ISWA MARINE TASK FORCE

PREVENT MARINE PLASTIC LITTER - NOW!

AN ISWA FACILITATED PARTNERSHIP TO PREVENT MARINE LITTER, WITH A GLOBAL CALL TO ACTION FOR INVESTING IN SUSTAINABLE WASTE AND RESOURCES MANAGEMENT WORLDWIDE

WITH SUPPORT FROM OUR PARTNER

AVFALL SVERIGE

THE MARINE LITTER TASK FORCE

The Marine Litter Task Force is an international partnership led and facilitated by ISWA. The aim is to explore and clearly establish the link between efficient waste management and the prevention of plastic waste reaching our oceans.

Sound waste management practices are the key to reducing marine litter. The waste and resources sector is the core enabler of immediate, and long-term, solutions for preventing marine litter.

We aim to:

- Prevent the littering and dumping of waste items, especially in areas where there is an absence of a suitable collection infrastructure.
- Develop and implement practices for sound collection, treatment and disposal of municipal waste.
- Identify and demonstrate realistic best practices. That can be adopted by local, regional, and national authorities.
- Promote a global evolution of efficient resource management.
- Promote the value of secondary plastics as part of a resource efficient circular economy.

ABOUT THE INTERNATIONAL SOLID WASTE ASSOCIATION

Vision and mission statement

ISWA's vision is an Earth where no waste exists. Waste should be reused and reduced to a minimum, then collected, recycled and treated properly. Residual matter should be disposed of in a safely engineered way, ensuring a clean and healthy environment. All people on earth should have the right to enjoy an environment with clean air, water, seas and soils. To be able to achieve this, we need to work together.

Our mission is to promote and develop sustainable and professional waste management worldwide. ISWA achieves its mission through:

- Promoting resource efficiency through sustainable production and consumption
- Support to developing and emerging economies
- Advancement of waste management through education and training
- Promoting appropriate and best available technologies and practices
- Professionalism through its programme on professional qualifications.

THE PARTNERSHIP VISION

"Sound waste management is the key to reducing marine littering. Our aim is to explore and clearly establish the link between sound waste management, and the prevention of plastic waste reaching our oceans"

FROM THE ISWA PRESIDENT

Marine litter is becoming a global challenge similar to climate change. Not only regarding its vast health and environmental impacts, but also because marine litter, exactly like climate change, is the global result of our local actions and inactions.

Our oceans are already the biggest dumpsite for million tonnes of used plastics per year. But, the visible plastic pollution, so usual in almost every shoreline in the world, is a relatively small problem in comparison to the invisible microplastics.

Microplastics are becoming an 'integral' part of marine ecosystems. Apparently, they can be part of the plankton's food chain, as recent research demonstrated. They are already present, in small but measurable concentrations, in several commercial salts and bottled water. They were identified in Marianna trench, the deepest and probably the most remote part of the planet, 11 km below the sea surface.

It seems that we are actually living in a multidimensional and continuously expanding plastic matrix. This is a key element that seems to be somehow underestimated in the relevant debate. Our dependencies have led to a conflict. On the one hand, we depend too much on plastics to get rid of them immediately. The pace of increase in synthetic plastics production and use has been exponential since 1950s and there is no sign of change. On the other hand, we, as humans, depend too much on our oceans to let them become 'plasticized' – laden with plastic fragments.

There is no silver bullet, but the urgent problem requires a rethink, not only about plastics, but about our economic models, development strategies and the future of consumption patterns.

In the meantime, better waste management and the shift to circular economy provide the best way to deal with this conflict. Investing in sustainable recycling and waste management systems is the best way to prevent marine litter. It will also provide the necessary time for shifting the supply chains of plastics towards circular economy.

This is why ISWA will make marine litter a key-element of its activities for the next years.

This report is just a key milestone in an effort to build a global partnership, able to identify and enable the implementation of the most appropriate preventive solutions for keeping plastics out of our waterways, rivers, seas and oceans.

Along with our existing supporters, we urge and invite you to align forces behind this effort facilitated by the International Solid Waste Association's Marine Litter Task Force, developing disruptive, yet effective, solutions – now!

Antonis Mavropoulos
President, ISWA

PREFACE

Welcome to our report on how to prevent marine plastic litter – now! It arrives at a critical moment in history where the global community decided to stand firmly behind a series of Sustainable Development Goals (SDGs), aiming at a better future for the entire humanity and the planet. Indeed, the work intersects major global challenges: how to minimise and eventually stop marine litter (part of SDG 14), whilst addressing the global crisis of inadequate waste and resources management for all (part of SDGs 11 and 12).

The case for marine litter is already well made, as it is for a circular economy. Many initiatives, from local to global, are gaining momentum. Our report casts new light on these issues, outlining how sound waste and resources management around the World, and in particular in low-income countries, can make a major difference in mitigating marine litter, achieving tangible effects within the near, rather than distant, future – hence, our focus on "Now!".

Plastic, the most successful material of our times, delivers unprecedented functionality and value to our lives. However, it is also the dominant material in marine litter. The resources sector knows well the major challenges associated with capturing the value embedded within plastics, whether as an engineered material or as a fuel. Indeed, the material that is the most successful example of closed loop recycling, the clear PET water bottle, is also an abundant type of marine litter - a paradox and a major systemic failure. It is such systemic failures we focus upon here.

A lack of infrastructure and unsound waste management practices in low-income countries is the key failure. If the 2 billion people without access to sound waste collection keep dumping their waste, much of which goes directly into aquatic environments, we will never be able to eliminate the marine litter crisis. And if the plastic waste is not captured upstream, before it fragments, it will eventually transform into innumerable micro- and nano-particles, which will be well beyond our abilities to control.

We therefore argue that, to complement all other major practical and policy efforts, the international community should join forces and concentrate on supporting the solid waste and resources management sector in its efforts to intercept the marine litter upstream, preventing the generation of marine litter in the first place. The sector is ideally placed, and possesses the necessary knowledge, skills and hands-on expertise, to deploy and operate the missing critical infrastructure. But such a massive undertaking cannot be achieved alone – cross-sectorial and intra-disciplinary solutions are needed – and we are here to enable them by assuming a cross-linking role.

In our report, we do not provide definitive answers on each and every aspect of plastics marine litter – our aim is to substantiate a bold statement: that the waste and resources recovery sector has a key role to play in addressing this global challenge, through raising awareness of the need for effective waste management for all, by sharing and exchanging expertise, and co-creating solutions with all stakeholders, at a local level. Join us – the moment is now!

Dr Costas Velis
University of Leeds
Leader, ISWA Marine Litter Task Force

EXECUTIVE SUMMARY

Marine litter damages ecosystems, and marine-based economic sectors such as tourism and fisheries. It also impacts upon other aquatic environments that are vital for human societies, such as rivers. The extent of marine litter is now global, with plastic particles having been detected in all of the world's oceans - even the most remote and untouched environments. And it has entered the food chain.

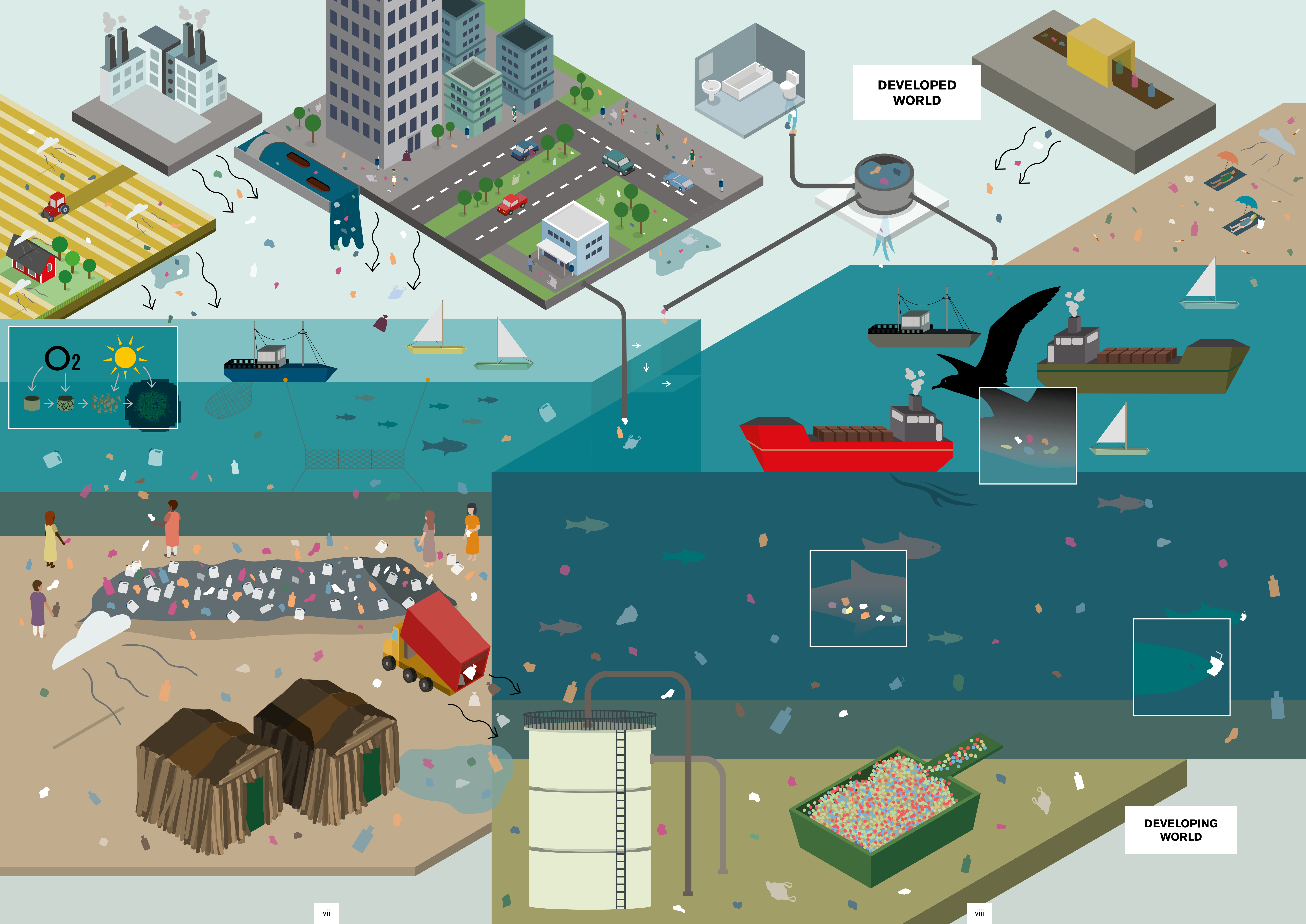
A global systemic challenge

Plastic marine litter is a challenge of planetary scale and implications. It is associated with four key systemic failures, which relate directly to the waste and resources management sector:

- Poor or absent solid waste management services and infrastructure (mainly in low-income countries), and insufficient monitoring & law enforcement (mainly in high-income countries).
- Problematic and vulnerable markets for secondary plastics, resulting in poor and very fragile incentives for material recovery.
- Lack of a systemic and in-depth understanding of:

  a. The technical challenges and the restrictions of material properties and the flows of plastics.
  b. The effects of social consumption patterns and littering behaviours on solid waste generation.

Plastic marine litter is another reminder, alongside climate change, of the serious global impacts that are 'generated' by millions of local inappropriate actions and inactions. In this respect, plastic marine litter provides an opportunity to demonstrate and make easily understood the impacts of improper waste management and the urgent need for a shift to a sustainable circular economy.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DEVELOPING WORLD

Can we control the sources of marine litter?

The majority of marine litter originates from unsustainable waste management practices, particularly in low and middle income countries. Sound solid waste and resource management is the only major effective prevention. It has the potential to significantly reduce the quantities of plastics released into the marine environment.

Why intervene upstream at macro-plastic item level?

The bigger plastics waste items are a huge pool of future microplastics – after being degraded they cannot be effectively intercepted. Preventing the leakage upstream is the best place to take action.

Plastic litter undergoes transformations both before and after entering the marine environment (i.e. large plastic items fragment into smaller pieces) and is transported to places well beyond its source (e.g. into ocean gyres or the coastlines of other countries). As it is not readily biodegradable, it persists and interacts with its environment, absorbing and adsorbing persistent organic pollutants (POPs) from the aqueous environment. The smaller and smaller fragments carry these pollutants to new environments and transfer them into living organisms and potentially into the food chain.

How does the solid waste management sector relate to interception points at generation hotspots?

The solid waste management and resources sector relates to all major sources and hotspots where interventions can be planned and implemented.

The key land-based sources of plastic marine litter are numerous. It includes plastics leaking into the environment as a result of uncontrolled dumping of waste from municipal sources (organised and unorganised dumping, fly tipping) – a significant problem in low-income countries, with direct dumpling into rivers or at/by the sea. The other key land-based source is littering by members of the public (e.g. through tourism, major public events, or in busy areas of cities). There is even some limited escape of plastics from existing waste management activities during transport, handling, treatment or disposal. Sustainable solid waste management also has a role in controlling other major sources and hotspots. Wastewater treatment related flows, if effectively intercepted at treatment plants, are eventually handled as biosolids in solid waste treatment plants. Lastly, control of maritime sources of marine litter (fisheries, shipping sectors (including cargo and leisure), recreational activities) also depends on provision of convenient and affordable solid waste management facilities.

How can we know that relevant policies are suitable and work?

Polices to combat and eradicate marine litter can be effective only if they are informed by good monitoring information on solid waste and resources management systems across the world.

There is still considerable uncertainty about the sources, pathways, transformations and final fate, especially at local/ regional level. This gap in knowledge affects our ability to devise effective mitigating policies. To monitor progress, better data will be needed on waste management systems and on the sources, pathways and fate of micro- and macro-plastics.

So, what should we do?

The waste and resource recovery sector has a key role to play in addressing this global challenge by sharing expertise, and creating solutions together with all stakeholders at a local level.

Marine litter is an issue that requires a global response from policy-makers, practitioners and the wider public. The waste management sector can significantly contribute with:

- **Technologies:** The sector has cost-effective technologies to deliver sustainable waste management systems that will prevent marine litter.
- **Knowledge:** The sector's thousands of companies and organisations have extensive knowledge and working experiences of applying successful waste and resource management in all contexts.
- **Experts:** The sector's hundreds of thousands of professionals cover a wide range of skills and expertise, including engineering, chemistry, social science, logistics and behaviour change.

So, what we should do? The following list provides the key elements and a call to action.

Call to Action for Effective Wins

Priority action is needed now to rapidly address the issue. Intervention will also be needed in the medium and long term to fully address the issue of marine litter and its causes.

Marine litter and the Sustainable Development Goals (SDG).

Goal 14 is to protect life below water. One of SDG 14's component targets is to prevent and significantly reduce marine debris. This cannot be achieved without implementing effective waste and resource management for all, which is also a key requirement for achieving SDG 11 (creating sustainable cities and communities) and SDG 12 (achieving responsible consumption and production).

ACTION AND RESULTS NOW

Investing in effective waste management in low-income countries is likely to represent the most cost-effective and immediately practicable solution to reducing marine litter in the short term. Sound waste management practices are the key to preventing and reducing marine litter. However, there is no on-size fits all solution. Actions need to be tailored to local situations.

We need to significantly reduce the 'leakage' of plastics into the environment by intervening at the source. This will require action to:

a. **Prevent uncontrolled dumping by providing collection services for all.** Dumping of wastes causes significant environmental, social and economic impacts, particularly for low income communities. It is estimated that over 2 billion people globally still do not have access to adequate waste collection services. These needs to be provided as a matter of urgency.
b. **Prevent littering and stop fly-tipping.** Waste items dropped by people 'on the go' or at major events/ gatherings are a key source of plastics that escape into the marine environment. Reducing littering will require proactive engagement with communities, public awareness-raising, and an enhanced understanding people's needs and behaviours.
c. **Close dumpsites and provide waste treatment and disposal facilities for all communities.** It is estimated that over 3 billion people globally still do not have access to appropriate disposal facilities.
d. **Work with the maritime sector** to establish effective take-back systems for recovering waste and recyclable materials from the fishing, shipping and touristic activities.

To prioritise, design and implement effective solutions, it is essential that we identify and address key gaps in knowledge.

Our understanding of the issue has increased significantly over recent years. However, a detailed understanding is lacking on many key aspects associated with plastics marine litter.

The flows of plastics in the environment are complex. Current estimates of quantities and sources are based on simplified assumptions and poor-quality base data of very low spatial resolution. Proper sets of indicators are not well established and they are not available for policy and decision-making support.

Many factors influence the release, movement and transformation of plastics. We need to understand these issues in far more detail so as to understand the most effective interventions to make. For example, macroplastics represent a huge pool of potential microplastics, but our insufficient understanding of the process of macroplastics fragmentation, and inability to control their multiple sources, are part of the reasons why recent emphasis has been on the engineered microplastics beads, rather on fragments generated from macroplastics.

MID-TERM ACTION

Capturing and enhancing the value of waste plastics. The waste and resources sector understands the challenges surrounding value retention. Action will need to include developing effective collection systems that maximise and stabilise the value of secondary plastics. These systems will need to consider specific social and market conditions of each municipality and region.

Properly functioning markets for recycled plastics. We need a fundamental move away from the current push markets (i.e. collecting more waste for recycling than markets require) to pull markets, driven by sufficient demand. We need to address issues associated with global supply chains and social and environmental justice, and reverse the often unfair competition with primary raw materials. Only then will littering/dumpling and therefore wasting used plastics becomes unthinkable. Better data and information sharing on waste and recycled materials at all stages of their use and end-of-life cycle can enable properly functioning, stable markets for secondary plastics.

Energy recovery and thermal processing: There will be considerable part of plastics that, after first use or cascades, may remain or become unsuitable for a genuinely sustainable materials recovery. It is important that the energy value of this fraction is captured through efficient and well-operated energy from waste plants or quality assured solid recovered fuels.

LONG-TERM ACTION

A step-change from the linear use of plastics to a sustainable and proven circular and cascading system is needed. We need to move from the current situation, where the majority of plastics are used once - with much of the material escaping the system - to a system based on the principles of sustainable and effective circularity and clean material cycles, where plastics are collected and cycled back into the system as valuable raw materials. This will require action on many fronts. The generic case has been widely made, but a more detailed and operational approach needs to be developed.

We need to address the issue at the very beginning: Innovate and invent at the materials, design and processing level. Priority actions could include reducing (i.e. rationalising) single-use items as a matter of priority and developing materials and designing products for recyclability and value retention after the use phase. This requires a new innovation model that goes beyond cost-effectiveness, functionality during useful life time, and narrowly defined utility needs to one that incorporates complex value. This will require a radical shift from today's practices, based on a cross-sector and intra-disciplinary scientific collaboration.

The Partnership

ISWA is determined to work in close collaboration with the international community, the local stakeholders and each individual motivated citizen around the world to implement effective and permanent solutions.

ISWA, through the Task Force, will:

- **Identify and share best practices** on how the sector can offer preventative upstream solutions in different socioeconomic contexts.
- **Contribute to addressing the knowledge gaps in identifying intervention hotspots,** based on understanding the generation, flows and transformations of plastics marine litter.
- **Actively participate in other major efforts and international fora,** including being present in major international events.
- **Assess the level of investment needed:** Align efforts to obtain a detailed understanding of the levels of investment needed in solid waste management infrastructure to combat plastics marine litter.
- **Create a platform** that facilitates the necessary links, and organisational relationships to enable actions and solutions through transfer of knowledge and expertise worldwide.

The Partners, through the Task Force, will:

- Endorse the ISWA MLTF vision.
- Join the Advisory Board of the Task Force.
- Support delivery of outputs and dissemination.
- Invite ISWA to be represented and participate and inform your own initiatives.
- Cocreate with ISWA localised solutions.

CONTENTS

1 INTRODUCTION

INTRODUCTION

The case for action on marine litter has been well-made [1]. Whilst there are still many gaps in our understanding of the issue, the evidence base on marine litter is growing. It is clear that a significant quantity of waste plastic is escaping into the aquatic environment, where it is causing long-term damage, affecting ecosystems, entering the food chain, and having a substantial negative impact upon the tourism and fisheries industries. This paper does not seek to reiterate the case for action on marine litter. That case has been made effectively and at length by many researchers, practioners, policy makers and activists.

Here we present a new reading of the evidence and propose a reorientation about where the focus of our immediate and concentrated efforts should be. In particular, this report explores how the waste and resources management sector can tackle marine plastics. The sector has a key role to play in significantly reducing the leakage of plastics from the system into the marine environment and enhancing the value of waste plastics so that it can be cycled back into the system as a valuable raw material.

Section 2 of this document presents an overview of our current understanding of marine litter issues in terms of its sources, pathways, transformations and fate. Section 3 summarises priority intervention points for tackling marine litter and Section 4 presents the Task Force's proposed next steps.

2

SOURCES, PATHWAYS, TRANSFORMATIONS AND FATE OF MARINE LITTER

INTRODUCTION

It is estimated that between 4.8 and 12.7 million tonnes of waste plastic was released into the marine environment from costal populations in 2010[2]. A further 1.2 to 2.4 million tonnes (Mt) of plastic is estimated to reach the oceans from inland sources via rivers[3]. To put this in perspective, approximately 380 Mt of plastic resins and fibres were produced in 2015, of which about 275 Mt is thought to have become waste[2] suggesting that if the quantity of plastic leaking into the ocean has stayed relatively constant then, at the very least, 2% by weight (wt.%) of total plastics production is 'leaking' into the environment each year.

