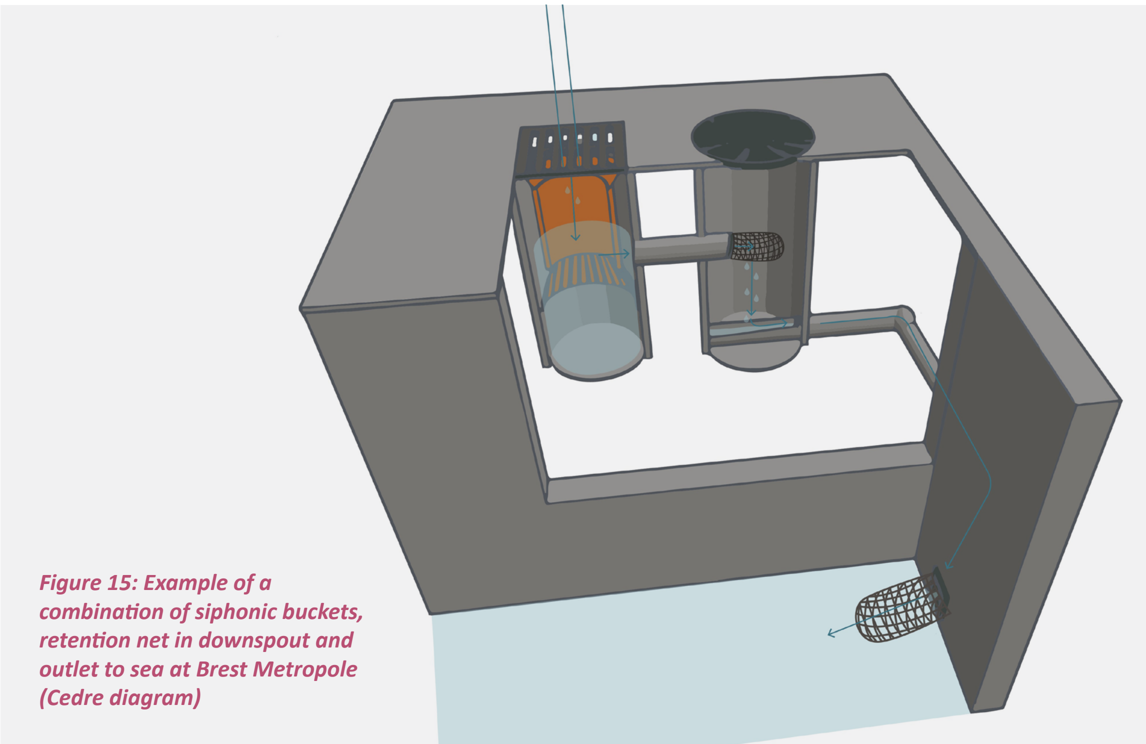


Figure 15: Example of a combination of siphonic buckets, retention net in downspout and outlet to sea at Brest Metropole (Cedre diagram)

Screening and filtration systems (passive collection)
Bar screens are devices used to capture waste upstream of treatment works, to protect retention basins and preserve natural environments from discharges of floating waste.

Figure 16: Vertical bar screen. Source/credit: Hydroconcept

Cleaning up waterways (active collection)
Waterway clean-up operations are localised and occasional. They can be carried out manually or mechanically. They consist of collecting waste on the banks or in the waterways. They are carried out by private individuals, companies, associations, etc., and are sometimes part of public policies.

Several technologies can be used to monitor and cleanup natural environments.

The case study presented on the Mekong illustrates the complexity of implementing methods and protocols, which requires very good coordination.

CASE STUDY 2 – Methodology for cost-effective, long-term monitoring of transboundary plastic debris pollution in the Lower Mekong Basin
Mekong River Commission Secretariat (MRCS)

With the Mekong River known to be one of the major rivers collectively transporting between 88-95% of the plastic in the world's oceans, the member countries (Cambodia, Lao PDR, Thailand and Vietnam) of the Mekong River Commission (MRC) have become increasingly concerned about the potential effects of plastic debris pollution on the Mekong's freshwater wildlife. To address this concern, the countries have asked the MRC to implement a series of activities under the Plastic Debris Pollution Monitoring Programme to provide a mechanism for understanding the status of plastic pollution in the region.

As part of this programme, the MRC is developing standardised protocols, sampling and analysis procedures to enable long-term, cost-effective monitoring in the four member countries. This has resulted in three protocols, namely (1) the river macro-plastics monitoring protocol, (2) the river micro-plastics monitoring protocol and (3) the fish micro-plastics monitoring protocol.

The development process not only allowed the methodology to be adapted to the Mekong situation, but also increased ownership of the methodology by MRC member countries, enabling it to be integrated into its routine water quality monitoring network for long-term implementation.

Through intensive collaboration with development partners and national agencies, the methodology was tested to ensure that it could be adapted to the situation in the Lower Mekong Basin, during both dry and wet seasons.

By ensuring the involvement of national agencies at all stages of the development and finalisation of the methodology, member countries are taking greater ownership of it.

The ultimate aim is to provide a protocol for the collection of comparable data and information to support the identification of the current status and trends of plastic debris pollution in the Lower Mekong Basin: valuable information that can be used to assess the effectiveness of plastic waste management in the Lower Mekong Basin.

Figure 17: Vietnamese national agency staff receive protocol training – June 2022

Figure 18: Fishermen in Kampong Cham province, Cambodia

Figure 19: Collection of debris by experts from the Natural Resources and Environment Research Institute of the Ministry of Natural Resources and Environment of the Lao People's Democratic Republic

Figure 20: Preparation of equipment and chemicals products by experts and staff from Thai national agencies in June 2022

The case study presented on the Aa and Lys rivers highlights the findings and prospects obtained from the aquatic environment monitoring programme.

CASE STUDY 3 – The Aa and Lys aquatic environment monitoring programme in France: findings and outlook

"Association Découverte et Participation à la Préservation des Milieux (DPPM)"

For three years, as part of the «Plastic Origin» study, all non-organic waste in the river Aa was collected, counted, weighed and identified.

The main problem encountered during this period was the crying lack of a common protocol for carrying out this monitoring. The aim is to use the partnerships with ULCO – Université du Littoral Côte d'Opale and SURFRIDER to establish common tools to standardise the results and make them comparable with identical initiatives, and even to propose a new protocol to extend the scope to include monitoring the quantity of plastic in sediments.

Following this initial phase, it was decided to continue the research by going further and continuing to track the flow of macro-waste in three areas (the LYS and AA rivers and part of the Marais Audomarois), as well as looking for micro-waste and analysing the water to identify chemical molecules linked to the degradation of "fire-retardant" plastic, twice a year.

The results show that the fragmentation of plastics and polymers has the greatest impact, particularly polystyrenes, which break up. All these fragments are likely to be ingested by animals and by humans at the end of the food chain.

Another aspect of the project is to find solutions to prevent the spread of plastic waste in nature: «securing plastic dustbin lids» and raising public awareness by involving them in waste collection or identification using the «Plastic origins» application set up by SURFRIDER through the use of «participatory science».

It should be noted that it is difficult to set up waste collection systems, partly because of the costs involved in maintaining them, but also because of the problem of processing the waste collected in these systems (material recovery is sometimes difficult).

Finally, in terms of raising awareness among elected representatives and the general public, steering committees and seminars are organised, and young people are asked to contribute by placing plaques or stencils on sewer drains stating «Don't throw anything away here – your river starts here».

Once the waste has been collected, it is important to characterise it in order to determine adequate treatment.

2.2.2 How is waste characterised?

The waste collected in aquatic environments can be sorted in its entirety, or partially, to be characterised and quantified.

Once the waste has been sampled to ensure that it is representative, it can be characterised based on various lists. The most widely used in Europe are the OSPAR (2020) and DCSMM (Fleet et al., 2021) lists, the latter also known as the «joint list». In France and several other countries, the MODECOM[3] method developed by ADEME is commonly used.

As well as providing data on the abundance and composition of pollution, characterisation makes it possible to identify the majority of waste and provides information on the activities that emit it. This information can be used to adopt targeted reduction measures.

Waste is generally classified by type of material and then counted by type (bottle, cigarette butt, fishing net, etc.). It can also be weighed by category. It is recommended that this be done on drained waste from which natural matter has been removed, particularly for heavily soiled waste such as that from urban networks (see study carried out on the Brest metropolitan area, Cedre and OiEau, 2023).

3 MODECOM®, gaining a better understanding of the composition of household waste | ADEME Indian Ocean Regional Office

The weighing approach is particularly relevant for defining and sizing the treatment and recovery to be envisaged, as contracts with operators are generally drawn up on the basis of incoming tonnes or m3 per material flow. It is therefore preferable to use weighing (and not counting) even if the waste is not clean and dry, but to ensure that it has been emptied of all liquids beforehand. For more precise information on the materials present and their origin, the waste can also be washed and dried before weighing (see PLASTOC study).

Figure 21: Characterisation of waste (Surfrider Vendée)

Figure 22: Characterisation of waste in stormwater discharge (Cedre)

Producer information
Power supply
Construction (BTP)
Industry
Hygiene / cosmetics
Medical
Leisure / entertainment
Agriculture
Road transport
Fishing and aquaculture
Clothing
Other

Information on the category/nature of materials
Plastic
Rubber
Fuel
Glass / ceramics
Metal
Wood
Cardboard / paper
Clothing / textiles
Other

Box 4 – Characterisation: essential for defining public policies and monitoring their effectiveness

Cedre[4] is a documentation, research and experimentation centre on accidental water pollution. It has been working for many years on the issue of aquatic waste. In fact, Cedre has regularly been called upon to tackle this issue, in particular in 1996, following the collapse of a coastal landfill on the Spanish coast, but also in 1997, on the perception by local authorities of pollution caused by macro-waste.

Since 2005, at the request of and in support of the French Ministry in charge of the environment (currently the Ministry of Ecological Transition and Territorial Cohesion), Cedre has been the national focal point for the OSPAR Convention's 'macro-waste' working group. In 2016, Cedre was also mandated to coordinate the French monitoring networks for macro- and micro-waste on the coast and in river basins. These actions are part of the dual regulatory context of the European Marine Strategy Framework Directive (MSFD) and the Regional Seas Conventions, including the OSPAR[5] Convention for the North-West Atlantic zone and the Barcelona Convention for the Mediterranean zone.

The aim of these monitoring activities is to provide data on the abundance and composition of waste and its evolution over time. In this context, waste characterisation is an essential stage in the monitoring carried out. The data is acquired using the recommended European protocol for monitoring marine litter (Galgani et al., 2023), which is based on the joint MSFD characterisation list, thus contributing to the acquisition of harmonised data on a European scale.

In 2023, the networks included 74 monitoring sites. That same year, the data acquired showed that there was still a significant amount of waste on the coast of mainland France, with a median abundance of 309 pieces of macro-waste/100m. In terms of type of material, 85% was plastic, with 17% of the waste collected being single-use plastic.

Total abundance reflects the pressure exerted by waste on the French marine environment and helps to assess its state of health. Characterisation data helps to identify the waste to be targeted as a priority. It is in this context that the data acquired by Cedre in 2015 and 2016 on the French coastline fed into a European study which highlighted the significant proportion of single-use plastics and fishing gear in the waste found on the European coastline. This data served as the basis for European Directive 2019/904, known as the «Single-Use Plastics and Fishing Gear Directive» of the European Parliament and of the Council of 5 June 2019 on the reduction of the environmental impact of certain plastic products, which introduces a combination of measures to reduce waste pollution.

Similar work is underway in freshwater environments, making it possible to identify the pressure exerted by waste in these environments and to define appropriate waste reduction measures.

4 https://wwz.cedre.fr/

5 The Convention for the Protection of the Marine Environment of the North-East Atlantic or OSPAR Convention sets out the arrangements for international cooperation for the protection of the marine environment of the North-East Atlantic. It came into force on 25 March 1998, replacing the Oslo and Paris Conventions.

BAR SCREEN 2,5 cm	LITTER CHARACTERISATION ON BREST METROPOLE TERRITORY STANG-ALAR WATERSHED	2021-2022

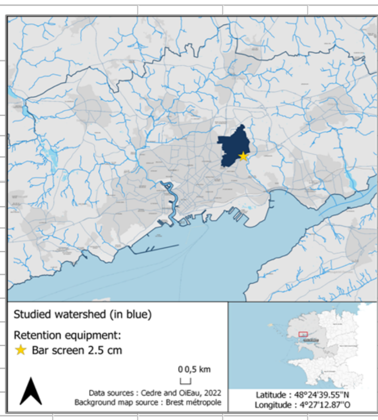
STUDY EQUIPMENT AND SAMPLING SITE

Permanent vertical bar screen, installed by Brest Metropole in a watercourse, which intercept litter transiting to the Stang-Alar brook that drains the watershed of the same name on Brest metropole territory.

Dimensions: Length of 2 m; height 1.5 m; mesh size 2.5 cm.

Maintenance: Rake for cleaning the grates; truck tray for transporting samples; 15 minutes cleaning time every 15 days.

