PlasticFreeDanube

D6.1.1
REPORT ON POSSIBLE SCENARIOS, RECOMMENDATIONS AND MEASURES FOR IMPROVEMENT

for Macro-Plastic Pollution in the Danube River

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1. Introduction

The term "littering" comes originally from the English but is also used in German and Slovak language and stands for the leaving and throwing away of waste in nature or in public places. Litter consists of waste products that have been disposed of improperly, without consent, at an undesirable location. Litter can also be used as a verb. To litter means to drop and leave objects, often man-made, such as aluminum cans, cardboard boxes or plastic bottles on the ground, and leave them there indefinitely or for others to dispose of as opposed to disposing of them properly (Wikipedia, 2019).

Typical litter are mostly short-lived consumer goods or take-away products, which are mostly largely consumed on the go, and the packaging is discarded on site (Hietler et al., 2018). Such waste has a negative impact on the aesthetics of public places as well as it can be easily dispersed by the wind, thus leading to pollution and reduce the quality of the environment (Arafat et al., 2007). In addition to visual pollution, such wastes also pose a danger to humans and animals (Hietler et al., 2018).

The aim of this report is to highlight the motivation and the background of the people with regard to littering. It should be shown, which countermeasures are effective and which are also considered useful by the population. This leads to the following research question: What are the determining factors for littering behavior and what successful measures can be taken against it?

2. Consequences of littering

Consequences of littering are manifold and can occur in many different ways. The following chapter will give an overview of possible consequences. In general, these can be divided into social, economic and ecological consequences.

2.1. Social consequences

Littering disturbs people, reduces quality of live and the security of the population in public space and damages the image of cities and communities. It can also have negative influence on people's health, e.g. when children cut at littered items or put contaminated/polluted waste in their mouths. Various studies show that the quality of life in many countries is very strongly correlated with safety, environmental friendliness, and cleanliness (Giap et al., 2014). Often, littering is very common in certain hot spots, while other places are spared from it, which can carry with it a spread social structure (Berger et al., 2008). Cleanliness is an important component for the quality of life of the population and the image of a region. Littering is therefore a problem because it is a visual nuisance and thus affects the quality of life (FOEN, 2018). Littering can also cause damage to health. Armstrong and Molyneux (1992) observed that 5% of all injuries at their hospital in Liverpool, England, were caused by glass and that most glass related injuries occurred on the street.

2.2. Economic consequences

Littering, in contrast to waste disposed of in appropriate bins, causes disproportionately high costs (Berger et al., 2008). This results in direct costs for the collection and disposal of the waste and indirect costs, such as the loss of property value and losses in the tourism sector, whereas the latter are difficult to capture (Wagner and Broaddus, 2016). As part of the Swiss study "Litter costs" by Berger and Sommerhalder (2011), the direct costs of cleaning up litter in 40 Swiss municipalities and 9 public transport operators between June and September 2010 were analyzed.

In 2010, there were about 192 million Swiss francs cleaning costs for littering, of which 144 million were incurred in the municipalities and 48 million in public transport (Berger and Sommerhalder, 2011). Converted to Austria, this amounts to €21 per inhabitant (Global 2000, 2018). In total this would be around €178.5 million for 8.5 million inhabitants. Likewise, the above-mentioned study by Berger and Sommerhalder (2011) determined, which costs are attributable to various fractions of littered waste. The largest part resulted from take-away packaging (50%), beverage packaging, newspapers (5%), flyers and cigarettes. Since the cleaning effort of cigarettes is disproportionately high, these accounted for 36% of the costs incurred (Berger and Sommerhalder, 2011).

In addition, high costs are incurred for the prevention of littering and for educational measures. Socio-economic damage for sectors such as tourism can also occur (FOEN, 2018). Littered waste in nature can also negatively impact the Agriculture sector.

2.3. Ecological consequences

Littered waste degrades the landscape, pollutes the environment and therefore the ecological balance is destroyed. Thus, there is damage to humans, animals and plants. For example, chewing gum takes five years to decompose, and a cigarette butt with its many pollutants can contaminate 40 - 60 liters of clean groundwater (Schoeppl, 2012). It should also be noted that materials that are littered cannot be returned to the material cycle. As a result, they cannot be recycled for reuse, which in turn means that new resources have to be extracted and processed. This is not only more cost-intensive, but also cannot be considered sustainable (Berger et al., 2010). Waste from littering can bring health hazards to people, such as cuts on metal cans with subsequent possible infection. Cows, birds, and other animals may inadvertently eat this litter, causing damage to them (Hietler et al., 2018). If hazardous wastes or problematic materials are littered, both water, soil, and air, as well as wildlife, through ingestion, poisoning, or injury, be harmed (Berger et al., 2010).

Litter in water bodies is a source of danger worldwide and a problem for humans, living beings and the environment as a whole. Due to litter from the land, such as recreational waste from the shoreline, windborne debris from watercourse edges and combined sewer overflows from the municipal sewer system during heavy rains, it can cause pollution of watercourses. Flotsam is difficult to remove and plastics pose a particularly significant problem because of their large volume and long residence time in water bodies. Waste that is dumped directly into the river or washed into the river by flooding leads to ecological problems. Even from the Danube, islands of litter have to be removed repeatedly (Clark and Pucher, 2014). "From the waste sector, the sources of plastics found in the Danube River include general littering on streets, public places and other traffic routes" (Hohenblum et al., 2015).

Plastic litter has historically been studied primarily in the oceans, although a major part of it enters the ocean through inflows from rivers. Sediments of some German rivers were found to be as heavily loaded with plastic as in the most contaminated sediments in the ocean (Ploetz et al., 2015). In flowing waters in Germany, litter levels of macro-litter (>5 mm) and micro-waste (1-5 mm) was investigated. It was detected in all water bodies, packaging, films, bags and sacks, i.e. mainly plastics, occurred most frequently. Plastic film fragments and plastic pellets predominated among the micro-wastes. Both Macro-, as well as micro-wastes consist mainly of plastics.

In flowing waters, the movement of waste can represent a pathway for the spread of bacteria (Breitbarth, 2017). Potential pathogens can be transported on a biofilm that forms on the plastic surface. Pollutants such as plasticizers, which have carcinogenic and hormonal effects and lead to malformations can be

transported. In addition, pollutants that were already present in the water may be resorbed (Ploetz et al., 2015). Plastic particles can contain various toxic substances, such as the carcinogenic insecticide DDT and PCBs, which can accumulate in plastic particles. The concentration of individual toxins in plastic powder can be up to one million times higher than in the surrounding water (Pretting and Boote, 2014).

