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Modeling the influence of biogeochemical and ecosystem processes on microplastics transport

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In this work we analyze how seasonal production and degradation of organic matter, and corresponding changes in the plankton ecosystem affect microplastics (MP) density and ability for transportation and burying in sediments. This is simulated with a coupled hydrodynamical-biogeochemical model that provides a baseline scenario of the seasonal changes in the planktonic ecosystem and changes in the availability of particulate and dissolved organic matter. We use a biogeochemical model OxyDep that simulates seasonal changes of phytoplankton (PHY), zooplankton (HET), dissolved organic matter (DOM) and detritus (POM). A specifically designed MP module BioPlast considers MP particles as free particles, particles with biofouling, particles consumed by zooplankton and particles in detritus, including fecal pellets. A 2D coupled benthic-pelagic vertical transport model 2DBP was applied to study the effect of seasonality on lateral transport of MP and its burying in the sediments. OxyDep and MP modules were coupled with 2DBP using Framework for Aquatic Biogeochemical Modelling (FABM). The model was applied to numerically predict the spatial distribution of MP in the water column and sediments after being discharged into the aquatic environment. We have used documented concentrations of MP (fibres) in the treated wastewater from a large wastewater treatment plant with discharge to the Bekkelaget basin in the Inner Oslofjord, Norway. Numerical experiments confirm, that biogeochemical cycling leads to seasonality in the vertical and horizontal transport of MP of neutral buoyancy from its source, with higher accumulation in the sediment during the summer-autumn period, while cleaning of the upper water layers resembles the winter period. That means that MP of neutral buoyancy could be transported to a smaller distance in summer, compared with winter. Transport of light density floating MP into the deep layers and the sediments can be explained by influence of biogeochemical processes. High density MPs are affected by the biogeochemical processes to a very small degree and tend to accumulate in the sediments close to the source point. Thus, we confirm that the “biological pump” can be one of the important drivers controlling the quantity and the distribution of MP in the water column. The biological pump can deplete MP from the surface water and accelerate MP burying in summer period compared to the winter.

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