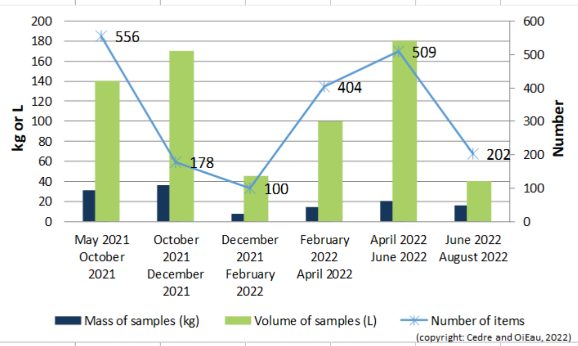
Adaptations made during the project:
None



ABUNDANCE OF LITTER INTERCEPTED

Data collected between April 2021 and September 2022

Monitored temporal abundance trends

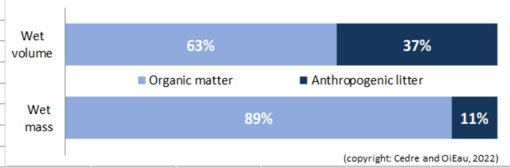


Total abundance and fluxes

Total mass collected = **126 kg**
Total volume collected = **675 L**
Total number of items collected = **1,949**

Annual average flux (number) = 1,460 ± 818 **items/year**
Annual average flux (mass) = 9.4 ± 6.8 **kg/year**

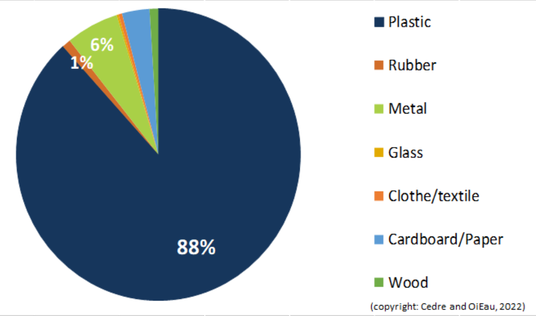
Proportion of anthropogenic litter in samples



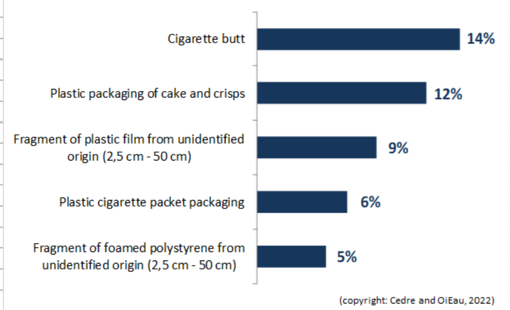
LITTER TYPES INTERCEPTED

Data provided as a percentage of the total number of litter items sampled

Distribution of litter types intercepted



TOP 5 litter types intercepted



Cedre and OiEau conducted a study, funded by the European Union and Brest metropole as part of the Interreg Channel project, aiming at determining types and sources of litter found on the coast and in retention equipment on the metropole territory. Litter collected from the study equipment and collected on the coast was sorted and then characterised. The analyses synthesised in this fact sheet were carried out by Cedre, with the support of OiEau, on samples collected between April 2021 and September 2022.

Cedre | OiEau Office International de l'Eau | Interreg France (Channel Manche) England | PREVENTING PLASTIC POLLUTION | Brest | R.23.18.C/5731

Figure 23: Example of an OSPAR/DCSMM characterisation INTERREG Brest Métropole – Cèdre OiEau 2022 project

It should be noted that organic debris of natural origin are collected in large quantities during pick-ups. These debris are not always taken into account when counting macro-waste: very rarely when working with interception equipment on rivers and more commonly on the shoreline. Organic waste of anthropogenic origin, from uncollected domestic waste, is rapidly degraded in aquatic environments and is therefore rarely collected during these collection campaigns.

THINGS TO REMEMBER: The study of waste present in the environment makes it possible to locate areas of accumulation on which the authorities should concentrate clean-up operations. Characterisation of the waste enables the nature and origin of the waste to be identified and the most appropriate measures to be taken by public authorities to reduce it at source to be defined.

2.3 – WHAT IMPACT DOES MACRO-WASTE HAVE ON AQUATIC ENVIRONMENTS?

The lifespan of macro-waste in the environment is variable. The time lapse between waste being discharged on land and ending up in offshore waters or sediments can be long. This depends on the characteristics of the waste, its composition, its degradability (either biological or mechanical), its size, its UV resistance, the environment in which it is deposited, etc. Macro-waste often sinks and remains in the riverbed, disrupting the hydrological cycle and causing injury and long-term chemical pollution (for example, an old car wreck whose seat foam will disintegrate over many years). As it ages, it breaks up into smaller and smaller pieces of debris and releases or adsorbs the potential pollutants of which they are or become the carriers/vectors.

The direct impact of waste on aquatic environments is firstly biological, affecting human health and biodiversity, possibly to the point of causing death. These impacts are followed by economic and societal impacts, as illustrated in Figure 24.

There are impacts inherent to the hazardous nature of the waste present in this macro-waste. Because of their intrinsic characteristics, they pollute soils and/or aquatic environments.

In the absence of a local adequate treatment solution, waste can generate dangerous and toxic pollutants in the natural environment, including in the atmosphere, if open burning is implemented, as illustrated in case study 4 on the consequences of not managing electrical and electronic waste in Côte d'Ivoire.

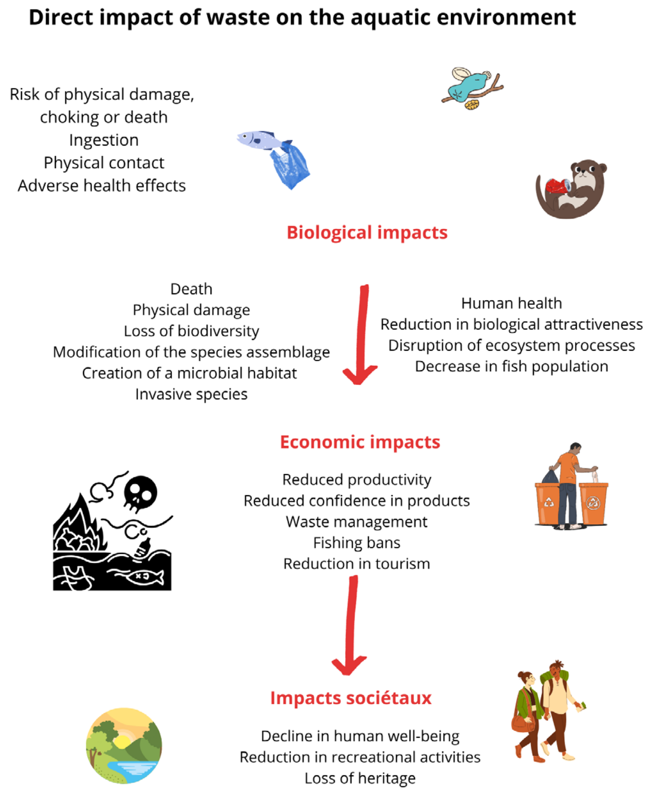


Figure 24: Risks and direct impacts of waste on aquatic environments (Source: OiEau)

CASE STUDY 4 – Preserving aquatic ecosystems in Côte d'Ivoire: an initiative against electronic waste

Young Volunteers for the Environment Côte d'Ivoire.

Figure 25: Young people burning electronic waste before dumping it in the lagoon – Young Volunteers for the Environment Côte d'Ivoire

In West Africa, in Côte d'Ivoire for example, the threat of electronic waste weighs heavily on aquatic ecosystems. Over the last five years, the situation has deteriorated considerably with the worrying observation of the devastating impact burning electronic waste has near the Ebrié lagoon in Abidjan. Every evening, young recyclers near the Amagou Victor Lycée Moderne in Marcory engage in this worrying practice. In their search for precious materials such as copper and iron, these informal recyclers expose themselves to the risks inherent in handling waste, thereby contributing significantly to polluting the lagoon.

In the national context, the problem of electronic waste in Côte d'Ivoire is reaching alarming proportions. «It is estimated that 50,000 tonnes of electronic waste are produced or end up in the country every year,» says Evariste Aohoui, director and founder of Electronic Wastes Africa (EWA), a private recycling platform based in Bingerville, to the east of Abidjan. This massive quantity of electronic waste underlines the urgent need to act to avoid irreversible environmental and health consequences.

The combustion of electronic waste releases toxic chemical substances into the air, exposing local populations to major health risks. Even more alarming, the residues of this careless practice are dumped in the lagoon, causing water pollution with harmful consequences for aquatic organisms and the ecosystem in general. This double threat, both airborne and aquatic, calls for urgent action to mitigate the devastating effects of the inappropriate management of electronic waste in this district of Abidjan.

Faced with this major challenge, the Young Volunteers for the Environment Côte d'Ivoire section Campus, in collaboration with Lind Key School, have decided to take the initiative. Their solution is based on two approaches in three phases. The first stage aims to raise awareness among local players, including local populations, administrative and financial managers, and young people, of the devastating impact of burning this waste on health and the environment.

The next steps are to raise awareness using a digital campaign, and to raise funds to supervise and support these young recyclers. The final phase will involve putting these efforts into practice by creating an appropriate collection site to train young people in best practice for managing electronic waste, and introducing a responsible incineration process.

NOTE: Macro-waste in aquatic environments has biological, chemical, economic and societal impacts.

3 - PLASTIC WASTE IN THE AQUATIC ENVIRONMENT

The management of macro-waste is complex and requires monitoring, analysis and coordination of all the players involved. The majority of macro-waste is plastic which is persistent in the environment and has very specific impacts and behaviours. For example, it is not uncommon to find plastic packaging on the banks of a waterway with an expiry date from the last century. This packaging has been travelling in the catchment area for over 20 years.

This new chapter therefore focuses on the special case of plastics and aims to:

- specify the path taken by plastics, depending on their nature, from their use to their transfer into aquatic environments,
- make scientific knowledge available on the impact of plastics on aquatic environments.

3.1 – THE PATHWAY OF PLASTIC TO AQUATIC ENVIRONMENTS

3.1.1 Everyday use of plastics

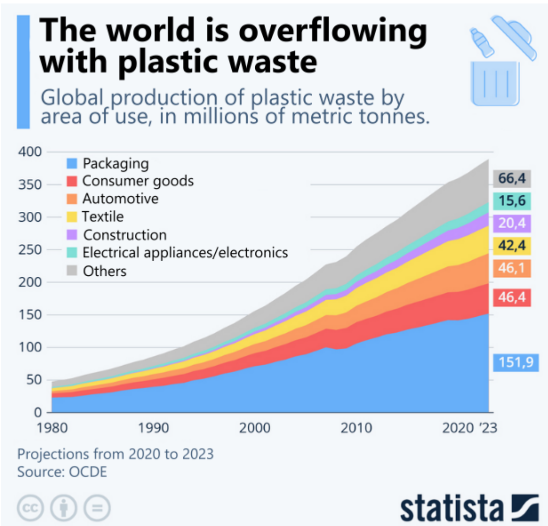


Figure 26: Projection of global plastic waste production from 2020 to 2023, OECD

To understand the pervasiveness of plastic in our society, it is important to understand its history.

The production of synthetic materials of petrochemical origin began in the mid-twentieth century. The first was Bakelite, a material that «neither melts nor burns», as its inventor Leo Hendrick Baekeland boasted, and which was also easy to mould. Heat-resistant and hard, it replaced the ivory of billiard balls, metal and porcelain in everyday objects such as radio casings, telephone handsets and combs. The chemical industry then developed a more complex recipe to meet new needs: to be more resistant, transparent, flexible, etc.

These materials are now part of our daily lives all over the world, and plastic production is growing all the time: 460 Mt produced worldwide in 2019; 1,231 Mt forecast for 2060 according to OECD projections. The growth of emerging economies, linked to growth in both consumption and population, explains this exponential curve: a threefold increase of plastics production in Asia by 2060 and a sixfold increase in sub-Saharan Africa are projected by the OECD (OECD, 2022).

The sectors in which we find these materials are, in descending order:

- Packaging: bottles, plastic bags, etc,
- the building and construction market: insulation, pipes, geotextiles, cable sheathing, etc,
- the textile sector: synthetic clothing, technical clothing, sanitary textiles, etc,
- the automotive sector: tyres, bumpers, seat foams, etc,
- the electronic devices sector: cases...,
- the domestic sector: household equipment, mattress foam, outdoor furniture, leisure, etc,
- the agricultural sector: greenhouse film, mulch film, harvest crates, fertiliser coatings, etc,
- the cosmetics sector: toothpaste, encapsulation of fragrances in detergents, etc.

Plastics are therefore omnipresent in all our daily activities and in all the places where we live. These plastics, which come in all shapes and forms, will in turn become waste in all sizes: from the largest (macro- and meso-plastics), through the particulate (micro-plastics) to the smallest (nano-plastics) – refer to definitions in the introduction. This plastic waste will therefore have a significant impact on the environment.

3.1.2 Plastics: from production to waste

Plastic is a man-made product with a variety of uses. To find out where to take action, it is useful to assess the baseline of plastics presence in a given area. *Figure 27 shows a plastic diagnosis of a large metropolitan area (Paris), based on the following method:

- **Diagnosis starting from the point of use**
  Each place of use (1) will correspond to a type of plastic used (2) : «housing» generates the use of cosmetics and synthetic textiles, packaging; «outdoor space» concentrates dust linked to tyre wear, cigarette butts (whose filter is made of cellulose acetate, a synthetic plastic fibre) and nomadic consumption; «industry» contains raw materials and plastics used in construction.
- **Diagnosis highlighting the two major collection systems**
  Plastics are disposed of in the rubbish bin (3): they are then transported in the waste collection system. Other plastics are carried away by water (4) and enter the sewage system. These include plastics found in cosmetics and toothpaste, which are washed away in the shower, and synthetic textile fibres, which are washed away during washing.
- **Diagnosis by looking at the transfer vectors involved (5)**
  The loss and incivility vector includes waste on the public highway linked to uncivil or accidental actions, the wind vector disperses fine plastic particles or waste from uncollected bins, and the rain vector carries waste into the urban drainage system or directly into aquatic environments.
- **Diagnosis by identifying the environmental compartments that receive these particles (6) :**
  the air, soil and aquatic environment are the final destinations for plastic.

