PDES IN THE MODELLING OF WASTEWATER TREATMENT PROCESSES AND THE NEED FOR RELIABLE SIMULATION TOOLS

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Abstract. ODEs have long been the preferred method to model phenomena in wastewater treatment (WWT) processes as computational speed was an important concern when modelling the entire process flow sheet. In this contribution we review the potential of using PDEs to model unit processes in WWT as well as specific requirements and challenges. A first important phenomenon occurring in bioreactors is mixing for which the traditional modelling approach is based on tanks-in-series (TIS). Alternatively, 1D/2D reactive advection-dispersion models can be used or even further rigour can be accomplished through Computational Fluid Dynamics (CFD), based on the Navier-Stokes equations. A second application are biofilm systems where carriers are used to grow the biomass on. Modelling these systems requires a detailed description of the biofilm thickness and the concentration gradients occurring within for which PDEs are imperative [3]. A third application of PDEs in WWT systems is in sedimentation processes. For secondary settling, where sludge is separated from the cleaned water, a modular simulation model was recently formulated based on a proper discretisation of the PDE [1]. Further challenges are: addition of reactive terms and inclusion of particle size dependent phenomena. Primary sedimentation of raw wastewater at the entrance of the WWT plant on the other hand has long been regarded as a less important process resulting in overly simplified models. However, with the transition to resource recovery, the need for better models has become clear. A modification of the model in [1] to primary clarifiers is a possibility that needs investigation. Finally, a framework is available to model the dynamics of size or density distributions based on integro-PDEs (i.e. population balance models (PBMs)) [2]. Despite its potential to model for example flocculation or bubble coalescence, the application of this framework in WWT modelling is still limited. In this contribution, the specific equations and current numerical practices will be briefly introduced in order to provide a state of the art and highlight future needs for development of new numerical techniques.

Keywords: biofilms, population balance models, clarifier, thickener, compression, sedimentation, reactive settling

Mathematics Subject Classifications (2010): 35K65, 35L65, 35Q35, 35Q70

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