BLASTIC

PLASTIC WASTE PATHWAYS INTO THE BALTIC SEA

SOURCES AND PATHWAYS OF MARINE LITTER

BACKGROUND REPORT

Prepared by Stockholm Environment Institute Tallinn Centre (SEI Tallinn)

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1. INTRODUCTION

Marine litter is a growing problem which imposes an increasingly serious threat to the environment. Marine litter consists of any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment. It consists of items that have been made or used by people and deliberately discarded or unintentionally lost into the sea and on beaches, including such materials transported into the marine environment from land by rivers, wind or draining or sewage systems. (UNEP 2005, UNEP 2009, Galgani *et al.* 2010). Marine litter is often also referred to as marine debris, but in this report we only use litter.

Even though all litter originates from land, the sources of marine litter are usually classified sea- and land-based (UNEP 2009, UNEP 2005, Mehlhart and Blepp 2012, ARCADIS 2012, Sherrington and Darrah 2014) depending on the type of activities through which litter enters into water. It is estimated that up to 80% of the marine litter is from land-based sources (UNEP 2005, Allsop *et al* 2006, Eunomia 2016). **The aim of this report is to compile a list of defined land-based sources and pathways of plastic marine litter relevant to the local context (at the municipal level).** The study focuses mainly on plastic marine litter as this is the dominant fraction of all litter existent in marine environment (Ryan *et al* 2009, Mehlhart and Blepp 2012, Derraik 2002). Two of the key characteristics that make plastics so useful - light weight and durability - make plastic litter a significant environmental threat (Ryan *et al* 2009). The report covers only macroplastic litter (>25 mm diameter). Special focus is given to urban areas, as these are the places where people are living in high-density.

The study proposes a classification of marine litter created through land-based activities and brings forward ways in which the litter moves into the marine environment. It is difficult to make a clear distinction between the sources and pathways as they are in some cases overlapping. Sources can be regarded as activities that create littering, whereas pathways are the means by which or the ways in which litter is transported into the marine environment from land to the sea, mainly by rivers, wind or drainage and/or sewage systems (Galgani *et al.* 2010).

This report is a part of the Mapping marine plastic litter sources, flows and pathways work package (WP2) of the BLASTIC[1] project. The report serves as a background overview for the development of a checklist for

1. Project "BLASTIC Plastic waste pathways into the Baltic Sea" (2016-2018) of the Interreg Central Baltic Programme (2014-2020).

mapping the sources and pathways of marine litter at the local level. The list of sources and pathways of marine litter put forward in this report is kept simple and applicable by municipalities when developing action plans and management measures for reducing and avoiding the marine litter. It is also further used in developing a methodology for the monitoring of marine macroplastic litter.

The study is based on the information found in relevant literature on the sources and pathways of marine litter. The proposal of classification for the relevant mapping of marine litter sources at the local level is put forward in chapter 4. The proposed classification is mainly based on the following three studies:

1) ARCADIS study Pilot project – plastic recycling cycle and marine environmental impact – Case studies on the plastic cycle and its loopholes in the four European regional seas areas (2012) was carried out for the European Commission to gather strategic information and support the implementation of the European Marine Strategy Framework Directive (MSFD) requirements on marine litter and further develop the policy framework. The study provides the results of the case study of Oostende, which was used as an illustrative example of the main types of litter found in the coastal and marine environment and the process of identification of their main sources, pathways and loopholes in this area, together with potential measures that could be used to avoid litter to enter the marine environment.

2) The Feasibility study – Litter Pathways to the Aquatic Environment by Sherrington and Darrah (2014) was commissioned by The Clean Europe Network to analyse the design and feasibility of a method for determining the sources and pathways of litter that finds its way into the freshwater aquatic environment. The aim was to develop a methodology that would be a cost effective and practical way of monitoring litter and directing litter abatement actions that will support the achievement of a 25% reduction target of litter in the aquatic environment.

3) The third main source used, the Study on Land-Sourced Litter (LSL) In The Marine Environment by Mehlhart and Blepp (2012) was commissioned by four associations of the plastics industry in Germany, Austria and Switzerland. The objectives were to gather information regarding the present situation of land sourced litter in the Mediterranean Sea, the North Sea and the Baltic Sea as well as to display possible research and implementation activities of different stakeholders and behaviour aspects in the field of LSL. Also, it sought to pave the way for sound impact assessment of effective and efficient measures to reduce land sourced litter.

2. CONTEXT

Marine litter is an environmental, economic, human health and aesthetic problem. It poses a complex and multi-dimensional challenge with significant implications for the marine and coastal environment and human activities. The persistence of marine litter is the result of a lack of coordinated global and regional strategies and of deficiencies in the implementation and enforcement of existing programmes, regulations and standards at all levels – international, regional and national.

