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Extension of plastic debris model to incorporate interaction processes of biofouling and heteroaggregation in global lakes and reservoirs

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Environmental contamination by plastics has been receiving considerable attention from scientists, policy makers and the public. Once plastic is released into the environment, it is gradually degraded by physical, chemical, and biological processes, leading to further subdivision into an enormous number of forms. In this study, the process-based plastic debris model NICE (National Integrated Catchment-based Eco-hydrology) (Nakayama and Osako, 2023a-b; Nakayama 2025a-b) was extended to couple with LAKE2K in stratified water quality model (Chapra and Martin, 2012) to evaluate the global plastic dynamics in both lotic and lentic waters in the extension of the previous studies. The new model developed to include the interactions processes of heteroaggregation and biofouling (Praetorius et al., 2012; Domercq et al., 2022) in the three vertical layers of global reservoirs and lakes. The result shows that the microplastic concentrations in the reservoirs were higher than those in the lakes and that the concentrations in Asian lakes and reservoirs are much higher, which indicates that plastic pollution is particularly serious in Asian lakes and reservoirs (Guo et al., 2021). The result also shows that more plastic remains in the upper epilimnion in the reservoirs, whereas more plastic settles to the deeper metalimnion and hypolimnion in the lakes. Further, the model clarified that aggregated and composite plastics make up the majority of the deposits on lakebed in most of reservoirs because sinking velocities of microplastics are related to biofouling, metal sorption, and aggregation there (Leiser et al., 2020). This is also related to the results that the proportion of pristine plastic decreases and that of other plastic increases like rivers as the retention time become shorter (Nakayama 2025b). These indicate that incorporation of the lake model in NICE led to improved estimates of plastic dynamics in inland waters, and may aid the development of solutions and measures to reduce plastic input to the ocean.