Chapter 3
Management and Modeling of Waste Water Treatment Systems

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ABSTRACT

In this chapter wastewater treatment and water resource management are discussed and analyzed. The goal of this chapter is to deepen the knowledge of application of adequate, precise process eco-technologies in the wastewater treatment from scientific and applicative aspect. This represents an ongoing problem in the modern process eco-engineering. The appropriate wastewater management issue is regulated by domestic and EU regulative as well as through recommendations of several relevant water and wastewater management associations worldwide. This chapter elaborates the application of SuperPro Designer software for modeling of a wastewater treatment plant, considering the technological, technical, environmental and financial aspects. Regarding the management of a wastewater treatment system, the application of an appropriate control system is essential from an engineer's point of view. The SCADA (Supervisory Control and Data Acquisition) control systems were found to be most adequate and effective control systems practically applied to real life wastewater treatment systems.

INTRODUCTION

In latter day, modern society, wastewater treatment and water resource management are being discussed and analyzed. Knowing the origin and composition of wastewaters is an essential precondition to determine the processes and operations included in the wastewater treatment plants. The goal of this chapter is to deepen the knowledge of application of adequate, precise process eco-technologies in the wastewater treatment from scientific and applicative aspect. This represents an ongoing problem in the modern process eco-engineering. Through the steps of

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design, optimization and complex regulation of simultaneous ecological bio-processes, a solid base for implementation of modern wastewater treatment plants in the process of wastewater treatment will be established. Besides scientific value, this chapter covers the practical significance of the implementation of adequate wastewater treatment systems in the area of process eco-engineering, which represents one of the main segments in the sustainable development for cleaner and healthier environment (Kuvendziev, 2009).

The appropriate wastewater management issue is regulated by domestic and EU regulative as well as through recommendations of several relevant water and wastewater management associations worldwide. The definition of the bio-sensitivity (presence of life forms as well as the pollution level of receiving waters) level of the effluent catchment area is the starting point when considering the appropriateness of a proposed wastewater treatment system. According to these recommendations a process engineer determines the most appropriate wastewater treatment technology applicable to a catchment area of interest. There are several conventional wastewater treatment technologies, or bioreactor types, that can be applied: CMAS (Completely Mixed Activated Sludge), Aerated lagoons, Trickling filters or Constructed wetlands. Each of these technologies can be subjected to a SWAT analysis in order to determine its technical, environmental and financial appropriateness (Kuvendziev, 2009, Kang et al; 2008, EC, 2007)

The design and optimization of a wastewater treatment plant is conducted related to the basic operating parameters. The wastewater production (volumetric and mass flows), the organic load represented through BOD and COD (biological and chemical oxygen demands) parameters, the sludge production and sludge retention time (SRT), the DOC (dissolved oxygen concentration) within the bioreactor and the biological energy consumption (energy consumption within the bioreactors) are the basic design parameters for any of the commercially available wastewater treatment technologies. A successful design of a wastewater treatment plant is followed by an adequate optimization of the process variables regarding the system's operation. This step is conducted through simulations of the treatment plant's operation under different operating conditions. This incorporates the mathematical definition of the influence of the operating parameters on the quality of the treated effluent. The final step of the engineering approach to a system of this type is to provide an appropriate control and monitoring system for the designed process (Kuvendziev, 2009, Kuvendziev et al., 2010; Lisichkov et al., 2009; Ertl et al., 2010; Dimitrovski et al., 2011; Kuvendziev et al., 2011; Lisichkov et al., 2013

Several software packages related to chemical engineering can be successfully applied when modeling a predefined and adequate wastewater treatment technology. This chapter elaborates the application of SuperPro Designer software for modeling of a wastewater treatment plant, considering the technological, technical, environmental and financial aspects. A complete design of the treatment process includes the design of the bioreactor, primary and secondary clarifiers (separators), definition of sludge retention time and sludge reflux ratio, sludge stabilization type (aerobic or anaerobic) and sludge stabilization time, according to the design values of the abovementioned operating parameters. It also incorporates the financial aspects in forms of investment and operating costs (Kuvendziev, 2009; Kuvendziev et al., 2010; Lisichkov et al., 2009; Ertl et al., 2010; Dimitrovski et al., 2011; Kuvendziev et al., 2011; Lisichkov et al., 2013a; Lisichkov et al., 2013b)

The optimization of the designed wastewater treatment plant can be conducted through the Statgraphics Centurion software package. In order to implement 3D optimization through the RSM (response surface method) it is necessary to determine the mathematical model of the influence of the relevant operating parameters and their interactions on the quality of the treated effluent. Further, this optimization process reflects