Monitoring litter in rivers

Sources of litter input to rivers and methods for monitoring micro-litter

Review document

Author: Robert Jönsson, WRS AB

Reviewed by Dimitry van der Nat, WRS AB

Uppsala, 2017-02-24

Contents

1 Introduction 1

1.1 Scope and objective 2

2 Land based sources of litter in rivers and the marine environment 2

3 Overview of existing work on litter monitoring in rivers in Europe 3

4 Methods for monitoring micro-litter (including microplastics) 4

4.1 Information and experiences of pump methodology for sampling micro-litter 5

4.1.1 Pump assembly 5

4.1.2 Choice of filters 6

4.1.3 The methodology used for sampling by pump 6

4.1.4 Filter analysis 7

4.2 Concluding remarks on the pump method and its potential applicability in river monitoring 8

5 Recommended further reading 9

6 References 10

1 Introduction

Input of anthropogenic litter to marine ecosystems is a well-recognized and widespread problem. The estimated annual litter load that reaches the world's oceans via various pathways is approximately 10 million tons. A large part of the anthropogenic litter load consists of plastics characterized by extreme longevity in marine environments (EEA, 2014). Fragmentation by ultraviolet light slowly degrades larger debris into ever smaller pieces to eventually become microplastics. The term microplastics is commonly used to describe plastic pieces smaller than 5 mm. The potential negative consequences of microplastic loads to aquatic life are thus far poorly described. Some studies show negative effects on biota, but more research is needed (JRC, 2013; Ogonovski et al., 2016).

There is no EU freshwater legislation covering plastic litter in freshwater ecosystems, due to plastics not being included in the Water Framework Directive (2006/60/EC, WFD) (van der Wal et al., 2015). Marine litter is, however, covered in the Marine Strategy Directive (MSFD) where one of its objectives is that "Properties and quantities of marine litter do not cause harm to the coastal and marine environment". The main goal of the MFSD is to achieve Good Environmental Status of EU marine waters (European commission, 2016). Inland activities play an important role in achieving good environmental status in the marine environment due to rivers discharging to the seas. There are several large river catchments that drain to the Baltic Sea. The rate of water circulation between the Baltic and the adjacent North Sea is extremely low, due to it being almost entirely land-locked (HELCOM, 2010). This means that plastics transported to the Baltic Sea can be expected to remain there for a long time. Litter of all size fractions from urban areas, such as cities is transported by run-off and ends up in streams and rivers and subsequently the marine environment. Little is, however, known about how large a pathway rivers are for microplastics. Even though some studies on litter abundance in rivers have been conducted thus far, the contribution of river plastic load to the oceans and its spatial and temporal variance is yet to be quantified by future monitoring.

1.1 Scope and objective

This paper is written on behalf of Coalition Clean Baltic and aims to describe a simple and robust technique that can contribute to gathering baseline data on micro-litter occurrence in rivers. The publication focusses on methodologies that do not require large logistic capacities and investments. River monitoring data obtained by the described techniques could support policymaking as well as identify hotspots where more elaborate research or mitigation efforts are required. The aims of this report are to:

- Summarize existing work on river litter monitoring and main sources of litter.
- Summarize methods for sampling and analysis of micro-litter.
- Use experience from field-testing to illustrate how methods can be applied in monitoring of micro-litter in rivers.

2 Land based sources of litter in rivers and the marine environment

A river is both recipient and pathway for land based litter ending up in the sea and a considerable portion of marine litter consists of plastic materials. Litter sources vary from public littering (either released directly into the rivers or indirectly via storm drains), improper waste management, landfills and litter spread via sewage (JRC (2016). After sampling both macro- and micro-litter in 4 large European rivers van der Wal et al. (2015) point out the industrial sector as the main source of riverine litter, particularly industrial packaging. They also point out urban areas, households, agriculture, fisheries, medical waste and wastewater treatment as potential sources. The greater part of the litter found in the studied rivers were identified as plastics (van der Wal et al., 2015).

