PlasticFreeDanube

D4.1.2 HANDBOOK FOR SAMPLING AND SORTING

to assess macro-plastic waste in and along river systems

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Table of contents

1. INTRODUCTION 4
1.1. Objective of the handbook 4
1.2. How to use the handbook 4
1.3. Outline of the handbook 4
1.4. Requirements on the protocols 5
2. SAMPLING OF MACRO-PLASTIC 6
2.1. The right sampling sites 6
2.2. Planning a sampling activity 11
2.3. How to use the Sampling Protocol 15
2.3.1. Preparation and Procedure 15
2.3.2. General Information 15
2.3.3. Description of the sampling area 15
2.3.4. Characterisation of river morphology & bankside area 15
2.3.5. Characterisation of the surrounding area 16
2.3.6. Graphic Description 16
2.4. Checklist for sampling 17
3. SORTING ANALYSIS OF MACRO-PLASTIC 18
3.1. Methodological approach of sorting 19
3.1.1. Comparison of existing Master-Lists 19
3.1.2. Categorisation 20
3.1.3. Possible Adjustments 24
3.2. Quantification of plastic litter 25
3.3. Size classes of macro-plastic 26
3.4. Planning a sorting analysis 27
3.5. Checklist for sorting 30
LITERATURE 31
ANNEX III i

Figures

Figure 1: Schematic procedure of a sorting analysis (Beigl et al.,2017)..... 18
Figure 2: EU plastic waste generation in 2015 (Eunomia cited in (European Commission, 2018) 21
Figure 3: Systematics of plastic litter classification in the “PlasticFreeDanube” project.....**Fehler! Textmarke nicht definiert.**
Figure 4: Sorting table and sorting containers for various categories..... 30

Tables

Table 1: Checklist for sampling activities 17
Table 2: Overview compared studies focusing on (marine) plastic litter 20
Table 3: Classification of plastic waste in and along the Danube..... 23

1. INTRODUCTION

Already 1990, the joint group of experts on the scientific aspects of marine pollution, called GESAMP, published in their report that land-based plastic debris account for up to 80 mass-% of marine pollution (GESAMP, 1990). Rivers are recognised as main path of pollution, but sources and transport behaviour as well as environmental impacts in fluvial systems are largely unknown. Existing studies are usually not comparable because different methods of sampling, measurement and sorting have been used. However, reliable estimates are essential in order to develop measures to reduce plastic pollution.

The two protocols developed within the project "PlasticFreeDanube" to ensure a future standardised collection and sorting of macro-plastic waste along riverbanks represent an important tool for generating a comparable database on quantities and types of plastic waste.

The following contents refer to **macro-plastic litter**. As a uniform definition of particle sizing does not exist so far, a common classification of the National Oceanic and Atmospheric Administration is used, which concluded that micro plastics be defined as pieces <5 mm, therefore macro plastics larger than 5 mm (Arthur et al., 2009).

1.1. Objective of the handbook

As there is no uniform approach to evaluate plastic litter in riverine systems, the project focuses, as a core task, on developing an adequate methodology for sampling (collection & analysis) of macro plastic waste along of water bodies and shore areas in form of a sampling and sorting protocol. Previous approaches to determine the occurrence and origin of plastic waste in rivers use different methods for sampling, measuring and sorting and are therefore largely not comparable. Prior initiatives often focus on voluntary collections with the aim of removing as much plastic waste as possible from the investigation area. Without the claim to standardized sampling, the results of such studies are of limited relevance with regard to plastic pollution.

Therefore, this developed methodology should provide a basis for prospective standardized evaluations in the Danube River region or other river systems. As an important tool for scientific organizations, research institutes, NGOs or cross-border bodies in future, this handbook serves as a detailed explanation on how sampling and subsequent sorting of plastic litter should be performed in a standardized way and how to use the protocol. Additionally, it also provides you the necessary background information for the organisation and accomplishment of a standardised collection along fluvial systems and subsequent sorting of macro plastic waste.

1.2. How to use the handbook

This manual serves as a supplement to the collection and sorting protocol (annex I+II). It contains detailed information of the applied methodology and further literature. In addition, this manual can be used to answer any questions that may arise during the collection or sorting of macro plastic waste.

1.3. Outline of the handbook

The manual is divided into two major chapters according to the two protocols. Chapter „sampling of macro-plastic“ lists the requirements for the sampling site, includes some handy tips for planning a

sampling activity and gives an overview of the handling of the sampling protocol. The second chapter "sorting analysis" summarizes the methodical process of the categorisation of macro-plastic waste, describes in detail the procedure of a sorting analysis and finally contains a checklist for the equipment.

1.4. Requirements on the protocols

In the course of a comprehensive literature search, existing guidelines, recommendations, catalogues and reports on the monitoring of (marine) plastic pollution were evaluated. The obtained findings were incorporated into the development process for the sampling and sorting protocol suitable for the issue at hand. The following requirements were taken into account:

- In order to ensure long-term monitoring, the implementation of sampling and sorting by laypersons (within the framework of voluntary collections) must be ensured.
- The results of the sorting analyses should provide information about the origin and sources of the plastics to realise appropriate prevention measures.
- With the help of the sampling protocol, it is possible to estimate the likelihood of occurrence of plastic litter, so that results from different locations can be compared, depending on e.g. bank structure, conditions in the hinterland and size of the collection area.

The developed sampling and sorting protocols were subsequently tested for practicability within volunteer collections and adapted on the basis of the findings. The results of this development process are implemented in the protocols that define the methodological approach, how the collection/sampling and sorting of macro plastic debris along riverbanks, such as those of the Danube, should take place.

2. SAMPLING OF MACRO-PLASTIC

The developed sampling protocol is an important tool to determine locations along rivers 1) where plastic waste is preferably discharged and 2) where a particular number of plastics accumulates.
Beside general information about the collection, sampling area, group size and others, the protocol contains a detailed questionnaire regarding the chosen river section (bank structure, vegetation, surrounding area). It also provides the opportunity of graphically recording noteworthy circumstances that were observed in the course of the collection.

2.1. The right sampling sites

First of all, one has to decide what the focus of the investigation should be to know where the right location for plastic waste collection and sampling could be. If the focus of the study is mainly to collect as much plastic waste as possible, you will have to visit other regions than if you want to get representative information about the plastic pollution in and along a certain distance of a river.

2.1.1. Find the right sampling site with focus on cleaning

The following section gives information how to - for the sake of the environment - get out as much waste from the river system as possible. The focal point of this collection are aesthetic aspects and environmental thoughts. Assertions regarding the quantification of plastic pollution in the river section under consideration are difficult to derive. A representativity of the data is not guaranteed, because especially for pollution hotspots an extrapolation would lead to an overestimation of the plastic discharge. The results of a subsequent sorting analysis can only be used as an overview of the plastic waste composition.

But how can these sampling places be found?

- **Own observations** e.g. during a walk along rivers, bicycle ride, visit of a “natural” bathing area: Identification of a river section or area close to a river with “own eyes”, which urgently needs to be cleaned of (plastic) pollution.
- **Experiences of other actors** e.g. national park rangers, NGOs, environmental organisations, fisheries associations, community representatives, etc.:
  Obtain reliable information from another party about a plastic pollution zone that is to be cleaned from litter and has a good accessibility.
- **Typical accumulation zones:** In some areas of a river, plastic accumulation is more frequently observed. If no other information is available, these can be targeted and waste can be collected there. One example of a typical zone is the riparian zone or the zone of the shoreline. In the areas with changing water shoreline, plastic can be



Figure 1: Identification of large-scale pollutions per web mapping

washed ashore, and if the area then dries out, a deposit will occur. Other examples would be the bushes (undergrowth) in outflow areas or in side arms systems. A third type of target zones would be eddy zones in running waters in which plastic waste circulates and is more likely to leave the system.

- **Large-scale pollutions** after flood events or other environmental disasters:
  In specific cases aerial photographs, satellite images, web mapping, etc. can also be used for detecting of polluted river sections. The up-to-dateness and a correspondingly good resolution of the images ("free" detection of pollution) is an important prerequisite for this. This method is also suitable for locating natural flotsam accumulations (not per se caused by a flood), which are often heavily contaminated with plastic litter (Figure 1).

2.2. The right sampling site with focus on representative results

In order to estimate and quantify the actual plastic discharge or the degree of pollution of a river, it is necessary to apply standardized sampling and sample analysis. Various conditions directly or indirectly influence the input or output of plastic litter in a fluvial ecosystem. On the one hand, land use or population density of the surrounding area directly affects the plastic entry into the watercourse, but only indirectly determine the discharge. On the other hand, river morphology (e.g. type of running water, river width, flow velocity), bank structure and protection or riparian vegetation directly influence the plastic discharge. Taking all these different conditions of the river system into account, general statements can be made. No clear relation between accumulation data and hydraulic parameters like water depth, flow velocities and specific discharge can be drawn. Accumulation processes, however, were found to have a clear correlation to vegetation and woody debris leading to high macro plastic concentrations. Maximum concentrations of 1130 g/m² compared with bank-near maximum concentration of 20 g/m² indicate, that the floodplain area works as a filter due to its vegetation.

The use of (2D, 3D) hydrodynamic models to predict plastic accumulation zones turned out to be a helpful tool. In general to get general statements about the pollution of a river section the focus could be laid on first of all identify via hydrodynamic models zones of higher or lower pollution potential and to take samples at selected zones of each category. The other possibility is to choose sampling zones randomly in advance without taking into account the river and bank morphology

2.2.1.1. Single sampling field to monitor changes

The simplest approach to monitor the riverine plastic pollution over a longer period of time would be to select a single measuring area for field test. This should be located near the water body and should also be "flooded" on a regular basis. Depending on the degree of plastic pollution, a minimum size of around 100m^2 (10x10m) would be recommended. If the area is too small, it could happen that no plastic items "land" in the test area. Natural conditions, e.g. prominent larger trees or stones, can be used as boundaries or markers. However, it is important to note that these markers must be able to withstand flooding and remain in place, otherwise the test area may not be able to be located or accurately determined. A calibration with GPS is recommended. Markers proved to be not fit for purpose.

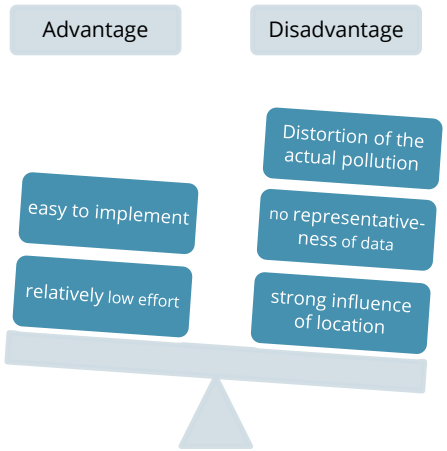


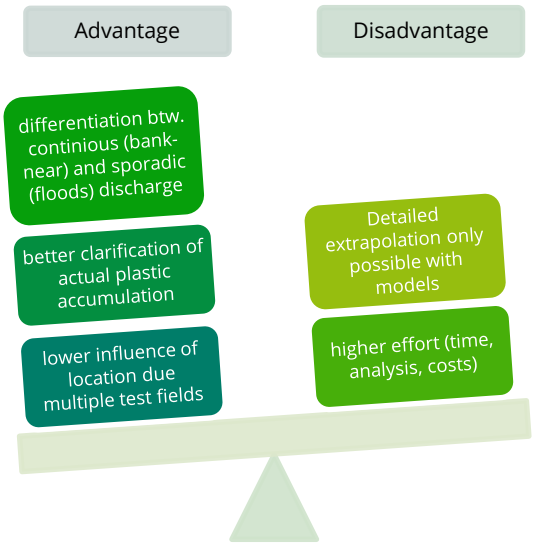
Figure 2: Pros and cons of single sampling fields

A major disadvantage of this approach is that the assessment of plastic accumulation has no claim to for generally valid statements about the degree of pollution of the river. Depending on the positioning of the test area, the generated data can deviate very strongly from the actual pollution situation (strong under- or overestimation).

2.2.1.2. Multiple sampling sites

In this approach, multiple sampling sites in a selected area are examined over an extended period of time. The individual test fields are either to be predefined on the basis of expected plastic pollution (by hydrodynamic modelling) or to be randomly selected. The statements about the actual "degree of contamination" are far more meaningful in this respect.

In principle, a distinction can be made between bank-near test fields and those located in the hinterland. While the areas close to the riverbanks can provide findings about the "daily" or continuous accumulation potential, sampling in the inundation area gives information about the discharge behaviour at higher flows/water levels or floods.
To arrange the test fields along the shore, a simple method would be to divide the investigated river section by the chosen number of sampling sites (e.g. 5km river length and 10 sampling sites → 500m). In this context, it should be noted that – from the statistical point of view - it makes more sense to have smaller test areas, but several. Experience in the PFD project has shown that, for example, a width of 5-10m is well feasible with two people. Collections were made side by side from the towpath (at the dam as a natural barrier) to the waterline.



The **test areas in the hinterland** can be selected with the help of flood maps (e.g. HQ1-5). The map should ensure that the areas will be flooded

in the foreseeable future or during the monitoring period (e.g. annual flood = HQ1). One option to randomly define the test areas is to place a grid over the floodplain to be studied (Figure 3). Each cell is numbered and represents a fixed size unit (e.g. 100m²). By means of randomization, a certain number of areas is determined. Finally, the coordination of the test fields can be assigned using a (online) map service or common GIS (geographic information system) software.

