Plastic City

Prospecting the plastic environmental debt in the Brussels Region – present status and future projections.

Rapport final

Natacha Brion (AMGC-VUB), Pierre Van Antwerpen (APFP_RD3-ULB), Marc Elskens (AMGC-VUB)

with the contribution of:

Isabelle De Waele (ULille), Myriam Moreau (ULille), Basma Najar (APFP_RD3-ULB), Yiqi Su (PhD, AMGC-VUB), Yuwei Jia (PhD, AMGC-VUB), Karolien van Kampenhout (Ma Chem, VUB), Jianqiao Song (Ma. Chem, VUB), Zoe Berry (Ma. Oceans and Lakes, VUB) and Nour Nasrallah (Ma. Oceans and Lakes, VUB)

Thème « FAIRE FACE AUX DIFFERENTES FORMES DE DETTES »

Table des matières

Used abbreviations :

BCR: Brussels Capital Region
Cin: Canal in Anderlecht
Cout: Canal in Haren
CSO: Combined Sewer Overflow
EAS: Endocrine active substances
MP: microplastics
Nin: untreated sewage at the inlet of wastewater treatment plant Brussels North
Nout: biologically treated wastewater at the outlet of wastewater treatment plant Brussels North
PA: polyamide
PACS: Polycyclic aromatic carbon substances
PAH: Polycyclic Aromatic Hydrocarbons
PAN: Polyacrylo-nitrile
PE: polyethylene
PET: polyethylene terephtalate
PP: polypropylene
PS: polystyrene
SS300µm: Surface suspended solids with a size between 0.3 and 5 mm
TRin: Trash-rack waste from the screens at the inlet of wastewater treatment plant Brussels North
WWTP: Wastewater Treatment Plant
Zin: Zenne in Drogenbos
Zout: Zenne in Vilvoorde

1. Introduction

Plastic is a durable and light weight product that is easy and cheap to manufacture, making it a very commonly used material. However, when discarded to the environment, and transformed to micro plastics (MPs) the plastic polymer is persistent and has a high potential to cause physical and toxicological harm. Microplastics (particle size between 1µm and 5 mm) have been identified as an artificial substrate which could affect a large variety of ecological processes. At present days, large knowledge gaps have been identified in two domains: (1) the knowledge about origin, abundance, and distribution of microplastics in freshwater systems is still limited and (2) the toxicological and environmental effects are also insufficiently understood. Among the various sources of MPs identified, cities with their high population density and plastic-based domestic activities, are identified as hotspots for MP deliveries towards aquatic systems. Obviously, focusing on the circulation of plastics in cities and their export to aquatic systems, and combining this knowledge with toxicological and potential ecosystem impact assessment could provide an essential key towards the management of the present and future plastic environmental debt.

Our study site is the Brussels Capital Region (BCR). The Brussels water cycle is characterized by its urban watershed mainly drained by a network of combined sewers, two wastewater treatment plants (WWTP) and 2 receiving waterways: the Zenne (partly flowing underground) and the Canal, both crossing the city from South to North. Combined sewers collect both household sewage and surface water runoff from rain events – both are hypothesized to be the main entry points of urban plastics and microplastics waste to the urban water systems. Collected combined sewage is drained towards WWTP-South (25% of the sewage) and -North (75% of the sewage), where it is purified and released to the Zenne River (Figure 1). The addition of treated sewage volumes doubles the discharge of the small river. In addition, during rainy conditions, sewage volumes exceeding the sewers volumetric capacity are released to the Canal and Zenne without treatment (combined sewer overflows = CSO).

2. Objective and Research Questions

The general objective of this project is to estimate the present and future contribution of the BCR as a microplastic source for its waterways and determine what are the environmental impacts associated to this contamination. With plastic-city, it is our intention to first build knowledge on the present situation of a problem known to be global but clearly understudied at the scale of whole cities, and never studied in the case of the city of Brussels and, from there, to foresee how this problem may evolve (in good and in bad) for different types of futures we may imagine as scientist but also according to the short and long term visions relevant to representatives of the Brussels Capital Region (administrations, companies, associations, ….).

Specific research questions are:

What are the typical concentrations and physicochemical characteristics of microplastics found in Brussels waterways?

How much plastics are used by the BCR, how much is collected, and how much is lost to the Zenne and Canal waterways?

What are the controlling factors of microplastics delivery to Brussels waterways? What may risk increasing them? And how could they be decreased? How will the present situation evolve in the future according to different scenarios affecting the MP export by the city?

Which potential contaminants are associated to microplastics?

What are the impacts of microplastics contamination on the water quality of Brussels waterways? In terms MP quantity? In terms of contaminants? Now? In the Future?

After a first technical chapter outlining the different analyses, calculation and evaluation methods used during the project, the results in this report is organized as direct answers to the defined research questions.

3. Methods

The methods are aimed to (1) establish quantitively the cycling of plastics in the BCR from consumers to the Zenne and Canal for the present day situation, (2) determine the quantity of specific pollutants associated to MPs in the Zenne and canal, (3) build prospective modelling tools based on circulation pathways and mass-balance equations, (4) and finally use these tools to estimate the effects of various scenarios on MP distribution in the BCR Zenne and Canal.

The following technical section first describes the methods and data used within the project.

3.1. BCR plastic use, collection, and recycling

Yearly Plastic consumed (in mass) in Belgium are estimated for 2018 by Essenscia[1]. Yeraly Mass of collected, recycled and incinerated plastic waste in Belgium for 2023 were from the 2024 annual report of the "Commission Interrégionale de l'Emballage". Values for Belgium were interpolated to BCR by considering the number of inhabitants.

3.2. Sampling

Sampling was done in February, June, September and December 2023. Samples were collected in the Zenne river and Canal, upstream (Zin and Cin) and downstream (Zout and Cout) the BCR, and at WWTP-North: in the waste containers of the coarse and fine trash-rack screen debris, in the unreated sewage inlet and at the outlet of one of the biological basins after clarification (Figure 1) .

For each station location and campaign, several surface water samples are collected with an inox bucket from a bridge (Zenne), a ponton (Canal) or directly from a water pipe (WWTP-North) and used to fill glass bottles for the determination of organic pollutants (pesticides, PAH).

For microplastics, we focused on particles in the size range 0.3 to 5 mm. It is important to mention that there is currently no standardized method for the sampling and analyses of microplastics in aquatic systems and that the concentrations presented here can only be compared to other studies considering the same size class. The method applied in this project is recommended by NOAA (US National Oceanic and Atmospheric Administration)[2] and considers the larger fraction of microplastics. This larger fraction was selected because it allows a direct determination of the mass of the collected particles by weighing, and it dominates the mass of MPs in aquatic samples[3].

---

[1] the Belgian federation of Chemical Industry and Life Science - https://www.essenscia.be/wp-content/uploads/2022/05/circularity-of-the-belgian-plastics-industry.pdf (28/03/2024)

[2] Masura J., Baker J., Foster G. and Arthur C. (2015). Laboratory methods for the analysis of microplastics in the marine environment: recommendations for quantifying synthetic particles in waters and sediments. NOAA Technical Memorandum NOS-OR&R-48.

[3] Xu et al (2023) https://doi.org/10.1021/acs.est.2c07810

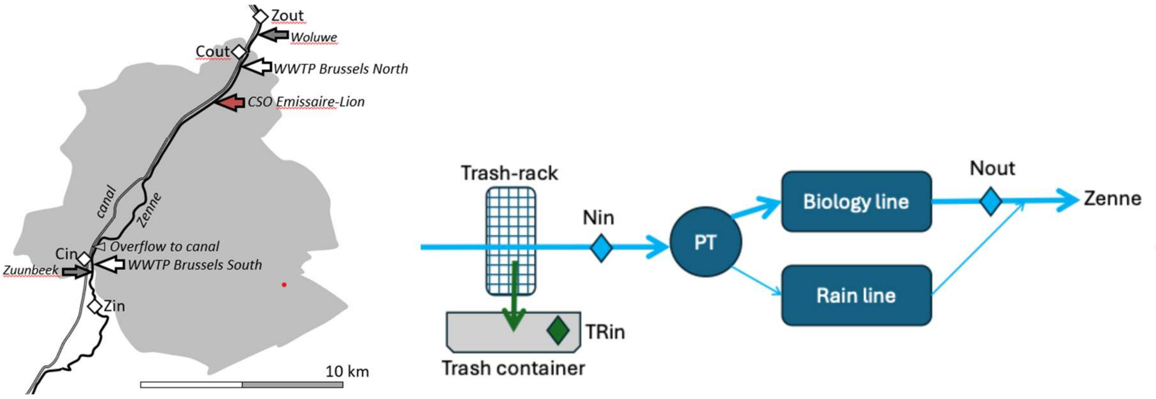


Figure 1 Left: Schematic representation of the Zenne and Canal in BCR with Sampling locations (diamonds), WWTP locations, Zuunbeek and Woluwe river tributaries, and overflow from the Canal to the Zenne. Right: schematic representation of the wastewater treatment line of WWTP-North and sampling locations (diamonds) of water (Nin and out) and of trash-rack debris (TRin).