Due to the poor quality of underlying data and the necessity to make a number of simplifying assumptions, these figures can only be considered to be order-of-magnitude estimates. They also do not include waste plastics from industrial and maritime sources and primary engineered microplastics (e.g. from cosmetics). Marine litter originating from the maritime sector, for example, is often cited to comprise on average roughly 20% wt. of total marine plastics, with the balance of 80% coming from land-based sources. However, it is important to note that this is based on expert opinion rather than any empirical analysis[4]. Overall, the scientific community has an incomplete understanding of the sources and flows of waste plastics into the environment and, in particular, implications of material properties, consumption patterns and littering behaviours on solid waste generation, and the transport mechanisms and transformations once it has entered the environment.

Notwithstanding the uncertainties surrounding these estimates, waste plastic is clearly widespread in the marine environment. Plastic debris represents 50 to 80% of shoreline debris[5] and plastic items are commonly recorded as some of the most common items collected during beach surveys and clean-up efforts[6]. The detrimental impacts of waste plastics on marine ecosystems and the fisheries and tourism sectors is widely documented[7],[8].

2.2

SOURCES

2.2.1 Overview

Land-based sources of plastic marine litter are numerous and include both direct littering and dumping of waste by those who generate it (e.g. householders, members of the public and businesses), as well as the release of plastic particles via wastewater and effluent. With respect to waste and resource management, the key sources are:

- **Littering by members of the public**, either in their day-to-day activities or as a result of recreational activities (e.g. tourism or major public events). Littering is common in all parts of the world, irrespective of income level.
- **Uncontrolled dumping of waste from municipal sources.** Uncontrolled dumping, also often referred to as mismanaged waste, fly-tipping or illegal dumping, refers to the disposal of wastes outside of a system for collecting the waste and managing it in a way that protects the environment and human health. Uncontrolled dumping is common in low and lower -middle income countries where there are insufficient waste collection systems, particularly in unplanned areas of rapidly urbanising areas[9], [10].

Other potential sources of marine litter include: release of plastics from agricultural and horticultural activities, particularly polyethylene films which are used extensively in both the livestock and horticultural sectors; leakage of plastics particles from industry in the form of leakage of pellets from plastic manufacturing; and potentially leakage of plastics from the waste management system itself, particularly where illegal and unregulated waste management activities are taking place in poorly regulated systems.

Furthermore, there are also several sources of plastic in the marine environment that, whilst they have a land-based source, predominantly make their way into the marine environment via wastewater, including: sanitary items and consumer products; synthetic fibres from washing clothes; and particles generated by road vehicle tyre wear. Albeit, some of these elements might be captured and then enter the waste management system at a later stage (for example, sewage treatment plants might capture sanitary items which are then removed for disposal within the solid waste management system).

Maritime sources of marine litter comprise wastes from the fisheries and shipping sectors (including cargo and leisure) and recreational activities. Items include equipment from the fisheries sector (e.g. redundant nets) and wastes generated by shipping activities, including municipal-type wastes.

2.2.2 Uncontrolled dumping

The deliberate disposal of wastes by householders and business into the environment is still widespread globally especially in the developing world. Furthermore, illegal dumping of waste by rogue waste operators still occurs throughout the developing world.

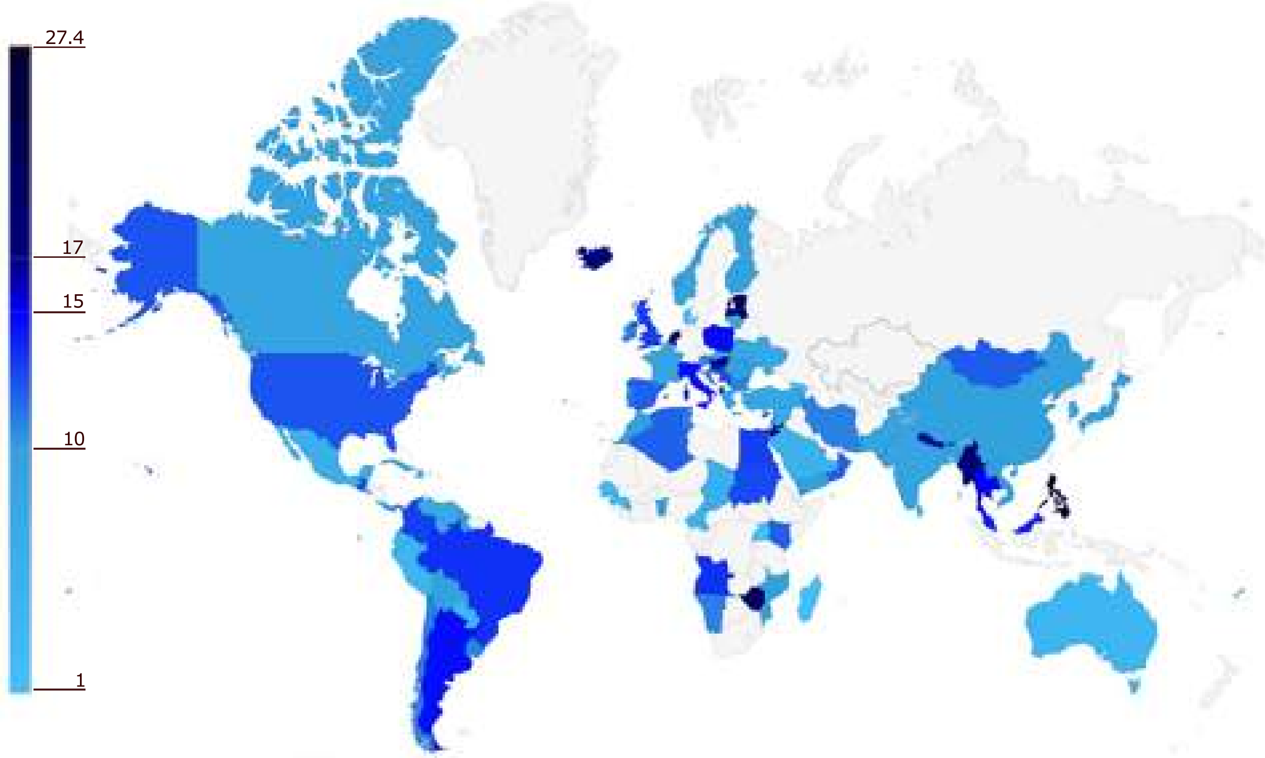
The degree of uncontrolled dumping of wastes by householders varies dramatically between, and also within, countries, cities and towns. It is a critical issue in low and middle-income countries where collection systems for waste may be inadequate, leading to householders having no option than to dispose of their waste by dumping in a location within or close to the community.

Whilst litter is a more critical issue in terms of sources of marine litter in high and middle-income countries, uncontrolled dumping still takes place. It is often associated with illegal waste activity and lack of effective regulation, than the absence of appropriate waste collection systems.

River banks, waterways and open drains provide a convenient location to dispose of waste so are commonly used for uncontrolled disposal and are often chosen intentionally in order to allow the wastes to be transported away by water flows. For example, in the case of the Aboabo River in Kumasi, Ghana direct dumping into or near the river represents almost 45% of the households' waste disposal practices[13].

Generally, the level of uncontrolled dumping in any specific community is related to its wealth, with areas of higher wealth less likely to dump wastes[17]. Where there are not adequate waste collection systems, uncontrolled dumping of solid waste into watercourse is common[18]. As such, uncontrolled dumping is much higher in low and lower-middle income countries and, in particular, in the informal and unplanned areas of cities. However, it is also important to recognise that the composition of municipal wastes in poorer countries has a relatively high organic (leaves, peelings, etc.) and low plastic content[19]. According to Waste Atlas, plastic waste in these economies comprises around 1-7% wt. of the total waste. Other studies show a slightly higher proportion ranging from 7% in low income countries to 12% in high income countries[9].

Percentage of the plastic fraction in the country's waste composition[20].



As a result, fast developing economies are the ones associated with the greatest quantity of plastic leakage into watercourses and the marine environment. Rapid population growth in countries such as China, Indonesia and Brazil, coupled with the increased consumption of disposable goods due to a growing middle class, has led to an increase of plastic waste in the municipal waste stream. Where the coverage and capacity of waste management systems has not kept pace, environmental pollution by plastic wastes has also dramatically risen.

Whilst uncontrolled dumping is relatively common in low and lower middle-income countries, it is certainly not a phenomenon that is restricted to less developed economies. Illegal dumping is also widely reported in transition and developed economies and is considered a criminal activity.

Type of Plastic Inputs: *Food packaging (wrappers, containers etc.), plastic bags and PET bottles, small plastic fragments, household and consumer goods from plastic may potentially dumped into the marine environment (plastic chairs, toys, plastic car parts, etc.)*[20] [21]

2.2.3 Littering

Littering by members of the public, either as part of their day-to-day movements or during specific leisure activities, is a key source of plastics that eventually find their way into the marine environment. It is a global phenomenon but is more critical in this context in the developed world. Uncontrolled dumping is a more critical issue, in relative terms, in low-income countries.

Hotspots for litter deposition tend to be areas where people congregate or pass through in large numbers. For example, rivers and coastal areas are popular places for leisure activities and public events. Other public areas, such as recreational parks and carparks, and areas where large numbers of people gather or transit through (e.g. train stations) are key hotspots for litter deposition. If not collected, these littered materials often enter drains and, in due course, streams and rivers[11]. They may also be blown directly into rivers or, in the case of coastal areas, directly into the sea.

However, the factors that affect the proportion of litter items that ultimately reach the marine environment are complex. Litter hotspots in urban areas will depend upon a mix of consumer behaviour, levels of deprivation, population density, traffic levels, the location of public events, and the number of visitors to different areas. A recent extensive study undertaken in Australia indicates that littering tends to be greater in areas that people transited through (e.g. retail parks, parking areas and shopping centres) rather than areas that people tended to spend time in, such as residential areas. Quantities of litter also tended to be lower in areas where people placed an amenity value on the area, such as a beach. This suggests that beaches themselves, whilst clearly directly associated with the sea, are not the dominant source of marine litter[12].

Consumer behaviour is a critical factor that determines how much, and the type of, material that is deposited on the ground and has the potential to enter the marine environment. A number of studies have suggested that litter attracts litter, indicating that once the local environmental quality of an area is affected by the presence of litter, this has a tendency to become worse. Litter is also linked to other local disamenities such as graffiti, uncontrolled dumping and dog fouling[13].

The extent and efficacy of waste collection systems, including the number and suitability of public bins and street cleaning operations, will also determine how much material is prevented from escaping into the wider environment. For example, key public spaces that experience high levels of littering but have regular street cleansing services may pose a low risk. Conversely, areas with lower numbers of people passing through but also a lower regularity of cleansing services (e.g. more deprived areas of cities) may actually experience higher levels of litter material and pose a greater risk of marine litter.

Type of plastic inputs: *Food wrappers, containers, plastic bags, plastic cups, plastic straws, PET bottles, and other plastic litter* [11], [14], [15].

2.2.4 Fly-tipping

In the UK fly-tipping is a significant cause of environmental damage[18]. The costs to local authorities to remove flytipped wastes in 2015/16 were £49.8 million [22]. In 2015/2016, there were a reported 936 thousand cases of fly-tipping incidences in England in 2015/16, two thirds of which are related to waste from households[22].

Fly-tipping is the illegal dumping of waste without a waste management licence and in is a criminal offence punishable by a fine in many developed countries. The size of plastic waste disposed this way may vary from one plastic bag of waste, to plastic chairs, tables and even plastic car compartments.

Type of Plastic inputs: *plastic bags, bulky household and consumer fgoods from plastic etc.* [23], [24]

2.2.5 Escape of plastics from mismanaged solid waste management activities

Although the role of waste management is aimed at controlling and managing waste and recovering resources, some plastics can unintentionally escape during transport, handling, treatment or disposal. Furthermore, illegal dumping of waste by rogue waste operators still occurs throughout the world, in low, middle and high income countries.

Waste management involves the movement of high volumes of waste materials from households, businesses and institutions to treatment and disposal facilities. Even as part of well-organised collection systems of high-income countries, accidental spillages may occur at collection, transportation or disposal sites; of interest here are particularly those close to watercourses[25]. Clearly, poorly managed waste management facilities are likely to have much more potential to be a source of marine litter, allowing materials to be transported away from the site via wind or via water runoff[26].

Materials that escape during waste collection and transportation may have a similar effect to littering. However, there can be also leakage of plastic during treatment of waste and the processing of secondary materials.

2.2.5.1 Engineered Landfills

In landfills, as opposed to dumpsites, waste is disposed of in specifically designed infrastructure that involves environmental pollution abatement equipment and where operational practices and waste control are carefully implemented[27]. For example daily cover of freshly placed municipal solid waste at an engineered landfill facility is intended to control various health and nuisance factors and prevent material being blown or washed away by wind and surface run offs respectively.

Nevertheless, in transition countries landfills planned as controlled engineered sites can end up being mismanaged. At such dumpsites (e.g. missing cover soil material) light plastic waste could escape through wind or runoff, as explained above, and be released to the surrounding environment. Also leachate, when not properly managed, could release micro-plastics that can enter waterways. Especially, when landfills are located in a high rainfall country, a production of leachate and surface runoff might be expected to escape into waterways[28].

2.2.5.2 Organic waste treatment

Compost, digestate and sewage sludge that results from the treatment of biowaste of municipal origin as well as wastewater treatment residues are often contaminated with macro- and micro-plastics impurities, which depend upon the source of the waste stream (e.g. plastic bags, undigestable / uncompostable food packaging mixed in food waste streams, or sanitary items from wastewater)[29].

Most organic waste treatment plants are equipped with extensive mechanical processes (pre-treatment and post-treatment around the biological reactor) to remove and the safely dispose of any contamination. However, the effectiveness of the equipment varies and in practice, sorting limitations can leave some impurities in the material that goes on for further treatment or on-land application.

In the European Union (EU), fertilizer products based on organic waste must meet quality standards, i.e. demonstrate compliance with the requirements of the fertilizer trade regulation in order to get into the market. The regulation requires that foreign objects (e.g. glass, metal, and plastic) in fertilizer products made from organic waste over 4 mm in size should not exceed 0.5% by weight of the dry matter product[29]. However this is not the case in all countries around the world. Further post-treatment processes for compost and biogas digestate can be applied to remove any impurities left to treated organic material, but implementation also depends on costs.

2.2.5.3 Plastics recycling facilities

Usually, all plastic recycling facilities have a system for sink/ float sorting of plastic waste according to the specific gravity of different plastic types. It is assumed that waste water of these facilities contain plastic items or particles from the rough washing and/or agglomeration processes. Also light plastic pellets can be lost in the environment during the process or storage phase and transported by wind and/or surface runoffs to different waterways. Leakage from mismanaged plastic recycling facilities could be the case either in low-income countries or in high-income countries.

However, the problem is greater in countries of low-income countries, where plastic is recycled mostly in small scale reprocessing facilities, that may not operate to stringent standards, taking advantage of poor levels of law enforcement of national environmental policies.

For instance, in China some of the imported and domestic plastics may end up at low-tech, uncontrolled plants. While there are many large licensed reprocessing facilities, the industry is dominated by small family-run enterprises. The size of these smaller companies allows them to develop highly specialized, niche services, making them the go-to destination for specific recyclables. Further, their business costs are far lower than licensed facilities because they are often looser with safety and environmental concerns. Licensed companies must responsibly dispose of excess nonrecyclable waste, while unregulated firms burn anything that cannot be recycled or dump them in improvised dumpsites. These unregulated practices pollute heavily and often destroy local land and waterways while introducing serious health issues to workers and their communities. Open burning or dumping of unrecyclable plastics residues is the normal case[29],[30].

2.2.5.4 Paper recycling

Paper recycling factories receive large amounts of paper, cardboard and corrugated board, which may contain plastic elements that have the potential to leak into the environment. For example, measurements of the outlet of a Dutch paper recycling plant demonstrated high concentrations of plastic content. Based on Dutch effluent measurements this was estimated to result in the release of microplastics of 60 t/year in 700,000 m^3 waste water[32]

2.2.5.5 Food waste shredders

Food waste shredders installed into kitchen sinks on ships and in institutions, used to grind food waste before disposing of it with wastewater, are popular in some countries. There might hence be a risk that plastic film and food wrapping follows the food waste through this maceration, and is then released as macro or microplastics[29].

Type of plastic inputs: *waste plastic items and materials of all types, including plastic pellets.*

2.2.6 Industrial sources

The industrial sector is a key source of microplastic litter items in the marine environment[33]. The litter generated by the industrial sector primarily comprises resin pellets, the virgin material used within the plastic manufacturing process [34]. These materials can become marine litter during disposal or transport [25].

Industrial micro-plastics can make up a surprisingly large percentage of the total load of plastic in rivers and the marine environment, particularly in industrialised countries in Europe and North America, but also fast growing economies in Asia. Industries such as the automotive, furniture, clothing and large packaging manufacturing companies are thought to be key sources of microplastics in the marine environment. 86% of the Danube River's plastic load originates from the activities of plastics manufacturing and processing companies operating near the banks of the river[35].

Types of plastic inputs: *microplastics*

2.2.7 Agricultural and horticultural sources

Plastic materials used in agriculture and horticulture, plastic particles contained in sewage sludge and compost from municipal sources are all potential sources of marine microplastics.

In agriculture and horticulture, polyethylene films are used extensively to increase yields, extend growing seasons, reduce the usage of pesticides and herbicides, and help conserve water[36]. These plastics comprise about 80% of the agricultural plastic waste.

Some plastic wastes, such as films for tunnels and greenhouses, can be successfully collected and recycled. Other thin film applications, such as mulch films, the plastic waste collection is more difficult due to contamination by soils and crop residues [37]. Farmers facing high landfill taxes to dispose this type of plastic, along with the difficulty to collect it, may prefer to bury these materials on farm or to dump them into rivers and other waterways [38]. Furthermore, a significant part stays in the fields and fragments, generating microplastics that end up in rivers with water runoff[37].

Application of sewage sludge in agriculture as a fertilizer may introduce large quantities of microplastics that originated in sewerage and has become part of sewage sludge. In Europe and North America approximately 50% of this sludge is reused as fertilizer. According to Statistics Norway, about two thirds of the sludge in the country is reused in this manner[39].

Nizzetto et al. estimate that between 110,000 and 730,000 tonnes of microplastics are transferred every year to agricultural soils in Europe and North America, comprehensively [36]. This is more than the estimated total burden of microplastics currently present in ocean water. Their studies, based on simulation modelling, indicate that meteorological conditions and river characteristics have a strong influence over the export of microplastics from agricultural soils and their transport via rivers to the ocean[39].

Macro and micro-plastic fragments shed from plastic-coated paper products and other plastic that are present in finished compost may disseminate into the environment through the application of compost to soils. These micro-plastics will eventually migrate into other land and aquatic ecosystems through wind and surface run-off[40].

Types of plastic inputs: *Irrigation plastic pipes, pots, plastic mulch and other plastic films/sheets from agricultural have been reported as sources of riverine plastics*[38] [41].

2.2.8 Fisheries and shipping in waterways

Whilst estimated to be a relatively small source in comparison to other sources, river fishing-related items from both recreational and commercial fishermen (e.g. nets, fishing line and bait boxes) have been found in rivers and are thought to make their way into the marine environment.

During the Grays Harbor/Chehalis River Derelict Fishing Gear Removal Project in 2011 a total of 50 derelict nets were removed from an area of less than 2000 m2[39]. In both years almost half of the lost fishing gear was collected near the harbour (i.e. in transit to the marine environment). Net filaments from recreational fishing have also been reported in the Po and Rhine rivers[30].

Furthermore, shipping and boating activities that take place on rivers may directly dump waste into the water bodies. Materials are likely to include industrial packaging, strapping, plastic containers, and plastics from municipal-like sources. However. data on this as a source is very limited.

Types of plastic inputs: *nets, fishing line, bait boxes from fisheries; industrial plastic packaging, strapping, plastic containers etc. from shipping.*

2.2.9 Sanitary items and consumer cosmetic products

Plastic items and microplastic beads from cosmetics are commonly flushed down toilets, but much of this materials passes through waste water treatment systems and escapes into river and marine environments.

Some of these particles are too small in size to be captured at wastewater treatment plant (WWTPs) [43],[44]. Where facilities exist, larger items would normally be captured by waste water treatment. However, materials can bypass systems and enter waterways when rain levels exceed sewage treatment facility handling capacities[45].

One example where this is particularly common is in Brazil where rainfall levels are high and/or treatment facilities are lacking[22]. Other examples of surveyed cases include the East Lyn River in the UK where survey data indicated that 2% of the litter was of sewage related origins[23]. Also in the case of the largest Welsh river, some 22% of the litter surveyed comprised feminine hygiene products[23].

In a study of over 1000 people in Ireland, 3 in 10 admitted to flushing such items down the toilet. Of these, 58% admitted to flushing baby wipes down the toilet, 40% facial wipes, 26% cotton bud sticks, 24% tampons and 21% cigarette butts. More than half of those who flush these items down the toilet did so simply due to a lack of knowledge of the impacts they would cause.