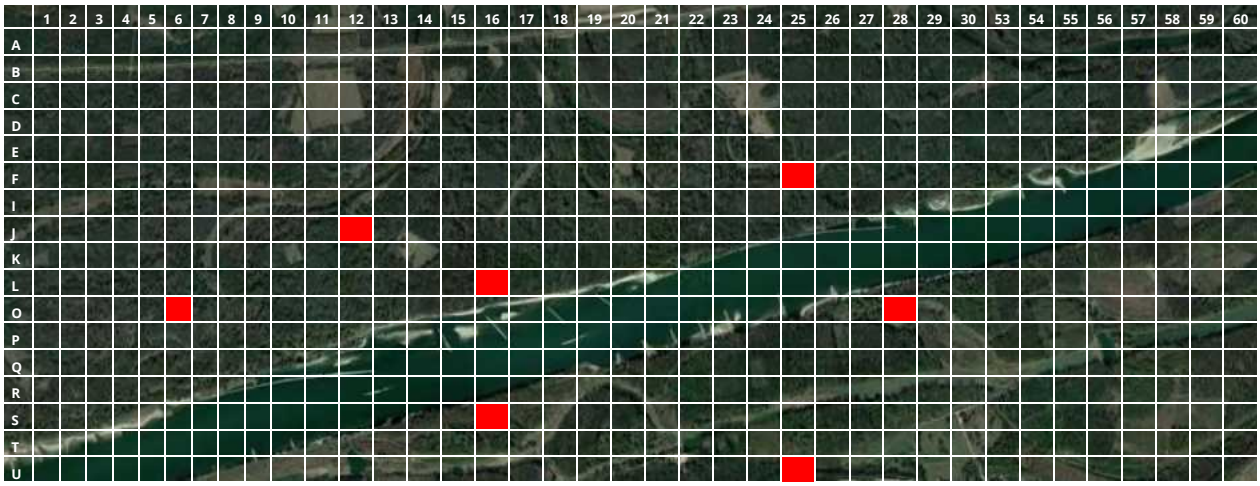


Figure 3: Determination of test fields in the hinterland

Depending on the research question as well as local conditions a focus of the sampling at **bank near testfields** might be preferable. Sample areas can be selected by defining test areas at specific intervals along the bank. The distances are determined by the length of the examined river section. A selection of a minimum of 15 test fields is recommended (Figure 4).

Furthermore, it should be ensured that sampling along the riverbanks can be carried out within one day, since fluctuating water levels can considerably influence the sample of the respective test area. Test fields in the hinterland are excluded in this respect because they are flooded only during occasional floods anyway, but are also usually associated with a greater volume of pollution. In this respect, there is more time to clean the respective testing zones, because flood events do not usually occur in immediate succession.

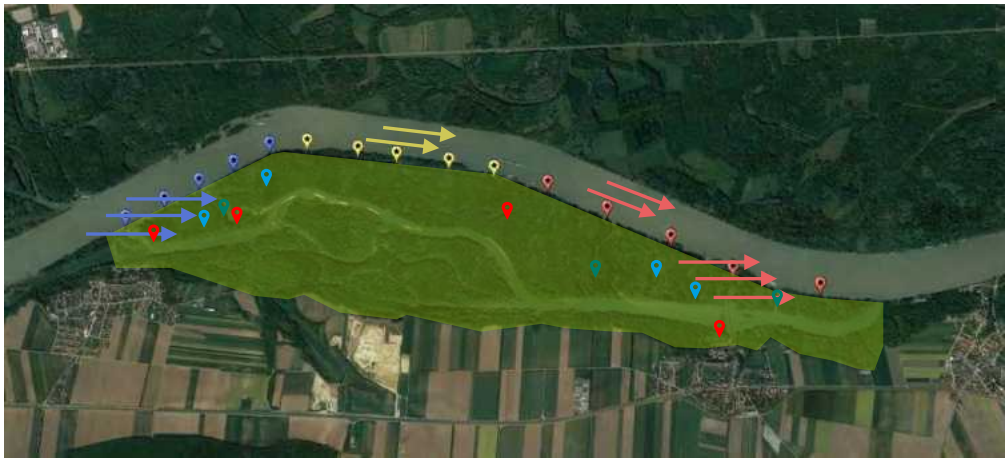


Figure 4: Possible multiple sampling design for bank-near and hinterland test fields

Another approach, which becomes essential if the analyses take place not only in the floodplain of rivers but generally along rivers is to divide the study area by pollution potential (Figure 5). The specific areas (depending on various conditions, such as river type, settlement density, bank stabilization, vegetation, flow course, location, etc.) essentially exhibit different levels of plastic entries (based on visitor pressure) as well as plastic accumulation potentials (Table 1). If the individual areas are tested, statements and a rough estimation can also be made about the pollution status in an extended river section or river catchment area.

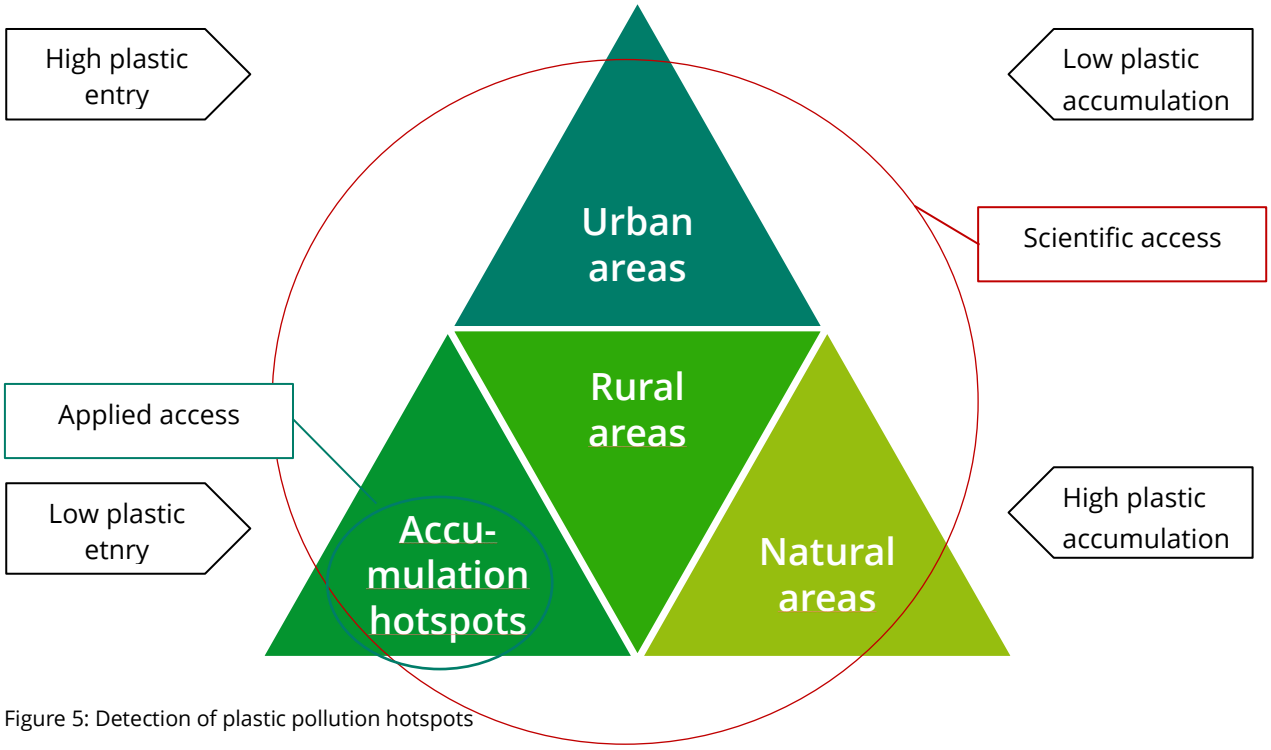


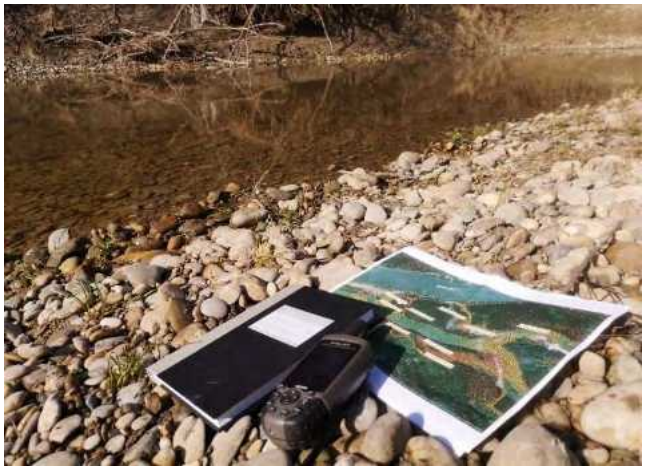
Figure 5: Detection of plastic pollution hotspots

Table 1: Typical conditions regarding plastic entry and accumulation in different areas.

URBAN AREA high entry – low accumulation	**RURAL AREA** moderate entry – moderate accumulation	**NATURAL AREA** no entry – high accumulation
• strongly regulated • straightened river course • bank reinforcement • flood protection • walkway/ cycle path • low vegetation • densely populated and sealed area (settlement area) in immediate surrounding • regular cleaning (by city administration) • easy removal of the waste	• Less regulated • More diverse shore conditions • Hydraulic engineering structures (groynes, longitudinal structures) • Agricultural and forestry use in surrounding • Limited access • Rare cleaning campaigns • More difficult removal of the waste	• Barely regulated – natural conditions • Distinct hinterland conditions: side arms, floodplains, alluvial forest, etc. • Strongly overgrown • No access by truck, only by boat • Normally no cleaning activities

2.3. Planning a sampling activity

For many people, the collection of carelessly discarded waste in nature or in public spaces (= littering) is primarily related to aesthetic aspects. At the same time, it is accompanied by the removal of potential environmental hazards (e.g. formation of micro-plastic caused by breakdown of larger plastic objects → adhesion of pollutants to these tiny particles → absorption via the food chain = bioaccumulation). However, the collected waste can be used to carry out further investigations, which are decisive for the development of measures to reduce environmental pollution. Besides chemical analyses, which can provide data on the environmental hazard potential of a substance, sorting analyses are a simple method of generating information on the composition and thus the origin and source of the waste. To get representative results, a correspondingly careful planning of the collection/sampling activity precedes this.



Check out these issues before sampling...

What is the purpose and the objective of the collection / sampling initiative?

- ↳ Is the focus of the activity solely on cleaning a river section of plastic litter (awareness raising) or to generate scientific data on plastic pollution in the study area?
- ↳ For whom could the resulting data & information also be of interest?

Who is the initiator and/or coordinator? Who takes over the organisation of a sampling activity?

- ↳ Division of tasks; for larger events an organising team is recommended
- ↳ Who bears the responsibility?
- ↳ Do I first determine the location that should be cleaned and then the number of collectors or vice versa?

Who should collect or take samples at all?

- ↳ Whom do I want to reach, whom do I want to invite? (organisations, associations, clubs, schools, colleagues, researcher, private people, etc.)
- ↳ Is it a private or public event?
- ↳ Ideally, the collection is done by volunteers, but of course it can also be done by researchers themselves; the advantage of a volunteer collection is the saving of time (for scientists) and the aspect of raising awareness; on the other hand, researchers usually obtain a more precise knowledge of the plastic pollution location

How can potential participants be reached?

- ↳ Where can I advertise the "event"? Special advertising necessary?
- ↳ Which channels can be used for communication and information (social media, newspaper, radio, word of mouth, etc.)?

Find a date and place for the collection:

- ↳ Where exactly is it to be collected? Are "permits" to be obtained (e.g. national parks)? Who would be the contact person for this?
- ↳ Find and fix a date for your campaign - you don't want to go collecting alone!
- ↳ Online calendar for coordinating meetings (e.g. doodle) could be a handy tool to narrow down or set a suitable date

How many people will participate approximately?

- ↳ compile a list of participants
- ↳ ask again if necessary

Clarify the route in advance:

- ↳ Parking lots available, if you arrive by private car?
- ↳ What is the public connection (bus, train) to the location?

Determine an exact meeting point

- ↳ Choose a prominent location that is easy to find (possibly also visible in web mapping services like Google Maps, Apple Maps, etc.)
- ↳ Locate GPS coordinates if necessary

Check list of equipment (2.4)

- ↳ Organize the purchase of cut-resistant gloves, garbage bags, writing materials, etc.
- ↳ Who is responsible for food and drinks of the volunteers?
- ↳ Printing Sampling Protocols

Organise in advance who will transport the collected waste. Where will they be stored?

- ↳ Suitable vehicle for transport
- ↳ Clarify access to collection areas
- ↳ Where can waste be stored temporarily until it is sorted
- ↳ Clarify who is responsible for the subsequent disposal (after sorting) and who will pay for any costs
- ↳ Where can the waste be finally disposed of?

Who is responsible for the collection team? Who is the person responsible on site?

Send an invitation to the participants with the most important information (date, time, meeting point, expected duration, personal goods, etc.).

On site, you should consider…



Give a short introduction

- ↳ Wherefore is the collection? Touch briefly upon the plastics problem.
  Why is it important to take the waste out of the river system?
  What happens to the waste (leading to the topic sorting analysis)?
- ↳ The introduction should motivate the volunteers to collect as accurately as possible, while making clear to them why it is important to collect accurately (to get adequate data)

Distribution of cut-resistant gloves and garbage bags (or other collection containers like buckets)

Distribution of the sampling protocols and pencils

- ↳ Brief explanation of the information to be collected
- ↳ Point out that the introduction of the protocol should be read thoroughly
- ↳ Designate someone in the group for the entry in the log (the others should help!)

Clarify who walks which route approximately

- ↳ Division into groups (if several people are present)
- ↳ Limit the "frame" (e.g. up to max. 50m away from the river)
- ↳ Avoid that the individual groups of the same section go off twice (cleaning)

Determine meeting point and time for break or end of collection

- ↳ Get a mobile phone number to contact each group
- ↳ Please note that it can happen that there is no reception outside to make a call.
  Agree already before the beginning, where you will meet again and when!

If possible, already collect plastic waste separately

- ↳ When you collect litter along the water body, then you will not only pick up plastic waste. For later specific analyses, it makes sense to separate the plastics from other waste in advance.
- ↳ in differently coloured bags for instance
- ↳ or mark the “plastic waste” bags

Define parking of full bags/containers along the route

At the end of collection assign the bags to the respective group or cleaned section by labelling or clearly marking them accordingly (e.g. date, name of group / river section, specific code that is also noted at the sampling protocol)

Collection done, but then…

Question round to the participants

- How have they been doing with the collection?
- Which (plastic) waste was discovered particularly frequently?
- Were there places along the route where a lot of waste was discharged?