At least 4 replicate samples were collected at each station. Special care is taken to avoid contamination. The sampling of surface (0-50 cm depth) suspended solids including microplastics occurs by using a 0.3 mm mesh-size plankton net (Figure 2) except in untreated sewage. For Zenne samples, the net equipped with a current meter is deployed for several minutes in the flowing water. For the canal and outlet of WWTP-North, an immersion pump is used to dispense the water in the net for 1h. The volume (1 to 30 m^3) of filtered water is recorded for each sample. The net collected suspended solids are poured over 2 stacked metallic sieves of 5- and 0.3 mm mesh-size and rinsed with filtered demineralized water. For the untreated sewage, the very turbid water was collected with an inox bucket and was directly filtered on the stacked sieves. Sieved fractions are transferred to tared glass bottles.

Figure 2 Picture of the sampling net. From left to right: in the flowing Zenne river, in the outlet channel of WWTP-North and in the Canal.

In the lab, 1 bottle per station was frozen and subsequently freeze-dried for the determination of endocrine actives substance (EAS) and active polyaromatic carbon species (PACS). The other 3 bottles were put in an oven at 70°C until complete dryness for microplastic analyses. After drying, the mass of the total solids were determined and the concentration of this surface suspended solids fraction (SS300µm) was calculated by dividing the dry mass with the sieved volume of water.

For trash-rack debris (TRin), waste was collected from the 2 containers in 6x5L bags (3 bags per container) and brought to the lab where they were immediately frozen before further processing.

3.3. Analyses of plastics and microplastics in samples

3.3.1. Analyses of plastics in trash-rack samples (TRin)

After thawing, the fresh debris are weighed, rinsed on a 2 mm sieve and plastic items are picked out manually and stored in a separate glass container. They are then dried and weighed to determine the plastic mass/fresh trash mass ratio. The average coefficient of variations on replicate samples was < 10%. With this, we calculated the monthly plastic trash mass collected at WWTP inlet by multiplying the ratio with the monthly amount of trash collected (provided by Aquiris), and the plastic trash concentration in sewage by dividing the monthly plastic trash mass collected with the monthly volumes of water treated (provided by Aquiris).

3.3.2. Analyses of microplastics in collected surface solid samples (Zin, Zout, Cin, Cout, Nin and Nout)

The concentration of MP in samples was determined both in mass (mg/m³) and in number of plastic particles (n/m³) for particles in the size range 0.3 to 5 mm according to Masura et al (2015)[3].

The dried surface solid samples are first digested with H_2O_2 to remove excessive natural organic material, separated based on density in a saturated NaCl solution, observed under a stereomicroscope where plastic-like particles are hand-picked, counted and sorted by shape and color, and weighed. Finally, some target samples were also analyzed spectroscopically at Université de Lille by Fourrier Transformed Infrared spectroscopy (FTIR) completed by Raman spectroscopy to determine the polymer distribution and eventually identify false positives in the visual counts. Final counts were corrected accordingly. Numbers and mass of MPs are then divided by the filtered volumes to compute concentrations in numbers and in mass in the samples. The average coefficient of variations on replicate samples was < 20%.

3.4. Analyses of contaminants

3.4.1. Dissolved contaminants: Pesticides, PAHs and Endocrine active substances

Three group of contaminants were considered: pesticides known for their high solubility and (probable) low interaction with particles, Polycyclic Aromatic Hydrocarbons (PAH) known for their hydrophobicity and high interaction with particles, and endocrine active substances (EAS) containing both hydrophilic and hydrophobic substances. All are well known for the environmental risks they represent.

Measurements of pesticides were obtained by a validated method that extracted pesticides from the water samples (QUECHERs method) before analyzing them with a mass spectrometer coupled to a liquid chromatography system. The method measures 14 pesticides among 56 that are detected in the serum and urine of people from Wallonia and Brussels Capital Region. Briefly, 10.0 ml of filtered water was mixed with salt and extracted with 10.0 ml of acetonitrile. The organic layer was picked up and evaporated then the residue was dissolved in 100.0 µL of acetonitrile. The sample was analyzed by a liquid chromatography system coupled to triple quadrupole.

Measurements of Polycyclic Aromatic Hydrocarbons (PAH) in water samples were obtained by a solid phase extraction of 100.0 ml of filtered water sample and elution with acetyl acetate. The elution solution was evaporated, and the remaining material was dissolved in 100.0 µL of acetonitrile (1000 factor concentration). The samples were injected in a liquid chromatography system coupled to fluorimeter to detected PAH in a ng/L range. The PAH concentration were converted in Bioequivalent activities on the AhR system as described in Su (2025)[6] to compare the values with the activity of PAH adsorbed on the MPs (see 3.4.2).

For EAS, we used existing measurement from the Zenne[4] made by ERα-CALUX, an effects-based bioassay.

3.4.2. Particulate contaminants potentially associated to MPs:

Contaminants associated to MPs can either be additives bounded to plastic polymer synthesized or adsorbed to the MP surface.

ERα and AhR activities adsorbed

Two families of adsorbed contaminants were considered: EAS and particulate aromatic carbon compounds (PACS), that include PAH and their methylated forms. Both were analyzed after extraction from solids. As the number and mass of MP collected per sample was insufficient to perform a correct analysis, the extractions were made on the total suspended solids collected by sieving (SS300µm). MP containing suspended solids were used as a proxy for MP considering they are composed essentially of biopolymers (cellulose), have the same density (floating in surface waters), size (0.3-5 mm) and are submitted to the same environmental conditions as MPs. The analyses were then done using effects-based bioassay: Erα-CALUX and AhR-CALUX. The AhR-CALUX method for PACS was developed and validated within the project[5] (PhD Yiqi Su). CALUX Effect based bioassays measure the combined effect of a family of substances in activating a specific/toxic cellular response. They do not consider single compound analyses but more a global toxicity/activity associated to a group of compounds. The concentration is then given as a “bioequivalent” concentration of a known standard molecule: estrone (E2) for EAS and Benzo-a-Pyrene (BaP) for PACS.

PAHs

PAH additives associated to MP composition were analyzed by pyrolysis coupled to gas chromatography with a MS detector. The purpose was to control the identity of MPs obtained by infrared spectra (see 3.3.2) but more importantly to measure whether pollutants were associated to plastic composition.

PAH associated to plastic by adsorption were measured on the suspended solid (SS300µm) proxy after extraction. The solids were weighted and extracted with 5.0 mL of ethyl acetate. Then 10.5 µL of DMSO was added before evaporation with the speedvacuum at 50°C. The remaining sample was diluted with 90.0 µL of acetonitrile before injection in a liquid chromatography system coupled to a fluorimeter.

3.5. The mass balance model

Mass balance models were developed to represent the yearly plastic and microplastics transfer fluxes from the city to the receiving rivers for reference year 2023 and are based on the known Brussels sewers, WWTP and surface water network represented in Figure 3. The model was divided in 3 interconnected compartments. The sewer model represents the global transfer fluxes of macro and microplastics from the city to the sewers, and from the sewers to the Zenne and the Canal through CSO and WWTP outlets. The Zenne and Canal models are based on a detailed longitudinal representation of the river and the Canal from South (Nin and Cin) to North (Nout and Cout) considering all input fluxes.

[4] Elskens et al. (2023) Water Emerg Contam Nanoplastics 2:9. https://doi.org/10.20517/wecn.2023.15

[5] Yiqi Su (2025) AhR- and ER-CALUX Bioassays for Environmental Monitoring of Polycyclic Aromatic Compounds and Xenoestrogens. PhD in Doctor of Science (VUB) and Biomedical and Pharmaceutical Sciences (ULB).

All fluxes represented by the arrows in Figure 3 were calculated based on the flow-weighted mean concentration method[6] based on MP concentration measurements done in the project (see 3.3) and daily solid and water flows obtained from: HYDRIA-FLOWBRU (CSO, Zenne and Aa overflow waterflows in Brussels), Waterinfo (water flows in Zenne, Woluwe, Zuunbeek and Neerpedebeek), OSIRIS project (yearly water flow in the Canal as well as unmonitored CSO), AQUIRIS (daily untreated and treated water flows, monthly trash-rack debris mass in WWTP-North) and HYDRIA (daily untreated and treated water flows and monthly trash-rack debris mass in WWTP-South). For Zenne and Canal the water mass balance was validated by checking that the water flow at Zout and Cout was equal to the sum of all water inputs flows from Zin and Cin.