Plastics are synthetic organic polymers that are lightweight, strong, durable and cheap (Derraik 2002). For these characteristics they are used for the manufacture of a very wide range of products and they have rapidly moved into all aspects of human life. For more than 50 years, global production of plastic has continued to rise (Worldwatch Institute 2015). Over 300 million tons of plastics were produced in 2014, representing a 28 % increase over 2004, whereas 20% of it is produced in Europe (PlasticsEurope 2016). Plastics cover a wide range of synthetic polymeric materials (such as polypropylene, polyethylene, polyvinyl chloride, polystyrene, nylon, and polycarbonate). Packaging, building and construction and automotive are the top three markets of plastics forming respectively 40%, 20% and 9% of the total plastic demand (PlasticsEurope 2016). Plastics that end up in the seas can include moulded, soft, foam, fisheries-related equipment (nets, ropes, etc.), smoking related items (cigarette butts, lighters, and cigar tips), plastic construction materials, plastic packaging (beverage bottles, bags, food wrappers, bottle caps), and household items such as toys (UNEP, 2005).

Due to the large scale use of plastics and extreme persistence in the environment they represent a considerable fraction of marine litter and the one that tends to receive the most attention. Due to multiple sources combined with the transportation of plastic litter by winds and rivers there is a great temporal and spatial variability in plastic litter loads (Ryan *et al* 2009).

Plastic articles can be produced already at different sizes but a gradual decomposition of large plastic articles into smaller ones also occurs over time. In scientific literature marine litter can broadly be divided into four different size classes: micro-, meso-, macro- and mega-debris. These size classes vary somewhat in the literature but generally they are within the same range, see Table 1. The size classes defined in HELCOM 2015 are used in BLASTIC, as the project is executed within the Baltic Sea area. Therefore, macro litter with size >25 mm is in the focus of this background report.

In the Central Baltic Region 60% of marine litter consists of plastic items, and more than half of all the plastics is composed of packaging waste (MARLIN 2013). The proportion of plastic articles among litter increases with distance from source areas because lightweight plastic items are transported more easily than more dense materials such as glass or metal (Ryan *et al* 2009).

TABLE 1 MARINE LITTER SIZE CLASSES FOUND IN SCIENTIFIC LITERATURE.

SIZE CLASS	Ribic *et al.* 1992	Barnes *et al.* 2009	Ryan *et al.* 2009	Eriksen *et al.* 2014	HELCOM 2015
MICRO	Powdered	<5 mm	<2 mm	<4.75 mm	<5 mm
MESO	<5 mm	5 – 20 mm	2 – 20 mm	4.76 – 200 mm	5- 25 mm
MACRO	5 – 30 mm	>20 mm	>20 mm	>200 mm	> 25 mm
MEGA	>20-30 mm	>100 mm			

3. SOURCES OF PLASTIC LITTER AND ITS PATHWAYS TO THE SEA

According to The Ocean Conservancy, all the litter in our water shares a common origin: "…at a critical decision point, someone, somewhere, mishandled it, either thoughtlessly or deliberately." Marine litter originates from different sources, circulates through various pathways and eventually accumulates in the sea and other sinks (see Figure 1). In general, sources can be regarded as sectors/activities of society or industry and pathways refer to means by which litter reaches the sea. However, since the different factors and the transformations that occur through the lifecycle of marine litter (and especially plastic litter) are very complex, the distinction between source and pathway is not always clear.

In general, most references have estimated that worldwide around 80% of marine litter arises from land-based sources and the remaining 20% come from sea-based sources (UNEP 2005, Allsop *et al* 2006, Eunomia 2016). The previous studies in the Baltic Sea region also show that land-based litter is a dominating fraction in marine litter (ARCADIS, 2012). The inland or coastal activities such as tourism, industrial and manufacturing facilities and different activities in a municipality all create waste[2]. Waste becomes litter when it has been disposed improperly, without consent, at an inappropriate location[3]. Litter can be swept away by wind or rain and/or washed down in storm drains (floods), rivers and other waterways. Once in these pathways, the waste can be carried to the sea and become marine litter.

Marine litter sources can be categorised in a number of different ways. Most of the earlier studies have used a bottom-up approach (found litter types are attributed to possible sources) to identify the origin/source of the marine litter. Since the sources of marine litter are diffuse, the ability to identify a particular source from an individual litter item is difficult, depending on the state of the litter item (weathering) or the possibility of multiple sources (Potts and Hastings, 2011).

[2] "An object the holder discards, intends to discard or is required to discard." EU Waste Framework Directive

[3] www.wikipedia.org

3.1. SOURCES

3.1.1. DIFFERENT CATEGORISATION OF SOURCES

A comprehensive overview of different marine litter monitoring programs and approaches for determining litter sources/pathways is presented by Sherrington and Darrah (2014), where the categories are based on Ocean Conservancy (2012) and ARCADIS (2012).

International Coastal Clean-up (ICC) is the only global monitoring program that has a standardised marine data collection method, which has been coordinated internationally by the Ocean Conservancy (Sherrington and Darrah, 2014). The ICC categorizes litter items into five sources, all of which are relevant to land-based litter sources (Ocean Conservancy, 2012):

- Shoreline and recreational activities – e.g. food-related litter, plastic and paper bags, clothing, shoes, toys, shotgun shells;
- Ocean/waterway activities – e.g. bait containers, strapping bands, tarps and plastic sheeting, pallets, nets, line, rope, and traps, light bulbs, oil bottles, cleaner bottles, fishing lures;
- Smoking-related activities – e.g. filters, lighters, tobacco packaging;
- Dumping activities – e.g. appliances, batteries, building materials, car parts, drums, tyres; and
- Medical/personal hygiene – e.g. condoms, diapers, syringes, tampons/applicators.

