PlasticFreeDanube

REPORT ON THE POSSIBLE IMPACT OF MACRO-PLASTIC WASTE POLLUTION IN AND ALONG THE DANUBE

[Subtitle if any]

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1. Introduction

Danube, the longest river within European Union – and second-longest on the continent. Its starting point is in the Black Forest in Germany and flows all the way in the direction of South-East till reaches the Black Sea in Romania. Danube is 2,860 km and flows through or makes part of the border of ten countries: Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Romania, Bulgaria, Moldova and Ukraine. It provides fresh drinking water for about 10 million people, with this Danube is one of the most important sources of water in this area. The Danube River Basin (DRB) covers an area of 801,463 km^2 that represents 10 % from the surface of Europe. Water quality in the Danube River Basin is largely influenced by the inputs of pollutants as nutrients, organic material, and hazardous substances.

After identifying the types of plastic waste, determining the possible origin (Act. 5.2), summarized in Report 5.2.1 [1] of PlasticFreeDanube project, as well as the fragmentation of typical plastic waste present in Danube waste (Act. 5.3) [2], in this report possible impacts and risks for the environment, animals and humans are identified.

Plastics can serve as media for the concentration or transfer of toxic substances, such as polychlorinated biphenyls, which can thus also enter living organisms. In addition, polymers are usually blended with various other components to improve their performance. These additives include inorganic fillers such as SiO_2, carbon black and the others, which improve their mechanical properties, plasticizers to improve their flexibility, heat and light stabilizers, various flame retardants and paints. This activity 5.4 identifies hazardous chemicals in plastic products and estimates their potential risk to living organisms.

In 2015, the Austrian Environment Agency found that 25-145 kilograms of plastic were floated away from Austria on the Danube every day. An average 40 tons of plastics leave Hainburg on the border with Slovakia every year. The plastic input via the Danube into the Black Sea was estimated to 4.2 tons per day [3].

The Joint Danube Survey 3 group, operating under the auspices of the International Commission for the Protection of the Danube River (ICPDR), has listed the top 20 substances that currently pollute Danube [4]. Only 7 of them are registered and under constant legislative supervision.

2. Impact of macroplastics in rivers

The biggest problem nowadays are the plastic islands in the ocean, but the main contributor to this problem are rivers. It has been estimated that about 90 percent of the plastic polluting our oceans comes from just ten rivers [5]. Eight of these rivers are in Asia, while the remaining two, the Nile and the Niger, are in Africa. There is lack of information about American rivers. In Guatemala, for example, there are almost no well-managed landfills and no public water treatment plants. The result is harmful sewage, industrial and agricultural drains where plastic waste is located. The beaches here and in neighbouring Honduras are regularly full of toothbrushes, old syringes, PET bottles, plastic packaging and foils. [6]

Significant research attention has focused on marine plastics, while only 13 % of published studies have been dedicated to plastic pollution in freshwater environments [7]. Of these, the majority (76 %) are on microplastics i.e. unidentifiable plastic pieces < 5 mm in size. Winton et al. [8] collected data about plastics in freshwater from literature in the years 2012-2018. The review of 857 titles and abstracts identified 27 European freshwater litter studies as meeting the criteria defined in the article. The studies were from France, Germany, Italy, Poland, Switzerland, Republic of Ireland and the UK, or pan-European. But after full texts review, just in nine studies sufficiently robust and numerous data were found. These data were grouped into 15 categories of consumer plastic waste. The top three most prevalent items, "food wrappers", "bottles and lids", and "bags" together made up 22 % of all plastic litter recorded [8]. Schwarz et al. [9] collected and compared data from 23 publications about the composition of plastic waste in different aquatic environments. Six sub-environments were identified: beach, epipelagic, and sediment, for freshwater and ocean. Polymers in this study were categorized to six groups: polyethylene (PE), polypropylene (PP), polystyrene (PS), polyamide (PA), polyester (PES) and others (which included PET, PVC, PMMA, EVA, PAN, PVOH, and alkyd polymers). PE was proportionally dominant in all environmental compartments, followed by PP and PS. In freshwater beach PE, PP and PS together represent on average 92.2 % of encountered polymers. Least observed were PES, PA, and "others". In freshwater epipelagic and sediment was "others" relatively high due to high PET contributions. In sediment polyester, PA, and PAN (and others) were often encountered; often these polymers are associated with fibre-based products [9].

The harmful effects of plastics on the environment can be considered in roughly five categories, their severity depending on an item's size and shape [10]:

- Ingestion of plastics;
- Entanglement in plastics;

- Breakdown in microplastics;
- Leakage of toxic additives and accumulation of toxins;
- Human livelihood.

When animals ingest plastic, it can have physical or nutritional problems. These problems include starvation (due to gut obstruction), a false feeling of satiation, reduced fitness, changes in behaviour, and affected reproduction and growth [11]. Some problems may be exacerbated by the presence of plasticizers in the particles themselves or by the presence of other toxic pollutants that have adsorbed to the surface [12].

Entanglement in plastic material has been recorded often in marine environments, often because effects of entanglement are more obvious compared to, e. g. ingestion. Mainly animals are entangled in abandoned fishing gear, due to the size and the nature of the material. However, fishing activities take place in riverine systems as well, although not in such quantities compared to the oceanic fishery.

Depending on the exposure rate of the plastic to ultraviolet (UV) and mechanical forces, plastics can either remain intact for decades or break down into smaller fragments [13]. As it was analysed in our report 5.3.1 [2], due to various degradation mechanisms, macroplastics tend to break down into smaller pieces until the size of micro and nanoplastics. Plastics can accumulate chemical contaminants from the surrounding aquatic environment due to their physical properties, such as size, shape and surface area, and the chemical properties of the specific polymer. The longer a plastic particle remains in the aquatic environment, the more concentrated the contaminants can become as they accumulate on the particle surface over time. Fragmentation, degradation, and weathering, which occur over time in the aquatic environment, increase the surface area-to-volume ratio of the plastic [14].

