Modelling Chemically Enhanced Primary Settlers for Resource Recovery Purposes

Emma Lundin[1], Magnus Arnell[1,2], Robert Sehlén[3], Sovanna Tik[4], Peter A. Vanrolleghem[4], Bengt Carlsson[5]

[1] Sp Urban Water Management, Chalmers Teknikpark, 412 88 Göteborg, Sweden.

[2] Division of Industrial Electrical Engineering and Automation (IEA), Department of Measurement Technology and Industrial Electrical Engineering (MIE), Lund University, Box 118, 221 00 Lund, Sweden.

[3] Tekniska Verken i Linköping AB, Brogatan 1, 581 15 Linköping, Sweden.

[4] modelEAU-, Université Laval, Department of civil engineering and water engineering, 1065, av. de la Médecine, Québec, Canada.

[5] Division of Systems and Control, Department of Information Technology, Uppsala University, Box 337, 751 05 Uppsala, Sweden.

Corresponding author: Emma Lundin, emma.lundin@sp.se, +46 73-652 4905

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INTRODUCTION

Wastewater treatment plant (WWTP) operation is slowly shifting from simply focusing on effluent qualities towards becoming resource recovery plants and viewing wastewater as a carrier of nutrients and source of renewable energy. The valuable energy recovery from WWTP's can possibly be net positive, which opens up for production and distribution. Anaerobic digestion of the sludge gives a great opportunity to decrease energy use and create a renewable energy source, biogas (Frijns et al., 2013). The primary settling tanks (PSTs) serve as the most important sludge producers and are therefore crucial for the biogas production as well as for the whole plant's energy consumption. The incoming organic material holds chemically bound energy, COD that will be lost through metabolic heat and emission of carbon dioxide in the aeration tanks if not extracted in the pre-treatment steps. Bachis et al. (2014) recommends reconsidering the function of PSTs within the activated sludge model framework as they are highly significant for the entire WWTP. Modelling the separation of solids from water has been shown to be difficult when the concentration and the flocculent nature vary between the layers of the tank.

METHOD

A case study was carried out at the Linköping WWTP combining generally known methods of experimental measurements and modelling in order to develop a deterministic process model of a chemically enhanced PST, simulating a dynamic influent (Lundin, 2014). At the WWTP, a chemistry system of three components is used: ferrous sulphate, cationic and ionic polymer. The concentration of TSS and the tendency of the particles to interact generate different settling behaviors.

The approach to characterize wastewater particles in settling velocity distribution classes with the ViCA's protocol, developed by Chebbo and Gromaire (2009), has earlier been shown to enable experimental results to be incorporated in mathematical modelling and simulation environments (Bachis et al., 2014). With 13 sets of ViCA's column tests (N0-N12) on influent wastewater with altered chemical dosage and time of sampling, settling properties were identified. Experimentally collected data on cumulative mass of settled particles in the ViCA's column at specific sampling time, t_i, was adjusted to result in the characteristic ViCA's curves, see Figure 1.

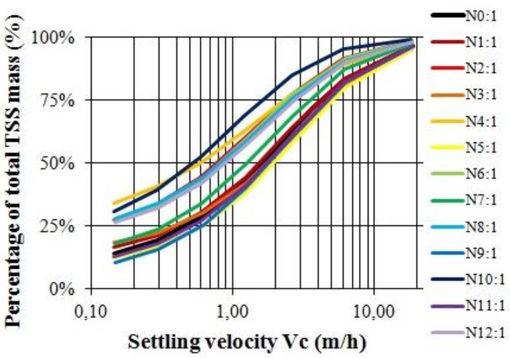

Figure 1. The settling velocity distribution, ViCA's, attained from column experiments. The bottom cluster of curves represents low flow samples and the top cluster high flow samples**.**

In the study, the settling velocity distribution was described by five particle classes, each given a specific settling velocity, v_s, the geometrical mean of $v_{c,min}$ and $v_{c,max}$ for each class. The primary clarifier model was developed similarly to the secondary settler in the simulation platform BSM2 (Benchmark Simulation Model no. 2), with ten layers of constant thickness continuously predicting the sludge concentration in each layer by calculating the mass balance around each layer. The specific settling velocity of each particle class was used to calculate the gravitational flux of particles between layers. The fraction of particles in each class was predicted as a function of chemical dosage and time, given by the coefficient model derived from statistical analysis of the experimental data.

RESULTS AND CONCLUSIONS

Modeling can provide more knowledge about the capacity of sludge withdrawal from the primary clarifier and how to set the optimal chemical dosage to maximize the reduction of COD. The full paper includes simulation results on dynamic influent data; see Figure 2 for a simulation example. Knowledge about settling behavior and particle properties can be strengthened by performing ViCA's column tests. The settling velocity distribution was shown to be clearly affected by the load of return sludge from the biological treatment step and a greater addition of coagulant increased the class of slowly settling particles due to precipitation of soluble components. Modelling is important in order to further develop the treatment processes and for utilizing wastewater as a resource.

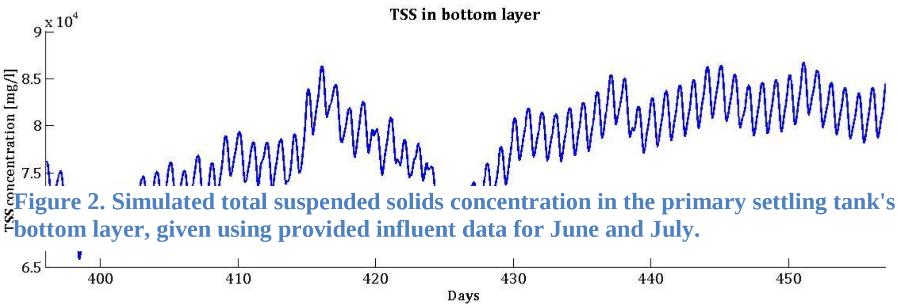

Figure 2. Simulated total suspended solids concentration in the primary settling tank's bottom layer, given using provided influent data for June and July.

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