Impacts on the ocean litter found in oceans comes from improper disposal by tourists and residents, from washing away from shorelines, or transported through long river stretches. 15% is waste floating on the surface, and another 15 % is washed up on coasts and 70 % sinks to the seabed. The quantities that are discharged into the world's oceans are about 4.8 - 12.7 million Mg in 2010 (Breitbarth, 2017). So-called garbage eddies form in the oceans, in the North Pacific this is called the "Great Pacific Garbage Patch." This is the size of Central Europe and contains approximately one million plastic pieces per square kilometer.

The plastic particles are transformed into microplastics by wave action, UV radiation and microbial degradation. Depending on the size and the type of the plastic, the temperature and the sunlight, it can take up to 600 years to decompose. The plastic pieces initially float in the ocean and then sink to the bottom of the oceans through biofouling (e.g. attaching to shells) to the bottom of the oceans (Ploetz et al., 2015). Living creatures can become entangled in plastic parts and suffer severe wounds and deformities. If mistaken for food, plastic pieces can be swallowed and lead to a reduction in hunger and gastric function, or immediate death. Hormonally active environmental toxins from plastics cause alterations in mating behavior and fertility in aquatic animals (Clark and Pucher, 2014). In 2012, 663 marine species were known to be affected by negative impacts from marine and coastal litter. Some chemical additives, such as plasticizers, antioxidants, heavy metals, flame retardants, and dyes, which are included in plastic along with polymers, have adverse health properties. They are toxic to aquatic organisms, affect the endocrine system of humans and animals and lead to poor classification of some water bodies.

Plastic waste is carried into the ocean, where it creates environmental toxin-enriched microplastics, which are eaten by filter feeders. Litter on the beach is eaten by worms, fleas and mussels. However, the plastic particles with the enriched environmental toxins cannot be excreted by the living creatures and, being eaten by more highly developed animals, they move further and further up the food chain where humans are at the end (Pretting and Boote, 2014). "One animal eats another, and in the end our waste, enriched with a wide variety of various industrial toxins, ends up back on our plate" (Pretting and Boote, 2014).

3. Reasons promoting littering

Littering has increased in recent years due to the fact that more people consume outside their home. The distribution of free goodies such as newspapers or flyers also causes littering (Loimayr 2010). In the following section possible reasons which promote littering are summarised based on a report from Hietler 2020.

3.1. Disposal infrastructure (distance and presence of bins, overfilled bins)

Disposal infrastructure is the most frequently cited reason for littering in the literature. (Schultz et al. 2013; Rangoni and Jager 2017; Ong and Sovacool 2012; Hansmann and Steimer 2017; Abdul Aziz et al. 2019; Loimayr 2010; Wilson et al. 2014; Daxbeck et al. 2017). In a Swiss survey by Hansmann and Steimer (2017), 97.4% cite inadequate disposal infrastructure (no / too few / overfilled bins) as a reason why they sometimes litter. Schultz et al. (2013) studied the distance from the litter bin as a reason for littering and concluded that at 6m distance 12% of people litter, between 6-18m this number increases to 30%. No further increase was found at a distance greater than 18m. In the survey by Abdul Aziz et al. (2019), 29% cited distance from the litter bin as a reason for littering, with a further 46% citing overfilled bins as a reason. Disposal infrastructure has an impact on simplicity of disposal (hedonic goal). In surveys, simplicity was blamed for littering by 40% (Abdul Aziz et al. 2019) and between 16.7% - 63.8% (Hansmann and Steimer 2017).

3.2. Litter is already visible

The presence of littering as reason for further littering is mentioned as often as the (missing) disposal infrastructure (Schultz et al. 2013; Rangoni and Jager 2017; Ong and Sovacool 2012; Hansmann and Steimer 2017; Abdul Aziz et al. 2019; Loimayr 2010; Daxbeck et al. 2017; Seco Pon and Becherucci 2012). It implicitly activates the descriptive norms of individuals who experience littering as the normal behaviour in the environment. Personal norms can thereby work against littering (Kort et al. 2008). In the survey by Abdul Aziz et al. (2019), 38% cited the presence of litter in the area as a reason for littering.

Rangoni and Jager (2017) also observe that the distribution of litter has an impact on the behaviour of people in the area. If litter is piled up in a few places, it will contribute less to littering by visitors than if the same amount was distributed in the surrounding area. They further assume that it takes a certain period of time from entering a littered environment for the littering inhibition threshold to drop.

3.3. Aesthetics of the environment (neatness of buildings, amount of greenery, etc.)

The aesthetics of the environment are mentioned as an influencing factor by Schultz et al. (2013), Weaver (2015), Daxbeck et al. (2017) and Ong and Sovacool (2012).

Weaver (2015) deals with the topic in detail. In the study, fieldwork was conducted in front of two supermarkets, in a rich and a poor neighbourhood, with and without litter present. The supermarket in the poor neighbourhood was also located next to a highway and in the middle of partly vacant houses on cracked pavements with generally weak greenery, while the landscaping around the second supermarket was well-maintained and well-vegetated. The study found that littering was more frequent in the run-down environment. Factors affecting the aesthetics of the environment are: Socio-economic status and resulting

neatness of buildings, walkability of surroundings (pedestrian paths, etc.), landscaping and the amount of greenery (Weaver 2015).

3.4. Number of people in the environment / anonymity

The presence of other people provides an implicit activation of socially injunctive norms (fear of social consequences) and thus slows down the decision to litter. This was also observed by Bateson et al. (2013), Schultz et al. (2013), Daxbeck et al. (2017) and Ong and Sovacool (2012). However, if a place is so crowded that people feel anonymous, littering behaviour may be reinforced, according to Cingolani et al. (2016), Seco Pon and Becherucci (2012) and Loimayr (2010).

3.5. Attitude

Personal attitudes towards litter as a resource and the act of disposing of it have a fundamental influence on littering behaviour (Ong and Sovacool 2012; Hansmann and Steimer 2017; Abdul Aziz et al. 2019; Rath et al. 2012; Kort et al. 2008; Mapotse and Mashiloane 2017).