Pieces of plastic debris also adsorb various pollutants, thus, when an organism ingests the plastic, it is also ingesting contaminants that have collected on the plastic. Plastics may themselves contain toxins such as bisphenol A (BPA), phthalates, or vinyl chloride, depending on the type of plastic [12].

Plastic debris in river systems directly affects human livelihood, through economic losses and increased flood risk in urban areas. Like the marine environment, plastic pollution in riverine ecosystems can damage shipping and transport vessels [15]. Plastic debris accumulates on riverbanks, potentially affecting tourism or real estate value.

The chemicals found in plastic debris can be classified in the following four categories of origin [16]:

- Chemicals intentionally added during the production process (additives such as flame retardants, plasticizers, antioxidants, UV stabilizers, and pigments);

• Unintentional chemicals coming from the production processes, including monomers (e.g. vinyl chloride, BPA, etc.) which may also originate from UV radiation onto the plastic waste and catalysts, normally present in traces (ppm);

• Chemicals coming from the recycling of plastic waste;

• Hydrophobic chemicals adsorbed from environmental pollution onto the surface of the plastics.

Additives improve polymer properties, affect the processability of the polymer, or protect it from degradation processes. Detailed description of additives used for polymer processing are described in our preliminary 5.2.1 Report on types, additives and attached substances of the collected plastic [1].

Plastic debris sorbs polychlorinated biphenyls (PCBs) and dichlorodiphenyldichloroethylene (DDE) about one hundred times better than naturally occurring suspended organic matter (PCBs and DDE sorb to polyolefin debris). PCBs are also good sorb to polystyrene [17]. Chen et al. [18] focused to endocrine disrupting chemicals adsorbed in plastic debris as androgens, progestogens, and glucocorticoids. Among all the estrogens, the highest detection frequency was found for BPA (75 %), followed by bisphenol S (BPS, 68 %), octylphenol (63 %) and nonylphenol.

The most commonly used chemicals released from plastics include:

Bisphenol A (BPA)

Inner linings of food cans, reusable water bottles, and baby bottles are manufactured using BPA. The process of BPA leaching from plastics is accelerated by storing acidic or basic items that can breakdown plastic polymers, exposure of the plastic container to high temperature, and by repeated washing of the plastic container. BPA is an endocrine disruptor which mimics estrogen in females. Women exposed to BPA have damaged health system such as polycyclic ovarian syndrome, obesity, recurrent miscarriages, endometrial hyperplasia and sterility [19]. The health risks of BPA are fiercely debated and, after more than 70 years of study, are still not fully understood. Monomeric BPA is classified as "weak estrogen and endocrine disruptor" [20].

Phthalates

In industrial applications, particularly in the manufacture of food packaging, raincoats, medical devices, toys, hoses, vinyl flooring and shower curtains, high molecular weight phthalates are commonly used. Phthalates with low molecular weight especially dibutyl phthalate (DBP) and diethyl phthalate (DEP) are used as solvents in the manufacture of products such as lacquers, coatings, varnishes and personal-care products. Lack of chemically bound between phthalates and the plastic matrix makes it easy for phthalates to leach out and contaminate the environment [21]. Phthalates are endocrine disruptors with antiandrogenic activity [19].

Brominated flame retardant

In the production of plastics, brominated flame retardants are raw materials used for safety purposes. The most commonly used brominated flame retardants in plastic production are tetrabromobisphenol A (TBBPA) and polybrominated diphenyl ethers (PBDEs). These are present in a variety of plastic products such as electronic thermoplastics (e.g. computers, phones and televisions) and textiles. PBDEs and TBBPA are hormone disruptors, altering the activities of thyroid hormones and oestrogen, thereby causing impaired development of both the nervous and reproductive systems [21].

Polychlorinated biphenyls (PCBs)

PCBs ingestion may cause reproductive disorders, enhance disease proliferation, alters hormone levels and death [19].

Metals

Metals can be added to plastics during the manufacturing process. However, metals are also found in the water column and sediments from a variety of other sources, and they can also sorb to plastic debris. Metal ions, such as aluminium, antimony, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, tin, uranium, and zinc, have also been shown to sorb to plastics in the aquatic environment [14].

Polymerisation reactions using for producing polymers are rarely complete, therefore, also unreacted residual monomers can be found in the polymeric material, several of which are hazardous for human health and the environment [22]. Chemicals that may leach from plastic into water include phthalates from PVC, nonylphenol compounds from polyolefins, brominated flame retardants (BFRs) from ABS or urethane foam, and bisphenol A (BPA) from polycarbonate [17]. Antimony trioxide is used as a catalyst for the production of PET and rubber vulcanization. Plastics made from PET must be prevented from high temperatures so as to prevent the leaching of some toxic additives such as acetaldehyde, antimony and phthalates. Antimony is a possible human carcinogen. PVC is considered highly toxic due to the presence of chemical constituents like heavy metals, dioxins, BPA and phthalates. Polystyrene, a type of petroleum-based plastic, contains benzene which is carcinogenic to humans [19].

3. Impact of macroplastics in and along the Danube

In our sampling and sorting of plastics along the Danube we found various kind of packaging, what are usually polyolefins (PE, PP) 40-50 wt.%, which is in line with the production (55 wt.% worldwide). Slightly higher portion of PET of 15-30 wt.% when compared to worldwide production of 7 wt.%. This is because of PET bottles; which people throw away after usage near river banks and also the fact that they can float on the water and are easily carried to the accumulation zones. Similarly, thanks to floating also foamed PS was present in higher amount of 8-20 wt.% than the general worldwide production of 7 wt.%.