Types of plastic inputs:

1. ***Macroplastics:*** *Sanitary related macroplastic litter from sewage consists of sanitary towels and backing strips, tampon applicators and residue, cotton bud sticks, facial scrubs, and condoms[11],[46].*
2. ***Microplastics:*** *Similar problems arise when microplastics are used within everyday life, such as cleaning synthetic clothes or using facewash with microbeads[47]. These materials are too small to be eradicated during wastewater treatment and remain within outflow water [47].*

2.2.10 Synthetic fibres from washing clothes

Microplastic fibres generated by washing synthetic textiles in washing machine effluent are often not captured by waste water treatment plants (WWTPs) and so are released into river surface waters or the sea[48]. According to Plymouth University, in the UK each cycle of a washing machine could release more than 700,000 microscopic plastic fibres into the environment[49].

These microfibres pass through domestic wastewater into sewage treatment plants where some of the tiny plastic fragments are captured as part of sewage sludge. The rest passes through into rivers and eventually, oceans. Research has shown that wastewater treatment effluent is a source of plastic fibres to marine sediment[43], fibres and particles to coastal waters[47], pellets to riverine sediment[51], and pellets, fragments, and fibres to river surface waters[52]. A paper published in 2011 found that microfibres made up 85% of human-made debris on shorelines around the world[43].

Types of plastic inputs: *microfibres*

2.2.11 Micro-plastics from road vehicle tyres

Secondary micro plastic particles generated by road vehicle tyre wear are the largest single source microplastics[53].

This comprises particles of rubber dust from tyre wear (mainly <80 micrometers). Part of the dust becomes airborne, and some lands directly on the road or adjoining land. From there a proportion will enter surface waters or drains. An unknown proportion will be carried to the sea.[4] A study performed by nova-Institut GmbH in 2015 estimates that in Germany between 60,000 and 111,000 tonnes of microplastics are caused each year by abrasion of car tyres. The figure for Europe is between 375,000 and 693,750 tonnes. Thus, the debate on microplastics cannot ignore car tyre abrasion as a source. More investigation is required[54].

Types of plastic inputs: *particles of rubber dust*

2.3

PATHWAYS

2.3.1 Introduction

Plastic fragments primarily reach the marine environment through waterways, rivers (covering entire catchment areas) and storm/wastewater discharges (including storm waste and surface water drainage systems). Light plastics can be also carried by the wind into watercourses or directly to the sea, if discarded or deposited in coastal areas. A proportion of plastics from land-sources are also deposited directly into rivers and the marine environment through dumping on coastlines and, in some cases, directly into the sea.

Once plastics are in the aquatic system, transport mechanisms are complex and are currently poorly understood. The movement of a plastic item or fragment will depend upon a wide range of interrelated factors including geographical location, local meteorology and hydrodynamics, ecosystem effects, and the properties of the plastic itself. They can be transported over long distances before being deposited onto shorelines or settling on the bottom of the ocean[45] [55].

It is also important to recognise that a substantial proportion of plastics that enter streams and rivers do not reach the ocean, either accumulating within or on the banks of rivers and estuaries. These plastics also have adverse effects on the local environment and ecosystems, and the fisheries and tourism sectors. Depositional patterns of litter in rivers depend on a range of factors density of vegetation, watercourse obstructions and climatic conditions[56]. Movement and depositional mechanisms of plastic marine litter along rivers are not fully understood. Mobility studies with tagged items showed the complexity of mechanisms involved in the transport of litter to the sea[23], [57]. For examples, plastics may be ingested accidentally by freshwater fish[58], cleaned away or picked up by waste pickers[59], [60].

2.3.2 Rivers: both a hotspot and a pathway

Rivers are considered to be the main mechanism for transporting plastics litter to the marine environment and are also considered to be a final sink for a large proportion of plastic litter[7], [23], [61]–[65].

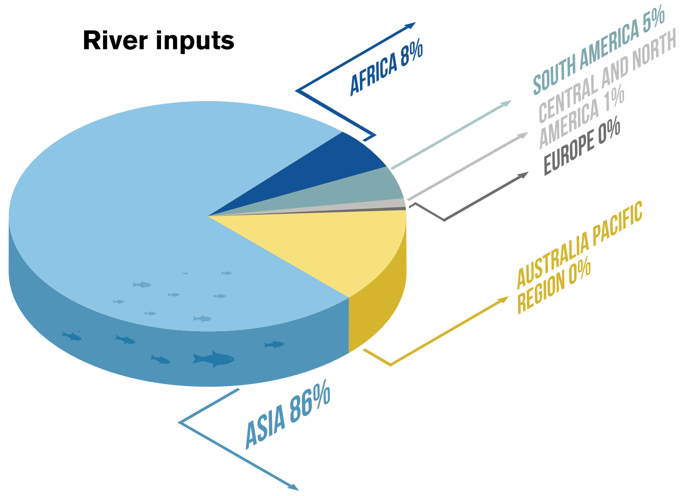
Over 50% of the world's population lives closer than 3 km to a surface freshwater body (i.e. river or lake), and only 10% of the population lives further than 10 km away[66]. Rivers have therefore played a key role in the development of cities and towns, but arguably urbanization has come at a high cost. Most urban rivers were channelled into canals and industrialization and increasing consumption patterns has led to further degradation, with waterways becoming dumping grounds for sewage, pollutants and other wastewater[67].

Studies show that most land-based litter is carried by water via rivers and storm-water[35], [68]. Large rivers in particular are considered a major pathway for land-based plastic litter reaching the marine environment. Thompson et al (2009) suggest that rivers can act as carriers for microplastic discharged from plastic industry[5] and Williams and Simmons (1996) estimated that some 80 % of the litter on the estuarine beaches of South Wales comes from riverine sources. How ever this estimation might be outdated and needs reconsideration.

Lebreton et al., 2017 estimate that between 1.2 and 2.4 million tonnes of plastic litter currently flows from the world's rivers into the oceans every year, and that inland rivers are responsible for around 48% of in-land marine litter while river systems within 50km from the shoreline accounts for 20%. The study uses a conservative approach that is based on plastics concentrations sampled from river surface waters in Europe, Asia, North and South America which do not consider very large and very small plastics items of fragments or fragments[3]. As such, Lebreton's estimate may be an underestimate.

The study indicated that almost 90% of plastic in rivers is actually flowing into 119 rivers crossing low income to upper middle-income countries around the world -103 rivers in Asia, 8 in Africa and 8 in South and Central America – representing 36% of global population. More specifically, Asian rivers are responsible for 86% of the total global input, 7.8% coming from Africa, 4.8% from South America 0.95% from Central and North America, 0.28% from Europe and the remaining 0.02% from the Australia-Pacific region.

River inputs

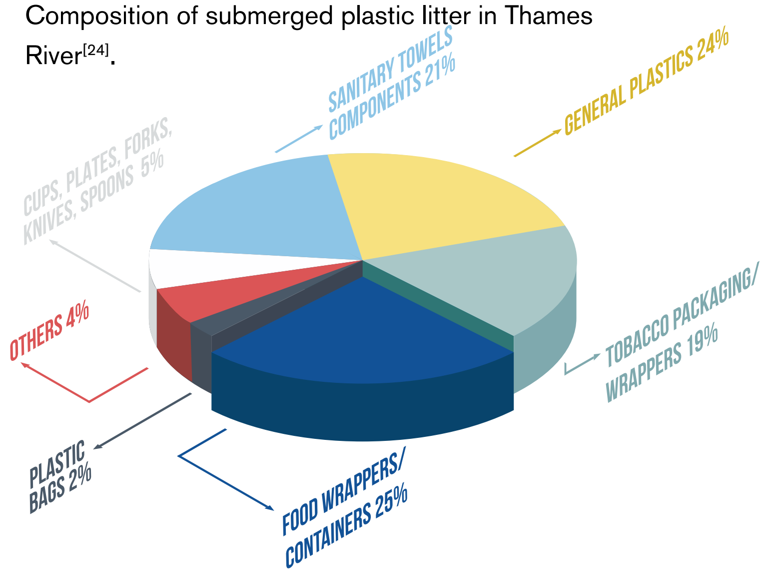


A considerably high-population density in Asia combined with relatively large plastic waste production rates and episodes of heavy rainfalls has resulted in this dominant contribution from the Asian continent. Over 74% of most of the release of used plastics from global rivers to the ocean takes place between May to October from Asia[3] during the East Asia Monsoon.

Land uses (e.g. residential, commercial or industrial) of the catchment area and stream area and the socioeconomic behaviours and activities are influencing factors that determine the composition of litter discharged within rivers[69], [70].

Litter items that are found in rivers can be whole objects, but mostly parts or fragments of products[24], [33], [70]–[73]. For example, a study by Morritt et al. (2014) reported on the composition of submerged plastic litter flowing down the River Thames, UK[24]. Packaging plastic waste accounted for nearly 45% while sanitary towels discharged with sewage accounted for 21%. The study findings on plastic litter composition are summarized in the following Figure.

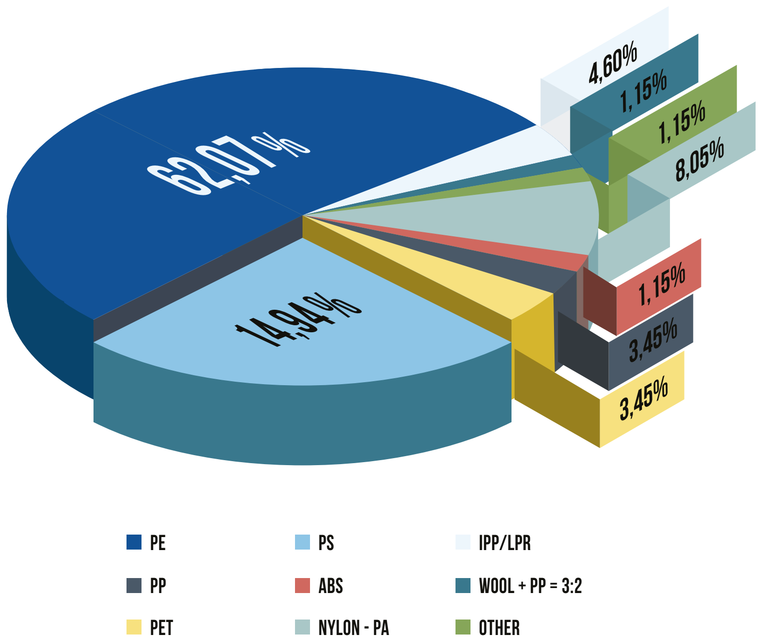
Composition of submerged plastic litter in Thames River[24].



Findings of another study in Brazil by Araujo and Costa (2006) indicate a similar pattern of plastic litter composition deposited on isolated beach along dry and rainy seasons cycle where food packaging and sewage related debris accounted for 48% and 17% respectively[74]. The majority of plastic items found were related to household activities. Three use-related categories - food, sewage/hygiene and house cleaning - were the most frequently found and accounted for more than 80% of total number of litter items.

Comparison of the content of plastic materials among European rivers for all plastic categories together shows that polyethylene (PE) is the most prevalent material in all rivers. In the Danube River the second most prevalent material is polystyrene (PS) and the third Nylon-PA. In the Po River the second most prevalent material is polypropylene (PP) and the third polyurethane (PU). The first and second samplings on the River Rhine have the same content of plastic material, which show that the second most populated material is PP and the third is PS. In the Dalålven River almost 40% of particles were not identified as plastic material. The most prevalent material PE is followed by Nylon-PA and PS.

Content of Plastic Litter in Danube River



2.3.1 Drainage systems and flooding events

Rainwater, particularly in urban areas, transports a wide range of waste materials into drains and waterway, and onward into rivers and the sea. Materials include street litter, municipal solid waste, and waste from dumpsites/ landfills [34], [71], [75], [76].

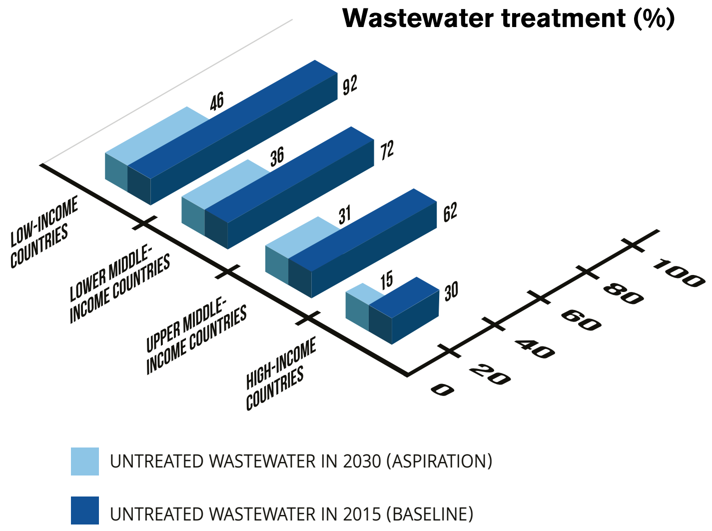
In communities without storm water drainage systems, plastic waste disposed on sidewalks and streets and in gutters flows directly into streams and rivers during rain events. This issue is exacerbated by flooding events which can serve to mobilise large volumes of waste material, including large volumes of waste material from dumpsites. In many cases, plastic waste may choke drains and cause serious flooding[77].

Flooding event in Lagos, Nigeria
(Source: Margaret Oshadi)

2.3.2 Sewers Overflow

During heavy rainfall episodes untreated wastewater can find its way into streams and rivers, either via combined sewer outfalls, or directly into the sea[48]. Where there are no waste water treatment plants sewage will pass directly into waterways[78].

Percentage of untreated wastewater in 2015 in countries with different income levels, and aspirations for 2030 (50% reduction over 2015 baseline) [79].



In the River Thames, there are 57 'combined sewer overflow' (CSO) sites which overflow approximately 60 times a year, resulting in approximately 39 million tonnes of raw sewage entering the watercourse. This has been identified as an extreme problem for the health of the River by the London Council, as well as being identified as being in breach of the EU Urban Waste Water Directive[80].

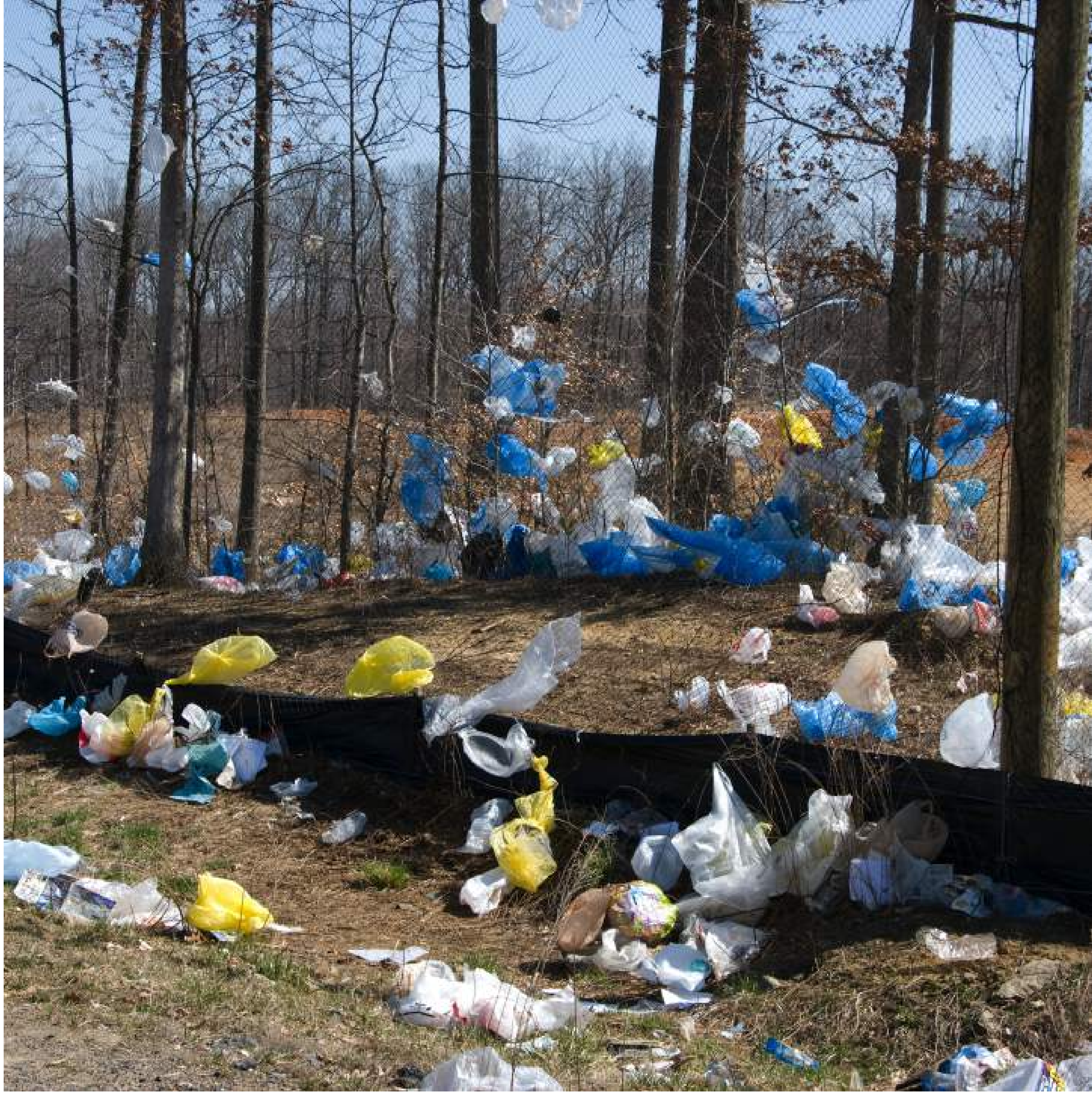
New York City has a combined sewer system. During storm events, rain falling within the Bergen watershed enters the storm drains and mixes with raw sewage in the sanitary sewer system. During heavy rainfalls, the combined sewage and stormwater overflow directly into the Gowanus Canal, discharging over 1.1 million cubic meters of combined sewage. Consequently, the Gowanus Canal remains listed on the New York State Section 303(d) list of impaired water bodies[81].

2.3.3 Wind blown litter

Due to the lightweight nature, plastics are particularly susceptible to being transported by the wind. This can play a key role in distributing plastic items, particularly bags and films, and transporting them into rivers or directly into the sea [73], [82]–[84]. Indeed, they often blow out of litter bins, landfill sites and other waste management facilities even after they have been collected. However, the surface tension of the water prevents them blowing any further [85].

2.3.4 Atmospheric Inputs

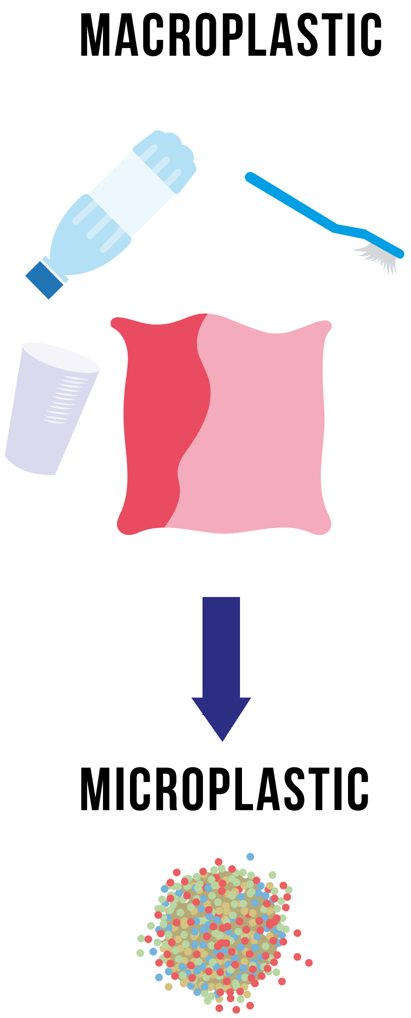
Some studies indicate that microplastics can be transported in the atmosphere.
A study by Galgani [86] identified high densities of plastic particles in a remote mountain lake in Mongolia distant from urban sources and suggested that the likely source was atmospheric deposition[87]. The concept of atmospheric fallout has also been used to explain fluxes of microplastics to the watershed of the River Seine in Paris[88]. Microplastics fallout ranged from 29 to 280 particles m-2 day-2 (average 118, fibers accounting for 90% of the total particles) depending on the period when rainfall occurred.



2.4

TRANSFORMATIONS

One critical factor that has not yet been assessed in detail by existing studies is the degree to which macroplastic items fragment and degrade during their transport towards and within the marine environment. Secondary microplastic, resulting from the breakdown of plastic litter caused by weathering/erosion, and not primary microplastic, is often regarded as the dominating contributor to microplastic in the sea[89].



The change from a macroplastic to a microplastic fragment has a significant effect in terms of the ease by which it can be captured and collected (and its value), and conversely, the ease by which it is disperses in the aquatic environment and ingested by marine organisms. Clearly, larger plastic items can be captured and potentially valorised (i.e. of beneficial value in material terms) whereas small fragments are very difficult to capture.

The rate and nature of fragmentation and degradation will depend upon the polymer and its exposure to sunlight and high temperatures. Light polymers such as polyethylene (PE), polypropylene (PP) and polystyrene (PS) are the most common types of plastic litter on surface waters. Denser polymers, such as polyester (PL), nylon (NYL) and polyvinyl chloride (PVC), tend to sink but may be transported in waterways due to turbulent blending as a result of wind and tidal streams causing their re-suspension in the water column [73].

