PlasticFreeDanube

D3.3.1 REPORT ON AVAILABLE DATA REGARDING PLASTIC POLLUTION

For the Material-Flow-Analysis

DOCUMENT INFORMATION	
Work Package	3 Material-Flow-Analysis and Transport Modelling
Activity	3.3 Collection of available data for the material flow analysis model
Detail Output	3.3.1 Summary report on available data regarding plastic pollution
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List of abbreviations

ABS	Acrylonitrile-butadiene-styrene
ASFINAG	Federal agency which finances, maintains and operates motorways and expressways in Austria
EPS	Expanded polystyrene
FCIO	Fachverband der Chemischen Industrie Österreichs = trade association of chemical industry Austria
HPP	Hydropower plant
IDSWC	International Danube ship waste convention
LDPE	Low-density polyethylene
LWP	Light weight packaging
PE	Polyethylene
PE	Population equivalent
PP	Polypropylene
PS	Polystyrene
PUR	Polyurethane
PVC	Polyvinyl chloride
UBA	Umweltbundesamt = federal environmental agency (FEA)
WEEE	Waste of electrical and electronic equipment
WWTP	Waste water treatment plant

1 Introduction

Despite plastic's many benefits, the ever-increasing mass of unmanaged plastic waste is causing significant damage to the global ecosystem (Seay et al., 2020). Especially plastic waste in marine ecosystems has become a great environmental problem on regional and global levels. Rivers are recognized as main vectors of pollution although sources and pathways of plastic in the rivers and its environmental impacts remain unclear. Within the project "PlasticFreeDanube" macro-plastic waste (> 5 mm) in and along the Danube river and parts of its riparian area is investigated. Data on origin, amounts, composition and properties of plastic waste entering the Danube river are collected from existing data, expert interviews and field studies like waste collection activities, tracing experiments, sampling of plastics in water and screenings from hydropower plant and sorting campaigns.

This report lays the foundation for the material flow analysis (MFA) of macro-plastic waste in the Danube river between Vienna and the Gabčíkovo hydropower plant (downstream of Bratislava) and provides the corresponding data basis for the MFA-model. The main sources, input and output pathways, transport and disposal routes of plastic waste of the Danube and its riverbanks are described in detail. Available figures on quantities, types and sources of plastics entering the system are compiled. The in-depth methodology of the MFA-model as well as the data acquisition and generation are summarized in report D 3.2.1 Material-flow-analysis model (Mayerhofer et al, 2021).

1.1 Scope of the project area

Concerning the emergence of (littered) macro-plastic waste, the project area has been defined as the territory of the Danube river and wetlands, as well as adjacent river banks between the metropolitan areas of Vienna and Bratislava down to hydropower plant Gabčíkovo in Slovakia (downstream border of the project area). As catchment area for direct plastic pollution within the cities a uniform distance of 250 m from the shoreline was defined, in rural areas (e.g. farmland etc.) a distance of 500 m. The width of the study area was chosen as compromise between manageable effort of investigations and necessary accuracy and aims to cover relevant pollution sources. Along the Danube Canal the distance is chosen to be only 100 m, because that is the distance to the residential areas (Figure 1). Within this distance's, transportation of plastics by wind, strong rain or floods seems to be likely although no figures about transportation pathways and distances of plastics by wind and runoffs exist. We assume, it cannot be ruled out that, especially during single events such as heavy rain or storms, plastic waste may be carried into Danube river from a long distance and is not considered in this MFA.

The chosen study area in general does not reflect the contribution of indirect plastic pollution by e.g. waste water treatment plants, as this would include for example total Vienna or tributaries. Within PFD project only municipalities whose settlements lay within the project area, not only the political territory itself, were considered. Within Vienna, all districts bordering on the Danube and the Danube Canal were considered. Identification with help of google-maps and GIS-map led to following list of municipalities/districts: Klosterneuburg – Weidling, Langenzersdorf, Mannswörth an der Donau, Maria Ellend, Haslau an der Donau, Regelsbrunn, Wildungsmauer, Bad Deutsch Altenburg, Hainburg. Corresponding number of inhabitants are compiled in Table 1.

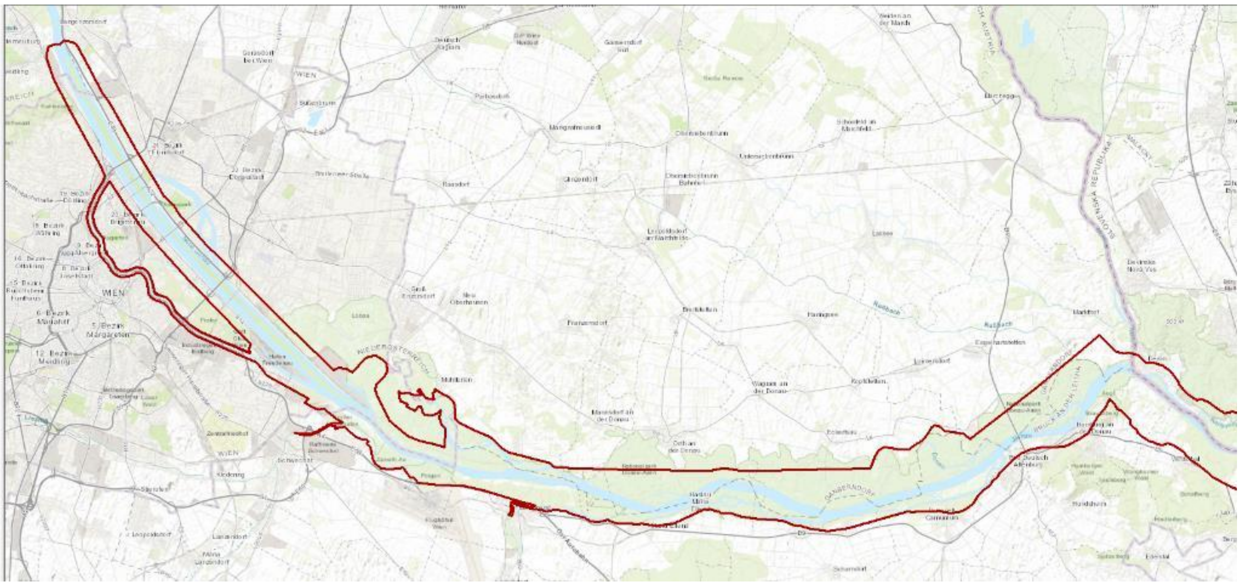


Figure 1: GIS-Map of project area (Austria) (HQ100 overlap with 500m area)

Table 1: Districts and communities within project area with corresponding number of inhabitants in 2019 (City of Vienna, 2020)

Districts of Vienna	**Inhabitants in 2019**
Floridsdorf (21st)	165.673
Donaustadt (22nd)	191.008
Döbling (19th)	72.947
Brigittenau (20th)	86.502
Leopoldstadt (2nd)	104.946
Alsergrund (9th)	41.958
Innere Stadt (1st)	16.306
Landstraße (3rd)	91.745
Simmering (11th)	103.008
Number of relevant inhabitants in Vienna	**874.093**
Municipalities in Lower Austria	
Weidling (Klosterneuburg)	3.268
Langenzersdorf	8.106
Manswörth an der Donau	1.600
Haslau - Maria Ellend	2.005
Regelsbrunn	333
Wildungsmauer	430
Bad Deutsch-Altenburg	1.772
Hainburg	6.725
Number of relevant inhabitants in Lower Austria	**24.239**
Total number of relevant inhabitants within AT part of project area	**898.332**

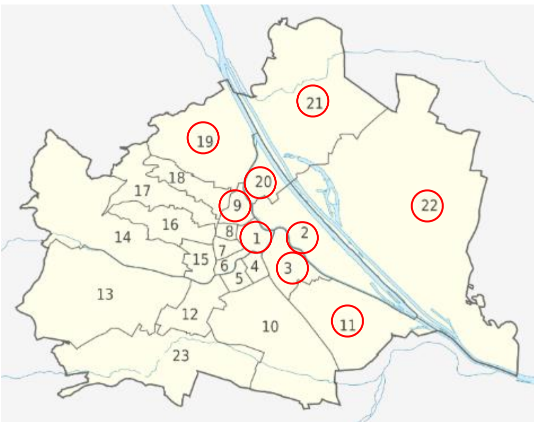


Figure 2: Districts of Vienna (Wikipedia, 2020), concerned districts are marked with red

2 Production, processing and consumption of plastic in Austria

2.1 Plastic production in Austria

Worldwide plastic production is still increasing and amounted 1.7 million tons in 1950, 322 million tons in 2015 (PlasticsEurope 2016 cited in UBA, 2017) and 348 million tons in 2017 (PlasticsEurope, 2018). Production of plastic in Europe (EU28+Norway and Switzerland) remains static and was 58 million tons in 2015. Worldwide production of bioplastics has increased recently and reached a capacity of 3.95 million tons in 2015. Applications of composite materials and bioplastics are increasing too.

In 2015 1,558,000 t of plastic was produced in Austria (UBA, 2017). This is approximately 0.5 % of worldwide plastic production. More than 590 companies produced and processed plastics in 2015. The production program ranges from standard plastics like polyethylene (PE), polypropylene (PP), expanded polystyrene (EPS), to resins for lacquers and adhesives and other plastics. Besides raw materials auxiliary materials for manufacturing and processing of plastics like stabilizers, color pastes, lubricants, fillers and separating agents are produced (FCIO cited in UBA, 2017).

Table 2: Production of plastic in 2015 (UBA, 2017)

Area	**Amount of plastic produced in 2015 (t)**
Worldwide	322,000,000
Europe (EU28+Norway and Switzerland)	58,000,000
Austria	1,558,000

2.2 Plastic processing in Austria

In 2015 1,667,000 t of plastic were processed in Austria (UBA, 2017). About 557 polymer processing companies are active in Austria. Centers of production are mainly located in Upper and Lower Austria. Main products according to turnover were:

- semi-finished materials like plates, foils, flexible tubes, profiles (36%),
- packaging materials (19%),
- builders ware products (14%) and
- other plastic products (31%).

In the absence of a significant domestic market the Austrian plastics processing industry is export oriented (NACE 222, lt. LSE cited in FCIO, 2019). The export ratio for plastic processing companies is currently about 33% in Austria; for some companies the share is even higher, as they focus on foreign markets (UBA, 2017).

Although plastic granulates that could originate from the production or processing of plastics were found during collection activities, they have not been investigated in detail because they are qualified as microplastics (< 5 mm) due to their size and are therefore out of scope of this study.

Results from collection activities and sorting analysis within PFD project suggests that collected macro-plastic waste (> 5 mm) within project area is not assignable to plastics production and processing. Furthermore, 80% of total plastic waste amounts in Austria are post-consumer wastes from private or commercial end users. The remaining 20% are process waste but UBA (2017) states that residues from production are only partly included in waste streams as they are traded as by-products. Also, Kawecki et al. (2018) which investigated material flow of seven commodity plastics in Europe stated, that waste produced at the production stage is very low. Hence, within this study macro-plastic is not considered to be lost during its production and processing. Within material-flow-analysis (D 3.4.1 MFA-diagram) plastic is therefore depicted starting with the consumption of macro-plastics by private and commercial end users.

2.3 Plastics consumption in Austria and project area

As most of collected plastics originate from private and commercial end use of plastics (e.g. pure plastic as packaging material, consumer goods like kitchenware or sport equipment or as component of a system like in cars), MFA within this project starts by taking a closer look at consumption and disposal behaviours of private and commercial end users (household and household like establishments). Also, the building and construction sector and with a lower portion industrial and commercial enterprises, agriculture & forestry, inland navigation and unknown sources contribute to plastic pollution. Collected waste cannot clearly be assigned to sources and responsibilities due to overlaps. Insulation panels, for example, could originate from commercial construction sites but also from households. Also, investigation of transport routes plays a crucial role as e.g. sanitary waste which is produced by households is often flushed via wastewater. In addition, the waste is often flushed into the system over long distances (discharges from drainage systems), making it considerably more difficult to estimate the catchment area.

According to van Eygen et al. (2017), who reported amounts of traded and distributed final plastic products in 2010, the proportions of the plastic quantities among the consumer goods are distributed similarly as among the materials for primary production. Packaging material and plastics from the construction sector make up the largest share.

In 2018 total European plastics converters demand was 51.2 million tons with following division: 39.9% packaging, 19.8% building & construction, 9.9% automotive, 6.2% electrical and electronic, 3.4% agriculture, 4.1% household, leisure & sports, 16.7% others (includes appliances, mechanical engineering, furniture, medical etc.) (Figure 3). Packaging and building & construction thus represent the largest end-use markets. The third biggest end-use market is the automotive industry. The demand for plastics in Austria in 2015 was around 1.03 million tons, whereby these were mainly used in the packaging sector and in the construction industry.

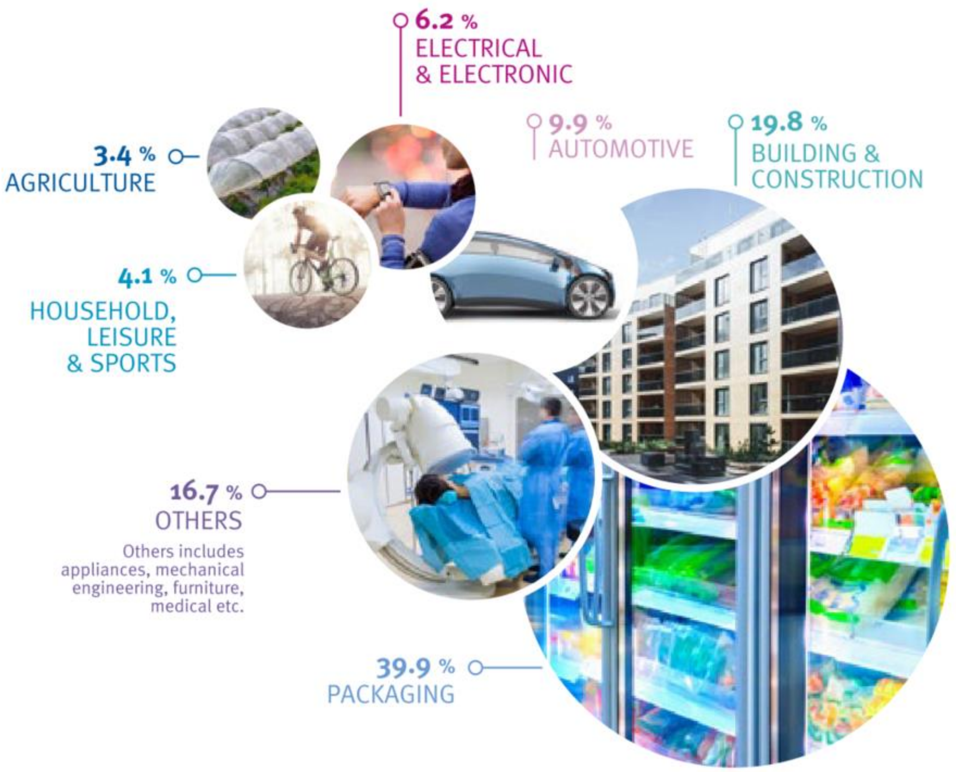


Figure 3: Distribution of European (EU28+NO/CH) plastics converters demand by segment in 2018 (PlasticsEurope, 2019)

Based on a total plastic converter demand of 1,030,000 t in Austria in 2015 and the shares of sectors in 2018 (PlasticsEurope, 2019), the quantities of plastics for consumer-sector were estimated in a first step for total Austria and then broken down to project area (related to inhabitants) and listed in Table 3. For the shares of the individual sectors, also Austrian Environmental Agency refers to figures of PlasticsEurope. Regarding the type of plastic, from total demand of 1,030,000 23% are accounted for

PE, 18% for PP, 10% for (E)PS, 6% for PET, 6 % for PUR, 4% for PVC and 33% for other plastics (UBA, 2017). In Austria an annual amount of 50,000 tons bioplastic is set onto the market (UBA, 2017).

Table 3: Self-estimated Austrian plastic converter demand per sector

Sector	**Shares [1]**	**Estimated amount [2] (t)**	**Estimated amount (kg/cap*a)**	**Estimated amount within project region[3] (t)**
Packaging	40%	410,970	46	41,674
Building & Construction	20%	203,940	23	20,680
Automotive	10%	101,970	12	10,340
Electrical & Electronic	6%	63,860	7	6,476
Agriculture	3%	35,020	4	3,551
Household, leisure & sports	4%	42,230	5	4,282
Others (includes appliances, mechanical engineering, furniture, medical etc.)	17%	172,010	19	17,442
Total	**100%**	**1,030,000**	**116**	**104,445**

[1] Shares of sectors based on PlasticsEurope, 2019

[2] Quantities of the respective sectors are estimated and based on the total demand in AT in 2015 and the shares (PlasticsEurope, 2019) of the respective sectors

[3] Quantities within project region are estimated based on total demand, shares of respective sectors and relation of inhabitants in whole Austria and project region

3 Plastic waste generation in Austria and project area

The amount of plastic waste generated in Austria was calculated to be 916,360 t in 2015 (UBA, 2017). In terms of origin, 80% of Austria's total plastic waste amounts are post-consumer waste from private or commercial users. In Austria industrial and commercial waste are no particular designated waste types, therefore barely separate figures exist (Pomberger and Eisenberger, 2010). The remaining 20% are process waste, but it is assumed that residues from production are only partly included in waste streams as they are traded as by-products (UBA, 2017).

In terms of economic activity, the results show that most of all plastic waste stems from households (51 %) and services (23 %) (Table 4) (UBA, 2017). Based on total population of Austria and population within project area figures were broken down in Table 4.

Table 4: Plastic in waste - generation according branches in 2015 (UBA, 2017)

Plastic (containing) waste sectors	**Amount of plastic in sector (t)**	**Shares**	**Estimated amount of plastic in sector within project area[1] (t)**	**Estimated specific amount of plastic per sector[1] (kg/cap*a)**
Household	467,313	51 %	48,900	54,43
Services	208,739	23 %	21,842	24,31
Production of chemical and pharmaceutical products including rubber and plastic goods	57,740	6 %	6,042	6,73
Construction (industry)	42,090	5 %	4,404	4,90
Production of electrical, electronical and optical goods; Equipment of machines and vehicles	25,057	3 %	2,622	2,92
Agriculture and forestry	20,074	2 %	2,101	2,34
Production of food and animal feed	17,761	2 %	1,859	2,07
Others	77,587	8 %	8,119	9,04
Total	**916,360**	**100 %**	**95,888**	106,74

[1] Estimation based on total Austrian population and population within project area

Only 21% of the plastic waste generated in Austria can be allocated to pure plastic waste streams, most importantly from plastic foils/films, plastic packaging and containers, other cured plastic materials, polyolefin waste and rubber. Approximately 77% of the amount of plastic is found in mixed waste containing varying amounts of plastic, mainly in residual waste and similar commercial waste, lightweight-packaging and bulky waste. Only 2% are amounted to plastics in colours and lacquers, cured colours and lacquers, plastic sludge and plasticizers (UBA, 2017). More details about composition of plastic waste streams have been previously described in Lenz et al. (2019).

Looking at the individual waste streams by application (Table 5), it turns out that packaging sector is the largest source of plastic waste in Austria and generates about 50% of the total post-consumer plastic waste. In 2015 294,888 t (33.9 kg/cap*a) plastic were generated and collected separately or in mixed fractions like residual or commercial waste (BMNT, 2017). Other large shares are allocated to households (17%) and other applications (27%).

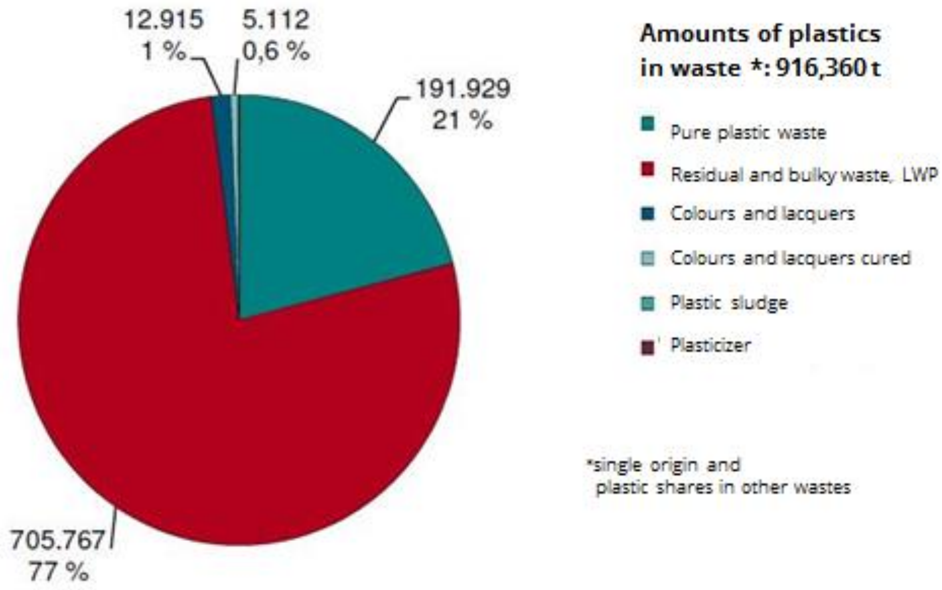


Figure 4: Plastic waste production in Austria in 2015 (UBA, 2017, modified)

In 2015, throughout Austria 1,311,246 t of packaging waste were generated and collected separately or in mixed fractions like residual or commercial waste, thereof 294,888 t were plastics (BMNT, 2017). Considering 8,690,076 inhabitants in Austria, packaging waste generation amounts to 33.93 kg/cap*a. According to Van Eygen (2018), out of the approx. 300,000 (±3%) t of plastic packaging waste generated in Austria in 2013, the main shares were:

- large films (71,000t ±13%);
- small films (69,000t ±10%);
- small hollow bodies (49,000t ±11%);
- PET bottles (45,000t ±2%);
- large hollow bodies (18,000t 13%);
- large EPS (2,300 ±5%) and
- others (39,000 t±13%)

The polymer composition of the waste stream was dominated by: LDPE (46%±6%), PET (19%±4%) and PP (14%±6%). A Material Flow Analysis (MFA) of waste packaging material (subdivided by product and by polymer) is depicted in Figure 5 according Van Eygen et al. (2018).