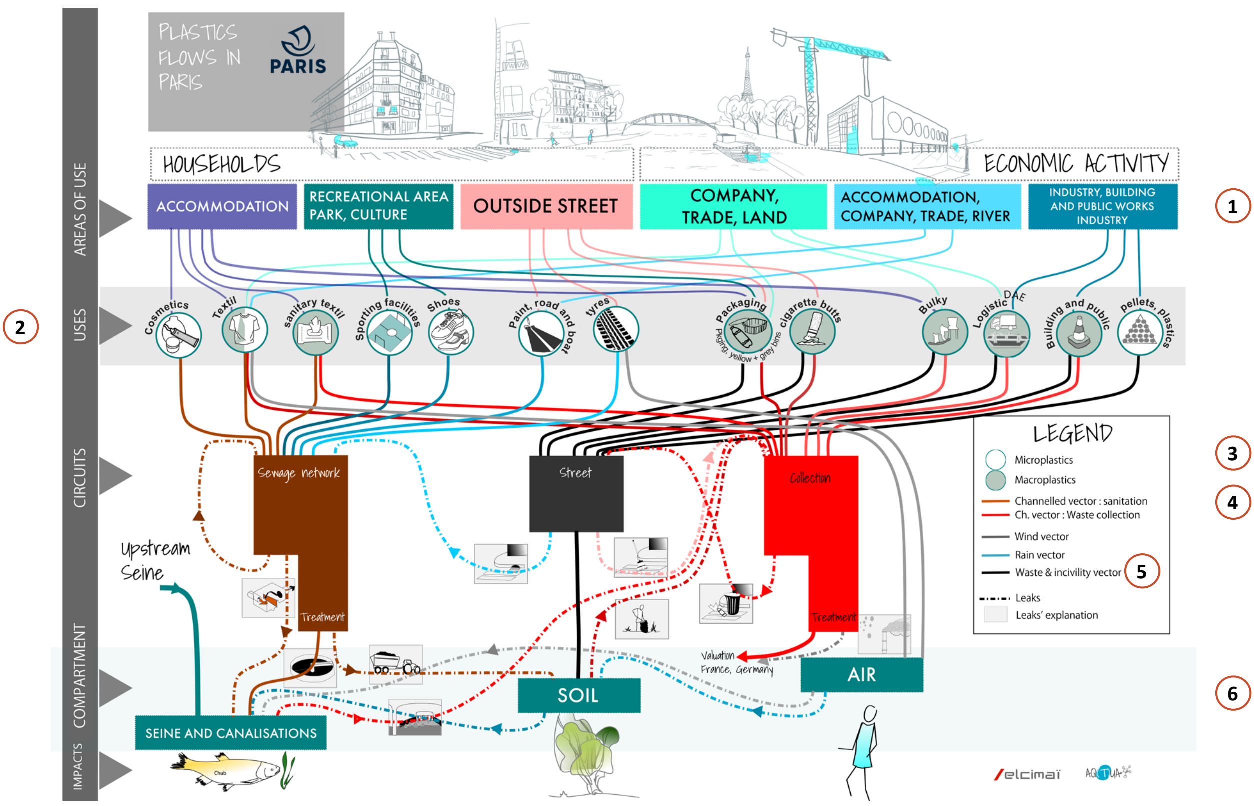


Figure 27: Example of an application – Plastics flow diagram – City of Paris – AQ(T)UA & ELCIMAÏ

3.1.3 Leaks: transferring plastics to the aquatic environment

Possible plastic leaks from the waste collection system

Each watershed has its own specific characteristics. Situations vary greatly between cities or countries: those with a collection system and those where the environment is the main receptacle.

Waste collection systems are not deployed to the same extent (collection rate, frequency of use, type of equipment) in every part of the world, leading to different levels of waste leakage into the environment, including the aquatic environment.

In Europe, where collection systems are well developed, leaks mainly concern packaging and small plastic items, as shown in the following box.

Box 5 – Leakage rate of plastic packaging and small plastics in Europe

MissManagedWaste on plastics in the 27 countries of Europe + Iceland has been documented (Winterstetter et al, 2023). As Figure 28 shows, this leakage rate for PPSI (Plastic packaging and small non-packaging plastic items) can be extremely variable, reaching 46% in Turkey and less than 2% in Finland.

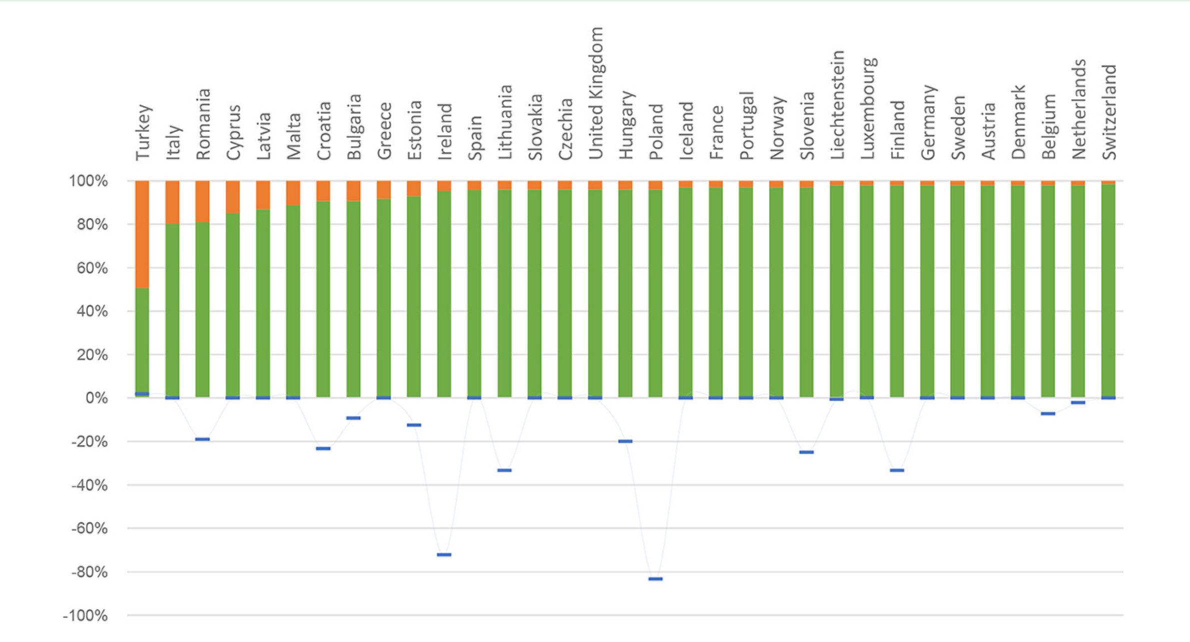


Figure 28: Breakdown between well-managed green and poorly managed PPSI (plastic packaging and small plastics items) in 2018 in the 27 European countries + Iceland

Possible plastic leaks from the wastewater system

In addition to the issue of waste collection, leaks may come from partial sewer coverage or from the operation of overflows in the sewer network. In addition, the quantity of plastic leaks discharged into the environment depends on the overflows frequency and the annual volumes discharged.

The weather is also a factor that affects transfer routes differently in dry weather than in wet weather:

- In dry weather

  Where they exist, wastewater treatment facilities (individual systems or centralised wastewater treatment plants) intercept the plastics drained by the wastewater network: studies show that primary decantation already removes 85% of micro-plastic particles and that a complete system including primary treatment and a biological stage and clarification removes 85-99% of micro-plastics. An additional initial screening stage removes almost 100% of macro-plastics.

- In wet weather

Urban drainage systems carry abandoned plastics such as cigarette butts, plastic leaks from the waste management system and leaks from the sewage system. Urban drainage systems also collect plastic particles resulting from the abrasion of certain materials such as tyres on roads. The loads of plastics drained into aquatic environments in wet weather are therefore much greater. It should be noted, however, that in the case of combined sewer systems, and if the purification system exists, these particles are directed and treated there.

Natural disasters are of course aggravating factors: see the previous chapter on this point.

3.1.4 Plastic waste in the aquatic environment

All environmental compartments are receptors of plastic pollution: soil, air, water.

The presence of plastics on the surface of the oceans and in the abyss has been the most widely publicised and investigated emerging aspect of plastic pollution. The role of watersheds in the transfer process has highlighted the complexity of the transit of plastics via rivers and their accumulation in aquatic environments.

As explained in the previous chapter, there are many ways in which macro-waste, and therefore plastic waste, is transported. It is washed away during rainy weather, deposited on riverbanks during flooding or the dry season, moved by tidal cycles, trapped in sediments, etc.

Research is currently being carried out on this interface between the continental environment and the aquatic environment to better understand and identify solutions for intercepting plastic waste that are appropriate for each territory (cf. box 6).

Box 6 – University research on macro-waste at European level: the MacroPLAST study (Tramoy et al., 2019) FRANCE

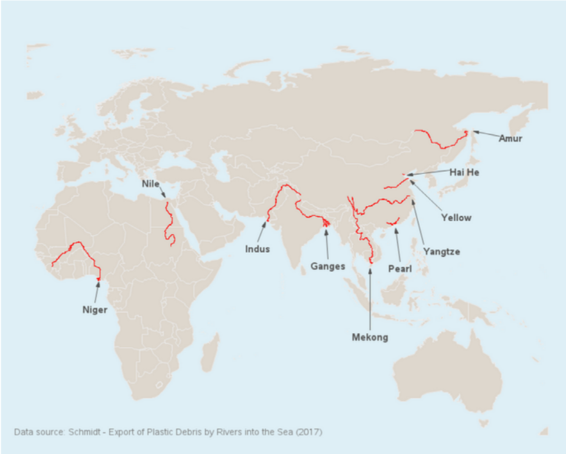
The MacroPLAST study (2017-2019) focused on estimating the flows of macro-waste from the Seine basin discharged into the sea. The study focused on plastic macro-waste, also known as «macro-plastics», due to the high proportion of plastic among macro-waste.

The aim of the project was to gain a better understanding of river inputs and their dynamics, which is a prerequisite for significantly reducing them at sea, and then to assess the public policies implemented to reduce them.

During the MacroPLAST project, various methods were tested with the following objectives:

- Test and develop existing and innovative quantification methods,
- Understand the dynamics of flows to better quantify them,
- Quantify the flows of macro-plastics going via the Seine,
- Develop a methodology for quantifying macro-plastic flows that can be replicated in other basins.

3.1.4.1 Is plastic transfer limited to a few rivers or a widespread issue?



While early studies highlighted between 10 and 100 rivers (amongst which the Yangtze or the Nile, refer to Figure 29), as major contributors of plastic pollution to the marine environment, this trend is changing. Recent studies have examined the geographical distribution of inputs from rivers and found that more than 1,500 rivers are responsible for 80% of plastic emissions into the marine environment (Meijer et al., 2021); small coastal rivers are heavily involved.

Figure 29: Map of 10 rivers transferring plastic into the ocean

3.1.4.2 In which compartment do plastics accumulate?

The water compartment has been the subject of numerous measurements and research studies: between 30 and 1000 g of plastic/inhab/year reaches the aquatic environment, with great variations between regions.

The soil compartment, although less well documented, appears to be the first compartment to be affected by uses (landfill sites, abandoned waste, agricultural uses, atmospheric fallout, spreading of sewage sludge, etc.). It is therefore the reservoir of plastic pollution that can feed the other environmental compartments. A compilation of studies carried out on the continental environment (Horton et al., 2017) concluded that plastic pollution on land was 4 to 23 times greater than in the aquatic environment.

Finally, the air compartment, which is still being studied in greater detail, appears to be polluted by plastic particles in much the same way as the aquatic environment, as shown schematically in Figure 30.

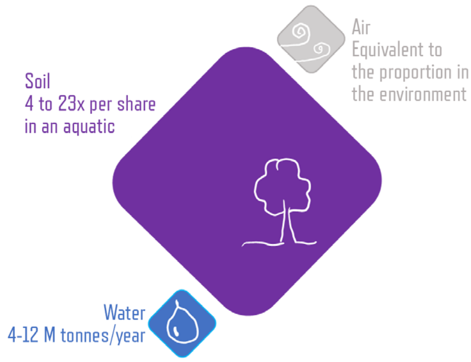


Figure 30: Breakdown of plastic pollution by compartment

3.1.4.3 A destination that is not always final

To shed light on transfers between different stocks of plastic in the soil, air or water, the CNRS[6] has built a mathematical model of the great journey of plastics in the environment (Jeroen, 2022). The model was calibrated with the plastic production since 1950. It reconstructs the dynamics of degradation, transport and sedimentation in order to calculate changes in stocks over time. Here again, the results show that the maximum stock is on the ground, therefore on the slopes of the watershed. Most of this stock can be mobilised by runoff and rivers to reach the oceans, and to a lesser extent it is put back into suspension in the air.

For the future, the model was used to test a scenario in which there would be zero leakage of plastic onto land in 2025. In this optimistic case, micro-plastics continue to move through the various compartments for millennia and the stock in the sediments at the bottom of the oceans continues to increase until the year 20,000.

6 CNRS: National Centre for Scientific Research in France

3.2 – THE IMPACT OF PLASTICS ON AQUATIC ENVIRONMENTS

3.2.1 One plastic, many plastics

3.2.1.1 A composition adapted to the intended use of the plastic

It should be pointed out (as a reminder of the definitions in introduction) that a plastic is made up of a polymer, also known as a resin, which provides the structure; fillers, which modify the reinforcement, density and cost; plasticisers such as phthalates, which modify the flexibility or rigidity of the product; and other additives, which modify the colour, introduce flame retardants, antioxidants, UV absorbers, biocides, etc. More than 13,000 molecules are thought to be involved.

In order to meet the specific properties of the final plastic part, the plastic manufacturing recipe becomes more complex. However, these added compounds are not chemically bound to the polymer, so they can be released during the life of the plastic and at the end of its life. In addition, micro-plastics behave like 'sponges for contaminants', which they adsorb, but which they can also desorb when environmental conditions change. Finally, each plastic object, and each piece of plastic waste, is virtually unique, both in terms of its composition and the quantities and qualities of the often harmful chemicals likely to make up its leachates.

3.2.1.2 Various sizes

Plastics are commonly classified according to their size. Experts have agreed (refer to introduction) to distinguish between macro-plastics larger than 25 mm, meso-plastics between 5 and 25 mm, micro-plastics for particles between 1 µm and 5 mm and nano-plastics for particles smaller than 1 µm, as shown in figure 31. For the sake of simplicity, plastics larger than 5 mm are often referred to as macro-plastics, so that there are only three distinct size ranges: nano, micro and macro-plastics.

