

CONTENTS IN BRIEF

Chapter 1 Introduction

This chapter provides a brief introduction into the field of biological waste water treatment and about the scope of this text.

Chapter 2 Organic Material and Bacterial Metabolism

The different types of organic material present in waste water are quantified while the main metabolic processes are identified that result in its removal. The appropriate parameter is selected to indicate mass of organic material, for use in mass balance equations.

Chapter 3 Organic Material Removal

The interaction between the activated sludge system and the organic material in the waste water and its effects on effluent quality, oxygen demand and excess sludge production is evaluated. The importance of the sludge age as an operational parameter and as the crucial design parameter will be highlighted. An ideal steady-state activated sludge model is developed that will be used throughout this text as the basis for activated sludge system design and optimisation.

The theoretical principles involved in the aeration process are extensively discussed, including methods for the appropriate sizing of aeration equipment (both surface aerators and diffused aeration systems). Practical examples demonstrate how to determine the values of aeration parameters in full-scale activated sludge systems. This includes the use of the oxygen uptake rate (respirometry) as a tool for calibration of the steady state model. Finally, different configurations of the activated sludge system are discussed.

Chapter 4 Nitrogen Removal

The stoichiometry and kinetics of nitrification and denitrification are presented. The steady state activated sludge model is extended to include nitrogen removal. An optimisation procedure is developed that will allow the reader to define the optimal configuration of the activated sludge system, as a function of the required effluent nitrogen quality, the influent characteristics and the operational conditions.

Recent developments on the subject of nitrogen removal will also be discussed (such as the Sharon and Anammox processes). The performance of these new technologies will be evaluated in several extensive examples, including the effect of their implementation on the performance of the main activated sludge process.

Chapter 5 Phosphorus Removal

The stoichiometry and kinetics of biological- and chemical phosphorus removal processes are presented. The design and performance of various chemical phosphorus removal configurations are discussed (pre-precipitation, simultaneous- and postprecipitation). As for biological phosphorus removal, the most popular configurations will be reviewed.

The steady-state activated sludge model is extended to accommodate both biological- and chemical phosphorus removal. An extensive design case, in which the design and performance of several nutrient removal configurations is compared, concludes this chapter.

Chapter 6 Sludge Settling

An extensive mathematical description is given of the activated sludge settling process and of its implications for the design and optimisation of final settlers and sludge thickeners. An optimisation procedure is developed to allow the minimal costs design of (1) the combination aeration tank and settler and (2) the combination of thickener and sludge digester, as a function of the influent composition and the settling characteristics of the sludge.

The static-point procedure is presented as a method to evaluate the performance of existing final settlers. A significant part of this chapter is devoted to the mechanisms involved in the occurrence of sludge bulking and scum formation, while methods are presented to prevent these problems.

Chapter 7 New System Configurations

The main focus of this chapter is on Membrane Bioreactors (MBR). The theoretical principles of MBR treatment are explained and a design procedure for the main configurations is presented (submerged and cross-flow MBR), including membrane unit sizing. The operation (including membrane fouling and -cleaning) of membrane bioreactors is discussed and the effect of MBR treatment on activated sludge system performance is evaluated. The steady-state activated sludge model is adapted to reflect the changes introduced by MBR treatment. Design data of the main membrane suppliers is presented.

The recently developed aerobic granular sludge process is also discussed: this includes theoretical principles, reactor configuration and operation.

Chapter 8 Sludge Treatment and Disposal

The kinetics, stoichiometry and operational parameters of both aerobic- and anaerobic sludge digestion are discussed. Models are developed to allow for design optimisation of the paired units sludge thickener and -digester. This includes the evaluation of the use of primary settling as a pre-treatment process.

Several alternatives for the final disposal of stabilized sludge are discussed. The focus is on the design and performance of sludge drying beds, as this is a cost-effective method to produce a very dry and high quality sludge in regions with a warm climate.

Chapter 9 Anaerobic-Aerobic Waste Water Treatment

A model for the anaerobic treatment process is presented, including the influence of the main operational and design parameters: retention time, sludge age and temperature. Modern high rate anaerobic treatment systems and combined anaerobic-aerobic treatment systems for secondary and tertiary treatment are discussed. The impact of the digestion of aerobic excess sludge on UASB performance is evaluated. The steady state activated sludge model is extended to include anaerobic pre-treatment.

Chapter 10 Integrated Cost-Based Design and Operation

In this integration chapter, the optimised cost-based design procedure of the activated sludge system is demonstrated in several extensive worked examples for common secondary- and tertiary treatment configurations. This includes the implications on effluent quality, the dimensions of the main treatment units and treatment costs (both investment- and operational costs). Finally, the application of the steady-state activated sludge model for the optimisation and upgrading of existing wastewater treatment facilities is demonstrated.