

NOTES ON THE SECOND EDITION

This significantly revised and updated second edition expands upon our earlier work. Valuable feedback was received from the wastewater treatment courses, based on this handbook, given in the period 2007 to 2011. This welcome feedback has been incorporated in the book in order to improve the didactic qualities. Where needed the book structure was adapted to make it more intuitively understandable by the reader, while many additional examples have been introduced to clarify the text. Finally, obsolete text has been removed and a number of obvious errors corrected. The main additions/changes with regards to the book contents are:

Chapter 3 - Organic Material Removal

First of all, a new section has been written that explains the model notation used in this book in much more detail. Additional examples facilitate the readers understanding about the way the steady state model for COD removal is constructed and how it can be used. The difference between true and apparent yield is explained, while also the section on the F/M ratio, and especially the reasons not to use it, has been expanded.

Chapter 4 - Aeration

The section on aeration, previously part of Chapter 3, has been updated and moved to a separate Chapter.

Chapter 5 - Nitrogen Removal

The effect of the oxygen recycle to the anoxic zones on the denitrification capacity is now explicitly included in the model. Furthermore, the concept of available nitrate, i.e. the flux of nitrate to the pre-D and post-D zones is explained in more detail. The design procedure for nitrification has been elaborated and several extensive examples for optimized design of nitrogen removal have been added.

Chapter 6 - Innovative Systems for Nitrogen Removal

As the developments on the subject of innovative nitrogen removal are so rapid, this section has been significantly rewritten and expanded and now merits its own chapter.

Chapter 7 - Phosphorus Removal

Several examples on the design of chemical phosphorus removal systems have been added.

Chapter 8 - Sludge Settling

To explain the theory better, several examples have been added. The section on sludge thickening was expanded with an alternative empirical design approach and has been moved to Chapter 12 - Sludge Treatment and Disposal.

Chapter 9 - Sludge Bulking and Scum Formation

The section on sludge separation problems has been rewritten and expanded to include the latest theories and experimental findings on the development and prevention of both sludge bulking- and scum formation.

Chapter 10 - Membrane Bioreactors

The chapter on new system configurations is now devoted to MBR only, as the section on aerobic granulated sludge has been updated based on the return of experience from full-scale installations and is moved to Appendix A9. Several new examples detail the design of both cross-flow and submerged membrane configurations.

Chapter 11 - Moving Bed Biofilm Reactors

A new chapter about a technology that has become popular due to its compactness and its potential for upgrading of existing activated sludge systems.

Chapter 12 - Sludge Treatment and Disposal

The chapter is expanded with a section on sludge thickening: both the solids flux design method and an empirical design approach are presented.

Chapter 13 - Anaerobic Pre-Treatment

This part has been completely rewritten based on the experiences obtained from an extensive review of large full-scale UASB based sewage treatment plants. The main design and operational issues in UASB treatment are discussed, while new sections have been introduced on the subject of the loss of methane with the effluent, the impact on greenhouse gas emissions and the problems related to the presence of sulphate in the raw sewage.

The anaerobic design model has been expanded to include the presence of sulphate in the influent and that of suspended solids in the effluent. A new section has been introduced that deals with the methodology of UASB reactor design. The section on combined anaerobic-aerobic treatment has been adapted to reflect the latest findings on the extent of nitrogen removal possible after anaerobic pre-treatment. Some interesting new treatment configurations are presented, combining anaerobic pre-treatment with innovative nitrogen removal. Finally a thoroughly updated section on industrial anaerobic reactors has been included, based on the authors experiences within Biothane Systems International.

Chapter 14 - Integrated Cost-Based Design and Operation

The section on cost calculation now contains several examples of the calculation of investment-, operational and annualized costs. Furthermore the chapter is expanded with two extensive integrated design examples: (I) combined nitrogen and phosphorus removal in which bio-P removal is compared with pre- and simultaneous precipitation and (II) MBR in which the system configurations for submerged and cross-flow membranes are evaluated.

List of Model Parameters

Complementary to the section on model notation, a comprehensive list of *all* parameters used throughout the book has been compiled and added for easy reference.

New Appendices

- Appendix A5 - Determination of Denitrification Kinetics
- Appendix A7 - Empiric Methods for Final Settler Sizing
- Appendix A8 - Denitrification in the Final Settler
- Appendix A9 - Aerobic Granulated Sludge