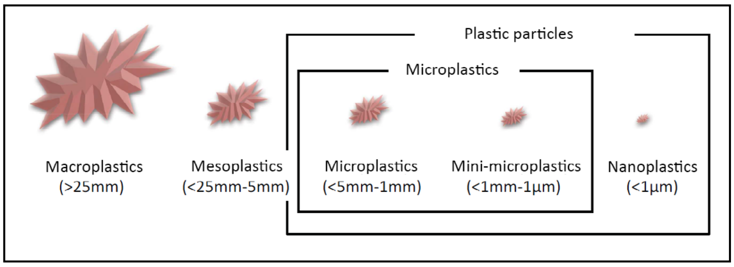


Figure 31: Plastic waste and downscaling, a possible terminology

3.2.1.3 Primary and secondary micro-plastics

Micro-plastics fall into two categories: primary and secondary.

A primary micro-plastic is produced directly at a micrometric size: it is a raw material that can be released in particulate form into the environment. It can be, for example, added abrasive elements, like the microbeads used in the composition of cosmetics and toothpaste, or polyester beads. These primary micro-plastics will enter the wastewater treatment circuit and will mainly be intercepted by the wastewater treatment plant when it exists.

A secondary micro-plastic is the result of the degradation of larger plastic parts in the media according to the mechanisms described in the sections below. This type of micro-plastic travels from compartment to compartment and is unlikely to be intercepted.

3.2.1.4 Distinctions of form

Micro-plastics can also be distinguished by their shape. Some are fibrous and filamentary, others spherical or fragmented, and the resulting impacts will differ.

3.2.1.5 Multiple degradation dynamics

Once in the environmental compartment, plastic degrades more or less quickly. Debris is subject to a variety of combined degradation mechanisms:

- Fragmentation by mechanical action,
- Fragmentation by the action of water,
- Photodegradation due to the action of UV rays, which break down the polymer's molecular chains,

- Degradation by micro-organisms.

Whatever the mechanism involved, this degradation of the plastic causes a reduction in size and the release of chemical molecules into the environment in air or in dissolved form.

The kinetics of plastic degradation depend on its composition, size, shape, the environmental medium in which it is used and the length of time it is used.

3.2.2 Ubiquitous plastics in rivers

Plastic bottles floating on the surface of rivers, packaging debris on riverbanks, packaging floating between two waters, tyre particles and textile fibres in the sediment: plastic pollution carried by rivers is both visible and invisible (see Figure 32).

The behaviour of plastics, as detailed above, was clearly identified during the observation campaign, as explained in box 7 'Tara Océan'.

Figure 32: Macro-waste including plastics in booms on the Seine, France – siaap

Box 7 – Transformation of macro-plastics into micro-plastics – TARAOcean

The project launched by TARA Ocean (TARA, 2020) on 9 European rivers has confirmed that macro-waste including plastics is indeed being transported. During this measurement campaign, 100% of the samples taken on board were polluted by micro-plastics.

Detailed analyses of the samples revealed the presence of secondary micro-plastics. The transformation of plastics into micro-plastics, which previous studies have shown to occur at sea under the effect of the sun and waves, now also seems to be taking place in rivers and their catchment areas.

At some sampling sites, microbeads from cosmetics were found, but these microbeads are not visible at sea. So rivers carry primary micro-plastics, even if they are not (yet) or no longer visible at sea.

3.2.3 The top plastics found in aquatic environments

As we saw in the previous chapter, it is still difficult to characterise the macro-waste present in freshwater. The protocols require the analysis of large volumes of water (up to 100m3 filtered through a manta net – a very fine-meshed net for collecting plankton or micro-plastic). In addition, the absence of standards makes quantitative comparisons difficult.

This is why increasingly complex technologies are being implemented to obtain as much information as possible about the specific behaviour of plastic waste, as in Australia, where AI and cameras have been deployed (refer to case study 5).

CASE STUDY 5 – Using artificial intelligence to combat plastic pollution in Australia

Commonwealth Scientific and Industrial Research Organisation (CSIRO) Marine Debris Research

As part of its mission to put an end to plastic waste, the CSIRO-Commonwealth Scientific and Industrial Research Organisation, an Australian government research body, is conducting research into the quantities, types, sources and transport dynamics of plastic pollution from land to sea.

The use of sensors combined with artificial intelligence (AI) is making it possible to work on stormwater and river pollution in two main ways:

- by installing sensors in storm drains and Gross Pollutant Traps (GPTs), combined with wireless communication technology, to allow monitoring the accumulation of debris in a safe, intelligent and cost-effective way. When the traps are full and need to be emptied, notifications are sent to agents so that they can empty them before they overflow and release their waste into the environment.
- To help tackle plastic pollution in waterways, combining images with machine learning tools and AI can reconstruct an accurate and comprehensive picture of individual plastic items floating in rivers, in Australia and around the world. Using a network of cameras placed under bridges or other areas of interest, this approach can enable users to identify the types of waste that end up in the environment and pinpoint hot spots.

Together, these tools can be used to characterize common objects, identify where they come from, understand how they move through the environment and identify areas of accumulation and problem objects. Then, by working with local community groups and authorities to develop local solutions, plastic can be managed before it becomes environmental pollution.

Monitoring plastic pollution with artificial intelligence – Marine Debris Research (csiro.au)

Studies currently underway in North America are showing that these efforts make it possible to model areas of accumulation. This makes it possible to increase the effectiveness of preventive measures, which can then be more accurately targeted.

CASE STUDY 6 – Reducing micro-plastics in the Delaware River estuary

Delaware River Basin Commission (DRBC)

The Delaware River Basin Commission is an interstate-federal resource management agency whose members are Pennsylvania, New Jersey, New York State, Delaware and the United States.

The DRBC wanted to collect reference data on micro-plastics in the urbanised portion of the upper estuary of the Delaware River. Understanding micro-plastic inputs is an essential first step in understanding the prevalence and potential problems posed by this contaminant.

Plastic is perhaps the most widespread type of debris in our oceans, rivers and large lakes. Plastic debris less than five millimetres long, known as micro-plastics, easily passes through water filtration systems and ends up in receiving waters.

The DRBC has been monitoring micro-plastics and modelling micro-plastic loads in the upper estuary of the Delaware River – from Trenton, N.J. to Wilmington, Del. This part of the estuary is heavily urbanised and visible accumulations of waste and macro-plastics are common in and around the river. Samples were collected at four sites in the main arm of the Delaware River estuary and at ten tributary sites using two methodologies: a net sampler and a grab sampler. Samples were analysed to determine the concentration, colour, size, shape and composition of micro-plastics.

Micro-plastics were found in all the samples taken (Figure 33). The concentration and composition of micro-plastics varied considerably between net samples and grab samples. Data collected during the micro-plastic monitoring efforts were used to model micro-plastic dynamics in the estuary and to target tributaries with high plastic loads for clean-up efforts. Clean-up and education efforts were organised with partners in Pennsylvania and New Jersey to reduce loads and raise public awareness.

The study was led by Jake Bransky, Senior Aquatic Biologist, and Fanghui Chen, Senior Water Resources Engineer, both DRBC staff members.

For more information, visit **https://bit.ly/DRBCmicroplastics.**

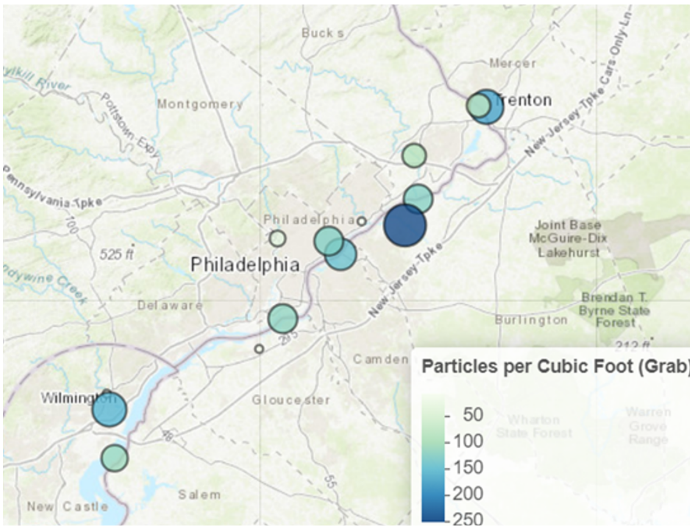


Figure 33: Concentrations of micro-plastics (particles per cubic foot, i.e. 0.03m3) collected by instant sampling in the Delaware estuary and its tributaries

Macro- and micro-plastics observed or estimated at the outlet of a catchment vary according to human activity within the watershed, but the following elements are most regularly found:

Macro-plastics	**Micro-plastics**
Packaging	Tyre particles
Economic activity waste	Textile fibres
Sanitary textiles	Plastics pellets
Cigarette butts	

In 2020, Tara Océan was also able to carry out water sampling on several rivers, including the Thames estuary (UK), the Elbe (Germany), the Rhine (France-Germany), the Seine (France), the Loire (France), the Gironde (France), the Tagus (Portugal), the Ebro (Spain), the Rhône (France) and finally the Tiber (Italy). Using a Manta net they could identify the different types of plastic present:

1. sample of micro-plastics,
2. microfibre sample (after machine washing),
3. sample of micro-plastics on a beach,
4. plastics on a beach,
5. cosmetics microbeads

Figure 34: Freshwater sampling using a manta net – (TARA, 2020)

3.2.4 Specific physical, chemical and biological impacts

Because of its composition, plastic, and therefore waste from items containing plastic, has specific impacts on living organisms.

3.2.4.1 Physical impacts

Animals in aquatic environments are affected differently depending on the size of the plastic waste:

- Less than 1 µm: molluscs and crustaceans are affected. Capable of filtering up to 2 litres of water a day, nano-plastics accumulate in their tissues.
- Up to 0.5 cm: fish and invertebrates ingest particles that they mistake for their usual prey. Worms studied in the Seine basin showed an ability to ingest and eliminate microbeads present in their environment. For a small crustacean (copepods), lethal effects have been demonstrated with the same micro-plastics.
- Up to 2.5 cm: larger fish and birds are affected. Plastic debris is present in the stomachs of 90% of birds.
- Lastly, plastic elements up to 1m in length, such as film, affect birds and large marine mammals: hobbled and suffocated, the animals can die.

3.2.4.2 Chemical impacts

Plastics are subject to the dynamics of degradation throughout their life, releasing the chemical molecules of the additives used in their manufacture. What's more, it turns out that the degraded plastic surface acts like a sponge for pollutants already present in the environment. These micropollutants, such as heavy metals, are adsorbed onto the surface of the debris. When this plastic debris is ingested by organisms, these chemical molecules are released into the body.

3.2.4.3 Biological impacts

The full ecotoxicological effects on the biology of the animals are still being studied; however, a study carried out by INRAE, Ifremer and the universities of Bordeaux in France and Orebrö in Sweden (Cormier et al 2021) has already shown a significant impact on physiological functions such as the growth and reproduction of individuals exposed to plastics.

The impact of micro-plastics is being studied more and more, for example in Europe, where the impact of pneumatic micro-plastics has been analysed in lakes (see Case Study 7).

CASE STUDY 7 – Impact of pneumatic micro-plastics on lakes in Europe

Global Nature Fund (GNF)

The Global Nature Fund (GNF), in collaboration with other partners in the European «Blue Lakes» project, has studied five lake regions in Italy and Germany to gain a better understanding of the pollution of lakes by micro-plastics.

The biggest source of micro-plastics is tyre abrasion. Abrasion particles from road traffic are made up of half road surface abrasion and half tyre abrasion; they combine to form a problematic mixture of rubber, synthetic rubber and a variety of chemical additives from the tyre materials.

Abrasion is released into the environment via the air or rainwater or ends up in sewage treatment plants via the sewage system, but only a few treatment plants in Europe are already equipped to remove these substances in trace amounts (BUND 2018).

In Germany alone, around 70,000 tonnes of micro-plastics from tyre abrasion find their way into the ground every year, and 20,000 tonnes into aquatic ecosystems. (Baensch, Baltruschat et al. 2021).

In lakes, the particles are filtered by water-filtering organisms such as mussels, which they contaminate.

Although solutions exist to reduce micro-plastic emissions from tyres, there is little incentive for tyre manufacturers to tackle the problem of micro-plastics and the causes of micro-plastic emissions.

Targeted action would be possible, as ADAC technicians and scientists have identified key factors and approaches for a significant and rapid reduction in abrasion. In addition to eliminating production residues, such as rubber hairs, before tyres go on sale, speed restrictions, weight limits and vehicle performance limits would be viable options.

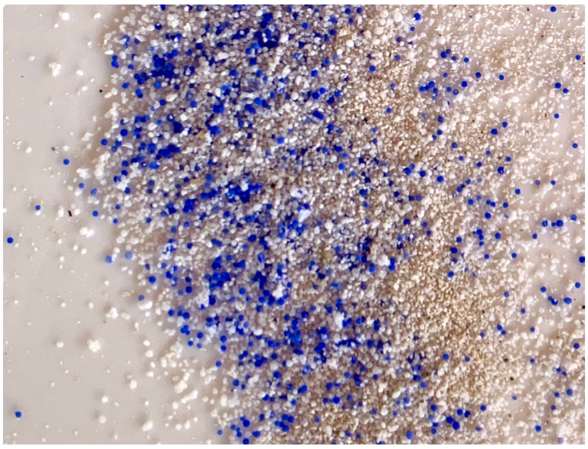


Figure 35: Micro-plastics in the river

Figure 36: Collection during the Blue Lakes project

3.2.5 The impacts on humans

When aquatic fauna is affected, the food chain is likely to be bio-accumulative. Scientists have therefore sought to identify the concentrations at each link in the food chain, right up to humans. The various stages at which contamination can occur are as follows: contamination of plants by soil, contamination by irrigation water, contamination by the food production process itself, contamination by the food chain (FAO, 2022).

People are contaminated either by ingestion or inhalation. Once in the body, the transfer between physiological partitions depends on the size of the particles. The largest particles can be eliminated, while the smallest reach the digestive tract. The fact that particles smaller than 20 µm are detected in the muscles indicates that they have been absorbed into the bloodstream. However, human contamination appears to be primarily due to nano-plastics passing through lung tissue (Amato-Lourenço et al., 2021) and the placenta (Ragusa et al., 2021). Figure 37 summarises the routes of human exposure to micro-plastics.

