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Different microplastics versus different bottom sediments: transport and accumulation pattern in the open-channel flow experiments

Igor Isachenko and Irina Chubarenko
Shirshov Institute of Oceanology, Moscow, Russian Federation (isatchenko@gmail.com)

Initiation of motion, resuspension, transport, and accumulation of microplastic particles (MPs) at the sea bottom are prescribed by their physical properties – density, size, and shape, as it is known for natural sediment grains. However, from sedimentological approaches, not much can be said about the behavior of non-spherical particles at the bottom covered by another type of material. Thus, experimental disclosure of general features of the MPs transport and accumulation pattern should aid a lot further theoretical description of such a complex process.

Laboratory experiments on the MPs transport by the open-channel flow and their accumulation in regions with various bottom roughness were carried out in 10 m long and 0.33 m wide hydrodynamic flume. The bottom had 4 sections (ca. 2 m long each) with the roughness increasing downstream: smooth-bottom section, followed by the sections covered by natural calibrated coarse sand (particle diameter 1-1.5 mm), marine granules (3-4 mm), and small pebbles (1-2 cm). The upper sediment surface was carefully horizontally leveled. The set of MPs included 1d (flexible and rigid), 2d (square/round/elongated; flexible/rigid), and 3d (round/cubic) particles made of polystyrene, polyester, polyamide (nylon), and polyethylene terephthalat (material density ranging from 1.05 to 1.41 g/cm^3). Principal sizes of MPs ranged from 0.5 mm (smaller than the smallest sediment grain) to 5 cm (larger than the largest sediment grain). At the beginning of the experiment, MPs were placed on the smooth bottom. Thereafter, the flow rate was increased step-by-step by small increments. At each step, after at least 5 min since the last particle movement, the coordinates of the particles in their (new) stationary positions were registered.

Although we did not aim to achieve a similarity between a laboratory experiment and natural conditions, the results of the present study can be useful for a qualitative interpretation of field observations and further theoretical efforts. The results show, that the initiation of motion of particular MPs is dependent both on MPs size and the sediment characteristics. The cumulative curve, integrating coordinates of all the kinds of MPs in their stationary locations at all the flow steps, indicates the potential for the existence of MP accumulation zones in the regions right after the change in the bottom roughness, at the side of coarser sediment.

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