According to this classification, in the Baltic Sea, shoreline and recreational activities are the source of most litter (57%), with smoking-related activities making the second largest contribution (38%). It is important to note that this does not reflect abundance, just composition, so comparing the absolute contribution of different sources from region to region is not possible with this type of data and method. However, contribution of coastal versus inland/waterway activities is unquantified. It must also be noted that this categorisation does not allow exclusive separation of land or sea-based sources.

Another bottom-up methodology analysed by Sherrington and Darrah (2014) was a pilot study for the European Commission (ARCADIS 2012). The aim of this study was to determine points at which plastic waste was escaping legitimate management systems in the EU. Fifteen different sectors contributing to marine litter were identified, which are presented in Table 2 and Figure 1.

TABLE 2. MARINE LITTER BY SOURCE (% COUNT), IN THE BALTIC SEA REGION (BASED ON RIGA CASE STUDY).

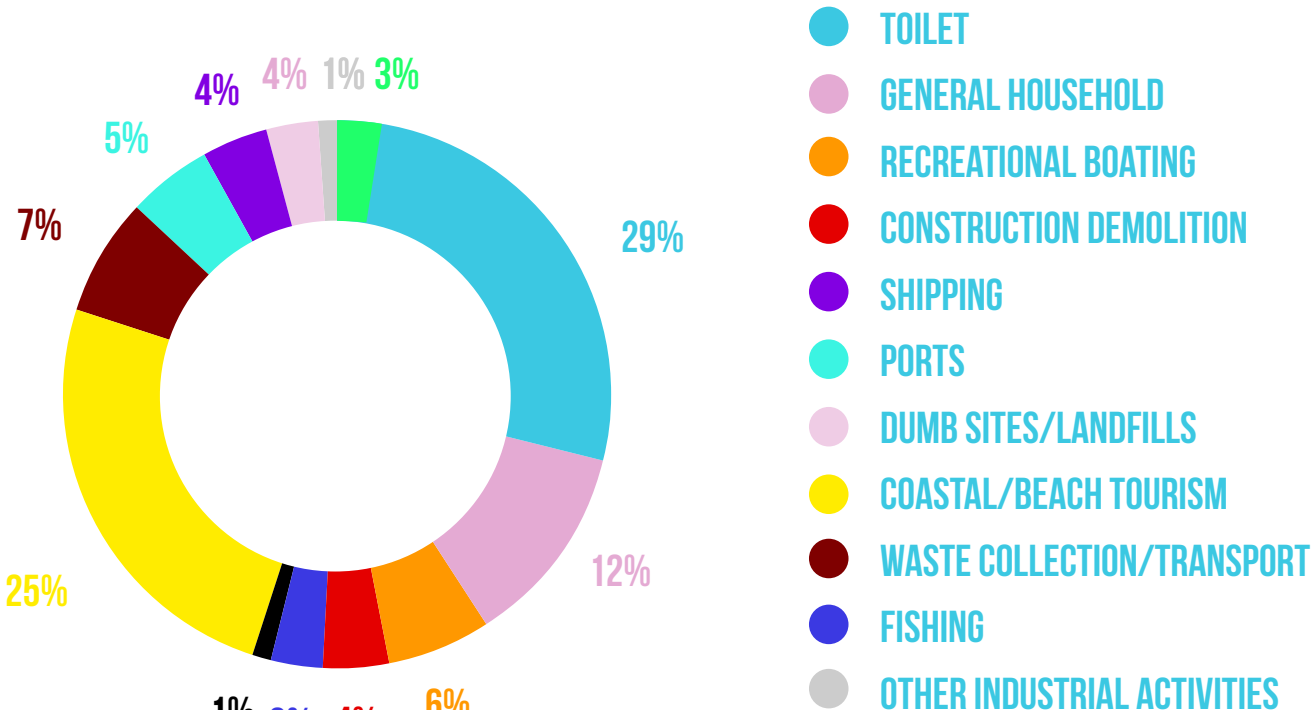
SECTOR	RIGA (BALTIC SEA)	COSTANTA (BLACK SEA)	BARCELONA (MEDITERRA-NEAN)	OOSTENDE (NORTH EAST ATLANTIC)	TOTAL
AGRICULTURE*	1%	0.02%	1%	1%	1%
CONSTRUCTION AND DEMOLI-TION*	4%	4%	4%	6%	6%
DUMP SITES/ LANDFILLS*	0%	5%	0%	1%	2%
GENERAL HOUSEHOLD*	12%	20%	11%	5%	12%
OTHER INDUSTRIAL ACTIVITIES*	1%	1%	1%	2%	1%
RECREATIONAL BOATING*	6%	10%	6%	10%	8%
RECREATIONAL FISHING*	3%	46%	3%	3%	14%
SEWAGE*	29%	0.32%	26%	1%	14%
WASTE COLLECTION/ TREATMENT*	7%	3%	6%	4%	5%
COASTAL/ BEACH TOURISM	25%	3%	32%	26%	21%
PORTS	5%	2%	4%	8%	5%
SHIPPING	4%	2%	4%	10%	5%
FISHING	3%	2%	3%	12%	5%