Gather the sampling protocols

- Brief check whether the most important points have been filled in

Gather and control the collected bags whether they are clearly labelled or marked

Take away the full garbage bags to the storage location





2.4. How to use the Sampling Protocol

2.4.1. Preparation and Procedure

After the sampling protocols have been distributed in the group, please read the points of the protocol listed above carefully! They contain precise instructions on how to use the protocol under the respective conditions (several groups, rapidly changing bank structures).

2.4.2. General Information

Most of this information can be entered before the sampling begins, some during and other at the end of the collection. It is therefore advisable to take a brief look at the entire protocol in advance!

The estimation of the cleaned area needs special attention. This is necessary in order to be able to make statements about the degree of contamination of concerning area (e.g. plastic items per unit area). In this context, it is important to record the cleaned area by means of GPS coordinates or river kilometres. In addition, the width/depth of the cleaned area should be determined by yourself (e.g. pace off the distance). A specification of the used equipment (mobile phone, GPS device) and further details, like the projection, coordinate system or used web/online-application facilitates the evaluation of the data. Experiences has shown that it makes sense to record the start (point) immediately, on the one hand in order not to forget it and on the other hand in order not to have to go back the entire route if the collection ends at another point (end point) and you leave the area from there.

Besides the number of participants (per group) and number of (full) garbage bags they have collected, an estimate of the most frequently found or picked up waste is also asked.

2.4.3. Description of the sampling area

Here you can choose between three options, depending on your distance to the river (“where exactly does the collection take place”). Essentially, a distinction is made between sampling at the riverbanks or collection in the hinterland (e.g. inundation area). Depending on your selection, you have further questions to answer. There is of course also the possibility to collect on the riverbank and in the hinterland (e.g. a regulated brook with a correspondingly small bank area and directly adjoining farmland or other area), in this case, all points in the protocol would have to be filled in. If the riverbanks to be cleaned and the collection area in the hinterland are correspondingly far away from each other and are nevertheless sampled together (by the same group), it is recommended to fill in two protocols.

2.4.4. Characterisation of river morphology & bankside area

In principle, deposited plastic litter along rivers originate from a) on-site littering at the riverbanks as well as the immediate environment or b) discharge as flotsam from the river. Depending on the general conditions, one or the other “pollution type” will prevail or can be excluded. Thus, it is especially important to note down a precise description of the present river section (river width, type of bank, where is the collection area located). This includes a guide for the approximate calculation of the flow velocity.

Bank structures and bank protection influence the plastic discharge of the river very differently. While sealed and smooth structures (e.g. concrete dams) hardly allow adhesion and thus the waste remains in the water stream, some natural conditions in combination with the riparian vegetation favour an

increased plastic accumulation. The vegetation acts as a natural ridge, depending on the type, size, area spread and much more, has a great potential to retain (plastic) waste already at the edge of the bank, and thus prevents it from spreading further into the rear zones.

Structural elements such as guiding walls or groynes can also influence the plastic discharge. Turbulences or prolonged retention times of the water in these fields increase the likelihood of a landing of contaminants.

Furthermore, popular recreation and bathing areas or other regular or highly frequented areas in the immediate littoral zone can implicate an increased littering. In some cases, it is really difficult to distinguish between the on-site littering waste and the plastic discharge by the river. "Natural soiling" by sand, mud, algae, or water residues may be a possible indication that the present plastic item concerns to discharged litter. New or clean plastic debris (e.g. clean flexible packaging) tends to indicate local littering waste.

2.4.5. Characterisation of the surrounding area

Try to depict the predominant type of land use in the immediate surroundings at this point. A range of examples is given in the table in the protocol, but other forms of land use can also be specified. Further, estimate the proportion of the selected areas (e.g. 70% farmland, 20% rural settlement area, 10% roads), the sum should be 100% obviously. Land use may provide some indication why one type of plastic has been detected particularly common (e.g. increased occurrence of littered waste at riverside promenade in urban areas; or mulch / horticultural film used in surrounding agriculture).

Other characteristics such as accumulation points are also queried. If places where a lot of waste are found, have been located along the sampling route, a short description should be given (e.g. accumulation of floating debris including pollution, punctual accumulation area of only a few square metres nearby a tributary, increased combing of foliage through riparian vegetation like willows or reeds).

2.4.6. Graphic Description

Some people may find it easier to record their observations graphically or to draw in any noteworthy circumstances, special structures or others that have caused increased discharge/accumulation of plastic.

2.5. Checklist for sampling

In the following table, you find some useful equipment for a successful collection:

Table 2: Checklist for sampling activities

General equipment	Optional equipment
☑ **PFD Sampling Protocol(s)**	☑ Rubber boots
☑ **Pens, permanent marker (waterproof)**	☑ Waste gripper
☑ **Clipboards for protocols**	☑ Warning vests
☑ **Cut resistant gloves (protection against e.g. syringes)**	☑ Roll scale or folding rule
☑ **Garbage bags or buckets for collected waste**	☑ Map of the river section / collection area
☑ **Duct tape or similar for labelling the bags**	☑ spare clothes for “emergencies”
☑ **First-aid-box (plaster, disinfection, bandage)**	
☑ **Camera (or mobile phone) for pictures**	
☑ **GPS device or mobile phone for coordinates**	
☑ **Clothing appropriate to the weather**	
☑ **Sturdy shoes**	
☑ **Sun block /cream, mosquito spray**	
☑ **Personal goods (food and drinks, spare clothes)**	

3. SORTING ANALYSIS OF MACRO-PLASTIC

To counteract the problem of riverine litter and to develop appropriate, application-oriented and pragmatic measures, sources of plastic pollution need to be identified. Possible origins of plastic waste covers (Faure et al., 2012; van der Wal et al., 2015):

- public littering - indirectly close to or on riverbanks as well as directly in the river
- waste from settlement areas and harbours
- poor waste management (missing infrastructure or mismanaged landfill sites)
- fly tipping (= illegally dump waste)
- product loss or improper disposal from industrial and agricultural processes / activities
- sewage-related debris (discharge of untreated waste water, through the lack of sewage treatment plants or from sewer overflows or discharge from untreated storm water which entrains waste collected in storm drains into the rivers)

A detailed description of possible entry sources in the project area of "PlasticFreeDanube" can be found in the *Report on available data regarding plastic pollution* (D 3.3.1). Furthermore, the report *Development of a methodology for a material-flow-analysis of macro-plastic waste in and along the Danube* (D 3.2.1) gives an overview about various approaches to classify sources of plastic pollution.

Sorting analyses of waste generally address the identification and examination of solid waste composition using physical procedures. Thus, this tool is ideally suited to answer the specific questions

» Where does the collected macro plastic waste in the investigated area come from? (Determination of origin by characterisation of plastic waste composition)

Figure 6 shows the schematic process of a sorting analysis of solid waste inspired by "Development of a guideline for household waste composition analyses" (Beigl et al., 2017).

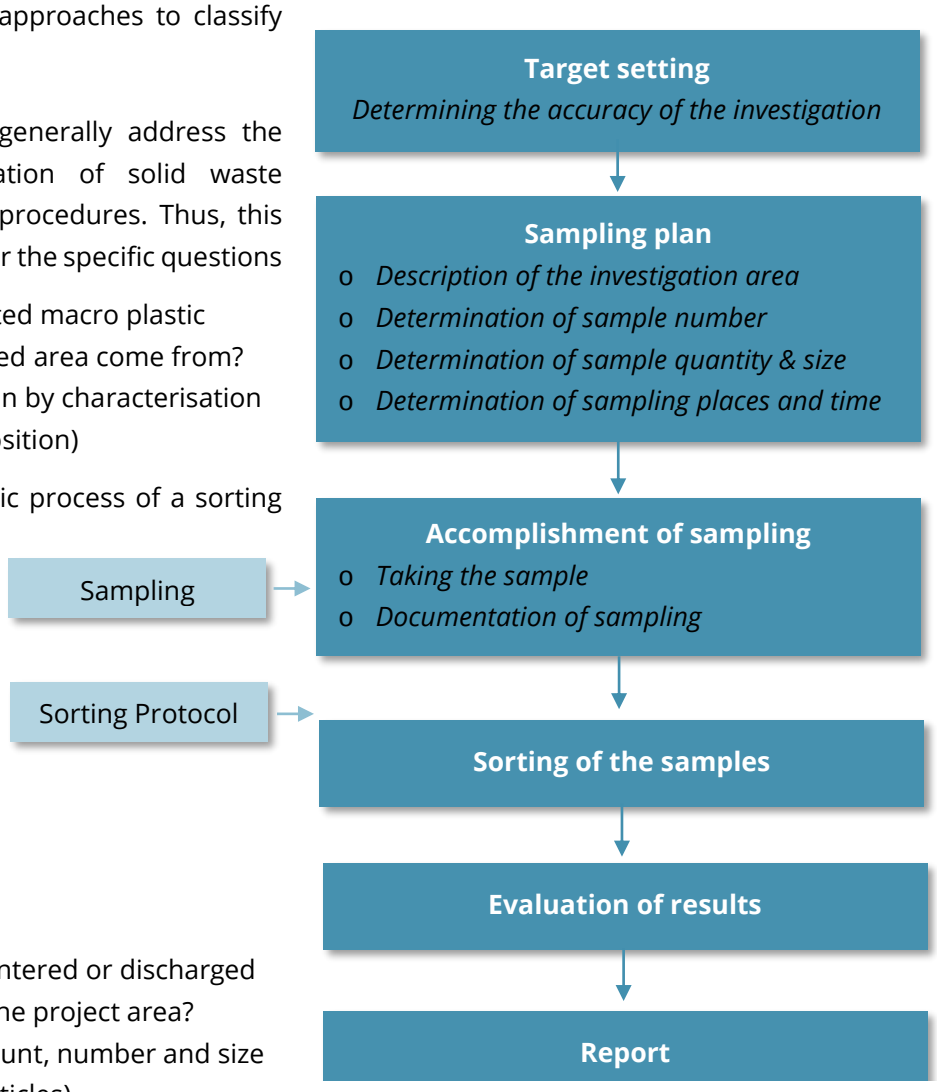


Figure 6: Schematic procedure of a sorting analysis (Beigl et al.,2017)

The question:

» Which quantities are entered or discharged in the river system in the project area? (Estimation of the amount, number and size of plastic pollution/particles)

Cannot directly be answered by sorting analysis. Here the answers depend on the selected sampling procedure (see chapter 2.2.1.2 Multiple sampling sites)

The target definition of the project implies the sources, origin and quantity estimation of the collected plastic litter in a specific area. Beside the sampling protocol, a sorting catalogue has been developed (ANNEX V) which primarily focuses on the identification of the origin of the collected litter. After the statistical evaluation and plausibility check, the analysis data serves to monitor the riverine litter situation.

3.1. Methodological approach of sorting

Concerning the monitoring of anthropogenic marine pollution, a wide range of waste classifications already exists (Cheshire et al. 2009, OSPAR 2010, van der Wal et al. 2015). These served as a starting point for a comparison of the existing catalogues and the plastic fractions defined therein. Also obtained information from other organisations and initiatives active in this field were included. In order to determine the input paths of plastics and to develop and evaluate avoidance measures, it is necessary to classify plastic debris.

A pre-test (first sorting) of plastic waste from the Donau-Auen National Park initially provided a rough overview of the material composition of the existing plastic items. On that basis, similar (product) groups or categories of pre-sorting and the reviewed protocols were combined, simplified and standardised to establish a preliminary categorisation of plastic waste in running waters. Due to the project-specific question of the origin of plastic pollution, a functional classification was chosen in order to be able to assign the respective fractions to the emitting sector or source in the best possible way.

In the course of the sorting analyses, the classification is checked for traceability and plausibility regularly and adjusted if necessary. Usually, the plastic items are assigned to the respective fractions (Table 4) purely visually “with the naked eye” during sorting analyses, following the general aim of the project to create a method that can be easily applied by volunteers.

The developed **sorting protocol** is designed to evaluate, estimate and monitor the macro plastic deposits along riverbanks and directly influenced surroundings as well as to identify possible sources of pollution. The chosen method, should be an important tool in the future to generate a comparable database on quantities and types of plastic waste.

3.1.1. Comparison of existing Master-Lists

Compared to waste in marine ecosystems, there are only a few studies dealing with plastic pollution in rivers. Insofar, most existing waste sorting catalogues (master-lists) target on marine litter in form of a monitoring protocol to evaluate changes of pollution grade in e.g. certain sections of the beach.

The composition of marine waste, however, sometimes differs greatly from those in rivers. For example, deep-sea fishing uses special nets that are not utilised in rivers because of their size or intended application (e.g. oysters). In addition, country-specific waste can be detected that does not occur in other regions (e.g. pack yokes/rings used in multi-packs for beverages cans e.g. in the US, but they are not available as such on the Austrian market).

For this reason, different catalogues were contrasted and compared in a first step (Annex I). Following, Table 3 gives a brief overview of some relevant studies.