The most detailed study on the topic was written by Ong and Sovacool (2012). They compare the political, social and institutional policies in Singapore and Yokohama (Japan). The cities are very similar in size, population density, level of industrialisation, wealth, quality of life and clean classification. Both cities have many awareness raising activities at school and community level as well as campaigns (corridor cleaning campaigns, etc.). Singapore, however, has a large and increasing littering problem (annual cleaning costs of $110 million), while in Yokohama there is virtually no littering and costs are even decreasing (annual cleaning costs of $9.8 million). This can be attributed to the attitude and type of awareness-raising measures.

In Singapore, the prevailing attitude is that litter is useless, that the sanitation department will clean it up and that littering is a menial task. The government organises intensive cleaning of the city and imposes heavy fines against littering. The awareness-raising measures consist largely of frontal lectures on the effects of littering and flyers as information material.

In Yokohama, litter is considered valuable and the material is to be reused. Residents have a personal sense of responsibility for keeping their surroundings clean and clean up litter on the streets in neighbourhood associations. This is an honourable activity for the community. In this regard, the municipality often leaves the cleaning of side streets to the voluntary community associations. Awareness-raising activities in schools are largely participatory. Students clean the class for about 15 min every day, clean up after big events and separate waste into 10 fractions. Visits to recycling and waste incineration plants are also on the curriculum.

On the one hand, residents' attitudes are crucial for littering behaviour, on the other hand, participatory awareness-raising measures are more effective than informative ones (Ong and Sovacool 2012).

3.6. Beliefs and level of information (lack of awareness, consequences unknown, someone else will clean up my litter)

Besides attitude, information and beliefs also play an important role in littering (Hansmann and Steimer 2017; Patel et al. 2013; Rath et al. 2012; Abdul Aziz et al. 2019; Ong and Sovacool 2012; Mapotse and Mashiloane 2017; Loimayr 2010). In Abdul Aziz et al. (2019), a lack of awareness was cited by 51% of

respondents as a reason for littering, while in Hansmann and Steimer (2017) it ranged from 11.5% (without accompanying conversation) to 91.3% (with accompanying conversation) for their own littering behaviour.

A common belief of individuals is that others will collect and dispose of the litter (Ong and Sovacool 2012). In the survey by Abdul Aziz et al. (2019) this assumption was reported by 36%. Lack of awareness of the consequences of littering was given as a reason by 47% in Abdul Aziz et al. (2019) and by 0-69.4% in Hansmann and Steimer (2017), depending on whether one meant one's own (0%) or others' littering behaviour (55.7%) and whether one had previously had a conversation on the topic (43.5% own behaviour, 69.4% others' behaviour).

Rath et al. (2012) found in a survey that those who do not consider cigarettes as littering and are not aware of their toxic effects on the environment are 3.5 times more likely to litter. Although 86% of the people in the survey considered cigarettes as litter and 74.1% had littered at least once, the frequency of littering was much higher among "unaware" people. Raising awareness about the problematic biodegradability and release of heavy metals and chemicals therefore seems to be an effective method.

3.7. Time of day

Time of day plays a role in littering according to Schultz et al. (2013), Daxbeck et al. (2017) and Patel et al. (2013). Patel et al. (2013) observed that more smokers litter in the Wellington city centre in the evening (85.8%) than at lunchtime (68.1%). They attribute this difference to lower social inhibitions after work, the influence of alcohol, more people from outside the city centre and lower fear of detection and punishment.

3.8. Littering (of cigarettes) is normal

Several studies have found that smokers perceive cigarette littering as normal or do not attribute environmental harm to cigarette butts. (Patel et al. 2013; Abdul Aziz et al. 2019; Rath et al. 2012; Loimayr 2010; Wilson et al. 2014).

For example, the New Zealand study by Patel et al. (2013) on cigarette littering in Wellington city centre finds that 76.6% of smokers carelessly discard cigarette butts. Multiple ashtrays are in sight at every point and never more than 24 metres away. A few smokers also littered right next to the ashtrays. (Patel et al. 2013) According to Wilson et al. (2014), as many as 84% of smokers litter at bus stops in New Zealand.

In the survey by Rath et al. (2012), 74% of smokers say they have already littered, 56% of them in the past month. Interestingly, 91.8% of respondents still consider cigarettes as litter (the study is otherwise consistent with the frequency of littering from other studies). Ong and Sovacool (2012) assign smokers a stronger tendency for littering in general.

3.9. Demographics

According to Schultz et al. (2013), demographic factors account for 85% of littering behaviour, while environment can influence behaviour by 15%. For cigarette butts, demographics influence 62% and the environment 38%.

- Gender: Men litter more frequently (Schultz et al. 2013; Ong and Sovacool 2012; Abdul Aziz et al. 2019; Rath et al. 2012). The American field survey by Schultz et al. (2013) attributes a littering rate of 21% to

men and 15% to women. The Malaysian survey by Abdul Aziz et al. (2019) reports 61% for men and 38% for women.

- Age: Younger people litter more often (Schultz et al. 2013; Kort et al. 2008; Ong and Sovacool 2012; Abdul Aziz et al. 2019; Hietler and Steger 2019; Daxbeck et al. 2017). According to Schultz et al. (2013), under 18-year-olds litter least frequently (13%), 18-29-year-olds litter most frequently (26%), and littering decreases again from the age of 30 (15%).

- Level of education: The higher the level of education, the less the respondents in Malaysia litter (67% - 44%), but at the highest level of university degrees, littering increases again to 65% (Abdul Aziz et al. 2019).

- Unemployment: Among the unemployed in Malaysia, 71% reported littering (Abdul Aziz et al. 2019).

- People in rural areas are more likely to litter: this is observed by both Schultz et al. (2013) in the Americas and Ong and Sovacool (2012) in Asia (Singapore and Japan).

- Visitors litter more often than residents (Ong and Sovacool 2012; Cingolani et al. 2016; Daxbeck et al. 2017). Cingolani et al. (2016) finds that the amount of littering per person is higher on high-traffic beaches in Argentina than on low-traffic beaches. They attribute this effect to the fact that low-traffic beaches have more locals and environmental enthusiasts who care more about beach cleanliness. In addition, they note that the number of visitors increases with heat, and on hot days more drinks are consumed and more waste is generated per person (Cingolani et al. 2016, p. 39).