* CATEGORIES RELEVANT TO LAND-BASED SOURCES SOURCE: ARCADIS (2012)

Around nine of these (asterisked) are sectors relevant to land-based sources of litter. Recreational boating and recreational fishing are relevant to both sea- and land-based sources – arguably contributing more to marine litter as a sea-based source. However, given that recreational use of lakes and rivers will be a source of litter on land, it is included in a list of land-based sources (ARCADIS 2012).

In order to provide better comparability with Ocean Conservancy data, the categories are grouped and the results are presented in Table 3.

FIGURE 1. MARINE LITTER SOURCES AS INDICATED BY SITE IN BALTIC SEA (ARCADIS 2012)



Based on the existing assessments from the Baltic Sea region, different land-based sources seem to contribute clearly more (88%) than the sea based sources (see Table 3). The EC Pilot study (Arcadis 2012) also ascribes much higher proportions of litter to the sewage for the Baltic (29%) than the similar group of medical/personal hygiene results in the Ocean Conservancy Coastal Clean-up results (0%). Also, it allows more for a comprehensive attribution to the waste management sector, which is a quite significant proportion, at 19%. The comparison between the two methods demonstrates how differences in the data collection can affect the outcomes of such assessments e.g. on the relative importance of different sources.

TABLE 3. MARINE LITTER BY SOURCE, GROUPED FOR BETTER COMPARISON WITH COASTAL CLEAN-UP DATA, (% COUNT), ACROSS FOUR EU LOCATIONS. REGIONAL SEA AREA REPRESENTED BY EACH LOCATION IN BRACKETS

SECTOR	RIGA (BALTIC SEA)	COSTANTA (BLACK SEA)	BARCELONA (MEDITERRANEAN)	OOSTENDE (NORTH EAST ATLANTIC)	TOTAL
RECREATION AND TOURISM*	34%	59%	41%	39%	43%
SEWERAGE	29%	0.3%	26%	1%	14%
WASTE COLLECTION/ TREATMENT/ LANDFILL/ HOUSEHOLD**	19%	28%	17%	10%	19%
SHIPPING, FISHERIES***	12%	8%	10%	41%	18%

* Sum of Coastal/Beach Tourism, Recreational Boating and Recreational Fishing categories
** Sum of Dumpsites/Landfills, General Household and Waste Collection/Treatment categories
*** Sum of Aquaculture, Fishing, Other Maritime Industries, Ports and Shipping categories
Source: Sherrington and Darrah 2014

A study on land-based sources of marine litter by Mehlhart and Blepp (2012 was based on a literature review regarding the present situation of land-sourced litter in the Mediterranean Sea, the North Sea and the Baltic Sea. In this study the land-based sources of marine litter (LSL) were categorised as follows:

- **Individual actions**
    - Littering in general (inland and coastal)
    - Littering caused by tourism (recreational visitors to the coast)
    - Events (e.g. charity, fly balloons)
- **Facilities and construction**
    - Industrial or manufacturing outfalls (e.g. by-products, plastic resin pellets)
    - Construction and demolition sites
    - Harbours (seaport, commercial port, fishing port, ferry port etc.)
    - Ship-breaking yard
    - Agriculture activities
- **Municipalities**
    - Litter and waste generated in coastal and inland zones from improper waste management
    - Wastes from dumpsites located on the coast or riverbanks
    - Untreated municipal sewerage

- **Transport of litter and waste (on land or on waterways)**
    - Rivers and floodwaters
    - Discharge from stormwater drains / sewer
    - Natural storm related events (e.g. mistral, tornadoes, hurricanes)

The last group is an example of how sources and pathways are in some cases mixed up as "Transport of litter and waste (on land or on waterways)" actually refers to pathways and will be therefore discarded in this section.

Also, several other studies and reports bring out possible sources of marine litter. UNEP has produced several reports about marine litter (2005, 2009, 2016). Land-based sources have been defined differently in these reports. UNEP 2005 and 2009 reports had a similar approach in categorising major land-based and sea-based sources of marine litter. However, the list they proposed in these reports does not distinguish source and pathway.

