# Macro- and mesoplastic abundance and composition in the water column of the river Waal

## Abondance et composition macro- et mésoplastique dans la colonne d'eau de la rivière Waal

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## RÉSUMÉ

La pollution plastique est considérée comme l'une des principales menaces pour les ressources mondiales en eau. Bien que les études sur les concentrations de plastique se concentrent principalement sur l'environnement marin, un nombre croissant d'études récentes soulignent les conséquences environnementales importantes sur les environnements d'eau douce dans le monde entier. Outre les impacts négatifs directs sur les systèmes d'eau douce, les rivières sont potentiellement la principale voie de transport de la pollution plastique vers la mer. Dans cette étude, nous fournissons une évaluation de la quantité et de la qualité des macro- et mésoplastiques au fil des ans dans l'ensemble de la colonne d'eau de la rivière Waal, le principal distributeur du fleuve Rhin aux Pays-Bas. En outre, chaque élément en plastique a été vérifié pour obtenir des informations permettant de déterminer le pays d'origine. La colonne d'eau de la rivière a été échantillonnée passivement à l'aide d'un filet d'arrimage à faible débit. La concentration moyenne de macroplastique par m³ (+/- SD) était de 2,2 $10^{-3}$ ± 0,001 et 7,1 $10^{-3}$ ± 0,003 particules.$m^{-3}$ pour octobre 2020 et novembre 2018, respectivement. Parallèlement, la plus forte concentration moyenne par m³ de mésoplastique a été enregistrée en septembre 2019 (5,64 $10^{-3}$ ± 0,003 particles.$m^{-3}$). Les catégories macro- et mésoplastiques les plus dominantes étaient respectivement " Film plastique 2,5 - 50 cm (plastique souple) " et " Film plastique 0 - 2,5 cm (plastique souple) ". La majorité des particules plastiques collectées dans le cadre du présent projet provenaient d'Allemagne.

## ABSTRACT

Plastic pollution has been considered one of the major threats to global water resources. Although studies on plastic concentrations mainly focus on the marine environment, recently an increasing number of studies point out to large environmental consequences in freshwater environments worldwide. Besides the direct negative impacts on freshwater systems, rivers are potentially the major transport pathway of plastic pollution to the sea. In this study we provide an assessment of the quantity and quality of macro- and mesoplastic over the years in the entire water column of the river Waal, the major distributary of the river Rhine in the Netherlands. Additionally, each plastic item was checked for information that would allow to determine the country of origin. The river water column was passively sampled using a stow net at low discharges. The mean macroplastic concentration per $m^3$ (+/- SD) was 2.2 $10^{-3}$ ± 0.001 and 7.1 $10^{-3}$ ± 0.003 particles.$m^{-3}$ for October 2020 and November 2018, respectively. Meanwhile, the highest mean concentration per $m^3$ of mesoplastic was registered in September 2019 (5.64 $10^{-3}$ ± 0.003 particles.$m^{-3}$). The most dominant macro- and mesoplastic categories were “Plastic film 2.5 - 50 cm (soft plastic)” and “Plastic film 0 - 2.5 cm (soft plastic)”, respectively. The majority of plastic particles collected in the current project originated from Germany.

## KEYWORDS

Freshwater systems, Plastic pollution, River OSPAR, River Rhine, Water column

# 1 INTRODUCTION

Plastic pollution has become one of the major contemporary environmental challenges (Winton et al., 2020). Until recently the majority of studies on plastic presence mainly focused on the marine environment. However, plastic presence in the freshwater environment is of increasing concern due to the potential role of rivers as main transport pathway and source of plastics to the ocean. Once plastics accumulate in the natural environment, they cause potential negative effects and become an environmental hazard (Van Emmerik, 2019). Despite the recent efforts to study riverine plastic pollution, assessment of plastic concentration in rivers is limited to floating plastic debris and the surface water layer (Vriend et al. 2020), highlighting the urge for more extensive monitoring. Therefore, the present study assessed the abundance and type of macro- and mesoplastic in the entire water column in the river Waal, a distributary of the river Rhine during multiple sampling years. Postulated research questions are: 1) what is the composition and origin of macro- and mesoplastic in the water column of the river Waal, 2) does the plastic concentration and composition differ over the years and 3) what is the quantity of macro- and mesoplastics in the water column of the river Waal?

# 2 METHODS

## 2.1 Sampling

Plastic sampling was performed in the lowland river Waal in the Netherlands from 2018 to 2021. Water column monitoring was performed using a stow net vessel (bag-shaped) connected to an anchored fishing-boat. The static net was held open by one beam partially above surface water and a second near to the bottom of the river, thereby passively monitoring plastic items in the entire water column (Buoyant + Suspended + Bed-Load). The collected plastic items were visually separated from organic debris and fish captured by the net.

## 2.2 Plastic identification and concentration

The plastic particles were sorted in the laboratory and grouped according to their size ranges: macroplastics (> 25 mm) and mesoplastics (> 5 mm ≤ 25 mm) and identified according to the River-OSPAR plastic checklist. For this study, a total of 65 plastic categories were considered. In addition to the River-OSPAR categories, plastic items were categorized based on a higher plastic classification system: consumer waste, industrial waste (fishing), miscellaneous plastic waste, and industrial waste (shipping/ other). Hereafter, the abundance of all macro- and mesoplastic categories per sampling month year combination were recorded and the proportion of all unique plastic categories were calculated. Relevant obtained data were used to monitor differences in macro- and mesoplatic composition throughout the months and years. If traceable, the county of origin of each collected plastic item was noted as well information about the year of production or expiry date.

