Semana de Engenharia 2010
Guimarães, 11 a 15 de Outubro

DISTURBANCES DETECTION IN ACTIVATED SLUDGE SYSTEMS

Daniela P. Mesquita, António L. Amaral and Eugénio C. Ferreira
Centre of Biological Engineering
E-mail: daniela@deb.uminho.pt

KEYWORDS
Activated sludge, image analysis, aggregates, filamentous bacteria

Activated sludge systems are biological processes greatly used in wastewater treatment plants (WWTPs). These systems are composed of an aerated tank where the biochemical phase occurs and a settler where the physical phase takes place. Solid-liquid separation is one of the most critical steps in activated sludge processes. This stage presents three main objectives: sludge thickening, effluent clarification, and sludge storage. Sludge settling ability is usual dependent of the structure, density and microbial aggregates size, which are prone to change, due to variations and disturbances of WWTPs conditions (Wilen et al., 1999). When the operating conditions are not perfect, mainly in terms of organic load, nutrients and oxygen supply, some malfunctions may occur such as pinpoint flocs formation, filamentous bulking, dispersed growth, and zoogleal or viscous bulking.

In recent years, microscopic observation is becoming an important method to monitor and control activated sludge systems and, as a result of that, this technique is becoming widespread for the characterization of activated sludge microbial aggregates (Andreadakis, 1993; Barbusinski and Koscielniak, 1995). Furthermore, the association of image processing methodologies with microscopic visualization allows an accurate evaluation of activated sludge in bright field or phase contrast acquisition (Li and Ganczarczyk, 1991; Grijspeerdt and Verstraete, 1997). Nowadays, several authors have already developed image processing procedures to characterize biomass from activated sludge systems (da Motta et al., 2002; Cenens et al., 2002; Amaral and Ferreira, 2005; Jenné et al., 2006; and Arelli et al., (2009), studying the relationship between operational properties, on one hand, and microbial aggregates and filamentous bacteria contents, on the other. However, up to the present, most correlations have been established between the sludge volume index (SVI) and sludge morphological properties in filamentous bulking conditions solely (da Motta et al., 2002; Amaral and Ferreira, 2005). Moreover, the emphasis of such studies has been focused on the biomass contents and morphology, and little attention has been paid for the Gram type and physiological status (viable or damaged) of such biomass.

Encouraged by the success of image analysis procedures over the last years in a broad range of different areas, the present work studies a lab-scale activated sludge system where operation conditions were modified resulting in normal conditions, filamentous bulking, pinpoint flocs and zoogleal bulking experiments.

The settling ability of the reactor sludge was measured alongside nitrogen contents and chemical oxygen demand in the feed, reactor bulk and settler. Furthermore, regarding the biomass characterization, the studied parameters reflected 4 major groups, covering free filamentous bacteria contents, aggregates contents, aggregates size and aggregates morphology. The biomass composition on gram-positive and gram-negative bacteria, as well as viable and damaged bacteria was also evaluated by image analysis coupled to epifluorescent staining. Finally, the resulting data was fed into a multivariate statistical analysis relating the image analysis information with the operational parameters.

The overall results revealed an improvement of the sludge morphological characterisation, combining these new image analysis procedures with the conventional routines. Furthermore, the results obtained during the monitoring period indicate that automated image analysis can help clarifying the nature of the events within the aeration tank when the system is submitted to disturbances.

ACKNOWLEDGMENTS

The authors acknowledge the financial support to Daniela Mesquita through the grant SFRH/BD/32329/2006 provided by Fundação para a Ciência e a Tecnologia.

REFERENCES

Amaral, A.L. and Ferreira, E.C. 2005. "Activated sludge monitoring of a wastewater treatment plant using image analysis and partial least squares regression." Analytica Chimica Acta 544, 246-253.

Andreadakis, A. 1993. "Physical and chemical properties of activated sludge flocs." Water Research 12, 1707-1714.

Arelli, A., Luccarini, L. and Madoni, P. 2009. "Application of image analysis in activated sludge to evaluate correlations between settleability and features of flocs and filamentous species." Water Science and Technology 59 (10), 2029-2036.

Barbusinski, K. and Koscielniak, H. 1995. "Influence of substrate loading intensity on floc size in activated sludge process." Water Research 29 (7), 1703-1710.

Bitton, G. 1994. "Wastewater Microbiology", Wiley-Liss Pub., New York.

Cenens, C., Van Beurden, K.P., Jenné, R. and Van Impe, J.F. 2002. "On the development of a novel image analysis technique to distinguish between flocs and filaments in activated sludge images." Water Science and Technology 46 (1-2), 381-387.

da Motta, M., Pons, M.N. and Roche, N. 2002. Study of filamentous bacteria by image analysis and relation with settleability. Water Science and Technology 46 (1-2), 363-369.

Grijspeerdt, K. and Verstraete, W. 1997. "Image analysis to estimate the settleability and concentration of activated sludge." Water Research 31 (5), 1126-1134.

Jenné, R., Banadda, E.N., Gins, G., Deurinck, J., Smets, I.Y., Geeraerd, A.H., and Van Impe, J.F. 2006. "Use of image analysis for sludge characterisation: studying the relation between floc shape and sludge settleability." Water Science and Technology 54 (1), 167-174.

Li, D. and Ganczarczyk, J. 1991. "Size distribution of activated sludge flocs." Journal of Water Pollution Control Federation 63, 806-814.

Wilén, B.M. and Balmer, P. 1999. "The effect of dissolved oxygen concentration on the structure, size and size distribution of activated sludge flocs." Water Research 33 (2), 391-400.

AUTHOR BIOGRAPHIES

DANIELA P. MESQUITA - PhD student in Chemical and Biological Engineering at the Department of Biological Engineering
ANTÓNIO L. AMARAL - Professor at the Polytechnic Institute of Coimbra
EUGÉNIO C. FERREIRA - Associate Professor with habilitation degree at the Department of Biological Engineering