- Singles litter more often than married people: 64.2% of singles have littered (Abdul Aziz et al. 2019).

4. Reduction of Littering

Littering is an increasingly important problem for the environment. With the Action Plan for the Circular Economy and in particular with the Plastics Strategy, the EU would like to address this issue. The Single-Use-Plastic Directive emerged from this problem in 2019. The aim of this directive is to curb marine litter. The directive includes partly precise and partly general measures. It affects single-use plastic items, as these are estimated to account for 87% of the littered plastics in the oceans, fishing gear made of plastic, and items made of oxo-degradable plastic (plastic which is easily fragmented by heat, UV rays and oxygen after actual use). The EU defines single-use plastics as items that are used only once or for a short period of time and then disposed of. Specifically affected are cotton swabs, cutlery, drinking straws, lightweight plastic carrier bags, plates, stir sticks, balloon wands, and expanded polystyrene food packaging, beverage containers and cups. The measures are intended to encourage consumers to consume sustainably. This can be done by means of economic or other instruments (European Union, 2019). Through the European Union Directive (2019), the following points are to be implemented by member states:

- Achievement of separate collection quotas. These are to be achieved through extended producer responsibility, separate collection quotas for single-use plastic beverage bottles, and/or deposit systems. By 2025, 77% of single-use plastic items placed on the market must be collected separately, and by 2029, 90% of these must be collected separately.
- Introduce awareness measures to inform consumers about availability of reusable alternatives, reuse systems, as well as the impact of littering. This is to be done by means of a labeling requirement on feminine hygiene products, wet wipes, tobacco products and beverage cups.
- A restriction on the marketing of conventional cotton swabs and disposable drinking straws, cutlery, plates, stirrers, balloon wands, as well as food packaging, beverage containers and cups made of expanded polystyrene.

Austria is attempting to implement the directive by restricting the marketing of certain items and achieving separate collection quotas. To this end, possible solutions are under discussion. These include the possible introduction of a deposit system (BMK, 2020). In Germany, a deposit system on PET beverage bottles, beverage cans and glass bottles has already been in place since 2003, with which collection rates of 98% can be achieved (Hauer, et al., 2020).

In order to implement the Single-Use-Plastic Directive, measures must be developed to increase the willingness of consumers to assume responsibility. To this end, special attention must be paid to educating and raising awareness among the population (Stoifl & Oliva, 2020). Some EU member states and Switzerland are already implementing a variety of measures. It is important that a situation-specific combination of measures is always chosen to reduce or prevent littering. Using combinations can lead to better results than applying single measures (Stoifl & Oliva, 2020). Anthropogenic pressures on areas affected by littering should also be considered when choosing measures (Gonzalez, et al., 2016). It is also important that measures not only raise awareness among the population, but also focus on desired behavior (Straughan et al., 2011).

The anti-littering measures described so far can be classified according to different aspects. Berger, et al. (2008) first divide the measures into the following categories:

- social network
- communication
- incentive systems

- monitoring/Intervention
- disposal infrastructures
- spatial design
- formation or change of the consumption offer

Subsequently, the measures are characterized according to their

- level of impact (social control, norms, correct behavior, incentives and prohibitions, valorization of public space) and
- impact classification (target group-specific, situation-specific, product-specific, reach, perception by polluters).

Stoifl and Oliva (2020) simplify this breakdown into three categories in their litter report:

- awareness and education measures
- measures to change situational conditions
- measures concerning sanctions and incentive systems

In order to gain a better understanding of the littering situation in Austria, an additional international comparison was made. This should help to understand this worldwide occurring problem in context and to illustrate how littering is dealt with in other countries. Table 1shows a comparison of measures from Switzerland, Austria and Singapore described in the literature. The classification of the measures was based on the classification of Stoifl and Oliva (2020), since the classification according to Berger et al. (2008) would be too complex here. In the following, examples from the countries are given for the individual categories.

In Singapore, it is a punishable offense to litter bottles, cans, food packaging, glass, cigarette butts and other litter in public places. In addition to penalties, the government has introduced Corrective Work Orders, with the aim of improving behavior in the long term. This work provides for those punished to litter in public places for up to 12 hours to collect litter in public places (Ong, 2012). The first littering offense is subject to a fine of up to $2,000, after which the fine increases to up to up to $10,000 (Boh, 2017). The government launched the "Keep Singapore Clean" campaign in 1968 to educate the population about the importance of a clean and litter-free cityscape. Since then, there have been annual exhibitions, beach clean-ups, and lectures on the impact of on the environment and the need to keep the city clean. Despite the efforts to raise awareness through environmental education, the number of Littering offenses increased. The government needs to spend $110 million each year on litter removal Litter and cleaning up the city (Ong, 2012). In 2016, there were 31,000 fines for Littering offenses, the highest in the last 7 years. Throughout Singapore, signs indicate the high littering fines, but the city is only truly clean where the bans are controlled. On the streets of the outer suburbs, one finds a lot of garbage and the pure city image does not apply much. The Ministry of the Environment admits that high fines cannot guarantee cleanliness, but only through Environmental education with long-term approaches can change behavior (Plutta, 2012).

In the U.S., millions of dollars are spent annually to clean up littered streets, parks and coastlines. Each state has laws prohibiting littering, but penalties vary however, depending on the amount, type, and location of the litter. For example, in 10 states the weight or volume of the trash determines the amount of the fines, other states focus on the type of waste. For relatively minor cases, the typical fine is a community service. Fines vary by state to state and range from $20 in Colorado to $30,000 in Maryland. In serious cases of littering, jail time can also be imposed, from 10 days in Idaho to 6 years in Tennessee. The severity of penalties increases in all states when offenders are repeatedly littering (Schultz et al., 2014).

"Keep America Beautiful" is a non-profit organization with the goal of reducing and prevent littering. Founded in 1953, there are now 600 partners with millions of volunteers. Environmental education in schools and universities reduced littering on U.S. campuses by 38% (Lowman, 2017).

Table 1: Comparison of anti-litter measures in Switzerland, Austria and Singapore.