For Zenne and Canal, the model considered yearly average daily flows, but also wet average and dry average daily flows. Wet flows were calculated for the 91 wettest days of 2023 (P75%) and dry flows for the 91 dryest days of 2023 (P25%) based on waterflows at Zout.

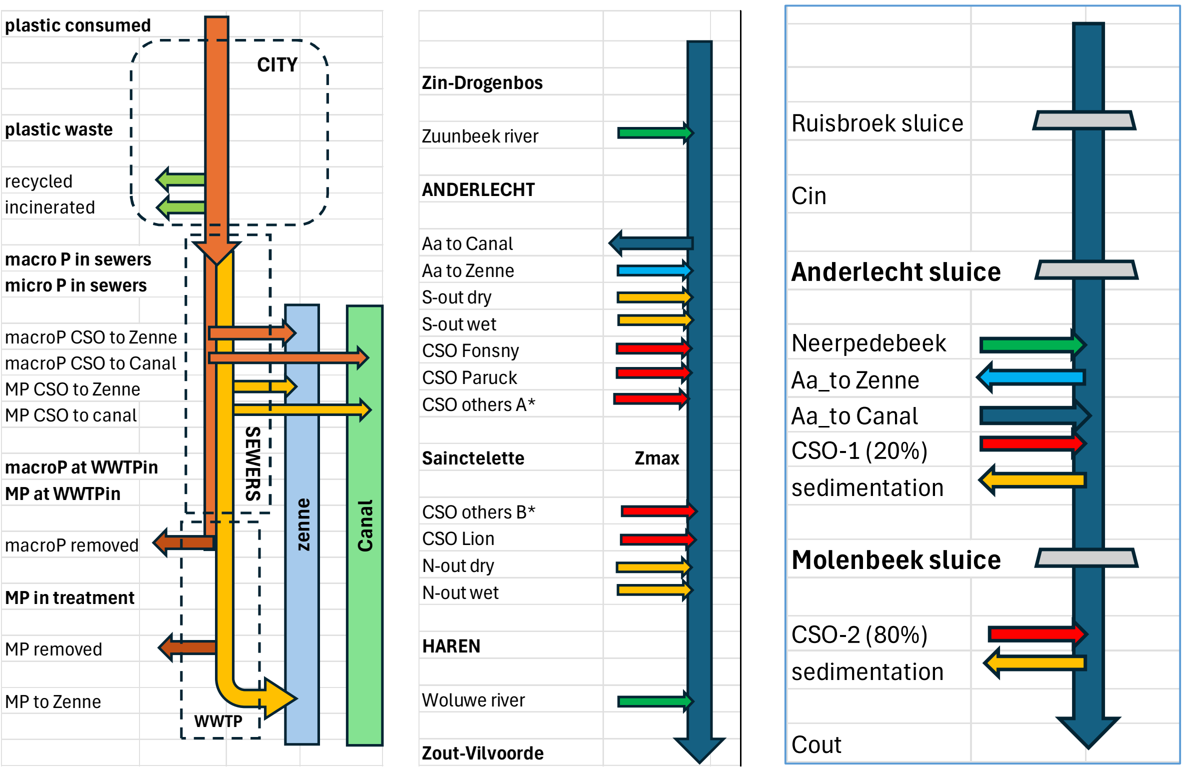


Figure 3 Mass balance models established in Plastic City to represent the transfer of micro- and macro-plastics in the BCR waterways from the city to the Zenne and Canal. Left: the sewer model; middle: the detailed Zenne model; right: the detailed canal model.

As concentrations were not measured at all inputs considered in the mass balance, several hypotheses were made: MP concentrations in Zuunbeek = Zout because it is very urban and receives inputs from CSO and WWTP, Woluwe and Neerpedebeek = Zin; micro and macro-plastic concentration in all untreated sewage = Nin; MP concentration at WWTP-South outlet = 0 in the dry line (clarification based on ultrafiltration) and = Nout in the wet line; MP concentration in WWTP-North wet line outlet = Nout;

[6] Moatar, F. & Meybeck, M. (2005). Compared performances of different algorithms for estimating annual nutrient loads discharged by the eutrophic River Loire. Hydrological Processes, 19(2), 429-444. https://doi.org/10.1002/hyp.5541

MP concentration in the Aa to Canal overflow = Zin; MP concentration in the Aa to Zenne overflow = Cin. The sensitivity of the model towards these hypotheses was verified.

The model was validated for Zenne and Canal by comparing the mass and number MP flux measured in Zout/Cout with the calculated sum of all MP fluxes from the different contributors. For the Zenne, the difference was < 20 %, showing MPs in surface waters had a rather conservative behavior.

For the Canal, Cout was much smaller than the sum of all input fluxes and a loss factor had to be introduced that we called "sedimentation". This factor was adjusted to fit the observed Cout concentrations and a reduction of more than 80% of all inputs was necessary. The Canal in Brussels is composed of a succession of different reaches separated by navigation sluices (sluices of Anderlecht and of Molenbeek). Exchange of water between reaches is discontinuous and within a reach, the water is relatively stagnant, in favor for sedimentation. Although the density of many plastic polymers is generally lower or equal to the one of freshwater, it is known that MPs thriving in aquatic systems are colonized by microbial biofilm that increase their density and decrease their floatability[7]. MPs may therefore sink, which could explain their lower concentrations in the Canal. It is worth mentioning that MPs do not disappear from the canal when sinking but rather accumulate to the bottom waters and sediments of the Canal as most particulate material. The Canal is known for its sediment accumulation necessitating frequent dredging. Dredged material is therefore believed to be enriched in MPs.

3.6. Future Scenario analyses

Families of scenarios were defined during a dedicated workshop organized in February 2025 in Brussels with the stakeholders of the project: Canal de Bruxelles, Bruxelles environnement, City to Ocean, Hydria, Innoviris, ULille, VUB and ULB. Selected scenario families were Climate change, Rainwater removal from sewers, wastewater management, and reduced MP losses towards sewers.

For MP loss reduction in sewage, we simply applied a 25, 50 and 75 % (scenario MP25, MP50, MP75) reduction on the MP concentration in untreated sewage. We kept all other input flows and concentrations as in reference year 2023.

For wastewater management scenario we considered: (1) the implementation of ultrafiltration as a final clarification step in the biological treatment line of WWTP-North (WWUF), as is the case at WWTP-South. For this, we set the outlet of the biological dry line at WWTP-North = 0. All other input flows and concentrations as in 2023. (2) the general implementation of a fiber filter at the outlet of all washing machines in BCR (WWFF). For this we first calculated the volume of domestic sewage in the total treated sewage by considering daily water flows to WWTP during dry weather conditions. The fiber concentration in this domestic sewage flow was then considered to be 0, and the number of fibers were subtracted from the total number of particles. All other input flows and concentrations as in 2023. (3) the reduction of CSO volumes by 50 % (WWCSO). This was obtained by removing 50 % of all CSO water flows and sending the removed water flows to the wet lines of both WWTPs where the sewage is treated before being released to the Zenne. This scenario thus decreased CSO but also increased the outlet of WWTPs. The concentration in sewage and all other input flows as in 2023.

For rainwater removal scenario, we considered a 10 and 20 % reduction of rainwater volume in sewers (R10 and R20). For this, we first estimate the proportion of rainwater flow in the total sewage discharge by knowing the domestic dry weather discharge. This volume was then reduced by 10 and 20%. The volumes removed were first deduced from CSO, then from the wet WWTP treatment lines. The

[7] Vercauteren et al. (2024) https://doi.org/10.1016/j.scitotenv.2023.168399

concentration in sewage is as in the 2023 reference. All other input flows and concentrations as in 2023.

For climate change scenarios, a different approach was used. Precipitation projections for 2050 and 2100 were gathered from the Belgian Climate Center[8]. These consist of expected rainfall (mm) per season for 2050 and 2100 for medium and high impact scenario. Daily rainfall in Brussels and BCR water discharge data for all considered fluxes in the mass balance models (see 3.5) were then collected for an extended 4 year period 2021-2024. Within this extended database, data were first classified by season and filtered for each season so that the seasonal average corresponded to the expected future rainfall. After filtration, a set of yearly water flows was then generated for each of the considered climate change scenario for 2050 (mediumCC-2050 and highCC-2050) and 2100 (mediumCC-2100 and highCC-2100). These water flows were then used in the Zenne and Canal mass balance models using MP concentrations as in 2023.

A summary of all tested scenario is given in Table 1.

