Experimental study on transport of microplastics in coastal sediment with an oscillating water tunnel

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Abstract This paper focuses on the characteristics of transport of microplastics in coastal sediment through experiment. For it, it uses a new form of oscillating water tunnel(OWT) with detachable sediment basin. It makes it possible to consider the change of depth of the sediment in high Reynolds number flow. The experiment was designed to turn out how the plastic particles embedded in coastal sediment get transported under wave forcing. After the system is being subjected to the wave forcing, the distribution of the beads is measured. Moreover, the relation between the wave and the seabed is studied by utilizing a particle image velocimetry(PIV) system.

Keywords: experimental study, microplastics, oscillating water tunnel, wave forcing, particle image velocimetry

Methods

An oscillating water tunnel is used in the experiment, which is equipped with a detachable sediment basin, illustrated in Figure 1. The Reynolds number based on the maximum free-stream velocity and the maximum displacement of water particle is on the order of $O(10^5)$, that is well within the turbulent regime.

The sediment basin is filled with the mixture of sediment and plastics beads. The beads have different diameters of 6mm and 8mm, and four different colors, as substitutes of microplastics. The sediment in the basin is divided into four sections, and distributions of the beads in each section are measured with different input velocities. Each section has 110 pieces of beads.

Furthermore, a particle image velocimetry system is utilized to figure out the precise flow velocity and to observe the relation between the wave forcing and the seabed such as boundary layer. The system is conducted in the velocity of 100m/s and the stroke length of 0.26m as input data.

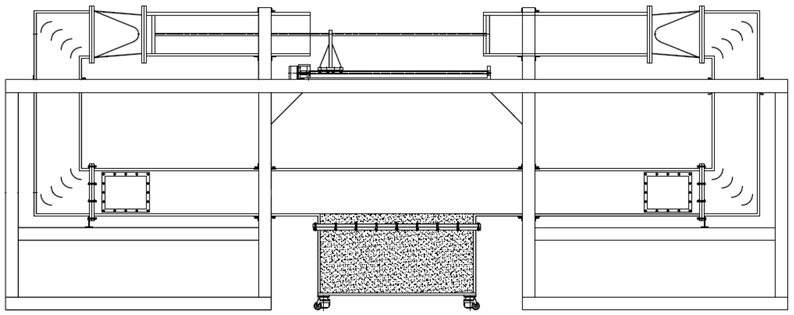

Figure 1: Sketch of the oscillating water tunnel

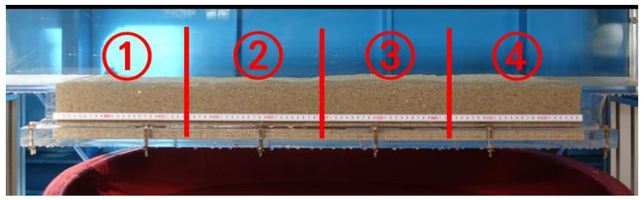

Figure 2: Indication of each section

Results

After the system in the input of 1000m/s, the distributions of Ø6 and 8mm beads are indicated in Table 1 and 2.

Ø6mm	red	blue	white	yellow
①	53	-	-	-
②	-	42	1	-
③	-	-	49	52
④	-	-	1	16
Left	40	38	21	16
Right	17	30	38	42
Sum	110	110	110	110
Ø8mm	**red**	**blue**	**white**	**yellow**
①	82	-	-	-
②	-	73	-	-
③	-	-	74	-
④	-	-	-	81
Left	25	26	13	6
Right	3	11	23	23
Sum	110	110	110	110

Table 1: Distributions of beads in each section

The Ø6mm beads is more out of the sediment than Ø8mm. Also, as soon as the beads come out, they moves to the both ends of the tunnel quickly.

The Figure shows the velocity profile obtained from the results of the particle image velocimetry.

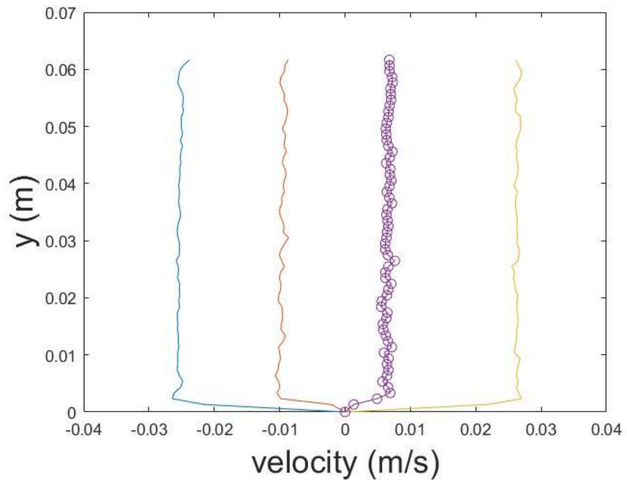

Figure 3: Velocity profile

As a results, the boundary layer thickness is about 3.3mm and the maximum velocity is 0.028m/s.

Conclusions

The paper introduces an experimental study for investigating the transport of microplastics in coastal sediment and shows initial stages of the experiment. The results of the distributions of the beads indicates the smaller and lighter debris can be come out of the sediment. Also, they moves to both end sides of the tunnel. So, the microplastics can travel very far quickly.

For further works, the more different sizes of the beads will be used and effects of boundary layer on the transport of microplastics will be investigated.

Bibliography