In order to determine the plastic concentration, an initial test was carried out to evaluate the catching efficiency of the net. Due to the larger mesh size, the catching efficiency of the net was reduced resulting in an underestimation of plastic concentration. The efficiency test was performed by introducing plastics pieces with different dimensions corresponding to macro- and mesoplastic of both hard and soft plastic in the water column right in front of the stow net. The subsequent retrieval rate was used to determine net efficiency. Subsequently the plastic concentration was calculated using the catching efficiency and the sampled discharge of the stow net. Hereafter, abundance of macro- and mesoplastic particles was expressed in particles per sampled volume (particles.$m^{-3}$).

# 3 RESULTS AND DISCUSSION

A total of 12,832 items of plastic were counted and classified during the monitoring, of which 9.137 were macroplastic items and 3.695 mesoplastic items. “Plastics film 2.5 – 50 cm (soft plastic)” and “Plastic film 0 - 2.5 cm (soft plastic)” were the dominant plastic items recorded. “Candy- snack- and chips packaging”, “Tampons and tampons packages”, “String and cord (diameter < 1 cm)” and “Undefined plastic pieces 0 - 2.5 cm (hard plastic)” were found often. The majority of plastic could no longer be identified to country of origin. A total of 23 source countries were identified of which only 5 belonged to the river Rhine basin. Most plastics were from Germany (70.87%) with only 7.61% originating from the Netherlands. A large amount of plastics from eastern European countries were found potentially linked to commercial navigation from these countries. Countries of origin such as the United of States could be a result of potential plastic input through tourism. Composition of plastic in the water column was found to be consistent in time. The mean macroplastic concentration

(particles.m$^{-3}$) was highest on November 2018 at 7.1 $10^{-3}$ ± 0.003 particles.m$^{-3}$ and lowest on October 2020 at 2.2 $10^{-3}$. The mean mesoplastic concentration (particles.m$^{-3}$) was highest on September 2019 at 5.64 $10^{-3}$ ± 0.003 particles.m$^{-3}$ and lowest on October 2020 at 0.92 $10^{-3}$ ± 0.3 $10^{-3}$. Variation between sampling dates was limited.

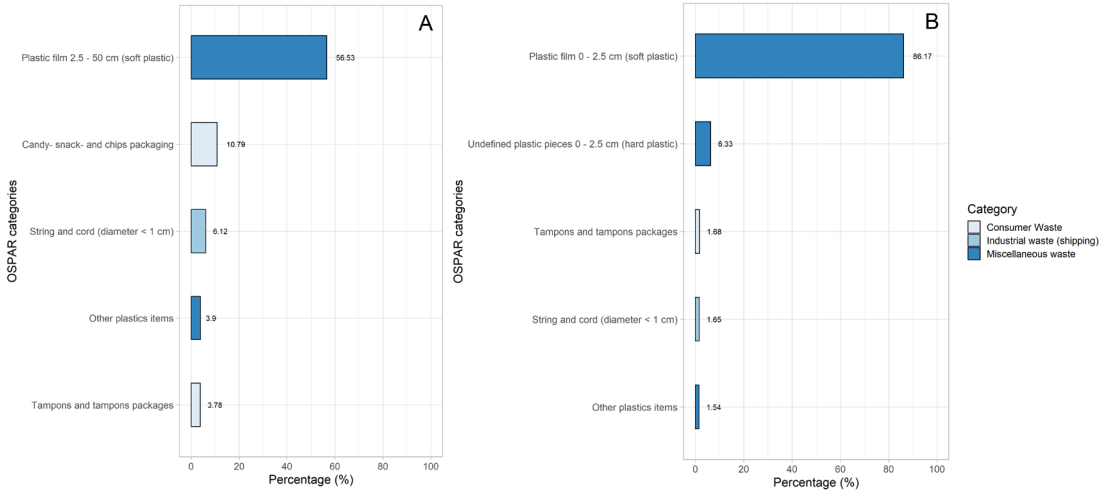


Fig. 1. Top 5 main (A) macroplastic and (B) mesoplastic items recorded in the water column of the river Waal, according to the fraction of categories.

## 4 CONCLUSION

Macro- and mesoplastic collected in the water column of the river Waal showed a large variety of plastic category, in different sectors and applications. Plastic categories did not vary between sampling days. Difference in fluxes may impact plastic concentration and composition among abiotic compartments. Results indicate the need of future research on determining the plastic composition and concentration during higher discharges

The majority of plastic particles sampled in the water column of river Waal were fragments, restricting the accurate identification of the plastic items. Undefined soft fragments (Plastics film (soft plastic)) were the dominant category recorded for macroplastic as well as for mesoplastic.

In the current study, macro- and mesoplastic concentrations in the water column of the river Waal were not influenced by the variation in the water discharge at the sampling date, during very low and low discharges. Differences in sampling methods and examined abiotic compartments among studies worldwide limited the comparison of plastic abundance in the freshwater systems.

Understanding the sources, different size ranges and type of plastic in the aquatic environment is important to develop mitigation and management measures, e.g., environmental policies, educational strategies, among others. Conclusions point out to a continues need of research on plastic survey in freshwater systems to understand the riverine plastic concentration and transport.

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