Plastic debris degrades by becoming progressively more brittle under the action of ultraviolet light and heat, eventually fragmenting under physical action from wind and waves into small microplastic pieces [90].

Compared to marine or riverine litter, plastic litter on land undergoes heat build-up due to UV sunlight exposure, leading to increased brittle fragmentation [91]. Due to the nature of litter transportation, fragmentation is also likely to occur before the debris encounters the aquatic environment. Litter can travel some distance over land becoming trapped in trees and branches for short periods on the way, mechanically fragmenting into smaller pieces [92]. There appears to be a lack of studies that investigate the effects of mechanical action (abrasion) on plastic debris over land (e.g. on pebbly beaches).

The majority of polymers are resistant to biodegradation within marine conditions, but will break down gradually through mechanical action. In a study conducted by Browne et al in 2010, a substantial quantity of the microplastic debris present had formed from the breakdown of larger items such as clothing, packaging, and rope. Hence, there is considerable potential for large-scale accumulation of microplastics [93].

The rate of degradation varies dramatically dependent on the situation and type of plastic available [94]. LDPE breaks down rapidly when it enters the marine environment, especially during the first week of exposure [95]. By contrast, HDPE and other plastics break down far less rapidly and so often persist in the form of larger items.

The fragmentation rates are typically very slow and vary greatly depending upon three main factors: plastic properties, biotic properties, and geographical features [25]. Note that a combination of environmental factors and the additives within the plastic lead to fragmentation, whilst other studies [88] identify that it also occurs as a result of a high humidity that affects the plasticising ability of plastic within water.

However, there are likely to be more factors that influence degradation as a whole to cause faster breakup rates than estimated here. For example, Browne et al. (2010) suggest that the sediment structure of the clay affects the fragmentation rate of the debris travelling along the riverbed [82]. Williams and Simmons (1999) theorise that the mechanical action of continuous contact with riverbanks and vegetation may cause fragmentation of plastic debris [45].

LDPE is often 'enhanced' to photodegrade in a short time period as this is viewed as being more eco-friendly [96]. Once this with hypothesis was tested by Andrady (1990), it was found that much of the unenhanced plastic subjected to a marine environment contracted a thick layer of algae, weighing the film down, it also failed to turn into a brittle state and decompose as with its in-air counterparts [96].

O'Brine and Thompson (2010) also studied the degradation of several types of plastic bags within the marine environment. They concluded that polyester, polyethylene and biodegradable LDPE significantly reduced their tensile strength over time. As a result, the authors argue that tensile strength is a useful measure of degradation within plastics[98]. However, it must be taken into account that this investigation aimed to model plastic flow within a riverine environment as opposed to a marine one. The salt water within a marine environment may contribute to weathering effects through the minerals present in the water, whereas this may not occur within a riverine environment as it will have a much lower mineral content [96].

Photo-oxidation is said to occur within PP and PS, after approximately 3000 hours, and this occurs in a shorter timeframe compared to LDPE and HDPE after approximately 2000 hours [98]. A study conducted by Weinstein et al. (2016) monitored the degradation rates of strips of HDPE, PP and extruded PS within a marsh environment with occasional water contact[99]. After 8 weeks, biofilm was found on all samples and their layers of plastic film had begun to peel off (delaminate). When samples were examined under a microscope, the pitted surfaces resulting from the delamination led them to conclude this was a result of microplastic production and that this mechanism began to occur after an 8 week period.

Weinstein et al. (2016) pointed to a combination of both biotic and abiotic factors causing the breakdown of the plastic samples [99].

2.5

FATE (FINAL SINKS AND PERMANENT STOCKS)

The abundance of plastics in the marine environment varies widely. Factors that have a key influence include the distance to coastal urban populated areas and popular tourist destinations, as well as with the occurrence of heavy rain and flood events. The speed and direction of surface water currents are also critical factors [83].

Plastic litter has four main fates:

1. It sinks and becomes buried in the sediments in rivers, estuaries or the ocean.
2. It becomes trapped on riverside vegetation and degraded on river banks.
3. It is transported to the estuary and then deposited on beach [23], [82], [100].
4. It is transported into the ocean.
5. It is ingested by terrestrial and aquatic animals, being a permanent stock that could be then excreted into the environment.

Clearly, once plastics have reached any of these destinations they become very difficult and costly to collect and have also possibly lost their initial plastics properties because of extensive exposure to ambient conditions such as the sunlight, or by adsorbing POPs. In many cases, the original plastic item will have fragmented into a series of microplastic fragments, exacerbating this issue.

For example, beach clean-ups are a resource intensive and costly way to remove marine litter deposited on beaches and coastlines. The Ocean Conservancy estimate that it costs in the region of USD 1000 per tonne to remove waste collected by clean-up activities [7]. However, it is important to recognise that, whist relatively expensive on a tonne-for-tonne basis, beach clean-up events perform a valuable role in raising awareness of the issues and promoting community action. They have also some provided useful data on the distribution of marine litter [6], [101], [102].

3 STOP THE LEAKAGE – NOW!

INTRODUCTION

Waste and resource management is a local issue but, in the context of marine litter, local actions will add up to global impact. The waste and resources sector, as custodians of the value embedded in materials and products after their use, has the potential to play a key role in tacking this global challenge. This will require partnership between all parts of the sector, including policy-makers, municipalities, private sector operators, the finance sector and the informal sector. This will also necessitate cross- and intra-disciplinary scientific approaches.

A recent study has estimated that 75% of land based marine litter in low to upper-middle income economies comes from litter and uncollected waste [7], [103], while the remaining 25% of the land-based sources is plastic which leaks from within the waste management system [103].

It is estimated that in low income countries, for every metric tonne of uncollected waste near waterways, almost 18 kilograms of plastic enters the ocean—equivalent to more than 1,500 PET bottles. Also for every metric tonne of plastic waste that is collected, as much as 7 kilograms of plastic waste are leaked to the ocean between collection and disposal [7].

Post collection leakage can be caused by improper dumping, as well as formal and informal dumpsites that are poorly located or lack proper controls [7]. Fly tipping and waste crime also play a key role in adding to the sources of waste that leaks into marine environments.

Based on this initial review of the marine litter challenge, we have identified four priority areas for intervention. These interventions will be explored in more detail by the task force over the coming months.

1. **Prevent uncontrolled dumping by providing waste collection for all,** including services for all **communities.**
2. **Preventing littering and fly-tipping** by engaging with communities and the public.
3. **Close dumpsites near waterbodies and provide waste treatment and disposal facilities for all.**
4. **Work with the maritime sector** to establish effective systems for recovering waste and recyclable materials from the fishing, shipping and tourism sectors.

[9] Average of five (5) focus countries: China, Indonesia, Philippines, Thailand and Vietnam

In the medium term it will be important to enhance and capture the value of used plastic, including: reducing single-use items; designing for recyclability; increasing effective collection and separation of waste plastics; and creating stable, strong markets for secondary plastics.

Over the long term, it will be necessary to transition to circular approaches for manufacturing, using and recycling plastics.

See figure below for an illustration of how these key interventions can dramatically reduce the flow of waste plastics into the marine environment.

These interventions have the potential to play a pivotal role in tackling marine litter and also contribute towards the Sustainable Development Goals (SDG) (see Table 1). Sustainable waste management is a prerequisite for achieving SDG 14 (conserve and sustainably use the oceans, seas and marine resources for sustainable development). Providing waste management for all will:

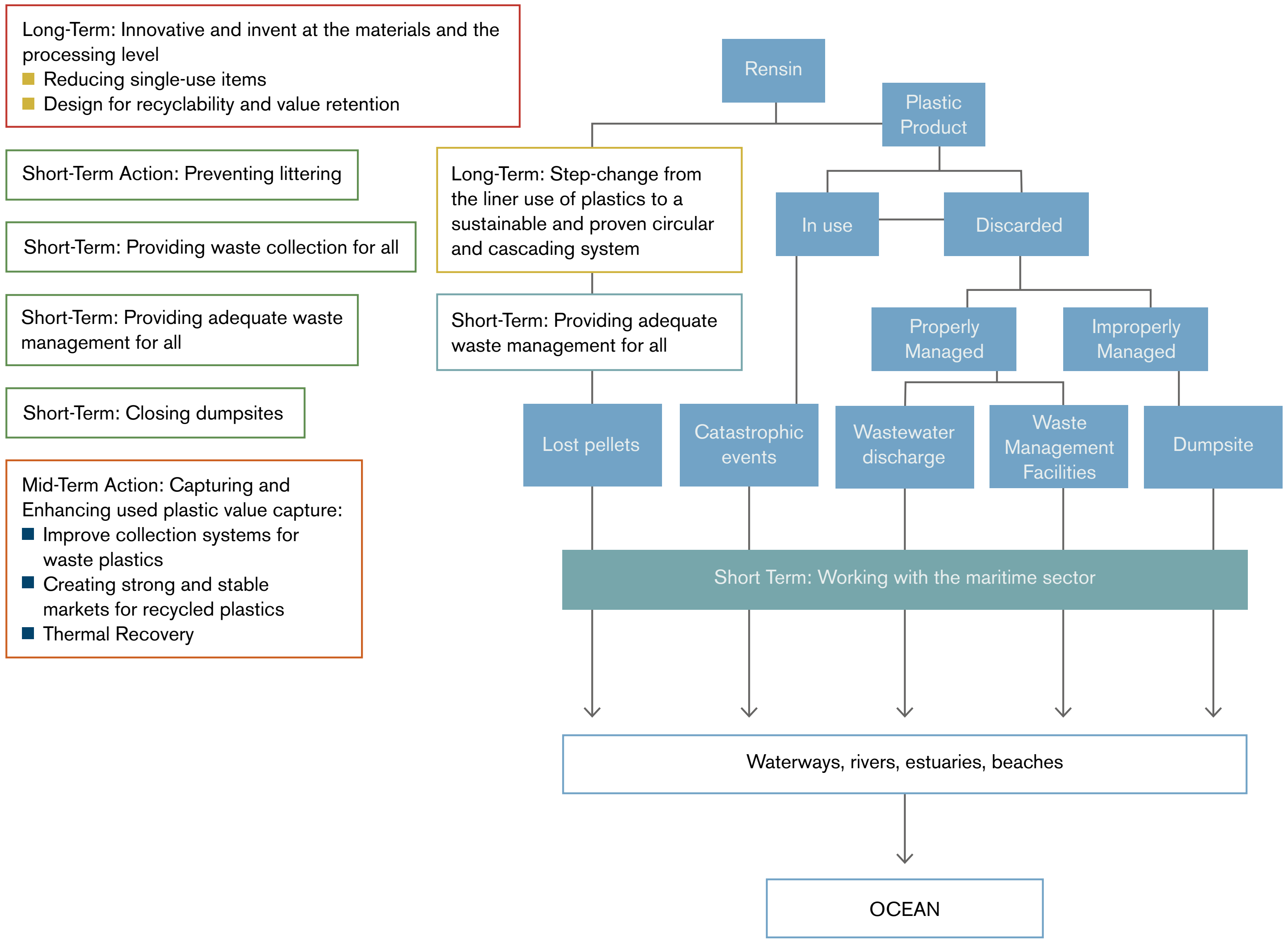
- Help make sure cities are inclusive, safe, resilient and sustainable (SDG 11)
- Facilitate the transition to production and consumption systems that are based on the principles of circularity, where wastes are minimised and those that are produced are cycled back in the production system as valuable secondary materials (SDG 12).
- Generate economic growth and create sustainable, decent livelihoods, particularly for the poorest in society, many of whom work in providing waste and recycling services (SDG 8).
- Reduce greenhouse gases by cutting methane emissions from uncontrolled dumps and landfills, and off-setting emissions generated other sectors by increasing the use of recycled materials and generating energy from waste products (SDG 13).
- Reduce harmful pollution by discouraging open burning of wastes, preventing unsanitary conditions in communities and the dumping of wastes in the wider environment (SDGs 3, 6 and 15).

Table 1: Sustainable waste management and the SGDs

Sustainable Development Goal		The role of sustainable waste management
1.	No poverty	The waste and resources sector provides livelihoods for millions of people globally, ranging from street cleaning and waste collection (including numerous informal sector workers) to waste treatment and materials reprocessing. Right to access to basic services such as waste collection is include here.
2.	Zero hunger	Reducing food waste is a priority for reducing hunger amongst the world's poorest people. The waste sector has the expertise to help reduce food waste and create value from unavoidable food waste, through composting and anaerobic digestion, creating useful fertilisers and energy.
3.	Good health and well-being	Poor waste management practices, such as open burning of waste and uncontrolled dumping causes serious health impacts, particularly amongst those living close to waste sites. Improving waste and resource management will reduce these health impacts.
4.	Quality education	Many informal waste sector workers are children. Working with the informal sector will help get out of this sector and into education.
5.	Gender equality	The majority of informal waste sector workers are women. Working with the informal sector to improve their working conditions will have a strong benefit to women working in waste and resource management.
6.	Clean water and sanitation	Effective solid waste management is a fundamental element of providing clean water and sanitary conditions for all.
7.	Affordable and clean energy	Waste has excellent potential as a source of energy.
8.	Decent work and economic growth	The waste and resource management sector is a key employer and is essential for economic growth. Clean cities attract business and investment.
9.	Industry, innovation and infrastructure	Waste and resource management is at the centre of innovation in the way that we use materials and consume services.
10.	Reduced inequalities	The poorest are harmed the most by poor waste management. Improving waste management will create benefits for those most in need.
11.	Sustainable cities and communities	Sustainable waste management is key to making sure cities are inclusive, safe, resilient and sustainable, where everyone has access to all the basic services.
12.	Responsible consumption and production	Developing sustainable models of consumption and production requires that we reduce waste and develop models of production based on the principles of circularity.
13.	Climate action	Uncontrolled emissions from landfills and dumpsites are one of the main sources of global methane emissions, a powerful greenhouse gas. Effective waste and resource management will reduce these emissions and also off-set emissions from other sectors, including industrial production (by encouraging the use of secondary materials) and energy.
14.	Life below water	Effective waste and resource management is essential to prevent the leakage of waste materials, particularly plastics, into the world's oceans.
15.	Life on land	Poor waste management leads to pollution of soils, rivers and waterbodies. Providing waste management services for all will eliminate these impacts.
16.	Peace, justice and strong institutions	Waste management is a critical issue at municipal level and can be used as an indicator of good governance. It is ranked amongst the most important issues by municipal officials.
17.	Partnerships for the goals	The waste and resources sector is an excellent example of a sector that, when working effectively, involves th ge of stakeholders, from government, the private sector and the informal sector, all working together.

Note: The Sustainable Development Goals are the set of 17 global goals developed by the United Nations in partnership with its 193 Member States. They were adopted in September 2015 and are a "universal call to action end poverty, protect the planet and ensure that all people enjoy peace and prosperity". For further info: http://www.undp.org/content/undp/en/home/sustainable-development-goals.html

Short, Mid and Long Term Actions
Interventions within plastics life cycle



3.2

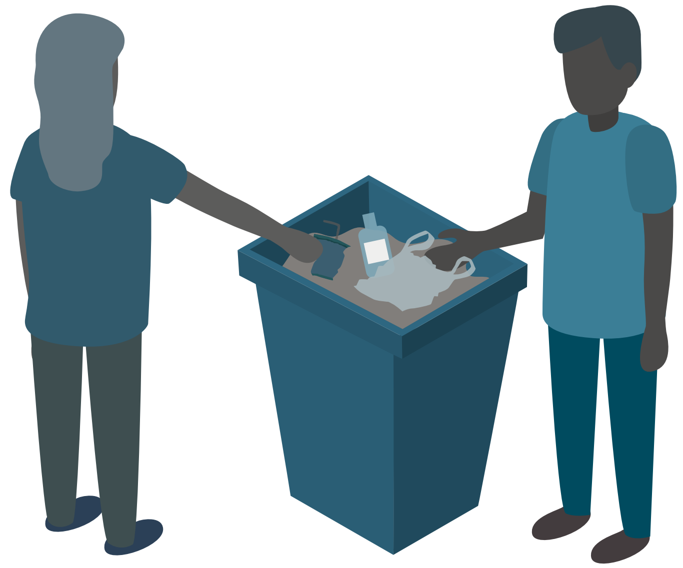
PROVIDING WASTE COLLECTION FOR EVERYONE

Providing appropriate waste collection services to developing economies could significantly reduce quantities of plastic marine litter [107], [108]. For example, Jambeck et al. estimate that reducing mismanaged waste in key rapidly developing economies could reduce quantities of litter escaping into the sea by over 40% by 2025 [1].

It is estimated that over 2 billion people globally do not have access to adequate waste collection services [19], [109]. Analysis by D-Waste indicates that at least 3.5 billion people and 62.3% of the global developing countries population lacks the minimum sound waste management services [110].

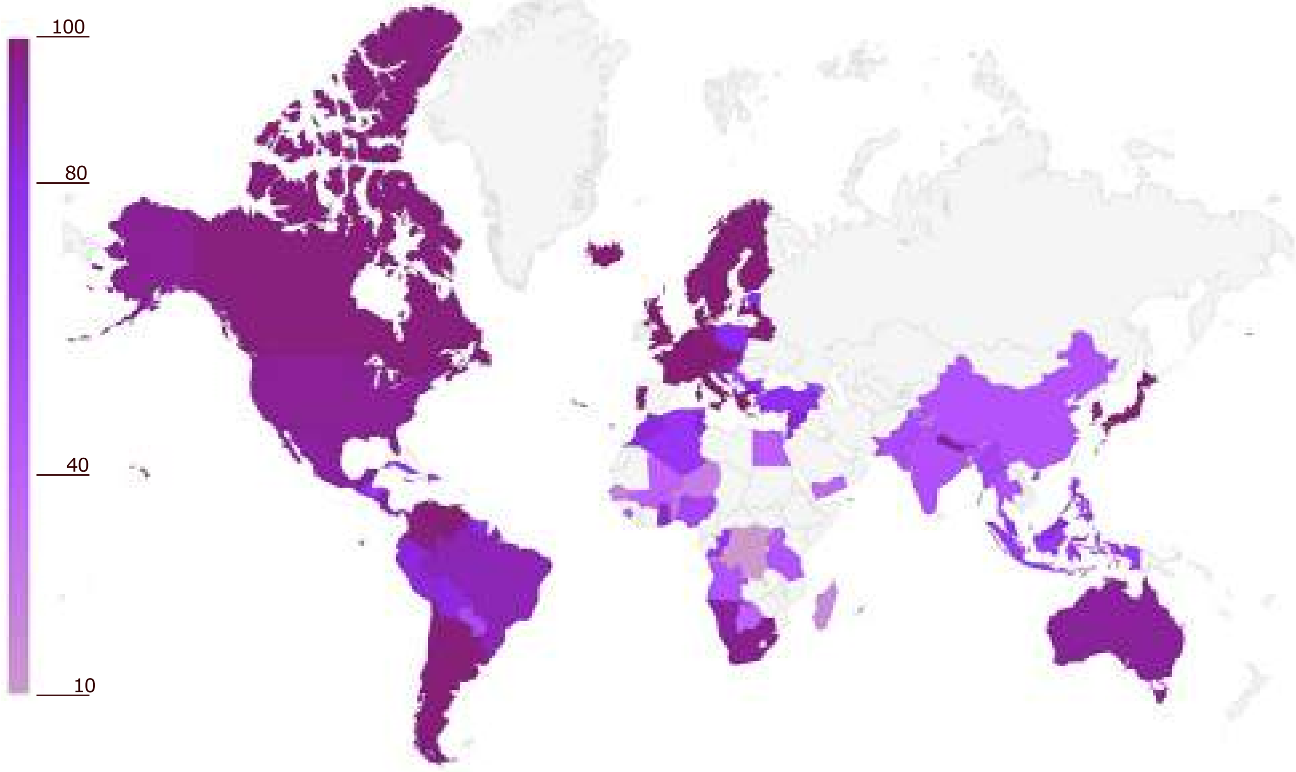
The majority of these people are in the poorer communities of low and middle income countries particularly unplanned and informal areas of rapidly growing cities. According to D-Waste (2012), per capita waste generated ranges between 0.4 and 0.7 kg per day in low income countries [110]. This equates to annual waste generation of between 146 and 256kg per capita per year. This indicates that about 0.5 to 0.89 billion tonnes of waste are uncollected. Approximately, 51 to 89 million tonnes of this material is thought to comprise of uncollected plastics [4].

Based on analysis using data describing the distribution of population by gross national income (GNI), it is possible to estimate the global distribution of people without access to elementary waste management services. Figures *on next page* present the results of initial analysis undertaken for this study (notice that percentages presented in figure 2 are on developing countries populations and not in the global one)[110]



19 Assuming that plastic waste represents 10% of total municipal solid waste

Collection Coverage (%)
The amount of Municipal Solid Waste (MSW) collected as a proportion of total MSW generated [20].



There is very strong evidence that providing adequate waste collection services in developing economies could significantly reduce quantities of plastics finding their way to marine environment. Furthermore, uncollected waste often accumulates close to communities where it becomes as haven for disease-carrying insects and rodents. Uncollected waste also builds up in drainage systems where it often causes serious flooding, blocking and damaging roads, causing damage to properties and even loss of life.

