Multiphysics Modeling of a Wastewater Treatment Plant

Imane Koufany*[1,2], Juan Manuel Paz Garcia[2].

[1]Department of Inorganic Chemistry, Crystallography and Mineralogy, University of Malaga.
[2]Department of Chemical Engineering, University of Malaga.
*Corresponding author: imane.k@uma.es.

Introduction

Wastewater treatment plants (WWTP) are special structures designed to purify wastewater. The main objective of this work is to model the WWTP from Antequera (Malaga, Spain). The model consists of two combined simulations: (1) a 0D biological plug-flow reactor in a stationary state, establishing the concentration profiles at along the volume of the multizone reactor and, (2) a 3D clarifier. The model is based on global material balances of the WWTP has been done, based on the information from the concentrations that exist in a stationary state in each of the streams.

Use of COMSOL Multiphysics

To mathematically describe the kinetics of biological degradation that take place in the biological reactor, the Monod model is used, which is based on the Michaelis-Menten equation, included in the Chemical Reaction Engineering Module. It describes the relationship between microbial growth and the substrate. The bacterium consumes the substrate through a series of kinetic reversible and irreversible reactions. The outflow of the reactor is fed to a circular secondary clarifier, where the separation of flocs from the water occurs. The CFD Module is used to study complex turbulent multiphase flow using the Mixture Model application mode. The sludge geometry as well as the clarifier geometry and water flow parameters obtained in the field were used to model the secondary clarifier.

Results

The figure shows the simulation results for the concentration along the longitudinal plug-flow biological reactor and for the concentration in the secondary clarifier.

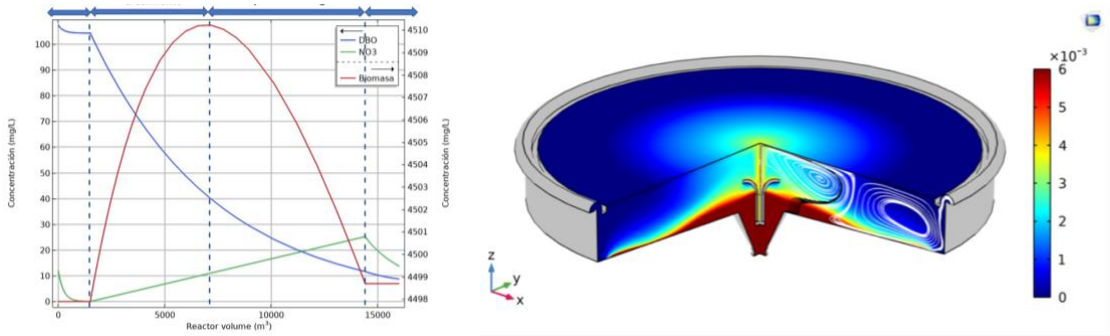

Figure 1: (a) Concentration profile throughout the biological reactor. (b) Simulation for the Circular Clarifier in 3D.

In Fig. 1.a, it is possible to distinguish the different parts of the recirculated plug-flow reactor: denitrification, growth, endogen respiration and final denitrification. A fraction of the outflow is recirculated to the reactor, while the rest is sent to the clarifier. The secondary clarifier has been solved using an axisymmetric 2D model. Figure 1.b shows that a clear reparation between the clarified water and the secondary sludge. The results of the numerical simulations have clearly shown the effectiveness of the clarifier, which forces the gravity-driven solid particles to reach the bottom of the tank, leaving the surface as relatively light solid effluent water.

Conclusion

Through this work, detailed description of two of the most important parts of the WWTP have been modeled. The results will be used in future works related to optimizing the use of these facilities for real problems related to controlling the phosphorus and nitrogen levels in the secondary effluent.

References

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