In "5.4 Impact assessment - Report on chemical analysis of piece of plastic in the gut of catfish" [23] we have described the plastic found in the gut of catfish (see **Figure 1**). Our study showed that the plastic piece found in the gut of catfish was some PE packaging. Besides some inorganic particles on the surface, the polymer was coated also with some adhered proteins and residua from carbohydrate metabolisms as glyceraldehyde. Since the plastic was relatively big, most probably it blocked the gastrointestinal tract for longer time (high degradation state of polyethylene) and could influence also the retention of other smaller objects as nylon fibers, what together with the interaction with proteins and products from carbohydrate metabolism is not beneficial for the life quality of that particular fish with still unknown impact on the other aspects as overall health and others. It is clear and in literature is nowadays a lot of evidence that macroplastics of relatively big dimension could be swallowed by fishes and create real problems as starvation (due to gut obstruction), a false feeling of satiation, reduced fitness, changes in behaviour, and affected reproduction and growth [10, 11]. Most problematic could be the packaging made from polyolefins with density around 1g/cm^3 resulting in the floating close under the water surface. Additionally, packagings are usually a thin film, which then faster and easily break into to the pieces of size, which could be swallowed by animals.

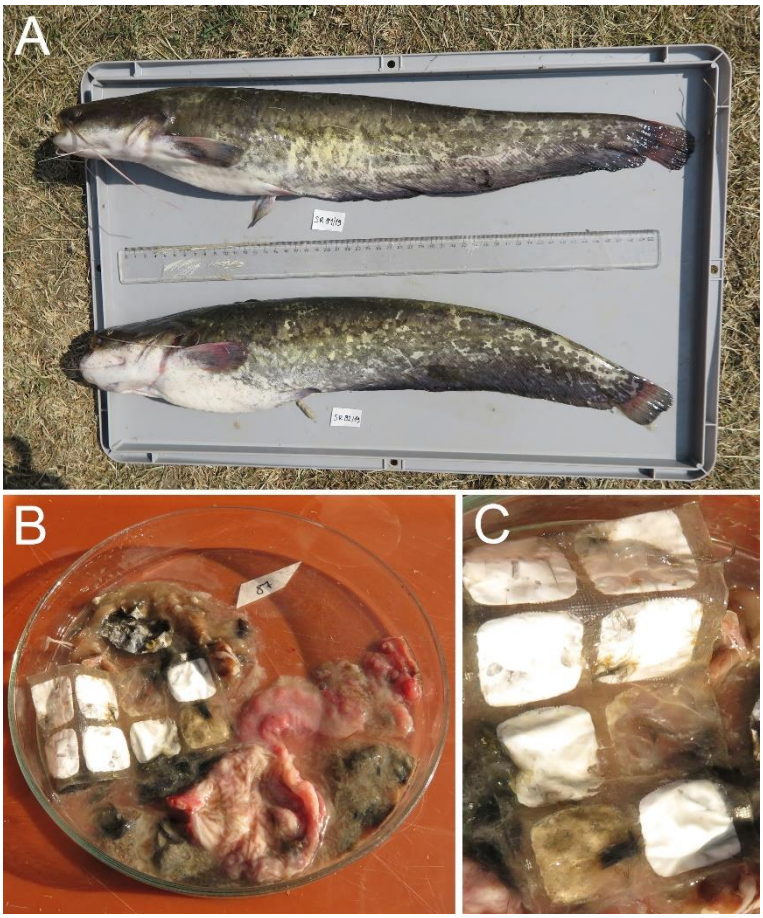


Figure 1. Photo of a) Wels catfish (Silurus glanis L.) caught in the River Bodrog, b) Piece of plastic waste found in the stomach of catfish, c) detail of the relatively big piece of plastic. [23].

In "5.3.1 Report on the abrasion and fragmentation behaviour of macro plastic in fluvial systems" [2] we have showed that the simple mixing of degraded plastic waste in the water could lead to the generation of microplastics. In order to evaluate the presence of microplastics in the case of foamed PS we did heating experiment coupled with optical microscopy. The sample "5 aS" (sample from a leaching experiment, aS means after sedimentation) was drop casted solution of water, where was before present piece of expanded PS. By this experiment we have clearly confirmed the presence of microplastics. In **Figure 2** in orange circles are marked PS microplastics of size ca 10 microns, which then at 190 °C clearly become more transparent (**Figure 2**). It is obvious that for the generation of microplastics in the case degraded plastic waste is in some cases very easy and no extra abrasion forces are needed.