The exact sources of found micro-litter in marine environments are hard to determine due to their small sizes. Apart from plastics, micro-litter also includes combustion particles and non-synthetic textile fibers from laundry. Even though cotton and other cellulose fibers aren´t as hard to degrade as synthetic fibers, they will still last a long time when emitted to the marine environment and can potentially pose a threat (Magnusson & Norén, 2011). The term microplastics is primarily used to describe plastic particles smaller than 5 millimeters. A distinction is made between two groups of particles; primary and secondary microplastics. Primary microplastics are microplastics produced intentionally in order to have certain attributes, e.g. abrasives in toothpaste and cosmetics as well as air-blasting media. The bulk of microplastics found in the marine environment, however, consist of so-called secondary microplastics originating from fragmentation of larger pieces (Lassen et al., 2015; Ogonovski et al., 2016).

Although many potential sources for microplastic emissions to the marine environment have been identified, quantification of contributions is difficult. Several national environmental agencies have attempted to determine pathways and quantify the land-based sources of microplastic emissions to the marine environment (Lassen et al., 2015; Magnusson et al., 2016; Sundt et al., 2014). The main pathways for land-based sources of microplastics entering the seas are suspected to be stormwater, sewage and wind. Although not entirely quantified, the main sources for microplastics in Sweden are assumed to be tire fragments from road wear, followed by washed out granules from artificial football turfs and laundry. Landfills and public littering are also suspected to be significant sources, but their contributions are even less well understood than those from the above sources. Transport mechanisms from the sources to the seas have not been studied sufficiently enough to draw any concrete conclusions about quantities that reach the seas and quantities retained on the way (Magnusson et al., 2016). The pathways (stormwater, sewage and wind) for land based sources of microplastics entering the marine environment also “discharges” into rivers. It is, therefore, safe to assume that the same land based sources for microplastics as for marine environment also find their way to rivers.

3 Overview of existing work on litter monitoring in rivers in Europe

Currently, there are no long-term programs for monitoring litter in European rivers on a regular basis (van der Wal et al., 2015). Globally, however, a number of projects that study litter in oceans, lakes, rivers and along beaches are being and have been conducted. Some projects were initiated by governments whilst others were initiated and carried out by NGO´s or through public initiatives. Following projects are examples of work regarding or related to litter monitoring in European rivers, table 1.

Table 1. Examples of projects and campaigns on litter monitoring in European rivers

Project or campaign	**Main organizer**	**Water body, location and litter category**	**Litter monitoring-related aim and information**
Ocean Initiatives	Surfrider Foundation Europe	Rivers, lakes, beaches and seas around the world. Macro-litter	Gathering of data from macro-litter collected in different clean-up campaigns. (Surfrider Foundation Europe, 2016)
Thames21	Thames21	The River Thames catchment, UK. Macro-litter	Organization of macro-litter clean-up activities and summarizing of their collection of data (Thames21, 2016)
Global Microplastics Initiative	Adventure Scientists	Rivers, lakes and seas around the world. Microplastics	Project where citizens around the world are encouraged to send in their own water samples, which are then analyzed for microplastics content in order to create a database (Adventure Scientists, 2016)
Identification and Assessment of Riverine Input of (Marine) Litter (*Project no longer in progress*)	DG Environment of the European Commission	Four rivers discharching to the North Sea, the Gulf of Bothnia, the Mediterranean and the Black Sea. Macro-and micro-litter	Aims described in the report: "1) To monitor litter in suspension in 4 European Rivers; 2) To assess the amount of litter discharged from these rivers into the sea: and 3) To identify the largest sources within the investigated river basins" (van der Wal et al., 2015)
Occasional scientific surveys for microplastics	Different research institutes	European rivers, lakes and seas. Micro-litter	Occasional surveys carried out by scientists aiming to study occurrence and effects of microplastics in different environments

4 Methods for monitoring micro-litter (including microplastics)

The field of studying micro-litter in the environment is still in its infancy and methods for sampling and analysis have thus far not been harmonized. The various methods all have their own benefits and recommending one particular method over the any other seems premature at present. When sampling micro-litter out at sea, the prevailing method has been trawling the surface using nets with mesh sizes of around 300 µm (JRC, 2013). Trawling with finer nets is difficult to do due to the high risk of clogging (Löder & Gerdts, 2015). Filtering smaller samples of water through fine filters has, however, indicated that the concentrations of micro-litter observed by trawling might be far too low. Micro-litter originating from tire wear, road wear and combustion of fossil fuels can be missed completely if finer filters are not applied (Norén, 2007; Magnusson & Norén, 2011). In order to monitor environmentally relevant micro-litter in the Baltic Sea, some scientists recommend filtering water through filters with mesh sizes of maximum 100 µm (Setälä et al., 2016). Sampling of micro-litter with filters finer than 300 µm, has on several occasions been conducted by pumping water through the filters (Enders et al., 2015; Jönsson, 2016; Magnusson & Norén 2011). An advantage of pumping is that the risk of contamination from airborne micro-litter is minimized. It also enables taking control samples to determine the effect of eventual contamination (Norén et al., 2014).