The main land-based sources (note that the land-based sources include coastal activities) in UNEP 2005 and 2009 report are grouped as follows:

- Municipal landfills (waste dumps) located on the coast
- Industrial facilities (solid waste from landfills, and untreated waste water)
- Tourism (recreational visitors to the coast)
- Riverine transport of waste from landfills, etc., along rivers and other inland waterways
- Discharges of untreated municipal sewage and stormwater (including occasional overflows)

The most recent report by UNEP released in 2016 focused on plastic marine litter (both macro and micro). The land-based sources of macro plastic litter were catalogued as follows:

- Packaging (food and drink)
- Agriculture (e.g. plastic used in irrigation pipes, planting containers and protective meshes and sheets)
- Coastal tourism
- Construction (various construction materials)

3.2. PATHWAYS

There are different ways on how to categorize marine litter pathways. Different studies show that the distinction between source and pathway is not always clear (Sherrington and Darrah 2014). Furthermore, it is even harder to associate marine litter item types with pathways than to attribute them to sources. One source can correspond to several pathways. There are various ways of categorising the pathways. The overview of different categorisations including definitions and descriptions of possible marine litter pathways as presented by Sherrington and Darrah (2014) are given in Table 4.

We consider categorisation of pathways by intentions rather a reason why the litter reaches the sea, but we have defined pathway as ways how the waste is transported to the sea, both directly and indirectly. Stemming from this definition, we conclude that the three main pathways how litters reached the sea are: 1) human (by direct dumping), 2) wind (through air), and 3) water (drains and rivers, runoff and stormwater/floods, and sewerage).

TABLE 4. DIFFERENT METHODS OF CATEGORISING LITTER PATHWAYS

METHOD	REF	CATEGORIES
BY INTENTION AND SOURCE	UNEP (2009)	Negligent - Loss
		Negligent - System failures
		Negligent - Outdated and inadequate waste management practices
		Intentional - Public behaviours leading to illegal waste disposal/indiscriminate littering and dumping
BY VECTOR	UNEP (2009)	Human - By direct dumping
		Water - Transported by stormwater, via drains and rivers towards the sea
		Wind - Blown into the sea
BY PHYSICAL PATHWAY, VECTOR AND SOURCE	UNEP (2009)	Wastes from legal and illegal dumpsites located on the coast or river banks
		Discharge via industrial outfalls
		Discharge from stormwater drains
		Discharge from municipal drains
		Untreated municipal sewage
		Litter dropping close to waterways and wind/water transport across land/water threshold
BY PHYSICAL PATHWAY, VECTOR AND SOURCE	Arcadis (2012)	Direct (on site dumping)
		Diffuse (sewage)
		Diffuse (inland waterways and rivers)
		Diffuse (others)
BY INTENTION	Arcadis (2012)	Intentional, including negligence
		Accidental
BY GEOGRAPHY OF ORIGIN	Arcadis (2012)	*In situ* generation
		Local (short distance)
		Long distance or transnational

Source: Sherrington and Darrah 2014.

1) Marine litter by **humans** through **direct** dumping includes both general littering directly into the water bodies as well as illegal dumping. There is not much data available how much litter reaches the sea through direct dumping by humans as very few countries keep records of it (Sherrington and Darrah 2014).

2) **Wind** can carry litter long distances. Wind-blown litter (e.g. recreational litter on beaches, foam insulation material) could contribute significantly to marine litter generation in several areas (beaches, ports, construction sites, transportation, etc.).

3) Water as pathway is further divided into three subcategories: a) drains and rivers, b) runoff and stormwater/floods, and c) sewage. Water-related pathways are sometimes also categorised as sources but they are more of pathways than direct sources, assisting the distribution of land-based litter to the sea.

a) A significant amount of (plastic) waste and litter reaches the sea through **drains and rivers** (Wal *et al* 2015). Litter originates from diffuse sources. Factors, such as high population density, poor waste management and insufficient street cleaning practises are considered to increase the risk for land-based litter to end up in rivers and ultimately in the sea.

b) The **runoff/stormwater**, which is generated during heavy rain events or floods, can be collected into storm drains if there is no sewerage system for stormwater. The drains directly discharge the stormwater directly into the sea or into nearby streams/rivers, which, in turn, may carry the litter into the sea (Allsop *et al* 2006).

c) Another important pathway for urban based marine litter is **sewerage**, especially discharge of untreated municipal sewage, including stormwater. Raw waste water contains litter like hygiene and sanitary articles and material flushed from paved or unpaved surfaces to the sewer. If no waste water treatment is established, these materials are in most cases discharged to rivers or the sea. If the sewerage system exists, there is still a possibility that untreated sewage gets into the sea due to sewerage system deficiencies. There are two types of sewers – separate and combined sewers. Combined sewers carry both sanitary sewage as well as surface runoff/stormwater into the waste water treatment plant. Under normal weather conditions, sewage is carried to a wastewater treatment facility where non-sewage wastes are filtered out. However, during heavy rains the handling capacity of the wastewater treatment system may be exceeded and the sewage plus stormwater is then not treated, but is directly discharged into nearby rivers or seas (Allsop *et al* 2006). In separate sewers the sanitary sewage and surface runoff is separated, but in some cases the latter remains untreated and is discharged straight into the sea. The discharge of untreated sewage due to lack of or ineffective waste

water treatment combined with sewer overflows (storm events and occasional overflows), results in an influx of litter into coastal waters. Especially the Eastern Baltic countries have a large percentage of coastal outfalls (mainly stormwater outfalls) that do not have preliminary treatment or screens to remove large items.

