Available online at www.sciencedirect.com
ScienceDirect
Environmental Modelling & Software 23 (2008) 19–26
Environmental Modelling & Software
www.elsevier.com/locate/envsoft

DESASS: A software tool for designing, simulating and optimising WWTPs

J. Ferrer [a], A. Seco [b], J. Serralta [a], J. Ribes [b,*], J. Manga [c], E. Asensi [a], J.J. Morenilla [d], F. Llavador [d]

[a] *Dpto. Ingeniería Hidráulica y Medio Ambiente, Universidad Politécnica de Valencia, Camino de Vera, s/n, 46022 Valencia, Spain*
[b] *Dpto. Ingeniería Química, Universitat de València, Doctor Moliner, 50, 46100 Burjassot (Valencia), Spain*
[c] *Dpto. Ingeniería Civil, Universidad del Norte, Km 5, Antigua Vía Pto. Colombia, Barranquilla, Colombia*
[d] *Entidad Pública de Saneamiento de Aguas Residuales de la Comunidad Valenciana, C/ Álvaro de Bazán, no. 10 Entl., 46010 València, Spain*

Received 13 January 2006; received in revised form 27 March 2007; accepted 3 April 2007
Available online 23 May 2007

Abstract

This paper presents a very useful software tool to design, simulate and optimise wastewater treatment plants. The program is called DESASS (DEsign and Simulation of Activated Sludge Systems) and has been developed by CALAGUA research group. The mathematical model implemented is the Biological Nutrient Removal Model No.1 (BNRM1) which allows simulating the most important physical, chemical and biological processes taking place in treatment plants. DESASS calculates the performance under steady or transient state of whole treatment schemes including primary settlers, volatile fatty acid generation systems by primary sludge fermentation, activated sludge systems for biological organic matter and nutrient removal, chemical phosphorus precipitation, secondary settlers, gravity thickeners and sludge digesters (aerobic and anaerobic). Biological conversions occurring in settlers and thickeners (primary sludge fermentation, denitrification) are also taken into account, i.e. they are considered as reactive elements. DESASS also includes pH calculation coupled to biological processes in all the elements, so pH effect on biological processes can be directly simulated. Furthermore, the effect of sidestreams on nutrient removal efficiency can be estimated because the performance of the whole plant can be simulated.

Keywords: BNRM1; Wastewater; WWTPs design; Modelling; Simulation; Optimisation; Software tool; pH calculation

Software availability

Name of software: DESASS (DEsign and Simulation of Activated Sludge Systems)
Developer: CALAGUA Research Group
Contact address: José Ferrer Polo, Dep. Ingeniería Hidráulica y Medio Ambiente, Universidad Politécnica de Valencia, Camino de Vera, s/n, 46022 Valencia, (Spain)
Telephone: +34 96 387 7617
Fax: +34 96 387 7617
E-mail: jferrer@hma.upv.es
Web page: http://www.upv.es/calagua
Year first available: 2004 (Spanish version), 2005 (English version)
Hardware required: MS Windows 98 or more recent versions
Software required: MS Excel (recommended)
Program language: MS Visual Basic 6.0
Program size: 15 MB
Availability and cost: Contact via e-mail
Maintenance: The software will be periodically updated with the new research advances

1. Introduction

Biological wastewater treatments are complex systems in which a range of physical, chemical and biological processes

* Corresponding author. Tel.: +34 96 354 3169; fax: +34 96 354 4898.
E-mail address: josep.ribes@uv.es (J. Ribes).

1364-8152/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.envsoft.2007.04.005

occur. Mathematical models are needed for a quantitative evaluation of these processes. Since Activated Sludge Model no. 1 (ASM1, Henze et al., 1987) was published, a great number of models for simulating biological processes have appeared. The most widely used models are those proposed by the International Water Association (IWA) (ASM series, Henze et al., 1987, 1995, 1999 and Anaerobic Digestion Model no. 1, ADM1, Batstone et al., 2002). These models are particularly interesting in nutrient removal WasteWater Treatment Plants (WWTP) for evaluating operational problems and implementing new operation strategies.