4.1 Information and experiences of pump methodology for sampling micro-litter

In 2011, Swedish scientist applied a new sampling technique involving pumping to take samples at several locations along the Swedish coast. Aim of their study was to test a sampling method that did not require trawling and offered the possibility of using finer filters than the usual 300 µm. A gasoline driven water pump with inlet and outlet hoses was used to pump water through a filter. Two types of filters were tested; plankton net (mesh size 300 µm) manually cut into circles and prefabricated polycarbonate filters (mesh size 10 µm)(Magnusson & Norén 2011). The method was later also applied for sampling micro-litter in a Swedish lake. Samples were taken either from piers protruding into the lake or small boats. The method was described as satisfactory and with a recommendation that sampling from boat should be performed by least two people for easier handling (Landbecker, 2012). Minor modifications of the sampling method have subsequently been used for sampling micro-litter in outlets of waste water treatment plants, with stormwater discharge points and out at sea (Jönsson, 2016; Norén et al., 2014).

In 2016 the method was used to sample microplastics from stormwater ponds and wetlands receiving effluent from wastewater treatment plants on 11 locations in total (Jönsson, 2016). Prior to the study the method was tested and fine-tuned by taking samples from the bank of a minor river. The following chapters describe the method in more detail and summarize experiences obtained during the study.

4.1.1 Pump assembly

The used setup was based on the method from the above-mentioned sampling of coastal waters (Magnusson & Norén 2011) and consisted of a gasoline pump, hoses, filter holder and filter. A mechanical volumeter was attached to the outlet hose in order to measure the volume of water filtered, figure 1. Alternatively, the filtrate could have been collected for subsequent volume determination. The 2.2 KW pump was purchased for about 200 euros at a local hardware store. The volumeter was also purchased at a hardware store for about 100 euros. The filter holder consisted of stainless steel pipes, gaskets, and a clamp. Together with hoses, these parts where purchased at a local hydraulics store. Some of the stainless steel parts where welded together to form the filter holder shown in figure 1. The inner diameter of the stainless-steel pipes was in this case 2 inches. The inlet and outlet hoses chosen had inner diameters of 1,5 and 1 inch. The dimensions where partly chosen out of availability and costs, but worked well for this project. The inlet hose was of sturdier material, not to deflate due to the suction pressure of the pump.

Figur 1. Equipment used for sampling of microplastics. On the left hand side: filter holder consisting of stainless steel pipes with a chamfer for gaskets, a nylon filter and a corresponding clamp. The filter holder was designed with a bend only to improve sampling in very shallow waters and to decrease the risk of sediments being filtered. To the right is the gasoline driven water pump connected to the filter holder and a red volumeter.

4.1.2 Choice of filters

Polyester plankton nets (Sefar Petex), where cut into circles to fit the filter holder. Two mesh sizes were used. The mesh size of 300 µm was used to allow for comparison of results with the majority of studies conducted thus far. The relatively large mesh size allowed large volumes of water to be filtered (up to several thousand liters). Additionally, new and smaller water samples (10-70 liters) was pumped through a filter with a mesh size of 20 µm. Larger volumes could not be passed through the 20 µm mesh due to clogging. Analyzing the particles caught in the finer mesh filters required more time and was associated with more difficulty than the analysis from the larger mesh filters. According to JRC, 2013 a trained plankton analyst can distinguish fragments of sizes down to 50-100 µm with an accuracy of 70 % by using a microscope. For smaller fragments, it is recommended that they are examined using more advanced equipment such as a Fourier Transform Infrared spectroscope (FT-IR).