4. CHOICE OF SOURCES AND PATHWAYS RELEVANT FOR MUNICIPALITIES

In the following section a selection of sources and pathways that may be the most relevant for municipalities, urban areas in particular, are proposed. It is taken into consideration that the proposed sources and pathways are relevant in the context of developing the marine litter monitoring programme and action plan (measures) for reducing and avoiding the marine litter. Therefore, these sources and pathways will be used as a basis for developing the checklist for mapping the concrete sources and pathways in any given municipality.

Sources are more relevant for different activities or economic sectors and locations where the littering takes place. Understanding the sources allows better planning and implementation of appropriate prevention measures. Information about related pathways gives a knowledge how the litter finds its way to the sea, which is important for the development of the monitoring and abatement measures.
Selection of the main sources relevant for municipalities (see Figure 2), i.e. for mapping of sources and pathways, developing action plans and monitoring programmes at municipality/regional level, followed the two main principles:

1. The categorisation of possible sources should be relatively simple/comprehensible and related to various activities (e.g. waste water treatment and sewerage system, municipal waste management system, industrial areas, ports etc.) that are relevant for different the municipality functions and physical locations.
2. The categories of sources should be chosen in such a way that the possible preventative and abatement measures/activities alone or in combination can be targeted predominantly to one category/activity/location.

The selection of the main land-based sources based on these assumptions and related to specific activities as well as possible pathways relevant for municipalities is presented in Figure 2 and Table 5 and explained further in chapter 4.1.1.