Table 1 Summary of all tested scenario in the Zenne and Canal mass balance model

Scenario families	name	Description
Ref	Ref 2023	reference year 2023
MP concentration reduction% in sewage	MP25	concentration of MPs in sewage reduced by 25%
	MP50	concentration of MPs in sewage reduced by 50%
	MP75	concentration of MPs in sewage reduced by 75%
Wastewater management	WWUF	Biological treatment of WWTP North equipped by an Ultra filtration clarification (like in WWTP-South)
	WWFF	100% of fibers are removed from domestic sewage by the installation of fiber filters at washing machine outlet
	WWCSO	CSO volumes to Zenne and Canal are reduced by 50%. The "spared" sewage volumes are sent to the wet lines of WWTPs
	WWUF+CSO	combined Fiber Filtration and reduced CSO
	WWFF+CSO	combined UF and reduced CSO
	WWUF+FF+CSO	Combined Fiber Filtration, UF and reduced CSO
Rainwater removal from sewers	R10	present rainwater volumes collected in sewers are reduced by 10% - volumes removed first from CSO, then rain lines, then dry lines
	R20	present rainwater volumes collected in sewers is reduced by 20% - volumes removed first from CSO, then rain lines, then dry lines
Climate change	highCC-2050	with expected rainfall in 2050 for high impact CC scenario
	highCC-2100	with expected rainfall in 2100 for high impact CC scenario

4. Results

A summary of most important results are presented as answers to our specific research questions.

4.1. What are the typical concentrations and physicochemical characteristics of microplastics found in Brussels waterways?

Concentrations of microplastics were measured from February to December 2023 in the Zenne and Canal entering BCR and leaving BCR as well as at the inlet and outlet of WWTP-North. Both mass concentrations (mg/m³) and number concentrations (n/m³) were measured. Different hydrological situations were covered from very dry weather with low discharges in June 2023 to very wet weather with high discharge in December 2023. These measurements were used to feed the mass balance model to generate typical yearly, dry weather and wet weather average concentrations along the Zenne and Canal in Brussels (Figure 4).

[8] Key Indicators for future Belgian Climate Ref: f8f2bbcf-d49f-11ee-95d1-3448ed07889e

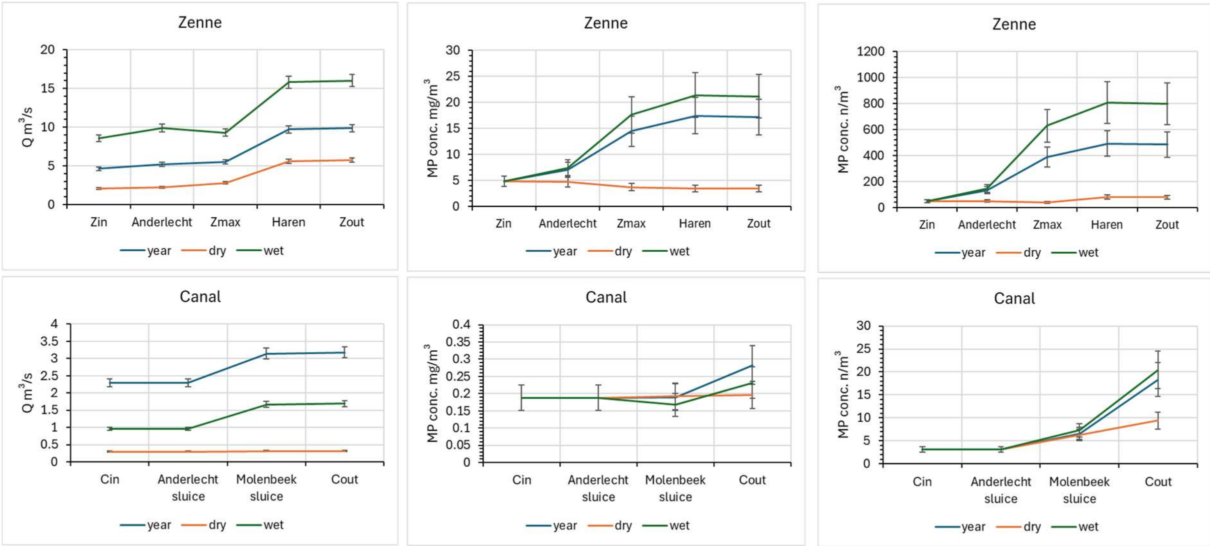


Figure 4 Average year, dry and wet discharge and MP concentration in the waters of the Zenne and Canal in 2023. Zin, Zout, Cin and Cout are the measuring stations. Concentrations in between are calculated using the mass balance model. Zmax: Zenne at the future parc "Max-sur-Zenne".

Concentration range in the Canal (0.2-0.3 mg/m³, 3-20 n/m³) are lower than in the Zenne (3-21 mg/m³, 40-810 n/m³). In the Zenne, yearly average concentrations increase from up to downstream and are triggered by the wet days profile. During dry days, concentrations were relatively low and stable all along the river and even decreased. Similarly in the Canal, yearly average concentrations also increase from up to downstream, and are triggered by wet days, but this is mostly seen in the number of MP particles. In the treated sewage delivered to the Zenne, the average concentration (combined for both WWTP) has low variability with MP concentration = 2.6 mg/m³, 100 n/m³. Untreated sewage which can reach the Zenne and Canal by combined sewer overflows (CSO) has the highest MP concentration of all considered water types: 215-360 mg/m³, 5100-10650 n/m³. These ranges are similar to other urban freshwater systems considering similar size range (0.3-5 mm)[9].

Considering the shape of MP particles in the various types of Brussels water, fibers are dominant (> 45 %) everywhere but are particularly numerous in the Canal (65 to 87 % of all particles) and in treated sewage (77 %), followed by fragments. Some films are also found but in small amounts. The high fiber and fragment distribution we observed aligns with other studies for river surface waters[10] and wastewater inlets and effluents[11].

Regarding the plastic polymer composition (Figure 5), 3 polymers dominate the distributions in all types of samples: polyethylene (PE), polyethylene terephthalate/polyester (PET) and polypropylene (PP). Together, these 3 account for more than 75% of all MP particles. Three other polymer account for almost all the remaining 25 %: polystyrene (PS), polyacrylonitrile/acrylique (PAN) and polyamide/nylon (PA). The proportions of each vary slightly between sample types but mostly depend on the shape of the MP particles: fibers are mostly made of PET, PP and PAN; films are almost all 100 % PE; and fragments are mostly PE, PP and PS. Note that all these polymer are also the most frequent in

---

[9] Driss et al (2015) https://doi.org/10.1071/EN14167
[10] Strady et al (2020) https://doi.org/10.1016/j.envpol.2019.113897
[11] Akarsu et al (2020). https://doi.org/10.1016/j.marpolbul.2019.110776

domestic plastic used in packaging material (PE, PP, PET, and PS)[12] and textile fabrics (PET-polyester, PP, PA-nylon and PAN-acrylic)[14].

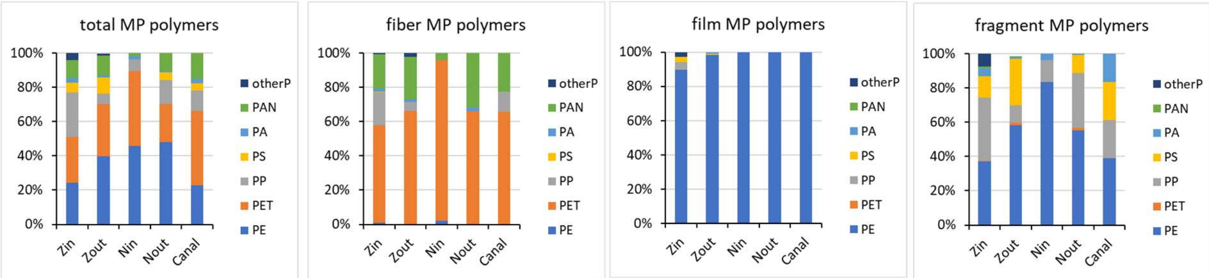


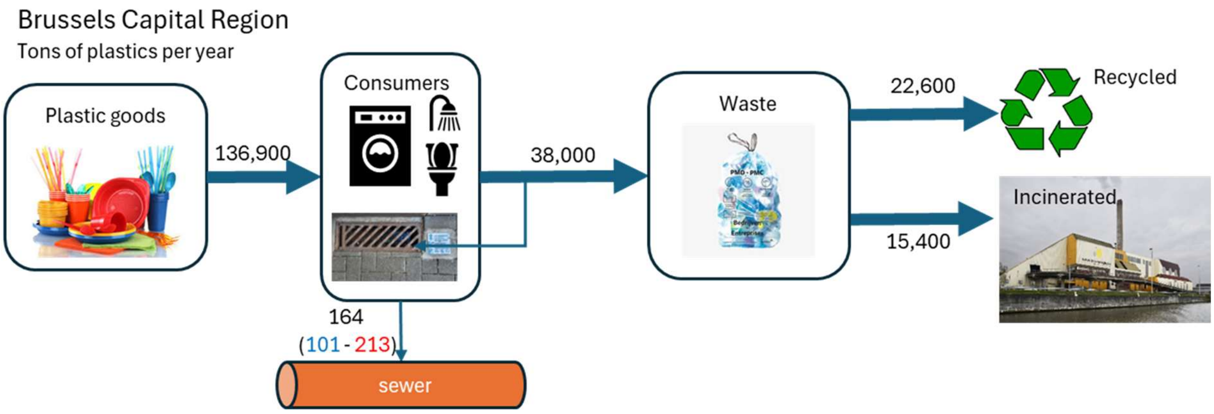
Figure 5 Polymer distribution in MP particles of Zin, Zout, Nin, Nout and in the Canal. The % represent the fraction of the total number of MP particles.

