Quantitative Image Analysis: a monitoring tool in wastewater treatment

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Computers are key equipment for the analysis of large amounts of data, for tasks requiring complex computation, and for the extraction of quantitative information, opposite to the qualitative evaluation of human analysis. Today, the automatic analysis of numerical images captured by digital cameras enables to rapidly extract quantitative information. Thus, quantitative image analysis (QIA) can be defined in general terms as the extraction of significant information from images, by means of digital image processing and analysis techniques.

In the last twenty years, QIA have gained an unquestionable role in several fields of research worldwide and our lab is considered a pioneer research unit on the development of QIA procedures for biological wastewater treatment processes monitoring. Over the years, the number of QIA studies [1, 2] for aggregated (granules and flocs) biomass and filamentous bacteria characterization has been increasing. It should be noticed, though, that some difficulties may be encountered in QIA procedures related to the suitability of the employed microscopy technique, regarding the intended biological process characterization.

So far, it has been demonstrated the applicability of QIA monitoring in pinpoint flocs formation, and filamentous and zoogleal bulking events identification in activated sludge (AS) systems, as well as in the prediction of sludge settling ability properties. QIA has proved to be adequate in terms of the main AS protozoa and metazoa recognition, as well as for operating conditions assessment. In enhanced biological phosphorus removal (EBPR) processes the ability to predict intracellular storage compounds, e.g. glycogen, polyhydroxyalkanoate, and polyphosphate concentrations, by QIA methodologies coupled to staining procedures, has been successfully proven. This novel approach, considered a faster technique to promptly monitor EBPR processes has the potential to surpass the off-line analysis, which is labor intensive and difficult to implement in full-scale plants [1]. Furthermore, it has also been found that the use of morphological and physiological data allowed predicting, at some extent, a number of effluent quality parameters. Other applications of QIA, in high-rate anaerobic processes, based on granular sludge, allowed detecting aggregation times and fragmentation phenomena during critical events, such as toxic and organic overloads [2]. Either way, the main goal is to improve the biological process efficiency through the combination of QIA information with operational parameters data.

Nowadays, great efforts are being made regarding the inclusion of staining procedures, with particular interest in the use of fluorescent dyes, due to the high amount of information provided by these techniques. In this way, it will be possible to obtain relevant data on the biomass characterization, viability and composition. However, further research is still needed to validate the obtained results with standard analytical analysis.

References

[1] Mesquita, DP, Amaral, AL, Ferreira, EC, Activated sludge characterization through microscopy: A review on quantitative image analysis and chemometric techniques, *Analytica Chimica Acta* 802, 14–28, 2013.

[2] Costa, JC, Mesquita, DP, Amaral, AL, Alves, MM, Ferreira, EC, Quantitative image analysis for the characterization of microbial aggregates in biological wastewater treatment: a review, *Environmental Science and Pollution Research* 20, 5887–5912, 2013.