© IWA Publishing 2010 Water Science & Technology—WST | 61.4 | 2010

Editorial: Status and future of wastewater treatment modelling

IWA Task Group on Good Modelling Practice: Guidelines for Use of Activated Sludge Models (L. Rieger, I. Takács, A. Shaw, S. Winkler, T. Ohtsuki, G. Langergraber and S. Gillot)

IWA Task Group on Good Modelling Practice: Guidelines for Use of Activated Sludge Models
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Modelling of wastewater treatment systems, originally developed by academics primarily motivated by their research interest, has become a standard engineering tool. Initially focussed on the activated sludge process, modelling is now routinely applied for the whole wastewater treatment plant, including sludge and sidestream treatment. The interest in process modelling, as measured by the number of publications (Figure 1), seemed to have reached a plateau in the early years of the millennium (Gujer 2006), but since then it has gained speed again. The number of citations has been exponentially growing for the last 25 years (Figure 2).

IWA's Good Modelling Practice Task Group (GMP TG) was fortunate to have the opportunity to review trends in this field in the past through literature and dialogs with academics, practitioners and industry leaders. The following is a personal perspective of the GMP TG on the future of modelling, and current challenges, drawn from the

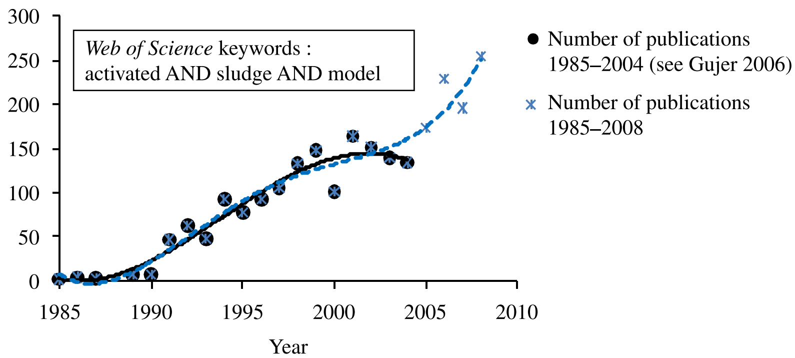

Figure 1 | Interest in activated sludge modelling by number of publications from Web of Science® between 1985 and 2008 (adapted from Gujer 2006).

information gathered. The purpose of this editorial is to promote further discussion of the topics it raises.

Most of the profession would agree that wastewater treatment modelling has left the ivory tower of academia and entered the real world of engineering. This transition had and continues to have its challenges, which can be listed in the following main categories: i) available models and default parameters, ii) knowledge transfer/training, iii) implementation (simulators).

Available models and default parameters: Starting in 1986 the IWA (formerly IAWPRC) Task Group on Mathematical Modelling for Design and Operation of the Activated Sludge Process published their well known series of activated sludge models (ASM1, ASM2, ASM2d, ASM3. Henze *et al.* 2000). The models identified the most important processes that occur in activated sludge systems. In terms of impact on model development, probably the most critical step was the introduction of the Gujer Matrix (formerly called Petersen Matrix) notation. It allowed a compact and well structured description of these very complex models.

In spite of the models being published in the intuitive and information-dense Gujer Matrix format, most models published to date contain inconsistencies and editorial typographical errors, as demonstrated by Hauduc *et al.* (2010). All corrected Gujer Matrices are provided in spreadsheet format as additional material to Hauduc's publication. The authors draw attention to a standard notation system suggested by Corominas *et al.* (2010), which was developed with the hope of improving the readability of models, particularly for non-model developers.

Another important element of a "good model" that can be used reliably in practice is the default kinetic and stoichiometric parameters. Most of the published models, with perhaps the exception of ASM1, focussed on process understanding and did not contain default parameters, rather examples of parameters derived from a limited number of laboratory tests and plant data. It became necessary

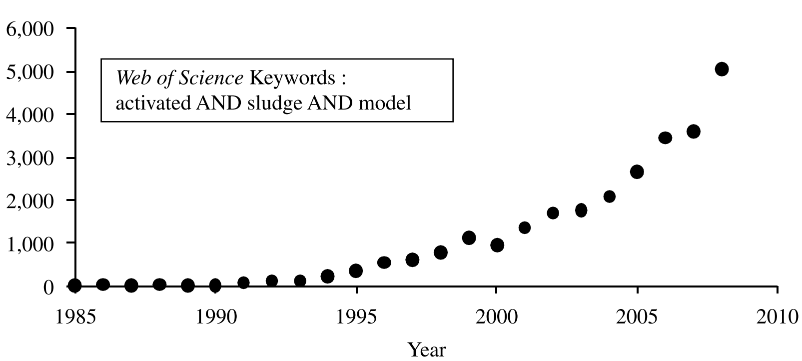

Figure 2 | Interest in activated sludge modelling by number of citations from Web of Science® between 1985 and 2008.

to recalibrate the models for each different application. Calibration techniques have developed, but there are limited practical benefits of models that do not predict typical process conditions under a wide range of scenarios without significant calibration. More effort is required in defining reliable default parameter sets, and in the cases of models where parameters exhibit high variability, this may point to insufficient understanding and perhaps the need to modify the model structure.

Knowledge transfer/training: Modelling requires a good understanding of all involved processes and their mathematical description, modelling theory, software and simulator settings and experience with the translation of practical problems into a simulation environment. Hauduc *et al.* (2009) found through a questionnaire that the majority of model users have never received organized training in process modelling. The authors feel that the modelling community needs a discussion on how to train engineers in using models in their daily work (see also Hug *et al.* 2009).

Implementation (simulators): During the initial years of the "dynamic modelling era" models were implemented in many spreadsheets or home-grown software programs in each research centre. The appearance of commercial simulators has slowly changed this and now most modelling work is done using professionally developed software. This transition allowed for a much wider use of process modelling in engineering applications. However, a powerful tool is a more dangerous tool: it places more responsibility on the craftsmen who forge it, and requires a well trained operator for its efficient use.

THE FUTURE

Wastewater treatment modelling has already undergone significant development from simple activated sludge equations to whole-plant models. It is the authors' opinion that the use of models will further spread both in research and practice. ASM1 gave us a powerful tool and methodology to calculate sludge production and electron acceptor distribution in time and space (e.g. for diffuser taper and peak blower capacity). There are other questions that the researchers need to understand, and there are more tasks that an engineer needs to deal with in the context of wastewater treatment process design. The models have to incorporate more knowledge about hydraulics, equilibrium chemistry, mass transfer, population dynamics and bio-kinetics in fundamental ways. A good model is one that is based on first principles as much as possible, is stable and easy to use. For example, no one needs to recalibrate the ammonia ionization constant in chemical equilibrium models! A fundamentally based, widely verified and validated model fits to many different plant conditions without the need for expensive recalibration. A lot of this information is already available in the literature. The main challenge of the industry is to consolidate knowledge into an easy to use form.

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