Table 5: Plastic waste in Austria in 2015 by application (UBA, 2017) and estimated amounts per person and within project area

Primary volume of plastic waste by application	**Description**	**Amount in AT 2015 (t)**	**Shares in 2015**	***Estimated amount (kg/cap*a)***	***Estimated amounts in project area[1] in 2015 (t)***
Packaging	Packaging waste according Packaging and packaging waste directive	294,888	32%	34.3	30,857
Building. construction & infrastructure	Plastic of construction site waste without building rubble	46,640	5%	5.4	4,880
Transport	Plastic components of vehicles and used tyres	45,755	5%	5.3	4,788
Electronics	Plastic content of waste electrical and electronic equipment including WEEE in residual waste	27,125	3%	3.2	2,838
Furniture	Plastic components of furniture and mattresses in bulky waste	37,678	4%	4.4	3,943
Agriculture	Separately collected agricultural film and agricultural film in residual waste	32,448	4%	3.8	3,395
Medicine	Plastic content of waste streams 97104.097101.097102 and 97105	25,137	3%	2.9	2,630
Household	Contains the plastics in residual waste and bulky waste from households that are not packaging. EAG, construction site waste or furniture. In addition, the proportion of plastics in textile waste from households was considered.	155,842	17%	18.2	16,307
Other Applications/ others	Contains plastics in residual waste and bulky waste from commercial operations that are not covered by municipal collection.[2]	250,847	27%	29,2	26,249
Total amount of plastic in waste		**916,360**	**100%**	**106,7**	**95,888**

[1] Referring to 898,332 inhabitants within project area in 2019

[2] They come from commercial facilities (industry, trade, agriculture, etc.) and are not packaging, WEEE, construction waste, agricultural film or furniture (e.g. hardened paints and varnishes, transport containers, buckets, canisters, films, refuse sacks, tools containing plastics). Also contains all remaining, unassigned quantities

PET bottles

Within collection activities 30-50% of collected plastic packaging were PET-bottles. In a recent study commissioned by the Austrian Government market volume of PET bottles is given with 41,500 t net PET quantity (without closures or labels). Separate collection (inclusive amounts which end up in mechanical biological treatment (MBT) or waste incineration plants covers 31,554 t (Hauer et al., 2020).

Plastic carrier bags:

In Austria, 5,000 to 7,000 plastic carrier bags per year are considered to become waste. That is about 0.1% of the total waste amount. Almost all of them get either recycled or incinerated due to a densely developed collection system and a relatively high environmental awareness (BMLFUW, 2017). According to the Directive (EU) 2015/720, the number of existing plastic carrier bags has to be reduced by 50% until 2019. In December 2018, the Austrian government announced a planned set of measures for January 2020, including a ban on non-biodegradable light-weight plastic carrier bags.

For more details of plastic waste generation and the collection of plastic containing waste streams in Vienna and Lower Austria please see D 3.1.3 waste management in Austria and Slovakia (Lenz et al., 2019).

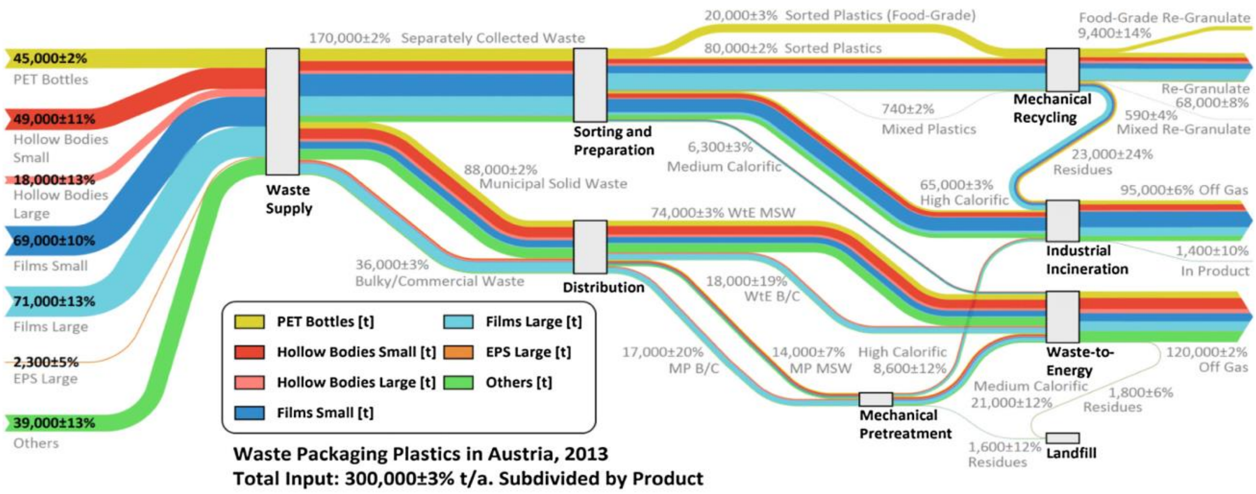


Figure 5: Results of the material flow analysis for the total waste stream subdivided by product category. The values are given by the mean (2 significant digits) and the relative standard deviation (Van Eygen et al., 2018).

4 Sources of plastic pollution and entry pathways into Danube river

Manifold sources of plastic pollution, pathways into and out of the Danube river and locations where they are leaked are described below. Natural disasters, such as historic flooding, which play a significant role in water pollution, are neglected in ongoing study to the extent that none of these events occurred during the investigation period.

To determine the material flow of plastic from the use phase to the littering step, littered items have to be allocated to certain sources. In literature the term "source" is used to describe either "user groups or branches" which are producing plastic waste or "places of production and origin of littered items" (Cheshire et al., 2009). For certain types of plastic waste (e.g. flushed cotton buds which are supposed to enter partially or largely via waste water) it is easier to trace back the origin than for others. In many cases difficulties occur to clearly define the origin of plastic waste. Different user groups might have similar habits, e.g. construction people might throw away their PET bottle similar to tourists.

Sources, pathways and litter sites are closely related and a precise delimitation is difficult. Though, in this study the term **source** is used to identify "**who**" (sector, society or industry that generate littered/ mismanaged waste) **is responsible** for the pollution, whereas the **location of release into environment** describes "**where" the waste is leaked** into the environment. **Pathways** describe **"how"** waste gets into the Danube river. An example that makes these connections better understandable is given in Figure 6. The "why" was not investigated in this study.

Figure 6: Example for sources, pathways and location of release.

The categorization of sources was made with the intention to be comprehensive and not neglect sources of waste, but also to be as simple as possible to allow assignment of collected plastic items in praxis to responsible persons or sectors. The classification also intends to follow branches and sectors for which waste streams are reported separately as good as possible.

The distinction between sources and pathways is not always clear. Waste and waste water management, for example, can be considered both a source and a pathway. For flushed waste that enters a river a household is responsible, but also the wastewater disposal company that did not remove the waste properly. It is important to keep in mind that the waste concerned is considered only once within a Material-Flow-Analysis. An overview of the chosen classification within PlasticFreeDanube project is given in Table 6, detailed information in Report D 3.2.1 Material-Flow-Analysis Model (Mayerhofer et al., 2020).

As main pollution sources households, and construction sector were identified by evaluation of collection and sorting analysis of waste from project area. Waste and waste water management as well as inland navigation play a minor role in Austria but are nevertheless described in more detail below. Also, industry and trade sector can be neglected in Austria, as only microplastic pollution is expected from it.

Table 6: Classification of pollution sources, entry locations and pathways according Mayerhofer et al. (2020)

Source (WHO?)	Location of release into environment (WHERE?)	Examples of plastic items (WHAT?)	Pathway into river system (HOW?)
Households (private and commercial end user)	Housing	Household goods and appliances, garden furniture and tools, office supplies, beverage and food packaging, non-food packaging like detergents, etc.	Littering and illegal waste disposals;
		Personal care and cosmetic products like hygiene articles, cotton sticks, wet wipes, toothbrush, etc.	Discharge via wastewater system
	Sport, Leisure and Recreation	Toys, sport items, camping equipment, single-use tableware, beverage and food packaging as well as sanitary waste (e.g. wet-wipes for picknick), etc.	Littering
	Street & Transportation	Beverage and food packaging, car parts like tyres, car accessories and automotive products (e.g. plastic packaging of engine oil)	Littering; discharge via rainwater sewer
	Fishing	Fishing gear like rod and line, bait box, fishing nets, etc.	Littering
Waste and wastewater management	Landfills, waste treatment or recycling plants, etc.	Waste that was originally disposed of properly but was generated from inefficient operation or treatment (losses from waste operation & transportation)	Discharge via rain- & wastewater system
Construction sector	Building and construction sites (private & commercial)	Insulating material (e.g. EPS or XPS insulation panels), tools, plastic building materials like tubes, pipes, etc. (incl. the packaging)	Littering; discharge via rainwater sewer
Industry and commercial sector	Industrial and comm. enterprises, include trade sector & service	Waste generated during manufacturing processes, branch-specific waste, packaging waste, etc.	Discharge via Industrial outfalls
Agriculture & Forestry	Fields, cultivated landscape, managed forests	Agricultural (packaging) films in e.g. the production of silage, greenhouse cover, plastic mulch for vegetable cultivation, growth protectors for trees, etc.	Littering
Inland navigation	Harbour, Docks, landings, river	Buoys, fender, ropes, etc. and “tourism-litter” like beverage and food packaging	Littering

The transport of the plastic can take place over long distances by wind and water. Animals can also play an important role (e.g. birds picking waste out of trash bins). Transportation processes are influenced by shape, density and size of plastics. As entry pathways via waterways tributaries, headwaters, extreme rain & flood events and wastewater-related entries (incl. rainwater) were identified as pathways via waterways; littering and illegal waste disposal as pathways via atmosphere. Littering is divided into direct littering, which involves active, conscious and deliberate action and indirect littering where the actor accepts littering as a consequence by his actions (e.g. insufficient protection of construction site waste during transport). Though, plastics can reach Danube river via various pathways and a clear assignment of collected plastics to pathways is rarely possible. Pathways are therefore not depicted in the MFA.

4.1 Mismanaging waste

Even though Austria has a very well-functioning waste management system illegal dumping cannot be completely avoided. In Figure 7, which shows an exemplarily deposit which was detected in June 2020 along Danube Channel al lot of plastic can be observed. Illegal disposing of waste is not the same like littering. Those who dispose of illegally do so specifically and after they have taken a decision to do so. e.g. in order not to have to pay a disposal fee. These are mostly larger quantities / items or entire garbage bags. Littering, on the other hand, involves smaller amounts of garbage and smaller items, such as an empty PET bottle or packaging (Amt für Umwelt, Thurgau, 2020). Illegal disposal sites are described in more detail in section 5.13. Other examples for improper waste management are e.g. crowded waste bins, uncovered transportation of plastic construction waste etc., which can subsequently lead to wind drift of plastic which may end up in the aquatic environment.

Figure 7: Illegal waste disposal along Danube Channel detected by Johannes Mayerhofer in June 2020

Treatment of waste (i.e. burning or removing of plastics) is mostly handled in buildings. Therefore, they are expected not to be a source of macro-plastic pollution. However, a study by the German Fraunhofer Institute UMSICHT identified waste management as the largest source of microplastics, after abrasion from tires and cars (Bertling et al., 2018). As in Austria municipal solid waste (MSW) is pretreated before landfilling since 2008, barely no plastics are landfilled. Thanks to proper landfilling technology (e.g. surface coverings also at abandoned landfills) drifts into surrounding areas can be excluded.
Also, waste collection centers are not considered as pollution sources within project since people who dispose of their waste in a targeted manner are less prone to pollute the environment and also the staff on-site is well trained. Only in extreme weather conditions (strong wind and heavy rainfall) we assume possible plastic emissions Examples include plastic collection containers blown away by storms whose contents are then transported further by wind and surface runoff.

4.2 Littering

Littering is difficult to assess in terms of amounts and pathways as it cannot be measured directly. Littering is often found in public places, at traffic hubs, along streets, near take-away restaurants, petrol stations, shopping centers and in natural recreation areas. It can be assumed that most of macro-plastic entry into Danube river is probably littering along riparian stripes and surrounding areas.

For the estimation of the pollution potential for rivers it is important to distinguish between total released litter amount in project area and litter which is not removed by infrastructure or cleaning measures, clean up events trough volunteers and urban water management. Then estimates are made of how much of the plastics in the environment remain in the soil and what proportion ends up in the water.

According a consortium study of Fraunhofer UMSICHT plastic emissions in Germany account 3.1% of the plastic consumption (5.4 kg/cap*a). Thereof 26% are macro-plastic-emissions (1.405 kg/cap*a) (Bertling et al., 2018). The authors interpret the littering rate as gross littering rate (= total share of illegally discharged waste; retention through infrastructure cleaning and urban water management is considered at a later stage) and they propose to relate the littering-rate to the difference between the amount of waste consumed and the amount of waste collected for future evaluations of the litter. Other studies (i.e. the BKV study (2017) and Jambeck et al. (2015)) define the littering rate as the share of unrecorded waste (= net littering rate). In future, it would make sense to relate the littering rate not to the amount of waste collected, but to the difference between consumption and waste collected.

Bertling et al. (2018) estimate that from of 1405 g/cap*a of macro-plastic emissions in Germany, an estimated amount of 412 g/cap*a is not recovered and remains in the environment. If these assumptions are applied to Austria and to project area, the estimated amount of plastic litter released would be 12.447 t in AT and 1.262 t within project area. The amount of macro-plastics which is not removed is estimated to be 3.477 t and 364 t per year, respectively.

According to a Swiss study, a total of around 5,120 t of plastic are released into the Swiss environment every year. Around 4,400 t enter the soil as macro-plastics, and another 110 t enter water bodies (BAFU, 2020). Kawecki and Nowack (2019) modeled the emissions of macro- and micro plastics based on a complete analysis of the flows from production and use to end-of life using probabilistic material flow analysis. They estimated macro-plastic emissions of 540 ±140 g/cap*year to the and 13.3±4.9 g macro-plastic emission to water. Based on these figures and referring to number of inhabitants within project area this would lead to an estimated amount of 485 tons of macro-plastic emitted to soil and 12 t emitted directly into water within project area. Figure 8 shows the composition of the total amounts of inputs to soil and water in Switzerland (note: Switzerland has only slightly fewer inhabitants than Austria). Main contributors are consumer bottles.

In a Conversio Market & Strategy study on plastic flow of EU28+2 countries, 30Mt generated plastic waste was estimated (Figure 9). Thereof 29.1Mt were collected, the fate of 900.000 t was unknown, 300.000t were expected to leak into the environment (Conversio Market & Strategy, 2018). Looking at these figures and calculating proportions, it can be concluded that within EU approximately 1% of the total plastic in waste or 33% of the "unknown amount" (= difference of plastic demand and plastic in waste) is littered. Considering that the waste management system in Austria works very well compared to other EU countries these would lead to a high overestimate of littered plastics. Therefore, this approach is not pursued further.

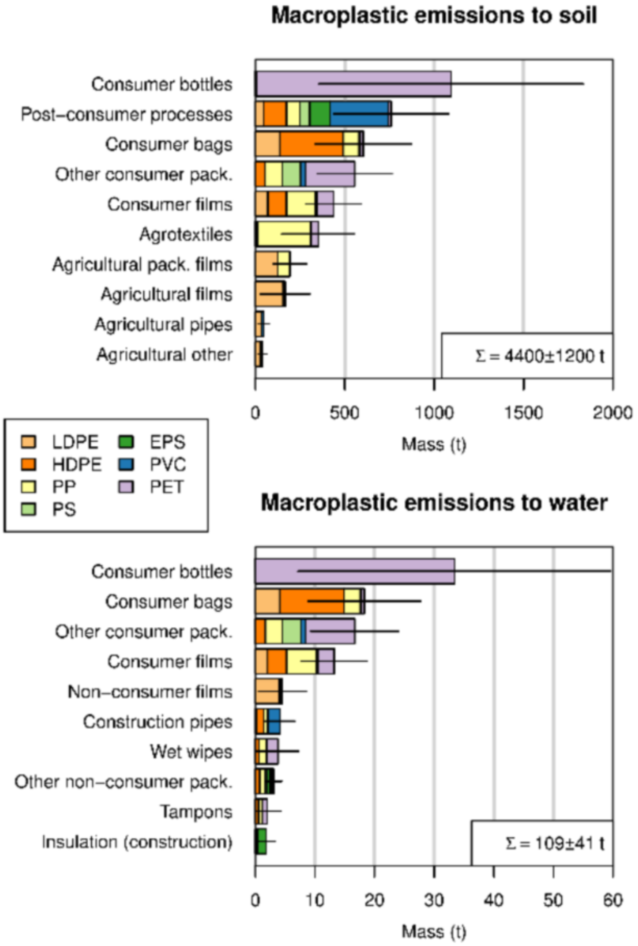


Figure 8: Macro-plastic emission to soil and water in Swizterland and their material composition. Only the ten largest contributions are shown (Kawecki, 2019)

The share of "unknown plastic" is influenced by lifetime of products. Packaging material for example is of short lifetime and expected to become waste within same year. The lifetime and time of usage of products is strongly related to field of application and ranges from 25 min (plastic bags), up to 25 years as building and construction materials. Packaging materials are therefore more likely to become waste than plastics window frames. For more detail of lifetimes see Appendix 3 and Appendix 4. In a German study plastic packaging waste was found to > 95% in waste. Durable plastic building products only have been increasingly used in past 40 years.

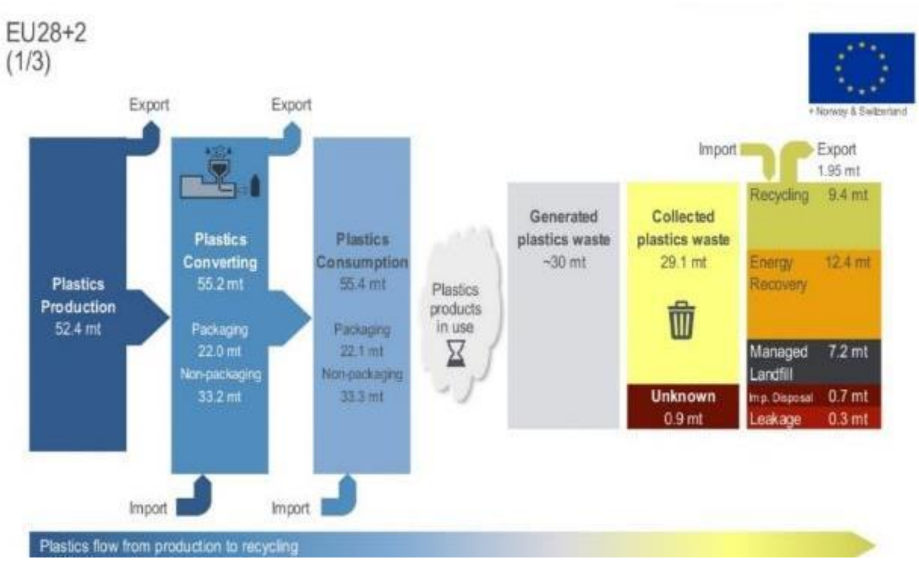


Figure 9: Linear global plastics flow chart from plastics production to plastics waste 2018 (Conversio Market & Strategy, 2018)

In Austria, littered waste is largely collected by cleaning streets and public spaces. Cleaning campaigns and measures of volunteers and waste management associations also play an important role in removing litter and illegal disposals. In 2018, a total of 2.774 cleaning campaigns in Austria collected around 1.000 tons of waste with the help of over 163.000 volunteers. In Burgenland. Lower Austria and Styria, the largest quantities of waste were collected, each with over 200 tons. The number of participants across Austria has almost doubled since 2008 (UBA, 2020). Mayr. J. (2019) reported amounts of collected waste during cleaning actions. The collected amount for whole Austria in 2019 was 983 t. Own extrapolations from data on litter collection activities in the context of spring-cleaning campaigns in Austria show littering rates of approximately 3,248 to 7,185 t per year.

4.3 Waste water & rainwater management

The composition of the urban runoff entering the water body every year in Austria was investigated by Austrian Government department (BMLFUW, 2014). Results of hydraulic quantification of the water-relevant entry paths from urban settlement areas in Austria reveals that around 9% of the total hydraulic load in urban areas originates from combined sewer overflows (CSOs) from mixed sewage systems, another 32 % from separated rainwater and 59% from WWTP outlets.

Macro-plastics can enter the water management system with wastewater and rainwater. In Austria rainwater as well as waste water from households, commerce and industries is discharged into the sewer system. Surface water from rooftops and traffic areas is either infiltrated, treated in waste water treatment plants (WWTPs) or discharged via rainwater sewage system. Waste water from household and industries in Austria is either collected with or without rainwater (Figure 10). Also modified versions are possible. Typical channel systems are therefore: mixed wastewater system, modified mixed wastewater system, separated sewer systems, modified separated sewer system and (sanitary) waste water system (Fenzl, 2011). In the case of mixed sewerage, waste water and rainwater are drained together in a sewer system. Mixed sewerage is the most common type of urban drainage in

Austria in inner-city, older and densely populated areas (BMLFUW, 2014). Although most of waste water and parts of rainwater in Austria is basically treated in waste water treatment plants (WWTPs), plastic can reach our rivers once it is in waste water or rainwater.

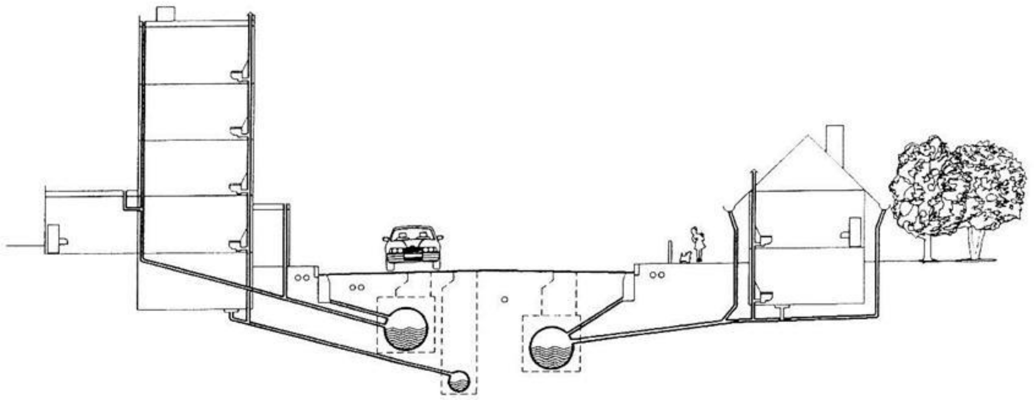


Figure 10: Traditional sewage system in Austria: separate sewage system (left) and mixed waste water (right) according Weiß and Brombach (2004) cited in (Fenzl, 2011)

4.3.1 Rainwater

Rainwater from sealed surfaces often carries littered items like cigarette buts or candy papers into sewage system. Littered rubbish, if not previously collected during street cleaning, is brought into the sewerage system via the street gully when it rains. It is drained through road gullies into either rainwater or mixed water sewage systems. Inlets of gullies can be equipped with sludge traps which prevent solids like leaves, paper or other impurities from entering sewage system. Smaller items like cigarette buts are not completely withheld.

