WEIGHTED SAND FLOCCULATION IN WATER TREATMENT: ANALYSIS AND MODELLING

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ABSTRACT

Flocculation is a stage in water treatment during which the destabilised particles in water are agglomerated to form flocs that are readily settleable. One of the flocculation techniques is to aggregate flocculent particles in the water to be clarified around one or several high-density material. This technique is referred to as weighted flocculation, and aims at increasing the settleability of the flocs, besides making them more resistant to tearing and erosion forces, thus producing more stable flocs.

In this study, micro-sand was used as the weighting media, in removal of moderate turbidity, simulated using clay powder. The water was coagulated with aluminium sulphate $[Al_2 (SO_4)_3.18H_2O]$ optimised in the vicinity of pH 6.5. Laboratory studies were conducted, to determine the kinetic parameters, optimum velocity gradient, ideal grain size and dose, as well as determining the coagulation conditions that would optimise flocculation. In the second stage, a laboratory scale clari-flocculator was constructed to test the true potential and applicability of using the micro-sand in its fullest extent, and the results fitted into a mathematical model.

Weighted flocculation, results to flocs with higher performance characteristics than the conventional methods. Optimum grain size was found to be about 160 μm at a dose rate of 3g/l. The weighted flocculation was characterised by a contact time of 8 minutes and 80% of the resulting flocs settled out within 1 hour, while it took 2 hours to attain the same level of efficiency with conventional flocculation. The size of the weighted flocs was much less than that of the conventional floc but very compact. Relative comparison of the settled sludge showed that, weighted flocs take up less volume in the settling basin and exhibited significantly high resistance to the scouring

forces with scouring velocity 7 times in weighted flocculation than in the conventional flocculation. On basis of the kinetic parameters, weighted flocculation exhibits higher strength against shear and erosion with the mean value of the break-up coefficient, K_B at 0.00013 against 0.003 for conventional flocculation.

The results were fitted in a mathematical model representing the removal ratio of primary particles as a factor of velocity gradient and time. The mathematical model prediction, for removal ratio compared well with the measured values for the product of velocity gradient and time (GT) less than 150,000 in conventional flocculation and 700,000 for the weighted flocculation, above which the predicted value was much higher than could be achieved. The process was optimised at 120,000 for conventional flocculation and 350,000 for weighted flocculation.

The study came to a conclusion that weighted sand flocculation has significant advantage over the conventional flocculation. As a result of higher strength against tear forces, and less time of residence required, the higher flow rates could be achieved in the flocculation and sedimentation basin. This translates to saving on volume and site area, consequently economy of construction. It was also observed that differential flocculation was greatly significant in weighted flocculation than in conventional flocculation.

On strength of these results, it was discovered that weighted flocculation using micro sand is a valid process, and recommended to be incorporated in the treatment works.

KEY WORDS

Weighted flocculation, micro-sand, turbidity, sedimentation, optimal design, modelling