Distribution, effects and risks of microplastics in Flemish surface waters

Executive summary

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Preface

The report present the results of a first broad explorative study on the microplastic pollution in freshwater in Flanders. The current situation in the Flemish freshwater ecosystem was analyzed, different sources were characterized and the microplastic removal efficiency in waste water treatment plants was investigated. The results were extrapolated using the *Water Emissions Inventory Planning Support System* (WEISS) model (performed by VITO). The results was coupled to relevant policy advice and identification of the knowledge gaps.

This document contains a summary of the most important results of this exploratory study. The detailed results are presented in the main report that can be found at www.vmm.be/publicaties and is available in Dutch.

This study is a result of a close collaboration between the Flemish Environmental Agency (VMM), Ghent University (GhEnToxLab) and the Flemish Institute for Technological Research (VITO).

Executive summary

Plastics are ubiquitous in our daily life and in our society. They exist in every imaginable shape and are so versatile that they can be adapted for numerous applications. Therefore, the plastic industry is a booming business with a worldwide **plastic production of 368 million tonnes** (anno 2019). **In Belgium, 7.35 million tonnes of plastic** was produced in 2018. Unfortunately, part of the produced plastics will end up in the environment including aquatic ecosystems. Unintentional losses (e.g. during transport), littering, wear of products and a failing waste management are possible causes of plastic emissions to the environment. In 2018, 86 million tonnes of plastic was estimated to end up in the environment worldwide. Once in the environment, the plastic will - under the influence of sunlight, temperature, wave action and friction - degrade and fragment into small plastic particles, called **microplastics** (smaller than 5 mm) or **nanoplastics** (smaller than 1 µm). Next to these secondary microplastics, primary microplastics (i.e. plastics produced in these small dimensions) can also end up in the environment through their use in for example personal care products, widely used detergents or paints (e.g. road markings). Microplastics are found worldwide in various ecosystems, from the deep sea to the highest mountains, from the North pole to the salt we use in the kitchen. Despite large (inter)national research efforts, many microplastic related questions remain unanswered. What is the microplastic concentration in the (Flemish) waterways? How many microplastics do we produce on a daily basis and which fraction ends up in the environment? Are we able to remove microplastics from the waste water? Do microplastics in our environment affect our health or the health of our aquatic ecosystems?

At this point, these questions cannot be answered, especially not at a local or regional scale, such as Flanders, where, except for a few pilot studies, **no information is available on the microplastic concentrations in the freshwater environment**. Therefore, the aim of the current study was to **explore the microplastic pollution in Flanders** by studying various sources, transport routes, and the distribution of microplastics in these freshwater environment. Furthermore, the exposure of aquatic organisms and humans and potential risks were assessed. The collected data provides a scientific basis for society, economy, and policy to tackle microplastic pollution and improve the sustainability of the Flemish water management.

This research, conducted from 2019 trough 2021, processed and analysed 210 samples collected from eight different matrices such as surface waters, waste water treatment plants and run-off from highways, distributed in 36 locations in Flanders. The samples were collected and processed according to the most recent scientific methods and the microplastic particles, with sizes larger than 25µm, were identified using Fourier-transform infrared spectroscopy.

To estimate the current microplastic concentrations in Flemish rivers and streams, nine waterways were sampled. Based on the gathered data, we conclude that microplastics are omnipresent in the freshwater ecosystems of Flanders. On **average, one litre of surface water contained 0.36 microplastic particles (ranging between 0 and 4.8 microplastics per litre).** The main polymer types that we identified in surface waters are polypropylene and polystyrene, widely used in packaging. The measured concentrations are comparable with reported concentrations in The Netherlands, Finland and Hungary. **The sediment of the waterways contained on average 2,480 microplastic particles per kg of dry weight sediment (ranging between 610 and 9,558 microplastics per kg).** Polyethylene terephthalate and polypropylene were the most frequently found microplastics in the sediments. Both polymer types are commonly present in daily-use products such as plastic bottles and packaging materials. The plastic particles found in the sediment were generally smaller compared to the particles found in the surface water. The concentrations observed in our sediment samples are comparable to

published concentrations in other European countries such as Germany and Italy. The temporal and spatial variation was considerable and should be studied in more detail in future research.