Table 3: Overview compared studies focusing on (marine) plastic litter

Source	Environment	Litter size	Approach & objectives
Cheshire et al. (2009): United Nations Environment Programme / Intergovernmental Oceanographic Commission: Guidelines on Survey and Monitoring of Marine Litter	Beach / Sea (floor)	Macro	Development of standardized operational guidelines for the assessment of beach, benthic and floating litter with the outcome of two classes of analyses: comprehensive and rapid surveys.
Hanke et al. (2013): Marine Strategy Framework Directive - Technical Subgroup on Marine Litter: Guidance on Monitoring of Marine Litter in European Seas	Beach / Sea (floor)	Micro & macro	Guidance describes specific protocols and considerations for the collection, reporting and assessment of data on marine litter, in particular beach litter, floating litter, seafloor litter, litter in biota and micro litter.
OSPAR (2010): Oslo- and Paris Convention: Guideline for Monitoring Marine Litter on the Beaches in the OSPAR Maritime Area	Beach / maritime area	Macro	Monitoring guideline for marine litter on beaches to collect data on litter in the marine environment. The tool has been designed to generate data on marine litter according to a standardized methodology for regional interpretation of the litter situation in the OSPAR area and comparisons between regions.
Pressl et al. (2013): Survey of floating litter in the Danube at Vienna	River	Macro	Survey of littering and plastic debris drifting between the water surface and about 1 m depth in the Danube at Vienna by developing a sampling approach for screenings of hydropower plants.
Schüttpelz (2014): Measuring Marine Litter density, mass and composition – including a case study on land-based litter along the Danube	Beach / Sea (surface, floor) / River	Micro & macro	Comparison of 190 scientific articles that determined marine litter quantities and composition at beaches, the sea surface and the sea floor. The master thesis includes also a small survey along the bank of the river Danube.
van der Wal et al. (2015): Final Report for the European Commission DG Environment: Identification and Assessment of Riverine Input of (Marine) Litter	River		The aim is to investigate the level of plastic pollution in EU rivers and to estimate the level of inputs of plastic litter from the rivers into four European regional seas.

3.1.2. Categorisation

As already mentioned in the introduction (1.4), the sorting catalogue has to fulfil the requirements of simplified handling, easy traceability and plausible assignment of origin (of the collected waste) with a certain degree of accuracy that even non-specialists and laypersons without background knowledge can use it. Regarding classification of macro-plastics, it is important to define comprehensible allocation criteria and to rule out any possibility of confusion.

The categorisation of the PFD sorting catalogue builds on the one hand on the classification of the EU plastic waste generation (Figure 7), which is divided in the two main groups "packaging" and "non-packaging". One the other hand, we identified those sectors in the plastic application from which a potential entry into the running waters is to be expected or could actually be proven by the first sorting analyses. In addition, those waste categories that are significant in terms of quantity or volume were outsourced separately (like PET-drink bottles, foamed plastics, etc.).

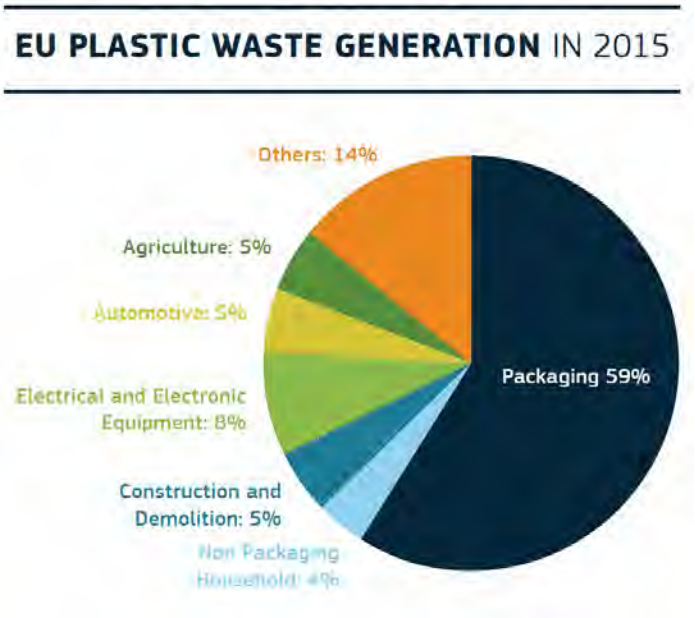


Figure 7: EU plastic waste generation in 2015 (Eunomia cited in (European Commission, 2018)

In the context of a categorisation of waste, there is usually a trade-off between the highest possible resolution in the classification and the expected effort (time and costs) in the analysis of waste. As mentioned in the UNEP / IOC Guidelines on Survey & Monitoring of Marine Litter (Cheshire et al., 2009) from a scientific point of view, a higher resolution in litter classification (i.e. the subdivision of litter into a greater number of discrete categories) is attended by a more accurate analysis and interpretation of data. However, a smaller number of categories is likely to result in a lower error rate and thus entails more coherence in data collection as well as making it possibly easier to gain acceptance and willingness of volunteers and survey staff, including in terms of training and support.

The approach for plastic litter classification presented in this handbook has been chosen to guarantee a good balance between operational efficiency and resolution. The system comprises a four-level hierarchy (**Fehler! Verweisquelle konnte nicht gefunden werden.**) that identifies plastic items firstly by main use "packaging" and "non-packaging" (with the exception of the difficultly assignable foamed plastics, which constitute an overlap) and then by utilisation sector (e.g. household, building sites, etc.). A further subdivision in categories primarily based on functionality as well as form and type of plastic. The classification system comprises a list of four different main groups, 9 sub-groups and a total of 24 discrete categories of plastic litter (Table 4).



Figure 8: Systematics of plastic litter classification in the "PlasticFreeDanube" project

Numerous sorting analyses in the course of the project supported the progress to check the classification for traceability and plausibility and the necessary adaptions. On this way, a simple sorting protocol for plastic waste in and along fluvial systems has been created that even non-specialists and laypersons without background knowledge can use (in subsequent projects). In combination with the sampling protocol, the sorting catalogue ensure a comparability of the composition and quantities of plastic litter along rivers.

As mentioned also in other studies, it is often difficult to assign an item to a source with a high level of confidence. For instance, the (PET) beverage bottles are often detected on riverbanks in the Donau-Auen National Park. These items, however, can originate from various sources, like ship-based tourism, directly littering at the shore from recreation activities, or discharge of litter (already entered upstream) from the Danube. Despite these existing uncertainties, good conclusions about the origin and thus possible avoidance measures can be assessed based on the classification made.

Table 4: Classification of plastic waste in and along the Danube

Main-group	Sub-group	No.	Category	No.	Sub-Category
Packaging	Drink bottles	1	PET drink bottles + caps		
	Food packaging	2	Food packaging	2a	Flexible packaging
				2b	Hard plastic containers
				2c	Liquid packaging boards
				2d	Foamed food containers
	Non-food packaging	3	Single-use tableware		
		4	Shopping bags		
		5	Cosmetic bottles & containers		
		6	Cleaner bottles & containers		
		7	Building & construction packaging		
		8	Packaging films and sheets		
		9	Other plastic packaging		
Foamed	Foamed plastics	10	Foamed plastic (packaging / insulation / foamed fillers / undefinable foamed plastic items)	10a	Expanded Polystyrene (EPS) for packaging*
				10b	Other foamed plastics for packaging*
				10c	Expanded Polystyrene (EPS) for construction materials (insulation)*
				10d	Extruded Polystyrene (XPS) for construction materials (insulation)*
				10e	Other non-packaging foamed plastic (e.g.PUR)*
Non-Packaging	Household / toys / sport / leisure	11	Housewares / household like items		
		12	Clothes, shoes and accessories		
		13	Toys, sport & leisure articles		
		14	Fishing gear		
		15	Cigarette items		
		16	Lighters		
	Sanitary & medical articles	17	Sanitary waste	17a	Feminine hygiene articles
				17b	Wet wipes/cleaning tissues
				17c	Cotton buds
				17d	Other sanitary waste
		18	Medical & pharmaceutical waste		
	Other non-packaging items	19	Plastic ropes and strings		
		20	Tapes		
		21	Shipping items		
		22	Car parts		
		23	Building & construction waste		
Others	Other plastic items	24	Unidentifiable plastic items		

* a method for visual differentiation is in progress

3.1.3. Possible Adjustments

The developed sorting protocol, more previously the waste classification is mainly addressed to the waste found during collections within project area. Nevertheless, this protocol should also be usable for similar rivers. If a different section of the Danube river or another river were to be sampled, there could be corresponding deviations in the waste composition. In this respect, the sorting catalogue (master list) should be regarded as flexible and expandable within its group or category but not in its structure (see Figure 8). Under the aspects of the chosen functional structuring, further categories can thus be redefined and subordinated (e.g. industrial waste, or waste from agriculture that could not be detected in the project area). Furthermore, it makes sense to explicitly emphasize waste that is abundant in terms of its mass, volume or number of items as a separate category for better illustration.

As part of the protocol evaluation, some categories have been modified, unified or deleted (for example, if no items of this class were found). The following points lists some changes:

- *Caps:* first collected separately, now (lose) PP-caps are assigned to the PET drink bottles (even if it is identifiable as part of beverage bottles, in addition, they can be recorded relatively easily via the size class); other caps belong to “food packaging - hard plastic” or “other non-food packaging”;
- *Other non-packaging container:* This fraction was rejected because it was mainly about buckets whose exact origin cannot be directly ascertained. Containers such as laundry baskets or food storage containers have been assigned to the new category “household items”.
- *Cleaner bottles & containers:* originally no own category, declare separately due to various findings
- *Industry items*: difficult assignment and no concrete items found;
- *Agricultural plastics:* no concrete items found; possible waste from that sector, such as agricultural films, has not yet been identified; the example above would be classified in the category "films"; sub-group rejected;
- *Foamed plastics:* Distinction between (EPS) packaging and (EPS/XPS) insulation by visual characterization with high probability in principle possible; further investigations in progress; foamed plastics should be assignable to “packaging” and “construction waste” in near future;
- *Hazardous plastic waste* was originally defined for articles, which pose an increased or immediate risk to the environment due to their composition, ingredients or properties. The category was rejected because of following reasons: 1) hardly any or no such items were found, 2) in most cases, the hazard for objects such as WEEE (electrical & electronic equipment) does not arise from the plastic per se, but from other installed parts such as batteries, accumulators, or hazardous substances likes oil and chemicals in bottles /canisters, etc., 3) it is often very difficult for laypersons to distinguish between hazardous and non-hazardous waste in sorting analyses

3.2. Quantification of plastic litter

According to UNEP/IOC Guidelines on Survey & Monitoring of Marine Litter (Cheshire et al., 2009) should be gathered both counts and weights for all litter classes within investigations where a litter collection is forced. Alternatively, the guidelines recommend weighing and indicating the waste quantity in kilograms. The combination of both counts and weights allows for a broad data integration and prevents the obvious drawbacks of performing only one measurement approach (see below).

Previous initiatives have often been limited to counting the plastic items, but this leads sometimes to many uncertainties. Therefore, both quantification approaches and their limits are discussed briefly below.

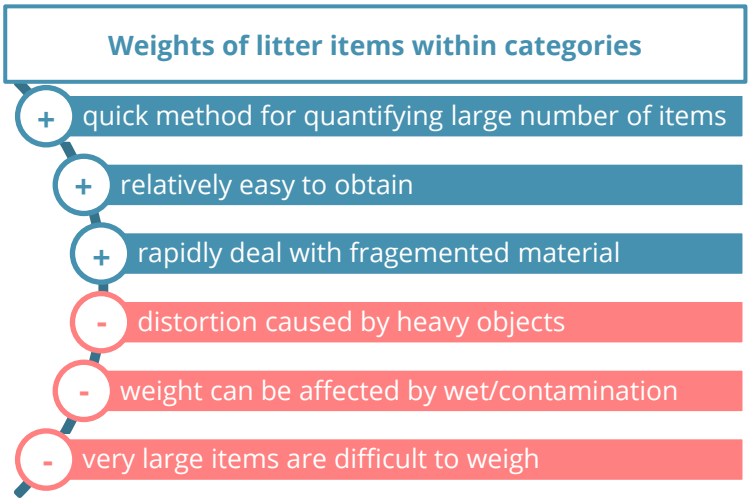


Figure 9: Pros and Cons of litter weighing to determine the plastic pollution (derived from Cheshire et al., 2009)

A decisive advantage of weighing is that waste management figures and statistics are usually only given in units of weight and thus gathered sorting data of riverine litter can be compared with the waste generation of a region or country, for example. However, the number of pieces cannot be inferred from the indication of a unit of weight alone, but this is decisive for the assessment of the downstream risks. For example, a 50 kg single roll of material tends to have a lower damage potential to aquatic organisms than 1,000 e.g. plastic bags or foil fragments. For instance, small plastic films are transported farther, they tend to degrade faster or could be confused with natural food and eaten by animals. In addition, several smaller parts or fragments, compared to a part with the same mass, have an increased surface area and therefore more pollutants can potentially adhere.

In terms of size, the approach of counting will be less useful when substantial differences of litter items in the same class are given. For example, counts of derelict fishing nets will grossly undervalue the influence of larger nets which may vary in size (< 1m² to hundreds of m²) and weigh as much as nine tons (Kiessling, 2003). The introduction of size classes tries to take this into account (3.3) but can only partially solve the problem. Furthermore, it is often necessary to evaluate how a large number of small pieces of a plastic drink bottle are counted – is it equivalent to one or many bottles?

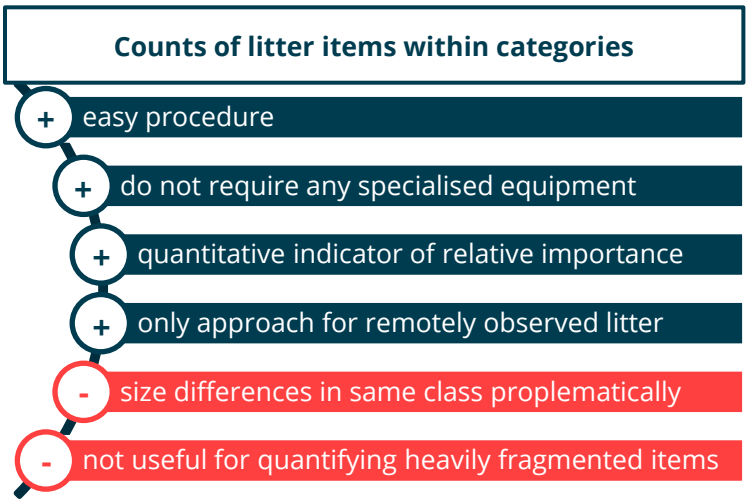


Figure 10: Pros and Cons of litter counting to determine the plastic pollution (derived from Cheshire et al., 2009)

For both approaches the difficulty initially arises in the definition of a comparable reference value (e.g. weight unit/items per area, river kilometre, flow rate, etc.). Depending on the information for the respective sample (e.g. size of the cleaned area) and the available resources (staff, financial means, time resources) at least one

of the two mentioned approaches has to be applied. Additionally, an estimation of the other non-chosen approach can be cited (e.g. weighing of the sorted waste incl. rough estimation of the number of items).

