A comparative study of numerical modelling for plastic dispersal and fate in aquatic environments

Wilhem Riom*†[1], Nithin Achutha Shettigar*‡[1], Qilong Bi[1,2], and Erik Toorman[1]

[1]Department of Civil Engineering - Hydraulics and Geotechnics [KU Leuven] – Kasteelpark Arenberg 40 - box 2448 3001 Leuven, Belgium

[2]Flanders Hydraulics Research – Berchemlei 115 B-2140 Antwerpen, Belgium

Abstract

Numerical modelling is an effective tool complementing in-situ or remote sensing observations of plastic litter from rivers to the ocean. It allows exhaustive simulation of particle dispersal dynamics and fate after their disposal in aquatic environments. Several modeling methods have been proposed. The most commonly used in the literature is based on the Lagrangian framework. It allows to follow individual particle trajectories by time-integration of the flow velocity. The tracking of a large amount of particles is at the cost of a high complexity. Nevertheless, it remains helpful when identifying (macro-) plastics spatial distribution patterns. On the other hand, the Eulerian framework is more efficient to follow the evolution of the number or mass concentrations. Compared to the Lagrangian framework, it is suitable for modelling transport and fate of micro-plastics in large-scale estuarine and marine systems. However, plastic debris are known to exhibit high polydispersity in their sizes, shapes, and densities. Hence, an in-depth study of microplastics distribution patterns in a large domain would require a numerous number of discrete classes, leading to higher model complexity . However, the polydispersity of plastics could be addressed in an effective way by using population balance equations (PBE) to track the evolution of the size distribution. In PBE, the moments of the number density function (NDF) are advected and diffused within the Eulerian framework. Subsequently, the plastic NDF can be recovered from the resulting moments of the distribution. With the three discussed modelling frameworks, we propose to investigate the effects of tidal pumping on the exportation or importation of plastics. These methods will be tested in a schematized estuary including deposition terms. Their performance in terms of computational resources and spatio-temporal dispersal of plastic litter will also be analyzed.

Keywords: microplastics, estuary, Lagrangian, Eulerian, population balance equation, method of moments

*Speaker

†Corresponding author: wilhem.riom@kuleuven.be

‡Corresponding author: nithinachutha.shettigar@kuleuven.be