4.2. How much plastics are used by the BCR, how much is collected, and how much is lost to the Zenne and Canal waterways?

Plastic cycling in the BCR was estimated for reference year 2023 (Figure 6 and Figure 7) based on the Sewer mass balance model (see 3.5.).

From City to Sewer (Figure 6): Almost 137,000 tons of plastics are consumed per year from which 38,000 tons are collected as waste. Almost 60 % of the plastic waste collected is recycled while most of the remaining is incinerated. A small fraction of plastics escapes the waste collection systems to end up in Brussels combined sewer system: 165 tons on average. The export of plastics to sewers depends on the precipitation and may vary between 101 (dry weather) and 213 tons (wet weather). The loss of plastics to sewers represents 0.3 to 0.6 % of the yearly produced plastic waste in BCR. Although this fraction might look small, it is the main entry point of plastics towards the Brussels Zenne and Canal.

In the sewer system, 55 % of plastics are large debris (> 5mm) such as small packaging fragments, synthetic wipers, etc. and 45 % are microplastics (0.3 to 5mm). The number of microplastic particles are composed of fibers (50 %), fragments (25 %) and films (25 %). Most fibers are made of PET (polyethylene terephthalate also known as polyester in the textile industry) and probably largely originate from laundry[13] while films and fragments are mostly made of PE (polyethylene, 83 %) and PP (polypropylene, 13 %) and probably originate from the fragmentation of larger plastic packaging debris.



[12] Plastics Europe. (2023). https://plasticseurope.org/knowledge-hub/plastics-the-fast-facts-2023/
[13] De Falco et al (2018) https://doi.org/10.1016/j.envpol.2017.10.057

Figure 6 From City to Sewers. Yearly plastic fluxes in the Brussels Capital Region for reference year 2023 and total losses to sewers. Yearly fluxes for consumption, waste, recycling and incineration are from national statistics while to loss to sewer was estimated in this project from measurements - in black: average per year, in blue: for dry situation, in red: for wet situation - as described in "Method".

From Sewers to Zenne and Canal: Once in the sewers, plastics may take different ways to reach Zenne or Canal (Figure 7). Some untreated sewage is directly spilled to the Zenne and Canal through CSO. These represent a direct input of macro and microplastic to the Zenne and Canal of 11.2 tons/year. This amount strongly depends on precipitations and may vary between 0.03 (dry – almost no CSOs) and 32 tons (wet). CSOs plastic loads to Zenne and Canal represent on average 7 % of the total loads transported by the sewers.

The remaining plastic load (153 t) are transported to the 2 Brussels WWTP: South and North. At the inlet of both WWTPs, screens remove all bigger macro-plastics (84 t) and only microplastics (69 t) enter the treatment lines. Most of the MPs are removed here (> 99%) and probably accumulate in the sludge removed during the treatment process. In Brussels, this sludge is ultimately incinerated (WWTP-South), or wet oxidized (WWTP-North) which eliminates MPs completely. The yearly MP flux entering the Zenne with treated wastewater is 0.4 t and represents clearly a minor input compared to CSOs.

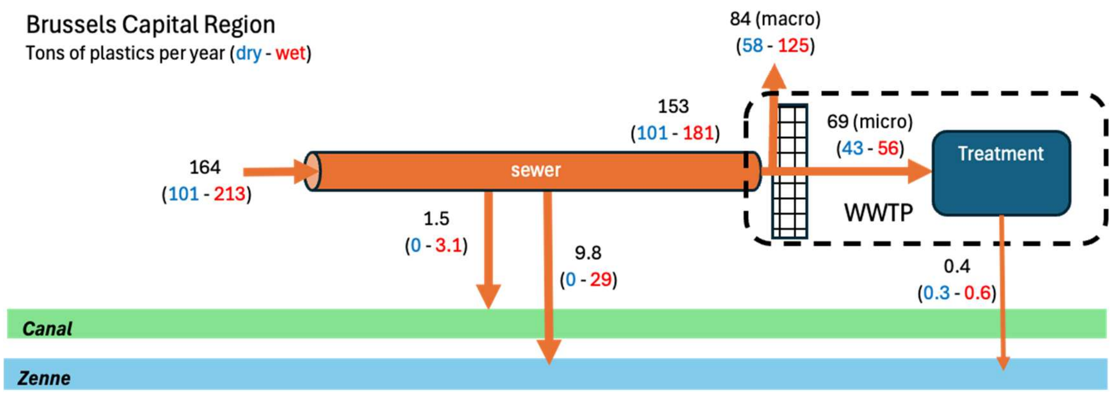


Figure 7 From Sewers to Zenne and Canal. Yearly plastic fluxes in the Brussels Capital Region for reference year 2023 from the sewers, to the Zenne and Canal. Estimated in this project from measurements - in black: average per year, in blue: for dry situation, in red: for wet situation - as described in "Method".

To summarize, for reference year 2023, the yearly mass of plastics released by the BCR to the Zenne and Canal is 11.6 tons per year from which 4.9 tons of microplastics. This represents 7 % of all plastics lost to sewers in BCR and is mostly due to the release of untreated sewage to both Canal and Zenne. Focusing on microplastics, the yearly number of MPs released to Zenne and Canal is 146 x 10^9 particles corresponding to an average of 400 million particles per day, and almost half of these particles are PET fibers.

4.3. What are the controlling factors of microplastics delivery to Brussels waterways? What may risk increasing them? And how could they be decreased? How will the present situation evolve in the future according to different scenarios affecting the MP export by the city?

The delivery of MPs to Zenne and Canal may occur through various ways. The Zenne receives MPs from Flemish/Walloon watersheds upstream Brussels at Zin and from river Woluwe and Zuunbeek tributaries, from WWTP outlets South and North and from Brussels combined sewer overflows. The Canal receives MPs from upstream Brussels at Cin, from river tributary Neerpedebeek, from the Zenne at the Aa overflowing structure and from CSO. The contribution of all MP input sources in Zenne and Canal within the BCR are shown in Figure 8.

From this figure it is clear that the yearly delivery of MPs to Zenne and Canal is dominated by the inputs of untreated sewage occurring during CSO events. Although CSO water fluxes are relatively limited compared to other water inputs (ca 3 % of all water inputs in Zenne and 1.5 % in Canal), the very high MP concentrations in untreated sewage result in high CSO MP inputs. Consequently, during dry situations with no CSOs, WWTP inputs become the dominant MP source for the Zenne. Hence, as the yearly average is completely triggered by the wet weather situations, CSOs are the main MP source towards both Zenne and Canal.

Figure 8 Contribution of different water (Q) and MP sources to the total inputs within the BCR for Zenne and Canal for reference year 2023. Average year situation (left), dry situation (center) and wet situations (right) as described in methods. mMP: mass flux of MP, nMP: number flux of MPs.

CSOs to Canal and Zenne in BCR are known to be numerous (12 on Zenne, 7 on Canal as identified in Hydria-Flowbru) and frequent and cause many problems to the water quality[14]. The recently upgraded Urban Wastewater Treatment directive (UWTD, 2024)[15] recommends CSO loads should be less than 2 % of the annual dry load to sewers – in 2023, yearly average CSO were 0.34 m^3/s which correspond to 7 % of the yearly load of sewage treated by both WWTPs, and 10 % of the average dry load.

By consequence the main control on MP delivery to Zenne and Canal will concern the control over these CSO input fluxes. These depend on 2 variables: (1) the volumes of untreated sewage that are spilled towards Zenne and Canal and (2) the concentration of MPs found in the untreated sewage.