Schweiz Berger et al. (2008)	**Österreich** Stoifl und Oliva (2020)	**Singapur** Ong und Sovacool (2011)
Incentive systems/monitoring	**Incentive systems/monitoring**	**Incentive systems/monitoring**
Deposit systems Competitions Penalties Police and security services Financial reward for cleaning up	Deposit systems Competitions Penalties Increased controls (ex. Waste Watcher Vienna), Littering fee (extended producer responsibility)	 Penalties Community service instead of fines
Raising Awareness	**Raising Awareness**	**Raising Awareness**
Intervention by peers Litter ambassadors and presence cleaning Space sponsorships, Participatory spatial planning Citizen Science Awareness-raising campaigns Media releases Art Waste lessons and waste events	Peer-to-peer communication Litter ambassadors, Involvement of businesses Space sponsorships Establishment of role models Information campaigns Online platforms Visual nudges Communication and education at institutions, Clean-Up Days	 Information campaigns at public events and in communities Education in schools
Changing situational conditions	**Changing situational conditions**	**Changing situational conditions**
Frequent cleaning Designing waste disposal infrastructures (e.g. temporary waste disposal infrastructure) Waste reduction through packaging minimisation, Quality of materials Design of recreational infrastructures	Increase cleaning frequencies Improve disposal infrastructure Packaging design	Regular cleaning of public spaces

4.1. Incentive systems / punishment

In Austria, there is only one province, namely Vienna, in which a law against littering exists. It is the Wiener Reinhaltegesetz (Vienna Cleanliness Act) (Loimayr, 2010). "The aim of this law is to keep streets with public traffic, publicly accessible green areas as well as publicly accessible water areas free of litter" (Wiener Landtag, 2007). This has been in use since February 2008. The law authorises employees of Employees of the Vienna Municipal Department MA48 (the Waste Watchers), as well as additional persons from Wiener Wasser, Gewerbetechnik, Feuerpolizei, Wiener Gewässer, Forst- und Landwirtschaftsbetrieb, Stadtservice and Wiener Stadtgärten to punish violations of the Vienna Cleanliness Act (Thon, 2020). Fines range from 50 to 2000 €. In case of non-payment, imprisonment is also to be expected (Wiener Landtag, 2007). By 2019, a total of more than 83,000 official acts had been enforced. Predominantly the offences "dog excrement" and "cigarette remains" were committed. Frequently, only informative talks take place without a fine being imposed. A total of 15,781 warnings, 55,434 fines, 11,924 charges and 454,671 information talks have taken place so far (Thon, 2020).

Both Switzerland and Austria do not currently use a mandatory deposit system, which is why the German deposit system is cited here as an example. There, a mandatory deposit has been in place for selected

disposable beverage containers since January 2003. This is regulated in the Packaging Act which includes placing packaging on the market as well as its taking back. Before being placed on the market, the packaging must be marked permanently, clearly legibly and in a conspicuous place as subject to a deposit. The minimum deposit is also regulated by law. This is 0.25 € including VAT per package (Federal Law, 2020). In principle, every distributor must take back the packaging that he carries in his assortment (DPG Deutsche Pfandsystem GmbH, see also). This system makes it possible to achieve a collection rate of around 98% (Mayr, 2020).

4.1.1. Punishment

Penalties are a common measure to tackle littering and are accordingly mentioned by many authors. (Bernhofer and Pladerer 2014; Hietler et al. 2017; Hietler and Steger 2019; Patel et al. 2013; Loimayr 2010; Seco Pon and Becherucci 2012; Daxbeck et al. 2017; Hietler and Pladerer 2017). In almost all regions that want to get to grips with littering, penalties are used to some extent. While these are not necessarily the most effective measures, they clearly convey desired and undesired behaviour in a society. The fines in the study by Loimayr (2010) range from 20€ (lower limit in Switzerland and Germany) to 5,000$ in New Zealand. In Japan, Canada, the USA and New Zealand, littering can even lead to a prison sentence. In Singapore, labour service is imposed on a case-by-case basis.

4.1.2. Holding businesses and homeowners accountable

Holding residents and polluters accountable is recommended by (Loimayr 2010). Take-away food outlets (businesses) can be obliged to take measures against littering. McDonalds, for example, has conducted a campaign on the issue and in Ireland businesses had to collect litter they indirectly cause 100 metres around their shop (Loimayr 2010).

4.1.3. Deposit on beverage containers and mandatory reusable quota or levies

In some studies, deposits on beverage containers are mentioned as a suitable means of reducing littering (Bernhofer and Pladerer 2014; Hietler et al. 2017; Hietler and Steger 2019; Cierjacks et al. 2012; Daxbeck et al. 2017; VABÖ 2017; ARA 2019; Hietler and Pladerer 2017; Hauer et al. 2020).

The introduction of a mandatory deposit on disposable beverage containers with an appropriate deposit amount is essential to act against littering. German Federal Environment Agency also emphasises the effectiveness of deposit systems to reduce littering and increase the collection of recyclables. (Umweltbundesamt 2019). The distribution of reusable dishes with a deposit instead of disposable dishes can also contribute to a reduction in littering (Vogl 2011).

4.2. Awareness raising

In Switzerland, so-called litter ambassadors are appointed at various locations. These are people who are not tied to a specific location and who are supposed to raise awareness of littering by talking to the users of public spaces. In addition, a recycling mobile is used to collect litter in a demonstrative manner. In this way, the population is to be motivated to deal correctly with frequently littered waste. The ambassadors do not act as lecturers and can thus contribute to a positive experience of the population (Berger et al., 2008).

In Austria, field cleaning campaigns take place regularly in all federal provinces. These are carried out by provinces, municipalities, schools, fire brigades, mountain rescue services and many other institutions. By

collecting the litter together, the aim is to raise awareness among the population. The litter clean-ups are often accompanied by awareness-raising campaigns (Loimayr, 2010).

4.2.1. Awareness-raising measures

Awareness-raising measures are among the most frequently mentioned measures to combat littering. (Bernhofer and Pladerer 2014; Hietler et al. 2017; Kort et al. 2008; Cingolani et al. 2016; Mapotse and Mashiloane 2017; Abdul Aziz et al. 2019; Ong and Sovacool 2012; Schultz et al. 2013; Daxbeck et al. 2017; Cierjacks et al. 2012; Loimayr 2010; Seco Pon and Becherucci 2012).

Schultz et al. (2013) found that littering is 85% dependent on personal/demographic factors, while environment only accounts for 15%.

