Floc modelling in activated sludge and beyond

Reporting

Project Information

FLOMAS

Grant agreement ID: 256440

Project closed

Start date
1 June 2010

End date
31 May 2013

Funded under
Specific programme "People" implementing the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007 to 2013)

Total cost
€ 45 000,00

EU contribution
€ 45 000,00

Coordinated by
UNIVERSITATEA POLITEHNICA DIN BUCURESTI
Romania

This project is featured in...

Final Report Summary - FLOMAS (Floc modelling in activated sludge and beyond)

“Floc modelling in activated sludge and beyond” (FLOMAS) was a multidisciplinary proposal that sought to obtain, through mathematical modelling backed by experimental evidence, a thorough understanding of the microbial community in activated sludge flocs.

The floc is an aggregate of suspended microorganisms and abiotic particles, and represents the main processing and oxygen consuming unit in activated sludge wastewater treatment reactors (the amount of non-floc suspended microorganisms is less than 20%). Floc size and morphology strongly influence the energy demands of activated sludge but cannot be explicitly manipulated or engineered. Understanding/simulating floc formation and functioning is the first step in trying to control the activated sludge process at its core.

The microbial community structure within activated sludge flocs was analyzed in samples from a municipal wastewater treatment plant (Spenneymoor, County Durham, UK) by the combined use of fluorescence in situ hybridisation (FISH) and confocal laser scanning microscopy. The images obtained showed different shapes and dimensions of the flocs, all having common characteristics, which were further abstracted into the model features. In all images obtained, ammonia oxidizing bacteria (AOB) and nitrate oxidizing bacteria (NOB) were forming compact globular micro-colonies.

Subsequently, a “first generation” multi-scale computational model of the formation of activated sludge flocs at micro-scale and reactor performance at macro-scale was developed. The model couples mass balances for substrates and biomass at reactor scale with an individual-based approach for the floc morphology, shape and micro-colony development. The model was implemented in a combination of MATLAB code (MathWorks, Natick, MA) as the main algorithm driver, COMSOL Multiphysics (Comsol Inc., Burlington, MA) finite element methods for solving the diffusion-reaction equations and own Java code for the individual-based floc model. Model solution involves a sequence of steps performed in a time loop. At any time t there are successively solved: (a) the mass balances for substrates at steady state to get the 2D concentration fields (with COMSOL finite element methods) given the 2D biomass distribution and given concentrations in the reactor liquid (which are the boundary conditions); (b) biomass growth,

division and spreading according to the local substrate concentrations (MATLAB and Java); (c) attachment of individual cells and micro-flocs (from a pool of structures previously created in the same conditions); (d) time evolution of reactor concentrations by coupling the reactor-scale balance with fluxes produced by all the flocs.

Among the novel model processes included are the group attachment/detachment of micro-flocs to the core structure and the clustering of nitrifiers. Simulation results qualitatively describe the formation of micro-colonies of ammonia and nitrite oxidizers and the extracellular polymeric substance produced by heterotrophic microorganisms, as typically observed in fluorescence in situ hybridization images. These results are the first step towards realistic multi-scale multispecies models of the activated sludge wastewater treatment systems and a generic modelling strategy that could be extended to other engineered biological systems.

The results obtained were disseminated the following way:

a) Ofiteru, I.D. Bellucci, M., Picioreanu, C., Lavric, V., Curtis, T.P. 2013, Multi-Scale Modelling of Bioreactor-Separator System for Wastewater Treatment with Two-Dimensional Activated Sludge Floc Dynamics, Water Research (impact factor 4.65; accepted October 2013)
b) A communication at the 21th European Symposium on Computer Aided Process Engineering, May 29 – June 1, 2011, Chalkidiki, Greece;
c) A subsequent paper published in Computer-Aided Chemical Engineering: Ofiţeru, I.D. Bellucci, M., Lavric,V., Picioreanu, C., Curtis, T.P.,,Multi-scale modeling of activated sludge floc structure formation in wastewater bioreactors, Computer-Aided Chemical Engineering (Eds. E.N. Pistikopoulos, M.C. Georgiadis and A. Kokossis), 29 (A) , 96-100

The researcher in charge of the project has participated also to other dissemination activities, were the results of the project were made public: NIMBioS Workshop: Individual-based Ecology of Microbes - June 8-10, 2011, Knoxville, TN, USA (oral presentation); and The First International Symposium on Microbial Resource Management in Biotechnology: Concept & Applications, 28 June – 5 July, 2011, Gent, Belgium (poster presentation).

The researcher is fully integrated in the Department of Chemical Engineering, University Politehnica of Bucharest, where she activates as a lecturer. She applied for national funding and secured a national grant (CNCSIS-UEFISCSU, project number PN II-RU 29/09.08.2010) which complements the existent reintegration grant.

It is important to recognize that the strategies proposed in this application are generic and they can be applied to any open microbial system where flocs, granules or films are formed (e.g. granular activated sludge, upflow anaerobic sludge blanket reactors). In fact, a very important outcome of FLOMAS grantis that it laid, in part, the foundations of a prestigious UK EPSRC Frontiers in Engineering grant awarded to Newcastle University (2013 – 2017): An New Frontier in Design: The Simulation of Open Engineered Biological Systems where the researcher in charge (Dr. Ofiteru) will be visiting researcher.The central premise of the Frontiers project is that the macro-scale properties of the system are the emergent properties of billions of individual bacteria and hundreds of species that interact at the micro-scale, but

whose effects are integrated up to those observed at the macro scale. Activated sludge floc modelling developed in FLOMAS project will be the starting point for developments in this direction.

Project website:

http://flomas.chim.upb.ro/

Last update: 8 July 2014

Permalink: https://cordis.europa.eu/project/id/256440/reporting