FIGURE 2. THE MAIN PATHWAYS OF MARINE LITTER

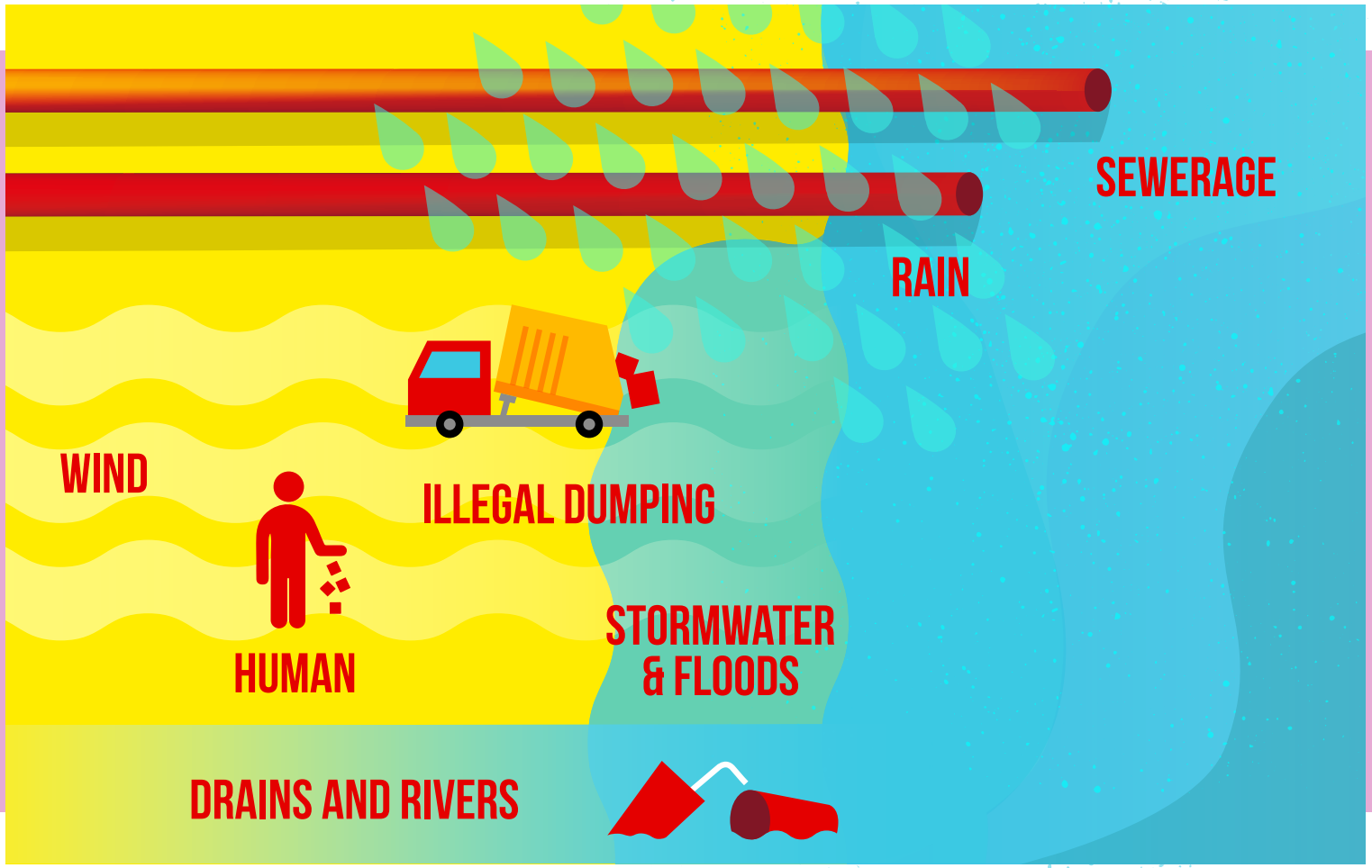


FIGURE 3. THE MAIN LAND-BASED SOURCES OF MARINE LITTER

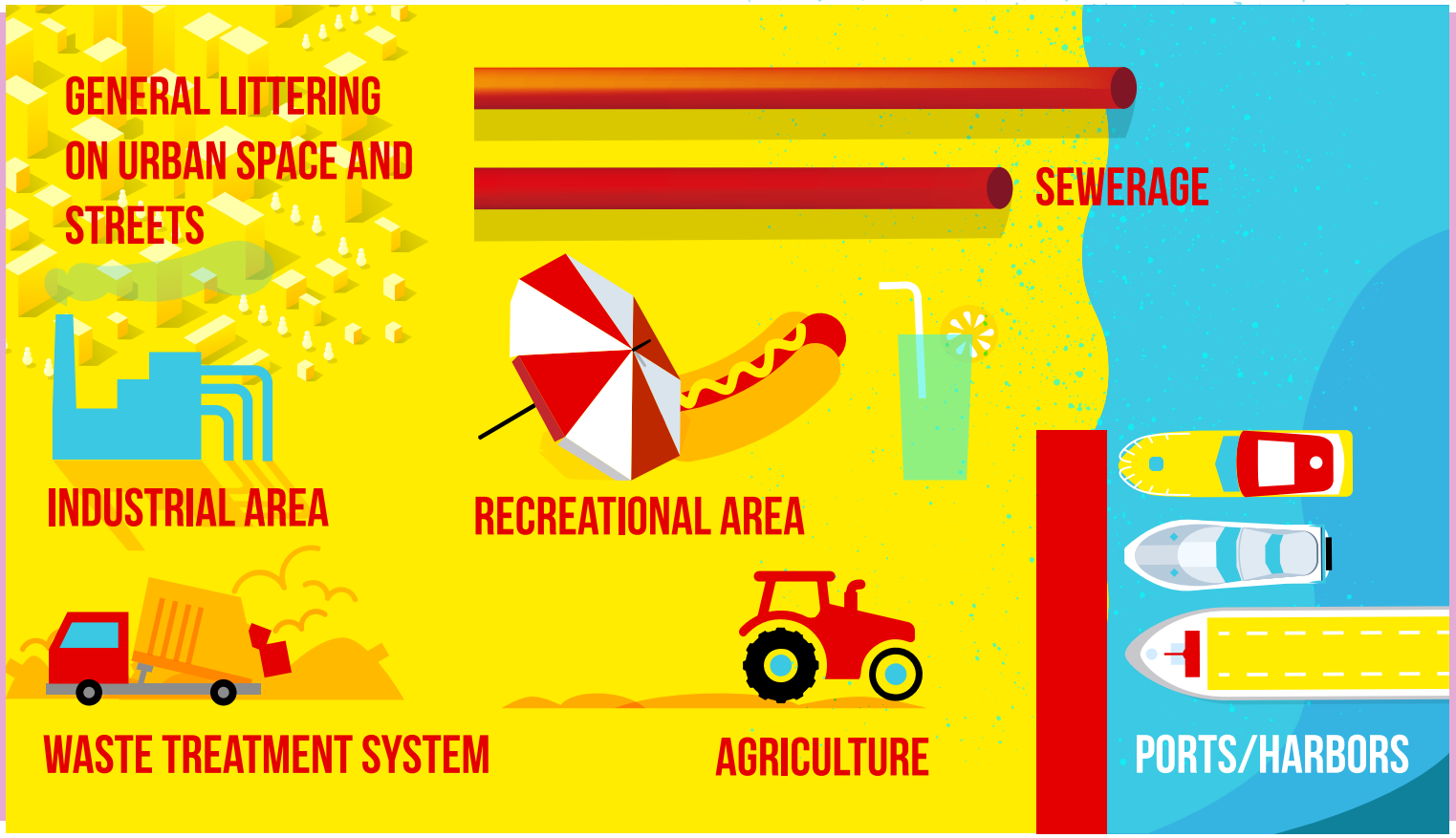


TABLE 5. THE MAIN LAND-BASED SOURCES, RELATED SPECIFIC ACTIVITIES/LOCATIONS, AND PATHWAYS RELEVANT FOR MUNICIPALITIES

SOURCE	RELATED ACTIVITIES AND LOCATIONS	PATHWAYS
RECREATION AND TOURISM	Littering - shoreline and recreation activities, such as events, visits, fishing, camping, picnics, etc. to the public and other beaches or by the riversides Smoking Boating and sailing (small harbours)	Human direct Wind Drains and rivers
GENERAL LITTERING	Littering on streets, roadsides and public areas Smoking	Human direct Run-off from streets and roadsides Discharge via sewerage system (sewer overflows) Drains and rivers
SEWERAGE	Waste water collection and treatment system – discharges of treated and untreated waste water (including stormwater and sewer overflows)	Discharge via sewerage system including sewage overflows
WASTE COLLECTION/ TREATMENT SYSTEM	Municipal waste collection and treatment system (Plastic) packaging waste collection system Illegal dumping and fly-tipping Illegal dumpsites or poorly managed former landfills and existing waste treatment facilities close the coast or river banks	Human direct Wind Drains and rivers Run-off from waste collection and treatment areas
CLEANING OF PUBLIC SPACES	Cleaning of streets and other public areas Snow removal from streets and storage close to coast/river banks or dumping directly to the sea	Wind Drains and rivers Run-off from streets and public areas
INDUSTRY AND COMMERCIAL SECTOR	Industrial areas – industrial discharges and spills (e.g. plastic resin pellets, particles, packaging waste) Construction and demolition sites Industrial and commercial waste management system Accidental losses during transport Activities at port territories – cargo handling and transport Waste management services at ports	Human direct Run-off from industrial territories or from port territory Wind Drains and rivers
AGRICULTURE	Use of agricultural film	Wind Drains and rivers

4.1. DESCRIPTION OF THE MAIN LAND-BASED MARINE LITTER SOURCES

A more detailed overview of the main land-based (plastic) marine litter sources presented in Table 4 and relevant for urban areas are given below.

RECREATIONAL AND TOURISM ACTIVITIES

According to relevant literature one of the most important land-based marine litter sources can be attributed to recreational and tourism-related activities both in the Baltic Sea area as elsewhere (see further Table 2). Litter sourced from such activities usually involves the inappropriate disposal of litter by the public, either accidental or deliberate, of which a large proportion is beach litter (incl. primary or sale packaging, plastic cutlery, straws, cigarette butts, sanitary items etc.) (Potts and Hastings, 2011). For some litter types however, it is difficult to distinguish their direct origin (boat user or beach). Waste (plastic) reaches the marine environment mainly because it is directly on the beach or in the sea, mainly intentionally disposed or through neglect and enabling the transportation of litter to the sea by wind or via drains and rivers. Loopholes are caused by human behaviour (low level of environmental awareness, consumption habits) during recreation as well by a lack of adequate infrastructure (insufficient amount of waste bins, location of waste bins, toilets, etc.) and quality of the waste management service.

Balloons and skylanterns released often in connection with some events have also recently received recognition as a potential source of marine litter (Sherrington and Darrah 2014).

