ACTIVATED SLUDGE MODELS ASM1, ASM2, ASM2d AND ASM3

Edited by

IWA TASK GROUP ON MATHEMATICAL MODELLING FOR DESIGN AND OPERATION OF BIOLOGICAL WASTEWATER TREATMENT

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Preface

Modelling of activated sludge processes has become a common part of the design and operation of wastewater treatment plants. Today models are being used in design, control, teaching and research.

History

In 1982 the International Association on Water Pollution Research and Control (IAWPRC), as it was then called, established a Task Group on Mathematical Modelling for Design and Operation of Activated Sludge Processes. At that time modelling of activated sludge processes had been a discipline for about 15 years, most noticeably and reaching the most advanced level at the University of Cape Town, South Africa, by the research group headed by Professor G.v.R. Marais. The various models developed at that time had only little use, owing partly to lack of trust in the models, partly to the limitations in computer power and partly to the complicated way in which these models had to be presented in written form.

The first task

The aim for the Task Group was to create a common platform that could be used for future development of models for nitrogen-removal activated sludge processes. It was the aim to develop a model with a minimum of complexity. The result was the Activated Sludge Model No. 1, today known under many names: IAWPRC model, ASM1, IAWQ model, and so on.

The model outline was discussed at an IAWPRC Specialised Seminar at Kollekolle, Denmark, in 1985, and was published in 1987 in its final form in the IAWPRC Scientific and Technical Report Series as STR No. 1. The five years used for developing the model was spent in discussing with many researchers and practitioners in order to get a solid platform for the work and only to include details that could stand the test of time. What was presented was not only a model, but also a guideline for wastewater characterization and development of computer codes, plus a set of default values that since then has proved to give realistic model results with only minor changes in the parameters.

The ASM1 was well received and has been widely used as a basis for further model development. The direct use of the ASM1 for modelling has been almost nil, but ASM1 has been the core of numerous models with a number of supplementary details added in almost every case.

It was especially the matrix notation, which was introduced together with ASM1, that facilitated the communication of complex models and allowed the concentration of discussions on essential aspects of biokinetic modelling.

Biological phosphorus removal

At the time of publication of the ASM1, biological phosphorus removal was already being used in a (limited number) of full-scale treatment plants. The theoretical status of the processes was such that the Task Group at that time did not enter into the modelling of it. But from the mid-1980s to the mid-1990s the biological phosphorus removal processes grew very popular and at the same time the understanding of the basic phenomena of the process was increasing. Thus in 1995 the Activated Sludge Model no. 2 was published. This model included nitrogen removal and biological phosphorus removal. In 1994, when the ASM2 was finished, the role of denitrification in relation to biological phosphorus removal was still unclear, so it was decided not to include that element. However, the development in research was fast, and denitrifying PAOs (phosphorus-accumulating organisms) were needed for simulation of many results from research and practice. Because of this, the ASM2 model was expanded in 1999 into the ASM2d model, where denitrifying PAOs were included.

Although the models might not have been heavily needed for nitrogen removal processes, the complexity of the combined nitrogen and phosphorus removal processes makes the models important for design and control purposes.

New platform

The models have grown more complex over the years, from ASM1, including nitrogen removal processes, to ASM2, including biological phosphorus removal processes and to ASM2d

including denitrifying PAOs. In 1998 the Task Group decided to develop a new modelling platform, the ASM3, in order to create a tool for use in the next generation of activated sludge models. The ASM3 is based on recent developments in the understanding of the activated sludge processes, among which are the possibilities of following internal storage compounds, which have an important role in the metabolism of the organisms.

Benefit from the models

The major impact of the ASM model family has been based upon three facts. The first is the common language that modellers speak when using the concepts, the nomenclature and the matrix notation of the ASMs. This has created a strong model development over the past 15 years, which would probably not have been the case if all the modellers had used their own concepts, notation and platforms.

The second is the organizing effect of working with a model. This has helped researchers to achieve more efficient experimental designs and helped treatment plant operators to better understand and organize the information available at their plants – and in many cases to spot errors in available information. The third is that the models have served as guidance for research. By demonstrating where research was needed, focus has been put on certain details, for example wastewater characterization, out of which much interesting research has grown.

Simulation programs

The ASM1 and ASM2 models, or ASM-based models, are included in most of today's commercial and non-commercial simulation programs. Thus it is easy to get access to, and use the models for various purposes.

Future

This report has been produced to give a total overview of the ASM model family status at the start of 2000 and to give to the reader easy access to the different models in their original versions. It is the hope of the present Task Group that this may facilitate the use of the models and their future development.

During the years the members of the Task Group have changed. This reflects the development in research over the years and the wish to develop the models further. The ASM3 is not the final or 'general model' for activated sludge. Like ASM1, it is a structure and a platform for further development. Many modellers are looking for the 'ultimate general model' for activated sludge systems. Experience over the past 15 years shows that new development comes fast and the 'general models' have a short half-life. Thus for the future development of ASMs, suggestions, experience and discussion points will be well received if the readers and users wish to share their ups and downs in modelling with members of the Task Group.

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