The most important risk identified for increased CSO MP inputs are increased rainfall events as expected from climate change scenarios. It is reasonable to believe that increased MP concentrations in sewage are unlikely to occur considering the recent evolution of waste collection and recycling efficiency observed in Brussels unless a drastic degradation of street cleaning and waste management

[14] Brion et al (2015) https://doi.org/10.1007/s11356-015-4493-8
[15] EU-UWWTD (2024) European Union Directive 2024/3019 of the European Parliament and of the Council of 27 November 2024 concerning urban wastewater treatment (recast).

policy would occur. On the other hand, any measure undertaken to decrease CSO volumes to Zenne and Canal and/or MP concentration reduction in sewage will decrease resulting MP inputs.

The relevance of change induced by climate change, CSO reduction and/or MP concentration reduction was evaluated quantitatively by using the mass balance model under various scenarios. Practically, each tested scenario results in changed water flows and/or MP concentrations in the relevant input sources. Modified MP loads to Zenne and Canal, and concentration distributions in the Zenne and Canal are then calculated using the mass balance model. A detailed description of the models are given in section 3.5 and a summarized list of tested scenario is in Table 1. Detailed results for all tested scenarios are available on demand. Results presented here are only shown for scenario that induce a relative change > 20% from the reference situation in 2023. Expected concentrations (in mass and number) in Zout for the Zenne and in Cout for the Canal are presented in Figure 9.

Without any change in CSO management practice, climate change related increased rainfall is expected to increase the volumes of CSO by 43 % (medium impact scenario) to 59 % (high impact scenario) by 2100 compared to 2023. We observed that indeed MP concentration in Zout is expected to increase by 30 % by 2100. MP concentrations in the Canal seem to be less impacted by climate change scenarios, probably because CSO contribution is less important than in the Zenne, and because particles in the Canal may sediment to deeper water layers or to the sediments (see the Canal model description in 3.5).

Implementing WWTP-North with an ultrafiltration clarification step does not result in a significant change in the yearly average MP concentration in Zout. It can only have an effect in a situation where there are no CSO – like observed during dry weather situation (Figure 8).

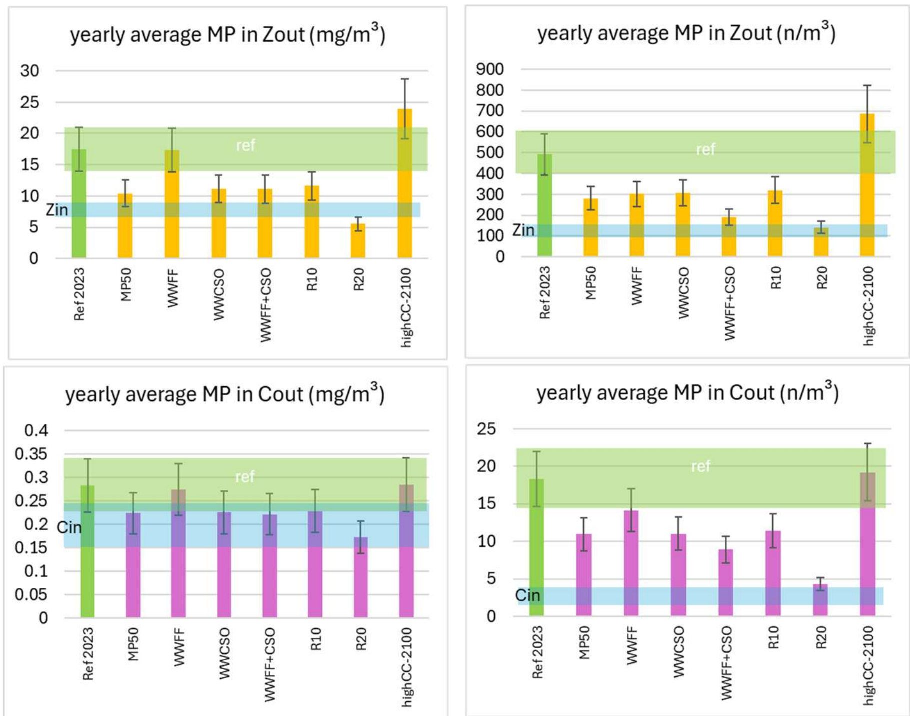


Figure 9 Reference (Ref 2023) and expected yearly average concentration in Zout and Cout for tested high impact scenarios. MP50: a 50 % reduction in the MP concentration of untreated sewage, WWFF: fibers removed from domestic sewage by washing machine filters, WWCSO: a 50 % reduction of CSO

volumes towards the Zenne and Canal, R10 and R20: a 10 % and 20 % reduction of rainwater flows towards the sewers, highCC-2100: predicted 2100 rainfall for high impact climate change.

On the other hand, reducing MP concentrations by 50 % in sewage (scenario MP50) or reducing CSO water flows to Zenne and Canal by 50 % (scenario WWCSO), results in a significant decrease of the concentrations in both Zout (-40 % in mass and number) and Cout (-40 % in number, reduced impact on the mass concentration). Interestingly a similar result may also be obtained by reducing the yearly rainwater collection to the sewers by 10 % (scenario R10). Indeed a 10 % reduction of this volume would result in a 50 % reduction of CSO volumes. We have calculated that this 10% reduction would correspond to a total yearly water volume of 5.8 x10^6 m³, which spread over the BCR area (161.4 km²) would correspond to a 37 mm rainfall. This volume can be compared to the total rainfall over the BCR in 2023 - 1074 mm. Compared to this value, an additional interception of 3% of the annual rainfall should be sufficient to reduce CSOs by 50 % and significantly decrease MP concentrations (but also other urban pollutants).

Finally, another interesting scenario concerns the retention of fibers at the outlet of washing machines. This relatively simple intervention – already a general practice in France – reduces very significantly the concentration in the number of MP particles in Zout and Cout. It however has a minimal effect on the MP mass concentration. Indeed, fibers are very numerous in sewage but have a very limited contribution to the mass. In our calculations fibers represent less than 10 % of the MP mass, while contributing to over 50 % in numbers.

4.4. Which potential contaminants are associated to microplastics?

Most important contaminant in this study that was clearly associated to MPs are PAH and results presented here thus focus on this group of contaminants.

The presence of PAH additives in microplastic particles was analyzed for a small amount of MP particles collected from the samples of February 2023 using pyrolysis-GC-MS at the University of Pisa (Italy). The results confirmed the polymer composition of the variety of MPs, such as PE, PVA, PS and PP. More importantly, the analyzed particles did not contain polluting additives such PAH, PCB or phthalates.

An attempt to measured PAH adsorbed on plastics was done using suspended solids SS300µm as a proxy for MP and plastics from WWTP trash-rack waste (TRin). Unfortunately, obtained concentrations (0.006 and 1 ng/g) were extremely low compared to literature. For instance, authors[16] measured PAH adsorbed on MPs and obtained concentration of 2-100 ng/g while the concentration of soluble water PAH was around 10 ng/L. We could explain our low values by the drying step of the sample preparation procedure (70°C) which is not suitable for PAH analysis as the most abundant ones (such as naphthalene) are volatile.

Finally, the bioactive PAHs adsorbed on MP could be assessed using SS300µm as a proxy by measuring the total activity with the CALUX-AhR bioassay. In this test, samples where freeze dried to avoid the loss of volatile compounds. The activity of bioactive PAHs adsorbed on microplastics (Figure 10) ranged from 1.8 to 91.7 µg BaP Beq./g with peaks during dry days (February and June) and lower activity during rainy days (December). Moreover, bioactive PAHs concentrations were higher in Zout compared to Zin, and lower in Nin and Nout compared to Zout. In absolute concentration, MP-associated bioactive PAH were 0.002 to 1.5ng BaP Beq/l in the Zenne, which is a similar range to the total dissolved PAHs.

[16] Wang et al (2024) https://www.mdpi.com/2079-4991/14/12/1030#

However total dissolved PAHs also contain molecules that are not active on the AhR receptor used for MP contamination assessment. Only considering bio-active dissolved PAHs, shows that these are 5 to > 100 times lower than MP associated bioactive PAHs for all samples considered (Zenne, Canal and WWTP-North, in and out), confirming the importance of MPs as a carrier for bioactive PAH.

Combining obtained concentrations with the daily MP loads computed with the Zenne mass balance model, allows to estimate the contribution of BCR inputs on the MP-associated pollution in the Zenne (Figure 10 right). This contribution is particularly important during the rainy December period, corresponding to the highest MP loads. Upstream Zenne and tributaries already contribute significantly to the MP-associated bioactive PAH loads. In the BCR, WWTP – although a minor source for MPs - contribute significantly to the MP-associated bioactive PAH load. In December, CSOs are an additional source, but although MP loads are particularly important in this period, associated PAH loads are relatively minor compared to other sources because of the relatively low contamination of MPs in untreated sewage (Figure 10 left). To conclude, the BCR is an important contributor to PAH contaminated MPs through the release of treated sewage.