People often refer to littering or large illegal dumping of wastes as sources of plastic emission to the environment. However, the **domestic waste water** could also, maybe unknowingly, contribute substantially to the microplastic pollution. Numerous daily use plastic products can emit microplastics during usage. The current research quantified the microplastic pollution present in domestic waste water in Flanders by analysing the influent water of a small scale waste water treatment plant of which the water is (mainly) derived from domestic waste water. Per litre of domestic waste water that enters the treatment plant, 0.96 to 39.8 microplastic particles per litre were found. The observed microplastics were mainly identified as small (25 – 100 µm) polystyrene and polypropylene particles, although polyethylene terephthalate, polyethylene and polyvinyl chloride were also present. These observations indicate that every Flemish person emits 1,145 microplastics (between 355 and 1,634 microplastics) daily through domestic waste water, resulting in a yearly discharge of 418 thousand microplastic particles per person. **For the total of population of Flanders, this results in a yearly emission via the domestic waste water of almost 3 billion microplastic or roughly 3,000 kg microplastic.** The domestic waste water is being transported to an active waste water treatment plant, this is at least the case for 83 % of the households of Flanders. From our measurements, we established that **Flemish waste water treatment plants are able to remove 97.5% (between 92.6 and 100 %) of the microplastics** from the waste water before it is discharged in the neighbouring waterway. During the treatment of the wastewater, the largest fraction of removed microplastics is found in the sludge. In Flanders, the sludge is removed and incinerated thus preventing reintroduction of the microplastics in the environment.

Another source of microplastic contamination in the environment are the microscopically small rubber tire wear particles that are formed due to the friction between the tires and the road. Based on the reported driven kilometres in Belgium and the reported emission of tire wear particles, we estimated an emission of 49,188 tonnes of tire wear particles (which end up on the road in Belgium). Tire wear particles can end up on the road or can be transported to the nearby environment by wind or rain action and emitted to the freshwater environment. A fraction of the tire wear particles is assumed to end up in the atmosphere. This study provides a first estimation of the emission of tire wear particles to the environment in Flanders. To do so, samples of run-off and atmospheric deposition were collected on the side of five highways. The run-off samples contained between 0.02 and 9.20 mg tire wear particles per litre per day, which corresponds to an **estimated emission of 10.8 mg tire wear particles per driven km by one vehicle.** Furthermore, other, more conventional microplastics were also found in the run-off (0.91 microplastics per litre per day; maximum of 11.73 microplastics per litre per day). Tire wear particles were not detected in the atmospheric deposition samples although we found on average 3.2 microplastic particles per m^2 per day, with a maximal observed concentration of 8.5 microplastics per m^2 per day.

The gross and net emissions of both above mentioned sources, i.e. domestic waste water and tire wear particles, were extrapolated to whole Flanders region area based on the 'Water emission Inventory Planning Support System' (WEISS) model. **From the yearly gross microplastic pollution in the domestic waste water, 20% corresponding to 623 kg of microplastic particles will end up in the aquatic environment**. The highest losses are identified to be originating from the households that are not (yet) connected to an active waste water treatment plant. In those cases, the domestic waste water is directly discharged, sometimes with limited treatment, in the aquatic environment. This discharge is responsible for 66 % of the net emission to the waterways. By increasing the fraction of households that are connected to an active waste water treatment plant, the emission of microplastics to the

freshwater ecosystem could be reduced substantially. The microplastic removal efficiency of individual treatment systems[1] needs to be studied, since these systems could offer a short-term alternative for the households that are not yet connected to an active sewage treatment plant.

In Flanders, **the yearly net microplastic emission of tire wear particles is estimated to be 245,926 kg**, a remarkably higher emission compared to the estimated emission from domestic waste water. The main identified emission route is the run-off from the road surface that does not end up in a waste water treatment plant. By studying the efficiency of sedimentation basins, filter systems or other passive or active systems that treat the run-off water is necessary to implement successful mitigation methods to reduce the emission of tire wear particles to the freshwater environment.

This exploratory research did not include all possible sources of microplastic pollution, leading to a large unknown fraction of sources of microplastics entering a waste water treatment plant. **More research on the contribution of industrial waste water, atmospheric concentrations and littering on the total microplastic pollution in the waste water** will be essential to pinpoint the role of different sources and set up appropriate mitigation strategies to reduce the microplastic discharge to the environment.

The risk of adverse effects of microplastic pollution for the Flemish surface waters, calculated according to accepted EU methodologies, are negligible. **Risks for benthic organisms in the waterways are low to negligible, although local risks cannot be excluded**.

The **tap water** that enters the Flemish households contains **very low amounts of microplastics (0 – 0.06 microplastics per litre).** Hitherto, the scientific (worldwide) knowledge on the effects and risks of microplastic exposure to human health is, however, too limited to perform a human health risk assessment; further research is required.

In conclusion, this research was able to demonstrate that microplastics are ubiquitous in the Flemish environment. Although, based on the available knowledge, the environmental (aquatic) risks associated with the observed concentrations are low to negligible. This research illustrates the current situation and proposes some possible improvements (both on emission and scientific knowledge). At the same time, it also offers a clear perspective on mitigation measures to reduce the net emission of microplastics to our rivers and way to improve a sustainable management of freshwater ecosystems.

[1] An individual treatment system ('Individuele behandelingsinstallatie voor afvalwater' or in short IBA) can be installed for households that are not connected to the sewage. The IBA can clean the domestic waste water of one household, based on small scale sedimentation and biological treatment of the waste water before discharge in a waterway.