4.2.2. Awareness raising campaigns

Campaigns are a popular form of awareness raising and are mentioned by some authors. (Bernhofer and Pladerer 2014; Hietler et al. 2017; Kort et al. 2008; Schultz et al. 2013; Cingolani et al. 2016; Ong and Sovacool 2012; Loimayr 2010; Daxbeck et al. 2017; Seco Pon and Becherucci 2012).

4.2.3. Active awareness raising in schools

Awareness raising in schools is mentioned in most of the papers that discuss or recommend interventions (Bernhofer and Pladerer 2014; Abdul Aziz et al. 2019; Kort et al. 2008; Mapotse and Mashiloane 2017; Ong and Sovacool 2012; Daxbeck et al. 2017; Loimayr 2010). There is a range of creative awareness-raising interventions around the world that actively engage students. In the Seychelles, the exchange project "Zero Tolerance towards Litter" took place in 2003 with two partner schools, developing a Zero Litter Plan for 2005. In Eco Schools near the North Sea, students learned about keeping the coasts clean through field trips, workshops and discussions. In Luxembourg, posters were created in art classes as part of an anti-litter campaign.

4.2.4. Personal talks

Face-to-face conversations are mentioned as effective measures by Bernhofer and Pladerer; Cingolani et al.; Hansmann and Steimer; Mapotse and Mashiloane; Daxbeck et al. (2014; 2016; 2015; 2017; 2017). Personal conversations can lead to a reduction in personal littering, especially through a positive relationship with the conversation partner and greater reflection on one's own actions. In a survey by Hansmann and Steimer (2015), conversations were clearly preferred to anti-litter posters (also presented there).

4.2.5. Voluntary clean ups

Hallway cleaning campaigns are a suitable measure to prevent littering and to create awareness. (Hietler et al. 2017; Ong and Sovacool 2012; Mapotse and Mashiloane 2017; Daxbeck et al. 2017; Loimayr 2010; Mayerhofer et al. 2018; ARA 2019; Hietler and Steger 2019).

Personal contact and visible corridor cleaning: Cingolani et al. (2016) conducted a study on beaches in Argentina where 1-2 times per day all visitors present were personally asked not to litter and subsequently cleaned up the litter on the beach.

4.2.6. Anti-litter slogans (posters, billboards, etc.)

The usefulness of anti-littering slogans is mentioned in a large proportion of publications. (Bernhofer and Pladerer 2014; Kort et al. 2008; Hansmann and Steimer 2016, 2015; Loimayr 2010; Cierjacks et al. 2012; Daxbeck et al. 2017).

Boards with slogans can activate or reinforce personal norms and thus positively influence littering behaviour. Hansmann and Steimer (2016) recommend focusing on environmental or funny slogans, as these reduce littering more (64% and 58%) than authoritarian slogans (25%), which could only achieve higher reductions in combination with threatened punishments. Funny and environmental slogans are also better at reinforcing personal norms, as they are more easily accepted by passers-by.

4.2.7. Anti-litter signs (explicit)

Most authors observe a decrease in littering through the use of posters, slogans, etc. (Schultz et al. 2013; Kort et al. 2008; Bateson et al. 2013; Hansmann and Steimer 2016, 2015; Loimayr 2010). Only Keizer et al. (2011) states that an anti-litter sign leads to more littering in a dirty environment, while in a clean environment they share the observations of the other authors.

Anti-litter signs can be explicit (slogan) or implicit ('watching eyes', mirror above the container in which one sees oneself) (Kort et al. 2008; Bateson et al. 2013). Kort et al. (2008) observed a similarly strong reduction of about 50% with both variants. A combination of both variants does not lead to an increased reduction. However, young people (20-40 years) react more strongly to the explicit posters, while older people (40+ years) react more strongly to the implicit signs. Bateson et al. (2013) determined that the implicit effect of "watching eyes" (stickers on bicycle racks) only leads to a reduction in littering when other people are present. In the study by Kort et al. (2008), people were always present (shopping centre), so there are no results on the topic here.

For the selection of slogans, Hansmann and Steimer (2016) examined the popularity of environmentally conscious, humorous and authoritarian slogans in a survey. The environmentally conscious poster (64% litter reduction) and the humorous poster (58% litter reduction) performed far better than the authoritarian poster (25% litter reduction).

4.3. Changing situational conditions

In Singapore, regular cleaning of public spaces is a central point in the litter prevention strategy. One of the agencies responsible for cleaning is the National Environment Agency (NEA). The NEA is responsible for the removal of littered waste along public roads and walkways as well as public beaches. Depending on how intensively the areas are used by the population, they are cleaned daily or on alternate days (Ong & Sovacool, 2011).

4.3.1. Disposal infrastructure

The disposal infrastructure should provide sufficient public waste bins close to the source of waste generation and with good visibility, and empty them sufficiently often. Loimayr (2010) recommends a large opening, robust base material and an ashtray on the bins. Schultz et al. (2013) note that convenience of disposal is crucial.

4.3.2. Design of the litter bin

Kort et al. (2008) cite persuasive design as an increasingly researched litter reduction measure. This involves designing the bin in such a way that individuals are instinctively enticed to dispose of it correctly (Kort et al. 2008).

4.3.3. Clean and well-maintained environment

A clean and well-maintained environment is recommended by some authors (Hietler et al. 2017; Kort et al. 2008; Schultz et al. 2013; Cingolani et al. 2016; Rangoni and Jager 2017; Weaver 2015; Vogl 2011).

Regular cleaning can reduce littering as it is no longer perceived as the typical behaviour in the neighbourhood (Cingolani et al. 2016).

A selection of measures in awareness-raising campaigns include anti-littering comic contests (Switzerland), photo competitions (Germany), gift campaigns (IPad prize opportunity for proper littering, Switzerland), awarding red cards with Italian referee Pierlugi Collina to chewing gum offenders (London), Awards ("Blue Flag" to committed people on beaches in the North Sea), sending plastic bags to reported drivers asking them to use them next time (Texas), celebrities as advocates, sustainable celebrations (Green Events, Austria-wide), handing out ashtrays to passers-by (Styria) and the use of mascots (South Africa). In campaigns, cinema and TV commercials, posters, homepages and social media, among others, can be used to raise awareness of the issue. (Loimayr 2010)

The Austrian Alpine Club started this campaign in 1970, placing anti-littering signs along paths, starting points and huts. The action has had a strong impact over the years.