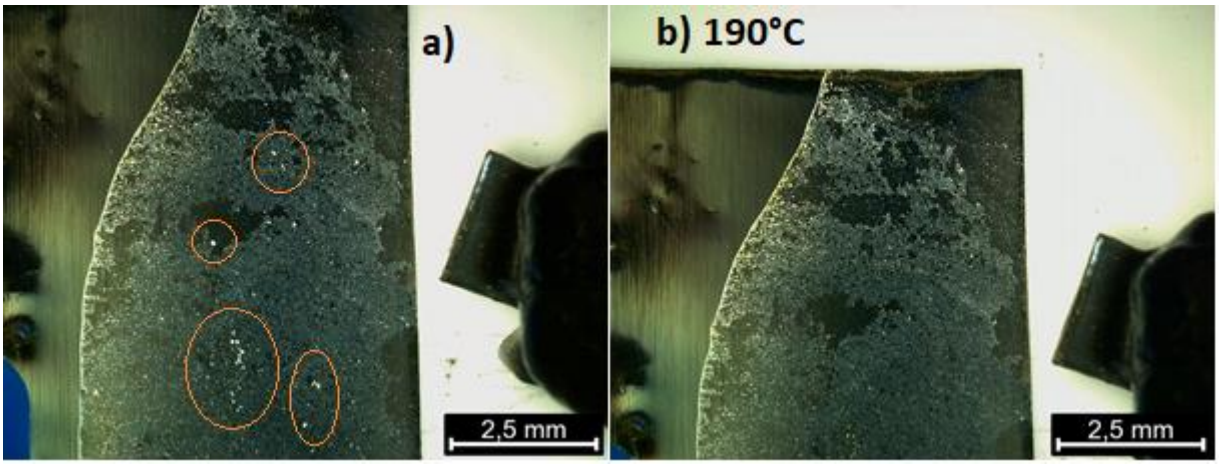


Figure 2. Optical microscopy of sample 5 aS a) at 25 °C and b) at 190 °C. In orange circles (a) are PS microplastics, which disappeared after heating (b) [2].

In "5.2.1 Report on types, additives and attached substances of the collected plastic"[1] we studied the leaching of organic substances and metal ions from plastic waste into the water. Although, we have detected various organic substances, the concentration of all these organic substances was in the order of ng/l. The hazardous limits are in the order of µg/l [NV SR 269/2010]. Plastic waste used in our experiment did not produce the hazardous concentration of any organic substance detected. Generally, it seems that to get the high concentration reaching the hazardous limits of particular organic substance, the pollution by plastic waste should be really high and with plastics of all kind including plastics where the stabilization by various additives is of high importance as e.g. is the case of engineering plastics used in building industry and automobile industry. Danube in the Vienna-Bratislava region is relatively clean and in recent years there was no problems with some exceeding of hazardous limits [24]. The most polluted rivers in Slovakia are Nitra and Small Danube, which are in bad condition.

The only metal above the limit of Slovak legislative for the water quality of category A1 (NV SR 269/2010) was the antimony. The limit for Sb is relatively low 5 µg/l, which was exceeded in all three samples tested (Bounty packaging, PET bottle, PS foam) (131 – 235 µg/l) [1]. This element is in plastics used as a flame-retardant additive in the form of Sb_2O_3 and is quite common for polyamide (2-Bounty orig), PET (4-PET-O1) and PS (5-F3 PS foam). In the case of PET also Sb-based catalysts are used for the polymerization. Antimony is considered to have none biological function and similarly to arsenic, it is toxic [25]. This first experiment was done with ultrapure water, and we did also one experiment with Danube water taken form Karlova Ves branch of Danube in Bratislava. This experiment is briefly described below in experimental section, since it is not part of 5.2.1 report [1]. The level of antimony was in Danube water slightly above the A1 limit of (5 µg/l) reaching 16 µg/l (**Table 2**). Interestingly the new not degraded pieces of PET bottle was able absorb some of the antimony and in both parallel samples the

concentration of Sb decreased to 6.6 µg/l. This indicate that plastics can also act as an absorber and then afterwards after degradation or when the conditions in the solution will change (pH, ionic strength, temperature etc.) can act as a source of substances as metal ions. In the case of sample 2- PET Coca Cola L06.07.19XE21:29 there was elevated also Ni content to 160 µg/l, while the a1 limit is 20 µg/l. Here we don't think it is because of PET bottle, it is either some contamination of the sample and for more solid conclusion a robust statistic is needed.

4. Experiment with new Coca Cola PET bottle

Coca-Cola PET packaging was the top source of plastic in Africa and Europe and the second largest source in Asia and South America. In North America, the company responsible for the most plastic found in the clean-ups was Nestle, followed by the Solo Cup Company, owned by the Dart Container corporation, and Starbucks. Coca-Cola ranked fifth among the companies responsible for plastic waste in North America [26].

The typical Danube bank litter macroplastics objects–plastic packaging (Bounty wrap found in bank and new one for comparison), PET bottles and polystyrene (PS) foam were chosen for leaching experiment for abrasion and fragmentation study in laboratory conditions.

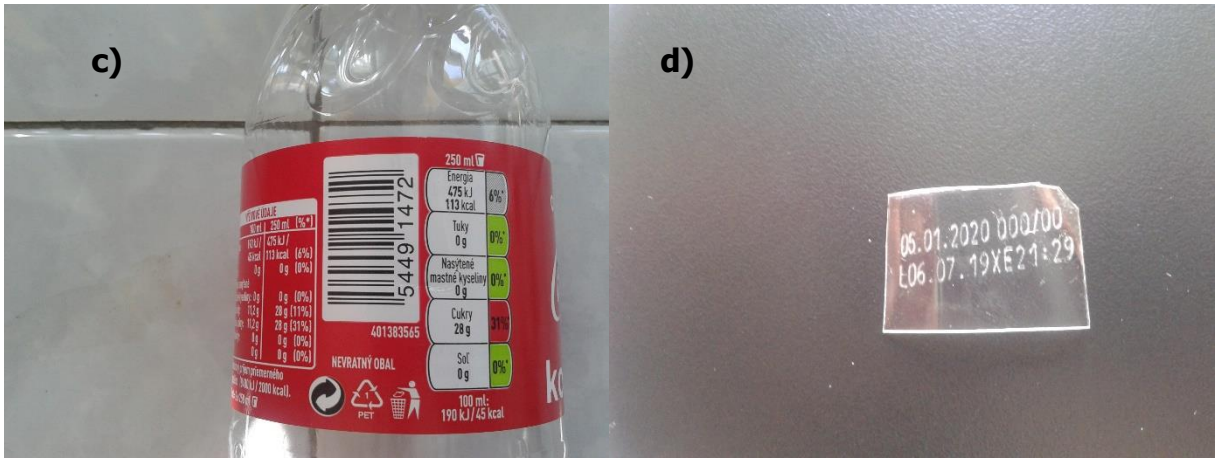
We have also studied leaching plastics parts in Danube water from Karlova Ves branch in Bratislava. New PET Coca Cola bottle was placed in 250 ml of this water as documented in Table 1. The duration of shaking was 78 and 259 days, respectively.

