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Passive Aeration of Wastewater: Analytical Model

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Abstract : Aeration for wastewater is essential for the proper operation of aerobic treatment units where the wastewater normally has zero dissolved oxygen. This is due to the need of oxygen by the aerobic microorganisms to grow and survive. Typical aeration units for wastewater treatment require electric energy for their operation such as mechanical aerators or diffused aerators. The passive units are units that operate without the need of electric energy such as cascade aerators, spray aerators and tray aerators. In contrary to the cascade aerators and spray aerators, tray aerators require much smaller area foot print for their installation as the treatment stages are arranged vertically. To the extent of the authors knowledge, the design of tray aerators for the aeration purpose has not been presented in the literature. The current research concerns with an analytical study for the design of tray aerators for the purpose of increasing the dissolved oxygen in wastewater treatment systems, including an investigation on different design parameters and their impact on the aeration efficiency. The studied aerator shall act as an intermediate stage between an anaerobic primary treatment unit and an aerobic treatment unit for small scale treatment systems. Different free falling flow regimes were investigated, and the thresholds for transition between regimes were obtained from the literature. The study focused on the jetting flow regime between trays. Starting from the two film theory, an equation that relates the dissolved oxygen concentration effluent from the system was derived as a function of the flow rate, number of trays, tray area, spacing between trays, number and diameter of holes and the water temperature. A MATLab ® model was developed for the derived equation. The expected aeration efficiency under different tray configurations and operating conditions were illustrated through running the model with varying the design parameters. The impact of each parameter was illustrated. The overall system efficiency was found to increase by decreasing the hole diameter. On the other side, increasing the number of trays, tray area, flow rate per hole or tray spacing had positive effect on the system efficiency.

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