A quantitative approach for estimation of the settling velocity of flocculated microplastics in estuaries

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Abstract

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Rivers are one of the main microplastic (MP) transport pathways to open seas and oceans. MPs are ubiquitous and found based on their size, polymer density and their interactions with other suspended particle matter (SPM) at the water surface as floating particles, in the water column as suspended particles, or deposited on the riverbed or buried in the sediment. The settling velocity, in turn, plays an important role on the fate of MPs. In contrast to the well documented formulations for determining the settling velocity of MP based on their size and polymer density, the quantitative approaches to include the influence of the other SPM on the settling velocity of MP are rare.

In estuaries, where the saline and fresh water meet each other and baroclinic circulation is dominant, the fine sediment concentration is increased and estuarine turbidity zone (ETZ) is resulted. Due to the size of small MP, they are likely aggregated within the fine sediment and produce larger flocs (flocculation mechanism). Therefore, the settling velocity of MP becomes significantly dependent on the concentration of fine sediment. As a result, the semi-empirical velocity formulations, which are applied for pure individual MP particles are not capable of reproducing the settling velocity of MPs and consequently, the numerical models, which implement the settling velocity for MP without attention to the concentration of fine sediment are failed to reproduce the MP concentrations in estuaries.

To include the effect of fine sediment concentration on the settling velocity of MPs, a quantitative approach for estimation the settling velocity of MPs based on the concentration of the fine sediment in the water column is presented. Finally, the numerical model results using implementation of this approach for a regional large scale river, the Weser estuary and adjacent Wadden Sea, are discussed and evaluated.

Keywords: Microplastic, settling velocity, fine sediment, numerical modelling

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