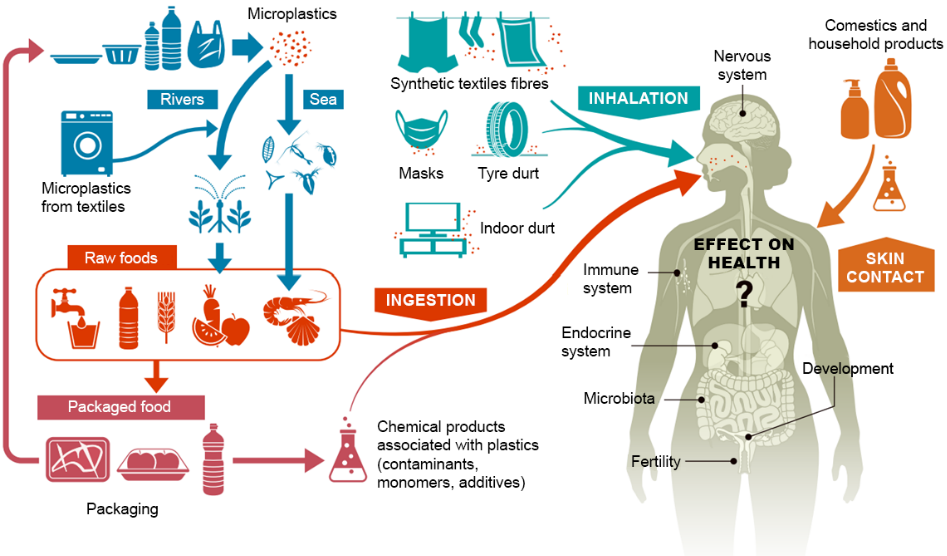


Figure 37: Humans come into contact with micro-plastics and chemical molecules in a number of ways (Source: A(Q)tua)

3.3 – INTERNATIONAL NEGOTIATIONS UNDERWAY TO ELIMINATE PLASTIC POLLUTION

Among the many countries working to combat the pollution caused by plastic macro-waste, France presented its «National Biodiversity Strategy 2030» on 27 November 2023. It clearly identified that reducing the pressure on biodiversity requires a ban on single-use packaging and the adoption of a common international policy through a draft Plastic Treaty.

CASE STUDY 8 – Producing parliamentary reports and passing laws to limit plastic pollution

Feedback from Philippe Bolo MP

In France, the Parliamentary Office for the Evaluation of Scientific and Technological Choices (OPECST) has been examining the issue of preventing the transfer of plastics into aquatic environments since 2019, in support of the legislative procedures for drafting legislation.

Philippe Bolo, Member of Parliament, and Angèle Préville, Senator, submitted three reports dealing successively with the causes and consequences of plastic pollution, the scientific issues of the international treaty and plastic recycling.

- “Plastic pollution: a time bomb?” – OPECST 2020
- “The scientific challenges of an international treaty to halt plastic pollution” – OPECST 2023
- “Plastics recycling” – OPECST 2023.

The recommendations made in these OPECST reports are being put into practice, particularly through legislative action. In December 2020, Philippe Bolo tabled a resolution in the French National Assembly on France’s commitment to strengthening international action to combat plastic pollution. Co-signed by more than 400 MPs, the resolution was unanimously adopted during its examination in public session in November 2021.

At European level, it aims in particular to incorporate a micro-plastic parameter into the Water Framework Directive as a criterion for assessing the good ecological status of water bodies.

At the Mediterranean basin level, the resolution calls on France to bring together all the countries bordering the Mediterranean to speed up political initiatives to significantly reduce the flow of plastics into rivers.

Finally, on a global scale, the resolution asks France to relay, amplify and enrich the initiatives for defining a binding legal framework to eliminate plastic pollution.

Parliamentarians have the power to use the law to guide the reduction of plastic pollution, of which aquatic environments are the vectors or receptacles.

Legislative action includes bans on certain plastic objects, the development of a circular economy based on reduction, reuse, recycling and eco-design, obligations to reincorporate recycled plastics, bans on the export of plastic waste, and policies to develop waste management infrastructures in countries that do not have them.

In conclusion, parliamentary action of this kind concerns all the world’s parliaments. We need to tackle global pollution, where plastic packaging produced in one country can end up in a river or ocean on the other side of the world!

In March 2022, the United Nations Environment Assembly adopted a landmark resolution to negotiate, by the end of 2024, a global treaty to combat plastic pollution that is legally binding and based on a global approach covering the entire life cycle of plastics.

This resolution is historic because it recognises the following:

- plastic pollution is a global challenge,
- there is a need for a global resolution,
- the response must be rapid, by proposing an ambitious timetable for the negotiations.

In order to reach a final agreement by the end of 2024, five negotiating sessions have been planned, as illustrated in Figure 38.

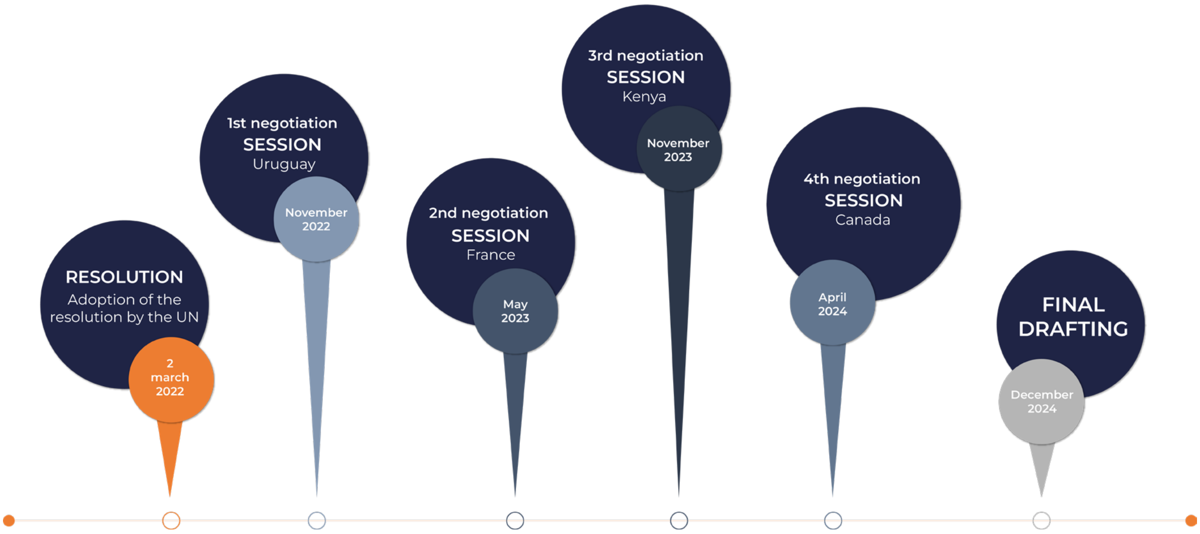


Figure 38: The timetable for negotiations

The session, which took place at the headquarters of the United Nations Environment Programme (UNEP) in Kenya in November 2023, did not result in any concrete measures, but rather in differences of opinion, in particular on the ambition to reduce plastic production and on simplifying the composition to facilitate recycling.

«International negotiations against the proliferation of plastic waste came to an end in Kenya on Sunday 19 November, against a backdrop of disagreement over the scope of the treaty and the frustration of environmental non-governmental organisations (NGOs) at the lack of concrete progress.» Le Monde, AFP 20/11/2023

However, there are still two sessions to go before an agreement can be reached by the end of 2024. At the very least, it would be important for this treaty to set out a binding framework for collection and processing, to prevent plastic molecules from being released into the environment.

4 - WHAT CAN BE DONE TO PREVENT WASTE BEING TRANSFERRED TO WATERWAYS?

To ensure that waste does not end up in waterways, the «avoid then manage» principle applies:

- Reducing waste at source by examining practices to minimise waste from human activities;
- Avoid storing it in places where it can be transferred and leaked into aquatic environments;
- Organise the collection and treatment of waste so that it is eliminated from the natural environment;
- Raise public awareness on all three action levers.

4.1 – REDUCING WASTE AT SOURCE

Reducing waste at source is part of a sustainable development policy coordinated by the public authorities and implemented with local players (at State, regional and local level, etc.) to ensure that less waste is produced and that the remaining waste can be recovered. However, projections indicate that waste volumes will continue to increase as GDPs rise, before declining very slowly. Furthermore, there are disparities between countries when it comes to managing waste, including its prevention. Some are succeeding, while others are finding it more difficult.

Reducing waste also questions the consumption practices of each producer of waste, whether an individual or a group, and this applies to all human activities.

A frequently-used phrase is that "to reduce waste, the most effective way is not to produce it", but putting this into practice is very complex.

4.1.1 Banning certain plastic products

It takes 2 minutes to drink a drink through a plastic straw, and it takes 200 years for the straw to degrade once in the aquatic environment.

Initiatives at various levels have led, for example, to a ban on plastic carrier bags. Many countries and localities are introducing bans on single-use plastics (SUP)in general.

In France, there has been a 30% reduction in the number of plastic bags found at the bottom of the English Channel within two years of the ban on plastic carrier bags (introduced in France in 2016 as part of the 2015 Transition for Green Growth Act). The 2020 AGEC law has since considerably strengthened the ban on the use of SUP, such as straws and single use cutlery.

At European level, directives and regulations now co-ordinate the conditions under which marketers produce packaging. By the end of the decade, bans will gradually be extended to primary micro-plastics incorporated into the composition of hygiene and beauty products.

Overall, to combat plastic waste, we need to establish a precise territorial strategy. One of the messages conveyed to the INC-2 negotiators of the plastics treaty underlines the strategic nature of the actions to be taken: «to reduce the volume of plastics, we need to tackle the most harmful plastics strategically and as a priority, and think in depth about the impact of the proposed replacement solutions».[7]

4.1.2 What are the best practices to implement?

Many solutions (Table 1) can be implemented at different levels to reduce the production of plastic waste. Some rely on increased awareness among the general public as well as economic and institutional players. Others require industrial infrastructures, complex organisations, substantial funding and coordination by the public authorities, which makes them difficult to implement.

7 Source: https://pfd-fswp.fr/les-acteurs-du-dechet-et-de-l-eau-portent-un-plaidoyer-commun-pour-lutter?lang=en

INDIVIDUAL	COLLECTIVE	INDUSTRIAL
Do not use disposable plastic	Organise eco-responsible events	Design objects that can be repaired or remanufactured more easily
Use reusable bags	Offer washable crockery and water bottles to fill in a fountain	Set up a system of reusable bags, boxes or crates for deliveries
Buy in bulk	Combat the waste of resources	Reduce single-use packaging
Favour reusable products	Improve street cleanliness	Reuse or recycle equipment
Develop the repair, bartering and sharing of objects	Introduce incentive-based pricing where the local context prevents a shift towards uncontrolled waste dumping	Sort waste
Sort your waste selectively	Develop recycling centres and resource centres Stimulate recycling, support repair workshops, inform and train citizens	Raise employee awareness
Limit packaging consumption	Reduce paper consumption	Reduce plastic consumption. Eliminate over-packaging.
Favour glass bottles	Equip canteens with reusable cutlery; provide free drinking water points in town	Facilitate refundable deposits and recycling
Buy second-hand or reconditioned		Reduce consumption of supplies

Table 1: Examples of good practice for reducing waste at source

Awareness-raising campaigns aimed at waste producers in different areas of activity can help to bring about changes in practices (see case study 9).

CASE STUDY 9 – The PROMISE project: Preventing marine litter in the Lakshadweep Sea (Maldives, Sri Lanka, India) – ADELPHI

PROMISE is a four-year initiative funded by the European Union (EU) as part of the SWITCH Asia programme, which runs from 2020 to 2024. The project aims to tackle the problem of marine litter, particularly in areas with high tourist numbers along the coast of Lakshadweep in the Maldives, Sri Lanka and India. The focus is on reducing the leakage of land-based waste into the sea, particularly due to the high consumption of plastic in the tourism and fast-moving consumer goods (FMCG) industries.

PROMISE is addressing this issue through a number of targeted activities, which include comprehensive measures such as:

- Mapping and identifying sources of marine litter,
- Supporting micro, small and medium-sized enterprises (MSMEs) in waste reduction: Training, advice and capacity building for 300 MSMEs in tourism hubs to implement waste reduction options based on recognised approaches such as Resource Efficient Clean Production (RECP) and Parley for the Ocean’s AIR programme.
- Creating a «Zero Waste Alliance»: setting up a framework for the Alliance in Lakshadweep, organising conferences, recognising best practice and developing compendia to facilitate replication within MSMEs.
- Improving access to finance: raising awareness among MSMEs of funding opportunities for waste reduction measures and working with national financial institutions to support these efforts.
- Political advocacy and strengthening governance: engaging in dialogue with policy-makers, publishing guidance documents and organising round tables to promote effective waste management policies in coastal areas.

- Disseminating knowledge and raising consumer awareness: cleaning up beaches, raising consumer awareness, creating awareness through films and developing online communication channels for widespread distribution.
- By adopting the sustainable consumption and production approach, the project aims to reduce the environmental impacts generated by the consumer-centred tourism industry. While focusing primarily on consumers, the project also involves suppliers, promoting green products and waste reduction strategies in the hotel and catering sector.

The next steps aim to strategically position the project for sustainable impact and expansion.

Figure 39: Material flow analysis, India

Figure 40: Collecting bottles on the beach

CASE STUDY 10 – The circular economy in action: when reusable crockery preserves the rivers in French Guiana's National Park

French Guiana National Park

The festival squares in Papaïchton, Maripa-Soula and Camopi, in the south of French Guiana, are major centres of life and festivity on the banks of the river... Events that generate waste often end up in the Maroni and Oyapock rivers...

With this in mind, the Amazonian Park of French Guiana is proposing a system of reusable dishes as part of its circular economy project. Residents and tourists taking part in these events have access to reusable dishes and a washing-up area, independently, close to the mobile caterers.