3.3. Size classes of macro-plastic

Depending on the overarching question, it may make sense to classify the collected macro-plastic litter into size classes. This can be integrated with "manageable" effort during the counting.
For some fractions, the resulting data can serve as a basis for the abrasion and degradation condition of plastic objects due weathering processes. An example would be many fragments of an item, such as plastic bag, box, toy, etc., found in close proximity. The prerequisite for this is of course that the individual parts can be assigned to the original object. This is important to understand, because the surface of the same mass of particles increases many times over, the smaller the particles are. The plastic particles act as pollutant magnets or adsorbents (EPA, 2016). So-called *biofouling* can change the density of plastics (like polyethylene or polypropylene which have a specific density lower than water) and cause large plastic objects to sink (Ye and Andrady ,1991; Morét-Ferguson et al, 2010; Fazey and Ryan, 2016)
Plastic parts of different sizes also exhibit different transport behaviour. In addition, it is also possible to draw conclusions which hydrodynamic structures enhance the discharge of particles of different sizes. Furthermore, the size distribution can play a major role in deriving measures for the removal of plastic waste from the water body (e.g mash size of manta nets).
Currently, no standardized size classes' definition of macro plastic exists. Barnes et al. (2009) subdivide macro plastics into micro-debris (< 5 mm), meso-debris (5 – 20 mm), macro-debris (20 – 100 mm) and mega-debris (> 100 mm) related to the longest side edge. The size classes of macro litter of the Technical Subgroup of Marine Litter (Hanke et al., 2013) encloses a more detailed range: 2.5 – 5 cm, 5 - 10 cm, 10 – 20 cm, 20 – 30 cm, 30 – 50 cm.
Inspired by the Ocean Cleanup (2019) and due the simplicity and practicability, here, macro-plastic was categorised into following three size classes:

- [Microplastic | < 5 mm]
- Mesoplastics | 5mm - 5 cm
- Macroplastics | 5 – 50 cm
- Megaplastics | > 50 cm

It is advisable to do the allocation to the size classes during the count. Thereby, it is helpful to stick a 5cm or 50cm long strip on the table (or draw it on the table/foil) as a rough indication. The longest edge length of the plastic items must be measured (see photo beside).



3.4. Planning a sorting analysis

The following points outline the procedure of a sorting analysis. They give you valuable tips what you should consider in your planning. The sorting protocol also contains a short version of the listed points and the list of equipment.

Location



Choose a weatherproof location for sorting

» Sorting analysis does not necessarily have to be carried out in closed rooms, it can also take place outside. The prerequisite for this is “good weather”, more precisely the place should be protected from wind and sudden rain. The location should also offer the possibility of moving quickly to a “protected environment”.
» The location should provide a protected storage facility for the samples over a period of sorting as well as an opportunity to work undisturbed.
» Power connection, access to toilet/WC and lounge, water connection for cleaning the equipment after sorting are desirable.
» Find out in advance, who the contact person on site is (timely consultation with the persons responsible on site regarding the fulfilment of the above requirements for sorting locations is recommended).
» Look out for the subsequent disposal of the sorted waste (who can dispose of the waste properly, when and how? Is a vehicle available for the transport? Alternatively, is disposal even possible on site?

Preparation & Equipment



Good preparation is half the battle

» Brief the persons who participate in a sorting analysis: What is the purpose of a sorting analysis anyway? How does the analysis work? What kind of information can I derive from it?
» It is advisable to clarify the responsibilities and the distribution of tasks among each other in advance: What does the respective person have to do in concrete terms? This also depends strongly on the number of participants. Agree exactly who, for example, will bring the samples and empty them onto the table, who will weigh the waste or enter the quantities and numbers of pieces into the list or laptop.
» Make all arrangements according to the sorting protocol or the checklist for the equipment (cut-resistant gloves, work clothes, containers, etc.)
» Safety introduction: Instruct the participants about potential (injury) risks e.g. through sharp or pointed items and make sure that all wear cut-resistant gloves
» Now it is time to label the containers (suitable examples are given in the checklist): It is best to attach a suitable label (highly adhesive) with the respective category name visibly to the container so that you can still read the designation even when the container is full (e.g. outside or inside high up). The choice of the size of the containers depends on the waste collected. If you have been at the collection, you will know approximately which waste is present in which quantities. Choose larger containers for those fractions that you have often found. This will save your time when emptying, counting and entering the amount of waste. If you don't have any information about the

composition (no participation at the collection), tend to choose larger containers for those fractions that are expected to take up more space (e.g. construction waste like pipes, shipping waste such as fenders, buoys, or items that are generally likely to be subject of littering).

» Determine the empty weight of the containers: Weigh each empty container and enter the tare weight in your list (evaluation table of sorting protocol-ANNEX V). Afterwards, you can also write it on the label.
» By the way, you can also fill in the already known information in the evaluation table
» Before starting the actual sorting analysis, it is necessary to determine the total amount of collected waste for control purposes. Weigh all the waste you have and enter the initial quantity in the corresponding line of your list, but do not forget to subtract the weight of the collection containers, e.g. garbage bags. In the end, the sum of all fractions should result in your initial quantity (with a certain permissible deviation). More details about this later.

Sorting & Counting

It's like Memory – but a bit more complicated

» Make sure that all participants wear cut-resistant gloves and explain the *INPORTANT PRINCIPLES of sorting analyses* (see below) again if necessary
» Try to assign the plastic items to the correct category / fraction according the PFD-Masterlist. For each category, you find some examples of different plastic items (incl. pictures) in the sorting protocol (ANNEX V).
» If you are not sure which category an item belongs to, discuss it with your "sorting buddies". Surely, you will find a solution together. In case a part is unclassifiable, because it is an unknown fragment, add it to the last category (no. 24) of *unidentifiable plastic items*.
» Sometimes it is difficult to differentiate between packaging and non-packaging. In this case, ask yourself the question of the purchase intention: Do I buy a product, where the present item serves as packaging, or do I buy the item as a separate product? An example is a flowerpot. When I buy potted flowers, a disposable flowerpot is usually included in the purchase price as transport and protective packaging. However, if I buy the flowerpot separately in order to put flowers in it, the flowerpot is not a packaging, but a separate product.
» Try to remove items from dirt, algae, mud/sand, organic substances, etc. as far as possible to avoid weight distortion. Put "dirt" in the *natural/non-plastic* fraction.
» Bottles or containers and other packaging may be emptied, provided they are filled with water or drinks. Be careful, do not simply empty the content, but capture it separately (→ natural/non-plastic fraction); Separate also unknown substances (e.g. oily mixture) and dispose them correctly!
» If an item (e.g. shoes, clothes) is very wet and there is no possibility to dry it, estimate the weight. You can use a similar dry object for help.
» In case of interest, you can also record and evaluate other *non-plastic materials* such as wood, glass, paper, metal, etc. but collect them separately in marked containers.
» Once you have assigned all waste to the appropriate categories (or there is a container full in between), weigh each fraction (also non-plastics waste) and enter the weight in the provided table (see appendix of sorting protocol). Do not forget to subtract the tare weight of the containers!
» Finally, count the items of each category and assign them to the defined size classes (according Chapter 3.3 or 3.2 in the sorting protocol). Enter the numbers again in the table.

Documentation

You never know, what info you still need…

» After entered the weight and the number of pieces assigned to the size classes, describe each analysed plastic waste fraction: what kind of plastic pieces did you mainly find? Have you noticed anything unusual (e.g. high number of same plastic items)?

» Note also "outliers" in the table → these are objects that are much heavier than average (e.g. in addition to a license plate and a broken side mirror, a car tire was found. The latter item is much heavier than the other two.) Statistical outliers must be considered in a differentiated way when evaluating the composition and should be excluded if several “sub-“samples are described together (but outliers can be included when you compare the subsamples)

» Document each category / container with a photo! If an error should have crept in with the quantity or number of pieces input, you can detect this afterwards by means of the photos!

Control

Trust is good, control is better!

» At the end, control the sum of all weighted categories with the initial weight. The permissible weight deviations between the initial determined total weight and the sum of all sorted categories should not exceed 3%.

» If the deviation is more than 3%, check again your list/table whether you made an error while entering or adding. But beware: when you sort outside on hot days, it can happen that very wet items (e.g. clothes) become dry in the meantime. The water loss is often difficult to estimate. It is therefore advisable to weigh such wet objects in advance.

IMPORTANT PRINCIPLES for sorting:

- Never underestimate the risk of sharp or contaminated items
- Open the bags carefully
- Handle waste carefully
- Try to clean dirty items as good as possible (also weigh the dirt)
- There is no disassembly of products with tools (do not dismantle objects into their individual parts)
- Wet objects should be dried, otherwise estimate the weight of the dry object
- Liquids must be emptied (but keep it and weigh it)

3.5. Checklist for sorting

The following list contains some useful equipment, which contributes to a successful sorting.

General equipment	Sorting equipment
☑ PFD Sorting Protocol (electronic + some printed)	☑ Sorting table (+ film)
☑ Pens, clipboards for protocols	☑ Balance[1] + cable + spare batteries
☑ Work clothing and warning vests (if necessary)	☑ Containers[2] incl. labelling (fraction, tare)
☑ Cut resistant gloves (protection against e.g. syringes)	☑ Reserve containers + labels
☑ First-aid-box (plaster, disinfection, bandage)	
☑ Roll scale or folding rule	
☑ Scissors, knife	
☑ Broom and dustpan	
☑ Camera (memory chip), batteries, charger	
☑ Laptop	
☑ Extension cable, distributor plug	
☑ Portable outdoor spotlight	
☑ Personal goods (food and drinks, spare clothes)	

[1] Balance with a recommend measuring accuracy of 0.01 kg
[2] Useful containers are waterproof mortar trough, buckets, bins, tuns (see picture below)



Figure 11: Sorting table and sorting containers for various categories

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ANNEX I – Comparison of existing Master Lists to classify plastic pollution

No.	Material	MSDF[1] ID	OSPAR[2] ID	UNEP[3] ID	BOKU[5] ID	SchP[6] ID	Litter type					
							MSFD TSG ML[1]	OSPAR Beach Protocol[2]	UNEP Beach Protocol[3]	SFRA0025[4]	BOKU / ARA[5]	Schüttpelz[6]
1	artificial polymer	G1	1	PL05			4/6-pack yokes, 6-pack rings	4/6-pack yokes	Drink package ring, six-packs rings, ring carriers			
2	artificial polymer	G2		PL07	27	4	Bags		Plastic bags (opaque & clear)		Plastic bags	Plastic bags incl. pieces
3	artificial polymer	G3	2	PL07	27	4	Shopping Bags incl. pieces	Bags (e.g. shopping)	Plastic bags (opaque & clear)	Shopping Bags incl. pieces	Plastic bags	Plastic bags incl. pieces
4	artificial polymer	G4	3	PL07	27	5	Small plastic bags, e.g. freezer bags incl. pieces	Small plastic bags (e.g. freezer bags)	Plastic bags (opaque & clear)		Plastic bags	Small plastic bags, e.g. bags for vegetables
5	artificial polymer	G5	112		27	4	Plastic bag collective role; what remains from rip-off plastic bags	plastic bag ends		Plastic bag collective role; what remains from rip-off plastic bags	Plastic bags	Shopping Bags incl. pieces
6	artificial polymer	G6	4	PL02	11		Bottles	Drinks (bottles, containers and drums)	Bottles < 2l		Drink bottles	
7	artificial polymer	G7	4	PL02	11	1	Drink bottles <=0.5l	Drinks	Bottles < 2l	Drink bottles < 0.5l	Drink bottles	PET drink bottles < 0.5l
8	artificial polymer	G8	4	PL02	11	2	Drink bottles >0.5l	Drinks	Bottles < 2l		Drink bottles	PET drink bottles > 0.5l
9	artificial polymer	G9	5	PL02		10	Cleaner bottles & containers	Cleaner (bottles, containers and drums)	Bottles < 2l			Other bottles & containers (drums)
10	artificial polymer	G10	6	PL06	8	6	Food containers incl. fast food containers	Food container incl. Fast food containers	Food containers (fast food, cups, lunch boxes & similar)	Food containers incl. fast food containers	Food containers (incl. take away)	Food containers (incl. take away)

[1] Marine Strategy Framework Directive - Technical Subgroup on Marine Litter: Guidance on Monitoring of Marine Litter in European Seas

[2] Oslo- and Paris Convention: Guideline for Monitoring Marine Litter on the Beaches in the OSPAR Maritime Area

[3] United Nations Environment Programme / Intergovernmental Oceanographic Commission: Guidelines on Survey and Monitoring of Marine Litter

[4] Final Report for the European Commission DG Environment: Identification and Assessment of Riverine Input of (Marine) Litter

[5] Erhebung von oberflächlich treibenden Abfallstoffen in der Donau bei Wien

[6] Master's thesis: Measuring Marine Litter density, mass and composition – including a case study on land-based litter along the Danube

