DEVELOPMENT AND VALIDATION OF THE BIMODAL FLOCCULATION MODEL: TWO-CLASS POPULATION BALANCE EQUATION

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The bimodal flocculation describes the physicochemical process in which particles or flocs aggregate and fragment with developing two separate peaks in their size distribution. This is caused by the different bonding strength of two constituent flocs, (1) dense micro-flocs and (2) floppy macro-flocs. The bimodal flocculation has been repeatedly reported by many marine and estuarine scientists and thus it seems to be very common in marine and estuarine environments. However, the empirical correlation between sediment settling velocity and solid concentration (ws versus Cs) has been simply used as a flocculation model, without considering the bimodal flocculation behaviour (van Leussen, 1994). Furthermore, Population Balance Equations (PBEs), which are recently being adopted as a mechanistic flocculation model for marine or estuarine cohesive sediment transport, still have limitation in simulating the bimodal flocculation, due to the excessive simplification of the Single-Class PBEs (SCPBEs) (Winterwerp, 2002; Son and Hsu, 2008) and the large computational load of the Multi-Class PBEs (MCPBEs) (Xu *et al.*, 2008). Therefore, to simulate the bimodal flocculation as well as to enhance the computational efficiency, the Two-Class PBE (TCPBE) consisting of (1) the size-fixed primary micro-flocs and (2) the size-varying secondary macro-flocs was developed and tested in this research. The capability of the TCPBE for simulating the bimodal flocculation was validated with the curve fitting analysis to the experimental data obtained from one dimensional settling column tests (van Leussen, 1994). In contrast to the SCPBEs, the TCPBE was able not only to simulate the interaction between two particle classes but also to estimate the collector efficiency of marine or estuarine cohesive sediments for fresh primary particles. In addition, the TCPBE required hundreds times less computational time than the elaborate MCPBEs, to generate the simulated results fitted well to the experimental data. Thus, the TCPBE proved the computational efficiency for simulating the bimodal flocculation of marine or estuarine cohesive sediments. In short, the TCPBE takes both the outstanding advantages, the computational efficiency and the model accuracy, from the SCPBEs and the MCPBEs, respectively, and so it will be an attractive mechanistic flocculation model for future application to large-scale cohesive sediment transport modelling.

References

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