4.4. Consideration of the type of use

In the literature available so far, several waste fractions are always considered simultaneously (Berger et al., 2008; Stoifl & Oliva, 2020; Straughan et al., 2011). The sorting analysis shows that, especially with high visitor pressure, less than 50% of the littered waste is plastic. Therefore, other waste fractions should also be addressed when implementing measures. Thus, more detailed data on other waste fractions are needed for the formulation of specific measures. Since the focus of this work is on plastics, the overall waste composition requires additional investigation. Furthermore, the effectiveness of the measures cannot be assessed across the board (Berger et al., 2008). The results of the sorting analysis show that the specific use of the areas has a great influence on the composition of the littered waste. In some cases, the composition changes considerably and certain plastic items are littered more or less often. Berger et al. (2008) also mention the influence of local conditions of sites on the waste composition. Furthermore, Hietler and Pladerer (2020) mention the relevance of evaluating measures. However, there are no evaluations of the measures applied so far.

Since there are no evaluations and the data basis for the specific land uses is insufficient, it is not possible to formulate specific measures. Nevertheless, recommendations for possible measures are to be given here in order to provide orientation or assistance for their elaboration. For the formulation of possible measures, the sampling areas are assigned to three area types in the following. The allocation is based on the respective visitor pressure of the area and the differences in waste composition. Unless otherwise stated, these are observations and conclusions based on the sorting analysis.

4.4.1.Areas with short, dynamic stay

The sampled area in the Danube Floodplain National Park belongs to areas with a short, dynamic stay. Passers-by are merely walking, running or cycling here. A few fishing huts can also be found along the bank. Since most of the activities carried out here are very short-lived, hardly any littering takes place on this area. As already mentioned the objects collected here are washed up by the Danube. Mayerhofer et al. (2020) also found this to be the case during their investigations in the National Park. Since no or hardly any direct littering takes place, a reduction of plastics can only be achieved through measures to change situational conditions, in the sense of regular cleaning.

4.4.2. Areas with long, static or dynamic stays

Areas with long, static or dynamic stays include some areas on the Danube Island and some sections of the Danube Canal. In these places, passers-by usually stay for a longer period of time. However, there are still differences in the specific type of use. The areas can be differentiated according to static and dynamic stay. Furthermore, a distinction can be made based on the specific activities carried out on the areas, such as barbecues, where the consumption of food is in the foreground, or sunbathing lawns, where mostly a cosy get-together with small sporting activities takes place. This generates different plastic waste compositions. Barbecue areas and barbecue sites are a hotspot for littering. To change this, measures from all categories of measures described in chapter 2.3 should be used. For example, informative signs could be placed at these places, improved disposal options could be offered and a more conspicuous design of the litter bins could be undertaken. For the concretisation of the measures, the user groups should be included in any case.

The distinction between stationary and dynamic areas was made by comparing the waste composition of the areas on the underground stations U1 bridge and the U6 bridge at the Danube Island. The collection around the station U1 can be considered a dynamic area. There are benches and meadows here, but the majority of passers-by do not stay here as long as on the static areas. The collection on the lawn near the U6 bridge can be described as a static area.

If all plastics that were littered on surfaces with a long, static or dynamic stay are considered, a reduction of up to 16% of the littered mass is made possible with the introduction of a deposit system or a reusable use of PET beverage bottles. It is interesting to note that the share of PET beverage bottles is lower when considering the number of units. This amounts to only 4%. This is because a littered cigarette butt is lighter than a littered PET beverage bottle.

Since plastic packaging accounts for 40% of the littered pieces and 56% of the littered mass of plastic waste, measures for the reduction of flexible and hard plastic packaging should also be developed. The differences in the littered cigarette articles depending on the collection location show that the structural condition of the surfaces, i.e. the specific usability, also has an influence on the waste composition. The problem of littered cigarette butts is described in several studies on littering (Blarer & Kull, 2018; Hietler & Steger, 2019; Stoifl & Oliva, 2020). All of them mention that cigarette butts are usually among the top 3 littered objects in terms of number of pieces. Some European cities, including Vienna, are already taking action against cigarette butt littering by means of fines. However, implementation is difficult (Stoifl & Oliva, 2020). Therefore, it is suggested to focus on awareness-raising measures in combination with better placement of ashtrays or the distribution of pocket ashtrays.

4.4.3. Urban areas with dynamic and partly static stay

Urban areas with dynamic and partly static stay are areas that are located in cities but due to their location are not visited as often. The sampling area at the Danube Canal between the slip road A22 and Spittelau-Gürtelbrücke is such an area. To underline why this area needs different measures than the sampling area between Schottenring and Schwedenplatz, the comparison of the two collections can be used. The main differences are the share of cigarette articles, medical waste, the high share of paper and the general cleanliness between Schottenring and Schwedenplatz. In order to reduce the plastic input into the Danube Canal starting from the sampled stone wall between the slip road and the Gürtelbrücke, investments should be made in more frequent cleaning of the area. However, a reduction in the occurrence of littering must also be strived for. A deposit system or the reusable use of beverage bottles and cans can also reduce littering in this area. As a possible approach to solving the problem of littered medical waste, increased controls could be introduced, since the mere presence of control bodies can have an influence on drug consumption (with regard to the generation of medical waste).

5. Ideas and best practice examples

5.1. Repressions - Waste Watchers in Vienna - Austria

Waste Watchers have been on the move since February 1, 2008 and are punishing impurities. Internationally, Vienna is one of the cleanest cities and cities with the highest quality of life. Initially ridiculed, the high popularity ratings of the control force and the drastic decline in illegal deposits prove the correctness of the measures taken. In the meantime, Vienna has served as an international and national model when it comes to cleanliness - both Hamburg and Berlin have adopted the Waste Watcher system; in many of the surrounding municipalities, contamination from dog faeces is also punished (Stadt Wien – MA 48 – Abfallwirtschaft, 2018).

5.2. Others - Fill-up stations for water-bottles

Water refill stations are an increasingly popular waste reduction strategy across the globe with stations implemented in the U.K. (https://refill.org.uk/), North America (https://findtap.com/), south-east Asia (https://refilltheworld.com/map/), and Africa (https://www.idropwater.com/). Considering the placement of stations and the intervention strategy behavioural change will be key to achieving their maximum benefit as an additive strategy for reducing litter (Willis et al., 2019).