11	artificial polymer	G11	7	PL02		7	Beach use related cosmetic bottles and containers, e.g. sunblocks	Cosmetics (bottles & containers e.g. sun lotion, shampoo, shower gel, deodorant)		Beach use related cosmetic bottles and containers, eg. Sunblocks		Cosmetics bottles and containers
12	artificial polymer	G12	7	PL02		7	Other cosmetics bottles & containers	Cosmetics		Other cosmetics bottles & containers		Cosmetics bottles and containers
13	artificial polymer	G13	12	PL02		10	Other bottles & containers (drums)	Other bottles, containers and drums				Other bottles & containers (drums)
14	artificial polymer	G14	8		9	8	Engine oil bottles & containers <50 cm	Engine oil bottles & containers <50 cm			fuel can	Engine oil bottles & containers, fuel cans
15	artificial polymer	G15	9	PL03	9	8	Engine oil bottles & containers >50 cm	Engine oil bottles & containers >50 cm	Bottles, drums, jerrycans, buckets >2l		fuel can	Engine oil bottles & containers, fuel cans
16	artificial polymer	G16	10	PL03	30	10	Jerrycans (square plastic containers with handle)	Jerrycans (square plastic containers with handle)	Bottles, drums, jerrycans, buckets >2l		Other plastic packaging	Other bottles & containers (drums)
17	artificial polymer	G17	11				Injection gun containers	Injection gun containers				
18	artificial polymer	G18	13	PL13	30		Crates and containers / baskets	Crates	baskets, crates & trays		Other plastic packaging	
19	artificial polymer	G19	14			14	Car parts	Car parts				Car parts
20	artificial polymer	G20		PL01	7	15	Plastic caps and lids	Caps/lids	Bottle caps & lids	Plastic caps and lids	Plastic caps and lids	Caps and lids
21	artificial polymer	G21	15	PL01	7	15	Plastic caps/lids drinks	Caps/lids	Bottle caps & lids	Plastic caps/lids drinks	Plastic caps and lids	Caps and lids
22	artificial polymer	G22	15	PL01	7	15	Plastic caps/lids chemicals, detergents (non-food)	Caps/lids	Bottle caps & lids	Plastic caps and lids	Plastic caps and lids	Caps and lids
23	artificial polymer	G23	15	PL01	7	15	Plastic caps/lids unidentified	Caps/lids	Bottle caps & lids	Plastic caps and lids	Plastic caps and lids	Caps and lids
24	artificial polymer	G24	15	PL01	7	15	Plastic rings from bottle caps/lids	Caps/lids	Bottle caps & lids	Plastic caps and lids	Plastic caps and lids	Caps and lids
25	artificial polymer	G25			31	12	Tobacco pouches / plastic cigarette box packaging			Tobacco pouches / plastic cigarette box packaging	plastic cigarette box packaging	Tobacco pouches / plastic cigarette box packaging
26	artificial polymer	G26	16	PL10			Cigarette lighters	Cigarette lighters	Cigarette lighters			Cigarette lighters

27	artificial polymer	G27	64	PL11	32	16	Cigarette butts and filters	Cigarette butts	Cigarettes, butts & filters	Cigarette butts and filters	Cigarette butts and filters	Cigarette butts and filters
28	artificial polymer	G28	17				Pens and pen lids	Pens		Pens and pen lids		
29	artificial polymer	G29	18				Combs/hair brushes/ sunglasses	Combs/hair brushes				
30	artificial polymer	G30	19		8		Crisps packets/sweets wrappers	Crisps/sweets packets and lolly sticks		Crisps packets/sweets wrapper	Food containers (incl. Take away)	
31	artificial polymer	G31	19				Lolly sticks	Crisps/sweets packets and lolly sticks				
32	artificial polymer	G32	20	PL08	47	17	Toys and party poppers	Toys and party poppers	Toys and party poppers	Toys and party poppers	Toys	Toys
33	artificial polymer	G33	21	PL06	5	18	Cups and cup lids	Cups	Food containers (fast food, cups, lunch boxes & similar)	Cups and cup lids	single-use tableware and plastic cups	single-use tableware and plastic cups
34	artificial polymer	G34	22	PL04	5	18	Cutlery and trays	Cutlery/trays/straws	cutlery, stirrers, straws	Cutlery and trays	single-use tableware and plastic cups	single-use tableware and plastic cups
35	artificial polymer	G35	22	PL04			Straws and stirrers	Cutlery/trays/straws	cutlery, stirrers, straws	Straws and stirrers		
36	artificial polymer	G36	23				Fertiliser/animal feed bags	Fertiliser/animal feed bags				
37	artificial polymer	G37	24	PL15			Mesh vegetable bags	Mesh vegetable bags	Mesh bags (vegetable, oyster nets & mussel bags)			
38	artificial polymer	G38			30	13	Cover / packaging			Cover / packaging	Other plastic packaging	Other plastic / composite packaging
39		G39		PL09	19		Gloves		Gloves			Gloves
40	artificial polymer	G40	25	PL09			Gloves (washing up)	Gloves (typical washing up gloves)	Gloves			
41	artificial polymer	G41	113	RB03			Gloves (industrial/professional rubber gloves)	Gloves (industrial/professional gloves)	Gloves (rubber)			

42	artificial polymer	G42	26	PL17	43		Crab/lobster pots and tops	Crab/lobster pots	Fishing gear (lures, traps & pots)			
43	artificial polymer	G43	114				Tags (fishing and industry)	Lobster and fish tags		Tags (fishing and industry)		
44	artificial polymer	G44	27	PL17			Octopus pots	Octopus pots	Fishing gear (lures, traps & pots)			
45	artificial polymer	G45	28	PL15			Mussels nets, Oyster nets	Oyster nets or mussels bags including plastic stoppers	Mesh bags (vegetable, oyster nets & mussel bags)	Mussels nets, Oyster nets		
46	artificial polymer	G46	29				Oyster trays (round from oyster cultures)	Oyster trays (round from oyster cultures)				
47	artificial polymer	G47	30				Plastic sheeting from mussel culture (Tahitians)	Plastic sheeting from mussel culture (Tahitians)				
48	artificial polymer	G48			42		Synthetic rope				Rope and strings	
49	artificial polymer	G49	31	PL19	42	21	Rope (diameter more than 1cm)	Rope (diameter more than 1cm)	Rope		Rope and strings	Rope and strings
50	artificial polymer	G50	32	PL19	42	21	String and cord (diameter less than 1cm)	String and cord (diameter less than 1cm)	Rope	String and cord (diameter less than 1cm)	Rope and strings	Rope and strings
51	artificial polymer	G51		PL20	43	22	Fishing net		Fishing net		Fishing gear (fishing nets, line)	Fishing nets, lines
52	artificial polymer	G52		PL20	43		Nets and pieces of net		Fishing net	Nets and pieces of net	Fishing gear	
53	artificial polymer	G53	115	PL20	43		Nets and pieces of net < 50 cm	Nets and pieces of net < 50 cm	Fishing net		Fishing gear	
54	artificial polymer	G54	116	PL20	43		Nets and pieces of net > 50 cm	Nets and pieces of net > 50 cm	Fishing net		Fishing gear	
55	artificial polymer	G55		PL18	43	22	Fishing line (entangled)		Monofilament lines		Fishing gear	Fishing nets, lines
56	artificial polymer	G56	33	PL20	43	22	Tangled nets/cord	Tangled nets/cord	Fishing net		Fishing gear	Fishing nets, lines
57	artificial polymer	G57	34	PL17	45		Fish boxes - plastic	Fish boxes	Fishing gear (lures, traps & pots)		Fish boxes	
58	artificial polymer	G58	34	PL17	43	24	Fish boxes - expanded polystyrene	Fish boxes	Fishing gear (lures, traps & pots)		Fish boxes	Fishing container/boxes

59	artificial polymer	G59	35	PL18	43	22	Fishing line/monofilament (angling)	Fishing line (angling)			Fishing gear	Fishing nets, lines
60	artificial polymer	G60	36	PL17			Light sticks (tubes with fluid) incl. packaging	Light sticks (tubes with fluid)	Fishing gear (lures, traps & pots)			
61	artificial polymer	G61					Other fishing related			Other fishing related		
62	artificial polymer	G62	37	PL14			Floats for fishing nets	Floats/Buoys				
63	artificial polymer	G63	37	PL14	44	23	Buoys	Floats/Buoys	Plastic buoys		Buoys	Buoys
64	artificial polymer	G64					Fenders					
65	artificial polymer	G65	38	PL03		25	Buckets	Buckets	Bottles, drums, jerrycans & buckets > 2l			Buckets
66	artificial polymer	G66	39	PL21		20	Strapping bands	Strapping bands	Strapping	Strapping bands		Strapping bands, tapes
67	artificial polymer	G67	40	PL16	28	11	Sheets, industrial packaging, plastic sheeting	industrial packaging, plastic sheeting	Sheeting (tarpaulin or other woven plastic bags, palette wrap)	Sheets, industrial packaging, plast sheeting	Packaging foil / films	Plastic sheets
68	artificial polymer	G68	41	PL22			Fibre glass/fragments	Fibre glass	fibreglass fragment			
69	artificial polymer	G69	42				Hard hats/Helmets	Hard hats				
70	artificial polymer	G70	43				Shotgun cartridges	Shotgun cartridges				
71	artificial polymer	G71	44	CL01			Shoes/sandals	Shoes/sandals	Clothing, shoes, hats & towels	Shoes/sandals		Shoes/sandals, backpacks, handback
72	artificial polymer	G72					Traffic cones					
73	artificial polymer	G73	45	FP01			Foam sponge	Foam sponge	foam sponge			
74	artificial polymer	G74					Foam packaging/ insulation/ polyurethane			Foam packaging/ insulation/polyurethane		
75	artificial polymer	G75	117				Plastic/polystyrene pieces 0 - 2.5 cm	Plastic/polystyrene pieces 0 - 2.5 cm				Plastic/polystyrene pieces 0 - 2.5 cm
76	artificial polymer	G76	46				Plastic/polystyrene pieces 2.5 cm > < 50cm	Plastic/polystyrene pieces 2.5 cm > < 50cm				Plastic/polystyrene pieces 2.5 cm - 10cm

77	artificial polymer	G77	47				Plastic/polystyrene pieces > 50 cm	Plastic/polystyrene pieces > 50 cm				Plastic/polystyrene pieces 10 - 50 cm; > 50cm
78	artificial polymer	G78					Plastic pieces 0 - 2.5 cm			Plastic pieces 0 - 2.5 cm		
79	artificial polymer	G79					Plastic pieces 2.5> < 50cm			Plastic pieces 2.5> < 50cm		
80	artificial polymer	G80					Plastic pieces > 50 cm					
81	artificial polymer	G81					Polystyrene pieces 0 - 2.5 cm			Polystyrene pieces 0 - 2.5 cm		
82	artificial polymer	G82					Polystyrene pieces 2.5 cm > < 50cm			Polystyrene pieces 2.5 > < 50 cm		
83	artificial polymer	G83					Polystyrene pieces > 50 cm			Polystyrene pieces > 50 cm		
84	artificial polymer	G84					CD, CD-box					
85	artificial polymer	G85					Salt packaging					
86	artificial polymer	G86					Fin trees (from fins for scuba diving)					
87	artificial polymer	G87			35	20	Masking tape			Masking tape	Tape	Strapping bands, tape
88	artificial polymer	G88					Telephone (incl. parts)					
89	artificial polymer	G89					Plastic construction waste			Plastic construction waste		
90	artificial polymer	G90					Plastic flower pots			Plastic flower pots		
91	artificial polymer	G91					Biomass holder from sewage treatment plants					
92	artificial polymer	G92					Bait containers/packaging					
93	artificial polymer	G93					Cable ties					
94	artificial polymer	G94					Table cloth					
95	artificial polymer	G95	98	OT02		30	Cotton bud sticks	Cotton bud sticks	Sanitary (nappies, cotton buds, tampon applicators, toothbrushes)	Cotton bud sticks		Sanitary Waste (sanitary towels, tissues, cotton buds, nappies, etc.)

96	artificial polymer	G96	99	OT02		30	Sanitary towels/panty liners/backing strips	Sanitary towels/panty liners/backing strips	Sanitary			Sanitary Waste
97	artificial polymer	G97	101	OT02		30	Toilet fresheners	Toilet fresheners	Sanitary			Sanitary Waste
98	artificial polymer	G98		OT02		30	Diapers/nappies		Sanitary			Sanitary Waste
99	artificial polymer	G99	104	PL12		31	Syringes/needles	Syringes	Syringes	Syringes/needles		Medical Waste (Syringes, containers)
100	artificial polymer	G100	103			31	Medical/Pharmaceuticals containers/tubes	Medical containers/tubes		Medical/Pharmaceuticals containers/tubes		Medical Waste (Syringes, containers)
101	artificial polymer	G101	121				Dog faeces bag	Bagged dog feaces				
102	artificial polymer	G102		RB02		34	Flip-flops		Footwear (Flip-flops)			Footwear (Flip-flops), sandals
103	artificial polymer	G103					Plastic fragments rounded <5mm					
104	artificial polymer	G104					Plastic fragments subrounded <5mm					
105	artificial polymer	G105					Plastic fragments subangular <5mm					
106	artificial polymer	G106					Plastic fragments angular <5mm					
107	artificial polymer	G107					cylindrical pellets <5mm					
108	artificial polymer	G108					disks pellets <5mm					
109	artificial polymer	G109					flat pellets <5mm					
110	artificial polymer	G110					ovoid pellets <5mm					
111	artificial polymer	G111					spheruloids pellets <5mm					
112	artificial polymer	G112		PL23			Industrial pellets		resin pellets	Industrial pellets		
113	artificial polymer	G113					Filament <5mm					
114	artificial polymer	G114					Films <5mm					

115	artificial polymer	G115					Foamed plastic <5mm					
116	artificial polymer	G116					Granules <5mm					
117	artificial polymer	G117					Styrofoam <5mm					
118	artificial polymer	G118					Small industrial spheres (<5mm)					
119	artificial polymer	G119					Sheet like user plastic (>1mm)					
120	artificial polymer	G120					Threadlike user plastic (>1mm)					
121	artificial polymer	G121					Foamed user plastic (>1mm)					
122	artificial polymer	G122					Plastic fragments (>1mm)					
123	artificial polymer	G123					Polyurethane granules <5mm					
124	artificial polymer	G124	48	PL24	34	33	Other plastic/polystyrene items (identifiable)	Other plastic/polystyrene items (specify)	Other (specify)	Other plastic/polystyrene items (identifiable)	Other plastic non-packaging	Other plastic items (non packaging)
125	rubber	G125	49	RB01	12	35	Balloons and balloon sticks	Balloons including plastic valves, ribbons, strings etc.	Balloons, balls & toys	Balloons and balloon sticks	Rubber	Balloons
126	rubber	G126		RB01	12		Balls		Balloons, balls & toys		Rubber	
127	rubber	G127	50		12		Rubber boots	Boots			Rubber	
128	rubber	G128	52	RB04	12	37	Tyres and belts	Tyres and belts	Tyres		Rubber	Tyres
129	rubber	G129		RB05	12		Inner-tubes and rubber sheet		Inner-tubes and rubber sheet		Rubber	
130	rubber	G130			12		Wheels				Rubber	
131	rubber	G131		RB06	12		Rubber bands (small, for kitchen/ household/post use)		Rubber bands	Rubber bands (small, for kitchen/ household/post use)	Rubber	
132	rubber	G132			12		Bobbins (fishing)				Rubber	
133	rubber	G133	97	RB07	12	36	Condoms (incl. Packaging)	Condoms	Condoms (incl. Packaging)	Condoms (incl. Packaging)	Rubber	Condoms (incl. Packaging)