In front of the dedicated bins, signs indicate the steps to follow (compost bin, soaking, washing, rinsing, drying). Each of these signs is translated into local languages. A Park official is on hand to guide users if necessary.

After encouraging results on the Maroni in 2022, the scheme was launched in Camopi at the end of 2023, to mark "Journée de l'abattis" (a traditional form of agriculture practised by indigenous people of French Guiana). This is a large market for food products and handicrafts, where culinary competitions and sales of meals are frequent. Once again, disposable plates, cutlery and cups are banned, in favour of stainless steel or traditional dishes (such as the calabash, traditionally used by these communities). The participants were naturally keen to play the zero waste game.

The National Park has no data on the amount of waste dumped in the rivers within its boundaries. However, it does support associations that are fighting against this tangible pollution. For example, with the help of the Park, "Le Mouvement à suivre" mobilised the people of Papaïchton during European Waste Reduction Week at the end of 2022 to collect waste from the riverbanks. The result: 173 kg were removed from the water and riverbanks. Operations of this type are fairly frequent and demonstrate the need to prevent this phenomenon.

Figure 41: The Amazonian Park's reusable dishes and washing-up system at the Maripa-Soula Sustainable Gastronomy Day in June 2023. In the background, the Maroni River. Copyright: Rosane Fayet / Amazonian Park of French Guiana

Although the Amazonian Park does not have a specific mission for waste management (which is the responsibility of the intermunicipal authorities), as far as possible it is working upstream to influence consumer behaviour. This is done through environmental education and sustainable development activities or by integrating this component into the implementation of its projects and organisation of its events, as in this case.

4.2 – REDUCING LEAKS AND COMBATING ILLEGAL DUMPING AND ABANDONED WASTE

Waste leaks create two types of waste distribution: diffuse waste and concentrated waste. In the latter case, the waste carried by wind or water gradually concentrates in one area, forming an accumulation zone.

An unauthorised dump is a place where waste is systematically and deliberately left to accumulate, used by residents and economic actors in the absence of appropriate waste collection, established and controlled by the public authorities.

Figure 42: Fly-tipping taken from the TARA Ocean 2019 video

In order to combat these illegal dumps, it is necessary to list, characterise and map the waste in order to gain a better understanding of where it comes from and to draw up an action plan with targeted measures. Some of this waste may be historical, while others may come from behaviours that are still current. In this latter case, an analysis of the collection system in place to understand its malfunctions (access, cost, control, etc.), is the first step to initiating behavioural changes.

For example, at the One Ocean Summit in February 2022, France made a commitment to eliminate historic coastal waste dumps over a ten-year period, as they present the greatest short-term risk of waste being released back into the sea. The Ministry of Ecology has published a guide to combating illegal waste dumping and abandonment, which is partly based on regulations.

Other countries, such as the Republic of Guatemala, are implementing preventive measures and creating controlled storage sites in order to manage their waste as effectively as possible (see case study 11). In all cases, an efficient collection system is the key to limiting the amount of waste entering the environment.

CASE STUDY 11 – Fly-tipping: the major threat to Lake Atitlán in Guatemala

Authority for the Sustainable Management of the Lake Atitlán Watershed (AMSCLAE)

The Lake Atitlán basin, an endoreic system located in the western highlands of the Republic of Guatemala, hosts one of the most beautiful lakes in the world, but is currently experiencing a number of environmental problems, including waste. The area is home to around 300,000 people, who generate around 100,740 tonnes/year of solid waste.

Figure 43: The Atitlán lake, Juan Carlos Bocel Chiroy

Of all the solid waste generated, only 53% reaches one of the 17 treatment systems in the basin. The rest of the solid waste is disposed of by producers in rural fields and inadequately, in open dumps (CECI/ AMSCLAE, 2017). More than 600 open dumps have been identified throughout the Lake Atitlán basin, which is the main source of residues and solid waste entering aquatic environments.

Of the existing solid waste treatment systems, the majority have operational deficiencies (operation and maintenance) and some do not function at all. Only 6 treatment systems have a sanitary landfill for the final disposal of inert waste. These sanitary landfills have collapsed before reaching their design life expectancy; this is due to the exaggerated amount of plastic waste, expanded polystyrene derivatives and other non-recoverable materials that are currently over-consumed.

Most of the waste and solid waste that is not properly disposed of is transported by surface run-off and the entire hydrographic network to Lake Atitlán, mainly by the Quiscab and San Francisco rivers, which are the lake's main tributaries.

This problem becomes more visible and is exacerbated by torrential run-off during the rainy season.

At present, a number of good practices stand out at institutional, municipal and community level. At institutional level, the Lake Atitlán Authority, through its Environmental Sanitation Department, has built waste and solid waste treatment systems in previous years and is currently carrying out a series of projects and actions aimed at strengthening waste and solid waste management by training operators and providing equipment and supplies for the rehabilitation and proper functioning of treatment systems.

In 2022, AMSCLAE, in collaboration with private initiative, the Ministry of the Environment, local authorities and spiritual guides, signed a coexistence pact for the conservation of sacred places, which regulates the entry of containers (bottles, cans, jars, etc.), plastic items, fireworks (bombs, rockets, etc.), cardboard boxes and other objects that pollute the environment.

Municipal authorities concentrate their efforts on paying the operators of certain treatment systems and, in other cases, they manage the purchase of materials, equipment and vehicles for waste collection. On the other hand, they also contribute to the development and promotion of municipal rules and regulations that contribute to the proper management of residues and solid waste in each municipal area.

At community level, there is the participation of several groups of people organised in the catchment area, some of them in direct coordination with the Lake Authority and other governmental and non-governmental institutions that carry out the cleaning and extraction of residues and solid waste directly from Lake Atitlán and in different areas of the catchment area.

During 2023, an agreement was signed with a non-governmental organisation and a women's cooperative called Atitlán Recicla, with the aim of providing materials for the construction of collection centres for recycling glass, PET and other waste.

4.3 – MANAGING AND TREATING WASTE

Managing waste upstream of waterways so that it does not reach them is a major issue in countries around the world. Once waste has reached the natural environment and rivers, each kg of waste becomes more expensive to manage properly, as the effort to recover it is significant, as shown in Figure 44.

Establishing a public policy that incorporates the main principles set out in international conventions can help define a sustainable action plan. However, one of the keys to the success of these public policies lies in the ability to finance, on a long-term basis, the whole of the service, which includes human capacity, infrastructure requirements, and the organisational system needed for stakeholders to play their respective roles. Another key to success is the introduction of a control system for independent public authorities to monitor the implementation of the service by the various players involved.

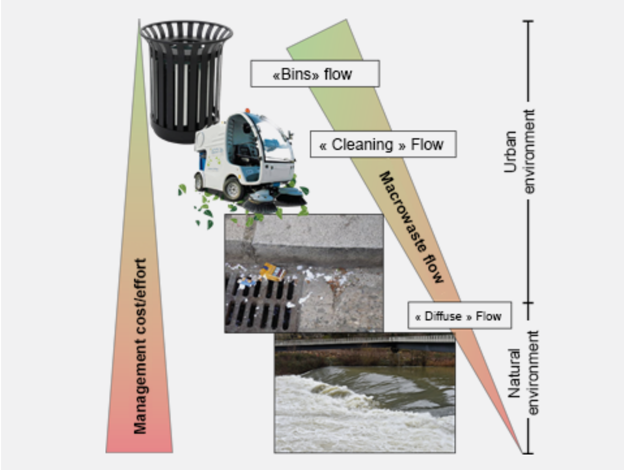


Figure 44: Conceptualisation of the management of macro-waste flows in modified urban areas based on PLASTOC – Romain Tramoy (LEESU)

4.3.1 The regulatory context for waste management

4.3.1.1 The international regulatory context

The Basel Convention, signed on 22 March 1989, entered into force on 5 May 1992, and amended in May 2019 at COP14, is the global treaty on waste, covering the control of transboundary movements of hazardous waste and their disposal, as well as waste in the broadest sense.

The fundamental principles are as follows:

- the proximity of waste disposal,
- environmentally sound management of waste,
- the priority to recover valuable materials and energy,
- the prior informed consent for the import of potentially dangerous substances.

One of the most important principles established by this convention is the environmentally sound management of hazardous and other wastes. This means that all practical measures must be put in place to ensure that waste, including hazardous waste, is managed in a way that guarantees the protection of human health and the environment against the harmful effects that such waste can have.

In addition, this text has recently been revised and specifies that from 1 January 2021, only non-hazardous plastic waste that is easily recyclable, i.e. sorted and not contaminated by other waste, may be exported to third countries for recycling. However, many types of plastic waste fall outside the scope of these regulations, particularly in the following cases:

- the hidden» plastics» in objects corresponding to other historic Basel Convention listings, such as textiles, electronic waste, Solid Recovered Fuel (SRF) and plastics from cars.
- plastics sorted by polymer for export, but whose additives have not been tested (as this is not compulsory) and which may therefore contain harmful substances. The Basel Convention's plastic waste guide recognises the presence in many plastics[8] of 128 substances regulated as hazardous in other multilateral agreements. However, the implementation of traceability to determine the composition of plastics, or tests on each batch, would be very complex and is therefore not agreed by the 189 signatory countries of the Convention.

As a result, many plastics waste products cannot be managed in an environmentally sound way because their composition is not known.

8 Basel Plastic Waste Guidelines, Paragraph 28.

4.3.1.2 The international waste treatment hierarchy

The WHO, similarly to the Basel Convention, points out that the principle of waste treatment hierarchy must be respected:

- Priority 1 is given to prevention, i.e. approaches that avoid the generation of waste and reduce the quantity of waste introduced into the waste stream.
- Priority 2 is to enable waste to be recovered for secondary use or recycling, as much as possible and where it is safe to do so.
- These first two principles are in line with the logic of the circular economy, which consists of sharing, reusing, repairing, renovating and recycling existing products and materials for as long as possible, and recycling waste.
- It should be noted that a move towards less added products in the composition of plastics for greater recyclability and safety is under discussion as part of the international treaty to combat plastic pollution. But there are still many obstacles to overcome, not least the sheer diversity of substances and their potential impact, with over 13,000 elements listed.
- Priority 3 is reserved for waste that cannot be recovered. It must then be treated and sent to a final sink (processed or sent to a controlled landfill) to reduce its impact on health and the environment.

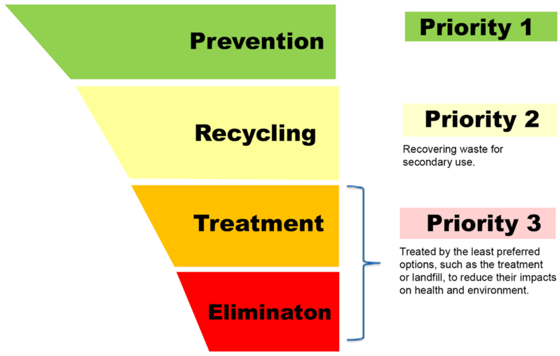


Figure 45: Waste treatment hierarchy (OiEau based on WHO)

Today, most international regulations propose a framework for waste management that respects these principles. However, it does not contain any binding elements on the establishment of a system for financing the service, nor any duties concerning the definition of the roles and responsibilities of the players and the means given to them to carry these duties out. As a result, many countries lack a systematic organisation to prevent waste from ending up in the environment.

Numerous actions in favour of the circular economy, either one-off or targeted at certain types of waste, are being carried out by groups of players (NGOs, local authorities, citizens' groups, etc.) to reduce the amount of waste being dumped in the environment and ultimately transferred to aquatic ecosystems. These actions should be encouraged, but they alone will not solve the problem of waste leaking into the environment.

When planning a waste treatment system, this pyramid of the treatment hierarchy can lead to misleading conclusions about the public policies and infrastructures to be put in place. While society as a whole has a duty to prioritise prevention and recycling in its consumption and production choices, public institutions have a duty to protect the health and environment from the impacts of waste. Indeed, despite prevention and recycling initiatives, there is still going to be a significant amount of waste to be managed. So until most countries have put in place effective, environmentally-friendly collection and treatment systems, waste transfer, particularly to aquatic environments, will continue to increase.

The choice of the treatment type should be adapted to the level of maturity of the country's waste management system. In places where the waste management system is underdeveloped, a reverse approach to the pyramid presented above should be considered: the first step is to identify how best to dispose of the waste in a final sink where its impact on human health or the environment is controlled. Once the system is well in place, the data and skills acquired can be used to identify ways of recovering the material and energy contained in the waste. It is then also necessary to train and recruit in order to meet increasingly high skill levels. Table 2 summarises this approach.

Type of treatment to be put in place to manage the waste that exists despite reduction initiatives	Cost per tonne of waste	Level of maturity required for the waste management system
Landfill sites with controlled environmental emissions	+	■ Collection must be organised; ■ Employees must be trained in safety measures and leachate treatment.
Mechanised sorting system for recycling	+++	■ Collection must be organised and the characteristics of the waste well known (tonnage, type); ■ Employees must be trained in the operation of an industrial facility, the associated IT tools, and the treatment of odours and leachates; ■ A market for materials to be recycled must be secured; ■ An outlet for sorting waste must be put in place.
Energy recovery with control of flue gas emissions	++++	■ Collection must be organised and the characteristics of the waste well known (tonnage, energy value); ■ Employees need to be trained in the operation of a highly complex industrial facility, the associated IT tools, and the treatment of flue gases, odours and leachates; ■ A market for energy recovery must be secured and energy networks must be capable of distributing the recovered energy; ■ A safe outlet for bottom ash and fly ash must be planned for.

Table 2: Priority for implementing types of treatment according to the maturity of the local waste management system

This reflection on approaches adapted to the local context feeds into discussions aimed at improving international frameworks for waste and plastics management.

CASE STUDY 12 – Urban Environment Programme in Lomé (PEUL), Togo

Project funded by l'Agence Française de Développement (AFD) for le District Autonome du Grand Lomé (DAGL)

Lomé has a population of around 1.8 million and an urban growth rate of almost 4%. There is chronic flooding during the rainy season, and the lagoon system requires major investment in redevelopment. More than 300,000 tonnes of solid waste a year are generated in the Greater Lomé region, and poor management of this waste causes public health problems and pollution. Unmanaged waste clogs up the storm drains, exacerbating the risk of flooding.