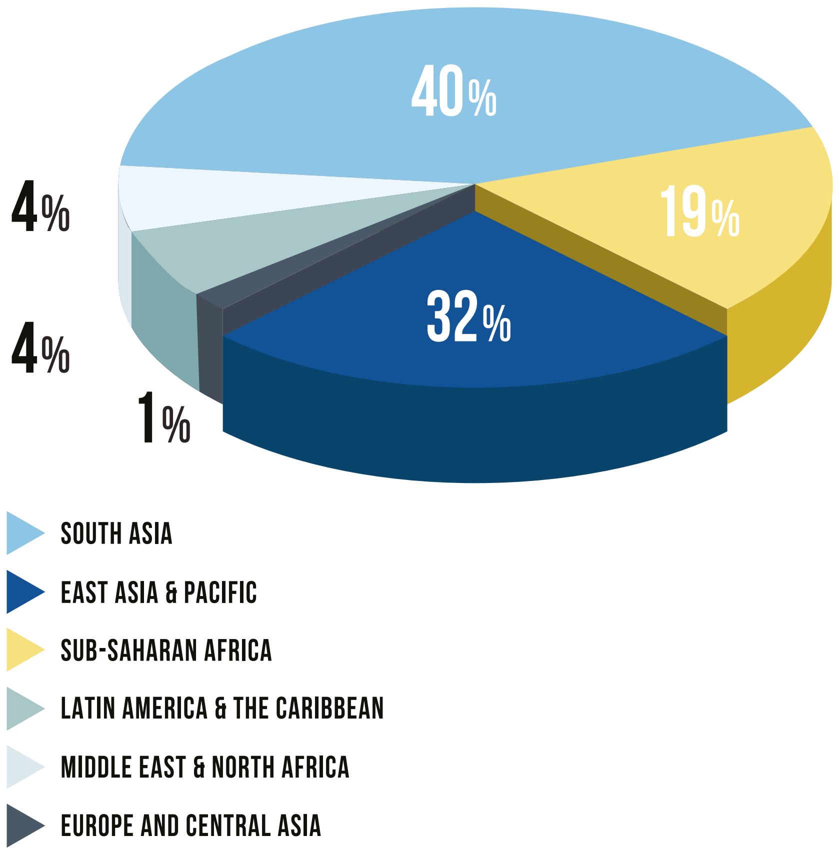
Even where solid waste is collected, environmentally safe disposal facilities often do not exist [111]. In China only 40% of all the waste is collected, and even when collected it has been estimated that about 10% disappears between collection and dumpsites[112].

Investments in effective waste management systems, particularly in Asia, Africa and Latin America will be critical in reducing the leakage of plastic waste into the ocean in the short-term. Investing in waste management will be especially important in where rising incomes is expected to be accompanied by an increase in plastic waste generation. Without proper waste management systems, these plastics are likely to become an increasing source of marine litter.

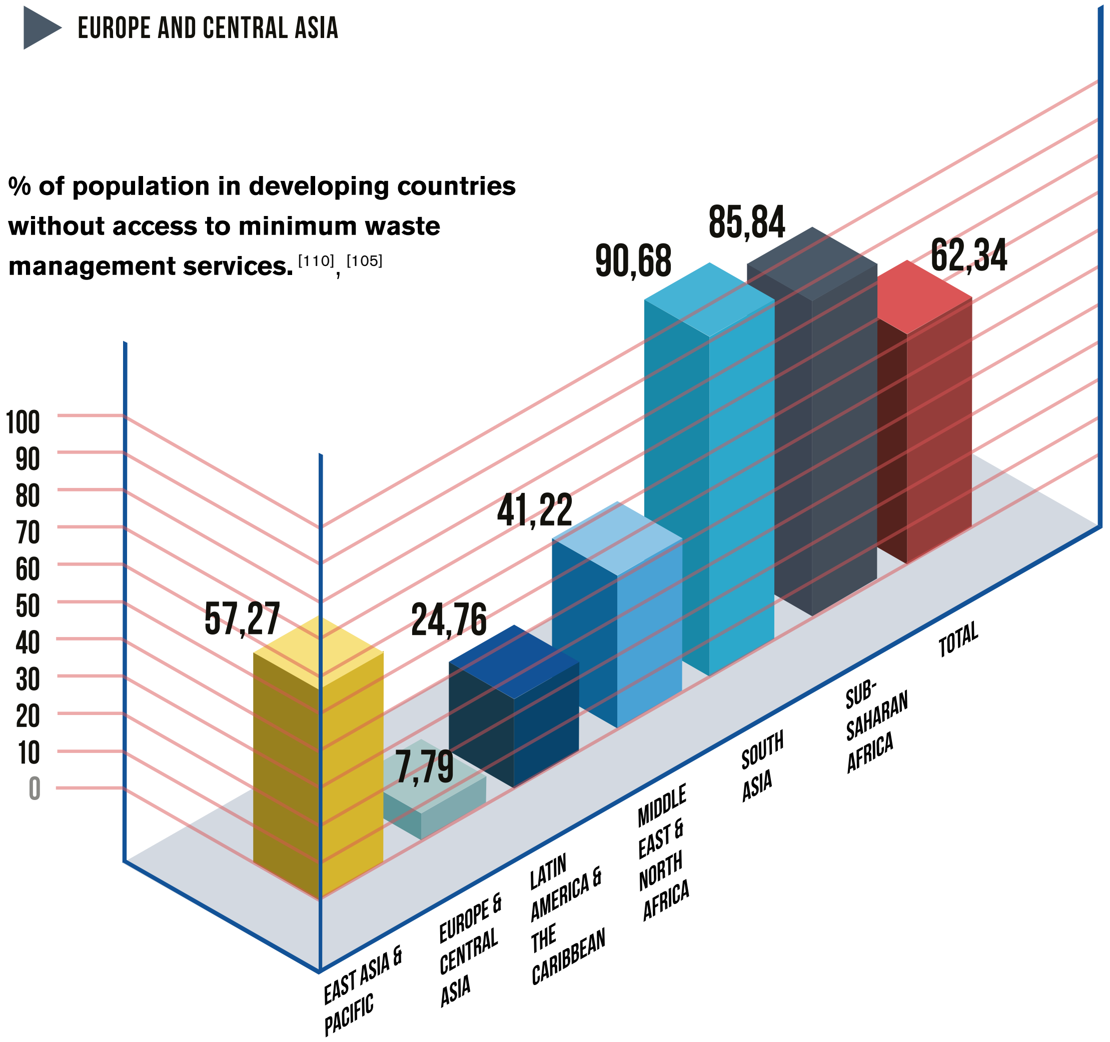
Trucost has estimated that, if the municipal waste collection rate in Asia was increased to a GDP weighted average of 80%, the yearly worldwide plastic contribution to the seas could be cut by more than 45% (equivalent to 1.1 Mt), reducing the natural capital cost of plastics waste by approximately $2 billion.

This investment in services and infrastructure needs to be coupled with intense efforts to raise public awareness and encourage citizens to change behaviour with respect to littering and dumping of wastes, particularly in countries with low collection rates.

Distribution of population with no access to minimum waste management services. [110], [105]



% of population in developing countries without access to minimum waste management services. [110], [105]



CASE STUDY: 46% increase of waste collection in Nakuru

Location: Nakuru Town, Kenya [113]

Nakuru town is the 4th largest town in Kenya after Nairobi, Mombasa and Kisumu. It is located some 160 Km north west of Nairobi city and was founded in 1904. The town is the capital of Nakuru County and covers an area of 294 km².

The Challenge:

The town's population is about 308,000 (CBS 2010) and comprises an estimated 75,000 households, 60% of which are located low income areas. The estimated waste generation rate for Nakuru town is 250 tonnes/day. Prior to 2007, only 20% of the waste generated in the city was collected.

Key Intervention:

In 2007, a decentralized solid waste management model was introduced using a Public Private Partnership (PPP) approach linked with local waste collection enterprises.

The new waste management system has significantly improved collection which now cover nearly the whole town (95%). An estimated 66% of all generated waste (approx. 160 tonnes/day) is being collected and disposed to a disposal facility. 15% of the collected is recycled.

A total of 26 garbage collection SMEs are involved in waste activities, including businesses collecting plastics and paper for recycling, and bio-degradable waste composting. These organisations received support for developing their waste businesses, including both technical and business development assistance. The new system also contributes to Nakuru County government's local revenue collection in the form of license fees. The system provides livelihoods for over 400 local people who are involved in a range of waste collection and recovery activities.

CASE STUDY: Jakarta's rivers come back to life

Location: Jakarta, Indonesia

The Challenge:

Jakarta has experienced rapid urbanization and population growth over the past three decades. The volume of solid waste generated in the city has also grown significantly – the volume of waste double within 10 years, growing from less than 20,000m3 per day in 1985 to over 40,000m³ in 2005 [114].

Jakarta's waste management system was not able to cope with this increase in waste quantities. The city's waste collection vehicles were old and unable to handle the increased volumes. Transportation of waste took a long time due to traffic congestion. Furthermore, the city did not have any modern waste disposal facilities due to delays in the development of planned landfill capacity.

In the absence of appropriate waste collection and disposal systems, the majority of municipal waste was discarded into the city's canals and rivers, blocking important drainage channels and causing severe flooding [115].

Key Intervention:

Since 2000, the Jakarta administration has implemented a number of programmes to address this issue and clean up the capital's thirteen rivers, including improved collection systems and a "Reduce-Reuse-Recycle" initiative.

One particularly successful element of these programmes has been the development of locally-run 'waste banks'. Households separate their recyclable waste materials into different containers and then take them to local collection points where they can exchange the materials for money. The income can be kept in an account at the waste bank or withdrawn.

As of 2013, 55 municipalities and agencies in Jakarta's 17 provinces were operating around 1,100 waste banks, allowing local residents to separate recyclables, generate some income and dispose of their residual waste easily [116].

In 2014 the Jakarta capital city administration began cleaning up the city's thirteen rivers and canals. About 4,000 workers were employed by the city administration who removed an average of 400 tonnes of waste each day [117].

By 2016, the programme had begun to show impressive results. Several rivers in Jakarta, including the capital's longest and most polluted river, the Ciliwung River, are now completely free of congestion from waste.

Whilst the waste management sector strives to operate in a professional manner, waste crime and waste trafficking is still a significant issue. The illegal trade of waste is estimated to be worth USD 10-12 billion annually [118], with rogue operators avoiding waste regulation and disposing of waste materials illegally often at significant individual profit and great environmental and societal cost.

Illegal dumping of waste is thought to be common in many low and middle income countries, particularly where controlled waste facilities are not available and where enforcement of waste regulation is limited. However, illegal waste activity is a global phenomenon and occurs in high countries as well. It is also a pervasive element of the international trade in secondary materials.

For example, even in a country where modern waste management systems and regulatory enforcement is well-established such as the UK, there were over 1 million cases of officially reported fly tippling in 2015 to 2016. This is estimated to have cost local authorities £49.8 million [22].

CASE STUDY: Tackling uncontrolled waste dumping ('flytipping') in the UK

Location: UK, Nationwide

The Challenge:

Cases of fly-tipping in England are increasing, with the number of incidents in 2016 up for the third year in a row. Councils across England reported over 936,000 cases, up 4% on the previous year according to data from the Department of Environment, Food and Rural Affairs (DEFRA).

Fly-tipping also has a huge financial impact on local authorities. Clearing this waste cost local authorities in England £50 million in the year up to March 2016. In the same year, local authorities carried out 494,000 enforcement actions to tackle the problem, costing £16.9 million. Illegal and uncontrolled waste disposal also significantly increases the risk of waste reaching waterways and entering marine environments.

In the UK, every individual and business has a 'Duty of Care' over their waste, even after it has left their home or premises. Failure to take reasonable steps to ensure that your waste is managed and disposed of appropriately risks prosecution and a £5,000 fine. Legislation states that

"anyone who produces, imports, keeps, stores, transports, treats or disposes of waste must take all reasonable steps to ensure that waste is managed properly. This duty of care is imposed under section 34 of the Environmental Protection Act 1990."

Fly tipping clearly goes against the duty of care, as does passing the waste onto a waste carrier who may dispose of the waste illegally.

Recent research suggests that 90% of those organisations who are currently breaking the law are Small and Medium-sized Enterprises (SMEs). The many cases, this is because the producers of waste do not know what they need to do to comply with its duty of care obligations.

Key Intervention:

The '**Right Waste, Right Place**' information campaign was initiated to help small businesses and establishments meet their Duty of Care obligations. The campaign targets agricultural, land management, construction and retail businesses. It raises awareness of Duty of Care legislation and provides practical information to help companies, partnerships, family businesses and sole traders to comply and help keep waste out of the hands of waste criminals.

An easy to use, interactive website[114] provides practical and useful information on UK legislation, types of waste, disposal options and waste transfer notes. 1,200 businesses and 500 farmers were surveyed on their understanding and compliance of Duty of Care in order to best provide targeted information.

Outcome:

The website has had over 16,000 [119] hits, providing information on Duty of Care and waste legislation to a broad range of businesses and promoting legislative compliance to reduce the risk of fly tipping.

There have been eight Right Waste, Right Place regional events, with 350 attendees. Media coverage and radio interviews have potentially reached 10 million readers of regional and trade publications.

There are 37 Right Waste, Right Place ambassadors from key individuals in the waste sector, who are committed to promoting best practice. These ambassadors have reached of over 500,000 customers and supply chain partners.

The campaign has also sponsored further research into fly tipping in order to help raise awareness of the important impacts of waste crime.

3.3

PREVENTING LITTERING

Waste items dropped by people 'on the go' or at major events are a key source of plastics that escape into the marine environment. Data on the quantities associated with this type of leakage are very limited but, for example, some recent studies suggest that litter comprises 2% of waste that does not enter the organised waste collection system (i.e. that which is both litter and uncontrolled dumped waste) [2]. Taking action on litter is a key intervention point that will address the issue of marine litter at the source and also help to raise public awareness.

Individual behaviours play a crucial role in getting waste plastics into rivers and waterways and the oceans. Whilst a large proportion of plastics can be technically recycled, or if they cannot, can be valuable as secondary fuel, they are still escaping from the system due to littering - people dropping of waste items whilst 'on the go'.

As described above, littering tends to be concentrated in areas where large numbers of people gather or pass through, such as public spaces, tourist areas or public transport hubs. There are also clear correlations between crime and litter. Key types of litter include fast-food and beverage packaging, cigarette butts, plastic bags and, single-use sachets used for water and household products, particularly in Africa.

Littering can occur in the presence or absence of relevant infrastructure – each would require different approaches. Public events, tourist areas, areas adjacent to city centres, and rural areas with very poor infrastructure for dealing with waste, may all become littering grounds. The large quantities of this plastic litter which is deposited on beaches, is a result of either direct littering, or littering in urban and tourist areas, which finds its way to the shore via the marine environment.

Clearing littering poses a huge cost to local governments and communities. A recent study of littering in the UK indicated that littering costs local authorities in the UK £800 million to clean-up[104] and has a wider economic cost of over £1 billion [105].

CASE STUDY: Keep America Beautiful [103]

Location: US

The Challenge:

Litter is more than just a blight on our landscape. Litter is costly to clean up, impacts our quality of life and economic development, and eventually ends up in our waterways and oceans.

Key Intervention:

Keep America Beautiful (KAB) is a non-profit organization dedicated to community improvement through litter prevention, waste reduction/recycling, and beautification.

KAB was founded in 1953 and has grown into the nation's leading community involvement organization, with more than 1,200 local affiliates and participating organizations. Much of the litter prevention work completed by KAB and its affiliates is based on seminal research conducted in the 1960s and 1970s about the sources and causes of litter.

In an effort to update and advance the research foundation for their litter prevention activities, KAB funded a series of studies in 2008 and 2009 with financial support from Philip Morris USA. These studies focused on two broad topics: litter and littering behavior. With regard to litter, the research team explored the composition of litter across America: its volume, locations and costs to local communities and businesses. With regard to littering behavior, the research team explored how often people litter, the individual and contextual variables that contribute to littering, and the effectiveness of various approaches to reducing littering rates.

The research findings are detailed in the two technical reports available through the KAB website.The Keep America Beautiful Litter Index and Community Appearance Index are step-by-step methods of assessing current litter conditions and other indicators which is used in thousands of communities and by municipalities nationwide.

The KAB has also driving the following campaigns:

- Great American Cleanup. The Keep America Beautiful Great American Cleanup is the nation's largest community improvement program, engaging more than 5 million volunteers and participants every year to create positive change and lasting impact in local communities.
- Cigarette Litter Prevention Program The Cigarette Litter Prevention Program, created by Keep America Beautiful in 2002, is the nation's largest program aimed at eliminating cigarette litter.
- America Recycles Day, a Keep America Beautiful national initiative, is the only nationally-recognized day dedicated to promoting and celebrating recycling in the United States. Each year, on and in the weeks leading into Nov. 15, thousands of communities across the country participate by promoting environmental citizenship and taking action to increase and improve recycling in America.

3.4

CLOSING DUMPSITES BY WATERBODIES

It is estimated that 3 billion people globally do not have access to environmentally sound treatment or disposal facilities for their waste. Uncontrolled dumping is still commonplace in many municipalities and regions across the globe. Dumpsites are a key source of marine litter. Taking co-ordinated and considered action to close dumpsites will have a high-profile effect on reducing the leakage of waste plastics into the oceans, and will also address the significant human health and local environmental impacts created by these sites.

ISWA's 'Roadmap for Closing Waste Dumpsites' in 2016 indicated that most of the world's major dumpsites are located in Africa, Latin America, the Caribbean and Northern Asian countries. These regions account for more than two third of the Earth's population. The study estimated that the poor environmental conditions of the world's 50 largest dumpsites affect the lives of 64 million people [29]. See the box below for more information.

In many cases dumpsites are intentionally located near rivers or on the coast in order for waste to be carried away by heavy rains or currents, refreshing the capacity of the dump to receive more waste [120]. Although there is no clear data on the percentage of plastic entering the seas and ocean from open dumpsites, it is estimated that up to 30% of the plastic waste disposed at dumpsites could potentially become marine litter. This represents approximately 114 million tonnes of plastics. If we consider the world's largest dumpsites, it is thought that between 1.65 and 1.9 million tonnes of plastic litter are generated by 38 of the biggest dumpsites that are located less than 20 km from the coastline.

ISWA's Roadmap for Closing Waste Dumpsites: The World's Most Polluted Places

Dumpsites impact upon the health and well-being of hundreds of million people who live close to them or, in some cases, within their boundaries.

They are a key source of pollution. Dumpsites are a key source of windblown litter (including plastics), they generate leachate which pollutes local watercourses, and they emit harmful air pollutants from burning of materials. Dumpsites are also a major emitter of methane, a powerful greenhouse gas and also an asphyxiation and explosion risk to those living nearby. The recent tragedies of collapses at dumpsites in Ethiopia, Delhi and Sri Lanka, where many lives were lost, highlight the risk that these sites pose to people working on them or living nearby.

In order to draw attention to this critical issue and promote action to tackle dumpsites, in 2016 ISWA launched a 'roadmap' for closing the world's largest dumpsites [29].

The Road Map identifies the world's 50 largest dumpsites and sets out a framework for closing or upgrading these sites by replacing them with sanitary landfills and implementing measures to reduce waste and recover valuable materials.

In many low income country contexts, a rapid change from an uncontrolled dump site to an integrated waste management system, incorporating sanitary landfill, is likely to be beyond the financial and technical resources of the local authorities. In these contexts, it will be necessary to implement a long-term programme to gradually improve the controls at dumpsites, reducing the risk they pose to human health and the environment by initially implementing simple measures (e.g. stopping open burning at sites, covering materials daily to supress windblown litter and reduce pests, fencing to restrict unauthorised access, and slope grading to help reduce thes risk of slopes collapsing.

It is also critical that any improvement programme engages with the informal sector. In many parts of the world, local people gather valuable recyclable materials from dump site. This is hazardous work but is also their livelihood, so it is essential that these individuals are involved in developing a long-term plan and are given alternative ways to earn income.

WORLD'S 50 BIGGEST DUMPSITES

CASE STUDY: Saida Garbage Mountain, Lebanon – Washing waste into the Mediterranean Sea - From Shame to Fame

Location: Saida,Lebanon

The Challenge:

Saida landfill was established in 1982, and managed by the Municipality of Saida.

The site was not specifically engineered as a landfill. It had a surface area of over 6 hectares and rose up to 58m above sea level, with extremely steep sided slopes. The site is estimated to contain at 1.5 million m^3 of waste and consists of demolition debris, municipal solid waste, hazardous waste and slaughterhouse waste from municipalities of the Saida district. It is situated on the southern shores of this coastal city, 200 meters away from urban, residential areas.

The site is a the result of waste collection vehicles dumping directly into the sea. It not only detracts considerably from the beauty of one of the country's most historical cities, but also caused serious marine pollution as well [116].

In November 2009, large quantities of medical waste washed up on the beach of Saida after sliding from the dump [122]. Waste was washed out to sea reaching Cyprus, 260 kilometres away in the Mediterranean, and was pushed across the city by winter storms [118].

Key Intervention:

Rehabilitation started in 2009 the closure of the site and the installation of a seawall around the sit. The city's waste started going to a newly opened facility further south. By mid 2013, construction works began for the treatment of some of the waste at the old site and land reclamation. The rest of the dump was turned into a sanitary landfill, lined with protective material and gas pipes [121]. In 2016, 3 years after the construction began, a park was opened on the reclaimed land. There are also plans for its expansion over the landfill site in 8 year-time once the material under it decomposes.