4.1.3 The methodology used for sampling by pump

Prior to sampling the filters were thoroughly checked and cleaned from micro-litter with the aid of a microscope, and subsequently stored in clean glass petri dishes. On every sampling location, a test run was performed to determine how much water could be pumped through a filter before clogging and to make sure that all components of the setup were water filled before sampling commenced. The filter holder was fixed at a constant depth by suspending it from a wire attached to a pole. Sampling procedure is summarized below.

- The filter holder was thoroughly rinsed with clean water and a clean filter was inserted with a pair of tweezers.
- The filter holder was submersed and fixed at constant depth.
- The pump was started and run until the desired filtered volume was reached. Pumping was halted well before the filter would clog for easier analysis.

- The filter holder was raised from the water and the filter was placed in its sealed petri dish using a pair of tweezers.
- Filtrate volume was noted down.
- The procedure was repeated for the desired number of replicates.

To avoid sample contamination, sampling personnel wore only cotton clothing and samples were handled upwind. The filtrate was released downstream to avoid it being filtered twice.

Contamination effects can be quantified by taking control samples, for example by quickly stopping the pump directly after starting it and thereby, not letting any significant amounts of water pass through the filter (Norén et al., 2014).

4.1.4 Filter analysis

All filters were visually inspected with binocular microscope and 40× magnification, figure 2. Definitions from previous studies (Norén et al, 2007; Noren et al, 2009) were used in order to separate plastic from non-plastic micro-litter. Fibers of around 20 µm without tapered ends were defined as plastic if they were homogenously colored and lacked signs of cellular structures. Other particles were also regarded as plastics if they were homogenously colored and lacked organic structures. Potential tire or combustion particles were defined as having a deep black color reminiscent of coal or tar. Particles were also compared to a number of photos depicting known micro plastics. Photos from various prior studies were used for reference (Adventure Scientists (n.d.); Leslie et al., 2013; Magnusson & Norén, 2011; Mani et al., 2015; Norén et al., 2009).

Figur 2. Stereo-microscope and petri dish containing a filter.

The visual microscopic analysis is summarized below:

- A grid was drawn on both the bottom of the petri dishes and on a notebook paper. The grid lines were visible through the filters.
- Particle position, size and appearance were scored and categorized one square at a time with the lid kept on the petri dishes to avoid contamination. Many particles were also photographed.
- After quantification, the petri dish lids were removed and suspected microplastics in need of further inspection were transferred to a clean part of the filter with a pair of micro tweezers for further determination. Identification and detection was facilitated by carefully moisturizing the filters by water.
- Some particles, suspected to be of synthetic origin, were transferred to a glass slide and heated over a Bunsen burner. Particles that melted were considered as synthetic.

A more advanced way for material identification is to analyze individual particles by Fourier Transform Infrared (FT-IR) Spectroscopy. This method was tested for some particles found in larger quantities. FT-IR spectroscopy uses infrared light and measures absorption at different wavelengths. The obtained spectrum can be compared to reference spectra of known materials. If no match to known materials is found, the peaks in the spectrum can be interpreted by hand in order to provide information about chemical bonds between the atoms and functional groups.

4.2 Concluding remarks on the pump method and its potential applicability in river monitoring

The main advantage of the presented technique is that it is a cost-effective and relatively simple, yet robust method to sample microplastics in the water column. It has been successfully applied and tested under a range of conditions and environments. Operation of the equipment involved does not require cranes or advanced setups and is possible from small vessels. Although the technique has not yet been applied in rivers, there is little reason to assume that it could not be applied even there.

In order to coordinate monitoring efforts and produce comparable results, one approach could be to use 300 µm filters for simpler visual quantification of microplastics in binocular microscopes. If possible, it is wise also to perform additional sampling using filters with finer mesh sizes. A suitable mesh size for these filters might be 100 µm. This, since it was recently recommended as maximum mesh size for monitoring environmentally relevant size fractions of the Baltic Sea (Setälä et al., 2016) and still is large enough to get quite accurate results when quantification is done in a microscope (JRC, 2013).

Future sampling efforts in rivers have to take into account that litter occurrence across a river's cross section could be very heterogenic, particularly for larger fractions. Turbulence of shallow rivers, however, could result in a more homogenous dispersion across the water column for litter smaller than 1 mm (van der Wal et al. 2015). Spatiotemporal variation of litter occurrence in rivers is poorly described and future research efforts should focus on taking samples from several locations along river cross-sections under various flow conditions. When sampling from a boat, samples should be taken upstream of the vessel in order to minimize sample contamination by antifouling paint particles from the hull.