The project aims to improve the holistic solid waste management system and support capacity-building for local stakeholders, with the ultimate aim of improving the quality of life of residents and workers. The project has carried out and continues to carry out the following tasks:

- It has supported the implementation of engineered landfills with long-term biogas and leachate management;
- It has strengthened recovery and recycling initiatives;
- It has supported the improvement of the sector's financial resources;
- It has enabled a gradual increase in performance requirements.

The project was structured in successive phases, allowing each phase to build on the achievements of the previous one:

■ PEUL I: €8 MILLION IN AFD SUBSIDIES, from 2007 to 2014

Infrastructure and implementation:

- Support for pre-collection structures and the informal sector in conjunction with Lomé town hall.
- Work with an NGO (Enpro) on composting.

Capacity-building:

- Revision of the organisation of formal collection in conjunction with Lomé town hall.
- Support for financing investments and improving financial management.
- Support for project management.
- Strengthening urban planning.

■ PEUL II: €21.5m (€5m AFD GRANTS + €7m EU GRANTS + €9.15m BOAD GRANTS), from 2011 to 2018

Infrastructure & implementation:

- Construction of the Aképé landfill site.
- Formalisation of recycling and recovery activities.
- Selection of a private operator to run the landfill.

Capacity building

- Improve fund-raising.
- Support for technical services.
- Support for municipal policy on the management of urban services and urban planning.
- Raising awareness among residents.

■ PEUL III: €14m AFD GRANTS, from 2019 to 2023

Infrastructure & implementation

- Closing and rehabilitating the former uncontrolled landfill site at Agoé-Nyivé.
- Rehabilitation and construction of transfer centres.
- Strengthening recovery and recycling initiatives.

Capacity building

- Specialised technical assistance in local authority administration.
- Social support plan for informal workers
- Financial and organisational optimisation of waste collection.
- Improved mobilisation of financial resources for waste collection.

■ PEUL IV: €15m AFD GRANT AND €5m EU GRANT, from 2021 to 2026

Future initiatives under PEUL IV

- Extension of the Aképé landfill site and operation for a further 5 years.
- Improving the operation of the landfill site with regard to climate, environmental and biodiversity issues.
- Improving the organisation of waste management in the Greater Lomé area.

- Reduction in the volume of waste transported and treated.
- Mobilisation of financial resources.
- Strengthen territorial planning

The overall impact of this project is improved quality of life for more than 1.8 million people thanks to access to essential public services. In addition, the project has provided technical vocational training to 325 beneficiaries.

Figure 46: Level of pollution of the lagoon system in Lomé in 2010 and Operation of the Aképé landfill site in Lomé in January 2022, Togo

4.3.1.3 Aquatic waste management at the interface of several public policies

The complexity of managing waste found in aquatic environments stems from the fact that it comes under both water and waste management, which makes it difficult to study, especially as one of the major challenges of managing waste in waterways is to reduce discharges into marine environments.

Aquatic macro-waste in waterways is at the crossroads of several public policies relating to water and aquatic environments, waste, sanitation, urban stormwater, biodiversity and the marine environment. It is therefore important to have an overview of these different sectors in order to work on prevention measures.

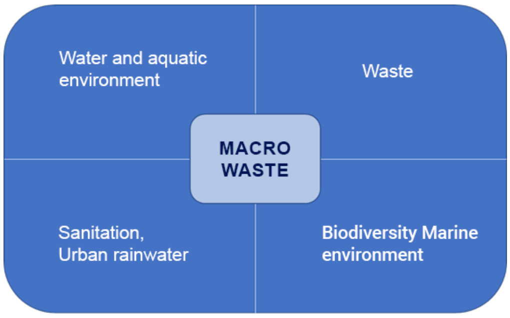


Figure 47: Macro-waste in waterways

4.3.2 Waste management challenges

The waste management system includes the collection, transport and treatment of waste. Mis-management of waste will result in waste ending up in aquatic environments via all the transfer routes identified in the previous chapters. The main challenges of the implementation of waste management, on the ground, are the following:

1. The lack of support mechanisms for the planning and operation of the waste management systems.
2. The complex social dynamics, and the interdependencies between stakeholders which are fundamentally very different
3. The diverging perceptions of the minimum requirements for waste treatment

The role of international financing institutions, such as multilateral and bilateral development banks, is essential not only to support investment in specific waste management infrastructure, but also to help local stakeholders implement the sustainable planning and governance structure needed to best meet these challenges, as illustrated in Box 8.

Box 8 – International donor support for public policies
Interview with A. Monteiro and M. Grignon (AFD), March 2024

The Agence Française de Développement (AFD) Group supports, finances and accompanies sustainable development dynamics in more than 150 countries and 11 Overseas Departments and Territories. It is made up of three entities, each with its own area of activity:

- *Agence Française de Développement, which finances development aid for public authorities,*
- *PROPARCO, which works with private companies,*
- *EXPERTISE FRANCE, which provides technical expertise to governments and/or public companies and can carry out studies.*

The AFD Group focuses its operations on low-income countries such as the Least Developed Countries and emerging countries (according to the OECD classification).

The AFD Group is therefore France's development aid bank. The financing granted may be the subject of international calls for tender by the entities assisted, in compliance with the rules set by international donors. AFD Group's financing has been on the increase for several years: it represents €12.3 billion in commitments for 2022.

To deploy this financing, the Group employs 3,600 staff in 86 countries. The AFD Group's operations are supervised by the Ministry of Foreign Affairs, the Ministry of Finance and the Ministry for Overseas France. Although AFD is an independent body, its strategic plan is validated by the French Council of Ministers.

All financing granted must comply with the 2015 Paris Agreements (resulting from COP21). The AFD Group also ensures that 50% of the actions it supports benefit climate change adaptation and/or mitigation actions. Each action is in line with the just transition principle and takes gender into account. Finally, none of the AFD Group's support should have a negative impact on one of the United Nations' 17 Sustainable Development Goals (SDGs or global objectives).

The AFD Group, like most donors, offers a range of products and services to support public and private stakeholders and civil society, from the emergence of projects to their implementation. The range of products and services on offer includes technical support (consultancy, technical assistance, etc.), grants, loans, guarantees, private equity, research and innovation (studies, research and evaluation, training, etc.). The AFD Group's areas of activity are highly diversified, with actions linked to waste management included in the «infrastructure and urban development» theme. Waste concerns around 10% of the projects in this area, i.e. around €200 million allocated to it in 2022.

The primary objective of the AFD Group's «sustainable city» strategy is to improve the quality of life of city dwellers through better solid waste management (from pre-collection to waste recovery). Among the key principles applied to waste management, the AFD Group aims for an integrated approach that is differentiated according to geography, with a concern for adapting to the local context and implementing progressive solutions over time. The aim is to integrate public and private players, civil society, NGOs and the formal and informal sectors. The AFD Group therefore works on structuring the solid waste management sector (public policy, regulatory and strategic support), on investment in the framework of a project or programme (studies and support for implementation, treatment infrastructure, rolling stock and maintenance workshops, skills transfer over 1 to 5 years of operation) and on building the capacities of local and national public stakeholders and populations affected by the project, as well as analysing the financing of the sector and its governance.

Since 2014, AFD Group has noted a growing demand for financing for waste management projects. This demand seems to have grown exponentially since 2019. There is therefore more talk about waste, with the link between waste and climate now on the international agenda. Many countries are beginning to see waste management as an economic development issue for their regions, with fewer illnesses, less environmental and visual pollution, cleaner soils for tourists and better quality aquatic environments. Programmes currently being financed include the public policy loans implemented by AFD in Albania and Costa Rica, which are helping to support the change towards a ban on plastic bags, as well as numerous measures to protect the environment and combat climate change.

4.3.2.1 Support mechanisms for waste management implementation

One of the challenges restraining the implementation of sound waste management systems is the lack of support mechanisms for their planning and operation. These required support mechanisms include the following four pillars, which rely on a local political will and vision:

- **A regulatory framework:**
  This framework enables the roles and responsibilities of the stakeholders involved to be clearly defined, and which establishes the control mechanisms and control authorities necessary for ensuring implementation of the service.

- **A territorial network of infrastructure and organisations that allows waste to be collected and managed locally as much as possible:**
  Indeed, waste managed locally is often managed more responsibly, as local stakeholders take on a stronger level of ownership.

- **Adequate funding mechanisms that allow the implementation of prevention, collection and treatment:**
  These funding mechanisms can be based on a combination of the following: direct or indirect fees, targeted taxes such as EPR or waste management tariffs, national or local authority general budgets, as well as business plans when recovered energy or materials can be sold. The dependency on the global oil price market needs to be accounted for when accounting for revenues from recycled materials or recovered energy. These revenues can vary significantly according to market prices, creating a challenge to cover the fixed investment and operational costs. Many waste streams, in particular residual household waste, do not have sufficient value for the funding mechanisms to rely solely on business plans, and most countries do not have a taxation of producers or citizens that enables full cost recovery of the service. It is also a challenge to implement a waste fee system as often citizens cannot afford or are not willing to pay for the waste management service. Therefore, most waste management services rely partially on funding from global development budgets, which are subject to many competitive requests, leading to deficient services in many places.

- **Adequate means for local authorities in charge of waste, with the necessary leeway to experiment with local solutions:**
  The local authorities in charge of waste management are the best positioned to tailor the waste management solutions to their local context. However, their financial and human resources being limited, the implementation of waste management relies on a strong political vision, and an efficient regulatory framework that can support the implementation of the public service by assigning responsibilities and defining the associated funding mechanisms.

4.3.2.2 Complex dynamics and stakeholder landscape

Waste management relies on complex social dynamics. Indeed, the behaviour of each citizen and of each economic stakeholder has an impact on the waste produced and on the ability to collect it. In addition, many countries have numerous informal workers that rely on part of the waste stream as a resource. Therefore, any change in landfill operations requires that this population is acknowledged and is integrated and included in the planning, to ensure and improve their livelihood.

In addition, many stakeholders are involved and interdependent in the waste management systems: manufacturers, vendors, recyclers, energy providers, raw materials providers, international trade, etc. Acknowledging the complexity of this landscape is key to a sound regulatory framework.

Local stakeholders can be coordinated by national institutions, communities or municipalities to set up a waste management system, but can also be driven by organisations that set up programmes to reduce waste leakage to oceans, as illustrated in Case Study 13.

CASE STUDY 13 – The "Clean Oceans Through Clean Communities" (CLOCC) programme in Indonesia: Building sustainable waste systems for healthier oceans

Indonesia is one of the countries that contributes most to ocean plastic waste. It is made up of many islands and regions, all of which, particularly rural areas, need better waste management.

CLOCC's work in Indonesia involves not only data collection and analysis, but also proactive community engagement. The initiative empowers local governments and stakeholders through capacity-building workshops and collaborative planning sessions, leading to the creation of solid waste management plans. This is part of the integrated and sustainable waste management approach, which advocates a comprehensive and inclusive planning tool with an emphasis on local engagement.

Recommendations:

- Focus on holistic waste management systems that manage all fractions to reduce plastic pollution.
- Improve and build on systems and structures that already exist and create waste management systems that suit local conditions and can be sustainable in the long term.
- Sustainable funding is essential to create waste management systems that will last. Waste charges are needed, as well as mixed funding for capital expenditure. The ability to fund the maintenance and operation of infrastructure also conditions its sustainability.
- Using a highly participatory approach is challenging and can take time, but it is important to create broad local ownership and include stakeholders.
- Behaviour change takes time and effort, initial investment and subsidies are often required.

Next steps for the project:

- Formally launch the waste management plan, which has been completed in Banyuwangi.
- Launch the waste management master plan for Tabanan.
- Engage in new governance in Indonesia, establish a memorandum of understanding with the regency's political leadership.
- Consider expanding to other regencies in Indonesia.

4.3.2.3 Waste treatment minimum requirements

A sustainable waste management system relies on the establishment of «environmentally sound» waste treatment sites that meet internationally accepted environmental standards, which often refer to higher standards, such as the European regulations. These standards can be overwhelming for countries that have not yet invested in basic waste management infrastructure and systems. It is therefore important to consider a step-wise approach, starting from minimum requirements and building up to higher and higher environmental standards, in order to avoid the status quo.

In many places, formal treatment facilities do not exist or are non-compliant, even with the minimum locally accepted requirements. The number one change needed is to reduce the pollution of the natural environment by plastics and other harmful substances. The level to which the pollution will be reduced by new projects is often dictated by those funding them (national government, local government, International finance institutes). However, it should be ensured that in the long run the operational costs associated with the higher pollution reduction ambition can be covered by the local authorities in charge. This requires adequate funding mechanisms as discussed in the previous section.

As mentioned previously, in the beginning the solutions implemented should consider a reverse order to the treatment hierarchy, as the basis of a treatment system is to have a final elimination facility so that all the waste that cannot be recovered can be safely disposed of. Setting up controlled sanitary landfill sites is the first stage in structuring a public waste management service, based on which other, more complex systems can then be built to recover materials or energy. These other systems, higher up in the treatment hierarchy, require good knowledge of existing waste flows, reliable collection, significant investment and operating costs, and a highly skilled staff.

In parallel to a structured effort to reduce the impact of waste on the environment, local treatment projects can thrive, depending on the resources available in the area, as explained in Case Study 14. However, care must be taken to ensure that they do not in turn create environmental problems, given the number of additives contained in plastics. When in doubt about the quality of a source of plastic, these private stakeholders should have the option of sending it to a controlled landfill site without a negative impact on their business model.

CASE STUDY 14 – Support for the collection and recycling of plastic waste into plastic pavers – a solution for combatting waste and plastics being transferred into aquatic environments in the province of South Kivu in the Democratic Republic of Congo

African Environment and Communities (AEC)

African Environment and Communities (AEC) is a non-profit association created on 16 May 2020 in Bukavu with the aim of contributing to the preservation of ecosystems by strengthening the capacities of indigenous communities, improving living conditions in the face of climate change and fighting poverty and climate injustice for sustainable development in Africa. It supports and accompanies young green entrepreneurs, women and indigenous people who are bearers of knowledge (traditional and/or modern), new ideas and initiatives offering or likely to offer services, innovative and beneficial indigenous or technological solutions to improve the resilience of indigenous and local communities in Africa.

