# Desalination for the Environment
## Clean Water and Energy

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## Dynamic modelling and analysis of an industrial reverse osmosis plant for scheduling and control with renewable energy power input

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Throughout the last decade, desalination industry using reverse osmosis (RO) has grown constantly in response to water scarcity challenges faced by a number of countries. Although the energy required for RO desalination is approaching the thermodynamic limit, it is still considered an energy-intensive process. Accordingly, several studies used renewable energy sources (RESs) to drive RO plants at small scale. However, the technology has not yet been transferred to large-scale applications, especially without using backup systems. This studyispartofaninternationalprojectthataimstoaccommodatethevariableandintermittent nature of RESs thus making possible the large-scale implementation of renewable energy- driven RO. As an initial step, the work presented aims to develop an understanding of an RO plant's dynamic behaviour, to help develop a method for plant scheduling and to select and tunethecontrolsystem.Consequently,adynamicmodelofasimpleROplantwillbepresented based on the solution-diffusion model. In addition, the dynamic response of permeate fluxand conductivity to step changes in feed flow rate and feed pressure will beanalysed.

*Keywords*: Reverse osmosis; Dynamic Model; Solution-diffusion model; Transient response; Renewable energy

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## Application of a model-based method for hydrodynamic processes in constructed wetland to management of livestock wastewater based on finite element method

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Nowadays, the increase in production and concentration of intensive livestock operation throughout the years all around the world, together with mismanagements of livestock manure, have raised the risk of contamination to the environment. The increasingly strict environmental regulation has created the need to find several solutions which combine low-cost facilities and

resource efficiency in wastewater treatment. Constructed wetlands (CWs) are now more widely applied than other technologies as an alternative of conventional methods. Several models of biochemical reaction in CWs have been developed over the last 60 years, however the great majority of authors agree that it is necessary to approach with more in-depth understanding processes in these treatment systems.

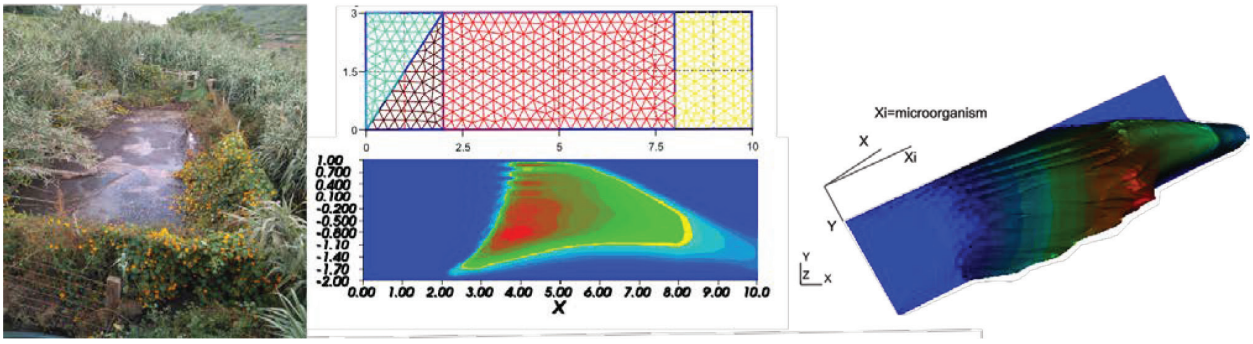
The main objective of this work has been to develop a computational fluid dynamic (CFD) Model to describe anaerobic digestion, that regularly occurs into the CWs in order to simulate the complex physicochemical and biochemical processes, offering higher spatial resolutions and different reaction rates, and considering simultaneous processes.

The method involves, simultaneously, dynamics characteristics of fluids with kinetic growth based on the IWA Anaerobic Digestion Model N°1 (ADM1). A mathematical model was developed based on mass balance for each system component, resulting 18 non-lineal system for second-order elliptic equations. On the other hand, a generalized Stokes variational formulation was implemented to describe the hydraulic performance. Finite element method (FEM) was applied to solve the equations subjetcted to Dirichlet and Neumann boundary conditions. To validate the method, simulations implemented with FreeFem++ are presented.

The obtained result offers dynamic behaviour of the model solutions for the microbial and the substrate in CWs, for each one of the phase of the biological processes. The performance will depend on the boundary condition. The result indicates that the model was be able to simulate, with good accuracy, substrate, microorganism, pH and total volatile fatty acids (TVFA) concentrations inside the system.

The conclusion was that the model was successfully implemented to simulate biochemical and physicochemical processes in CWs. This original method of simulation which has been applied to CWs allows develop different design including boundary conditions. Plans for the future will be to develop 3D model and to validate the results with experimental models.

*Keywords*: Constructed wetland; Water quality; Anaerobic digestion ; ADM1; Numerical simulation; Finite element method



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# Application of the ADM1 model in a batch multi-chamber anaerobic digester

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A model of anaerobic digestion process is a very useful tool that allows to determine the effect of the characteristics of the substrate and the load in the evolution of the process, to implement control systems in the operation, to predict the development of processes and to improve the knowledge of them in comparison with experimental data and test assumptions.

In this article, a model proposal based on the ADM1 is described, which corresponds to a digester installed in a livestock farm since 2008 together with natural treatment wastewater systems (NTWS), formed by three serial chambers. This biodigester follows a batch workflow and it is a key element in the design of NTWS, in which a typical anaerobic process is developed that allows modeling with several variables and clear and defined equations.

Starting from a system with a reactor with continuous load, the mathematical model has been adapted to be able to simulate a complete mixing reactor operating in batches. In the references consulted, digestion takes place in a single anaerobic digester. Once the proposed model has been implemented, it can be assumed that this process can be extrapolated to multiple serial digesters.

Simulations have been carried out taking different initial states, volumes of digesters, different seasons of the year, etc. Throughout all the simulations it has been proved that, with the proposed model adapted to three serial digesters operating on a discontinuous basis, you get a stable response from the system.

The proposed model of the anaerobic digestion process allows to analyse the behavior, thus it can be predicted the concentration values of the substances and chemical elements, for a certain substrate.

*Keywords*: Anaerobic digestion, Batch digester, ADM1, Mathematical model

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## Effect of pressure on feed solution at hollow fiber FO process

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In these days, wastewater reclamation and seawater desalination play essential role in addressing the challenge of worldwide water scarcity. Particularly, reverse osmosis (RO) for seawater desalina-