5 Recommended further reading

- A guide on how to analyze microplastics using a microscope, by Adventure Scientists: https://drive.google.com/file/d/0B7XLXGyqE-9iNkd1eVoyTHJtWmc/view
- A presentation by IVL Swedish Environmental Institute Research Institute, on the pumping method being tested in 2011: https://www.google.se/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwi1gp2Q6ZvSAhVF3iwKHTVqAsUQFggfMAA&url=http%3A%2F%2Fgesreg.msi.ttu.ee%2Fdownload%2F20130206_Kerstin%2520Magnusson.pdf&usg=AFQjCNGKDTEewLcM0q8l0hSGFeW5bHLQiA
- A working document made by the European Commission in 2012, overviewing EU policies, legislations and initiatives related to marine litter: http://ec.europa.eu/environment/marine/pdf/SWD_2012_365.pdf
- A study of litter occurrence in four large European rivers, by (van der Wal et al. 2015). Here some reference data can be found on both micro- and macro-litter: http://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/pdf/iasFinal%20Report.pdf

6 References

Adventure Scientists, *Global Microplastics Initiative* [Online] (2016) Available from: http://www.adventurescience.org/microplastics.html. [Accessed 2016-12-28]

Adventure Scientists (n.d.) *Guide to Microplastic Identification*. Adventure Scientists. Available from: https://drive.google.com/file/d/0B7XLXGyqE-9iNkd1eVoyTHJtWmc/view. [Accessed 2016-12-28]

Enders, K., Lenz, R., Stedmon, C. A. & Nielsen, T. G. (2015). Abundance, size and polymer composition of marine microplastics ≥10µm in the Atlantic Ocean and their modelled vertical distribution (ABSTRACT). Marine Pollution Bulletin, 100(1). Available from: https://www.researchgate.net/publication/282765621_Abundance_size_and_polymer_composition_of_marine_microplastics_10mm_in_the_Atlantic_Ocean_and_their_modelled_vertical_distribution. [Accessed 2017-01-28]

European Commission, Our Oceans, Seas and Coasts [Online] (2016). Available from: http://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/index_en.htm. [Accessed 2017-01-18]

European Environment Agency, *Litter in our seas* [Online] (2014) Available from: http://www.eea.europa.eu/signals/signals-2014/close-up/litter-in-our-seas. [Accessed 2016-12-28]

HELCOM (2010). Ecosystem Health of the Baltic Sea 2003–2007: HELCOM Initial Holistic Assessment (No. 122), Baltic Sea Environment Proceedings. Available from: http://www.helcom.fi/Lists/Publications/BSEP122.pdf. [Accessed 2016-12-28]

JRC, 2013. Guidance on monitoring of marine litter in European seas. Available from: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC83985/lb-na-26113-en-n.pdf. [Accessed 2016-12-28]

JRC (2016). Riverine Litter Monitoring - Options and Recommendations. Available from: https://ec.europa.eu/jrc/en/publication/riverine-litter-monitoring-options-and-recommendations. [Accessed 2017-01-18]

Jönsson, R., 2016. Mikroplast i dagvatten och spillvatten - Avskiljning i dagvattendammar och anlagda våtmarker (Master Thesis). The Department of Earth Science, Uppsala University. Available from: http://www.diva-portal.org/smash/get/diva2:1049924/FULLTEXT01.pdf. [Accessed 2016-12-28]

Landbecker, D. (2012). Anthropogenic Particles in Lake Mälaren (APILM) - With focus on microscopic and plastic fiber pollution in the water of the third largest lake in Sweden. Project Work 30 credits. Uppsala University. Available from: http://landbecker.se/wp-content/uploads/2012/09/Landbecker-2012-Anthropogenic-Particles-in-Lake-M%C3%A4laren.pdf. [Accessed 2016-12-28]

Lassen, C., Foss Hansen, S., Magnusson, K., Norén, F., Bloch Hartmann, N.I., Rehne Jensen, P., Gissel Nielsen, T., Brinch, A. (2015). Microplastics: occurrence, effects and sources of releases to the environment in Denmark. Danish Environmental Protection Agency. Available from: http://www2.mst.dk/Udgiv/publications/2015/10/978-87-93352-80-3.pdf. [Accessed 2016-12-28]