GENERAL LITTERING

The most common activity that causes general littering is smoking. Smoking-related items such as cigarette butts, lighters and empty cigarette packages are among the most common marine litter items worldwide, including the Baltic Sea (Ocean Conservancy 2012). In this report smoking is not considered as a separate source as in some literature (Ocean Conservancy 2012) but together with general littering that includes also throwing away all kinds of things on streets, roads and public areas. Beach littering is not considered in this category. General littering is closely connected to human behaviour and attitudes towards the environment. Thus, lack of awareness of the public is an important factor for marine litter generation.

WASTE COLLECTION/TREATMENT SYSTEM

Poor municipal solid waste management practices (collection and treatment of municipal waste, waste from dump sites located near coasts or rivers, poor management of packaging waste) can be a major source of (plastic) litter, enabling the transportation of litter into the marine environment through a variety of path-

ways (wind, drains and rivers, sewerage). Poor municipal waste collection system, lack of waste management infrastructure, illegal dumpsites or poorly managed former landfills and existing waste treatment facilities can contribute to the marine litter generation.

CLEANING OF STREETS AND PUBLIC SPACES

Street litter which is washed, blown or discharged into nearby waterways by rain, snowmelt, and wind can contribute to marine litter generation. The responsibility for clearing litter from streets and public areas lies usually with local authorities. Thus, poor cleaning of streets and public areas can be an important factor for marine litter generation.

COMMERCIAL AND INDUSTRIAL ACTIVITIES

The following land-based commercial sectors might contribute to littering of the seas:

- industrial or manufacturing outfalls (e.g. by-products, plastic resin pellets, packaging waste, particles)
- construction and demolition sites
- transport - transporting goods may cause littering through accidental losses during transport (ARCADIS 2012)
- ports and harbours - small plastic resin pellets used as the feedstock for plastic production are an example of industrial discharges. The handling of ship-generated waste and cargo residues is regulated in the Baltic Sea area. Despite this, ports may be an important source for marine litter due to careless handling of materials and waste. Ports and harbours are in some studies categorised as sea-based sources of marine litter, but as the main activities of ports and harbours take place on land, the ports as a source is included into land-based sources under industrial activities.

AGRICULTURE

The inland and coastal agricultural activities also contribute to marine litter. Usage of plastics in agriculture can be various: e.g. irrigation pipes, planting containers, agricultural film. The latter can be a significant source of plastic waste to the environment if it is not collected correctly, and even becomes a source of marine litter in agricultural fields close to the coastline or rivers. This waste can enter to rivers and discharges or directly in to the sea both as agricultural litter mobilised by rain and flood water or wind, or during the waste management process. As there are many agricultural lands very close or even at the city territory, agriculture as a source is included into this report to be further analysed during the mapping of sources and pathways.

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