Table 1. "Leaching experiment" – plastic information.

Sample ID	**Sample (specification), place/date of sampling**	**weight(g)/water volume (ml)**
Ref.	Danube water from Karlova Ves	—/250
1	PET Coca Cola L06.07.19XE21:29	1.3568/250
2	PET Coca Cola L06.07.19XE21:29	1.2400/250

4.1. Leaching experiment in Danube water







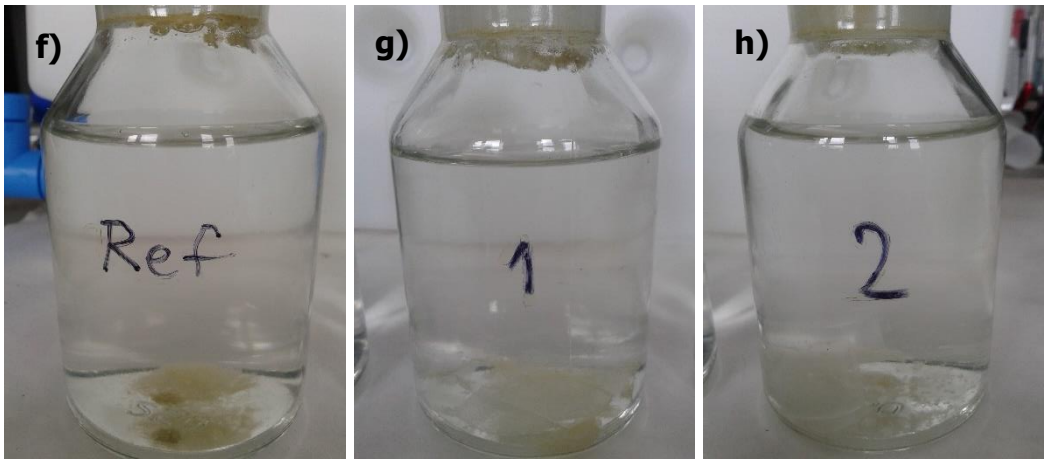


Figure 3. Optical images of Coca Cola PET bottle used for this experiment. a), b), c), d) PET Coca Cola bottle used; e) shaking of samples; f) Ref sample after sedimentation, g) 1- PET Coca Cola L06.07.19XE21:29, and h) 2- PET Coca Cola L06.07.19XE21:29.

Leaching experiment in Danube water was done in order to evaluate the possible hazardous materials leaching form the plastic waste collected in the Danube banks. We placed 2 pieces of new PET Coca Cola bottle (Coca Cola L06.07.19XE21:29 bottle identification according label) into 250 ml of Danube water from Kralova Ves branch of Danube in Bratislava. Samples were left to shake for ca 259 days in glass bottles at 320 rotations per minute (rpm). Piece of Sample 1 we took for analysis after 78 days. For the chemical analysis XPS, FTIR were used. Optical microscopy study provided information what happened with the plastic waste after the experiment. The decanted water was then analysed for metals content. Since the agency has not refunded our previous water analysis we have not performed analysis for organic substances and metal content analysis was done in another company, which was cheaper, but in some cases had higher upper limits. However, these upper limits were still above the hazardous limits for water quality of category A1 (see **Table 2**).

Table 2: Metal content of analysed samples.

Sample	Metals [µg/l]											
	Sb	As	B	Cr	Cd	Mn	Cu	Ni	Pb	Hg	Se	Fe
Ultra-pure water*	<1	<1	<10	<1	<0.02	<10	0.35	<1	<0.3	<0.02	<1	<10
2-bounty orig*	131	<1	156	<1	<0.02	<10	0.68	<1	<0.3	<0.02	<1	<10
4-PET-O1*	235	<1	29.3	<1	<0.02	<10	2.72	<1	0.77	<0.02	<1	214
5-F3 PS foam*	149	1.05	98.2	<1	<0.02	14.8	2.62	<1	0.37	<0.02	<1	113
Danube water	16	<2	33	<1	<0.3	<5	<3	14	<10	<0.1	<1	85
1- PET Coca Cola L06.07.19XE21:29	6.6	<2	32	<1	<0.3	<5	<3	<5	<10	<0.1	<1	10
2-PET Coca Cola L06.07.19XE21:29	6.6	<2	<30	<1	<0.3	<5	<3	160	<10	<0.1	<1	<10
Limits for drinking water NVSR/269/2010*	5	10	1000	50	5	50	50	20	20	1	10	300

*results from Report 5.2.1 [1].

Figure 4 shows XPS measurement points of original PET Coca Cola L06.07.19XE21:29 bottle and this PET bottle in Danube water after 78 days and 259 days. Surface chemical composition of original PET bottle revealed some degree of inorganic contamination surface by siloxane (Si2p at ca 102 eV), phosphates (P2p at ca 133 eV), chlorides (Cl2p at ca 198 eV) and sulphates (S2p signal at ca 169 eV).