According to Schaffner (2017) components of urban rainwater may be synthetic swimming substances like plastics, organic particles and oils and fats. Stepwise reduction of discharges, emissions and exchange of hazardous substances should protect aquatic ecosystems. Possible mechanical rainwater treatment procedures are: grates, filter beds, vortex separators, light material separators. In Vienna for example, slug traps at sewage inlets are common. More detailed info about rainwater sewage system in Vienna and Lower Austria is provided in the Appendix.

4.3.2 Mixed sewage system

Within mixed sewage system rainwater and waste water are drained. In case of heavy precipitation mixed sewage systems can be overloaded and a discharge via CSOs into receiving waters is necessary.

Within collection activities in the project area from 2017 to 2020 (Mayerhofer et al., 2021a), waste was repeatedly found, which was very likely discharged into the Danube via wastewater. These were, for example, WC stone holders, condoms cotton swabs and wet wipes. In principle, it can be assumed that all objects that can be found in screens of sewage treatment plants (like plastics removed from German WWTP shown in Figure 10) also enter the receiving water with CSOs. On the other hand, wet wipes, for example, which one would initially assign to the sewage side, possibly at least in part also originate from direct littering (during a local inspection on the Danube island many wet wipes were observed in waste bins; it seems people use them a lot while recreation activities, and therefore they could also be littered). Also, cotton buds were found on a parking space at the Danube island.

4.3.3 Waste water treatment plants (municipal and industrial direct dischargers)

Macro plastics that reach the wastewater treatment plant are mostly recovered. During first step of waste water treatment, screenings are removed from waste water. Till now little information about screenings composition is available, but they are mainly composed of impurities which should actually not be disposed via sewage system but via residual waste. These are for example hygienic items like cotton buds or wet wipes.

Removed plastic amounts within wastewater treatment were estimated also by Environmental Agency. Screenings from WWTPs were estimated to amount yearly 330 t in Austria, plastics in sludge 360 t. Residues from sewer cleanings were estimated at 1,100 t (UBA, 2020). Related to inhabitants in project area this would be 35 t plastics in screening, 38 t in sludge and 115 t residues from sewer cleanings. Though water management plays an important role for the retention of mismanaged waste.

Investigations of screenings from wastewater treatment plants according to Hanßen 1999 cited in Wittler (2015) consists to 80% of water. The solids are mainly composed of cellulose (80%), plastics (2-14%) and organic material. Plastics are packaging materials, foils and cotton buds. Uckschies (2017) defines screenings as undissolved substances in wastewater which consist mostly of faces, paper, plastics and organic waste (DWA M 368 cited in Uckschies (2017).

Screenings of 218 WWTPS in Germany, Luxemburg, Austria. Switzerland and Italy were analyzed by Kuhn 2013 cited in Uckschies (2017). Results showed that screenings are depending on seasonal variations. In mixed sewage systems overflows are of importance. The larger the number of overflows, the more solids are discharged into rivers. According to Uckschies (2017) the mean specific dewatered screening amount in Austria is 1.33 l per person and year.

Figure 11 shows items which were present in waste water in Germany and removed by waste water treatment plant. Similar incorrectly disposed of plastics are also suspected in Austria.

Today 99.8% of Viennese households are connected to sewage system. Sewage system is 2.500 km long and is mainly composed of 5 catchment areas. Most areas of Vienna are connected to combined sewage system but also separate rainwater and waste water system is existing. Their distributions can be requested by KANIS-information system. Vienna is organized in main catchment areas where collector ducts drain huge amounts of waste water. To minimize risk of water pollution through entry of waste water several measures were set by Vienna City. Several relief sewers were built in last years to buffer waste water in case of heavy precipitation or service measures and forward them to WWTP

Simmering time shifted (City of Vienna - MA 22, 2018) (Figure 12). Also, some areas of lower Austria are connected to Viennese sewage system, namely the communities Langenzersdorf, Gerasdorf, Hagenbrunn, Purkersdorf, Kaltenleutgeben, Mauerbach and Perchtoldsdorf.

Figure 11: Incorrectly disposed substances in screenings in German waste water treatment plants (Kuhn, 2013 cited in Uckschies, 2017)

Within Lower Austria no Wastewater treatment plant is located within the project area. Pollution via waste water should not be considered according to delimitation of the project area (1.1). On the other hand, people of Vienna who live outside the defined area are considered in terms of plastic consumption and improper disposal, as all wastewater generated in Vienna is disposed of via the Vienna wastewater treatment plant. It can be assumed that plastics in waste waters in Vienna enter rivers only in very particular cases (City of Vienna, 2018). Collector ducts and corresponding catchment areas as well as relief sewers which are preventing discharge of waste water into receiving water are shown in figures below. Main collector ducts and relief sewers are described in the Appendix.

Only possible but less likely way for plastics to enter receiving water via sewage systems in Vienna seems to be rainwater channels. Rainwater inlets are equipped with sludge traps to catch solids before entering sewage system. Furthermore, rainwater from 21st and 22nd districts flows through a culvert and a pumping station, where solids are removed from the waste water before it is forwarded to WWTP.

Figure 12: Liesingtal-sewer (left) Wiental-sewer (right) (City of Vienna, 2019)

4.4 Inland navigation

Connecting 10 countries on its way to the Black sea and the fact that Danube River is the second longest river in Europe, it represents an important waterway. Though, inland navigation is a promising, environmental-friendly transport mode, in general its plastic pollution potential is considered high in some sectors and regions of the Danube stretch. It can be distinguished between waste pollution potential of passenger and cargo ships and their associated infrastructure facilities (harbours, landing stages, etc.).

Although efforts were made in last years to harmonize waste management system along Danube and to implement a transnational financing system for waste of inland navigation, the availability of data about generated plastic waste quantities and proper disposal rate is poor. Data used within PFD-project were mainly compiled during two previous projects dealing with ship waste management along Danube river, namely WANDA and CO-WANDA (Appendix 6) and by viadonau, Austrian waterways society. In addition, a local inspection at the landing stage Reichsbrücke closed some knowledge gaps. Furthermore, an expert interview with a captain (an instructor for captains) of an internationally active and leading river cruise company also provided insights in this sector (Preymann, 2020). Nevertheless, the data situation is very limited and the actual pollution of the Danube by shipping can only be roughly estimated. As key impact factors for waste management the number of operating vessel costs of collection services and availability of infrastructure were identified (Kneifel, 2014).

As major waste streams, which possibly contain plastics, household waste from passengers and crew members as well as waste water have been identified. Cargo plastic waste can be neglected within this project as harbors in model region barely handle plastic made cargo. Therefore, focus concerning pollution potential lies on passenger vessels.

4.4.1 Waste from Passenger vessels

Passenger vessels are required to dispose of their waste in accordance with legal regulations at the collection facilities provided at passenger landing stages and in winter ports; or the disposal can be organised externally in designated areas (viadonau, 2019). Passenger vessels carrying several hundred passengers and crew have been compared to “floating hotels”. The volume of wastes they produce is comparable large, consists sewage, wastewater from sinks, showers, pools, laundry and cleaning activities (grey water), hazardous wastes, solid waste, oily bilge water and ballast water. The generated waste streams can result in discharges to the fluvial environment. Passenger ships generate larger amounts of sewage water, packages and food leftovers, because of bigger number of persons and duration of their stay on-board, compared to cargo vessels. If trends of the last years continue, these aspects will become even more important, since the number of international cabin vessels navigating on the Danube is steadily increasing. Storage space for waste on board is very limited (Prišćan and Meel, 2014).

Passenger vessels shall dispose their waste only in collection facilities of passenger shipping landing stages and winter harbors as well as disposal facilities organized by landing stages and harbor operators according to legal requirements (BMVIT, 2019a). In the project area, following waste reception facilities along Danube River and Danube Canal exist:

- Passenger Terminal Reichsbrücke Vienna
- Donaustationen Wien Nussdorf – Nr. 29 &34
- Lände Werf Nordufer (Hafen Korneuburg)
- Schwedenplatz
- Custozzagasse/ Hundertwasserhaus

Passenger Terminal Reichsbrücke is biggest one and offers 12 mooring places for vessels (Figure 13).

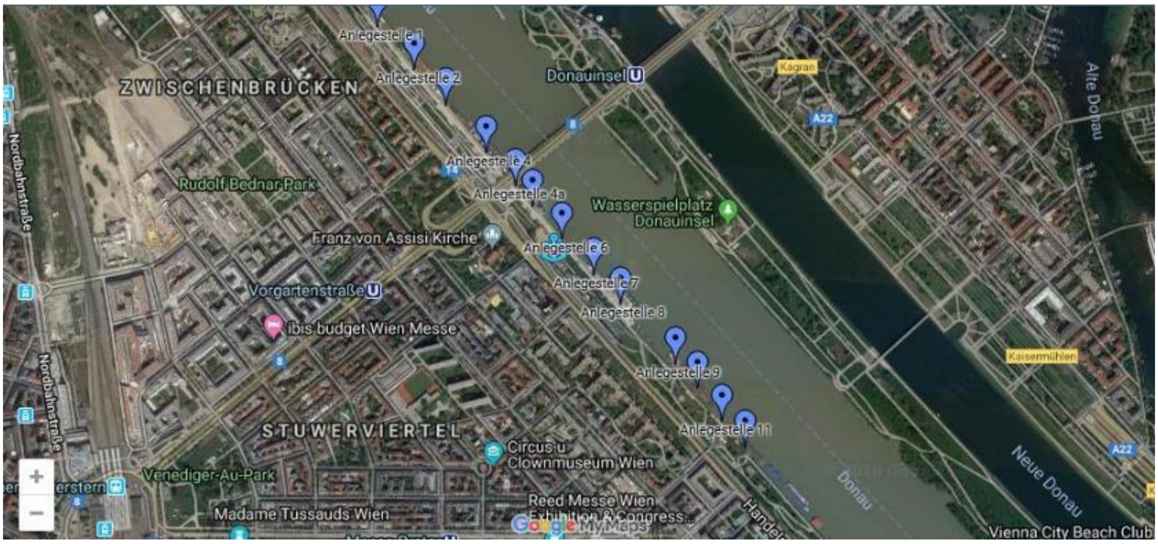


Figure 13: Landing stages at “Reichsbrücke”: 1. Viking River Cruises AG, 2. A-Rosa Flussschiff GmbH, 3. AMA Waterways GmbH, 4. GRC Global River Cruises GmbH, 5. ALSACE CROISIERES Croisi Europe, 6. Linienschiffe, 7. DDSG Blue Danube, 8. KD Premicon, 9.-12. divers landing stages

Figure 14: Waste disposal by a passenger vessel in the "Schiffahrtszentrum Reichsbrücke", Vienna

More and more people spent their vacations on ships travelling from Passau via Vienna to the Black Sea. According Cruise Line International Association (CLIA) river cruises rise about 10% in the last years. In passenger landing stage "Reichsbrücke" passengers have doubled in the last 10 years and amounted 260,000 in 2013 (130,000 in 2004). In 2015, about 2,600 vessels moored in "Reichsbrücke", which are 300 more than 10 years before (Wienholding, 2015). Mainly all big providers of river cruises moor their vessels on the quay of the passenger landing stage Reichsbrücke. Leading providers are Viking River Cruises, A-Rosa, Alsace Croisières, KD Premicon or AMA Waterways). Passenger transport on the Austrian stretch of the Danube was able to record an increase in numbers for the fourth year running in 2017. A total of approximately 1,265,000 passengers were transported, representing a plus of 2.8% in comparison to 2016.

The number of **river cruises** also continued to rise in 2017, exceeding last year's record with **450,000 passengers transported** (+8.4%). A total of six newly constructed vessels were brought into service on the Austrian section of the Danube, thereby increasing the number of operational **cabin vessels to 174** (+3.6%). In total, 4,977 journeys (+7.8%) were completed. Due to the continuing growth of the existing fleet, the capacity for river cruises increased to 34,382 passengers (+10.6%). This corresponds to an average of 198 passenger places per ship. River cruise ships can be considered as swimming first-class-hotels with 100 or more cabins. About 50 crew members take care of about 250 passengers. Cruise liners stay for an average of about 32 hours in Vienna. While passengers are busy with sightseeing or relaxing on board, the crew has to fill up water, beverages and food as well as non-food articles like toilet paper. Waste has to be disposed – invisibly for guests.

In 2017, **liner services** carried approximately 705,000 people. The DDSG Blue Danube Schifffahrt GmbH recorded a total of 249,700 passengers (+0.6%) transported in the Wachau and Vienna. A total of 147,801 passengers (+2.4%) were transported between Vienna and Bratislava on the two Twin City Liners. 50,929 passengers (+11.4%) took advantage of the services offered by DDSG (formerly known as Donau Touristik). The Slovakian hydrofoils operating between Vienna and Bratislava transported 18,534 passengers (–31.2%). The liner service between Vienna and Budapest was discontinued by the Hungarian operator in 2017.

Non-scheduled services carried approximately 110,000 passengers in 2017. The DDSG Blue Danube Schiffahrt GmbH carried 58,200 passengers (+8.4%) on theme, special and charter cruises and the MS Kaiserin Elisabeth (owned by the Donau-Schiffahrts-Gesellschaft mbh) recorded 9,885 (–23.9%) passengers on non-scheduled trips. The MS Donaunixe and the MS Maria owned by Donauschiffahrt Ardagger GmbH recorded approximately 5,937 passengers (+12.0%).

Passenger traffic volumes for companies which carried less than 5,000 passengers in 2017 are not reported separately here. There are no figures available for this reporting period for other scheduled and non-scheduled services operated on the Austrian section of the Danube (viadonau, 2017).

According MARAD (2002) cited in (Pallis, 2017), an average cruise ship (on sea!) generates a minimum of 1 kg of solid waste plus two bottles and two cans per passenger per day and an average of 50 tons of sewage (black water) per day. A figure of 3.5 kg/passenger/day is quoted by the IMO (Butt, 2007 cited in (Pallis, 2017)). River cruises can be compared with hotels concerning waste amounts and composition (Preymann, 2020). To the best knowledge of the authors, no data about plastic waste production by tourists is available for Austria. Summarizing results from screened literature, it is assumed that 1.6 – 2.1 kg/solid waste is produced per tourist and day (Urban Waste, 2016), whereby the share of plastic is estimated to be around 10 %.

A reliable estimation of the waste potential is not possible due to the thin data situation. Although it was tried to give a very rough estimation for cruise liners, based on the above-mentioned information and the scarce knowledge regarding disposed waste and disposal interval. Available data from viadonau (2020) shows, that approximately 15 sacks of residual waste (120 l) and 3 bags of plastic waste (120l) are disposed of properly at Reichsbrücke by the cruises every 2-3 day. According to Wienholding (2015), 2,600 cruise ships come to Vienna per year. Assuming that the cruise has been on river before for 2-3 days and dispose of all waste while being in Vienna (residual waste with an estimated amount of 10% plastic: 15 bags*120 l * 0,1 kg/l + plastic waste 3 bags*120l *0,02 kg/l[1]), approximately 65.5 t (46.8t +18.7t) of plastic is collected. Considering that 450,000 passengers have been transported through Austrian stretch and every passenger produces 1.6kg/ solid waste (or 0.16 kg plastic waste) per day, this would lead to an amount of 720t waste (or 72 t plastic waste) per season. The differences between the two types of calculation are certainly due to the insufficient data basis. Furthermore, it is not known how many of these vessels actually dispose of waste, at what interval they dispose of waste, the actual amount of waste delivered per ship and the length of stay of the respective passengers. The landing stage Vienna is a very popular infrastructure facility for disposal of waste. Therefore, along Danube stretch, it may come to a distorted disposal in Vienna. According to the expert interview with (Preymann, 2020), the pollution potential from passenger vessels is to be classified as very low or can be neglected, since there is a wide range of disposal options for the shipping companies.

[1] Conversion from volume to weight: plastic light packaging mixed - Waste conversion table (VHS, 2016)

Pollution through littering at landing stages cannot be completely excluded. High number of passengers are leaving e.g. cruise ships at the landing stages Reichsbrücke for sightseeing or to change to buses etc. A local inspection in summer 2019 showed that the pollution potential is relatively low due to the density of disposal possibilities and the clean state of the quay. Nevertheless, plastic waste that is littered along the quay wall could easily enter the Danube river during wind or rainfall as there is no protection by vegetation or fences towards the water. Pollution potential is therefore strongly influenced of littering behaviour of people and also of cleaning and sweeping frequency.

Within sampling and sorting analysis considerable amounts of wet wipes and cotton buds were found. Thus, the question raised, if these products could originate from waste water of vessels. Although 83 % of passenger vessels questioned within frame of CO-WANDA project (Berger & Kneifel, 2014) stated that there are not enough possibilities along Danube river to dispose waste water, the pollution potential is assumed to be low in project region. Most of cabin vessels are equipped with sewage treatment plants (82%), the remaining 17 % use faecal tanks which are pumped out when vessels are mooring. Liner services and non-scheduled services have only rarely sewage treatment plants and use mainly storage tanks. Only cargo vessels (<10) persons are allowed to directly discharge the waste water. Since there are empirical values for the generation of waste water quantities on board and the quantities pumped out from the storage tanks are registered, there should actually be no pollution of the Danube river through waste water from passenger vessels. Of course, it cannot be ruled out that individual "black sheep" may discharge their wastewater into the Danube. Waste water discharge into Danube river has been reported recently in the media: According to insiders, storage tanks are discharged into the waterway up to two times a day. Also shredded kitchen waste is discharged in to the waterway (Kurier, 2019). After discussions and inventions of Ministry of Transportation, shipping companies signed a voluntarily commitment to declare proper disposal of waste and waste water (Die Presse, 2019). In August 2019, Kurier published that according to investigations conducted by the department of water management of Lower Austria ships are not responsible for high germ numbers in the Danube river, which were measured in the past. Municipal waste water discharges seem to be responsible for germs as values increase after heavy precipitation events (Kurier, 2019a).

4.4.2 Waste from cargo vessels

Along the Austrian Danube stretch cargo vessels have the possibility to dispose of their ship waste in the provided collection facilities in ports, or a collection service can be organised upon demand. Collection of waste in public ports via the usage of containers is included in port charges, in private ports its costs depend on arrangement. In addition, viadonau provides collection containers for recyclables and residual waste free of charge for cargo vessels at 3 locks: Persenbeug, Abwinden and Greifenstein (viadonau, 2019). Residual waste, waste paper, plastics metals, and glass can be disposed of separately (BMVIT, 2019c). The collection of residual waste from cargo vessels is a standard procedure along the Austrian Danube Stretch, whereas bins for separate collection of recyclables are provided at three locks but not in all ports; at the locks and in the public ports, the use is free of charge (Appendix 8). However, not all ports provide a separate waste collection system, due to the unwillingness of skippers to separate waste and concluding high miss throw rates.

Figure 15: Waste collection facilities at an Austria lock

Some data about waste generation on cargo vessels was generated within CO-WANDA project from June 2013 until July 2014 (Kneifel, 2014):

- Estimated amounts of recyclables generated on board = 65 kg/crew member = 700 liters/year and crew member (Gabriel, 2001 cited in Prišćan and Meel (2014))
- Estimated amount of residual waste = 130 kg/crew member*year = 1,200 liters/crew member and year (Gabriel, 2001 cited in Prišćan and Meel (2014)
- Rough estimations based on a study conducted in 2007 considering the ports Linz Handelshafen und Tankhafen, Ennshafen, Hafen Krems, Wiener Häfen revealed that in all ports of Austrian Danube stretch (not only project region) 128t of residual waste was collected in 2007.Thereof 2 tons were plastic packaging materials (Berger, 2012).

Here too, extrapolations are difficult to make in view of the database and similar reasons that have already been enumerated for passenger vessels.

Direct discharging of wastewater into the water was is in Austria not permitted if less than 10 people are on board – like on cargo vessels. It is not to be assumed that cotton sticks or sanitary towels are thrown into the toilet on cargo ships, but cotton swabs in particular cannot be ruled out and would represent a significant source of input on around 12,000 freighters per year.

Ports and transshipment points are facilities for the transshipment of goods. They connect the transport modes of road, rail and waterway and are important service providers in the fields of transshipment, storage and logistics. In addition to their basic functions of transshipment and storage of goods, they also often perform a variety of value-added logistics services to customers, such as packaging, container stuffing and stripping as well as sanitation and quality checks (viadonau, 2019c). According information by viadonau (Kneifel, 2019), ports have notifications that forbid pollution. In case of high-water levels, the harbor sites have to be emptied. Most goods are transported unpacked (bulk material, ore, etc.). Large scale piece goods are usually also unpacked. Stuffing and stripping are mostly done in warehouses and not directly at the quay wall. Pollution potential is therefore regarded as low.

Figure 16: Unpackaging of transported goods at cargo port Vienna (Hafen Wien, 2018)

4.4.3 Boats and small vehicles

Motorboats and sailboats also sail the Danube River. In the investigated area locking is possible together with commercial shipping at Greifenstein and Freudenau. Marinas in project areas are listed in Appendix 8. Due to the small number and the assumption that private persons do not intentionally throw garbage into the Danube, a low pollution potential is suggested.

Figure 17: Marinas in Austrian part of the project area. Left: Kuchelau (Marinas-Info, 2018) (Vienna), right: Korneuburg (WMCW, 2018)

4.5 Headwaters, tributaries and remobilisation from floodplains and riverbeds

With regard to the plastic load in the **headwaters** of the Danube (west of Vienna), no useful data exist. Previous measurements so far in the "upper" region of the river focused only on microplastics. In 2015, for example, an investigation of microplastics (500µm – 5mm) was carried out by the UBA-AT and IWA (BOKU) in Aschach (Upper Austria). The average plastic load for micro plastics range between 6 to 40 kg per day. If all size fractions included (also larger parts than 5mm), the plastic transport amounts to 10 and 59 kg/d (UBA, 2015). Nevertheless, the figures can only be used to a limited extent, since the sampling design was based on microplastics. In course of the PFD no macro-plastic measurements in headwater of the project region were done. However, to verify the developed measuring-devices for assessing macro-plastic load in large rivers (D.4.3.1), one measurement has been conducted to date in the Danube mainstem immediately downstream of the Freudenau HPP, and two others in the Danube Canal, just upstream of the confluence with the Danube. The preliminary extrapolation lead to an estimated amount of 68 kg per day. Detailed information and explanations of the measurement design and procedure are presented in deliverable 4.3.1 "Sampling-strategy and recommendations for a measuring device to directly assess the macro-plastic load in large rivers (Mayerhofer et al, 2021b).