Willis et al., 2019 evaluated the success of filtered water refill station, implemented along the Brisbane River in Queensland, Australia. They found plastic bottle litter decreased after a water refill station was put into operation. In Australia where the majority of people have the luxury of safe-to-drink, high-quality tap water, an estimated 10% of water consumption is derived from bottled water.

In Vienna Drinking Water stations are already widely spread (Figure 1, Figure 2).

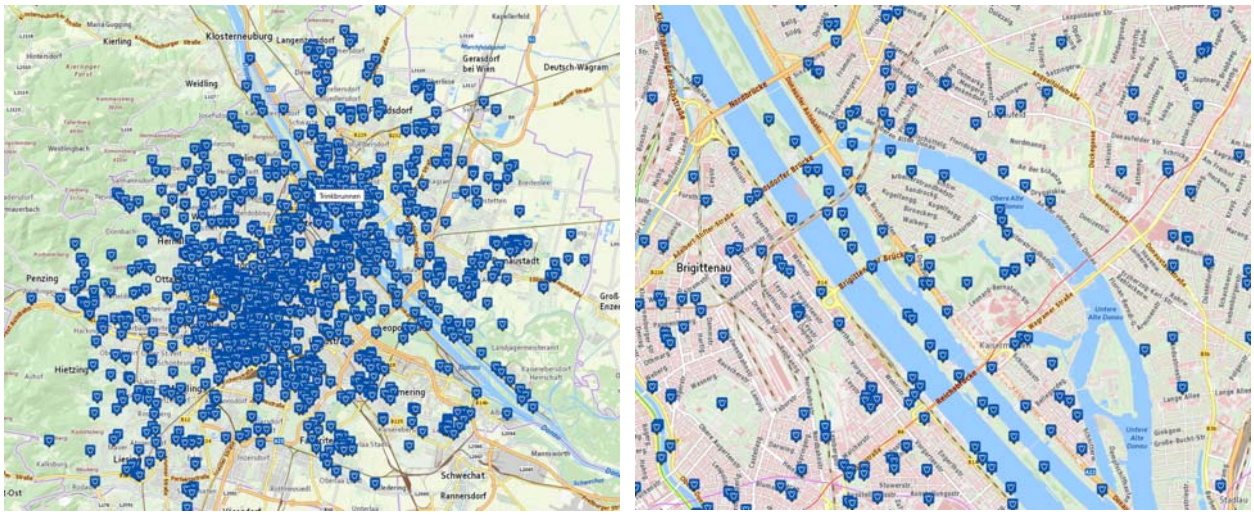


Figure 1: spread of drinking water stations in Vienna (https://m.wien.gv.at/stadtplan/#zoom=12&lat=48.2269&lon=16.4152&layer=trinkbrunnen&base=karte)



Figure 2: drinking water stations in Vienna https://vienna-insight.at/blog/2018/07/31/viennese-water-free-charge-drinking-fountains/)

5.1. Campaigns - "Reinwerfen statt Wegwerfen"

A successful information campaign against littering was already initiated in 2012 by the Austrian economy. "Throwing in instead of throwing away" is the slogan against carelessly throwing away waste in the landscape. It aimed to raise awareness of the problem of waste and in particular of the littering problem., Carelessly throwing away and carelessly disposal are a mirror of our throw-away society (Ökologie-Institut, 2013). More information is available at the webpage www.reinwerfen.at.



Figure 3: Logo zur Kampagne "Reinwerfen statt Wegwerfen" (Ökologie-Institut, 2013)

5.2. Campaigns – "No littering" – Switzerland

The interest group for a clean environment (IGSU) is the Swiss competence center against littering. It campaigns against littering throughout Switzerland and for a clean environment. With its measures, it promotes personal responsibility in dealing with waste. The main goal of the IGSU is to contain the littering problem sustainably. This can only be achieved in the long term by changing attitudes and behavior among the population. Prevention and awareness-raising measures are necessary for this - an approach that the IGSU has been successfully using since 2007.

The IGSU supports cities, municipalities, schools and other actors affected by littering free of charge in the planning and implementation of their own measures against carelessly throwing away or leaving waste in

public places. Since 2017, it has been awarding cities, municipalities and schools that are actively committed to littering with the no-littering label (https://www.no-littering.ch).

As measures against littering IGSU recommends on its website (IGSU, 2020):

- Order our posters and use them in locations that are littering.
- Take part in the national clean-up day and free the public space from Littering together with friends, your family, your club or your company.
- Get involved as a sponsor and voluntarily take responsibility for the cleanliness of a selected section or area (Raumpatenschaften).
- Become an IGSU ambassador against littering.
- Support us against littering and become an IGSU fan on Facebook.
- Place enough recycling bins and waste bins. You can also find helpful information at Swissrecycling.
- Distribute pocket ashtrays and waste bins and motivate people to dispose of cigarette butts correctly.

5.3. "Sponsorships" = Raumpatenschaften

Based on the research and interviews, it can be concluded that sponsorships represent a promising approach to improve cleanliness in public space in Switzerland that has already been successfully implemented in many places. There were problems and obstacles with individual projects, but these could be overcome. Sponsorships in most cases contribute significantly to reducing littering and increasing cleanness in public spaces and can thus help to reduce the cleaning effort for cities and communities. The many positive examples and working approaches and approaches that were described in interviews can contribute substantially to avoiding problems or obstacles for future sponsorship projects. A "Guide to Spatial Sponsorship in Practice" was therefore derived from the knowledge gained in the sense of a best practice approach (Steimer and Ralph, 2016).

5.4. No littering label - Switzerland

The no-littering label honors cities, municipalities and schools that actively and effectively takes actions against littering as public institutions play a central role in combating littering - not only in terms of cleaning, but also in terms of awareness-raising, prevention and repression. In order to support them in their efforts, the Interest Group for a Clean Environment (IGSU) awards the no-littering label. The label must be applied for via the web form, is provided free of charge if all conditions are met and can then be used in all communication.





Figure 4: No-Littering Label (https://www.no-littering.ch/)

The results of the latest survey by the IG clean environment (IGSU) and the numbers of IGSU measures carried out annually show: Awareness raising of people and a dense collection infrastructure work against littering. For the fourth year in a row, the Swiss population has the impression that littering is decreasing. Swiss cities and municipalities are also seeing a slight improvement (IGSU, 2019).

6. Literature

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