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Numerical simulation of separation process for enhancing fine particle removal in tertiary sedimentation tank mounting adjustable baffle

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HIGHLIGHTS

- The hydraulic behavior of a sedimentation tank was studied using the finite element method.
- The sedimentation tank was equipped with adjustable baffles to better analyze particle settling.
- The simulation results matched well with the experimental data.
- The particle removal efficiency varied considerably by varying the angles of the adjustable baffle.
- The results can be used to design a compact sedimentation tank for aquaculture farming.

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ABSTRACT

The presence of flow control devices and/or obstacles in the fluid flow such as baffles and spacers complicates the solid-fluid mixing pattern, which remains difficult to describe by classical analytical solutions. In this study, the removal of fine particles in a tertiary sedimentation tank mounting an adjustable baffle was investigated using the computational fluid dynamics code-COMSOL. The solid-fluid motion was solved by consecutively applying the equations of the continuity and momentum using the finite element method. The experiment was conducted by the sedimentation tank with the adjustable baffle inclined at 30° in a pilot scale plant. It's used as the reference data set for numerical simulations that were run on a 2-dimensional domain by modifying the configuration settings of angles for an adjustable baffle (i.e., 30°, 45°, and 60°) and without one. Results showed that the simulation results matched well with the experimental data for an adjustable baffle at 30° (NSE = 0.97). The sedimentation tank with the adjustable baffle at different angles had a lower overflow rate (in the area of flow rebound) and mixing intensity (in the area of flow curve) than without one, eventually leading to enhanced particle removal efficiency. This tendency became more pronounced as the particle motion stabilized over time. The sedimentation tank mounting the adjustable baffle at 30° provided the best settling efficiency among the four different flow patterns. However, the conventional index that represents the mixing properties did not correctly address their relative efficiency for fine particle removal. Therefore, a numerical simulation tailored to a given geometry should be conducted to fully elucidate the fluid dynamics in the sedimentation tank with complex devices or obstacles.

1. Introduction

Fluid dynamics in water treatment systems plays an important role in facilitating the particle removal process and ensuring effective system design in affordable budget (Brouckaert and Buckley, 1999). A sedimentation tank, a popular unit in advanced water treatment processes, is traditionally used to remove suspended solids from turbid water by settling via gravity. The performance of the sedimentation tank is affected by two universal factors, flow patterns and particle properties (Goula et al., 2008b). More precisely, the flow motion is determined by the flow rate or velocity (that determines the turbulence), temperature, and mixing characteristics. The intrinsic particle properties include their size, density, shape, and charge, which affect the ways they interact with water through drag and buoyancy forces. In addition, the geometry of the sedimentation tank is tightly bound to these two dominant factors, which further complicates the description of the hydraulic behavior in the sedimentation tank, specifically in the

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