Title of Article: Optimization of Waste Stabilization Pond Design for Developing Nations using Computational Fluid Dynamics

Authors: Olukanni, D. O. and J.J. Ducoste

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Abstract: Waste stabilization ponds (WSPs) have been used extensively to provide wastewater treatment throughout the world. However, no rigorous assessment of WSPs that account for cost in addition to hydrodynamics and treatment efficiency has been performed. A study was conducted that utilized computational fluid dynamics (CFD) coupled with an optimization program to optimize the selection of the best WSP configuration based on cost and treatment efficiency. The results of monitoring the fecal coliform concentration at the reactor outlet showed that the conventional 70% pond-width baffle pond design is not consistently the best pond configuration as previously reported in the literature. The target effluent log reduction can be achieved by reducing the amount of construction material and tolerating some degree of fluid mixing within the pond. As expected, the multi-objective genetic algorithm optimization did produce a lower-cost WSP design compared to a SIMPLEX optimization algorithm, however, with only a marginal increase in the effluent microbial log reduction. Several other designs generated by the CFD/optimization model showed that both shorter and longer baffles, alternative depths, and reactor length to width ratios could improve the hydraulic efficiency of the ponds at a reduced overall construction cost. In addition, a study was conducted to validate a computational fluid dynamics (CFD) model of an optimized WSP configuration based on minimum cost and maximum treatment efficiency. In this study, the optimized WSP consisted of an anaerobic, facultative, and a maturation stage whose baffle orientation, length to width ratio, was specified by a CFD model prediction and was compared with a three stage WSP designed according to literature suggested reactor geometric configurations. Experimental tests were performed on a pilot scale version of the three-stage WSP where the removal performance was based on a number of parameters (Faecal coliform, pH, TDS, and Conductivity). Results showed that the significantly lower cost design based on the optimized CFD simulations displayed slightly better removal performance compared to the standard WSP design developed from literature data. The results of this study clearly showed that unit treatment process designs based on rigorous numerical optimization can aid in producing cost effective designs that make it more possible for developing nations to incorporate adequate and effective sanitation.