Tributaries directly contribute to plastic pollution and are enlarging catchment area for plastic waste significantly. In the project area of *PlasticFreeDanube* following tributaries exists: Wien, Schwechat, Fischa, Rußbach and March as boarder river between Austria and Slovakia, in Bratislava the Malý Dunaj. Weiß C. (2020) conducted a survey about the challenges in handling with waste materials in screenings of small hydro power plants (SHPP focussing on these tributaries. The study investigated in which quantity litter can be removed from rivers via extraction of screenings.

26 of the 69 participants (38%) indicated that screenings are removed from the water body at their power plant, of which 17 participants (65%) perform sorting of waste. In the case of other plant operators, the screenings are often not removed from the flowing water at all due to the orientation of the screen/turbines (e.g. by inclined screens). More than 90% of the participants stated that litter is regularly found in the screenings of their hydropower plants. According to their assessment, plastics and metal packaging are the most common type of waste, which occurs particularly frequently in the summer months. However, 83% also state that this waste predominantly makes up less than 5% of the total screenings and thus usually plays only a minor role in the operation of a hydropower plant.

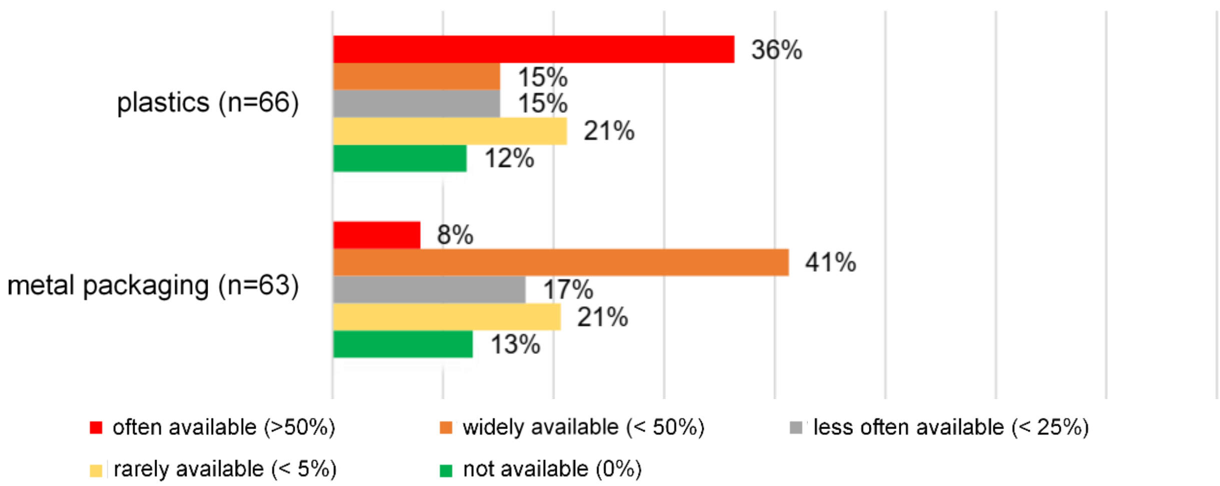


Figure 18: Assessment of waste composition in screenings of small hydropower plants

Additional sorting analyses of screenings of a SHPP in Enzersdorf on the Fischa - an approximately 50 km long right tributary of the Danube in Lower Austria – reflected these statements of the survey:

For the period of ~50 days the collected screening (width coarse screen 10 – 15cm; fine screen 4.5cm) makes up a total weight of 11 kg anthropogenic waste. Plastic waste was clear dominating the composition of the screenings with 92 mass-% and respectively 97 pieces-%. With the calculated discharge (average value of about 4.52 m³/s for this period) and waste data, the concentration of litter in the Fischa river with low flow conditions can be roughly estimated with 0.58 kg and 78 pieces per $1x10^6$ m³. However, projections and reliable statements on annual loads could not be made because of the data gap during mean discharge and floods as well as the distribution during the year. The sampling period was characterized by dry weather / low water without any flood event. It is also a notable aspect, that the analyses have coincided with the COVID-19 crisis (legal restrictions such as curfews may have influenced the pollution situation during this state of emergency).

Weiß (2020) stated that he wanted to perform further measurements, especially during summer due to more leisure activities, to get a more reliable data basis. It may be possible to derive input and output values for plastic contamination of tributaries in the project area.

Small hydropower plants can thus contribute significantly to the (plastic) purification on tributaries. However, as mentioned above, not every SHPP is designed in such a way that the waste is removed from the river. In this case floating litter ends up in the main stream, such as the Danube. Further information about the effect of plastic discharge of hydropower plants is summarized in chapter 6.1

When plastics or other anthropogenic wastes enter streams, they can remain in the river system for several years or decades until they eventually end up in the world's oceans. Many deposited items and particles accumulate and thus also persist in the river system. Thus, an essential aspect in the quantification of riverine plastic pollution is the **remobilisation** of contaminations **from riverside, floodplains and riverbeds**.

Since no studies or assessments currently exists, the PFD project tries to address this issue in the context of river systems. On the one hand, hydrodynamic and numerical modelling (D3.6.1 and D3.7.1) is used to determine the transport and accumulation behaviour of plastics and to quantify the discharge potential at bankside zones. On the other hand, with the help of GPS-tracked plastic items in field tests, the assumptions in the models will be checked and validated. In addition, first findings of remobilization of plastics along riverbanks should be obtained. Initial trials have already been carried out, thereby, the tagged items were accompanied by boats in the Danube (Figure 19).

Figure 19: GPS tracking experiments to assess and validate transport, accumulation and remobilisation behaviour

5 Locations where plastic leaks into the environment

Much consideration was given to which release sites into environment are relevant for further investigations. On the one hand, certain sources of plastic waste can be identified through the places where they leak into the environment (plastic that is flushed into Danube river from a combined sewer overflow, probably originates from households), on the other hand, the differentiation between the different transport routes and/or release locations enables a better determination of the cause of the pollution. For example, both a PET bottle that is left on the playground and a wet wipe that reaches the Danube via sewage system originate from households, but the pathways into the river and though the measures to avoid such pollution will differ greatly. Special attention in terms of pollution-cause and prevention measures must be laid on the locations, where plastic leaks into the environment. Most relevant locations where identified already within report D 3.2.1 – Development of a Methodology for a Material-Flow-Analysis of Plastic Waste in and along the Danube River (Mayerhofer et al., 2020) and are listed in Table 7.

Table 7: Locations where plastics release into environment, suspected sources and assigned pollution potential within project area

		1.household (private & comm. End-user)	2. Construction sector	3. Industry and trade sector	4. Agriculture & forestry	5. Inland navigation	6. Waste and wastewater management	Source is located within project area	Collected plastics could originate from respective source	Pollution potential is considered to be relevant due to high amounts and missing measures like regularly cleaning/protection through fences/ measures in WWTPs etc.	Cleaning, sweeping by municipality, private operator, etc.?	Retention barriers (fences, noise barriers, windbreaks, etc.)	Collected plastic can be assigned to source	**Pollution potential in project region of PFD**
Area	**Location of release into environment**	**Sources**						**I**	**II**	**III**	**IV**	**V**	**VI**	
infrastructure	road network (open roads, highways, streets)	✓	✓	✓	✓		✓	✓	✓	✓	yes	~	⦸	red
	public places	✓						✓	✓	⦸	yes	⦸	⦸	green
	railways	✓		✓				✓	⦸	⦸	yes	✓	⦸	green
	cycle path	✓						✓	✓	⦸	partly	⦸	⦸	yellow
	railway-, underground stations	✓						✓	✓	⦸	yes	⦸	⦸	yellow
	parking spaces	✓						✓	✓	✓	partly	⦸	⦸	red
	airports	✓		✓				⦸	✓	⦸	yes	✓	⦸	green
	industry harbour	✓		✓		✓		✓	✓	⦸	?	⦸	~	green
	marinas / yacht harbour	✓				✓		✓	✓	⦸	?	⦸	~	green

	landing stages for passenger vessels	✓				✓		✓	✓	⊘	yes	⊘	~	
resid. & comm.	residential area: households and (allotment) gardens close to the river, household like facilities like offices	✓						✓	✓	✓	no	~	✓	
	building and construction sites	✓	✓					✓	✓	✓	no	~	✓	
Cultivat	agricultural and forest land / area	✓		✓	✓			✓	✓	⊘	no	~	~	
On	cargo vessels	✓				✓		✓	✓	⊘	no	⊘	~	
	passenger vessels	✓				✓		✓	✓	⊘	no	⊘	~	
Industrial	plastic production and processing plants	✓		✓				✓	✓	⊘	no	✓	⊘	
	industrial and commercial companies (incl. recycling plants)	✓		✓				✓	✓	⊘	no	✓	⊘	
Recreation & leisure areas	sports facilities	✓						✓	✓	⊘	yes	✓	~	
	camping sites	✓						✓	✓	⊘	Yes	✓	~	
	restaurants	✓						✓	✓	⊘	Yes	~	~	
	beaches and swimming sites	✓						✓	✓	⊘	part ly	⊘	~	
	public outdoor pools	✓						✓	✓	⊘	yes	✓	~	
	nature reserve	✓						✓	✓	⊘	yes	~	⊘	
	fireplaces	✓						✓	✓	✓	yes	~	⊘	
	picknick sites	✓						✓	✓	✓	yes	~	⊘	
	playgrounds	✓						✓	✓	✓	yes	✓	~	
	dog areas	✓						✓	✓	✓	yes	~	⊘	
	park areas (incl. public green area)	✓						✓	✓	✓	yes	~	⊘	
	festival & event sites	✓						✓	✓	✓	yes	⊘	⊘	
	popular fishing places	✓						✓	✓	⊘	no	⊘	✓	
Waste Management	waste treatment and recycling plants						✓	✓	✓	⊘	no	✓	⊘	
	landfills						✓	⊘	✓	⊘	no	✓	⊘	
	waste collection centers	✓					✓	✓	✓	⊘	yes	✓	⊘	
	waste collection sites	✓					✓	✓	✓	⊘	yes	~	⊘	
	public waste bins	✓					✓	✓	✓	~	yes	⊘	⊘	
	waste water treatment plants (incl. CSO combined sewer overflows)	✓					✓	✓	✓	~	no	~	✓	

The following sections further examine and describe the pollution potential of the identified locations within the project area.

5.1 Road network

A Swiss study indicates that macro-plastics are found mainly on roadsides because of littered consumer packaging and lost construction and demolition waste (expect LDPE and PP, which are mainly emitted to agricultural soil). With all polymers combined, **road side pollution constitutes 67% of all the macro-plastic emissions.** The largest amount of litter generated arises for PET because of the high consumption of PET bottles and their high on-the-go consumption (Kawecki and Nowack, 2019).

Motorways and expressways are operated by ASFINAG in Austria. The maintenance of state roads is within the responsibility of the respective federal states. In Vienna, state roads are naturally also community roads. There are also private roads and forest and freight routes existing. State roads are supervised by the road masters of the federal states. The municipalities themselves are responsible for municipal roads.

ASFINAG operates 2,223 km motorways and expressways in Austria. The operation of these routes causes ASFINAG's own waste such as street sweepings, shrub, tree and green cuttings. Other wastes are generated by road users who throw away their garbage either in the designated containers at parking and rest areas, but unfortunately, also along the route.

According to ASFINAG, 8,763 t of waste were generated by parking and rest areas as well as through regular collections next to the streets (ASFINAG, 2019). This quantity of waste includes the properly waste disposed of in bins / containers, illegal dumping (excl. waste electrical and electronic equipment, building rubble and similar waste fractions) and latent waste, but no shrub, tree or green cuttings. Thereof 1,738 t are attributed to Lower Austria and 36 t to Vienna. 1,800 t of the 8,763 tons had to be picked up by hand. Most of it was littered waste, but occasionally it was also illegal disposed waste (such as pieces of furniture, household waste or car tires).

Waste that is littered mainly includes all types of packaging waste but proportions are not known (plastic bags, PET bottles, aluminum cans, cigarette packs and cigarette butts) but proportions are not known. Above all, take-away packaging from fast-food chains is increasingly problematic. ASFINAG estimates the **amount of littered waste to be approximately 5-10% of total yearly waste amount which is generated at rest and parking spaces and along the streets**. For whole Austria this is an estimated amount of 400-800 t in 2018.

Like in the higher-ranking road network also in operating state roads and municipality roads leads to waste likes street garbage, bush-, tree and green cutting. Waste is also produced by road users who dispose of their waste proper at parking or resting areas or dispose of their waste improper along the route. Discussions with the Austrian road authorities of the federal states as part of a large-scale littering study conducted by the federal agency revealed that carelessly disposed waste at or near state roads is just as problematic as on higher-ranking road networks (UBA, 2020).

As far as information could be collected during littering study of federal agency, along country roads, plastic bottles, beverage cans, plastic bags, cigarette packaging and take-away packaging are carelessly thrown away. There are isolated hotspots where groups of people apparently selectively extract their waste, e.g. drinks cans from bus trips. In addition to littered waste, other waste such as residual waste, old car tires, full garbage bags with various types of waste and building rubble are repeatedly disposed of as illegal deposits along the streets (primarily at rest areas and parking lots). With regard to the disposal of classic household waste, this phenomenon occurs increasingly in the vicinity of regular waste bins. Basically, litter is found along entire Austrian country roads, but there are hotspots existing: urban and densely populated areas, on commuter routes, at village entrances, feeders to motorways and expressways, around petrol stations and shopping centers, around fast food chains and at rest and parking lots. **Estimations about littered waste amounts along Lower Austrian and Viennese state roads do not exist** (UBA, 2020). The total waste quantities are basically recorded by the road maintenance departments, but it is not possible to divide these quantities into littering along the streets and the quantities accumulated at rest areas and parking lots or illegal dumping, since there is no separate recording by means of specific records during operation.

Based on the information provided by the road administrations (for the provinces of Upper Austria, Burgenland, Styria and Vorarlberg), estimated amounts of littered waste per km of road were estimated. The total amounts of waste generated are generally recorded by the individual road maintenance departments. However, it is not possible to divide these quantities into "littering" along the roads and waste accumulated at rest areas and parking lots or illegal waste dumping, as there is no separate recording through specific records in ongoing operations. An estimation results in values between 56 and 155 kg litter/km*a. Using the average value of 105.5 kg/km, an annual amount of 3,587 t of littered waste throughout Austria can be estimated on country roads. (UBA, 2020).

In principle, the entry of waste along roads by wind or water is possible. However, analyzes have shown that due to the fact that large parts of the project area consist of National Park Donau Auen, there are comparatively few km in a corresponding proximity to the Danube. Most of motorways, highways and federal roads are shielded by noise barriers, fences or forests. Furthermore road sides are mown regularly and prior to that all waste is removed (ASFINAG, 2019).

Within the city of Vienna, high littering rates are expected and the streets are close to the river, but regular cleaning measures collect most of the waste. Nevertheless, the pollution potential from roads is assumed to be high, because of the high littering rates and the fact that from the time of littering to the cleaning, which sometimes takes place daily, often only one strong gust of wind is needed to transport the waste into the river.

5.2 Public places

In the project, as public places, street sections and squares are defined that invite people to linger longer (e.g. through points of interests or seat possibilities) but are not public green spaces or parks with a space of approximately ≥ 50m². Within our project this applies only to a few locations like Schwedenplatz, Morizinplatz and Gaußplatz. Especially Schwedenplatz and Morizinplatz are highly frequented and affected by considerable littering rates. Due to regular cleaning measures and the fact that there is a three-lane road between the squares and the Danube Canal, a manageable pollution potential can be assumed.

5.3 Railways

Since most of the train sets in use today are closed (windows cannot be opened), no waste can be littered by passengers during the journey. Litter found along the route originates mostly from wind drifts and is of low density (e.g. foils, plastic bags or light-weight packaging). Food packaging's are disposed of improperly at access roads and streets. Therefore, littering along the route is a minor problem compared to illegal disposal, which is a problem along the route and in areas that are not visible to the public. In 2018 340 t waste was produced in this way. The real amount ("dark figure") is estimated much higher by ÖBB. **For littered waste no estimations do exist**, as littered waste is collected together with proper disposed waste (UBA, 2020).

As within project area only 5.3 km railway tracks are located (2,2 within 250 m boarder, 3.1 km within 500 m boarder) the amount of litter from railways within project area can be neglected. Illegal disposals at ÖBB railways consist mostly of waste which cannot be transported easily be wind or water (old tires, bulky waste etc.). This fact and regular cleaning measures strongly minimize the risk to pollute the Danube river.

5.4 Railway stations and stations of public transportation

According to ÖBB (cited in UBA, 2020) littering in and around stations is not an immediate problem, with a few exceptions such as cigarette butts, chewing gum and fast food packaging. Littered waste is collected together with residual waste, and not recorded separately. Only few railway stations and stops within Vienna (e.g. Wien-Mitte & Handelskai) are located within project area (Figure 20); but due to spatial situation (densely built-up area, no direct road connection to the water & shielding by multiple tracks and rails) there is no potential for contamination of the Danube river. In Lower Austria Railway track and stations are mostly at least 1 km away from Danube river separated by settlements, farmland and riparian forests (Figure 20). Pollution potential can therefore be neglected under normal condition. Indirect input of plastic waste from railway stations which is discharged by wind or washed away during heavy precipitation event are also rather unlikely.

More frequent are bus and tramway stations in Vienna. Although stations are equipped with bins, waste is still littered. Pollution potential of different stations varies and depends on proximity to the water and on frequency of cleaning measures.

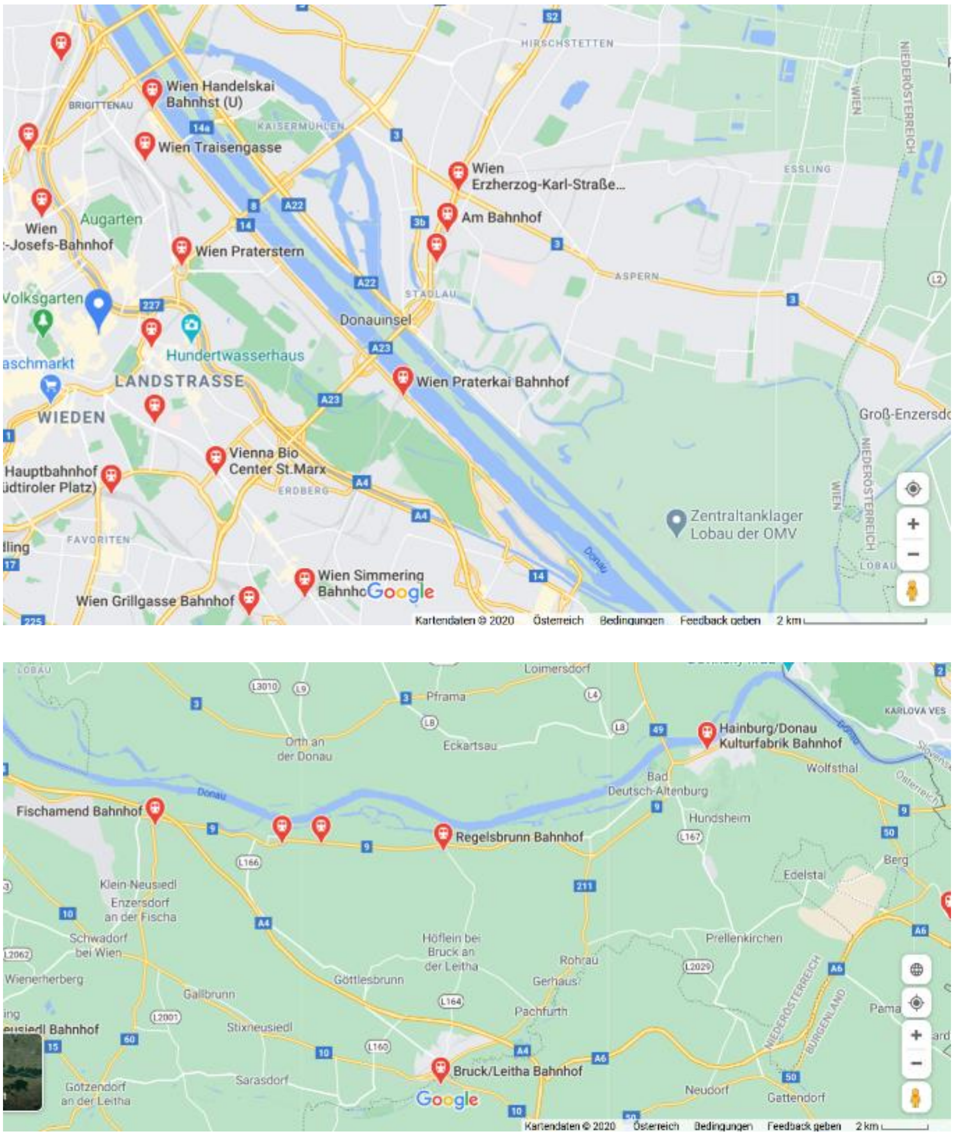


Figure 20: Google Maps sections of parts of Vienna (above) and Lower Austria (below)

5.5 Cycle pathway

About 350 km of cycle pathway extends along the Austrian stretch of Danube River. Of this about 40 km are located within project area (Figure 21). The cycle pathways within Vienna are throughout towpaths, in Lower Austria it is often far from the river and leads through the floodplain forest. In the course of spring-cleaning-events Lower Austrian environmental and waste associations in the west of Vienna were contacted and asked to store the collected (plastic) waste for subsequent sorting analysis.

Figure 21: Cycle pathway from Vienna (Wien) to Bratislava (Bikemap, 2018)

Within a Master-Thesis plastic waste at cycle pathways along the Danube were investigated (Dornbusch. 2019). By evaluating the quantities collected along the route, an average value of 3 kg plastic per km collected section length in one year can be given. The value and ranges from 0.3 kg to 10 kg collected waste per km and year.