Mathematical models for these processes are very complex and they are usually packaged in special software platforms called simulators. Simulators have been extensively used in many disciplines over the years and are powerful tools for design, planning, process analyses, operator guidance and education and training. There is a large number of applications reported in the literature were simulators have been used for WWTP design or optimisation. Some of the most used programs are GPS-X, AQUASIM, EFOR and SIMBA (COST, 2001). All of them include a biological model based on IWA models for simulating activated sludge systems and some of them include other models for simulating settling units, fixed film operations, anaerobic reactors, and algorithms for dissolved oxygen control.

This paper presents DESASS (DEsign and Simulation of Activated Sludge Systems), a software tool for WWTP design, simulation and optimisation. This software includes the Biological Nutrient Removal Model no. 1 (BNRM1, Seco et al., 2004b) developed by CALAGUA research group. This model is based on a new concept of WWTP modelling: the model includes the most important biological and physico-chemical processes taking place in all treatment units, so the same model is used to design, simulate and optimise the whole plant including wastewater and sludge treatments. This paper focuses on illustrating the potential uses of the software rather than describing the implemented mathematical model. Software features and capabilities are described and demonstrated through the design of a full scale WWTP.

2. Software description

DESASS is a powerful WWTP simulator developed for PC computers by using Microsoft Visual Basic 6.0 programming language and able to assist the design, upgrading, simulation and optimisation of municipal and industrial WWTPs. The software code and therefore the mathematical model cannot be changed by the user. DESASS has been financially supported by Entidad Pública de Saneamiento de Aguas Residuales de la Comunidad Valenciana, the entity responsible for the management of all the urban WWTPs in the region of Comunidad Valenciana (Spain). Therefore, the program development was carried out with two main objectives: (a) to develop a useful tool for research work (modelling, calibration, devising and testing new control algorithms, studying treatment schemes for nutrient removal and recovery, sludge minimisation, etc.) and for engineering and consulting applications (design, upgrading and optimisation of WWTPs), and (b) to develop a user-friendly program to be easily handled by plant operators in order to study the effects of modifying the plant operation criteria by simulating the WWTP performance. As a matter of fact, plant operators are using this software mainly as a decision support system. Also, DESASS is being used in several Spanish Universities for researching on nutrient removal processes as well as for educational purposes. Changing plant configuration and comparing the results over different influent conditions and different scenarios is really straightforward even for non skilled users.

DESASS allows calculating the performance under steady or transient state of the following treatment units: primary settlers (considering fermentation processes inside), prefermenter tanks to generate volatile fatty acids, activated sludge reactors, secondary settlers (considering denitrification processes inside), gravity thickeners, aerobic and anaerobic sludge digesters and sludge dewatering systems. The effect of recycling the supernatants from the sludge dewatering system can be taken into account. The nitrogen and phosphorus load from this sidestream must be considered in an accurate nutrient removal WWTP design or simulation.

For dynamic simulations, although the user can establish the initial concentrations of all the model components, it is advisable to start with a steady state calculation in order to obtain initial conditions for the dynamic simulation study. Computing time for a steady state depends on the number of reactor units and also the number of layers considered in the settlers and thickeners. For instance, a UCT configuration with 10 layer secondary settler can last 5 min, while the steady state solution of the whole WWTP presented in the example below (see Fig. 3), with 10 layers in settlers and thickener, was obtained after 30 min. These simulations were carried out in a conventional Pentium IV (CPU 2.80 GHz with 512 MB RAM).

2.1. Mathematical model

The mathematical model implemented in DESASS is the BNRM1. This model considers the most important physical, chemical and biological processes taking place in a WWTP to maximise potential applicability without increasing neither model calibration nor wastewater characterisation efforts. The physical processes included are: settling and clarification processes (flocculated settling, hindered settling and thickening), Volatile Fatty Acids (VFA) elutriation and gas-liquid transfer. The chemical interactions included comprise acid-base processes, where equilibrium conditions are assumed, and phosphorus precipitation processes in the same way as in ASM2. The biological processes included are: organic matter, nitrogen and phosphorus removal; acidogenesis, acetogenesis and methanogenesis. The effect of temperature on the processes rates is considered in this model by using the general Arrhenius equation.

The settling processes model consists in a one-dimensional model based on the solids flux concept and the conservation of mass law. This model uses the settling velocity function