134	rubber	G134	53	RB08	12	38	Other rubber pieces	Other rubber pieces (specify)	Other rubber (specify)	Other rubber pieces	Rubber	Other rubber items/pieces
135	artificial polymer			FP02					foam cups & food packs			
136	artificial polymer			FP03					Foam buoys			
137	artificial polymer			FP04					Foam (packaging, insulation)			
138	artificial polymer			FP05		56			Other foam (specify)			Other foamed plastics (>2,5 <50cm)
139	artificial polymer				1	9					Bonded drinks cartons	Bonded drinks cartons
140	artificial polymer				2						Composite food packaging	
141	artificial polymer				29						Other plastic foils /films	

PlasticFreeDanube

D4.1.2 HANDBOOK FOR SAMPLING AND SORTING

For the assessment of plastic pollution along rivers

How the plastic waste collection succeeds…

- The present protocol helps us to determine where plastic waste related to rivers is mainly transported and where a particularly large number of plastics accumulates.
- Please **read this protocol at the beginning**. Some points can be filled in immediately, other questions can only be answered at the end of the collection.
- If you are collecting with a group and you split up, please use a **separate protocol for each subgroup.**
- If you are moving along a river with rapidly changing bank structures within short distances, it is easier to fill in an additional **protocol for each section**.
- In some cases (e.g. large rivers with wide river banks), it is advisable to divide the collection area in sub areas and agree which subgroup will "clean" which terrain strip in advance (e.g. one group will march along the gravel bank near the water, another group within the overgrown zone).
- Finally, it is important to **assign your collected bags to the respective group and cleaned section by labelling or clearly marking** them accordingly.

1. General Information

1.1. Information about collection

Name of river/creek, you collect:

Name of the "cleaned" area:

Date (d/m/y): Time: start: end: duration:

Nearest town / city

Choose one of the following three options to indicate the start and end of the collection area:

1) GPS-coordinates: start end

Further information about GPS recording (coordinate system, projection, device, etc.):

2) River kilometer: start end

3) Other recording:

Sampled width of the area (e.g. 10m to water; 20m wide strip in alluvial forest / wetland):

Collection point/area is located orographically (in flow direction): ☐ left ☐ right

Date of the last cleaning / collection activity: (d/m/y)

Name of organisation / association that collects:

Number of persons of your (sub)group:

How many garbage bags* were filled with plastic waste in your (sub)group?

Number	Volume of bags in litre	Filling level in percent (e.g. half full)

*IMPORTANT for more than one group: try to make your garbage bags assignable to your collection protocol, e.g. by labelling, colour marking, etc.

Which plastic wastes were mainly (number of pieces) collected (*e.g. beverage bottles, food packaging, films, bags, wet wipes, cotton swabs, cigarettes, etc.*)?

What other waste did you find (*e.g. metal cans, glass bottles etc.*)?

How was the weather during the collection?

☐ fair weather ☐ rain ☐ snow ☐ wind ☐ fog

1.2. Sampling area

Where did you mainly collect? Choose one of the three following options:

(1)	(2)	(3)
☐ riverbank*	☐ hinterland	☐ riverbank and hinterland
For collection on the riverbank, please answer points 2.1 to 2.6 below. *to the water	vegetation at the place of collection in the surrounding hinterland (tick): O grassland, pasture O bush O (alluvial)forest O agricultural land O other: _____ If known, continue with point 2, otherwise point 3	For collection on riverbank **and** hinterland, please answer all the following points

Does the vegetation impede the collection? ☐ no ☐ yes If yes, how far?	*For instance: due high vegetation (densely overgrown area, high grass) plastic waste is hardly visible; inaccessible places, because under water; etc.*

2. Characterisation of river morphology & surrounding area

2.1. River width

☐ trickle, rivulet, brook (width 1-3 m)

☐ creek (width 3-10 m)

☐ river (width >10 m, flows into stream)

☐ stream (width >10 m, flows into sea)

2.2. Flow velocity

Estimation of the flow velocity by

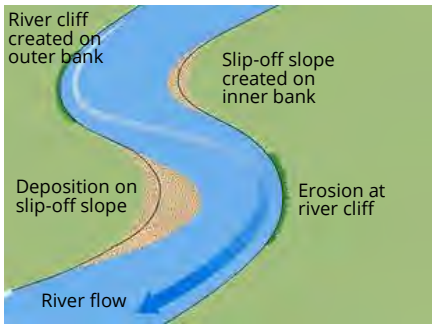
(1) walking a distance of 10m along the shore and marking start (S) and end (E),
(2) a stick (or similar floating natural material) is thrown into the river at (S)
(3) the time from start to end point is recorded,
(4) the procedure is repeated three times and
(5) is then inserted into the following formula to calculate the average flow velocity:

$$Average\ Time = \frac{measure\ 1: \quad [sec] + measure\ 2: \quad [sec] + mesure\ 3: \quad [sec]}{3} = \quad sec$$

$$Flow\ velocity = \frac{10\ m}{sec} = \boxed{\quad} m/s$$

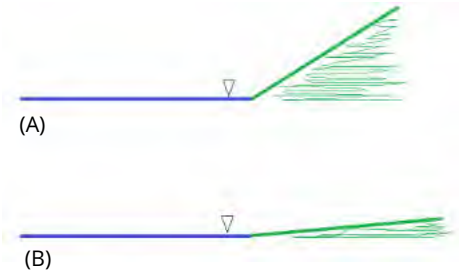
☐ Flow velocity could not be determined because:

2.3. Description of collection area at the river



Location: ☐ straight river section
☐ outer bank /cut bank
☐ inner bank / slip off slope

Type of shore: ☐ rather steep bank (A)
☐ rather shallow bank (B)

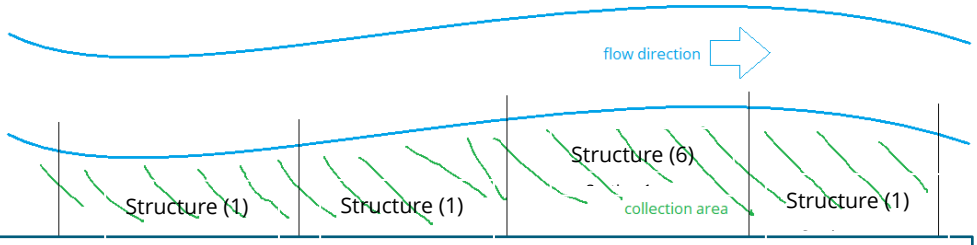


2.4. Bank structure und protection

Please tick the main structure (natural or obstructed) along the collection route. If the structure changes, you can also select several shapes and enter them graphically below (*see example*).

Description	Picture	Description	Picture
(1) ☐ natural bank (e.g. gravel and sandbank)		**(2)** ☐ natural rock, "no bank protection"	
(3) ☐ Concrete dams, sheet piling, etc. (smooth bank reinforcement)		**(4)** ☐ rip-rap revetment (rather smooth)	
(5) ☐ ecological bank protection (e.g. using wooden stakes)		**(6)** ☐ rough array of stones (larger blocks)	

Example:



Sketch

2.5. Description of riparian vegetation

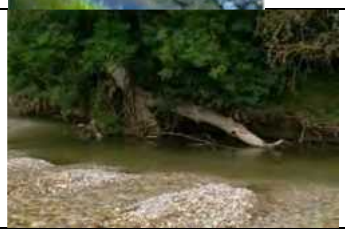
Please tick the mainly occurring riparian vegetation along the collected route. In case of changing vegetation, choose several and enter them graphically below (*see example above*).

Vegetation	Picture	Vegetation	Picture
(1) ☐ "green" slope, embankment		**(2)** ☐ perennials, bushes, herb corridor, grassy / weedy vegetation	
(3) ☐ reed bank		**(4)** ☐ (alluvial) forest (also with undergrowth)	
(5) ☐ gallery forest		**(6)** ☐ none (due to erosion)	
(7) ☐ none (due to bank protection)		**(8)** ☐ other	

Sketch

2.6. Other structures

Which of the following hydraulic engineering structures did you notice along the collection route? You can then record these elements graphically.

Description	Existing?	Picture
transverse structures like groynes or flow-directing longitudinal structure like guiding wall; other flow-affecting structures?	☐ yes ☐ no	
damming transverse structures like weirs, ramps etc.	☐ yes ☐ no	 
hydraulic channel narrowing	☐ yes ☐ no	
woody debris	☐ yes ☐ no	
diversion (e.g. hydro power plant) /tributary	☐ yes ☐ no	Which one?

Sketch

3. Characterisation of the surrounding area

3.1. Description of land use

What is the predominant type of land use in the immediate surroundings of the collection area? Describe only the cleaned bank side and indicate how the areas of use listed below are proportionally present *(e.g. 30% roads, 70% farmland = 100% → please note that the sum is 100%).*

☐	natural landscape or nature reserve			____ %
☐	agricultural land	O	*farm-, cropland*	____ %
		O	*grassland, pastures, meadow*	____ %
		O	*(alluvial) forest, flood plain*	____ %
		O	*vineyards*	____ %
☐	settlement area	O	*urban settlement area*	____ %
		O	*rural settlement area*	____ %
		O	*Industrial area (description if known):* _____ _____	____ %
		O	*Municipal facilities* *o waste collection center, recycling yard* *o sewage treatment plant* *o landfill* *o other:*	____ %
		O	*sport-, leisure and recreation area (e.g. bathing area, picnic, dog area, playgrounds; description if known):* _____ _____	____ %
☐	traffic area	O	*roads*	____ %

		O	*rails*	____ %
		O	*cycle paths*	____ %
		O	*hiking trails*	____ %
		O	*parking lots*	____ %
☐	other	O	*Flood protection (dam)*	____ %
		O	*Flooding area*	____ %

3.2. Other characteristics

Did you find any accumulation points (increased quantities of plastic waste at specific points) along your collection route? ☐ yes ☐ no

If yes, how many have you seen? ☐

4. Comments

If you noticed any noteworthy circumstances, you can note it here:

5. Graphic description

You can also draw the observed noteworthy circumstances (like pollution hotspots) along your collection route instead.

Sketch

PlasticFreeDanube

D4.1.2 HANDBOOK FOR SAMPLING AND SORTING

to assess macro-plastic waste in and along river systems

DOCUMENT INFORMATION	
Work Package	4 Sampling and Sorting of Plastic Waste in and along of river systems
Activity	4.1 Methodology for standardised sampling of plastic waste
Detail Output	4.1.1 Sorting protocol

Version	Date	Author	Organisation
v.2.0	26/10/2018	J. Mayerhofer, S. Lenz, G. Obersteiner	ABF-BOKU
v.3.0	20/03/2019	J. Mayerhofer, S. Lenz, G. Obersteiner	ABF-BOKU
v.4.0	18/10/2019	J. Mayerhofer, S. Lenz, G. Obersteiner	ABF-BOKU

1. PROCEDURE OF SORTING ANALYSIS

Sorting analyses represent an essential tool to identify and assess the composition of solid waste. In the course of the "PlasticFreeDanube" (PFD) project, this method is ideally suited to get information about possible sources of riverine plastic pollution as well as the assessment of the quantities. The following points briefly outline the procedure of sorting analysis and what should be considered in the planning. Subsequent a list of useful equipment is also given (Chapter 2).
In addition to a developed sampling protocol, which serves as a basis for the collection of plastic waste along rivers, the PFD-handbook contains a detailed description for handling with the sampling and sorting protocol.

SORTING ANALYSIS PROCEDURE	
☑	**Choose a weatherproof location for sorting** (protection against sudden rain, strong wind, etc.)
☑	**Select suitable containers** (e.g. mortar trough for larger fractions like food packaging or housewares; barrels for beverage bottles and foils; buckets for smaller fractions like sanitary waste; additional containers for sludge, dirt, water, etc. as well as reserve)
☑	**Label the containers** (and determine their tare weights)
☑	**Arrange the fraction containers around the sorting table** (good accessibility for stuff, arrange similar categories next to each other)
☑	**Weigh and document the total weight of each sample** (do not forget to subtract the weight of the collection containers, e.g. garbage bags)
☑	**Assign the plastic waste to the correct fraction according the PFD-Masterlist** (depending on the research question, other non-plastic materials such as wood, glass, paper, metal, etc. can also be recorded and evaluated; remove items from dirt, algae, mud/sand, organic substances, etc. as far as possible and put them in the "organic/non-plastic" fraction; bottles and containers may be emptied, provided they are filled with water/drink {→ also "organic/non-plastic" fraction}; separate unknown substances {e.g. oily mixture} and dispose them correctly)
☑	**Document all categories / containers with a photo**
☑	**Weigh each single fraction and enter them in the provided table (see appendix)** (also non-plastics waste and other recorded fractions or materials; do not forget to subtract the tare weight of the containers)
☑	**Count the items of each category and assign them to the defined size classes** (according Chapter 4; enter the numbers again in the table)
☑	**Describe each analysed plastic waste fraction and note "outliers" in the table** (items, that are heavier than the average)
☑	**Control the sum of all weighted categories with the initial weight** (Permissible weight deviations between the initial determined total weight and the sum of all sorted categories should not exceed 3%).

2. LIST OF EQUIPMENT

The following list contains some useful equipment, which contributes to a successful sorting.

