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Application of image analysis techniques in dispersed and aggregated bacteria determination in wastewater treatment processes

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Image processing and analysis methodologies are considered nowadays as extremely useful tools in a wide range of applications. One of their main advantages resides on the ability to remove human subjectiveness and extract quantitative data that would be either very difficult or indeed impossible to obtain otherwise as well as to avoid extremely tedious or time-consuming tasks for the researcher. Therefore, in the last years it has been reported an exponential increase on the use of image processing and analysis techniques in the WWTP aerobic and anaerobic processes.

Ideally an aerobic microbial aggregate should be composed by a balanced number of filamentous and floc-forming (zoogleal) bacteria, have an adequate dimension, high robustness and settling ability to obtain a final clarified effluent and low organic matter contents. Classical methods for filamentous and zoogleal bacteria assessment have relied on manual microscopic counting. However, these techniques are quite straining, imprecise and time-consuming, which halted their implementation in a daily basis in the WWTP laboratories. Bearing this in mind, an image processing and analysis methodology was proposed and subsequently tested in the monitoring of bulking phenomena in a municipal WWTP.

Regarding the anaerobic processes, the granular structure of the microbial aggregates within the digester is of crucial importance. In adverse conditions the granular biomass may deteriorate affecting the reactor stability leading to biomass wash-out phenomena and, hence, to a decrease on the reactor efficiency. Although it is common knowledge that the granulation process is coupled with macroscopic morphological changes, systematic observations have not yet been used widespread due to the fact that such methodology revealed to be quite tedious and difficult to implement. Therefore, the use of image analysis techniques with the macro and microscopic observations may reveal as a quite useful tool as it allows for a methodical study of both the free filamentous and the aggregated biomass.

In the scope of this work image processing and analysis methodologies were applied in order to obtain the morphological data subsequently treated by multivariable statistical techniques such as partial least squares.. Globally this study comported two main axes: monitoring of a WWTP with respect to the aerobic activated sludge process and of an EGSB digester regarding the anaerobic granulation process.

Regarding the WWTP aerobic process the high SVI values confirmed the existence of a severe bulking problem that was proven to be of filamentous nature by the results from the image analysis methodology. Moreover the dispersed bacteria per suspended solids ratio was shown to be related with the SVI values for WWTP with filamentous bulking phenomena and a second relationship was also established between the TSS and the total aggregates area. With respect to the anaerobic granulation process the results showed an increase on the aggregates size and contents within the reactor throughout the experience. Furthermore, it was found possible to determine the granulation time by the analysis of the aggregates morphology as well as the mechanism of granulation.