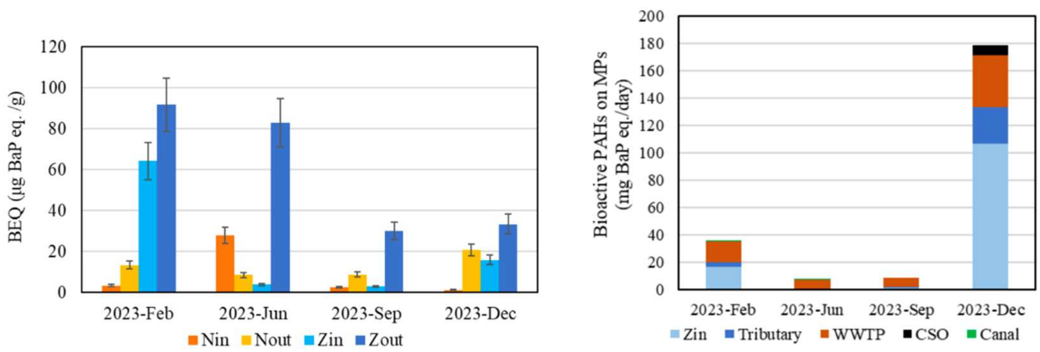


Figure 10 left: Concentrations of bioactive PAHs associated to MPs in the Zenne and at the in- and out-let of WWTP North; right: daily Bioactive PAHs loads associated to MPs in various sources. Right: Sources of daily MP associated bioactive PAH fluxes in the Zenne at Zout.

4.5. What are the impacts of microplastics contamination on the water quality of Brussels waterways? In terms MP quantity? In terms of contaminants? Now? In the Future?

In terms of water contamination by MP particles, it is the number of particles per volume of water and their shape that are the most important because with their size similar to plankton, they are misidentified as a food source by many aquatic organisms and are thereby known to enter the food chain and cause physical, physiological and behavioral harms[25].

This project has demonstrated that nowadays, the BCR is a significant source of MP for the Zenne and Canal. Average concentrations are typically between 3 and 20 (Canal) and 50 and 480 n/m³ (Zenne) with peaks at 800 n/m³. It is also important to mention that measurements were carried out in surface waters of the Canal and Zenne and our mass balance suggests that particles are more concentrated in the deeper waters of the Canal. As Canal is characterized by a stagnant water where sedimentation can occur, we could expect an underestimation of MP concentration for this waterway. Another important finding is that more than half of the MPs are long thin PET fibers.

Whether these concentration levels present a risk for aquatic organisms in Zenne and Canal is a difficult question to answer as there is no definition of what a "harmful" concentration is. It is known that the type of harm varies with exposure levels but also with the aquatic organisms, though a recent review[17] indicate that for organisms thriving their whole lifetime cycle in contaminated waters, concentrations higher than 0.001 to 0.009 mg/L corresponding to 8 to 18 n/m³ can already result in negative impacts. Harmful effects depend on exposure time and concentration, but also size and shape, and even polymer type. Small fibers – as typically found in Zenne and Canal surface waters – were particularly shown to cause more harm than other types of particles[18]. With present day average concentrations as high as 20 particles/m³ in the Canal and 480 particles/m³ in the Zenne (Figure 4) and a dominance of fibers, we can clearly conclude that especially Zenne waters from the future open air river stretch in Parc Max-sur-Zenne to downstream Brussels in Haren are highly contaminated and may present high risks for aquatic organisms after ingestion.

In addition to the direct harmful effect associated to the MP particles themselves, MP associated pollutants are another factor of concern. It has been shown that microplastics with adsorbed pollutants increase oxidative stress in aquatic organisms and induce bioaccumulation of pollutants that may result to increased mortality and decreased reproduction[19]. The toxicity of pollutant carrying MPs is thus higher that the toxicity of the MP themselves. In this study, we showed that MP particles from the Zenne in the BCR carry significant amounts of bioactive PAH with concentrations at Zin from 3 to 40 µg Beq BaP/g and at Zout from 15 to 92 µg Beq BaP/g (Figure 10). It is useful to keep in mind that these bioactive substance concentrations were determined using bioassay and only comprise the most harmful PACs that induce a cellular toxic response. Downstream Brussels, these values largely exceed measurements made in an uncontaminated soil in Flanders with the same method (0.7 to 4.6 µg Beq BaP/g)[20]. They are also higher than total PAHs values reported for beach litter MPs (1.4 to 6.0 µg/g)[21]. When animals ingest PAH contaminated MPs, the chemicals adsorbed onto the MPs can desorb and be released into the animal's gastrointestinal tract, making these chemicals bioavailable for absorption into the animal's tissues.

To conclude, nowadays, the co-occurrence of high MP concentration levels, and high levels of bioactive PAH associated to these MP constitute a double threat, particularly in the downstream part of the Brussels Zenne and further down where both MP concentrations and PAH contamination are highest.

When exploring possible futures, only likely evolutions of MP concentrations were considered.

Without any change in the present-day wastewater collection and management system, climate change resulting in increased rainfall over the BCR was shown to have to most negative impact. By 2100, expected increased rainfall over the BCR will result in increased CSO volumes to the Zenne and Canal, which will increase concentrations by 50% at Zmax and by 40% which mean average yearly concentrations of in Haren putting the environment even more at risk than it is already.

More interesting, several mitigation measures were shown highly effective to reduce MP concentration at more acceptable levels, and or to reduce the overwhelming presence of fibers.

An effective measure that would be easy to implement is the installation of fiber filters at the outlet of washing machines. This should result in a decrease of the MP concentration in Brussels by 30 to 40%. The resulting average concentrations would however still be high (280-300 n/m³).

---

[17] Nam et al (2023) https://doi.org/10.1016/j.jhazmat.2022.130532
[18] Kwon et al (2020) https://doi.org/10.3390/ijerph17186710
[19] Witczak et al (2024) https://doi.org/10.3390/toxics12080571
[20] Su et al (in prep) Environmental impact of treated wastewater reuse: AhR and ER mediated bioactivity in groundwater and soil – a case study in Kinrooi, Belgium.
[21] Gorman et al (2019) https://doi.org/10.1016/j.chemosphere.2019.02.094

Other identified effective measures concern the management of the rainwater flows towards the sewers. Catching 10 % of the rainwater to sewer flow would already result in a 50 % reduction of CSO volumes and a decrease of concentrations to 260-320 n/m³, and a 20 % reduction would even completely eliminate the occurrence of CSOs and result in the lowest concentrations we could expect from Brussels water management only (140 n/m³).

Similar results could also be obtained through engineering solutions aiming at increasing the volumetric capacity of sewers or a better management of existing stormwater basin, notably by a dynamic management of the overflow.

Recommandations pour la Région Bruxelles Capitale

Une liste de recommandations et/ou de nœuds de décision concrets (plus fournis que dans le policy brief si besoin) ainsi que les leviers d'action possibles pour la Région bruxelloise, basée sur les résultats de la recherche prospective

Despite the improvements of Brussels water quality following the implementation of wastewater treatment in the years 2000, the BCR watercourses (Zenne and Canal) are still in a critical situation regarding several known pollutants while the situation for emerging pollutants, such as microplastics, was completely unknown. The Plastic city project highlights the fact that the Zenne and Canal in the Brussels Capital Region are presently contaminated by high concentrations of Microplastics from which a large proportion (> 45%) are small fibers. These microplastics are also contaminated by elevated levels of polyunsaturated aromatic hydrocarbons. The co-occurrence of MP in association with PAH is particularly putting the environmental status of the aquatic systems at risk. By these, microplastics and their associated contamination, join the already long list of studied contaminants deteriorating Brussels waterways quality. Although not a direct threat for the health of Brussels Citizens, deteriorated water quality contributes to a degradation of the quality of their living environment. Degraded water quality often results in foul odors and unattractive water conditions that deteriorate the living environment and decrease human well-being. Therefore, preserving and optimizing future access to Brussels' water resources of good quality is a critical factor in the urban quality of life.

During the project, several important observations were made:

Plastic City is the first and – to our knowledge – only project related to microplastics in the Brussels Region and, although our results allowed to unravel a series of important questions, these rely on a limited number of observations and many assumptions (for example, an important sedimentation in the Canal). **Our first recommendation will thus concern to increase the knowledge on MP distributions in the BCR**.