After mixing 78 days in Danube water some of the elements were washed out of the surface (P, Na) and some adsorbed as Ca. As it is obvious from **Figure 6**, after 78 days optical images showed some scratches on the surface (**Figure 6c** compared to **Figure 6a**), but some big particles are not present on the surface in higher amount. However, after 259 days the solid particles are clearly visible on the surface, which is accompanied also by the increase of Si signal, this time at ca 103 eV corresponding to SiO_2 and magnesium together with calcium most probably as carbonates [27]. In the case of PET Coca Cola L06.07.19XE21:29_259d we have measured two points on the surface. First one with visible solid particle, and the second point was on the place with less solid particles on the surface (**Figure 4c**). On this point lower amount of Si and no Ca was detected, but higher amount of Mg with some increase in sulphates content was found.

From this is obvious that the whole surface of PET is covered with some minerals or solid particles coming from the sediment of Danube water. This is confirmed also by FTIR analysis (**Figure 5**) showing that in both cases (sample 1 and 2) there is a strong signal related to inorganic substances as carbonates at ca 1400 cm^{-1}.

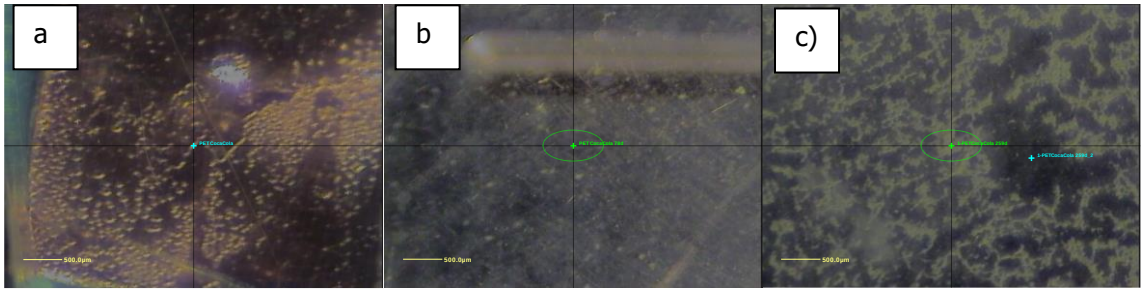


Figure 4. Optical images from XPS measurements points of Coca Cola PET bottle used for this experiment. a), original PET Coca Cola L06.07.19XE21:29; b) sample 1 after 78 days in Danube water, and c) sample 1 after 259 days in Danube water.

Table 3. Apparent surface chemical composition of pieces from PET bottle of Coca Cola as determined by XPS.

Sample	Surface chemical composition [at.%]									
	C1s	O1s	N1s	Na1s	Si2p	P2p	Ca2p	Mg1s	Cl2p	S2p
PET CocaCola	68.1	26.1	1.3	1.3	1.3	1.4	—	—	0.2	0.4
1-PET CocaCola 78d	72.7	21.7	3.2	0.3	0.7	—	1.0	—	0.2	0.3
1-PET CocaCola 259d	54.2	35.7	5.0	—	3.5	—	1.0	0.5	—	0.1
1-PET CocaCola 259d_2	62.1	30.4	3.1	0.9	1.7	—	—	0.8	0.4	0.6

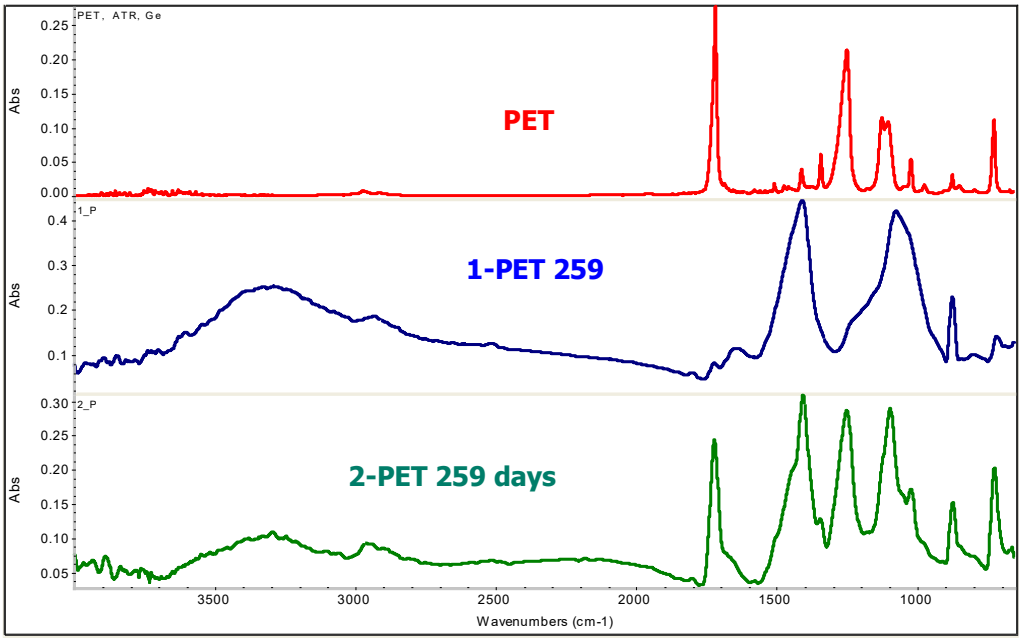


Figure 5. FTIR spectra of original PET Coca Cola L06.07.19XE21:29; 1-PET Coca Cola L06.07.19XE21:29 after 259 days in Danube water; 2-PET Coca Cola L06.07.19XE21:29 after 259 days in Danube water.

Optical microscopy of studied samples, **Figure 6e and 6f,** confirms that after 259 days solid particles present in the water of Danube clearly adhered on the surface of the piece of PET bottle. Also some fiber of unknown origin (**Figure 6e**) and some really big solid particles (ca 100 μm) on the surface (**Figure 6f**) were found.