As significant factor for littering intensity the inhabitants of municipalities were identified. According personal information from the organizers of clean-up-events littering decreased significantly in the past. Therefore, no cleaning of riparian stripe of adjacent areas was performed. Employees of National Park Donau-Auen confirmed, that along the cycle pathway on the northern damn in the National Park no notable pollution was detected. Cyclists mostly ride and throw away little waste. However, routes on which cyclists travel are also used more often by pedestrians. Therefore, there is naturally a certain potential for pollution.

5.6 Parking spaces

At parking spaces litter potential is high. Concerning waste composition, it has to be distinguished between parking spaces that are highly frequented (supermarkets, gas stations, etc.) and such one like on the Danube Island where people are often unseen and where specifically clear and empty their car. The identification of parking spaces in the project area was not possible but pollution potential is considered to be high.

5.7 Airports

Pollution potential of airport Vienna Schwechat can be neglected. No pollution is expected from the airport operation itself due to proper procedures. The high passenger frequency in turn leads to a high littering potential. But regular cleaning measures, which bring the airport into a pleasant clean condition for guests, remove these contaminations. Furthermore, due to distance of approximately 1 km and the highway A4 which runs between airport and Danube River the airport can be excluded as a source of pollution.

5.8 Residential area: households and (allotment) gardens close to the river and household like facilities like offices

In Vienna households within respective distance are mainly located along Danube Canal, but these are predominantly multi-party houses without gardens. Along Danube River and Neue Donau, the settlement is not so dense due to industrial and commercial areas as well as recreation zones such as Vienna Prater and Lobau; however, also gardens can be found here. In Lower Austria, sum of all residential areas close to the river is due to extension of the National park Donau Auen low and accounts 13,5 km^2 within 250 m distance and 21,6 km^2 within 500 km distance to Danube River. Therefore, it is expected that waste which is collected within project area and classified as “household waste” (e.g. garden chairs, mixing bowls etc.) only partly originates from residential areas within project area and is more likely to come via tributaries and the upper reaches.

Residential and garden areas are usually not or only slightly littered with waste. Littering is more likely to occur in public spaces. Plastic objects in gardens are therefore usually not carried into the water. Of course, it can happen that waste containers are blown over by the wind and plastics end up in the Danube. Only few properties with so-called cabanas (small houses on stilts e.g. in Kritzendorf) or fishing huts are flooded again and again during high water and can thus become a source of plastic pollution.

5.9 Building and construction sites

Especially packaging materials or insulating (EPS) which can be drifted easily by wind pose a pollution risk to Danube river. Due to changing locations of construction sites the pollution potential is difficult to quantify. Sorting analysis of collected plastic waste revealed a certain amount of packaging and auxiliary materials which could arise during minor construction works at home or at big construction sites. It is therefore difficult to determine the origin of such materials.

Parts of littered building and construction waste probably does not originate directly from the construction site, but is lost during transport (e.g. wind shifting from uncovered loading areas). In a Swiss study release pathways are considered; construction and demolition plastic is considered as indirect emission to road sides (Kawecki and Nowack, 2019).

5.10 Agricultural areas and forest land

No plastics from agriculture or forestry sector were found during the sorting analyses which were performed to investigate plastic waste which was collected by volunteers and project partners within PFD project. But this fact does not necessarily mean that none were present - as they are difficult to distinguish from other films and may have been overlooked. Within a Master-Thesis which dealt with litter along Danube River in Lower Austria and Vienna, plastics from agriculture sector were found. Plastic waste collected in 2017 and 2018 at nine locations in Lower Austria along the Danube-shore and at Danube Island in Vienna was investigated. In relation to the total mass, about 5 % plastics were assigned to the garden and agriculture fraction. This draws in, for example, flower pots, potting soil bags, silage film, game bite protection and so on. Within Master-Thesis also land use was considered. Collection areas with a lot of agriculture near the shore, tended to have lower abundance of plastic waste (Dornbusch, 2021). Looking at the distribution of land use in the project area, there are barely no agricultural areas along the Danube in Vienna, and there are hardly any agricultural areas in Lower Austria due to the extensive floodplain forests along the National Park. Therefore, plastics from agricultural sector are considered to be neglectable. Within forestry plastic is, to best knowledge of the authors, of minor importance and therefore neglectable.

5.11 Plastic production and processing plants

Following plastic production plants are located within project area:

- VTS GmbH Kunststoffe Vertriebs- u. Techno-Service
- Henkel Central Eastern Europe GmbH:
- Diezel GmbH
- TUPACK Verpackungen GmbH

Within Austrian project area one is located within 250 m distance to Danube river and one within 500 m distance. Furthermore, five (2 within 250m and 3 within 500 m distance) industrial facilities are settled nearby the Danube river in Vienna. Since waste from plastic production is normally reused as by-product, a pollution potential for the Danube under normal conditions can be excluded, but this does not apply for accidents.

Commercial enterprises are not specifically identified but are very common, especially in Vienna. Due to the strict legal regulations governing the handling of operational waste, a pollution potential of these sources can be excluded with high probability.

5.12 Recreation and event sites

Recreational areas tend to have an increased pollution potential in the form of littering. However, depending on the actual form of use (e.g. playground vs. park area), the prevailing commandments and prohibitions (e.g. permission to grill/for fishing in specially designated areas) as well as the "visitor types" (environmentally conscious target groups), they can differ considerably from the amount of litter. Following recreation and event sites and activities were considered within this project:

- Fireplaces/grill places
- Picknick sites
- Playgrounds
- Dog areas
- Park areas
- Public green area
- Fishing places
- Public green areas
- National Park Danube Auen
- Festivals, event location sites (e.g. Donauinselfest, Summer stage etc.)

The city of Vienna offers 15 barbecue areas with costs along the Danube Island (Figure 30) (City of Vienna, 2020a). Visits to the Danube Island in spring 2020 showed that the barbecue areas are in clean condition and equipped with waste bins. However, at some places visited, bins were crowded and people therefore placed their wastes beside the containers, often in garbage bags which they brought by themselves. As there are no fences around grill places wind drift of plastic waste into Danube River cannot be excluded.

Figure 22: Exemplary selected grill places along the Danube Island

A total of 32 designated picnic areas were identified in the project area (16 in AT 250 m and 16 in AT 500 m). A certain pollution potential can be expected, depending on whether the area in question is cleaned regularly and the range of disposal options.

There are many playgrounds and dog zones in Vienna (Figure 23), which are also visited by many people. Inspections showed that especially cigarette buts and beverage bottles are littered frequently.

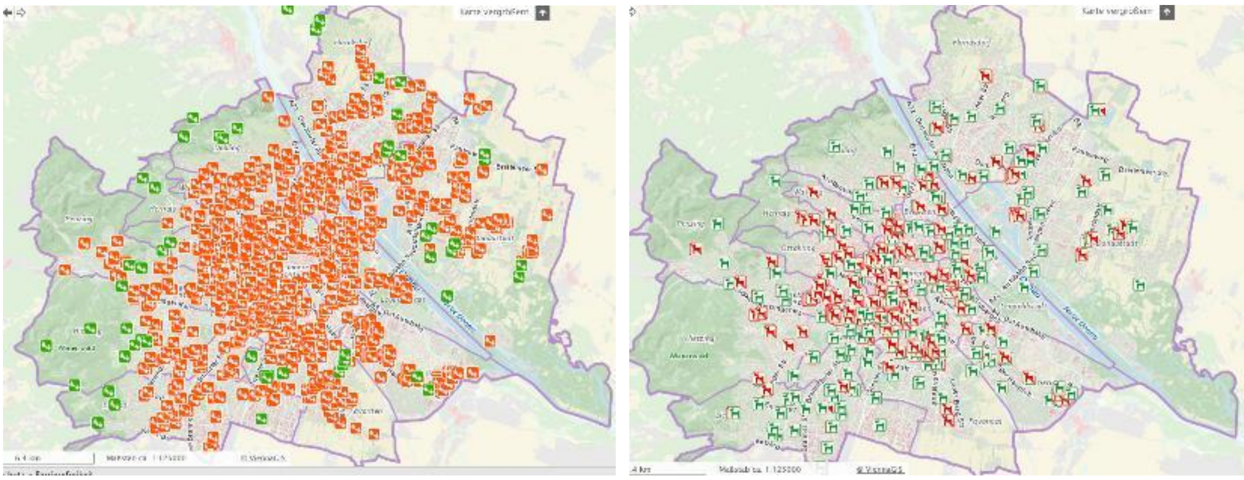


Figure 23: Playgrounds (left) and dog areas (right) in Vienna (source: https://www.wien.gv.at)

Playgrounds and dog areas are usually equipped by sufficient waste bins to avoid littering. If waste is nevertheless not disposed of properly fences prevent plastics from being transported into Danube River by wind or water. According GIS-Map, 30 playgrounds are located within 250 m zone of Austrian project area and 45 within 500 m zone; 24 dog parks are located within project area (11 in 250 m zone and 14 in 500 m zone). Playgrounds and dog areas in the immediate vicinity of the Danube are cleaned regularly by cleaning companies at, which also empty waste bins and bins for dog waste excrement bags. Therefore, pollution potential is considered to be low even though it cannot be excluded. Birds for example could remove plastics from crowded bins (Figure 27) and transport them to open spaces where the wind could blow them into the Danube river.

Figure 24: Waste bin at a playground (left) and fence of this playground (right) at the Danube island in June 2020

In the course of collecting and sorting activities waste that can be attributed to fishing has been found from time to time but comparatively small quantities (mainly styrofoam bait boxes). During a local inspection along the Danube Island some fishermen were observed fishing, but not causing pollution.

Within Master thesis Dornbusch, 2021 investigated littering pressure along Danube river in Lower Austria and at Danube Island and assumed that places which are densely populated and/or heavily visited like recreational areas, are highly affected by littering. Recreational areas should therefore be protected by wind-barriers (fences, vegetation) and possibly also be equipped by more and well signed waste bins (Dornbusch, 2021).

Among plastics which are collected at PlasticFreeDanube test fields also plastics that are assigned to fishing (e.g. bait boxes, floats) are found. Whether these originate from the project area or the upper reaches/ feeder cannot be determined. Along the Danube island some fishermen were observed during a local inspection in June 2020; however, they did not seem to produce any waste. Also, there are also some fishermen's huts in the project area, but they have not attracted attention through pollution either. Even if fishing is not considered to make a relevant contribution in terms plastic waste amount, it must be pointed out that fishing lines in particular can be very dangerous for animals. They can get caught in them and lose their freedom of movement or suffocate.

5.12.1 Danube Canal, Danube Island and National Park Donau Auen

The Danube Canal is the closest Danube arm in Vienna to the city center. The 17.3 km^2 long Danube Canal branches off from the main stream shortly before the Nussdorf weir at the border of the 20^{th} to the 19^{th} district, and rejoins to the Danube river at the Albern harbor at the so-called Praterspitz at the border of the 2^{nd} to the ^{11}th district (Wikipedia, 2020a). The paved areas along the bank are to be considered separately as they are important open spaces and recreational areas that offers gastronomic options, footpaths, cycling pathways, green areas etc. Due to high frequency of people along the channel, the proximity to the water and the lack of a structural separation from the water, at the areas adjacent to the Danube Canal high amounts of waste are generated and littered. However, it must also be noted that the areas are cleaned very frequently. It is difficult to estimate how much of the improperly disposed waste ends up in the Danube Canal. Due to the proximity to the water and the lack of barriers, a gust of wind between cleaning activities is sufficient to carry the waste into the water. Due to this fact and the high amount of waste, the pollution potential is considered to be high.

During “Corona measures” in 2020 restaurants were closed and people were asked to go outside only for a few reasons. After Austrian government announced a few Corona loosenings, restaurants opened again and lots of Party’s were celebrated along Danube channel. To get rid of huge amounts of waste, the city garden troop responsible for cleaning is now deployed with twice the manpower; cleaning in this period is carried out three times a day - on all seven days of the week (heute.at, 2020).

Figure 25: Along the Danube canal (above left and right), Danube Canal from above (bottom left), beach bar along the Danube canal (bottom middle) and disposed waste at the Danube canal after a “Party-Saturday” (bottom right) (heute.at, 2020)

The Danube island is part of Vienna's flood protection system and also serves, together with the Old and New Danube, as a recreational area in the Vienna Danube region. It represents the largest recreational area within project area. The Danube Island and the left flood embankment of the New Danube are a popular cycling and recreation area for the Viennese population. In addition to sunbathing areas and water entrances into the New Danube, there are also two barbecue zones that can be used free of charge and 15 barbecue areas that require prior registration, as well as various other free recreational areas like a water playground or volleyball and other sport fields, skater areas, dog zones, and commercial facilities (Wikipedia, 2021).

Within the investigations on the Danube Island and the Danube Canal measurements, some waste deposits were found in the vicinity of the Danube in Vienna. Under normal conditions (no major flood event), a direct entry can nevertheless be ruled out, since after consultation with the responsible authorities (MA 45 and MA 48), such contamination will be removed as quickly as possible or anyway as part of the daily street and green space cleaning.

Waste within National Park Donau Auen does not accumulate there but is washed up there by the Danube. Illegal disposal of waste barely occurs in Austria. Due to information of National Park Donau-Auen, only sporadically minor illegal accumulations of waste were observed, for example, at fire places near the riverbanks or garbage bags in the hinterland (Figure 26).

Figure 26: Illegal waste disposals in the Donau-Auen National Park (NPDA, 2019)

Public waste bins along the Danube can be found in the Austrian project area mainly in the urban area (Vienna). On the Danube Island and the adjacent water edge strips of the Danube the MA45 is the responsible authority, the MA48 is handling the rest of the urban area. The possible plastic entry through installed waste bin along the Danube canal is described in chapter 5.12.1.

In the fall of 2018, the waste collected from waste containers and from clean-ups of the green area on the Danube Island was sorted to obtain a rough picture of the waste composition. It is by the City of Vienna - MA45 (2020) that over a year, around 50,000-100,000 bags (110l) fall on the floor cleaning, but exact weights are not known. Furthermore, in June 2020 the responsible waste disposal company was accompanied during the waste collection (emptying of the waste containers as well as cleaning of the green area) on and along the Danube Island in order to find possible pollution hotspots. The waste from of the ~150 daily emptied bins and the clean-ups was again collected separately and then sorted. Figure 28 shows a comparison of the composition of waste from the waste bins and clean-ups. In terms of weight, biowaste predominates in all samples, followed by residual waste, plastics as well as paper and cardboard. The two samples differ only slightly in the proportion of plastics related to the collection type. The clean-ups have a plastic share of about 20% (S1: 17%; S2: 20%), the waste bins on average 15% (S1: 13%; S2: 17%). With regard volume and number of pieces of waste fractions, however, plastic is in first place due to its low weight.

The number of weekly tours for collection is adapted to seasonal visitor fluctuations. During the summer months, the waste containers are emptied daily. In addition, a 3 to 5m wide strip is cleaned from litter along highly frequented paths and roads. A large-scale cleaning of meadows, wooded areas, green spaces, etc. is carried out three to four times a year.

In addition to "ordinary" waste containers, whose full garbage bags are simply replaced, there are considerable number firmly anchored (flood-resistant), open bins made of concrete rings on the Danube Island, which are vacuumed with a special vehicle. If necessary, these must be freed from larger items (e.g. full residual waste bags). However, the open construction favours the discharge of mainly light waste such as plastic foils or packaging by drifts. In addition, plastic waste can be released from the containers into the environment by animals (e.g. crows). But there is anyway a discussion about exchanging the concrete bins for other waste collection solutions because a new vehicle would have to be purchased.

Figure 27: Waste-bin at the Danube island in June 2020 (ABF-BOKU, 2020)

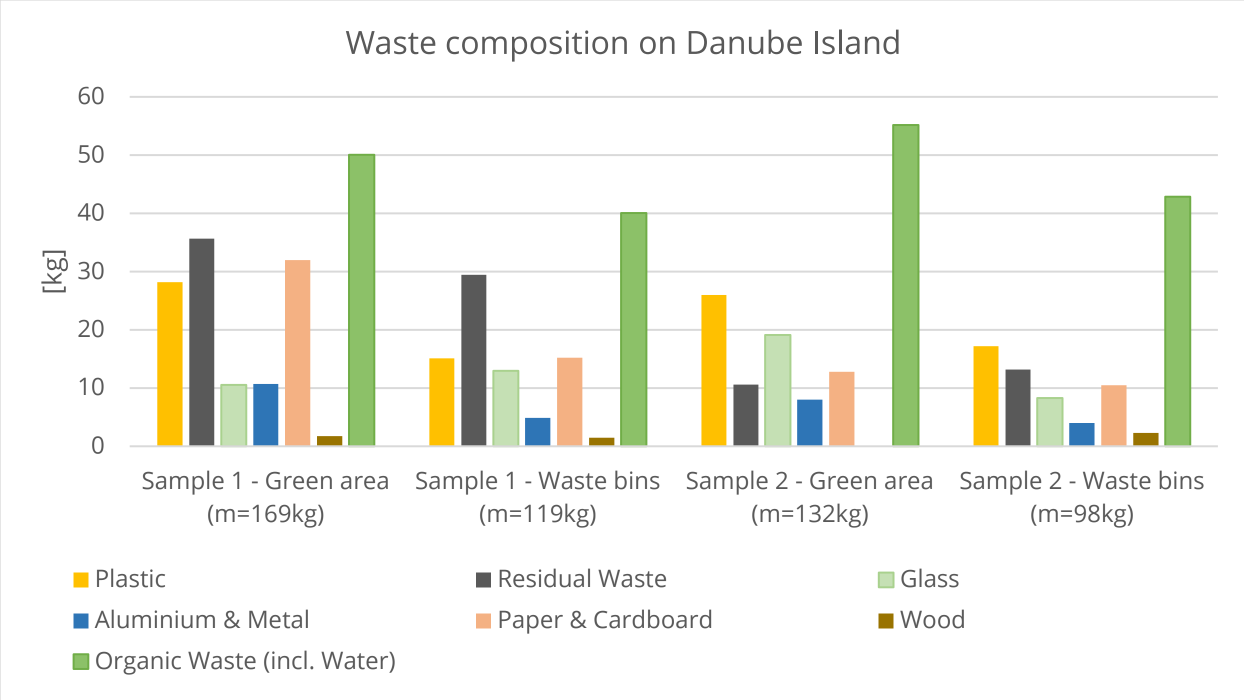


Figure 28: Waste composition of emptied waste containers and the green area clean-ups on the Danube Island

During the initial sorting analysis, only a small sample of the total amount of waste collected (clean-ups + waste bins) could be analysed. The second analysis allows to investigate the total daily amount, which are made up as follows: **waste bins** 438.6kg (60%), **green area** 105.9kg (15%) and **illegal disposal** 180.6kg (25%). Not included in these quantities were the separately collected waste materials (PET bottles, aluminium) and the concrete waste containers, which are emptied directly by the MA 48.

The plastic composition of littered waste from green areas (Figure 29) has a high proportion of packaging (sample 1 >50 mass-%; sample 2 >60 mass-%), whereby single-use tableware and food-packaging (flexible and hard plastic containers) and packaging foils dominates that group. The fraction "Household, sport and leisure" is very inhomogeneous, besides left (bathing) shoes, toys for children and dogs as well as household items used for picnics, for example, were found. Interestingly, some empty garbage bags were also picked-up. It can be assumed that although people take the garbage bags to collect their waste with the best intentions, they no longer prefer it on site. Sanitary waste, mainly cleaning wipes, represents also a larger share with 15 mass-% in sample 2, household, sport and leisure items amounts to almost 20%-mass-% in both samples. Foamed plastics - compared to other sorting analyses - play a minor role. In terms of number of pieces (only sample 2 was counted), flexible food-packaging (n=655), single-use tableware (n=370), plastic foils (n=195) as well as cigarette filters (n=274) and wet wipes (n=164) represent the bulk of the plastic debris. Especially these items can be quickly blown away and entered into the Danube due to their low weight.

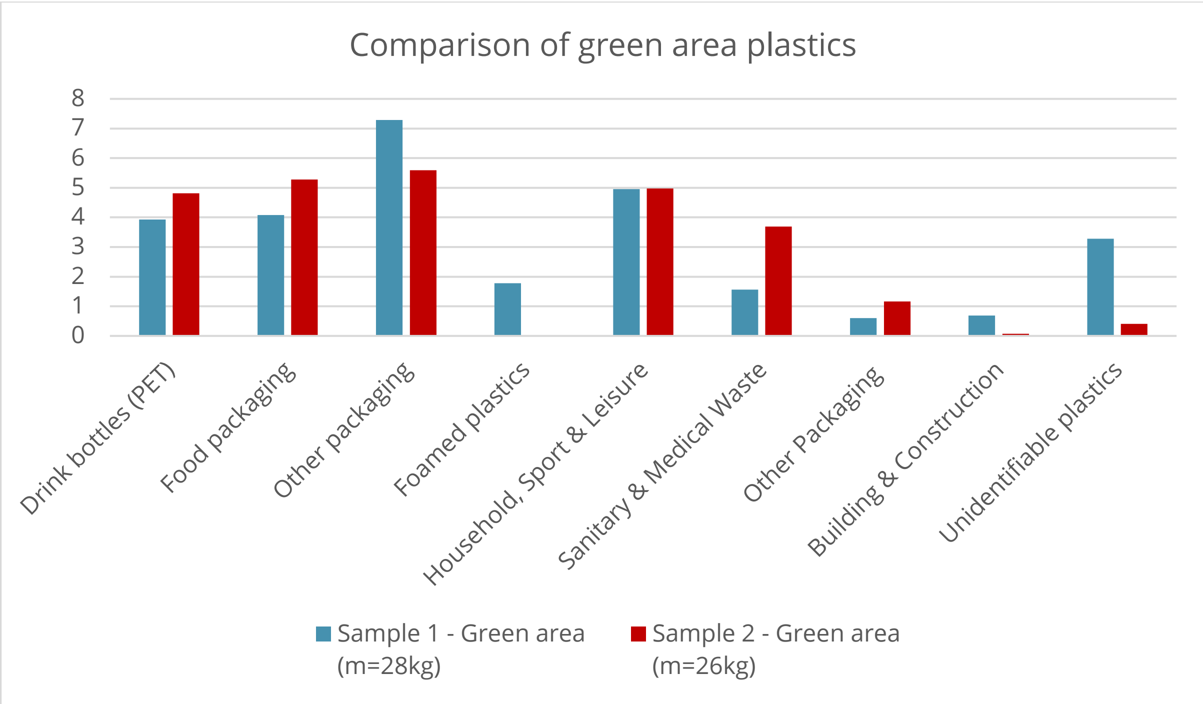


Figure 29: Comparison of the plastic composition of the green area clean-ups on the Danube Island

It is noticeable that waste is often lying next to concrete ring waste bins. In that case, it is not clear whether this waste is discharged by crows or other animals during forage, for example, or whether it is a possible loss during extraction by the garbage truck.