The project has shown that the major entry point of microplastics to the Brussels Zenne and Canal was through the loss of microplastics to the Brussels sewer system. This loss can occur through the release of fibers from synthetic textile fabrics washing and through the wash-out and fragmentation of plastic street litter by surface runoff to the sewer drains of the combined sewer system. As a result, concentrations in MPs are very high in untreated sewage and **our second set of recommendation will thus concern this escape of MPs to sewers**.

Finally, results also showed that, although MPs are also present in the Zenne, Canal and their river tributaries upstream Brussels, the high microplastic concentrations observed in the BCR waterways are essentially related to BCR inputs – and are more specifically linked the regional wastewater collection and treatment system. This means that the BCR authorities have the trigger to change the situation in their hands. Brussels wastewater treatment plants were shown to be very efficient in retaining microplastic particles from sewage. However, not all sewage is treated and most of the microplastic contamination in the Zenne and Canal are from the release of untreated sewage occurring during combined sewer overflows. Without any change in the present-day management of wastewater collection and treatment, the already critical situation against microplastics will become worse under expected climate change. Indeed, increased rainfall is expected by 2100, and we have shown that this will result in a 30 to 40 % increase of the MP concentrations related to increased CSO. **Our final set of recommendation will thus concern stormwater management.**

Recommendations:

1. Increase and strengthen the knowledge on microplastic distribution in the BCR. Not only in the water but also in sediments, and in street litter to better identify hot-spot places of accumulation and release. A nice example of study is the one made by UGhent and Vito for the Vlaamse Milieu Maatschappij in 2021[22].

2. Reduce the loss of plastics and microplastics to sewers

Reduce the loss of Fibers: On of the most important microplastic particle found in untreated sewage, and further on in the environment are synthetic fibers, and more particularly PET fibers that originate from textile fabrics. It was shown that reducing the fibers in domestic sewage collected by Brussels sewers would ultimately substantially reduce the MP concentration by 30 % to 40 %. This BCR measure alone will not be enough to reach low levels of MP contamination but when applied nation-wide, it could make a difference. In France, Article79 of the AGEC law (2020) mentions that « from the 1st of January 2025, new washing machines are equipped by a plastic microfiber filter. A decree precises application modality »[23]. Although the measure was delayed as the French decree is still in the making, similar initiatives are expected at European level in the framework of the Commission Regulation (EU) 2023/2055 of 25 September 2023 amending Annex XVII to Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) as regards synthetic polymer microparticles.

We therefore recommend BCR authorities in a first stage to promote the voluntary installation of washing machine fiber filters. These types of filters are already available on the market[24], and some washing machine brands even propose already equipped devices. In general, the devices are equipped with disposable filters that need to be replaced. It is of course important that the filters are cleaned/disposed of the proper way to avoid re-release towards the environment.

In a second phase, more constrained regulations like the one foreseen in France could be put in place.

Reduce the loss of Fragments: The other important group of plastic particles that are commonly found in Brussels sewage and water ways are fragments originating from plastic packaging waste. This group representing 50 % of plastic particles dominates the mass of microplastics (90 %) released to Zenne and Canal and losses to sewers are known to be related to street litter, and so to a large set of controlling factors concerning citizen behavior towards waste dumping, waste management practice, street cleaning practices, but also plastic packaging design, and many more. Unravelling the importance of these various controls would require more detailed information about the plastic litter distribution patterns in the BCR which was out of scope of our project. We can therefore only refer to our first recommendation to **Increase and strengthen the knowledge on microplastic distribution in the BCR.**

3. Better manage stormwater flows to sewers to reduce CSOs

---

[22] Vercauteren et al (2021) Onderzoek naar verspreiding, effecten en risico's van microplastics in het Vlaamse oppervlaktewater. https://vmm.vlaanderen.be/publicaties/onderzoek-naar-verspreiding-effecten-en-risico2019s-van-microplastics-in-het-vlaamse-oppervlaktewater-kernrapport

[23] la loi 2020-105 du 10 février 2020 relative à la lutte contre le gaspillage et à l'économie circulaire (AGEC): «A compter du 1er Janvier 2025, les lave-linges neufs sont dotés d'un filtre à microfibres plastiques. Un décret precise les modalités d'application du present article.»

[24] For exemple: AEG, Planet care, Samsung, Bosch – price from 70 to 90 euro per unit.

Contamination of Brussels waters linked to stormwater management is a long-known problem in the BCR for conventional pollutants (organic matter, N and P, and particulate bound pollutants such as PAH). This project now also showed that stormwater entering Brussels sewage and resulting in combined sewer overflow are the most important MP source towards the Zenne and Canal and that a reduction of CSO undoubtfully would result in decreased concentrations.

There are various engineering ways to control CSOs such decrease CSO entry points, increase sewer capacity and/or WWTP treatment capacity, etc... however these need heavy and costly infrastructure adaptation. A now well documented and used solution to reduce CSO without changing existing infrastructure is an optimized use of stormwater reservoirs based on dynamic flow controls and these would certainly result in decreased MP concentrations in Zenne and Canal.

We recommend to study efficiency of stormwater reservoir and move towards dynamic regulation to reduce overflows.

Moreover, an interesting result of the project is that we estimated the amount of rainwater that needs to be intercepted before entering the sewer system to reduce CSO volumes. Several nature-based solutions (NBS) exist to mitigate stormwater flows towards sewers in urban setups, and most are already considered and used in different neighborhoods of Brussels. These NBS include green roofs where vegetation can absorbs rainwater and evaporate it back to the atmosphere, retention rain gardens where urban depressed areas collecting rainwater are planted with vegetation to favor evaporation and absorption, permeable pavements (where possible) to enhance infiltration, vegetated rain swales that intercept and slow down surface runoff again in favor of evaporation, infiltration trenches and basins that are filled with gravels to store water and favor evaporation, increased areas of green zones with trees acting as water pumps towards the atmosphere, increase the use of individual rain tanks, and others…

We therefore recommend that a regulation of stormwater flows through the implementation of NBS becomes a priority in the BCR. For reducing microplastics, but also other pollutants. Initiated efforts in the creation of NBS solutions need to continue and our reduction estimates may be a guideline when discussing rainwater interception measures at parcel scale.

Publications

Une liste de publications liées au projet. Cette liste doit permettre au lecteur intéressé par le rapport de recherche de retrouver les détails des résultats de recherche du projet. Il peut s'agir, par exemple, d'un ou plusieurs rapports de recherche, d'articles scientifiques, d'un livre et/ou d'un doctorat. Veuillez également mentionner les doctorats qui sont en phase de finalisation. Veuillez utiliser le système APA comme style de référence.

Brion, N., Najar, B., Van Antwerpen, P., Jia, Y., Su, Y., & Elskens, M. (2023). Plastic-City: European cities as sources for microplastics and associated organic contaminants to their waterways. Poster presented at *Dioxin 2023 - 43rd International Symposium on Halogenated Persistent Organic Pollutants (POPs).* September 10-14, 2023, Maastricht, The Netherlands.

Elskens, M., Van Langenhove, K., Carbonnel, V., Brion, N., & Eisenreich, S. J. (2023). Dynamics of estrogenic activity in an urban river receiving wastewater effluents: effect-based measurements with CALUX. *Water Emerg Contam Nanoplastics 2* (9). DOI: 10.20517/wecn.2023.15

Nasrallah, N., & Brion, N. (2025). *Tracing Microplastics in River Flow: A Case Study of the Zenne River in the Brussels Capital Region*. Thesis for the degree of Master in Marine and Lacustrine Sciences and Management, VUB.

Song, J. Q., & Brion, N. (2024). *Estimating the contribution of combined sewer systems and wastewater treatment plants as a source of macroplastics and microplastics in the Brussels waterways*. Master thesis PartimII, Faculty of Sciences and Bio-Engineering Sciences, VUB.

Su, Y. (2025). *AhR- and ER-CALUX Bioassays for Environmental Monitoring of Polycyclic Aromatic Compounds and Xenoestrogens*. Thesis for the PhD Degree in Doctor of Science (VUB) and Doctor in Biomedical and Pharmaceutical Sciences (ULB).

Su, Y., Zhang, X., Matranxhi, B., Jia, Y., Gao, Y., & Elskens, M. (2023). Assessing the AhR-mediated activity of Polycyclic Aromatic Hydrocarbons (PAHs) and their Methylated Derivatives using AhR-CALUX Bioassay. Oral communication presented at *Dioxin 2023 - 43rd International Symposium on Halogenated Persistent Organic Pollutants (POPs)*. September 10-14, 2023, Maastricht, The Netherlands.

Van Campenhout, C., Elskens, M., & Brion, N. (2023). *Testing and optimizing methods for the sampling and Determination of microplastics in Brussels waterways.* Master thesis PartimII, Faculty of Sciences and Bio-Engineering Sciences, VUB.