Impact of micro-plastics on sediment settling properties

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Introduction: Micro plastics (MPs) are of increasing concern to our society, not only because they might affect human and animal health, but also because it is unknown if they influence the sedimentation processes in estuaries. MPs can interact with suspended particulate matter (SPM) in the water column and thereby cause an increase in the SPM settling. This results in an increase in dredged volumes for a port. The current models to predict SPM transport and settling in ports do not incorporate the potential role of MPs on SPM settling, underestimating the deposited sediment volumes. This research was focused on quantification of the impact of MPs on SPM settling in the port of Rotterdam, using experimental results as input in a numerical model (Delft 3D flow / Delwaq).

Methods: The impact of MPs on settling velocity is studied by using settling columns. The expected impact of MPs is on the settling of the finer sediment fraction (<64 µm), hence natural sediment cores were taken from relative shallow and undisturbed dock sites in the port of Rotterdam. The sediments in the top of these cores is relative young (a few years), the sediments at the bottom of the core is estimated to be from 2000 - 2005. Since MP concentrations have increased over the last decade, the top of the core is expected to contain high MP concentrations, while the bottom samples should be almost free of MPs. By adding artificial aged[1] MPs in two size ranges (10-20 µm and 63-75 µm) to the sediment, the settling column tests showed that adding MPs enhanced the settling rate. We have tested the potential of MPs to initiate flock formation by studying the zeta potential of the different samples.

Results: In the presence of MPs we observed an increase in the settling rate of 15-70%. We could not contribute this settling speed increase in the presence of MPs to changes in the zeta potential behavior, suggesting that the MPs do not influence the charge bases repulsion of small particles. Based on the measurements a theory is formed which is that MPs aggregates are loosely bind with organic matter (OM) and clays. These loose flocs are prune to shear, which explains why we do not observe these flocs in the main channel of the port. MPs seem to accumulate in the less disturbed parts of the harbor.
To test if the influence of MPs on SPM settling in the port can be quantified, a simulation was run with numerical model Delft 3D flow and Delwaq. This was done by increasing the settling velocity of SPM particles in the presence of MPs (due to their increase in floc size) in the model. This resulted in a shift of sedimentation from the harbors to the main channel, which is opposite to the observed trend. The floc formation due to the presence of MPs and the impact of shear forces on these flocs are currently oversimplified in the model. Based on the current insights it is too early to advice a different dredging strategy for the port, but when more insight in the role of MPs becomes available this might change in the future.

[1] Aging by UV light and adding nutrient rich water, to form an eco-corona. This decreases the hydrophobicity of the plastics and increases the density.