INFLUENCE OF SURGE WAVE ON CARRYING CAPACITY AND TRANPORT OF MACROPLASTICS

Preet Patel YP*, Magdalena Krol, Shooka Karimpour

Department of Civil Engineering, Lassonde School of Engineering, York University, Toronto, Canada

*Correspondence YP: Preet26@my.yorku.ca

Abstract A total of 8.3 billion tons of plastics have been manufactured since the start of the plastic industry and of this, 6.3 billion tons have ended up in a landfill or the natural environment, like oceans. Rivers and storm events near coastal regions are responsible for transporting millions of tons of plastic waste to oceans and other marine environments and therefore understanding this phenomena is important. For this research, a surge wave will be generated in a flume and marco-sized plastic particles will be introduced and tracked using multiple single-board computers (Raspberry Pi) and particle velocity and trajectory will be determined using an open-source particle tracking velocimetry (PTV) program.

Keywords: surge waves, coastal plastic waste, macroplastics, particle tracking velocimetry, Froude number.

Methods

Numerous single-board computers (SBC) and acoustic sensors will be mounted on the experimental flume to capture particle behaviour and fluctuating water depth during a generated surge wave. Three cameras will be mounted on the side of the flume, and two cameras will be mounted on top of the flume (Figure 1). Each Raspberry Pi board (i.e. small size SBC), will be connected to an independent camera module featuring an 8-megapixel sensor. Since the transport of plastic particles from downstream to upstream region in a generated surge wave occurs within a few seconds, it is crucial to trigger the recording in all Raspberry Pis with microseconds accuracy in order to minimize pre-processing efforts (Eichhorn et al., 2020).

Objective: to analyze surge waves with respect to carrying capacity and transport of plastic particles.

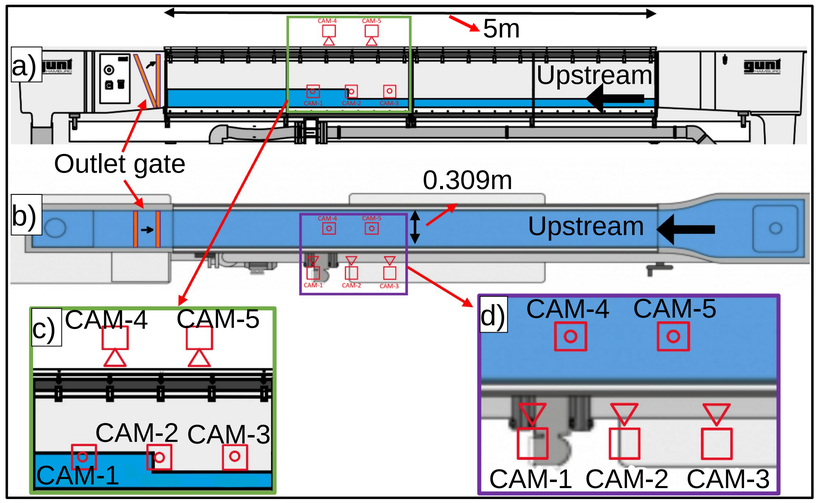

Figure 1: Experimental setup schematic: a) & b) flume length and width. c) & d) Raspberry Pi camera mount locations.

Results

PTV is a Lagrangian approach where individual particles are tracked using as many consecutive frames and cameras as possible, as this maximizes accuracy. Data obtained from multiple Raspberry Pis are analyzed to determine particle velocity and trajectory using PTVResearch (open-source PTV software), developed by Higham (2020) (Figure 2).

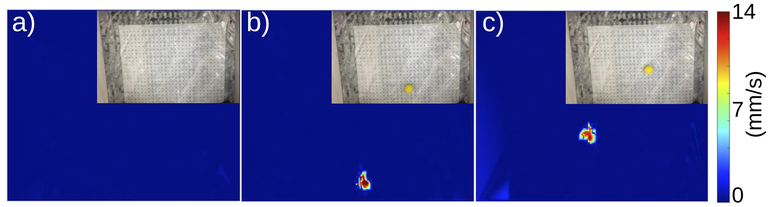

Figure 2: Sequence of frames displaying vector length of a particle in motion. Unprocessed frames are shows on top right. Time, t: a) 0s; b) 0.17s; c) 0.50s

Surge waves with a Froude number of greater than 1.5 were generated by controlling bed angle and flowrate, in order to produce a breaking bore with significant turbulent energy and intense air entrainment (Koch & Chanson, 2008). After initial experiments in the experimental flume, it was determined that an ideal breaking bore with Froude number of >1.5 will be generated at flowrates >40m³/hr, and 0° bed angle (Figure 3).

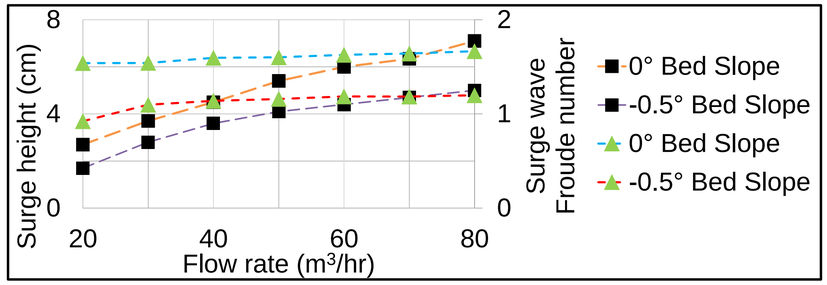

Figure 3: Experimental results of surge height & Froude number vs. flowrates. Black and green markers depicts surge height and surge wave Froude number, respectively.

Conclusions

Plastic industry has seen a surge in demand, which has generated substantial plastic waste leading to enormous environmental challenges. One such issue is the increased plastic waste that ends up in marine environments. The anticipated outcome of this research is to comprehend the coastal transport of plastic waste in surge waves, including surge wave carrying capacity, predicting plastic debris trajectory, and locating clusters of plastic waste. To investigate plastic debris in aquatic environments, a synchronized system of Raspberry Pis will be used to capture buoyant plastic particles in an ideal breaking bore (surge Froude numbers >1.5). PTV will be adapted to investigate the transport of plastic debris and surge capacity. Findings may yield new insights and initiate further research to design better mitigation plans to improve the aquatic environment.

Bibliography

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