Due to the regular collection and cleaning operations (daily in the main season), the input of plastic waste in the area of the Danube Island can be classified as a tendency to be low, but cannot be completely excluded.

The situation in the Donau-Auen National Park is completely different. A targeted awareness-raising measure in recent years. namely the reduction of existing waste bins along popular paths and recreational or leisure areas. have led to a significant reduction in the volume of waste (Baumgartner, 2018). Visitors have been successfully sensitised to take their waste with them.
The few waste bins set up in the National Park area east of Vienna are located in communities directly bordering the Danube on the southern bank (e.g. Hainburg). The respective municipality is responsible for emptying and shipment of waste. A plastic entry through possible overfilled waste bins cannot be completely excluded. Due to the small number of these containers installed and the corresponding emptying intervals, the pollution potential can nevertheless be classified as "negligible".

While only selected waste materials can be brought to collection points throughout the day (like waste paper, organic waste, clear/coloured glass, plastic bottles/drink cartons/cans), the range of waste that can be handed in at supervised centres (usually free of charge) is much wider. In addition to the above-mentioned wastes bulky waste, large electrical appliances, wood, styrofoam, large cardboard boxes, green waste, used tires, cooking oils and any hazardous waste like batteries, energy saving lamps, small electrical appliances, lithium ion batteries, and medical drugs at any of the hazardous waste can be delivered.

Although some of these sites are located nearby the Danube, waste collection points as well as centres are regularly emptied or cleaned. Plastic waste pollution is therefore to be classified as negligible.

Figure 30: Illegal waste disposal near the a) Danube Island b) Freudenauer Hafenbrücke (ABF-BOKU, 2020)

5.12.2 Sport facilities

Within Austrian project area border 4 indoor and 39 outdoor sport facilities are located within 250 m border; 12 indoor and 56 outdoor facilities within 500 m zone. Due to waste management structure at sport facilities, amount of littered plastic items is estimated to be low. Further fences and hedges which are enclosing most sport facilities prevent waste from drifting into river Danube via wind.

5.12.3 Campgrounds

Campgrounds are usually equipped with fences and appropriate infrastructure and are therefore not considered a source of pollution. Campground "Camping Wien Neue Donau" for example which is located at the "Neue Donau", a 20 km long artificial tributary of the Danube (spillway for floods), is equipped with pitches with direct water and sewer, motorhome service area/chemical WC disposal, clean and spacious shower facilities, environmentally friendly water heating, modern washing and drying facilities, heated kitchen including refrigerator and cooking facilities, large adventure playground for children, self-service restaurant etc. and properly managed. In project area only one campground with certain pollution potential has been identified namely the "Auterasse Stopfenreuth". It serves as a free of charge camp ground and is located directly on the shore of River Danube. This is a pure campground for tents and not a real camping site. In the rest of National Park Donau-Auen camping and tenting is in general prohibited. There are no sanitary facilities. Guest have to take possible waste with them as there are no waste bins installed. National park rangers stated that pollution potential of camping is neglectable.

5.12.4 Festivals, Event location sites

Waste management around large events is a major challenge. Especially at mass events - in addition to a professional waste management and disposal concept - creative solutions such as incentive systems are needed to motivate every visitor or participant. Since 2012, festivals in Austria have also been able to eco-label - and since then the trend has been increasingly towards so-called green events. The "Reinwerfen statt Wegwerfen" anti-litter initiative of the Austrian business community supports measures against careless littering, including at festivals (Altstoff Recycling Austria AG, 2018). A mobile tableware service of the City of Vienna helps to reduce event waste and to hold an event in an environmentally friendly way. It is suitable for larger events with 200 or more visitors. Vienna's reusable tableware rental system is a comprehensive service package. The concept replaces environmentally harmful and waste-intensive disposable cups at small and large events with a deposit system using washable reusable cups (Ökoevent, 2021). Nevertheless, events represent a considerable pollution potential. Especially during the summer, events take place along the Danube, the New Danube and the Danube Canal (Danube Island Festival, Africa Days, Summer-stage, etc.). Every year, several thousand people visit the Danube Island during the Danube Island Festival. Professional collection of residual waste and used materials with 898 containers, 850 waste bags and 200 jumping baskets for environmentally friendly disposal of around 1,200 m^3 of garbage and 900 kg of used cooking oil during the event prevents environmental pollution. Likewise, two modern WC containers, six WC trailers including a barrier-free additional module are provided. The cleaning of the event area by MA 48 starts at 4.00 a.m. in the morning and ends in the afternoon (City of Vienna, 2018a).

The hotspot CopaBeach is a recreational area located close to Reichsbrücke and in the opposite to the Danube Island (Figure 31). It stretches out over 300 m shore and covers approximately 4 hectares. Since 2015 this area is rebuilt and new zones for sports, recreation and especially gastronomy are established (City of Vienna. 2019b). Especially at Danube Canal (5.12.1) and at CopaBeach a recreational area along Neue Donau the risk of plastics to enter the water is high due to high personal frequency and missing barriers like fences or vegetation.

Figure 31: Copa Beach (City of Vienna, 2021 and 2021a)

5.12.5 Beaches and swimming sites

In Vienna, especially at the Danube island, several free accessible beaches are located (Figure 32). Due to a lack of lifeguards and high visitor numbers, a considerable littering potential for macro-plastic is assumed. Within project area also public outdoor pools can be found (e.g. Familienstrandbad Neue Donau in Vienna or the outdoor pool in Klosterneuburg). It is expected that due to infrastructure (i.e. waste bins & toilets) and personnel on-site, the pollution potential for macro-plastics is negligible.

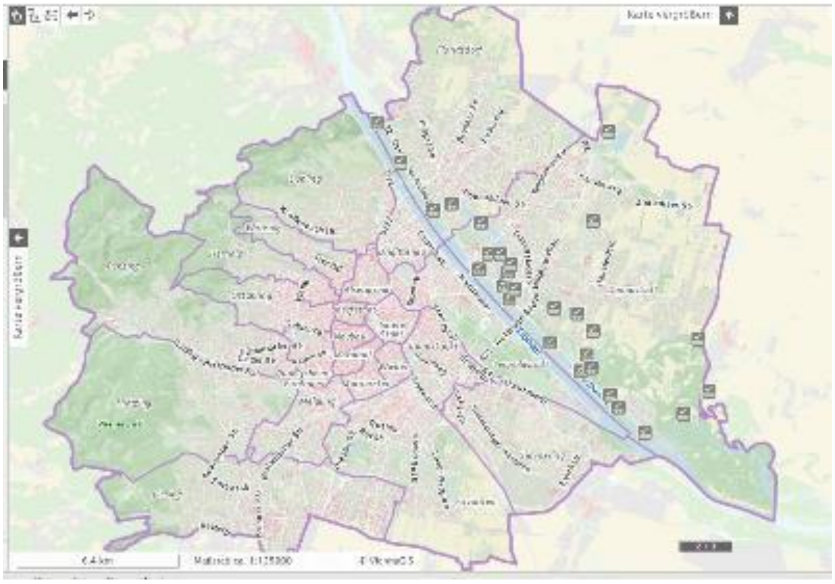


Figure 32: Public bating places in Vienna (www.wien.gv.at)

5.13 Waste, wastewater and rainwater management related entry points

Waste and wastewater management acts as a source but also as pathways with certain locations were plastics ends up in the environment.

5.13.1 Waste and rainwater inflows, wastewater treatment plant effluent

Entry points of rain and waste water are outlets of waste water treatment plants, rainwater sewages and combined sewer overflows. Within project these pathways are considered as neglectable (compare chapter 4.3) within Vienna. Also, for Lower Austria along the Danube river bellow Vienna no pollution potential via waste or rainwater is expected, as no waste water treatment plant is located within surveyed area and most of Lower Austrian project area is located within National Park Danube Auen, where no waste or rainwater is discharged into the Danube river. Pollution cannot be excluded coming from regions upstream Vienna.

5.13.2 Waste management related sites

According Federal Waste Management Plan 2017 34 plants with a capacity of 318.000 t/a were available. Whereby 17 plants are producing re-granulates. Flakes, ground material and 8 plants plastic products and plastic semi-finished products. In eleven plants styrofoam grind is produced (BMNT, 2017). In 2018, 23 plants with a capacity of 381.000 t/a were available for plastic recycling in Austria. The majority of old plastic is used for production of re-granulates, flakes and ground material in 17 plants. In six plants plastic products or plastic semi-finished products are made from used plastics. Quantitatively most important waste stream which was used for recovery of old plastics was polyethylene terephthalate (PET), followed by plastic foils and other cured plastic wastes. There are also some further plants existing, which offer little capacity and only produce Styrofoam regrind, which is in some companies used for production of building materials (BMNT, 2019).

According to Figure 33 where plastic treatment plants are depicted, no plants are located within project area. Furthermore, the pollution potential of recycling plants is neglected for macro-plastics due to proper operation (e.g. pressing into bales). Only the emission of polystyrene beads is not excluded. However, since these are plastics < 5mm, they are not considered within PFD project. Therefore, recycling plants are not considered to pollute Danube river with macro-plastics.

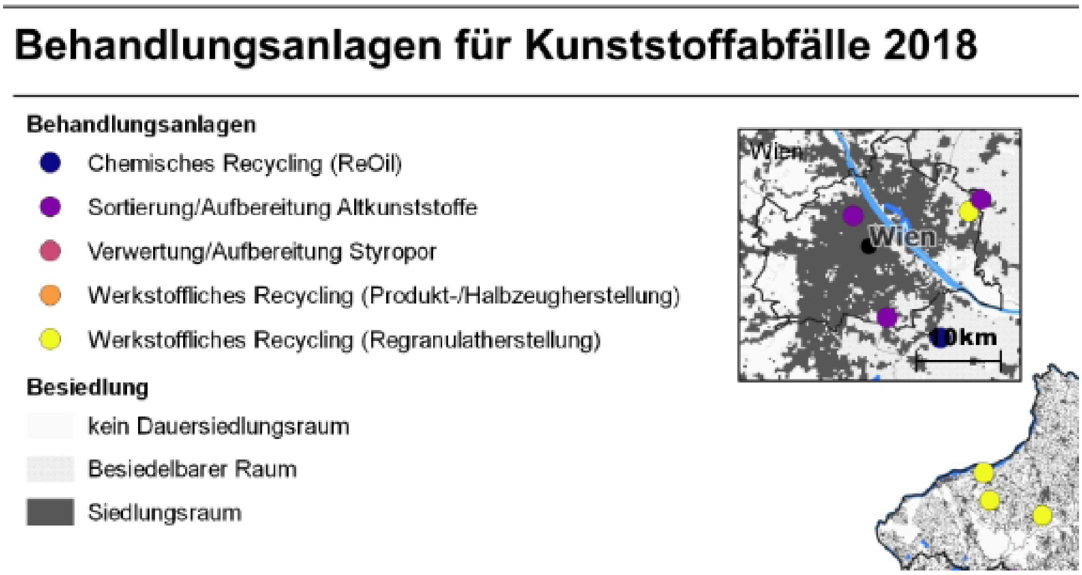


Figure 33: Plastic treatment plants in Austria in 2018 (BMK, 2020)

Illegal disposal of waste barely occurs in Austria (compare 5.12).

5.14 Inland navigation related locations of release

Waste generated in the course of inland navigation may be released into the environment at the following locations: industry harbours, marinas/ yacht harbours and at landing stages. Also, a direct entry from the ships would be possible. As already described in section 4.4, plastic pollution potential of inland navigation is considered to be low. To summarize pollution potential caused by different vessels through solid waste, waste water and infrastructure facilities most important parameters were compared in Table 8.

Table 8: Pollution potential through inland navigation

	Persons on vessels	Solid waste disposal	Waste water disposal	infrastructure facilities (mismanaging of waste/ littering)
Passenger vessels	high numbers of passengers (increasing!)	Proper disposal of waste is common procedure; Pollution potential through direct littering of tourists cannot be completely excluded	Proper waste water discharge within project area expected	Landing stages/ locks: risk of littering when passengers change to buses etc. cannot be fully neglected.
Cargo vessel	Only few crew members	Barely no plastic made cargo	Direct discharge not permitted for vessels <10 persons	Harbors, locks: Plastic waste is supposed to be disposed of properly
Small vehicles	Only few persons on board		Direct discharge not permitted for vessels < 10 persons	Risk of mismanaging waste and littering seems to be neglectable

6 Exit pathways – collection of plastic waste and removal by hydropower plants

As soon as plastic waste has entered the river by one of the manifold input pathways only few exit pathways out of riverine systems exist. These exit pathways also give the possibility to learn more about the degree of contamination of rivers and can be useful for monitoring of plastic waste in and along rivers:

- Drift of flotsam and/with litter outside the river "sphere" or fluvial system under consideration;
- shift of flotsam and/with litter due floods or high waters outside the river "sphere" or fluvial system under consideration (e.g. floodplains with changing water levels "comb" out plastic regularly);
- discharge of plastic litter with screenings from hydropower plants (HPPs);
- bankside cleaning through municipality or other authorities as well as volunteer collection of plastic waste that was washed up along riparian stripes;
- related to a project area or system, those plastic debris that leave the defined boundaries with the downstream count as the exit path;

To gather data about amounts, composition and origin of plastic waste and also to estimate the capacity of exit pathways for plastics in and along Danube river, collection and sorting analyzes were performed. To make results comparable standardized methods were developed within ongoing project. Voluntary and formal waste collection activities were performed along the riverbanks.

Additionally, screenings of HPP Freudenau and water first samples from downstream HPP Freudenau and the Danube canal were investigated. The methodology of sorting and sampling of plastic waste as well as generated and analyzed data are described in more detail in Mayerhofer (2021, 2021a, 2021b).

6.1 Plastic discharge through hydropower plants

In the course of the "survey of floating litter in the Danube river in Vienna" first investigation in this field were carried out over a period of six month in 2012. Specifically, anthropogenic waste in the screenings of the Freudenau hydropower plant (Vienna) was investigated. The sample consisted of six ~40m^3 containers with a total mass of about 25 tons. Two containers each were sorted in October, November 2012 and May 2013. The sorting results show that the most massively share with about 80 mass% was assigned to the fraction "dead wood". The "anthropogenic waste" was on average slightly less than 20 mass% (3.04t) whereby the material group of plastics and composites were the second largest groups after "treated wood" in terms of mass (Pressl et al., 2013).

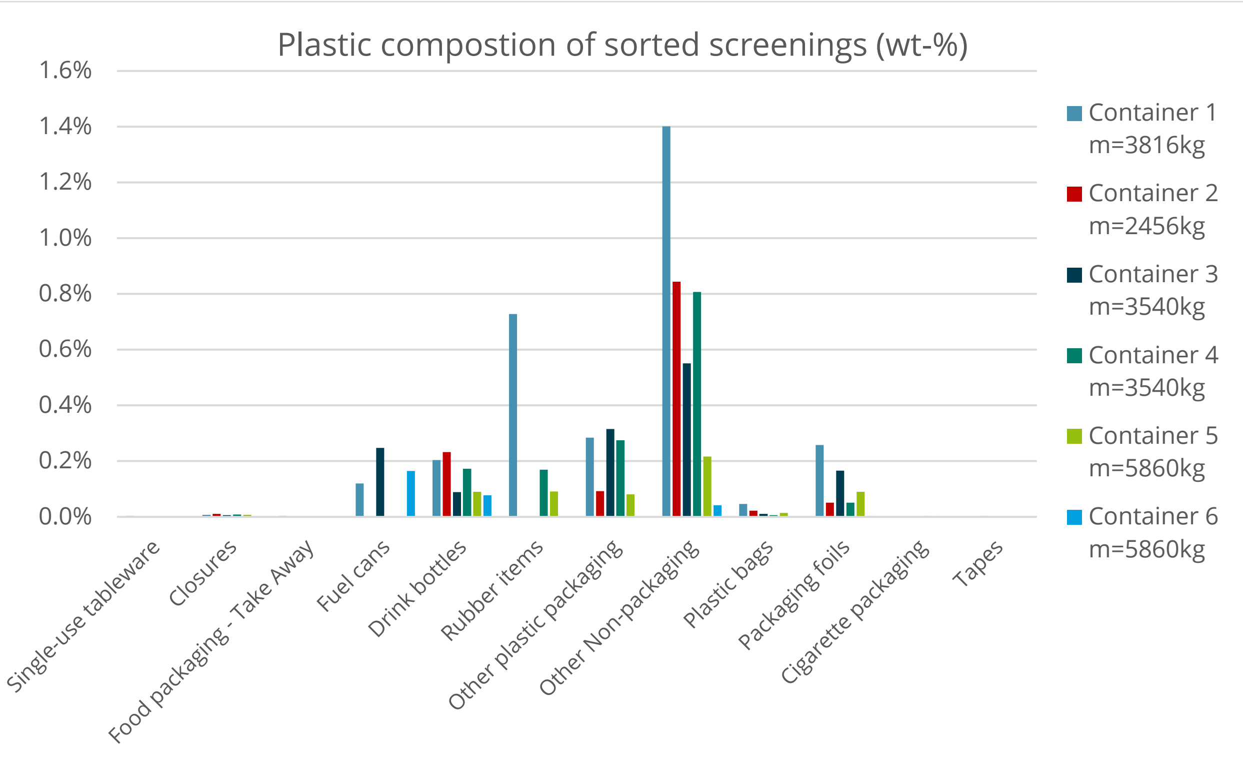


Figure 34: Composition of plastic waste (weight-%) in screenings of HPP Freudenau in 2012/2013 (Pressl et al., 2013)

Within the PFD project, seven screenings containers of the HPP Freudenau have so far (status 12/2020) been examined for their plastic content (among other anthropogenic waste). The results show great similarities to the data gathered in the 2012/2013 study, with the proportion of waste in the total weight ranging from 0.9 - 2.5%. The share of plastics in relation to the mass of waste varies considerably, from 10-60% (depends on "treated wood"). Regarding number of pieces, plastic is clearly ahead of all other waste materials.

The composition of plastic waste (related to weight) sorted from screenings containers is illustrated in Figure 35. Container (Cont) 1 and 6 show a high proportion of packaging (> 50%), while the mixed container Cont2+3 as well as Cont7 are dominated by the "other non-packaging" subgroup. This is because Cont2+3 contained larger shipping parts (62%; fenders), while in Cont7 three car tires (62%) were found. Sports and recreational items account for over 20mass% in four containers, one of which is even over a third. The high percentage of "Other Packaging (Non-Food)" is due to packaging film in Cont1 (15%) and Cont7 (6%), while the Other Packaging category predominates in Cont6 (18%).

If the data are adjusted by "outliers" (e.g., ship fenders, car tires), the composition of Cont1-6 is quite similar, PET beverage bottles and household, sporting and recreational goods dominating the fraction. Foamed plastics play a rather minor role in contrast to the sorting results of plastic debris collected in the Donau-Auen National Park.

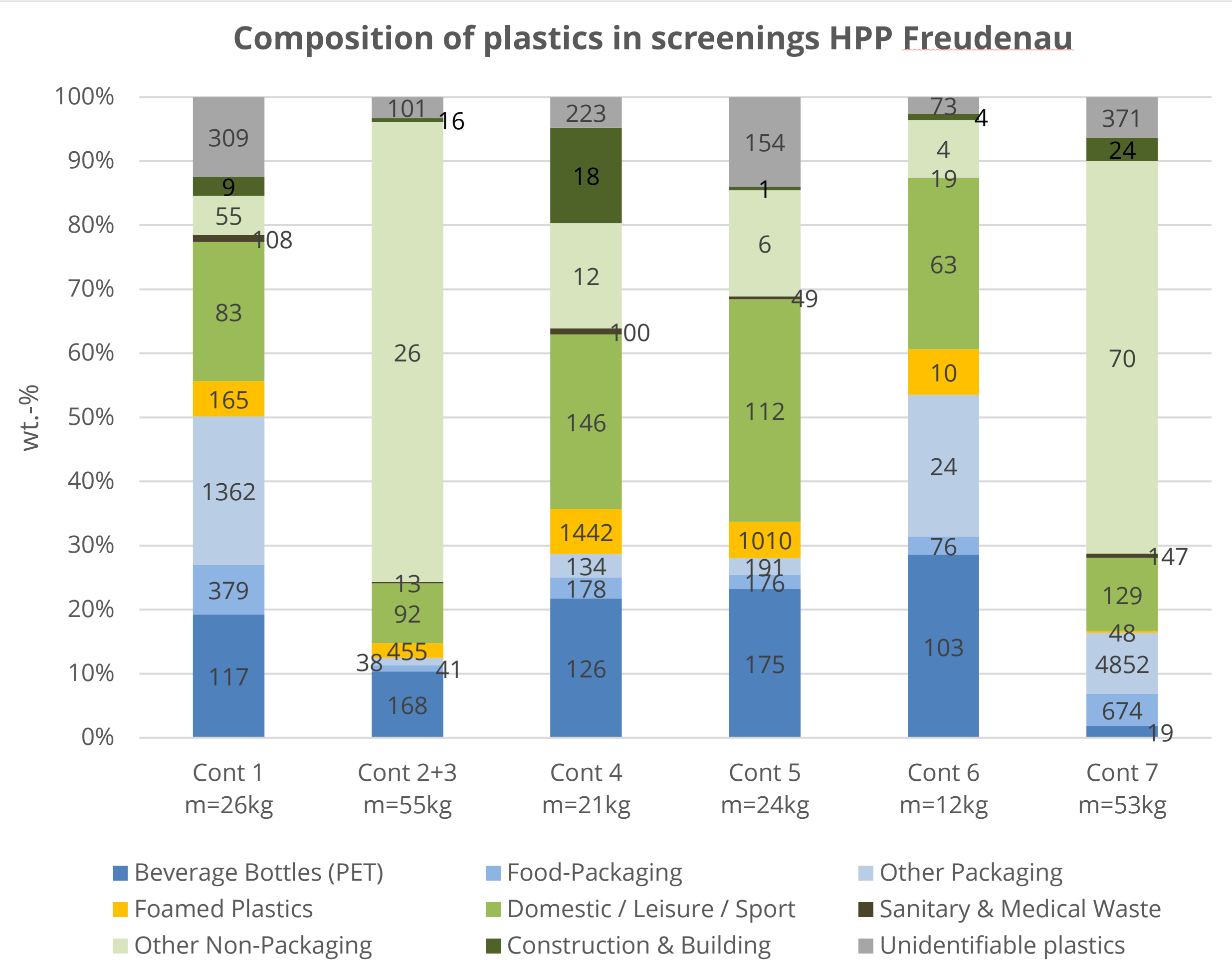


Figure 35: Composition (weight-%) of plastic waste in the screenings of HPP Freudenau (note: Container 2+3 is a composite sample of two containers, because they were misleadingly mixed with the wheel loader (when distributing the flotsam) in the course of pre-sorting.