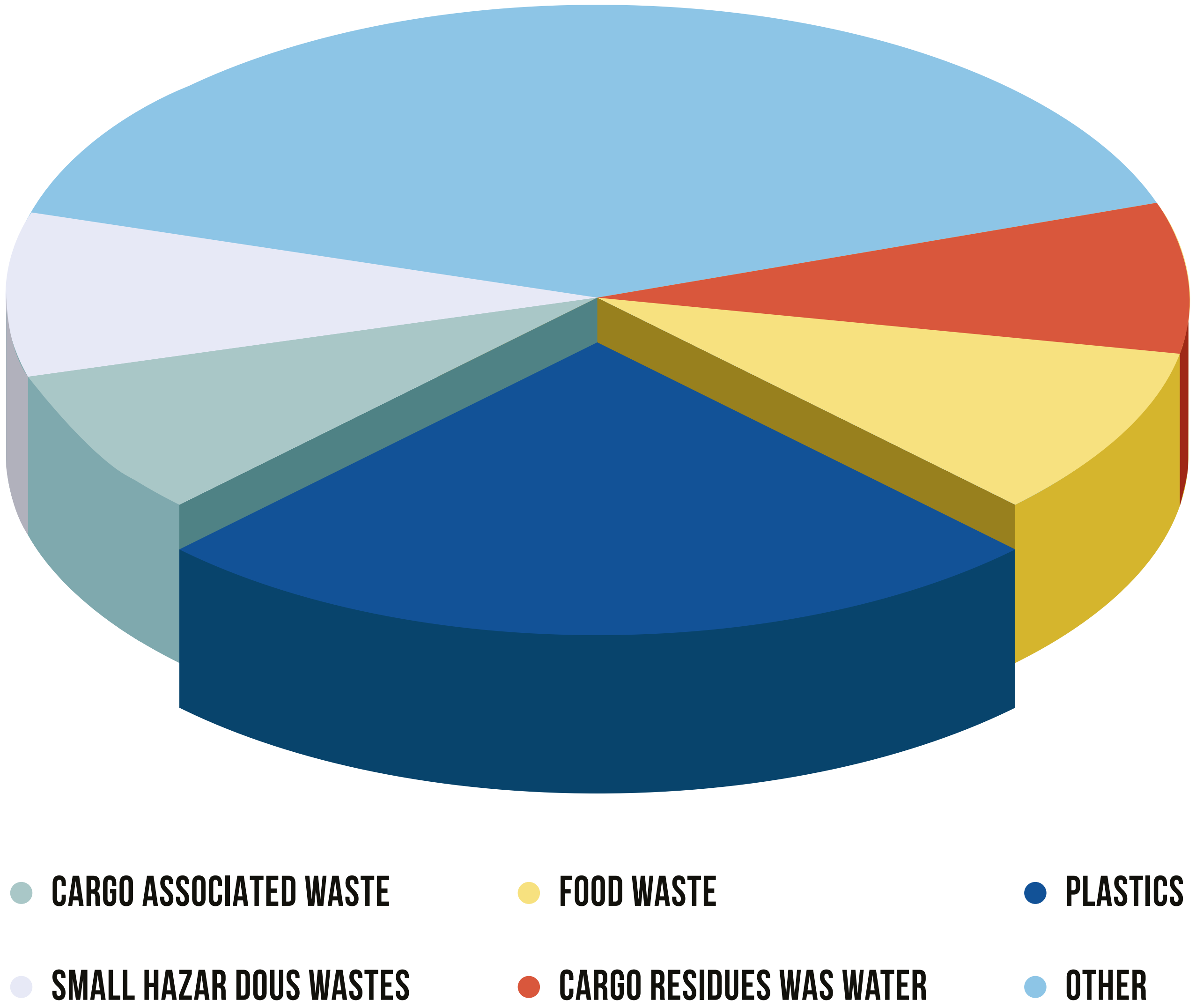
The bottom picture depicts what rehabilitation to the extreme can achieve - the Hiriya dumpsite (25 million tonnes of waste) in Tel Aviv, Israel, closed down in 1998 and was turned into a stunning educational park.

WORKING WITH THE MARITIME SECTOR

The waste and resources sector and the maritime sector need to work together to establish effective systems for recovering waste and recyclable materials from the fishing, shipping and tourism sectors. Infrastructure for collecting waste from marine vessels, including fishing, shipping and tourist vessels could play a crucial role in order to avoid plastics entering the ocean. According to Ocean Conservancy, (2012), an estimated 0.5 to 5.9 million tonnes of plastics enters the oceans from sea-based sources every year [124]. Since shipping accounting for an estimated 20% of global discharges of wastes and residues at sea [125], the development of adequate port reception facilities, along with incentives for ships to use these utilities, are core elements to reduce ships' discharges into the sea [125].

The International Maritime Organisation (IMO) has moved to address the delivery of ship-generated waste and cargo residues via initiatives aiming at enhancing the availability and suitability of Port Reception Facilities (PRF). In particular, regulations and requirements defining which waste can be discharged into the marine environment have been adopted as part of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) [125]. Appropriate PRF is essential but unfortunately many ports around the world do not yet provide appropriate waste reception facilities. The problem is worldwide, but more acute for low income countries [126].

Marpol Annex V waste from maritime shipping (in m²) collected in port of Antwerp 2014.



CASE STUDY: Free disposal of clean plastic waste in ports of Rotterdam and Amsterdam [127]

Location: Rotterdam and Amsterdam

The Challenge:

Prevent plastic waste within the ports of Rotterdam Rijnmond and the North Sea Channel district

Key Intervention:

Since 2016, sea-going vessels have be able to dispose of plastic waste' free of charge in the ports of Rotterdam Rijnmond and the North Sea Channel district. The waste must be presented separated and clean. The port authorities of Rotterdam and Amsterdam agreed on this with the waste collectors in the ports.

This action was implemented as part of the Green Deal Ships' Waste Supply Chain that the Minister for Infrastructure and the Environment, Schultz van Haegen, entered into with the sector on 10 September 2014. Participants in the Green Deal are the Port of Rotterdam Authority, Port of Amsterdam, Zeeland Seaports, Groningen Seaports, Port of Den Helder, NVVS (ships' suppliers), KVNR (ship owners), collectors of ships' waste, ILT and Stichting De Noordzee.

The Green Deal has been operating for three years and the separate collection of plastic ships' waste has grown steadily. Extra quality requirements have been incorporated into new and renewable licences for waste collectors when it comes to collecting, sorting and recycling plastic. In addition, Dutch and Flemish ports have agreed on a joint financing system for the waste collection.

3.6

CAPTURING AND ENHANCING PLASTIC VALUE

3.6.1 Introduction

There is an urgent need to find opportunities for creating more value from plastic. Whilst recycling rates of plastic packaging are steadily increasing, more action is needed to support these markets and also to create better markets for low value plastics such as plastic film, plastic bags and hard plastics that do not have the same financial incentive to recycle.

3.6.2 Improving collection systems for waste plastics

Retaining and enhancing the value of waste plastics will require effective collection systems that can segregate high value materials. These systems need to be tailored to the local context to make the most of the local technical and social technologies that exist. Both the formal and informal sectors have a key role to play here and need to work in partnership.

3.6.2.1 Collection services and infrastructure

Increasing the supply of waste plastics from post-consumer sources, so that they can be recycled into valuable input materials for new products, will be a critical element in reducing marine litter. This will require development of systems that maximise the collection of high quality plastics. Contaminants will need to be minimised and the quantity of individual polymers will need to be maximised.

Providing people with appropriate facilities for recycling a range of plastics – both at home and 'on the go' - is a crucial element for ensuring that these materials are returned into the system and for maximising the value of waste plastic. Developing the scope and quality of collection and sorting at source needs to be a key priority for local authorities and those organisations working with local government to provide waste collection services.

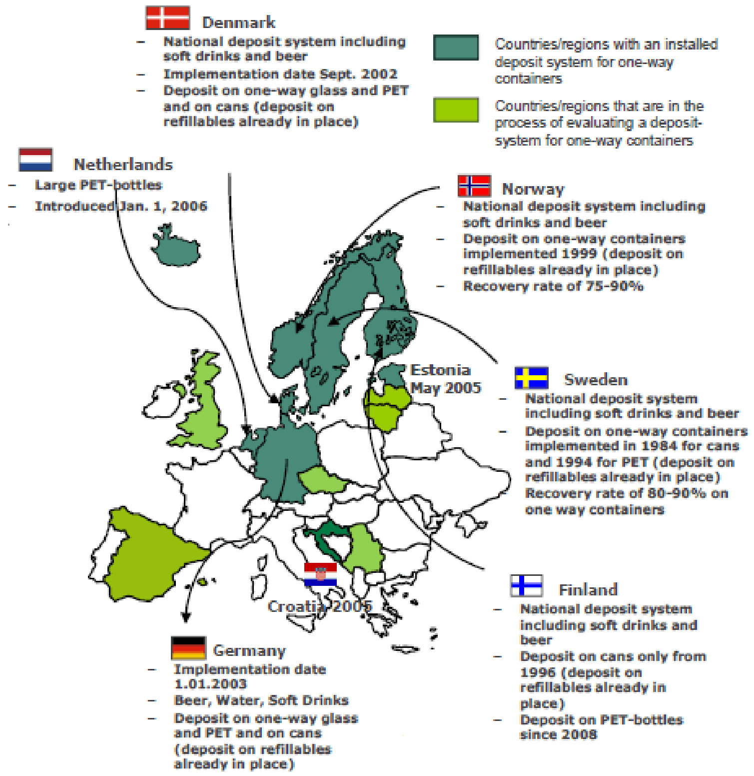
Developing and implementing the necessary services and infrastructure to provide collection systems will require substantial investment and the development of sustainable financing streams. For at least the short and medium term, it is likely that market values for secondary plastics will be far below the levels required to financially support the costs of effective collection systems, at least for all but the most valuable polymers (e.g. PET). As such, other revenue sources will need be used to finance recycling schemes, either through direct fees on residents, general taxation or producer responsibility schemes (i.e. placing the cost back on the consumer via the producer).

3.6.2.2 Supportive policy

Developing and sustaining these systems requires supportive policy and effective regulation. A range of policy tools exist for encouraging recycling. Setting statutory recycling targets for plastics has driven plastic recycling rates in many regions (such as in the European Union). Producer responsibility legislation is also well-established as a means to encourage plastics recycling, particularly plastics packaging.

Deposit refund systems for PET bottles and other plastic beverage packaging are a useful tool for raising mono-stream collection rates. The financial deposit levied on packaging encourage consumers to return empty packaging for recycling, preventing the materials finding their way into the municipal waste stream or the environment [128]. In Sweden a deposit system for PET bottles for on-way containers has introduced in 1994 and it has reached recovery rates of 77% [129]. Evidence also suggests that phasing out the landfilling of plastics is an approach that can stimulate plastics recovery. Those nations in Europe with the highest plastics recycling rates all have landfill bans on plastics [130].

Deposit systems for packages in European countries [129]



3.6.2.3 The informal recycling sector

The informal recycling sector has a major role on material conservation delivering circular economy on the ground, across the world. In low and upper middle-income countries, and some high income countries pickers extract plastics that are sold to recyclers [131].

It is estimated that almost 20% of the municipal plastic-waste has high value and waste pickers collect it. What remains is more likely to leak into the ocean[7]. In countries with no adequate waste infrastructure, and also in some formal systems, the informal sector waste pickers play an important role in waste collection, providing a constant supply of secondary raw materials to the local manufacturing industries and significantly reducing the quantity of waste to landfill sites and in the sea. In Johannesburg, for example, informal waste pickers provide at least 84 percent of all recyclable materials through merchants, recyclers and producers [132].

According to the Waste Atlas Report (www.atlas.d-waste.com) more than 50,000 informal recyclers make their living in the world's 50 biggest dumpsites. In many cases informal recyclers have their homes nearby or even inside the dumpsites. This informal sector has a tremendous potential to serve as a barrier and prevent plastics marine litter. It is crucial to engage and support the informal sector in waste management by providing equipment, opportunities and incentives to enhance their collection of low and high-value plastic waste.

Still, the informal sector encounters many challenges. Informal sector workers are often marginalised members of society and are typically exploited by other organisations (e.g. waste merchants) occupying higher levels of the supply chain who can control the value of materials. Waste pickers will also only target the valuable components of the waste stream, meaning that low value plastics such as films will also typically become waste.

CASE STUDY: Mumbai - the plastics industries taking an approach that involves local people [133]

Location: Mumbai, India

The challenge:

In Mumbai, waste collection and recycling systems are not sufficient, so litter is common. The problem is particularly pronounced in India's densely-populated cities.

In Mumbai, as in other Indian cities, waste is mostly collected by informal waste pickers. They are normally women. They make their living collecting plastic waste and selling it to intermediaries. The problem is that they collect and trade very small amounts on a scale that is inadequate for commerially viable recycling.

Key Interventions:

In 2013 on behalf of Germany's Röchling Stiftung, the German Association of Plastics Converters (GKV) and the Organisation of Plastics Processors of India (OPPI) conducted an analysis to assess the conditions for plastics recycling in the Indian state of Maharashtra and found that there was much scope for improvement. They have realised that waste pickers need to be involved in a well-structured waste management system and that it would not be possible unless the solution has been beneficial to the waste pickers themselves.

Since 2014, the Röchling Stiftung has been funding SMS' efforts to establish the local collecting and sorting stations and to provide financial support for involving waste pickers in a new established waste management systemin Chembur-West and Mulund, two districts of Mumbai. The local government has contributed by providing adequate fleet to collect and transport the waste land and storage areas.

In 2016 the following activities were underway in order to improve waste collection and recliying:

1. raising people's awareness towards the need for adequate waste management;
2. encouraging local waste pickers participation;
3. Training waste pickers on better sorting of materials;
4. purchasing waste from local pickers at fair prices according to accurate weighing;
5. collecting waste using city waste transporters and transferring it to one of the collection and storage areas provided by the city; and
6. documenting waste collection and sales

As part of the project, the waste storage areas have been improved. Safety and ventilation technology was installed, and shredders and balers were acquired. Accordingly, working conditions and economic prospects have improved for more than 70 waste pickers in both districts. Furthermore the new infrastructure has allowed for larger amount of plastic to be collected and stored, and has increased recycling.

Case study: plastics recycling in the Netherlands

Location: Netherlands

The Challenge:

A critical step for reducing the escape of plastic waste into the environment is effective solid waste management, which would result in more plastics being collected, separated, recycled and treated. Municipal household waste collection schemes with effective recycling collection are key to managing plastic wastes produced at home.

Key Intervention:

More than 90% of Dutch people separate their household waste[134]. Lack of space and a growing environmental awareness forced the Dutch government to take measures early on to reduce the landfilling of waste. This in turn gave companies the confidence to invest in more environmentally friendly solutions.

Plastics are either collected in the kerbside collection in a blue wheelie bin, or in communal containers on the street. There are underground refuse containers in city centres for paper, glass, plastics containers and PET bottles. The newest generation of refuse containers are equipped with electronic devices to manage access and payment. There is also a deposit system for larger plastic bottles, which can be taken to automated machines at supermarkets.

Some municipalities offer volume-based-waste fee systems and others manage their household waste through pay-as-you-throw (PAYT) systems, such as in Maastricht.

Outcome:

67% of plastic packaging is recycled in the Netherlands, [136] the highest recycling rate of plastics in Europe.

The amount of collected plastic packaging waste has increased considerably since 2008, from 8 tonnes in 2008 to 116 tonnes in 2013[130]. This is following a 2007 agreement between the Ministry of the Environment and the packaging industry about targets for collection and recycling of plastic packaging (Ministry of the Environment, 2007). [137]

3.6.3 Creating strong and stable markets for recycled plastics

Creating strong and stable markets for secondary plastics will be essential to drive recycling and provide the confidence for the sector to invest in recycling services and infrastructure. Markets for plastics from post-consumer sources are very fragile. A range of efforts will be needed to improve these markets and help provide financially viable outlets for these materials.

As secondary plastics are typically a replacement material for primary plastics, market prices for waste plastic are largely determined by the price of virgin polymer, which is closely linked to the price of oil as well as the behaviour of oil markets and major oil producers-refiners. However, there is a range of other factors that have an increasing influence on secondary plastic prices:

- Availability of waste plastics supply which depends on the quantities collected by local authorities, private waste operators and the informal sector, which is also affected by patterns of consumption that determine the types and volumes of plastics entering the waste stream.
- Quality of waste plastics and particularly the levels of contamination by other materials, which depends on the collection scheme and the technology for separation as well as consumer behaviour.
- International demand of plastic products which drives demand for overall polymer volumes.
- Legislation can sometimes constrain markets for recycled materials by imposing administrative burdens for waste plastic production. However, at the same time, legislation and accompanying enforcement is needed to provide a well-regulated environment for producers and traders and to prevent the illegal waste trade distorting markets.
- Policy can encourage markets for recycling by, for example, setting targets for recycling collections (which increases supply and reduce associated costs) or sets targets for the use of recycled materials (for example, by mandating the use of recycled content in certain products or by certain sectors, such as the public sector).
- Costs of alternative outlets to recycling will determine whether it is cheaper to send plastics for recycling or for other forms of treatment or disposal. For example, landfill tax has had a driving effect in this respect in some regions by making landfill disposal more expensive than recycling. As long as the costs of the alternatives (landfill/incineration/other) exceed the costs of waste plastic collection and reprocessing, there is an economic basis for waste plastic recycling.

The demand of given qualities of waste plastic strongly depend on the targeted quality of the plastic producer's finished products, and the production techniques. Reprocessors and merchants are continuously looking for markets and good price opportunities. In most cases, the profit margin and the net price (delivered sales price minus outbound transport costs) are the main drivers for deciding where waste plastic is sold. Like any other commodity, waste plastic is delivered to the best bidder. Other reasons for outlet management of waste plastic include risk spread, optimisation of logistics and exchange rate risk management. In some cases, specific waste plastic grades can have limited outlets because only a few plants can use it in their plastic conversion process.

Whilst end markets for the main post-consumer polymers (PET, HDPE and LDPE) have gradually grown over the last two decades, at present it is clear that some plastics are only recycled in limited quantities (e.g. polystyrene (PS) packaging from household waste streams).

To grow and increase the sustainability of materials recycling, we need a robust and well-established reprocessing industry with high environmental standards. Various measures are needed including:

- Setting globally accepted standards for recycled materials.
- Encouraging demand for recycled plastics by encouraging consumer demand for products that include recycled content.
- Reducing the range of polymers and additives used.
- Supporting the reprocessing sector, to help it become more resilient to global market variation and mark shocks.
- Providing better market data to help recycled plastic suppliers explore new markets and reduce dependence upon single markets (e.g. China).

Overall, developing and enhancing recycling markets is essential. Recycling is one of the most important sectors in terms of employment creation and currently employs 12 million people in just three countries - Brazil, China and the United States [138]. Overall, including the informal sector, the number of people working in recycling is assessed to 15-20 millions.

3.6.4 Energy recovery and thermal processing

Mechanical recycling of post-use plastics into new products can conserve resources and reduce energy use and greenhouse gas emissions. However, some plastics are not recycled in commercial markets. These non-recycled plastics (NRP), found in the municipal solid waste (MSW) stream, could provide an abundant source of alternative energy.

According to the Earth Engineering Center of Columbia University [139] only about 6.8% (2.66 million tons) of post-use plastics in the U.S. were recycled in 2013 and 9.9% (3.9 million tons) were thermally converted to energy at the 85 waste-to-energy facilities. These facilities displace fossil energy and produce useful heat and electricity from mixed, non-recycled waste, including NRP. The majority of NRP in the US, approximately 82.7% (32.5 million tons), is currently landfilled. This represents a loss of a valuable alternative energy resource. In these contexts, there is a significant opportunity to transform the abundant energy in NRP into electricity and heat and to commercialize new processes that produce higher value fuels and chemical feedstocks [139].

3.7

TRANSITION TO CIRCULAR APPROACHES FOR MANUFACTURING, USING AND RECYCLING PLASTICS

We need a step-change from the liner use of plastics to a sustainable and proven circular and cascading system. This needs to be supported by innovation at the materials and process level.

To enable this change, we need to fundamentally alter the way in which we consider the value of materials, products and services. We need to embed the concept of complex value into the decisions about materials; an approach that considers the wider impacts on, and benefits to, society and the environment that are associated with different materials and processes. This will require a new innovation model that goes beyond cost-effectiveness, functionality and narrowly defined utility needs, to one that incorporates complex value. This will require a radical shift from today's practices, based on a cross-sector and intra-disciplinary scientific collaboration [145], [146].

Approaches such as reduction of single-use items as a priority action and designing products for recyclability and value retention after use will help address the issue at source.

3.7.1 Reducing single-use items

The design and function of plastic products is a fundamental determinant of their fate.

The ubiquity of single-use items produces a steady stream of low value waste plastic items, of which a significant proportion leak from the system and eventually become marine litter. Reducing the use of these items will make great gains in reducing marine litter.

CASE STUDY: City to Sea and Fidra - Single-use item initiatives

Location: UK, Europe

The Challenge:

Plastic cotton bud stems are the sixth most common item found on UK beaches in the latest survey by the Marine Conservation Society, and are often found in the stomachs of marine mammals and birds[147].

Key Intervention:

Initiatives to tackle specific items have proven to be very effective in some areas, with recent examples including campaigns to change cotton bud stems from plastic to paper construction and measures to reduce the consumption of lightweight plastic bags.

