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Feasibility of the porous zone approach to modelling vegetation in CFD

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ABSTRACT

Vegetation within stormwater ponds varies seasonly and its presence affects the flow field, which in turn affects the pond's Residence Time Distribution and its effectiveness at pollutant removal. Vegetated flows are complex and, as a result, no suitable tools exist for evaluating realistic stormwater pond designs. Recent research has suggested using a porous zone to represent vegetation within a CFD model, and this paper investigates the feasibility of this approach using ANSYS Fluent. One of the main benefits of using a porous zone is the ability to derive the relevant parameters from the known physical characteristics of stem diameter and porosity using the Ergun equation. A sensitivity analysis on the viscous resistance factor $1/\alpha$ and the inertial resistance factor C_2 has been undertaken by comparing model results to data collected from an experimental vegetated channel. Best fit values of C_2 were obtained for a range of flow conditions including emergent and submerged vegetation. Results show the CFD model to be insensitive to $1/\alpha$ but very sensitive to values of C_2. For submerged vegetation, values of C_2 derived from the Ergun equation are under-predictions of best-fit C_2 values as only the turbulence due to the shear layer is represented. The porous zone approach does not take into account turbulence generated from stem wakes such that no meaningful predictions for emergent vegetation were obtained. C_2 values calculated using a force balance show better agreement with best-fit C_2 values than those derived from the Ergun equation. Manually fixing values of k and ϵ within the porous zone of the model shows initial promise as a means of taking stem wakes into account.