Commercial activity in the city of Bukavu and the surrounding area involves the use of plastics as packaging for a number of commercial goods. These non-biodegradable plastics, once used by their holders, constitute a threat and a serious environmental problem. Made up of cans, bottles, bags and sacks, these plastics often accumulate on the banks of rivers, in Lake Kivu and near prestigious sites and public thoroughfares. Throughout their life cycle, they are a source of pollution with harmful consequences for human health, livestock and the aesthetics of the city. This plastic waste discharged into Lake Kivu hampers the operation of the dam to the point of blocking the turbines of the largest hydroelectric power station in the east of the country, installed on the Ruzizi river in South Kivu. This situation is forcing SNEL to stop operating its machines every day in order to clear the plastic waste. As a result, there are power cuts. Fish and communities living on the shores of the lake, in the town and in neighbouring countries, are affected by the plastic waste that can be seen all over the lake.

The private company Plastycor and its team are currently collecting plastic waste to make «baskets, flower pots, rubbish bins, stools, pedestal tables, etc.», but the work is manual and the aim should be to industrialise the recycling and processing system.

4.4 – MOBILISING CITIZENS

To combat waste proliferation, we need to inform, raise awareness and educate people over the long term.

Mobilisation is based on a collective commitment and a common interest. It involves the following:

- Raise awareness of the problem of waste and its impact on aquatic environments and human life;
- Encourage people to change their practices to reduce waste as much as possible and to dispose of it properly, including segregating at source when infrastructures are in place;
- Proposing solutions that make life easier for residents.

There are many examples of this, and a number of case studies show that involvement can have an impact on people's feelings and commitment.

CASE STUDY 15 – An eco-cultural solution in Senegal: culture at the service of the environment for a sustainable change in behaviour

Terangagée Association

According to Terangagée's observations in Senegal, in the Diembéring region, waste is dumped in the water (mangroves and sea) for the following reasons:

- Lack of means to collect waste in the neighbourhoods, on the beaches and at the market (waste is dumped in the adjacent stream that flows into the Bolongs);
- Lack of awareness among communities and local authorities;
- Lack of local waste processing solutions to limit the quantity of polluting waste;
- Lack of regulations and enforcement on the import and consumption of plastic and on illegal dumping or even the direct dumping of waste into waterways.

In response to these observations, Terangagée is proposing an Ecological-Cultural Solution that is original, duplicable and adaptable to a locality:

- Reduce marine plastic pollution: raise awareness among the community, the authorities, fishermen, hoteliers, merchants, traders and restaurateurs; place litter bins in coastal villages and on beaches, which not only help to educate people to change their behaviour but also reduce the amount of waste blown away by the wind and ending up in the waterways (sea and mangroves); carry out waste collection operations on the beach and near waterways; clean up the beaches regularly.
- Educate, change attitudes and encourage a sense of responsibility: awareness-raising visits and workshops, calls for initiatives, training, transforming unauthorised dumps into gardens and play areas.
- Introduce waste recovery and recycling: simplified waste sorting in households, construction of a waste sorting and recovery centre (reuse and recycling) to look at waste differently.
- Limiting the consumption of single-use plastic: incorporating alternatives to plastic waste such as bags, cotton pads and nappies made from fabric, or egg cartons made from recycled cardboard.

In short, awareness-raising is a crucial priority, and must be accompanied and followed up by a community-based approach. It must also be complemented by concrete clean-up actions involving the community and supported by a waste management system that is adapted to the configuration of the villages, efficient and sustainable. It should not be forgotten that women are more sensitive and committed than men to the issues of pollution and its consequences, with an average of 90% participation by women in village activities. They are leaders and spokespeople for changing community behaviour.

Waste management is a collective challenge that requires the mobilisation of everyone. Reducing waste pollution implies a profound change in practices in all activities.

CASE STUDY 16 – Combating plastic pollution in the Danube

International Commission for the Protection of the Danube River (ICPDR)

The International Commission for the Protection of the Danube River (ICPDR) has taken important steps towards a basin-wide management strategy to combat plastic pollution.

Scientific studies have revealed undeniable links between marine pollution and the continental areas where human activities develop. Factors such as incorrect waste disposal, inadequate waste management, fly-tipping, plastic industry facilities, the use of textile and cosmetic products in households or tyre abrasion collectively contribute to the pollution of waterways. Plastic waste is then discharged from rivers into receiving seas, exacerbating the contamination of marine ecosystems by plastic waste.

During the fourth surface water monitoring campaign, consistent sampling and analysis methods for micro-plastic pollution were used to obtain results for the entire Danube.

Macro-plastic pollution is also a major issue. A Plastic Cup initiative launched in Hungary to combat plastic pollution, particularly during floods, aims to raise public awareness and help clean up the upper Tisza river. The initiative brings together local residents, environmentalists, artists, volunteers, businesses, families and children in a common mission to protect the aquatic environment.

The project has led to major technical advances, including harmonised methods for monitoring micro-plastics and hotspot mapping showing the main sites of plastic accumulation along and in the river. A clean-up operation has been launched in cooperation with the Hungarian water authorities and supplemented by the actions of volunteers.

The project also produced dissemination and awareness-raising tools and materials, policy recommendations, a clean-up manual, an exhibition and a reduction toolbox.

Recommendations on implementing regulatory actions, financial instruments, advisory tools and soft measures to effectively manage plastic pollution were published in 2024. The document highlights the most important strategic interventions in line with the waste hierarchy, a framework that prioritises waste management options according to environmental benefits. These include setting up an appropriate waste management system and a favourable regulatory framework, supporting innovation and recycling and providing economic incentives to do so, monitoring and mapping plastic pollution and organising river clean-up activities.

Behavioural change, education and raising public awareness are key to encouraging more responsible and sustainable use of plastics. The Danube countries are encouraged to incorporate these guiding principles into their national efforts.

Figure 48: Macro-Waste in the Danube River

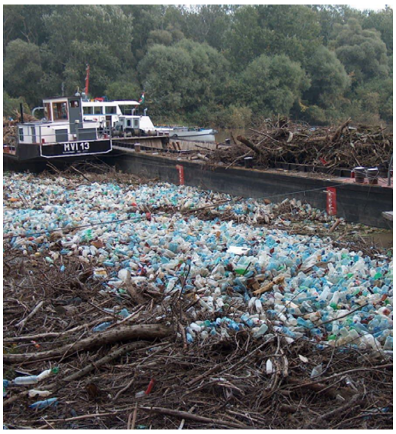


Figure 49: Collecting macro-waste in the Danube River

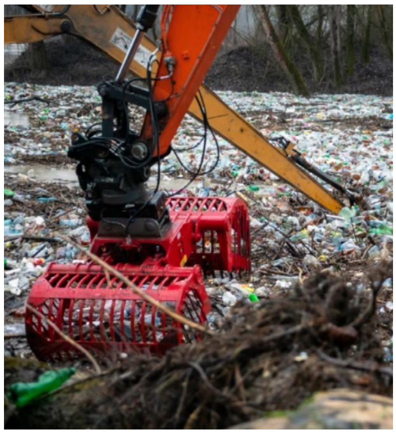


Figure 50: Extracting macro-waste from the Danube

4.5 – DIVERSE BUT COORDINATED LEVELS OF REGIONAL COMMITMENT

As such, the fight against plastic pollution, like the fight against macro-waste, requires action at every level:

- Changes in individual practices to reduce plastic consumption and the use of alternative solutions, when deemed more virtuous, including for the manufacturers behind the packaging.
- Combined action on a territorial scale. Regional commitments are emerging to provide a collective response. For example, co-signed charters define targeted objectives relevant to the basin. This is the right scale for public authorities to define a functional waste management system to prevent transfers to aquatic environments.
- National or international regulations take over to enact and support the implementation of strong strategic actions decided at the highest levels and which can be applied on a large scale.

Figure 51: Examples of solutions at different levels of governance

All these interventions are essential, but we must not forget the territorial complexities that are obstacles to overcome, as shown by the case study of the ODE in French Guyana.

CASE STUDY 17 – The threat of plastic waste in the transboundary catchment areas of the Maroni and Oyapock rivers in French Guiana

French Guiana Water Office (ODE de Guyane)

The worrying threat of waste in the transboundary catchment areas of the Maroni and Oyapock rivers requires urgent attention because of its impact on the environment and the health of local populations. Per capita solid waste production in these regions is comparable to that of large urban areas. Unfortunately, the lack of adequate management systems has led to the uncontrolled proliferation of open dumps, particularly on the Surinamese shores.

This situation is exacerbated by the lack of awareness among local communities about proper waste management, leading to practices such as burning and inappropriate disposal, causing soil and water pollution and endangering local wildlife. The increasing presence of plastics and micro-plastics, particularly in the Maroni river, underlines the urgent need for increased monitoring of water quality.

The unique ecosystems of the Maroni and Oyapock watersheds, with their mangrove swamps, river islands and mudflats, are essential for small-scale and industrial fishing. The rational management of solid waste is therefore crucial to ensuring a sustainable future, in line with the objectives of the United Nations' new global agenda to reduce waste production by 2030.

Faced with these challenges, a collaborative approach between France, Suriname and Brazil is needed to develop a shared vision for the sustainable management of these cross-border territories. This involves coordinating action at different levels and increasing user participation in decision-making.

In conclusion, preserving the integrity of these unique environments and their exceptional biodiversity requires concerted efforts to adapt environmental practices and policies to local realities. It also requires new methodologies to be developed that take account of the interdependencies and specific features of these cross-border regions, in order to guarantee a sustainable future for future generations.

5 - CONCLUSION

“Macro-waste» in freshwater is a major source of pollution in the oceans, transported by rivers and streams. It comes mainly from land-based sources and human activities. To prevent this pollution, it is essential to identify the sources and transfer routes of waste along the land-river-sea continuum, to quantify and characterise the flows and to have a good understanding of public waste management policies. Macro-waste arrives in waterways by various means, such as run-off, river flows, sewage, grey water and wind, but also as a result of abandonment on riverbanks, illegal dumping, leaks from collection systems or the spreading of poor-quality compost. Extreme weather events, exacerbated by climate change, increase these flows and contribute significantly to their spread in aquatic environments. The transport of macro-waste in waterways has been studied by a number of researchers; it is complex and depends on hydrological, geomorphological and physical factors.

Most of the macro-waste is macro-plastic. It is then transformed into micro- and nano-plastic. It poses a complex problem that requires monitoring, analysis and coordination between all the stakeholders involved. Plastics are persistent in the environment and have specific impacts. Their path towards aquatic environments is influenced by their nature and use, and it is important to understand their history in order to grasp their omnipresence in our society. Plastic production continues to grow, with major projections for the coming decades. They are present in many sectors of activity, which use them for their valuable characteristics, obtained by combining polymers and additives to produce around 13,000 different plastics. Their widespread presence in our daily lives has turned them into a source of waste with a significant impact on the environment, including aquatic environments.

To prevent the transfer of macro-waste into waterways, it is crucial to adopt a prevention and management approach. Extreme events and natural disasters add further complexity to this issue, requiring a proactive and adaptive approach to protect our aquatic ecosystems.

Among the main actions to be implemented, this manual emphasises the importance of reducing waste at source by challenging practices to minimise its production, but above all it stresses the importance of setting up waste management systems for all waste that exists and will continue to exist in the medium-term. Avoiding storing waste in places that are prone to its transfer to aquatic environments, or putting in place environmental standards with incremental ambitions that are adapted to the local context in order to progressively eliminate waste from the natural environment also factor into this fight against macro-waste. However, political will is the key. It enables sustainable development policies to be coordinated with local stakeholders to produce less waste, recover the waste that remains, and eliminate the waste that cannot be recovered. It enables effective measures to be put in place, such as the ban on certain disposable plastic products like plastic bags. It accompanies a range of individual, collective and industrial practices, to be found in this handbook, and which can be implemented to reduce the production of plastic waste. It structures actions to raise awareness and provide support for waste producers in different sectors of activity, in order to accelerate changes both in practices and in economic models towards manufacturing items that are longer-lasting, reusable, repairable, remanufacturable, etc.

It is possible to effectively reduce the transfer of waste into waterways and thus preserve the aquatic environment for future generations. Everywhere, this depends on a network of local stakeholders combined with political will and vision. In addition, the discussions surrounding the international treaty on the elimination of plastic pollution currently being negotiated represent a major step forward. It is a step towards better coordination between international economic players to reduce the production of plastic waste, but also towards more enlightened national political will on the need to implement waste management despite the reduction measures.

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Plastic is the most common type of waste found in aquatic environments. Waste management and stopping waste leaks are key to reducing water pollution.

Dive into the heart of an international collaboration with this handbook on the transfer of waste and plastics into aquatic environments, the fruit of a collective effort by the International Network of Basin Organizations (INBO), French Solid Waste Partnership (FSWP) and the International Solid Waste Association (ISWA) to combat a global environmental threat.

Bringing together the expertise of specialists from a variety of backgrounds, this book illustrates this alarming phenomenon and invites us to think about how to improve the management of plastic waste. It is accompanied by a number of pragmatic, practical case studies to help preserve our aquatic ecosystems.

This handbook is intended to be an easy-to-use tool for environmental, waste and water resource professionals, decision-makers and representatives of public authorities and, more broadly, all those wishing to tackle this major challenge effectively.

It received funding from the Agence Française de Développement (AFD) and the French Biodiversity Agency (OFB).

The International Network of Basin Organizations (INBO), created in 1994, supports the implementation of integrated water resources management at the scale of river, lake and aquifer basins. It brings together basin organisations and other government agencies responsible for basin management, with the aim of promoting exchanges of experience and developing effective tools for better management of water resources at cross-border, national and local levels.

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The International Solid Waste Association (ISWA) is an international network of waste professionals and experts from around the world whose mission is to promote and develop sustainable and professional waste management worldwide and the transition to a circular economy.

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