In 2016 two UK-based campaigns, Fidra's The Cotton Bud Project and City to Sea's Switch the Stick, called for the plastic stem to be replaced with a paper to reduce the impact on the marine environment, whilst reinforcing messages to consumers that such items should never be flushed down the toilet. The public pressure raised by the campaigns led to commitments from 12 major retailers to change their cotton buds to use paper stems.

The majority of retailers committed to changing their products within a year, demonstrating how quickly organisations can respond to environmental issues even when it affects manufacturing processes. The impact of the campaign extends beyond the boundaries of the UK, most notably as Johnson and Johnson, the main producer of cotton buds in the UK, announced in March 2016 that it would be phasing out plastic stems across Europe by the end of the year.

3.7.2 Designing for recyclability and value retention

The diversity of plastics materials is a constraint on their recyclability. Obtaining high values for secondary plastics requires large values of single polymers but the range of polymers in post-consumer waste streams currently means that the volumes of individual polymers collected is often relatively small, particularly at municipal level. The numerous polymers produced, and the additives that are used, are also technical barrier to products being recycled. For example, the use of black pigment in polypropylene containers prevents it being easily sorted from other material streams. This is a polymer that is widely produced but is not widely recycled.

Whilst the use of lighter plastics, particularly in packaging, can result in an environmental benefit, due to reduced energy and material use in production and transportation, it means that these materials are less valuable as secondary plastics and are less attractive to the formal and informal recycling sectors. Lighter plastics also more readily dispersed once they escape into the aquatic environment. For example, the polymers polyethylene, polystyrene and polypropylene float in water and are readily moved by wind and currents. In contrast, polyester, nylon and polyvinyl chloride sink and move differently through the aquatic system, often becoming trapped in bottom sediments and vegetation.

The design of the already existing products needs to be enhanced by introduction of global eco-design guidelines in order to improve the recyclability. This will help to ensure that plastic waste is separated from other waste at disposal and improve the quality of recyclables by improving product design to facilitate material separation and recyclability.

CASE STUDY: Innovation - Plastics as a fuel

Location: Bristol, UK

The Challenge:

Over the past few years, plastic to fuel technologies have emerged as one potential solution to reducing plastic marine litter and the landfilling of end-of-life plastics [140]. Waste conversion technology may be considered complementary to existing recycling efforts as it typically does not target plastic resins that are highly valued by commodity recycling markets. Furthermore, since plastics have an energy value higher than coal the landfilling of end-of-life plastic waste constitutes a loss of an important energy resource.

Key Intervention:

Suez Environment has opened a unique plant that turns end-of-life plastics into diesel. It is the first of its kind in the UK. The plant was opened in Spring 2016 in Avonmouth, South West England. The Suez Cynar plant is located on an industrial estate in Avonmouth, Bristol, approximately 1,500 m from the nearest domestic household. It is part of the Suez Bristol Resource Recovery Park that encompasses a material recycling facility and waste transfer station [141].

Key process:

- Feedstock shred and clean
- Plastic extrusion at 300oC
- Thermal depolyr to break down carbon chains and reform
- Fractional distillation (standard oil refinery process)
- Fuel extraction and storage [142]

However, although the plant is producing diesel to the required specification, its launch has been delayed due to delays in finding a long-term commercial buyer for the fuel [143]. Commercial viabiity is still to be proven.

Outcome:

It is the first plant of its kind and is able to convert around 6,000 tonnes of end-of-life plastics, such as meat trays and yoghurt pots into around 5.7 million litres of high-specification diesel each year (yielding a theoretical conversion rate of approximately 96%) [144].

The plant is able to process plastics wastes which are not easily recyclable, including shrink wraps, agricultural plastics and residual plastics from materials recycling facilities.

According to Suez, the waste plastic recovery process is expected to be produced at a lower cost compared to conventional diesel and the fuel itself is expected to have a lower carbon footprint than normal diesel. The fuel qualities of the recycled diesel are anticipated to be on a par with conventional diesel, without the need for any further refining and therefore suitable for commercial use.

3.8

POLICY AND MONITORING INDICATORS

Effective monitoring of waste and resource management practices, the nature and levels of marine litter, and the links to the SDGs will be essential. Monitoring needs can be described in terms of these three interlinked sets of indicators and protocols:

1. **Comprehensive data on waste management practices that allow progress towards providing effective waste management for all (including collection systems and appropriate disposal) to be monitored.** Data on waste management practices and performance is collected by numerous different actors for a wide range of purposes.

   For example, the vast majority municipalities collect data on waste management performance. National governments also typically collect data on wastes management practices, and this data is often used to report performance to international agencies such as the United Nations, European Union or OECD that publish collated datasets on waste management performance. A wide range of private sector actors, NGOs and development agencies also collect data for project and programme-specific purposes.

   However, as a result of the wide range of stakeholders involved in collecting data and there being no clear internationally agreed protocol for data collection and reporting, the quality and type of data collected on waste management activities varies significantly in terms of quality and scope. This makes it very difficult to establish a clear baseline; it makes is very challenging to monitor changes in provision of effective waste management; and almost impossible to track the effect that changes in waste management provision may be having on leakage of litter into the wider environment.

2. Consistent data on the quantities and movement of marine litter. These data need to include:

   a. ***the quantities of marine litter leaking from the system.*** As with existing estimates of the quantities escaping into the marine environment (e.g. Jambech et al, 2015), these data will well need to be derived from other sources, such as waste management practices described above;

   b. ***the pathways and sinks for marine litter.*** Collecting adequate data on the movement of marine litter from its source and into the wider environment will be a difficult challenge but this information will be critical to help understand the effectiveness of interventions and ensure that the most cost-effective efforts are made to tackle marine litter. One key source of this information will be marine litter surveys. This is already an extensive source of information on the distribution and nature of marine litter (e.g. Ocean Conservancy, Keep Australia Beautiful, the National Oceanic and Atmospheric Administration of the United States of America, CSIRO, Arcadis and Nelms et al) but the types of information vary considerably between actors and regions. More consistent protocols for collecting and sharing information will be needed.

      Litter survey data needs to be expanded from the current focus on beaches to other key areas that are sources and sinks of litter (e.g. rivers, estuaries and the hinterlands around these areas).

      Clearly defined mechanisms will also be needed to establish how this survey data can be combined with other data to provide a clearer picture of the movement, transformation and build-up of litter into and within the marine environment.

3. **Linking the monitoring data to the SDGs.** The monitoring indicators described above will need to link clearly to the SDGs, particularly SDG 14 [1] but also other SDGs where waste and resource management has a key contribution to make, including SDG 11 [2] and 12 [3]. This will require a clear protocol for using the above data and linking this to the goals and specific targets that form the SDGs.

[1] Conserve and sustainably use the oceans, seas and marine resources
[2] Make cities inclusive, safe, resilient and sustainable
[3] Ensure sustainable consumption and production patterns

4 THE NEXT STEPS

PRIORITY INTERVENTIONS

This report describes four priority interventions that are key to reducing and preventing the leakage of marine litter into the environment:

- **Prevent uncontrolled dumping by providing waste collection for all.**
- **Prevent littering and stop fly-tipping.**
- **Close dumpsites near waterbodies and provide waste treatment and disposal facilities for all.**
- **Working with the maritime sector to tackle plastic waste from fishing, shipping and tourism.**

These interventions are ambitious and will require co-ordinated action for a wide range of stakeholders.

Significant investment will be needed in services and infrastructure to provide waste and resource management services for all.

This needs to be supported by community and stakeholder engagement to encourage behaviour change and prevent littering and uncontrolled dumping.

Achieving the longer-term goals of enhancing plastic value and applying the principals of circularity, will require close engagement with the designers plastics production and resource recovery supply chains.

ISWA'S CURRENT ACTIVITIES

With the right support, the waste and resource sector has the expertise and capacity to make these interventions a reality. The sector comprises a diverse set of organisations and individuals with a wide range of skills and capacities. Best practice for achieving many of the interventions above is already being demonstrated in various parts of the world and ISWA is already proactively supporting organisations and individuals to provide waste management for all.

For example:

- **Dumpsite closure campaign.** ISWA's Dumpsite Closure campaign seeks to raise awareness of the impact that dumpsites have on communities and the environment, and establish a framework for closing or up-grading these sites. See http://closedumpsites.iswa.org/ for more details.
- **Official partner of Let's Do It!** The Let's Do IT World campaign is a civic-based movement focused on clean-up and awareness raising. https://www.letsdoitworld.org/
- **Lead partner and project implementer for the Climate and Clean Air Coalition (CCAC).** The initiative provides technical support to cities in their efforts to reduce emissions and greenhouse gases and black carbon through effective waste management. http://www.waste.ccacoalition.org/
- **Barriers to sustainable resource management.** This ISWA project investigates what can be done to make the production and consumption patterns of today more circular in practice. ISWA gathered a group of manufacturers, designers and waste managers around two specific and tangible cases: jeans and plastic packaging. The results of the project are five overall recommendations for manufacturers wanting to go circular, matched them with five commitments from the waste management sector to support that movement. The recommendations and commitments are presented in two booklets, one for each of the two cases investigated. iswa.org/resourcemanagement
- **The Global Waste Management Outlook (GWMO)** was jointly prepared by ISWA and UNEP's International Environmental Technology Centre (IETC). The GWMO is a comprehensive, integrated and scientific publication, which provides an authoritative overview, analysis and recommendations for action of policy instruments and financing models for waste management around the world. Following the release of the GWMO, ISWA has been working with partners on regional waste management outlooks such as the Waste Management Outlook for Mountain Regions and the Asia Waste Management Outlook.
- **Resource Management Task Force.** In June 2014 ISWA established the Task Force on Resource Management, which investigated the role of waste management sector in a circular economy, and to identified barriers and challenges to be overcome in a transition from waste management to resource management. 6 reports were published. http://www.iswa.org/iswa/iswa-groups/task-forces/task-force-details/tf/show_detail/task-force-on-resource-management/

THE TASK FORCE'S NEXT STEPS

The Task Force's role is to support the waste and resources sector and wider stakeholders in playing a key role in preventing marine litter. Based on its scoping review of the issue and careful consideration of the gaps in knowledge and resources, the Task Force has identified a number of activities that will assist the sector.

Task 1: Communicate best practice much more effectively. There is a real need to highlight the role of sound waste and resource management in preventing marine litter by exploring and collating key facts, challenges, and opportunities, and identifying, analysing, and communicating examples of best and worst practices. ISWA and its members needs to communicate this best practice more effectively. The Task Force will develop a programme for consolidating and disseminating ISWA's extensive knowledge base.

Task 2: Identify hot spots for intervention. We will engage with the ISWA family and other stakeholders to identify key hot spots that require action now (e.g. key dumpsites). We will compile information related to of cities, rives, dumpsites and ports to assess hotpots and, as part of this work, we will develop a simple intervention tool that will allow practioners working at a local level to identify the best intervention point and also gain access to best practice and technical guidance.

Task 3: Actively participate in other major efforts and international fora, including being present in major international events.

Task 4: Assess the level of investment needed. In contrast to other sectors (e.g. water, sanitation and hygiene), there is no detailed understanding of the levels of investment needed in solid waste management infrastructure. Detailed assessment is needed to identify investment needs and to explore the economic benefits of providing waste management for all. This will help make the case for investing in waste and resource management as a means for achieving development goals, and will help galvanise action.

Task 5: Information and platform. These efforts will be supported by a platform that facilitates the necessary partnerships, links, and organisational relationships to facilitate actions and solutions through transference of knowledge and key stakeholder sensitisation.

5

REFERENCES

[1] C. A. Velis, “Plastic waste in marine litter: Action now and at the source ”, Waste Management & Research vol. 32, no. 5, p.251 , 2014.

[2] J. R. Jambeck, R. Geyer, C. Wilcox, T. R. Siegler, M. Perryman, A. Andrady, R. Narayan, and K. L. Law, “Plastic waste inputs from land into the ocean”, Science,., vol. 347, no. 6223, pp. 768–770, 2015.

[3] L. C. M. Lebreton, J. Van Der Zwet, J. Damsteeg, B. Slat, A. Andrady, and J. Reisser, “River plastic emissions to the world’s oceans”, Nature Communications , vol. 8, pp. 1–10, 2017.

[4] GESAMP, “Sources, fate and effects of microplastics in the marine environment: a global assessment”, Reports and Studies GESAMP, vol. 90, p. 96, 2015.

[5] D. K. a Barnes, F. Galgani, R. C. Thompson, and M. Barlaz, “Accumulation and fragmentation of plastic debris in global environments”, Philosophical transactions of the Royal Society of London. Series B, Biological sciences , vol. 364, no. 1526, pp. 1985–1998, 2009.

[6] S. E.Nelms, C. Coombes, L. C. Foster, T. S. Galloway, B. J., Godley, P. K. Lindeque, and M. J.Witt, , “Marine anthropogenic litter on British beaches: A 10-year nationwide assessment using citizen science data”, Science of the Total Environment, vol. 579, pp. 1399–1409, 2017.

[7] McKinsey Center and Ocean Conservancy, “Stemming the Tide. Land-based strategies for a plastic - free ocean”, p. 47, 2015.

[8] NOAA, “Impact of “Ghost Fishing“ via Derelict Fishing Gear”, p. 25p, 2015.

[9] “Global Waste Management Outlook”, United Nations Environment Programme (UNEP), 2015.

[10] D.C. Wilson, C.A. Velis, and Rodic, “Integrated sustainable waste management in developing countries,” Proceedings of the Institute of Civil Engineers: Waste and Resource Management vol. 166, pp. 52–68, 2013.

[11] Environment Ageny, “River Avon, Bath -,” prepared by North Wessex Investigations Team, 2000.

[12] ‘CSIRO, “Understanding debris sources and transport from the coastal margin to the ocean”, 2017’.

[13] L. Brooks and S. Davoudi, “Litter and social practices”, Journal of litter and environmental quality, vol. 1, no. 1, pp. 16–25, 2017.

[14] “Health & Public Services Committee Transcript”, Appendix A, pp. 1–39, 2004. Available: https://www.london.gov.uk/modern-gov/Data/Health%20and%20Public%20Services%20Committee/20041109/Agenda/3%20Appendix%20A%20PDF.pdf. [Accessed: 18-Sep-2017].

[15] J. G. B. Derraik, “The pollution of the marine environment by plastic debris: A review”, Marine Pollution Bulletin, vol. 44, no. 9, pp. 842–852, 2002.

[16] L. Danquah, K. Abass, and A. A. Nikoi, “Anthropogenic Pollution of Inland Waters: the Case of the Aboabo River in Kumasi, Ghana”, Journal of Sustainable Development, vol. 4, no. 6, pp. 103–115, 2011.

[17] B. Sedova, “On causes of illegal waste dumping in Slovakia”, Journal of Environmental Planning and Management, vol. 568, pp. 1–27, 2015.

[18] B. Franz and M. A. V Freitas, “Generation and impacts of floating litter on urban canals and rivers: Rio de Janeiro megacity case study” WIT Transactions on Ecology and the Environment, vol. 167, pp. 321–3,32, 2012.

[19] T. Getahun, E. Mengistie ,A. Haddis, F. Wasie, E. Alemayehu , D. Dadi , T. Van Gerven and B. Van der Bruggen, “Municipal solid waste generation in growing urban areas in Africa: current practices and relation to socioeconomic factors in Jimma, Ethiopia”, Environmental Monitoring and Assessment, Springer Netherlands, vol. 184, no. 10, pp. 6337–6345.

[20] D-Waste, “Waste Atlas”. [Online]. Available: http://www.atlas.d-waste.com/. [Accessed: 16-Aug-2017].

[21] Y. Liu, F. Kong, and E. D. R. Santibanez Gonzalez, “Dumping, waste management and ecological security: Evidence from England”, Journal of Cleaner Production, 2016.

[22] DEFRA, “Fly-tipping statistics for England, 2015/16”, vol. 33, pp. 1–14, 2017.

[23] A. T. Williams and S. L. Simmons, “Estuarine Litter at the River/Beach Interface in the Bristol Channel, United Kingdom”, Journal of Coastal Research, vol. 13, no. 4, pp. 1159–1165, 1997.

[24] D. Morritt, P. V Stefanoudis, D. Pearce, O. A. Crimmen, and P. F. Clark, “Plastic in the Thames : A river runs through it”, Marine Pollution Bulletin, vol. 78, no. 1–2, pp. 196–200, 2014.

[25] J. Mouat and R. L. Lozano, “Economic impacts of marine litter”, Kommunenes Internasjonale Miljøorganisasjon (KIMO), p. 105, 2009.

[26] S. B. Sheavly and K. M. Register, “Marine debris & plastics: Environmental concerns, sources, impacts and solutions”, Journal of Polymers and the Environment, vol. 15, no. 4, pp. 301–305, 2007.

[27] A. Mavropoulos, D. Wilson, C.A Velis, J. Cooper and B Appelqvist., “Globalisation and Waste Management, Final Report”, ISWA Task Force on Globalisation and Waste Management, 2014.

[28] D. Shira & Associates, “Trash or Treasure? Prospects for China’s Recycling Industry – China Business Review”, [Online]. Available: https://www.chinabusinessreview.com/trash-or-treasure-prospects-for-chinas-recycling-industry/. [Accessed: 18-Sep-2017].

[29] A. Mavropoulos, A., Cohen, P, Greedy, D, Plimakis, S, Marinheiro, L, Law, and J, Loureiro, “A Roadmap for closing Waste Dumpsites”, ISWA., vol. 50, no. 7, pp. 109–116, 2016.

[30] A. Camba, S. González-García, A. Bala, P. Fullana-I-Palmer, M. T. Moreira, and G. Feijoo, "Modeling the leachate flow and aggregated emissions from municipal waste landfills under life cycle thinking in the Oceanic region of the Iberian Peninsula", Journal of Cleaner Production, vol. 67, pp. 98–106, 2014.

[31] F. S. Peter Sundt and Per-Erik Schultze, "Sources of microplastic- pollution to the marine environment", Mepex, Norwegian Environment Agency, pp. 1–108, 2014.

[32] C. Lassen, "Microplastics Occurrence , effects and sources of releases" 2015.

[33] M. Van Der Wal, M. Van Der Meulen, M. Peterlin, A. Palatinus, and L. Coscia, "SFRA0025 : Identification and Assessment of Riverine Input of (Marine) Litter Final Report for the European Commission DG Environment under Framework Contract No", 2015.

[34] J. Woodley, "Assessing and monitoring floatable debris," pp. 1–78, 2002.

[35] A. Lechner, H. Keckeis, F. Lumesberger-Loisl, B. Zens, R. Krusch, M.Tritthart, M. Glas, and E. Schludermann, "The Danube so colourful: A potpourri of plastic litter outnumbers fish larvae in Europe's second largest river," Environmental Pollution, vol. 188, pp. 177–181, 2014.

[36] I. Kyrikou and D. Briassoulis, "Biodegradation of agricultural plastic films: A critical review", Journal of Polymers and the Environment, vol. 15, no. 2, pp. 125–150, 2007.

[37] Bioplastics and EuropaBio, "Fertiliser regulation: Biodegradable mulch film",position paper, 2016.

[38] J. Moore, "Plastic mulch in fruit and vegetable production : Challenges for disposal", 2016.

[39] L. Nizzetto, G. Bussi, M. N. Futter, D. Butterfield, and P. G. Whitehead, "A theoretical assessment of microplastic transport in river catchments and their retention by soils and river sediments," Environ. Sci.: Processes Impacts, pp. 1050–1059, 2016.

[40] Woods End Laboratories and Eco-cycle, "Micro-plastics in Compost: Environmental hazards of plastic-coated paper products", . 2016.

[41] C. Guerranti, S. Cannas, C. Scopetani, P. Fastelli, A. Cincinelli, and M. Renzi, "Plastic litter in aquatic environments of Maremma Regional Park (Tyrrhenian Sea, Italy): Contribution by the Ombrone river and levels in marine sediments", Marine Pollution Bulletin, vol. 117, no. 1–2, pp. 366–370, 2017.

[42] E. Delvin, "Grays Harbor County Derelict Gear Removal Project – Annual Report December 16, 2013", vol. 1, 2013.

[43] M. A. Browne, P. Crump, S. J. Niven, E. L. Teuten, A. Tonkin, T. Galloway, and R. Thompson, , "Accumulations of microplastic on shorelines worldwide: sources and sinks", Environmental science & technology, pp. 9175–9179, 2011.

[44] L. S. Fendall and M. A. Sewell, "Contributing to marine pollution by washing your face: Microplastics in facial cleansers", Marine Pollution Bulletin., vol. 58, no. 8, pp. 1225–1228, 2009.

[45] A. T. Williams and S. L. Simmons, "Sources of riverine litter: The river Taff, South Wales, UK", Water. Air. Soil Pollution, vol. 112, no. 1–2, pp. 197–216, 1999.

[46] L. Jeftic, S. Sheavly, and E. Adler, "Marine Litter : A Global Challenge", UNEP2009.

[47] H. S. Auta, C. U. Emenike, and S. H. Fauziah, "Distribution and importance of microplastics in the marine environment.A review of the sources, fate, effects, and potential solutions", Environment International, vol. 102, pp. 165–176, 2017.

[48] A. R. McCormick, T. J. Hoellein, M. G. London, J. Hittie, J. W. Scott, and J. J. Kelly, "Microplastic in surface waters of urban rivers: Concentration, sources, and associated bacterial assemblages", Ecosphere, vol. 7, no. 11, 2016.