Related to the number of pieces, a completely different picture emerges (Figure 36). Here, food packaging and packaging films predominate. In Cont2+3 and Cont4, the large proportion of foamed plastics is also noticeable. However, this can be explained by the breaking of EPS panels by the emptying of the containers or the distribution of the material by the wheel loader. The fraction of non-attributable (or non-identifiable) plastic parts also takes a higher place here.

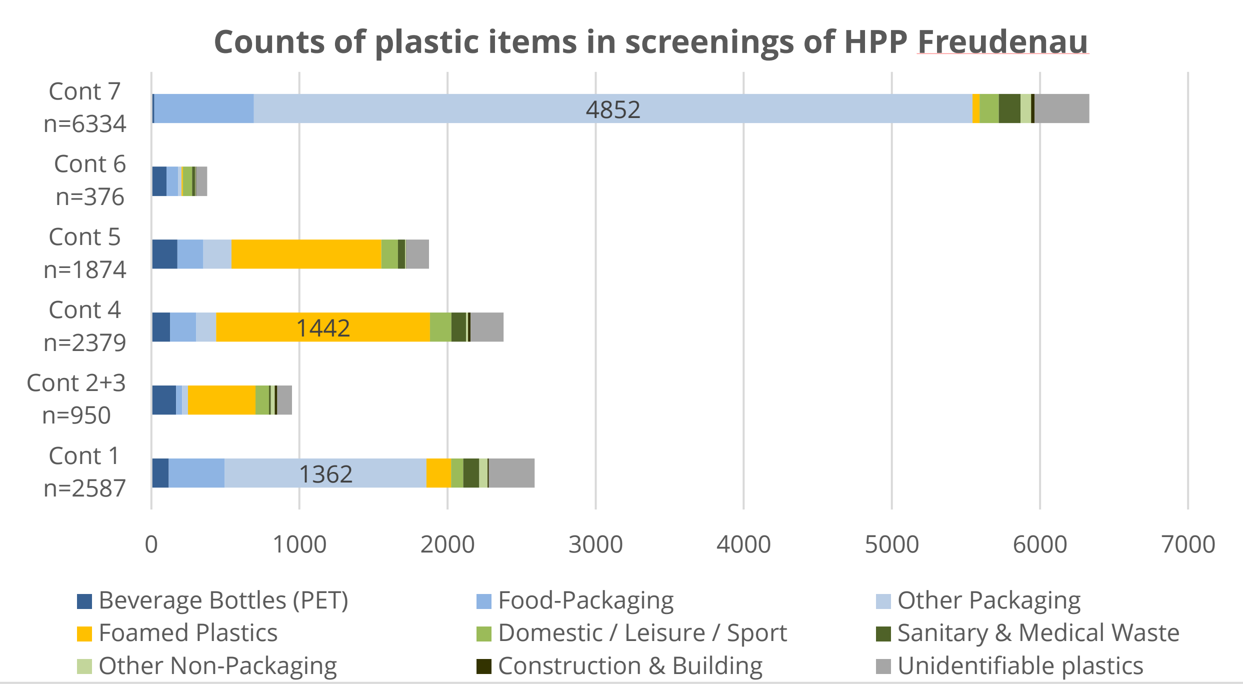


Figure 36: Number of plastic pieces in the screenings of HPP Freudenau

In terms of material composition, it can be seen that plastic waste can be classified as the second largest category by mass after wood waste ("processed wood", furniture, boards, etc.) (even the largest for Cont.7). Looking at the volume or the number of pieces, plastic is clearly in the top position.

Preliminary projections for the HPP Freudenau based on the available data (disposed quantity of screenings) estimate the retention potential at approximately 2 tons of plastic per year by an average discharge of 1560m^3/s (mean over project duration). However, further investigations are planned regarding retention capacities of hydropower plants. Detailed information can be finally found in D 4.2.1 “Report on data concerning quantities, types and sources” (Mayerhofer et al., 2021a).

6.2 Voluntary waste collection activities within project activities

Coordinated by National Park Donau-Auen collection activities with volunteers (school classes, companies, associations, etc.) are performed since approximately 15 years to remove (plastic) litter from Danube River shores and surrounding wetlands. Volunteer collection campaigns offer plastic samples for scientific analysis (sorting analysis ABF-BOKU) and are an important public relation measure to make people sensitive for plastic waste pollution.

Since project start (Oct 2017), more than 1860 kg pure plastic waste have been removed by clean-up-teams from riverbanks in the National Park. Detailed information is listed in Table 9. Main collection areas were determined according knowledge of national park rangers who already know from their experience where plastic accumulates regularly. Furthermore, these areas are easy to reach for the volunteers. Within few square kilometers increased accumulations zones are observed, whereby surrounding areas are not polluted.

Table 9: Volunteer collection campaigns in Donau-Auen National Park within the PFD-project (till Feb 2020)

Year	Events	Participants	Σ River-km	Σ Bag-Vol. [hl]	Σ Plastic [kg]	Σ Other waste [kg]	Σ [1]Water, sludge [kg]
2017	8	80	5.9	118.3	314.6	258.5	83.0
2018	9	220	22.1	139.2	625.7	512.7	219.0
2019	13	353	16.4	223.8	[2]893.4	[2]695.3	-
2020	3	31	4.5	38	70	56	-

[1] "Natural" contamination, such as mud, sand, leaves, etc. and water residues
Note: quantities extrapolated over bag volume, no sorting and weighing performed

6.3 Waste collection on the shore and in the floodplain in defined sectors

Depending on the bank structure and the regular changes of the water level, plastic accumulate on the banks of the Danube. To investigate the discharge of plastics into the shores 5 test fields were randomly selected each in three shore sectors which are exposed to different hydrodynamic conditions due to river course of the Danube. In total 15 standardized test fields in the area of Haslau (between river kilometre 1901.8 – 1895.4) are investigated in frequent intervals in a harmonized way, depending on the fluctuating water level (Table 10). The generated data serve not only as a basis, but also to validate the numerical model (D3.6.1 and D3.7.1, Liedermann et al., 2021 and 2021a) for a better understanding of the plastic transport behaviour and hotspot locations as well as to quantify near-shore accumulation potential.

Evaluations so far indicate that the distribution of collection amount data (boxplot in Figure 37) from the harmonized sampling and volunteer clean-ups at the NPDA riverbanks show great similarities. Depending on the particular riverside sampled or cleaned, the amounts can vary widely, from 4 to 143 kg/river-km (mean= 45; median 27) for the standardized sampling and between 5 to 123kg/river-km (mean= 56; median 45) for the volunteer collections. While several factors can influence the amount of plastic collected from volunteers (available time, group size, motivation, etc.), harmonized sampling largely breaks this down to the direct influence of the conditions of riparian zones. Previous experiences show that, in addition to the location of the investigated area in relation to the river, in particular bank structure (for example, rip-rap or gravel banks tend to discharge lower amounts of flotsam) and especially vegetation (e.g., filtering effect of riparian willow scrub, reed occurrence, etc.) have a significant influence on plastic discharge potential. In further investigations and with the help of hydrodynamic and numerical modelling in D 3.6.1 and D 3.7.1, dependencies should be identified and determined (Liedermann et al., 2021 and 2021a).

Table 10: Amounts of collected (plastic) waste in Haslau, Austria in 2019

Year	Samplings	Number test areas	Σ River-km	Σ Plastic [kg]	Σ Plastic [pieces]	Σ Other waste [kg]	Σ [1]Water, sludge [kg]
Sampling riverbanks							
2019	6	15	6.4	22.8	3110	21.1	13.3
2020	4	15	6.4	3.5	853	4.2	1.1
Sampling floodplain / hinterland							
2019	1	17		12.1	-	4.7	3.6
2020	3	17		68.4	-	62.0	20.1

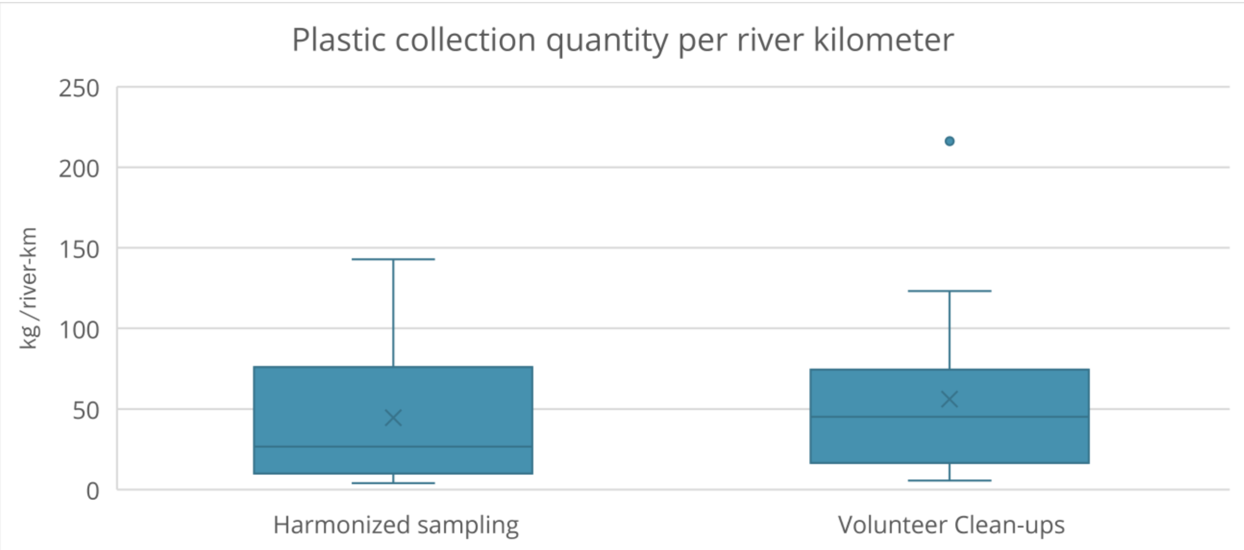


Figure 37: Boxplot of plastic quantities per river kilometres at the Danube riverbanks in the NPDA

More details on the composition of the collected plastic waste along the Danube bank and in the adjacent hinterland can be found in the report on D 4.2.1 (Mayerhofer, et al., 2021a)

Alluvial forests in the hinterland are flooded in larger time intervals and therefore investigated less frequently within project activities. Based on hydrodynamic models three categories which varying accumulation potential are defined. In each category 3-5 test fields are specified and investigated. In addition, a major focus of the sampling in the floodplains is on accumulation hotspots like driftwood log jams.

6.4 Sampling in the Danube river within project activities

In the previous project period, three measurements (as of Oct. 2020) - two of them in the Danube Canal and one measurement in the outlet of the HPP Freudenau - were carried out with newly developed grids. Thereby, a special measurement device was used – a bed load sampler specifically adapted for macro plastic with trapping nets. However, a precise evaluation and analysis of the data is still pending.

6.5 Waste collection activities beyond project activities along the Danube

To mitigate negative effects of littering, clean up events involving population are organized for several years and are increasingly popular. In 2015 about 130.000 people attended around 1,700 events. Thereby, estimated 860 t waste was removed from environment. Throughout Austria more than 75 waste prevention and anti-littering projects were promoted. Examples are actions like "Saubere Alpen" (means: clean alps) and "Saubere Gewässer" (means clean waters) (BMNT, 2017).

In the project area, a range of volunteer's waste collection campaigns exists, organized by different institutions and organisations like the NÖ-Umweltverbände (environmental associations), fishing associations or NGO's such as Plastic Planet Austria. However, in most cases no weight or other information of the collected waste is gathered or documented during these actions. Detailed information about general anti-littering campaigns in Austria, included roughly estimated collected quantities, can be found in chapter 4.2.

In the framework of the "Vienna cleans up" campaign, around 17,000 participants get involved every year. According to estimates, in 2017 28 tons of waste with a volume of over 283 cubic meters were collected (APA, 2018). For schools, kindergartens and clubs/associations, cleaning actions (focus actions) are offered in every district. For some years now, divers have also been searching for hidden "treasures". The diving sportsmen and women are supported by the Department of Vienna Waters (MA 45). This department brings the waste recovered from the water with work boats to land. The MA 48 then takes care of the professional disposal. Exact information on the composition of the waste (→ plastic content) is not available for either event (on land or underwater). Furthermore, it is not clear how much of the collected litter was picked up in the surrounding area of the Danube.

Based on knowledge we gathered from sampling activities within the project, we estimated the amount of waste which was extracted by waste collection activities and screening collection.

7 Appendix

Appendix 1: Most commonly applied polymers in Austria (UBA, 2017)

In Austria the most commonly applied polymers in the packaging sector are:

- PE (polythene)
- PP (polypropylene)
- PET (polybutylene terephthalate)
- PS (polystyrene). which are used to produce films, bottles, hollow bodies, and similar products
- EPS (expanded polystyrene)
- PVC (polyvinyl chloride).

Within the construction sector plastics are used in a wide range of applications, resulting in a demand for plastic types such as

- PVC
- PS/EPS
- PE
- PUR (polyurethane) and
- PP

With regard to new polymers. bioplastics and composite plastics are becoming more and more important. The bioplastics industry is experiencing a strong growth. with packaging being the main application area. Composite plastics. in particular fibre-reinforced plastics (such as glass-fibre reinforced plastics) are very much in demand due to their advantageous properties and their wide range of applications (UBA, 2017).

Type of Plastic	Shares in Austria (%)	Amounts in Austria (t)[2]	Amounts in Vienna (t)[3]	Amounts in Lower Austria (t)[4]
PE	23 %	236.900	49.597	45.172
PP	18%	185.400	38.815	35.352
PS/EPS	10%	103.000	21.564	19.640
PVC	4%	61.800	12.938	11.784
PET	6%	61.800	12.938	11.784

[2] Calculated from total plastic demand and published shares of plastic types

3 Referring to 1,797,337 inhabitants in Vienna in 2015. Total population in Austria in 2015: 8.585.000 inhabitants

4 Referring to 1,637,000 inhabitants in Lower Austria in 2015: Total population in Austria in 2015: 8.585.000 inhabitants

PUR	6%	41.200	8.626	7.856
Others	33%	339.900	71.161	64.813
Total	**100%**	**1.030.000**	**215.639**	**196.402**

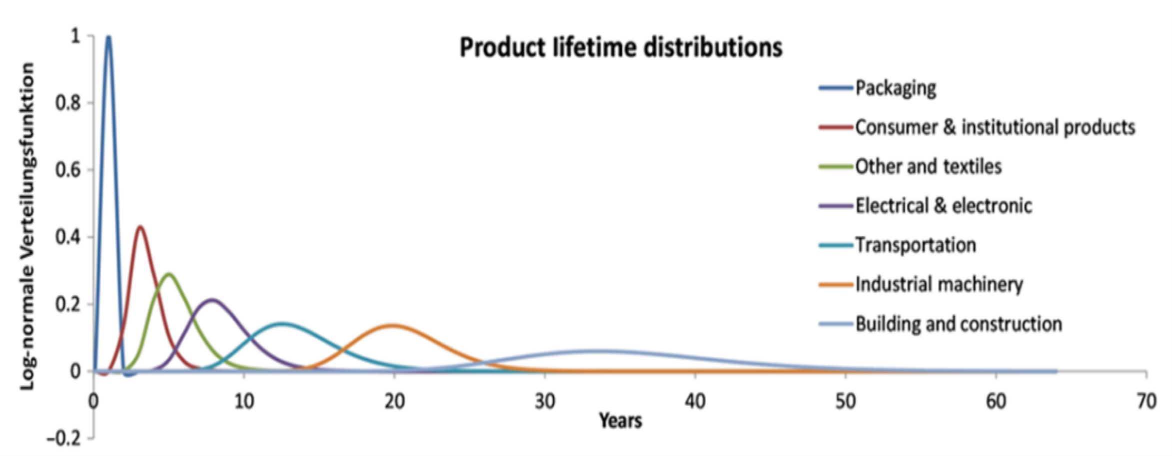
Appendix 2: Plastics budget for Austria in in 2015 (UBA, 2017) and in 2010 (Van Eygen et al., 2017) including mean value and relative standard deviation

Packaging	294.888	32	280.000±2%	48
Building and construction	46.640	5	28.000±17%	4.8
Transport	45.755	5	54.000±10%	9.26
Electronics	27.125	3	31.000±10%	5.32
Furniture	37.678	4	19.000±20%	3.26
Agriculture	32.448	4	33.000±32%	5.66
Medicine	25.137	3	14.000±9%	2.4
Household	155.842	17	41.000±42%	7.03
Textiles	-	-	36.000±6%	6.17
Other Applications/ others	250.847	27	47.000±35%	8.06
Total amount of plastic in waste	**916.360**	**100**	**583.000**	**100**

Appendix 3: Average lifetime / time of usage of selected plastic containing goods and production wastes (UBA, 2017)

Product	**Average lifetime** (UBA, 1997)	**Examples for time of usage** (AK Wien, 2015)
Production waste	0	-
Packaging material	<1	-
Household goods	5	-
Clothes	4	T-Shirt : 2.5. Jeans : 3. Coat/jacket :3.9
Toys	5	-
Furniture	10	couch: 8.6. closet: 10.5
Vehicles	10	car: 7.5
Household appliances	10	Washing machine:8.3. E-stove:10.8
Electrical devices and appliances	10	Laptop/notebook: 4.1. TV: 7.3
Tools. instruments	15	-
Building and construction materials	25	-

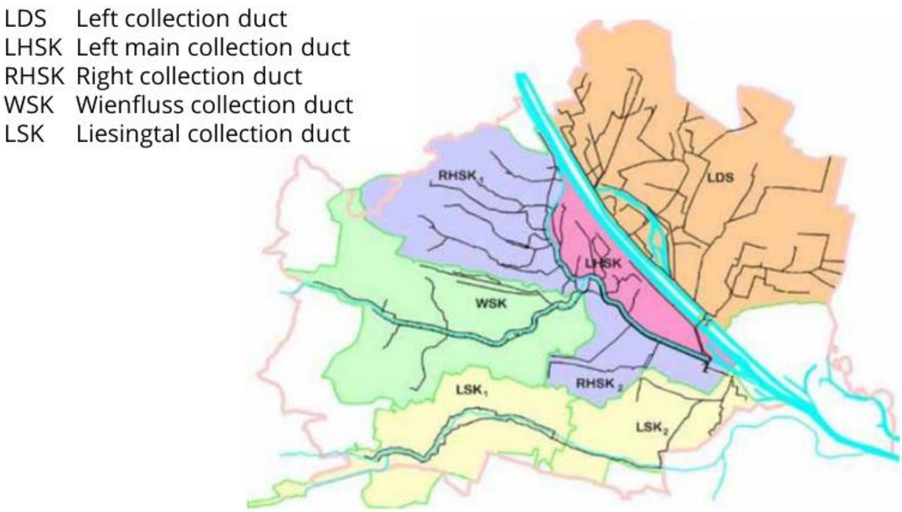
Appendix 4: Probability distribution of useful plastics lives according industrial branches (Geyer et al., 2017)



Appendix 5: Further info on waste water treatment and disposal

Mixed sever system: During heavy precipitation events sewage system may be overloaded. Then the mixed waste water is either buffered in retention facilities or discharged into the receiving water (river) via combined sewer overflows (CSOs). Expansion of central settlement areas and land use soil sealing is increasing nowadays. In combination with increasing number of heavy precipitations events the risk of “urban floods” is rising (ÖWAV, 2018).

To remove impurities, installations at CSOs are installed. No satisfactory solution for swimming and suspended solids are baffles (Schaffner, 2017). Another possibility is the implementation of weirs which are e.g. common in most areas of Vienna. But weirs do not prevent floating plastics from entering receiving rivers. Better options for trapping plastics are e.g. vortex separators which have proven in England and France Wastewater treatment plants (WWTPs).



Main collector ducts in Vienna (Radon, 2005 modified)

Wastewater from Vienna 's households, commercial and industrial establishments and also stormwater flows from the sewer into the main wastewater treatment plant – 680,000 m³ a day during low flow (dry weather) and 1,550,000 m³ a day during heavy rainfalls. During heavy rainfalls or winter snow melt. the waste water treatment plant Vienna is loaded with up to 1.6 million m³ of highly diluted wastewater per day. As a result of plant expansion and controlled retention measures in the sewer system, the wastewater reaches the plant at a maximum flow rate of 18 m³/sec and is cleaned by a fully biological process. The wastewater takes around 20 hours to flow through the plant (EBS, 2019).

Purification is reached by mechanical treatment (screens, sand trap. preliminary sedimentation) and biological treatment (first step. intermediate step. second step). In the second installation of the mechanical cleaning stage most of the solids and suspended particles carried along with the wastewater are removed by coarse and fine screens with 8 resp. 3 mm openings. This allows to hold back plastic packaging, rags, or sanitary items.

Revolving scrapers with their tines reach into the screen bar openings to remove the filtered-out scraps. The scraps are dewatered, intermediately stored in containers and passed on to Wien Energie, where they serve as fuel for district heating. The screens remove around 10 to 15 tons of solids from the city's wastewater weekly.

After intermediate sedimentation solids can no longer be identified by naked eyes. In this last step of mechanical cleaning the flow rate inside large tanks is reduced to 2 centimetres per second. so that flaky sediments and smaller particles can settle down to the tank bottom. Flight scrapers push the primary sludge to the end of the tank. from where it is removed.

Every day between 80 and 120 tonnes of solids (primary sludge) are removed from the primary clarifiers and transported to the sludge thickening tanks. Floating sludge that rises to the water surface as scum is mostly comprised of cigarette butts or pollen.

Cigarette butts should not end up in the sewer system, and need to be extracted from the tanks to avoid operational breakdowns in the downstream technical installations. Solids can no longer be identified with the naked eye, and around 30% of the impurities have now been removed from the wastewater. The remaining impurities are available in dissolved form and will be removed in the two following biological cleaning stages.