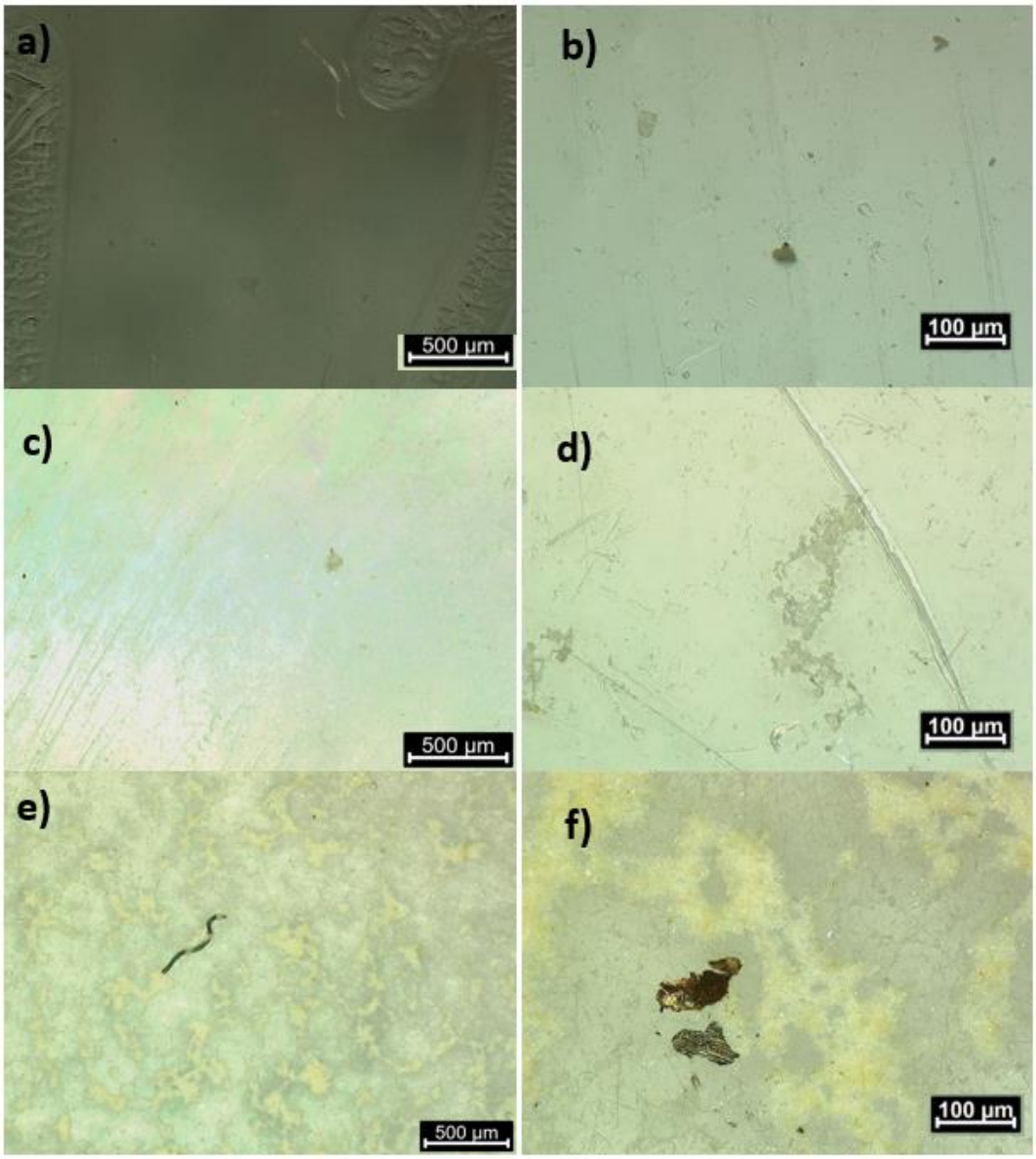


Figure 6. Optical microscopy of a, b) original PET Coca Cola L06.07.19XE21:29; c, d) 1-PET Coca Cola L06.07.19XE21:29 after 78 days in Danube water; e, f) 1-PET Coca Cola L06.07.19XE21:29 after 259 days in Danube water.

We have analysed also sediments of Danube water. In optical images we are not seeing any differences (**Figure 7**). XPS showed higher amount of carbon on the surface and lower amount of Si, Mg (**Table 4**) indicating that some polymer or other organic contamination on the surface of PET bottle has interacted with solid particles. However, µFTIR has not proved the presence of polymer (not shown here), so it is difficult to make some more solid conclusion.