[49] I. E. Napper and R. C. Thompson, "Release of synthetic microplastic plastic fibres from domestic washing machines: Effects of fabric type and washing conditions", Marine Pollution Bulletin, vol. 112, no. 1–2, pp. 39–45, 2016.

[50] J. Talvitie, M. Heinonen, J.P. Pääkkönen, E. Vahtera, A. Mikola, O. Setälä, and R. Vahala, "Do wastewater treatment plants act as a potential point source of microplastics? Preliminary study in the coastal Gulf of Finland, Baltic Sea", Water Scienceand Technology, vol. 72, no. 9, pp. 1495–1504, 2015.

[51] R. A. Castañeda, S. Avlijas, M. A. Simard, A. Ricciardi, and R. Smith, "Microplastic pollution in St. Lawrence River sediments", Canadian Journal of Fisheries and Aquatic Sciences, vol. 71, no. 12, pp. 1767–1771, 2014.

[52] A. McCormick, T. J. Hoellein, S. A. Mason, J. Schluep, and J. J. Kelly, "Microplastic is an abundant and distinct microbial habitat in an urban river", Environmental Science and Technology, vol. 48, no. 20, pp. 11863–11871, 2014.

[53] RIVM, "Quick scan and prioritization of microplastic sources and emissions", , 2016.

[54] R. Essel, L. Engel, and M. Carus, "Sources of microplastics relevant to marine protection in Germany" , Umweltbundesamt, vol. 64, p. 48, 2015.

[55] J.M. Veiga, D. Fleet, S. Kinsey, P. Nilsson, T. Vlachogianni, S. Werner, F. Galgani, R.C. Thompson, J. Dagevos, J.Gago, P. Sobral, and R. Cronin, ," Identifying sources of marine litter", MSFD GES TG Marine Litter Thematic Report",JRC Technical Report, EUR 28309,2016.

[56] S. Rech, V. Macaya-Caquilpán, J. F. Pantoja, M. M. Rivadeneira, C. K. Campodónico, and M. Thiel, "Sampling of riverine litter with citizen scientists: findings and recommendations" , Environmental Monitoring and Assessment , vol. 187, no. 6, 2015.

[57] J. A. Ivar do Sul, M. F. Costa, J. S. Silva-Cavalcanti, and M. C. B. Araújo, "Plastic debris retention and exportation by a mangrove forest patch" ,Marine Pollution Bulletin, vol. 78, no. 1–2, pp. 252–257, 2014.

[58] U, Oliveira and M, Vieira, "Occurrence and Impacts of Microplastics in Freshwater Fish" , Journal of Aquaculture & Marine Biology, vol. 5, no. 6, 2017.

[59] K.S. Devi, A. V.V.S. Swamy and R. H. Krishna , "Studies on the Solid Waste Collection by Rag Pickers at Greater Hyderabad Municipal Corporation, India" , International Research Journal of Environment Sciences, vol. 3, no. 1, pp. 13–22, 2014.

[60] D. C. Wilson, C.A. Velis, and C. Cheeseman, "Role of informal sector recycling in waste management in developing countries", Habitat International, vol. 30, no. 4, pp. 797–808, 2006.

[61] M. H. Depledge, F. Galgani, C. Panti, I. Caliani, S. Casini, and M. C. Fossi, "Plastic litter in the sea" , Marine Environmental Research, vol. 92, pp. 279–281, 2013.

[62] J. A. Ivar do Sul and M. F. Costa, "Marine debris review for Latin America and the Wider Caribbean Region: From the 1970s until now, and where do we go from here?" , Marine Pollution Bulletin, vol. 54, no. 8, pp. 1087–1104, 2007.

[63] F. Galgani, J. P. Leaute, P. Moguedet, A. Souplet, Y. Verin, A. Carpentier, H. Goraguer, D. Latrouite, B. Andral, Y. Cadiou, J. C. Mahe, J. C. Poulard and P. Nerisson, , "Litter on the sea floor along European coasts", Marine Pollution Bulletin, vol. 40, no. 6, pp. 516–527, 2000.

[64] UNEP/MAP MED POL Programme, "Marine Litter Assessment in the Mediterranean", 2015.

[65] A. Stapley, "Riverine Plastic Litter: A Global Problem," University of Leeds, 2017.

[66] M. Kummu, H. de Moel, P. J. Ward, and O. Varis, "How close do we live to water? a global analysis of population distance to freshwater bodies," PLoS One, vol. 6, no. 6, 2011.

[67] European Environment Agency, "Restoring European rivers and lakes in cities improves quality of life", 2016. Available: https://www.eea.europa.eu/highlights/restoring-european-rivers-and-lakes. [Accessed: 18-Sep-2017].

[68] P. G. Ryan, C. J. Moore, J. a van Franeker, and C. L. Moloney, "Monitoring the abundance of plastic debris in the marine environment", Philosophical transactions of the Royal Society of London. Series B, Biological sciences, vol. 364, no. 1526, pp. 1999–2012, 2009.

[69] N. Armitage and A. Rooseboom, "The removal of urban litter from stormwater conduits and streams: Paper 2 - Model studies of potential trapping structures" Water SA, vol. 26, no. 2, pp. 189–194, 2000.

[70] S. Rech, V. Macaya-Caquilpán, J. F. Pantoja, M. M. Rivadeneira, D. Jofre Madariaga, and M. Thiel, "Rivers as a source of marine litter - A study from the SE Pacific" , Marine Pollution Bulletin, vol. 82, no. 1–2, pp. 66–75, 2014.

[71] C. J. Moore, G. L. Lattin, and a. F. Zellers, "Quantity and type of plastic debris flowing from two urban rivers to coastal waters and beaches of Southern California", Revista de Gestão Costeira Integrada, vol. 11, no. 1, pp. 65–73, 2011.

[72] J. Gasperi, R. Dris, T. Bonin, V. Rocher, and B. Tassin, "Assessment of floating plastic debris in surface water along the Seine River" , Environmental pollution, vol. 195, pp. 163–166, 2014.

[73] S. S. Sadri and R. C. Thompson, "On the quantity and composition of floating plastic debris entering and leaving the Tamar Estuary, Southwest England", Marine Pollution Bulletin, vol. 81, no. 1, pp. 55–60, 2014.

[74] M. C. B. Araújo and M. F. Da Costa, "The significance of solid wastes with land-based sources for a tourist beach : Pernambuco , Brazil", Pan-American Journal of Aquatic Sciences, vol. 1, pp. 28–34, 2006.

[75] E. van Sebille, C. Spathi, and A. Gilbert, "The ocean plastic pollution challenge: towards solutions in the UK" , Grantham Institute Briefing paper, No. 19, 2016.

[76] T. R. de Barros, S. D. Mancini, and J. L. Ferraz, "Composition and quantification of the anthropogenic and natural fractions of wastes collected from the stormwater drainage system for discussions about the waste management and people behavior" En,vironment, Development and Sustainability, vol. 16, no. 2, pp. 415–429, 2014.

[77] A. Van Leeuwen, "Plastic Bag Bans and Third World Countries",," 2013. Available: https://fighttheplasticbagban.files.wordpress.com/2013/08/plastic-bags-and-third-world-nations.pdf [Accessed: 18-Sep-2017].

[78] A. M. Renn, "Wasted: How to fix America's sewers", 2016. [Online]. Available: http://www.infrastructureusa.org/wasted-how-to-fix-americas-sewers/

[79] WWAP (United Nations World Water Assessment Programme), "The United Nations world water development report 2017: wastewater: the untapped resource; facts and figures", UNESCO, 2017. Available: http://unesdoc.unesco.org/images/0024/002471/247153e.pdf [Accessed: 18-Sep-2017].

[80] S. J. Bell, "What Is The Thames Tideway Tunnel?", Londonist. [Online]. Available: https://londonist.com/2015/08/what-is-the-thames-tideway-tunnel. [Accessed: 18-Sep-2017].

[81] "ASLA 2010 Professional Awards | Gowanus Canal Sponge ParkTM", [Online]. Available: https://www.asla.org/2010awards/064.html. [Accessed: 18-Sep-2017].

[82] M. A. Browne, T. S. Galloway, and R. C. Thompson, "Spatial patterns of plastic debris along estuarine shorelines", Environmental Science and Technology, ., vol. 44, no. 9, pp. 3404–3409, 2010.

[83] T. Kukulka, G. Proskurowski, S. Morét-Ferguson, D. W. Meyer, and K. L. Law, "The effect of wind mixing on the vertical distribution of buoyant plastic debris", Geophysical Research Letters, vol. 39, no. 7, 2012.

[84] M. Thiel, I. A. Hinojosa, T. Joschko, and L. Gutow, "Spatio-temporal distribution of floating objects in the German Bight (North Sea)", Journal of Sea Research, vol. 65, no. 3, pp. 368–379, 2011.

[85] Marine Conservation Society, "Marine plastics pollution policy and position statement", Pollution policy and position statement, p. 33, 2015.

[86] F. Galgani, "Marine litter, future prospects for research," Frontiers in Marine Science, vol. 2, no. October, pp. 1–5, 2015.
[87] C. M. Free, O. P. Jensen, S. A. Mason, M. Eriksen, N. J. Williamson, and B. Boldgiv, "High-levels of microplastic pollution in a large, remote, mountain lake" , Marine Pollution Bulletin, vol. 85, no. 1, pp. 156–163, 2014.
[88] R. Dris, J. Gasperi, V. Rocher, M. Saad, N. Renault, and B. Tassin, "Microplastic contamination in an urban area: A case study in Greater Paris", Environmental Chemistry, vol. 12, no. 5, pp. 592–599, 2015.
[89] J. Strand, "Marine Litter: Pollution with plastic debris in our aquatic environment", Aarhus University, 2015.
[90] A. L. Andrady, "Plastics and Environmental Sustainability", 2015.
[91] J. E. Pegram and A. L. Andrady, "Outdoor weathering of selected polymeric materials under marine exposure conditions", Polymer Degradation and Stability, , vol. 26, no. 4, pp. 333–345, 1989.
[92] D. A. Cooper and P. L. Corcoran, "Effects of mechanical and chemical processes on the degradation of plastic beach debris on the island of Kauai, Hawaii," Marine Pollution. Bulletin., vol. 60, no. 5, pp. 650–654, 2010.
[93] R. C. Thompson, "Lost at Sea: Where Is All the Plastic?" , Science., vol. 304, no. 5672, pp. 838, 2004.
[94] A. Cheshire and E. Adler, , "UNEP/IOC Guidelines on survey and monitoring of marine litter", Regional Seas Reports and Studies no. 186. 2009.
[95] A. T. Williams and S. L. Simmons, "The degradation of plastic litter in rivers: Implications for beaches" , Journal of Coastal Conservation, vol. 2, no. 1, pp. 63–72, 1996.
[96] A. L. Andrady, "Weathering of polyethylene (LDPE) and enhanced photodegradable polyethylene in the marine environment", Journal of Applied Polymer Science, vol. 39, no. 2, pp. 363–370, 1990.
[97] T. O' Brine and R. C. Thompson, "Degradation of plastic carrier bags in the marine environment", Marine Pollution Bulletin, vol. 60, no. 12, pp. 2279–2283, 2010.
[98] D. Feldman, "Polymer weathering: Photo-oxidation", Journal of Polymers and the Environment, vol. 10, no. 4, pp. 163–173, 2002.
[99] J. E. Weinstein, B. K. Crocker, and A. D. Gray, "From macroplastic to microplastic: Degradation of high-density polyethylene, polypropylene, and polystyrene in a salt marsh habitat", Environmental Toxicology and Chemistry, vol. 35, no. 7, pp. 1632–1640, 2016.
[100] N. Armitage, "The reduction of urban litter in the stormwater drains of South Africa", Urban Water Journal, vol. 4, no. 3, pp. 151–172, 2007.
[101] B. D. Hardesty, Q. Schuyler, T. J. Lawson, K. Opie, and C. Wilcox, "Understanding debris sources and transport from the coastal margin to the ocean",, 2016.
[102] B.D. Hardesty, C. Wilcox, Q. Schuyler, T.J. Lawson and K. Opie , "Developing a baseline estimate of amounts , types , sources and distribution of coastal litter – an analysis of US marine debris data Citation", CSIRO: EP167399,2016.
[103] O. Campbell,A. Bushong, D. Gartman, S. Bhargava" Identifying sources of ocean plastics : A methodology for supply chains", 2017.
[104] Environmental Services Association, "The Role of Extended Producer Responsibility in Tackling Litter in the UK", pp. 1–8, 2016.
[105] C. Sherrington, C. Darrah, and S. Hann, "Exploring the Indirect Costs of Litter in England", pp. 1–92, 2014.
[106] P.W. S. R. Stein, "Litter in America: National findings and recomendations", Executive Summary, 2009. Available: https://www.kab.org/sites/default/files/News%26Info_Research_LitterinAmerica_ExecutiveSummary_Final.pdf. [Accessed: 18-Sep-2017].
[107] D.C. Wilson and C.A. Velis, "Waste management–still a global challenge in the 21st century: An evidence-based call for action", Waste Management & Research, no. 33(12): 1049-1051, 2015.
[108] D. Lerpiniere , C.D. Wilson, C.A. Velis, B. Evans, H. Voss and K. Moodley "Review of development co-operation in solid waste management", Report prepared by University of Leeds on behalf of ISWA Globalisation and Waste Management Task Force. 2014. International Solid Waste Association, 2014.
[109] F. C. Mihai, "One global map but different worlds: Worldwide survey of human access to basic utilities", Human Ecology, vol. 45, no. 3. pp. 425–429, 2017.
[110] D-Waste, "Waste management for everyone", p. 24, 2012. Available: https://www.d-waste.com_ [Accessed: 18-Sep-2017].
[111] J. B. Nyakaana, " Solid wste management in urban centers: the case of Kampala city - Uganda", East African Geographical Review,, vol. 19, no. 1, pp. 33–43, 1997.
[112] E. Kosior and I. Crescenzi, " Solutions for ocean plastics and agenda for action", Artists Project Earth ,2016.
[113] , "The solid waste collection in Nakuru , Kenya has improved", 2016. Available: http://wash-alliance.org/wp-content/uploads/sites/36/2016/08/Case-study-Kenya.pdf [Accessed: 18-Sep-2017].
[114] Indonesia Ministry of Settlement and Regional Infrastructure, "Jakarta Solid Waste Management System Improvement Project", pp. 1–17, 2005. Available: https://www.jica.go.jp/english/our_work/evaluation/oda_loan/post/2003/pdf/2-14_full.pdf [Accessed: 18-Sep-2017].
[115] R. Padawangi and M. Douglass, "Water, water everywhere: Toward participatory solutions to chronic urban flooding in Jakarta", vol. 88, no. 3. 2015.
[116] K. Menteri, "Indonesia ' S Garbage Problem", pp. 29–35, 2015. Availabe: http://www.ina.or.id/images/stories/magazine/2015-July/29.pdf. [Accessed: 18-Sep-2017].

[117] C. A.Wijaya, "Jakarta seeing results with cleaner rivers - City - The Jakarta Post", The Jakarta Post. [Online]. Available: http://www.thejakartapost.com/news/2016/05/23/jakarta-seeing-results-with-cleaner-rivers.html. [Accessed: 18-Sep-2017].
[118] J. Cooper and B. Appelqvist, "Waste Trafficking, Challenges And Actions To Be Taken," ISWA Task Force on Globalisation and Waste Management, 2014.
[119] "Right Waste Right Place", [Online]. Available: http://www.rightwasterightplace.com/#intro. [Accessed: 18-Sep-2017].
[120] J. Moss, E., Eidson, A., Jambeck, "Sea of opportunity", Malaysian Bus., p. 14, 2017.
[121] Maurice Picow, "Lebanon Sidon Garbage Mound Becomes City Park | Green Prophet", [Online]. Available: https://www.greenprophet.com/2014/12/lebanons-sidon-garbage-mountain-to-become-city-park/. [Accessed: 18-Sep-2017].
[122] "Saida Garbage Mountain, Lebanon | EJAtlas", [Online]. Available: https://ejatlas.org/conflict/garbage-mountain-saida. [Accessed: 18-Sep-2017].
[123] AFP, "In Lebanon, a garden blooms on former 'trash mountain' | Daily Mail Online." [Online]. Available: http://www.dailymail.co.uk/wires/afp/article-2869973/In-Lebanon-garden-blooms-former-trash-mountain.html. [Accessed: 18-Sep-2017].
[124] Ocean Conservancy, "The Ocean Trash Index - Results of the International Coastal Cleanup (ICC)-2012",2012.
[125] A. A. Pallis, A. A. Papachristou, and C. Platias, "Environmental policies and practices in Cruise Ports : Waste reception facilities in the Med", vol. 67, no. 1, pp. 54–70, 2017.
[126] A. Hena and M. Mamun, "Feasibility study for the establishment of port waste reception facility in context of ports in South Asian countries", p. 132, 2000.
[127] "Free disposal of clean plastic waste in ports of Rotterdam and Amsterdam", Waste Management World, 2016. [Online]. Available: https://www.portofrotterdam.com/en/news-and-press-releases/free-disposal-of-clean-plastic-waste-in-ports-of-rotterdam-and-amsterdam. [Accessed: 16-Aug-2017].
[128] "Deposit-refund system", [Online]. Available: https://www.palpa.fi/beverage-container-recycling/deposit-refund-system/. [Accessed: 18-Sep-2017].
[129] "Germany deposit refund system – Zero Waste Europe", [Online]. Available: https://www.zerowasteeurope.eu/tag/germany-deposit-refund-system/. [Accessed: 18-Sep-2017].
[130] Plastics Europe, "Plastic - the Facts 2016", p. 38, 2016. Available: http://www.plasticseurope.org/documents/document/20161014113313-plastics_the_facts_2016_final_version.pdf [Accessed: 18-Sep-2017].
[131] C.A. Velis, C.A., D.C. Wilson, O. Rocca, S.R. Smith, A. Mavropoulos and Cheeseman "An analytical framework and tool ('InteRa') for integrating the informal recycling sector into waste and resource management systems in developing countries", Waste Management & Research, no. 30(9 Suppl), pp. 43–66, 2012.
[132] D. Mamphitha, "the Role Played By Subsistence Waste Pickers in Recycling,", pp. 1–110, 2012.
[133] O. Möllenstäd, "A systems for collecting waste", " [Online]. Available: https://www.dandc.eu/en/article/how-local-initiative-encouraging-waste-pickers-mumbai-contribute-date-plastics-recycling. [Accessed: 18-Sep-2017].
[134] G. Feller, "Dutch Successes", Waste Management World, 2010. [Online]. Available: https://waste-management-world.com/a/dutch-successes. [Accessed: 18-Sep-2017].
[135] J. Kennedy, "How The UK Compares At plastic recycling with Holland", Plastic expert, 2016. [Online]. Available: http://www.plasticexpert.co.uk/uk-plastic-recycling-holland-compare/. [Accessed: 18-Sep-2017].
[136] European Environment Agency, "Municipal waste management Netherlands", p. 19, 2016.
[137] A. Hutchinson, "Recycling Statistics - Is recycling worth It", 2008. [Online]. Available: http://www.popularmechanics.com/science/environment/a3752/4291566/. [Accessed: 18-Sep-2017].
[138] UNEP, "Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication", 2011. Available www.unep.org/greeneconomy. [Accessed: 18-Sep-2017].
[139] N. J. Themelis and C. Mussche, "2014 Energy and Economic Value of Municipal Solid Waste (MSW), Including Non-Recycled plastics (NRP), Currently landfilled in the fifty States", Columbia University, p. 40, 2014.
[140] Ocean Recovery Alliance, "2015 Plastics-To-Fuel Project Developer's Guide", Ocean Recover. Alliance, p. 74, 2015.
[141] J. Sneddon, "Plastic to Fuel Market Review", no. 2, 2017.
[142] James Pike, "Turning Waste into a Resource - James Pike, Suez Environement," 2015. [Online]. Available: https://www.slideshare.net/GoGreenBusiness/turning-waste-into-a-resource-james-pike-suez-environement. [Accessed: 18-Sep-2017].
[143] "Delay hits opening of unique plastics-to-diesel plant | ENDS Waste & Bioenergy", 2015. [Online]. Available: http://www.endswasteandbioenergy.com/article/1353764/delay-hits-opening-unique-plastics-to-diesel-plant. [Accessed: 18-Sep-2017].
[144] Ricardo-AEA, "Case Study 3: Cynar plastics to diesel", Report for ZWSA", no. 1, p. 8, 2013.
[145] M. Coronado and C.A. Velis, "Circular Economy: Closing the Loops", Rep. Prep. by Univ. Leeds behalf ISWA Resource. Management Task Force. 2015. Int. Solid Waste Assoc. Vienna, Sept. 2015., p. 44, 2015.
[146] E. Iacovidou et al., "A pathway to circular economy: Developing a conceptual framework for complex value assessment of resources recovered from waste", Journal of Cleaner Production, 2017.
[147] Marine Conservation Society, "Great British Beach Clean 2016 Report", p. 5, 2016. Available: https://www.mcsuk.org/downloads/gbbc/2016/487-2016%20Beachwatch%20GBBC%20Summary%2016pp%20A5%20WEB%20Spreads.pdf [Accessed: 18-Sep-2017].

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THE MARINE LITTER TASK FORCE

An ISWA facilitated partnership to prevent marine litter, with a global call to action for investing in sustainable waste and resources management worldwide

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