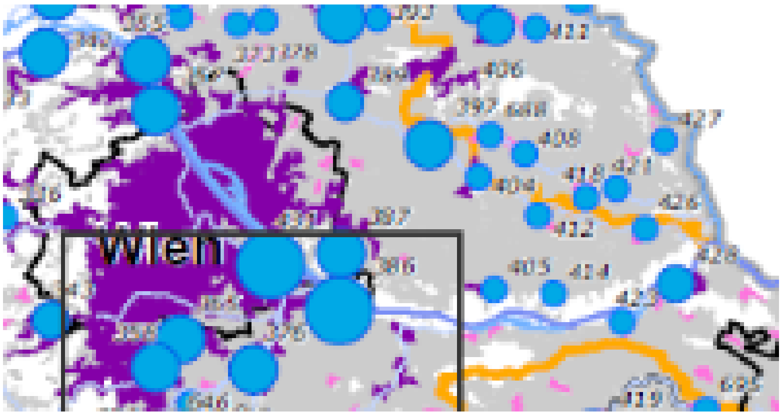
Figure 38: Screening system and primary sedimentation (right) of wastewater treatment plant Vienna (left) (EBS, 2019)

After the wastewater passed all treatment stages, the purified effluents are drained through submersible pipes to a collecting channel and from here flow to the outlet structure and into the Potential of plastic entry into rivers via rainwater sewage system in Vienna (EBS, 2019).

For every community and household in Lower Austria proper treatment of waste water has to be ensured. This can be done by communal WWTPs. small home treatment plants or by cesspools. The connection rate currently is about 94% and will increase up to 95% within the next years. Water disposal is task of communities which join to cooperatives and/or associations to take care of water disposal. More than 30 waste water associations exist in Lower Austria. Approximately 640 municipal sewage plants with a population equivalent (PE) of more than 50 are operated (Land NÖ, 2019).

In Lower Austria 192 WWTPs (≥ 2,000 PE_{60} [5]) existed in 2016. Nearly 30 WWTPs (> 100,000 Population Equivalents (PE60) of them discharge either into Danube River or into its tributaries. The biggest ones are these of the waste water association Schwechat with 370,000 population equivalents and the plants of the waste water association An der Traisen with 280,000 PE. Total capacity including partial cleaning of commercial waste water accounts for 4.3 million PE (Land NÖ, 2019).

[5] The population equivalent is a reference that describes the specific load of a wastewater treatment plant. The BOD_5 for one PE is defined as 60g BOD_5/d (biological oxygen demand, determined over a period of 5 days.



Wastewater treatment plants (blue dots) with further treatment in 2016 in Vienna and Lower Austria (> 2000 EW) (size of dot correlates with population equivalents)

Main settlement areas in model regions are Vienna, the region Krems, Wiener Neustadt, St. Pölten and Schwechat. Biggest WWTPs, besides WWTP Vienna, are located in Traismauer and Schwechat, WWTP Traismauer was expanded and renewed in 2013 and is considered by local government to be now one of best WWTPs in Austria (SPÖ Traismauer, 2014). According to local newspaper an annual amount of 400 t waste, mainly hygienic articles, are removed and properly disposed (Bourguignon, 2018). Also waste water treatment plant Schwechat of is equipped with screens, sieves, sand traps and sedimentation basin (AWV Schwechat, 2019). Short research provides several press releases where upgrading of WWTPs are reported (e.g. a new WWTP in Krems with 4 mm screenings, WWTP Hainfeld where solids bigger than 3 mm are caught, Windigsteig – new fine screen, or Zwettel were screens were also improved (GAV Krems, 2019, Mein Bezirk, 2013, SPÖ Hainfeld, 2015, NÖN, 2019). Mechanical treatment of waste water treatment plant Schwechat is equipped with screens, sieves, sand traps and sedimentation basin (AWV Schwechat, 2019). As in other regions hygienic articles and other plastics have to be removed from waste water in treatment plants of Lower Austria. Especially the disposal of wet wipes into toilets increased recently and causes troubles and costs (Land NÖ, 2017).

To conclude, the authors assume that there is big potential for improving waste management behavior of Lower Austrian people to avoid plastic solids in waste water. But due to high standards pollution via WWTPs are negligible.

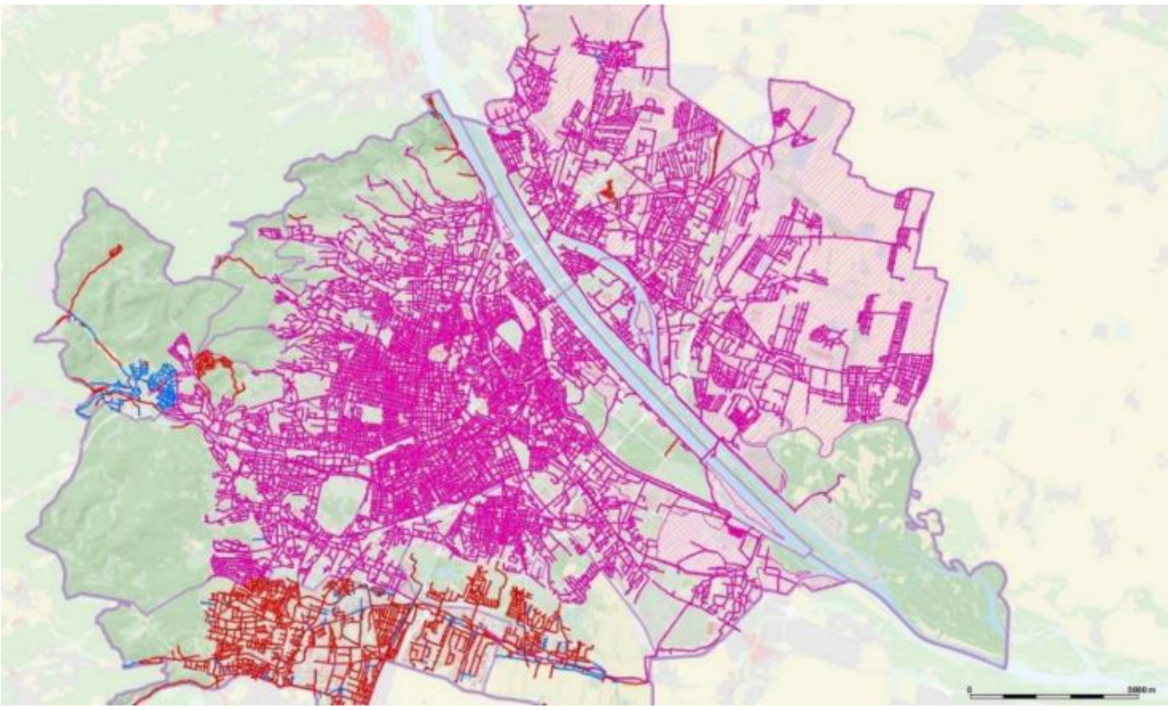
Intensity of plastic pollutions, numbers of combined sewer overflows, frequency of spillovers or amount of wastewater getting into receiving water are unknown by the authors. Considering that during literature research we did not found information's about raising buffering capacities to prevent discharges and also due the fact that mixed waste water sewer is five times longer than that in Vienna, it can be assumed that there is a certain potential for macro plastics pollution via waste water in Lower Austria.

Length of municipal waste water sewages in Austria in 2007 (KPC cited in Fenzl, 2011)

Region	Rainwater sewage (m)	Waste water sewage (m)	Mixed waste water (m)	Total length sewage (m)
Lower Austria	3.574.519	9.428.211	6.763.233	19.765.963
Vienna	249.840	313.680	1.718.712	2.282.232
Austria	9.573.102	48.991.237	23.430.700	81.995.039

Vortex Separator – Mixed sewage system. England (Schaffner, 2017)

Sewage system in Vienna (blue= rainwater sewage system. red=waste water sewers. pink=mixed sewage system; source: http://www.kanis.at



Main collector ducts and corresponding catchment areas as well as in Vienna:

Sewer/ collector duct name in German	**Drainage area and description**
Linker Donausammelkanal	21th and 22nd district • Drainage area: 4.054 hectares. thereof 1.200 hectares non-permeable surfaces • Drains 21th and 22nd district • Length: about 11 km A drop structure is located at the end of left Donausammelkanal (=collector duct) then a culvert leads under the "Neue Donau". Mixed sewage wager is led to WWTP Simmering.
Linker Hauptsammelkanal (Donaukanal)	2nd an 20th district • Drainage area: 1.050 hectares. thereof 600 hectares non-permeable surface • Drains den 2. und 20. Bezirk • Length 9.9 Kilometer Serves dewatering inner-city residential areas. Household and commercial waste water is transported in natural gradient to WWTP Simmering.
Rechter Hauptsammelkanal (Donaukanal)	1st. 3rd. 8th. 9th. 11th. 17th. 18th and 19th district (right collection sewer – Donaukanal) • Drainage area about 13.000 hectares. thereof about 5.300 hectares non-permeable surface • Drains districts no 1., 3., 8., 9., 11. and 17., 18., 19. • Length: 16.6 km Right collection sewer = combined sewage system. Waste water from households and commerce is transported in natural gradient to WWTP Simmering
Rechter Hauptsammelkanal-**Entlastungskanal** (Donaukanal)	Amounts of waste water increased significantly in past century. especially amounts which are thransported through "Rechten Hauptsammelkanal". Designed as combinded sewers waste water and also rainwater and has to be drained. Especially during heavy precipitation events discharg peaks occured which overload the "Rechten Hauptsammelkanal" in the past and waste water had to be discharged into Donaukanal. To avoid avoid direct discharge into Donaukanal in 2000 the "Rechter Haupsammelkanal-Entlastungskanal" (=right collection sewer relief sewer) was finished along the right shore of Donaukanal. It runs from the estuary of Wienfluss at Urania to WWTP Simmering.
Donaukanal Verbindungsleitungen	To guarantee undisturbed operation. the sewage system has to be cleaned periodically. Formerly waste water was discharged into to Donaukanal in the meanwhile and amounts increased rainwater amounts. Hence 3 connecting canals

	were built from 1998 to 2003 below the bridges Friedensbrücke. Schwedenbrücke and Franzensbrücke. These pressure pipes connect “Rechten and Linken Hauptsammelkanal” (right and left main sewers). Since 2003 no operational discharges occurred during maintenance and cleaning works.
Liesingtal Sammelkanal	• Drainage area: about 4.240 hectares. thereof about 970 hectares non-permeable surface • Drains districts 10 and 23 • Length: about 20.5 kilometers The „Liesingtal Sammelkanäle“ discharge via separate sewer system about 3.500 hectares. Only sewer „Gelbe Heide“discharges an area of about 325 hectares in mixed severs. The catchment area outside Liesingbach which reaches Donaukanal and WWTP Simmering. respectively covers parts of Simmering and Kaiserebersdorf – about 740 hectares which are dewatered via mixed system.
Liesingtal Kanal	To reduce loads of Liesingtal Sammelkanal Liesingtal Kanal was built. This transport canal was built when WWTP was taken out of service.

Wienfluss-Sammelkanäle	• Drainage area: 5.800 hectares. thereof about 2.500 hectares non-permeable surface
	• Drains 1st. 3rd. 4th. 5th. 6th. 7th. 12th. 13th. 14th. 15th and 16th district
	  ○ Length: Linker Wienflusssammler circa 15 km
	  ○ Rechter Wienflusssammler circa 12.5 km
	
	The right and left Wienflussammler are the oldest collector ducts in Vienna. Already at low precipitation rates mixed waste water had to be discharged into Wienfluss before Wiental Kanal was built.

Wiental Kanal	Since 2005 no more discharges into Wienfluss are necessary. About 3.5 km long sewer was built. 2.7 km of this sewer can buffer 110.000 m3 water.

Big cities and settlement areas in Vienna and Lower Austria in 2016 (Lenz and Zieritz, 2018):

Name of settlement area	**Federal state**	**Capacity (PE60)**
Raum Krems (Krems-Weinzierl)	Niederösterreich	255.000
Raum Wiener Neustadt (Wiener Neustadt Lichtenwörth)	Niederösterreich	260.000
Raum St. Pölten (Traismauer-Stollhofen)	Niederösterreich	280.000
Raum Schwechat (Schwechat-Mannswörth)	Niederösterreich	370.000
Wien (HKA Simmering)	Wien	4.000.000

WWTPs in Lower Austria which are either discharging into Danube River or discharging in tributaries and > 100.000 PE60 (Lenz and Zieritz, 2018)

District	Settlement area	WWTP-label	WWTP-name	Capacity (PE_{60})	Receiving water
Amstetten	Wallsee-Sindelburg	ATTP_3_128	ARA Wallsee-Sindelburg	2.700	Donau
Amstetten	Ardagger	ATTP_3-141	ARA Ardagger-markt	4.500	Donau
Amstetten	Raum-Amstetten (Amstetten-Schönbichl)	ATTP_3-104	ARA GAV Amstetten	150.000	Ybbs
Baden	Raum Bad Vöslau (Bad Vöslau-Vöslau)	ATTP_3-34	ARA GV Abwasserbeseitigung Raum Bad Vöslau	105.000	Wiener Neustädter Kanal
Bruck a. d. Leitha	Petronell-Carnuntum	ATTP_3-194	ARA Petronell Carnuntum	3.000	Donau
Bruck a. d. Leitha	Hainburg/ Donau	ATTP_3-92	ARA AV Raum Hainburg	15.000	Donau
Gänserndorf	Eckartsau	ATTP3-120	ARA Eckartsau	2.200	Donau
Gänserndorf	Orth/Donau	ATTP_3-220	ARA Orth an der Donau	3.700	Donau
Gänserndorf	Groß-Enzersdorf	ATTP-3-142	ARA Groß-Enzersdorf	144.000	Donau
Korneuburg	Hausleiten-Stettelsdorf (Unteres Schmidatal)	ATTP_3-829	ARA GAV Unteres Schmidatal	6.000	Donau
Korneuburg	Raum Korneuburg (Korneuburg-Korneuburg)	ATTP_3-132	ARA AV Raum Korneuburg	40.000	Donau
Krems a. d. Donau	Raum Krems (Krems-Weinzierl)	ATTP_3-119	ARA GAV Raum Krems an der Donau	255.000	Donau
Melk	Emmersdorf/Donau	ATTP_3-58	ARA Emmersdorf	3.000	Donau
Melk	Raum Melk (Melk-Melk)	ATTP_3-3	ARA Melk	14.000	Donau
Melk	Raum Persenbeug (Klein Pöchlarn-Klein Pöchlarn)	ATTP_3-7	ARA GV Abwasserreinigung im südlichen Waldviertel	16.800	Donau
Melk	Raum Ybbs/Donau (Ybbs/Donau-Ybbs)	ATTP_3-6	ARA AV Ybbsfeld	20.000	Donau
Melk	Raum Pöchlarn (Pöchlarn-Wörth)	ATTP_3-51	ARA GV Abwasserbeseitigung Raum Pöchlarn	25.000	Donau
Mödling	Raum Mödling (Wiener Neudorf-Wiener Neudorf)	ATTP_3-403	ARA Mödling	130.000	Krottenbach

St. Pölten – Land	Raum St-Pölten	Traismauer-Stollhofen	ATTP_3-47	280.000	Donau
Tulln	Zwentendorf/Donau	ATTP_3-112	ARA Zwentendorf	8.000	Donau
Tulln	Raum Kirchberg/ Wagram (Nördliches Tullnerfeld)	ATTP_3-810	ARA GAV Wagram – Nördliches Tullnerfeld	17.000	Donau
Tulln	Raum St. Andrä-Wördern	ATTP_3-105	ARA GAV Raum St. Andrä-Wördern	20.000	Donau
Tulln	Tulln	ATTP_3-430	ARA Tulln	45.000	Donau
Wien-Umgebung	Raum Pressbaum Tullnerbach-Purkersdorf	ATTP_3-55	ARA Wiental Sammelkanal GmbH	23.000	Wien
Wien-Umgebung	Raum Klosterneuburg (Klosterneuburg-Klosterneuburg)	ATTP_3-32	ARA Klosterneuburg	55.000	Donau
Wien-Umgebung	Raum Schwechat (Schwechat-Mannswörth	ATTP_3-11	ARA AWV Schwechat	370.000	Donau
Linz-Land	Linz Umgebung	ATTP_4-41003001	Asten – Regional-Kläranlage	950.000	Donau

Appendix 6: Brief information about project CO-WANDA

Danube River is the second longest river in Europe and connects 10 countries on its way to the Black Sea. Thus. vessels of countries with different social. economic and political systems use the Danube as an international waterway. Therefore. ship borne waste is treated in different manner. Within this context. suitable solutions have to be found and within EU project CO-WANDA efforts were made to develop an **International Danube Ship Waste Convention (IDSWC)** which provides basic arguments and documents for policymakers in order to regulate ship waste disposal on the Danube in a transnational and harmonized manner. The project CO-WANDA aimed at the development and promotion of a permanent and coordinated transnational advanced waste system for vessel waste along the length of the Danube river and deals with reception of waste material from vessels. but it did not develop models for further treatment and monitoring of waste through the final processing or disposal destinations (Presburger Ulnikovic et al., 2012)

From 2012 to 2014 the project CO-WANDA was performed on initiative work for a binding treaty. which shall provide clear guidelines for ship waste management along the Danube. The idea was that harmonisation and adaptation of available ship waste management systems would decrease the risk of illegal discharges of ship waste and thereby support the protection of valuable river ecosystems and the means of livelihoods for future generations in the Danube region (Danube region strategy. 2014). During project information was gathered through literature. research interviews with skippers and questionnaires distributed in Austria, Slovakia, Hungary, Croatia, Romania and Bulgaria. Much knowledge about waste management was gained, and also some information about plastic waste or illegal waste disposal.

Appendix 7: Legal framework of ship waste management in Austria and Slovakia

Following EU-Directives envisage framework conditions for ship waste management and have to be implemented into national law: Water Framework Directive. Waste Framework Directive. Technical Requirements for Inland Waterway Vessels and Directive on Port Facilities for Ship-generated Waste and Cargo (for maritime Danube Ports).

In Austria, ship waste management is covered by the Austrian Navigation Act. containing obligations for crew members as well as for infrastructure operators (ports. terminals. landing stages) regarding financing. equipment and operation of waste disposal sites. The operation of waste collection facilities is regulated by the Waste Management Act. and obligations regarding water quality by the Water Act.

In Slovakia the Navigation Act. the Waste Act. the Water Act and the Environmental Act regulate ship waste management. The disposal of waste from foreign vessels is prohibited as it is considered as waste import. Only Slovak vessels are allowed to dispose of their waste within the Slovak territory (http://www.ines-danube.info).

Appendix 8: Further information on inland navigation

Name of port	**River km**	**Disposal of waste and plastic waste**
Freudenau	1920	Disposal of waste possible; separate disposal of plastic not possible
Albern	1918	Disposal of waste possible¸ separate disposal of plastic not possible
Lobau	1917	Disposal of waste possible; plastic is permanently collected separately, amounts not limited
Private port Korneuburg		

Waste reception facilities for passenger vessels along Danube in project area:

Waste reception facilities	**River km**	**Address**	**Description of disposal faclities**
Passenger Terminal Reichsbrücke Vienna	1929. right bank. landing stages 1-12	1020 Vienna. Handelskai 265	The disposal facilities are only available for customers and clients in the course of morning
Donaustationen Wien Nussdorf – Nr. 29 & 34	934.425. right bank=No. 29. 1934.300 right bank =No. 34	1190 Vienna. Heiligenstätterstraße 180 Contact. Kerstin Heigl. (www.donaustationen.at)	Separate disposal of plastic not possible. only disposal of residual waste possible
Lände Werft Nordufer (Hafen Korneuburg	River-km 1943.190 – 1943.025 left bank	2100 Korneuburg. Werft Nordufer. Am Hafen 6 (hafenkorneuburg.at)	
Schwedenplatz	Danube Canal. right river bank	For Twin-City Liner Excursion boats of DDSG	Waste reception facilities available (www.donauraum.at):
Custozzagasse/ Hunderwasserhaus	Danube Canal. right river bank		Waste reception facilities available (www.donauraum.at):

Berths in Austrian part of project area (viadonau, 2018):

Berth	**River km**	**Info**
Jägerhauslände	1.944.6 left river bank	
Tuttendörfl	1.940.8 left river bank	
Kuchelau	1.937.0 right river bank	
Nussdorf	1.934.8 right	
Brigittenau III	1.932.6 right river bank.	only for passenger vessels. max. time allowed for berthing 2 hours. boarding and deboarding permitted)
Brigittenau II	1.932.1 right river bank	
Nordbahnlände	1.929.7 right river bank	
Lagerhauslände III	1 927.6 right river bank	
Lagerhauslände I	1.927.5 right river bank	
Lagerhauslände II	1.926.9 right river bank	
Krieau	1.925.4 right river bank	
Stadlau III	1.925.0 right river bank	
Stadlau II	1.925.0 right river bank	

Mannswörth	1.918.6 right	
Tanklände Neue Donau linkes Ufer	1.917.2 left river bank	
Tanklände Neue Donau rechtes Ufer	1.917.1 right river bank	
Petronell	1.883.9 right river bank	
Hainburg	1.883.9 right river bank	
Thebener Straßl	1.879.0 right river bank	

Marinas for ships and small vehicles:

Name of Marina	**River-km**	**Info**
Greifenstein/ Altenberg	1951.3 /right bank	
Greifenstein – Lände für Kleinfahrzeuge. die auf Schleusung warten – Fernsprechstelle (im Altarm)	1949.98 – 1949.93 right bank	
Korneuburg	1942.5 left bank	
Kuechelau	1935	Hafenstraße 2. 1190 Wien. Kuchelauer Hafenstraße
Marina Wien	1925.930 right bank	1020 Wien. Handelskai 343. 200 Bootsliegeplätze
Wien-Freudenau – Lände für Kleinfahrzuege. die auf Schleusung warten	1921.945 – 1921-795 Right bank	
Wien – Freudenau – Lände für Kleinfahrzuege die auf Schleusung warten - Fernsprechstelle	1920.600 – 1020.570 right bank	
Orth – Lände für Kleinfahrzeuge	1902.2 – 1901.8 left bank	
Wildungsmauer – Lände für Kleinfahrzuge	1894.82-1894.7 right bank	
Hainburg – Lände für Kleinfahrzuge	1884.45 – 1884.33 right bank	
Altenburg (?)	1887 right bank	

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