Wastewater Treatment Plants – Classical vs. Advanced and Intelligent Control Approaches

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Wastewater treatment is a process used to eliminate contaminants from wastewater and convert it into an effluent that can be returned to the water cycle. Wastewater Treatment Plants (WWTPs) are complex facilities in which a combination of various processes is used to treat wastewater and remove pollutants. WWTPs can range from small decentralized systems to large centralized systems involving a network of pipes and pump stations which convey the sewage to a treatment plant. Water treatment can involve two or three main stages, called primary (mechanical), secondary (biological), and tertiary (chemical) treatment. The secondary treatment is very important since it can reduce organic matter using aerobic or anaerobic biological processes.

The research and industrial applications in monitoring and control of WWTPs emphasized open problems such as advanced modelling, instrumentation, software sensors, optimization and control for bioprocesses. The efficient control of WWTPs can be achieved by using interdisciplinary approaches from information technology, control engineering and biotechnology. The biological processes inside WWTPs are nonlinear, uncertain, interconnected, with delays, characterized by the absence of cheap and reliable instrumentation. Thus, it is necessary to design modern estimation and control methods, and to ensure their practical software and hardware implementation.

The first part of the talk will focus on the architecture of WWTPs, including the Distributed Control Systems/ Supervisory Control and Data Acquisition (DCS-SCADA) that are usually implemented to control these complex processes. Practical examples of WWTPs will be analysed.

In the second part of the talk, several aspects related to the modelling of biological processes from WWTPs will be presented. Thus, the modelling paradigms will be investigated, and some specific models will be presented. For example, the so-called ASMs (Activated Sludge Models) developed by Henze *et al.* since 2000s are very complex models, which necessitate further reduction and interpretation to be used in control design.

The last part of the talk will be dedicated to WWTPs control. As we can observe in many reports and from the field situation in several WWTPs, the implementation of advanced control is very poor. In many cases, the SCADA systems are working by using empirical rules and classical controllers (such as PID, on/off). Thus, the performance of WWTPs is not as expected. The use of advanced control would lead to a significant improvement in both efficiency and performance. The trends in the design of bioprocess control algorithms are related to adaptive, intelligent, predictive and/or optimal control. Several approaches will be presented, starting with the adaptive control initially developed by Bastin and Dochain in 1990s and continuing with model predictive control and intelligent approaches (Neural Networks, bio-inspired algorithms, etc.). Some practical examples of control implementation from a WWTP will be provided.