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The use of impulse response tracer experiments in horizontal subsurface flow constructed wetland development

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ABSTRACT

In the past three decades there has been an increased interest in constructed wetlands (CW) and their effectiveness in treating water. The hydraulic efficiency of a CW can be determined by using chemical reactor theory to develop residence time distribution (RTD) parameters such as effective volume (V_{eff}), normalized variance (σ^2) and mean residence time (τ_m). Five experiments were conducted to study the effects on these RTD parameters in a CW by using a glass pilot-scale laboratory rig and varying the inlet-outlet positions. The rig made use of a glass tank 250x250x500mm filled with clear superabsorbent polymer balls as a packing. The clear tank and balls made it possible for the flow to be observed when a FWT red impulse tracer dye was inserted into the system. The flow was photographed at specific time intervals for visual analysis and comparison. . The visual results showed the formation of a hull-shaped velocity profile in all the experiments. The RTD was obtained by collecting tracer samples at specific outlet positions during the course of each experiment. The five inlet-outlet configurations RTD parameters results showed; a straight flow path from a single inlet to outlet yielded the lease desirable hydraulic performance with dead volumes contributing to up to 67% of the CW. An increase in the number of outlets and changing the direction of flow diagonally showed up to a 96% improvement to the effective volume of the system could be achieved when compared with single inline inlet-outlet flow. The best result was achieved by combining the visual and RTD data to make changes to the rigs geometry in order to eliminate dead zones and yielded up to a 148% improvement in the effective volume of the system when compared with single inline inlet-outlet flow. A well designed CW with respect to inlet-outlet position can result in reduced land requirements and construction costs by minimizing the dead volume and improving hydraulic efficiency.