Lowland rivers as sinks for plastic? A model-based case study relying on in situ observations for the Scheldt estuary in Belgium

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In this study the objective was to map plastic waste accumulation zones and to quantify the plastic flux from Flemish estuaries and ports to the southern North Sea. Over a period of 2 years and following a strict sampling design and protocol, 131 microplastic (100 µm – 5 mm) and 263 macroplastic samples have been collected in the water column and sediment at 20 sampling locations in the Yser estuary, the port of Ostend, the port of Antwerp, the Ghent-Terneuzen canal, and the Scheldt estuary in Belgium. The sampling strategy included three types of campaigns: (1) seasonal samples; (2) 13h tidal cycle samples; and (3) bimonthly spot samplings. All samples have been processed in line with state of the art laboratory procedures and quality assurance/quality control criteria, including replicates, positive controls, negative controls, micro-FTIR or ATR-FTIR confirmation. It was found that plastic is an abundant pollutant in riverine and estuarine ecosystems in Flanders. The plastic concentrations vary spatially, and the highest microplastic concentrations have been observed in the river Scheldt (42.9 ± 70.6 particles/m³). All sediment samples contained plastics, and the highest concentrations were found inside harbour areas in Wintam in the Scheldt river (4301.6 ± 4926.8 part kg DW^{-1}). Clear spatial differences have been detected in the most dominant polymers. A hydrodynamic plastic dispersion model in the open-source software TELEMAC was used to quantify the plastic flux towards the marine environment. This model consisted of an ensemble analysis, a flood-ebb cycle analysis, a flux analysis, and a residual mass flux analysis. The model was calibrated and validated and a general circulation pattern of the plastic transport was inferred. From this model and its simulations, three patterns were inferred. First, based on the residual plastic mass flux, the plastic transported towards the sea was mainly following ebb channels. Plastic moving into the estuary mainly used flood channels. In the estuary, there are small-scale circulation patterns which suggest that plastic particles can be trapped and do not leave the estuarine region. Secondly, sources of plastic upstream of the Dutch-Belgian border contributed little to the mass of plastic that reaches the North Sea. As such, the Flemish estuary of the river Scheldt is considered to function as a plastic reservoir, with a plastic plume that moves around the plastic injection points. A final observation was that a significant part of the net plastic flux reaching the estuary does not move upstream of the Dutch-Belgian border, and is thus trapped in the estuary. Overall, plastic particles are expected to move up and down with the tide in the estuary, but their travel does not extend beyond 20 km. The tested scenarios suggested that the Scheldt estuary is a major sink for plastics. Plastic particles had the tendency to accumulate in intertidal areas, suggesting that beaching is a very important process. As beaching is considered an important process, dedicated monitoring campaigns can be initiated to quantify the amount of plastic on the river bank, and further finetune the model.