Leslie, H. A., van Velzen, M. J. M. & Vethaak, A. D. (2013). Microplastic survey of the Dutch environment - Novel data set of microplastics in North Sea sediments, treated wastewater effluents and marine biota. Institute for Environmental Studies VU University. Available from: http://www.ivm.vu.nl/en/Images/IVM_report_Microplastic_in_sediment_STP_Biota_2013_tcm234-409860.pdf. [Accessed 2016-12-28]

Löder, M.G.J., Gerdts, G. (2015). Methodology Used for the Detection and Identification of Microplastics—A Critical Appraisal. Chapter 8 in: Bergmann M., Gutow L. and Klages M. (eds). (2015). Marine Anthropogenic Litter. Springer. Available from: https://www.researchgate.net/publication/277584833_Marine_Anthropogenic_Litter [Accessed 2016-12-28]

Magnusson, K., Eliasson, K., Fråne, A., Haikonen, K., Hultén, J., Olshammar, M., Stadmark, J., Voisin, A. (2016). Swedish sources and pathways for microplastics to the marine environment - A review of existing data (No. C 183). IVL Svenska Miljöinstitutet. Available from: https://www.naturvardsverket.se/upload/miljoarbete-i-samhallet/miljoarbete-i-sverige/regeringsuppdrag/2016/mikroplaster/swedish-sources-and-pathways-for-microplastics-to-marine%20environment-ivl-c183.pdf. [Accessed 2016-12-28]

Mani, T., Hauk, A., Walter, U. & Burkhardt-Holm, P. (2015). Microplastics profile along the Rhine River. 2015 Available from: http://www.nature.com/articles/srep17988. [Accessed 2016-12-28]

Norén, F. (2007). Small plastic particles in Coastal Swedish waters. KIMO Sweden. Available from: http://www.n-research.se/pdf/Small%20plastic%20particles%20in%20Swedish%20West%20Coast%20Waters.pdf. [Accessed 2017-01-23]

Norén, F., Ekendahl, S. & Johansson, U. (2009). Mikroskopiska antropogena partiklar i Svenska hav. N-Research. Available from: http://naturvardsverket.diva-portal.org/smash/get/diva2:717410/FULLTEXT01.pdf. [Accessed 2017-02-16]

Norén, F., Norén, K. & Magnusson, K. (2014). Marint mikroskopiskt skräp - Undersökning längs svenska västkusten 2013 & 2014. Available from: http://www.lansstyrelsen.se/vastragotaland/SiteCollectionDocuments/Sv/publikationer/2014/2014-52.pdf. [Accessed 2016-12-28]

Ogonowski M, Schür C, Jarsén Å, Gorokhova E (2016) The Effects of Natural and Anthropogenic Microparticles on Individual Fitness in Daphnia magna. PLoS ONE 11(5). Available from: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0155063. [Accessed 2016-12-28]

Setälä, O., Magnusson, K., Lehtiniemi, M., Norén, F. (2016). Distribution and abundance of surface water microlitter in the Baltic Sea: A comparison of two sampling methods (ABSTRACT). Marine Pollution Bulletin. Available from: http://www.ivl.se/sidor/publikationer/publikation.html?id=5348. [Accessed 2017-01-23]

Sundt, P., Schulze, P.-E., Syversen, F. (2014). Sources of microplastics-pollution to the marine environmnet (No. M-321). Mepex for the Norwegian Environment Agency (Miljødirektoratet). Available from: http://www.miljodirektoratet.no/Documents/publikasjoner/M321/M321.pdf. [Accessed 2017-01-23]

Surfrider Foundation Europe, *Ocean Initiatives* [Online] (2016). Available from: http://www.initiativesoceanes.org/en/ [Accessed 2016-12-28]

Thames21, *About us* [Online] (2016). Available from: http://www.thames21.org.uk/about-us/. [Accessed 2016-12-28]

van der Wal, M., M. van der Meulen, G. Tweehuysen, M. Peterlin, A. Palatinus, M. Kovač Viršek, L. Coscia and A. Kržan (2015). SFRA0025: Identification and Assessment of Riverine Input of (Marine)

Litter. Available from: http://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/pdf/iasFinal%20Report.pdf. [Accessed 2016-12-28]