General equipment	Sorting equipment
☑ PFD Sorting Protocol (electronic + some printed)	☑ Sorting table (+ film)
☑ Pens, clipboards for protocols	☑ Balance* + cable + spare batteries
☑ Work clothing and warning vests (if necessary)	☑ Containers incl. labelling (fraction, tare)
☑ Cut resistant gloves (protection against e.g. syringes)	☑ Reserve containers + labels
☑ First-aid-box (plaster, disinfection, bandage)	
☑ Roll scale or folding rule	
☑ Scissors, knife	
☑ Broom and dustpan	
☑ Camera (memory chip), batteries, charger	
☑ Laptop	
☑ Extension cable, distributor plug	
☑ Portable outdoor spotlight	
☑ Personal goods (food and drinks, spare clothes)	
* Balance with a recommend measuring accuracy of 0.01 kg	



Figure: Sorting table and sorting containers for various categories

3. CLASSIFICATION OF MACRO-PLASTIC

3.1. Categorisation of macro plastic waste

The following table gives an overview of the classification of macro-plastic waste, defined in the framework of the "PlasticFreeDanube" project. This functional categorisation aims at allocating plastic waste to its origin or input sources. Another important aspect of this classification is that even laypersons without special prior knowledge can manage the allocation of plastic waste within the scope of sorting analyses. Corresponding data and information on plastic waste are essential to derive appropriate prevention measures.

Table 5: Classification of plastic waste in and along the Danube

Main-group	Sub-group	No.	Category	No.	Sub-Category
Packaging	Drink bottles	1	PET drink bottles + caps		
	Food packaging	2	Food packaging	2a	Flexible packaging
				2b	Hard plastic containers
				2c	Liquid packaging boards
				2d	Foamed food containers
	Non-food packaging	3	Single-use tableware		
		4	Shopping bags		
		5	Cosmetic bottles & containers		
		6	Cleaner bottles & containers		
		7	Building & construction packaging		
		8	Packaging films and sheets		
		9	Other plastic packaging		
Foamed	Foamed plastic	10	Foamed plastic (packaging / insulation / foamed fillers / undefinable foamed plastic items)	10a	Expanded Polystyrene (EPS) Packaging*
				10b	Expanded or Extruded Polystyrene (EPS/XPS) for insulation*
				10c	Other foamed plastic*
Non-Packaging	Household / toys / sport / leisure	11	Housewares / household like items		
		12	Clothes, shoes and accessories		
		13	Toys, sport & leisure article		
		14	Fishing gear		
		15	Cigarette items		
		16	Lighters		
	Sanitary & medical article	17	Sanitary waste	17a	Feminine hygiene articles
				17b	Wet wipe/cleaning tissue
				17c	Cotton buds
				17d	Other sanitary waste
		18	Medical & pharmaceutical waste		
	Other non-packaging items	19	Plastic ropes and strings		
		20	Tapes		
		21	Shipping items		
		22	Car parts		
		23	Building & construction waste		
Others	Other plastic items	24	Unidentifiable plastic items		

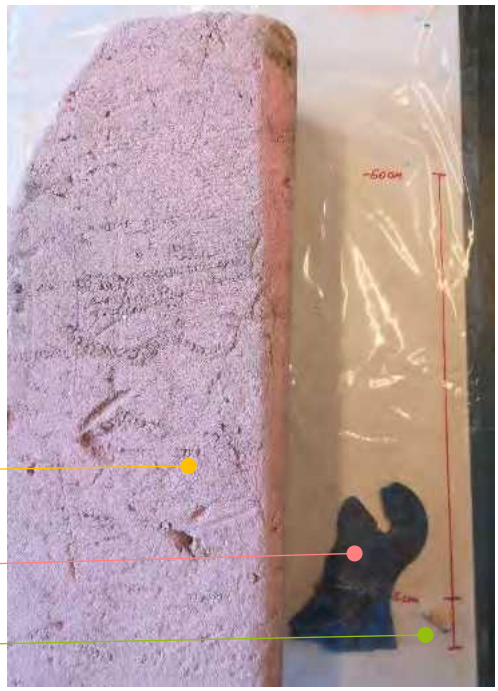
*currently there is only one "foamed plastic" fraction, a description for differentiation is in progress

3.2. SIZE CLASSES OF MACRO PLASTIC

In order to get information of the size distribution of macro-plastic waste, it is necessary to assign the collected items to a size class. The resulting data can serve as a basis for the abrasion and degradation condition of plastic objects. Following size classes have been defined:

- Mesoplastics | < 5 cm
- Macroplastics | 5 – 50 cm
- Megaplastics | > 50 cm

It is advisable to do the allocation to the size classes during the count. Thereby, it is helpful to stick a 5cm or 50cm long strip on the table (or draw it on the foil) as a rough indication. The longest edge length of the plastic items must be measured (see photo beside).



MASTERLIST - Sorting Protocol for Plastic Waste



ID 1 PET DRINK BOTTLES

PET Getränkeflaschen

PET nápojové fľaše

Description	All sizes (0.5l, 0.75l, 1l, 1.5l, 2l), incl. bottle caps (PP); also single bottle caps, which can be assigned as part of a PET bottle
Note	Empty liquids; count also single caps



ID 2a FOOD PACKAGING

flexible pack/foils

Flexible Lebensmittelverpackungen

Flexibilné balenie potravín

Description	Crisps packets, sweets wrappers, salad foil pack., nets for lemons/oranges, bubble wraps for fruits, external pack. for PET-bottles, etc.
Note	May contain a thin aluminium layer, if the heavier part is the plastic (e.g. Chips Packaging)



ID 2b FOOD PACKAGING

hard plastic container

Lebensmittel-Vpkg. - Hartplastikbehälter

Balenie potravín - plastové kontajnery tvrdé

Description	Food containers for meat, fruits, vegetables, yoghurt, (curd) cheese, cream, spread, etc.
Note	Top film on a meat packaging (e.g. MAP) remains on, so that no falsifications occur during the counts; without foam pack;



ID 2c FOOD PACKAGING

liquid packaging boards

Lebensmittel-Vpkg. Getränkeverbundkartons

Balenie potravín - Nápoj zložený kartón

Description	TetraPak, bonded drinks cartons for e.g. milk, orange juice, cream, etc.
Note	



ID 2d FOOD PACKAGING

Foamed food container

Geschäumte Lebensmittel-Vpkg.

Description	Foamed take away boxes (e.g. for ice cream), foamed protective covers for e.g. fruits
Note	



ID 3 Single use tableware

Einweggeschirr

riad na jedno použitie

Description	Plastic cutlery (spoon, fork, knife), plates, trays, straws, plastic cups, etc.
Note	Included foamed cups for tea



ID 4 Shopping Bags

Einkauftragetaschen

nákupné tašky

Description	Exclusively shopping bags, which are handed out by the trade (but also knot bag for fruits and vegetables)
Note	No garbage bags, no bags for animal faeces



ID 5 COSMETIC BOTTLES & CONTAINERS

Kosmetikartikel

Kozmetické fľaše a nádoby

Description	Sunblocks, shower gel, deodorant, etc.
Note	



ID 6 CLEANER BOTTLES & CONTAINERS

Reinigungsmittel

Description Detergent, cleaner, etc.

Note



ID 7 BUILDING & CONSTRUCTION PACKAGING

Verpackungstuben und Behälter

Description Packaging of adhesives and sealants (e.g. silicone tube); packaging of building and construction materials, etc.

Note



ID 8 PACKAGING FILMS & SHEETS

Verpackungsfolien

Description Sheets, foils, films, (also film parts that can no longer be precisely identified)

Note



ID 9 OTHER PLASTIC PACKAGING

Sonstige Kunststoffverpackungen

Description Fuel can, engine oil bottles, undefinable bottles, strapping bands, plastic flower pots (one-way), big-bags, etc.

Note Includes composite packaging



ID 10 FOAMED PLASTIC

Geschäumte Kunststoffe

Description	"Styropor", refrigerator trays and boxes, insulation panels and boards, spray foam, filling material for furniture
Note	Without foamed food and fishing gear pack



ID 11 HOUSEWARES / HOUSEHOLD LIKE ITEMS

Haushaltswaren, haushaltsähnliche Artikel

Description	Typical household articles: kitchen appliances (kettle, coffee machine), keep-fresh container, laundry basket, office supplies, cleaning utensils (broom, dust wiper, rubber gloves), curtains, tablecloth, gardening equipment (planter), etc.
Note	Exclude "streetwear" textile (→ ID 12)



ID 12 Clothes, shoes and accessories

Straßenkleidung inkl. Accessoirs

Description	Shoes/sandals (incl. flip-flops), clothes, handbags, backpacks, etc.
Note	If the polymer content of the cloth can be determined for mixed fibres (e.g. polyester/cotton), use the percentage weight; If unknown, whether natural or synthetic fibre → fire test *(*see below)*



ID 13 TOYS & LEISURE ITEMS

Spielsachen sowie Sport und Freitzeitartikel

Description	Sport items (tennis racket, football, etc.) balls, dolls, plastic sandbox buckets, etc
Note	



ID 14 FISHING GEAR

Fischereizubehör

Description	Nets, lines, fishing rod, foamed plastic packaging for fishing baits
Note	



ID 15 CIGARETTE ITEMS

Zigarettenartikel

Description	Butts & filters, tobacco pouches / plastic packaging of cigarette box
Note	No paper/no alu packaging



ID 16 LIGHTERS

Feuerzeuge

Description	
Note	Lighters are weighed in total. Exact plastic weight is determined later by multiplication with the factor 0.8 to exclude metal content



ID 17a FEMININE HYGIENE ARTICLES

Damenhygieneartikel

Description	Sanitary towels, tampons (incl. packaging)
Note	



ID 17b WET WIPE / CLEANING TISSUE

Feucht- und Reinigungstücher

Description

Note



ID 17c COTTON BUDS

Wattestäbchen

Description

Note



ID 17d OTHER SANITARY WASTE

Sonstige Sanitärabfälle

Description Toothbrush and other dental hygiene articles, Urinal deodorizer block holder, etc.

Note



ID 18 MEDICAL & PHARMACEUTICAL WASTE

Medizinische und pharmazeutische Abfälle

Description Syringes, medical strip/plaster, pill blister, etc.

Note



ID 19 PLASTIC ROPES & STRINGS

Kunststoffseile und -schnüre

Description	All sizes
Note	If unknown, whether natural or synthetic fibre → fire test *(*see below)*



ID 20 TAPES

Klebebänder

Description	adhesive strips, fabric tapes (e.g. Gaffa tape)
Note	



ID 21 SHIPPING ITEMS

Schiffsgegenstände

Description	buoys, life jacket, fender etc.
Note	specify larger items



ID 22 CAR PARTS

Fahrzeugteile

Description	fenders, hubcaps, tyres, licence tag holder, fluid container/tanks, etc
Note	specify larger items (e.g. tyres)



ID 23 BUILDING & CONSTRUCTION WASTE

Baustellenabfälle

Description	Pipes, cable sheath, frames, tools, tubes, etc.
Note	If the metallic part clearly predominates in cables (copper), then to the category of non-plastics



ID 24 UNIDENTIFIABLE PLASTIC ITEMS

Nicht identifizierbare Kunststoffgegenstände

Description	unidentifiable plastic items or other plastic articles which cannot be clearly assigned to any of the other categories with respect of their origin
Note	specify larger items

ID 25 ORGANIC & OTHER NON-PLASTIC ITEMS

Organik und andere Nicht-Kunststoffabfälle

Description	Water, sludge, other organic components (like leaves, grass, smaller twigs, etc.); also other non-plastic waste (“residual waste”);
Note	Collect organic and residual waste separately in order to dispose of them correctly;

*Fire Test:

Plastic/Fibre	Combustibility
Cotton	*burns quickly, glows after, embers can be inflamed by careful blasting*
PP,PE, Polyester	*melting, then burning*

OPTIONAL CATEGORIES (OTHER MATERIALS)

ID 27a RESIDUAL WASTE



Restmüll

Description

ID 27b GLAS



Glas

Description

ID 27c ALUMINIUM & METAL



Aluminium und Metall

Description

ID 27d PAPER & CARDBOARD



Papier und Kartonagen

Description

ID 27e WOOD



Holz

Description

EVALUATION TABLE

Code of sample:			
Date of Sampling:		**Initial weight** (brutto):	**kg**
Date of Sorting:		**Tara** (collection cont.):	**kg**
Time / Duration:		**Sample weight** (netto):	**kg**

No.	CATEGORY	TARE WEIGHT Container	NET WEIGHT Fraction	COUNT / SIZE CLASS			COMMENT
				< 5cm	5–50cm	>50cm	
1	PET drink bottles + caps						
2a	Flexible packaging						
2b	Hard plastic containers						
2c	Liquid packaging boards						
2d	Foamed food containers						
3	Single-use tableware						
4	Shopping bags						
5	Cosmetic bottles & containers						
6	Cleaner bottles & containers						
7	Building & construction packaging						
8	Packaging films and sheets						
9	Other plastic packaging						
10	Foamed plastic						
11	Housewares / household like items						
12	Streetwear						
13	Toys, sport & leisure article						

No.	CATEGORY	TARE WEIGHT Container	NET WEIGHT Fraction	COUNT / SIZE CLASS			COMMENT
				< 5cm	5-50cm	> 50cm	
14	Fishing gear						
15	Cigarette items						
16	Lighters						
17a	Feminine hygiene articles						
17b	Wet wipe/cleaning tissue						
17c	Cotton buds						
17d	Other sanitary waste						
18	Medical & pharmaceutical waste						
19	Plastic ropes & strings						
20	Tapes						
21	Shipping items						
22	Car parts						
23	Building & construction waste						
24	Unidentifiable plastic items						
25a	*Non-Plastic Fraction*						
25b	*Organic*						
S	**SUM [kg]**		**kg**				
C	**TOTAL (Counts)**						
TW	**Total weight [kg]** (before sorting)		**kg**				
WD	**Weight deviation** (in kg and %)	= TW before[kg] − Sum [kg]	**kg**	$= \frac{WD\ [kg]}{TW\ before\ [kg]}$		**%**	Deviation should be less than 3%, otherwise check the weights again!