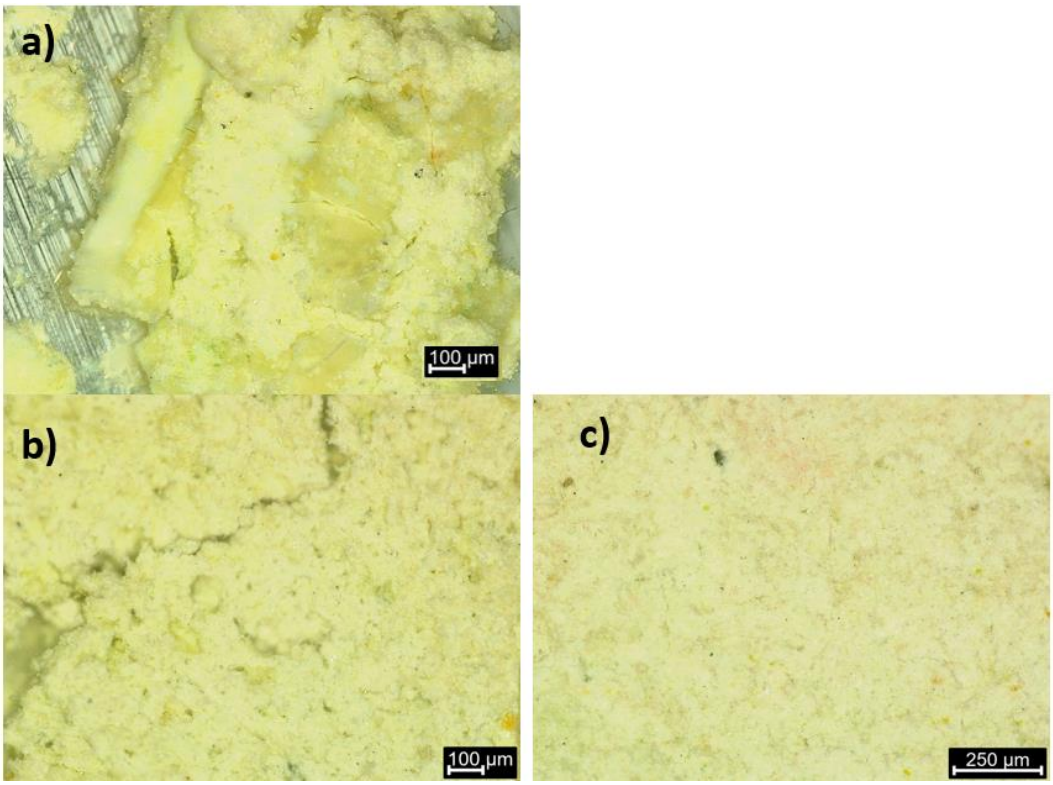


Figure 7. Optical microscopy of a) sediment from reference Danube water, b) sediment from Danube water after 259 days with 1-PET Coca Cola L06.07.19XE21:29, c) sediment from Danube water after 259 days with 2-PET Coca Cola L06.07.19XE21:29.

Table 4. Apparent surface chemical composition of sediments after 259 days with PET bottle of Coca Cola as determined by XPS.

Sample	Surface chemical composition [at.%]									
	C1s	O1s	N1s	Na1s	Si2p	P2p	Ca2p	Mg1s	Cl2p	S2p
Reference sed.	24.1	49.2	2.2	—	14.5	—	0.9	7.9	—	1.2
1-PET CocaCola 259d sed.	59.1	33.2	4.0	—	2.0	—	0.9	0.4	—	0.5
2-PET CocaCola 259d sed.	47.1	38.0	5.6	—	5.9	—	1.4	0.4	—	—

5. Conclusion

The main impact of plastic waste is the direct influence on the nature environment simply by its presence. The plastic waste with the combination of water, sun and mechanical abrasion can very easily fragment into the smaller pieces, which can then be swallowed by animals and deteriorate their quality of life. We found elevated concentration of antimony readily exceeding the hazardous limit of 5µg/l reaching 131-235 µg/l (leeching experiment, Report 5.3.1). That is why it is important to trace the accumulation zones to avoid plastic wastes to elevate local Sb concentration, which might be toxic to living organisms. No other harmful organic substances were detected within lab-scale leaching experiments. But microplastics could accumulate in the sediment, and that there is still a need for research here as well.

In this report studied leaching experiment was done. New PET Coca Cola bottle was placed in 250 ml Danube water from Karlova Ves branch in Bratislava.

Optical microscopy of studied samples showed that after 259 days solid particles present in the water of Danube clearly adhered on the surface of the piece of PET bottle. XPS confirmed, that surface chemical composition of original PET bottle revealed some degree of inorganic contamination surface by siloxane, phosphates, chlorides, and sulphates. After mixing 78 days in Danube water some of the elements were washed out of the surface (P, Na) and some adsorbed as Ca.

This is confirmed also by FTIR analysis, where a strong signal related to inorganic substances as carbonates was detected

Within project it a selection of plastics which were frequently collected within National Park Donau-Auen was investigated. Further investigations on a wider range of plastic waste may identify more leachable pollutants.

Time frame of degradation rates of plastics are not exactly known. It is unclear where frequently cited degradation durations come from (e.g. 450 years for PET bottles). But this time frames refer only to decomposition and not to full degradation of plastics.

During lab-scale experiments, the production of microplastic particles was clearly demonstrated. Abrasion and fragmentation processes in the open environment are influenced by a variety of overlapping boundary conditions, which need to be further investigated. Field trials are problematic due to very long-time frames of degradation processes. Within conducted experiments PET bottles released less microplastic particles than foamed PS items. Since foamed PS forms significant microplastic particles after a short period of time and it is much more difficult to collect microplastics than macro-plastics when they are released into nature. Foamy plastic s expanded PS and other easily decomposable plastics should be avoided as far as possible.

Mmicroplastic particles are a potential hazard, therefore, to really understand the possible impacts of plastics in riverine systems further research is recommended.

Animals often mistake plastics for food. Investigations of a catfish revealed a relatively big piece of plastic in the gut which most probably blocked the gastrointestinal tract for longer time. Compared to marine environment in riverine systems, the hazardous effects of (micro) plastics to species and humans are rarely investigated.

Currently, waste management in Slovakia is primarily financed by the central government. The national strategy aims to make the waste management industry fully self-sufficient by 2030, by initiating a system in which the population and private sector will fully cover the expenses. It is planned that the system will be gradually introduced from 2020. This for sure will also help in plastic waste management, and amount of plastic waste will be decreased. It consecutively will bring positively effect on amount of plastic waste in Danube.

Report on the possible effects of plastics on the environment, is based on data obtained from the laboratory, from field measurements and a literature review. Strategic partners will be consulted in seminars and stakeholder conferences for completion and improvement of obtained knowledge. The developed methodology and the results of the environmental impact assessment will be available on the website and will be further disseminated through the action plan of educational campaigns.

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