Foreword

For over one hundred years the effective treatment of sewage has been dominated by aerobic fixed film and suspended growth processes. The activated sludge process, the leading technology for larger urban sewage treatment works, has been very successfully adapted over time to meet increasingly stringent effluent standards. Activated sludge plants, however, require substantial energy inputs and hence come at a significant economic and environmental cost.

In the resource constrained world we now live in, a compelling case can be made to fundamentally change how we treat sewage by switching to anaerobic sewage treatment. In warmer tropical and sub-tropical climates, anaerobic sewage treatment is already successfully applied. However, recent developments and the establishment of firm design principles, as described in this book, offer the exciting prospect of not only delivering high effluent treatment standards, but achieving truly energy neutral if not energy positive sewage treatment in both cool and warm climates.

Anaerobic Reactors for Sewage Treatment: Design, Construction and Operation consolidates 20 years of academic and practical industry experience gained by the leading proponents of anaerobic sewage treatment to detail best practice in optimising anaerobic sewage treatment processes and managing liquid, solid and gaseous phases. The introduction covers the fundamentals of anaerobic sewage treatment and how it can deliver more sustainable sanitation. Subsequent chapters discuss the design, construction, operation and full-scale experience of Upflow Anaerobic Sludge Blanket (UASB) reactors. Invaluable information is provided, based on a large survey of academic and industrial experts in Brazil, highlighting potential pitfalls in UASB design and operation and how to avoid them. Later chapters cover the wider treatment system; energy recovery, controlling fugitive greenhouse gas emissions and post-treatment of anaerobic effluents to achieve the desired final effluent quality. The incorporation of ultra-filtration membranes to the UASB flowsheet, as covered in Chapter 11, is particularly relevant for applications in more temperate climates, where the control of solids in the reactor is a key factor. The book is brought to a conclusion by exploring the considerable opportunity that exists with anaerobic flowsheets for a more circular approach to sewage treatment, for example in recovering nutrients.

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This book will be a valuable reference for water industry professionals - engineers, designers, operators, and managers, as well as researchers, undergraduates and graduates in the fields of civil engineering, environmental engineering and process engineering.

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Are UASB reactors indeed a proven and effective technological option for sewage treatment? What is the role of anaerobic sewage treatment in the circular economy? Should the reported constraints of UASB reactors be faced as inherent limitations or could they be seen as an advantage? Is toxicity an issue in anaerobic sewage treatment? What are the key design parameters to be considered and how to effectively manage them? How are full-scale UASB reactors currently performing? How can critical construction and operational issues be tackled? How can recurring problems with sludge and scum management be addressed? What are the best technological options for biogas recovery? How can odour and methane emissions in UASB reactors be controlled? Which post-treatment technology should be applied? Are membrane-based systems an alternative for temperate climate regions?

This is a glimpse of the issues that *Anaerobic Reactors for Sewage Treatment: Design, Construction and Operation* seeks to address. The use of UASB reactors for sewage treatment is relatively recent (around 30 years), especially when compared to processes such as activated sludge. Additionally, a significant part of the development of anaerobic technology for sewage treatment comes from the work of research groups and professionals associated with institutions in developing countries, notably Brazil, Colombia, Mexico, and India, who have been developing applied research in demo- and full-scale reactors, and working together with water authorities. Therefore, there was a latent demand for the consolidation of experiences in the design, construction, and operation of UASB reactors for sewage treatment. The advantages of the anaerobic process make it a more sustainable option for sewage treatment, especially in warm climate regions, but there are still important constraints related to the design, construction, and operation of anaerobic reactors when applied to sewage treatment. On the other hand, there is enough knowledge, experience and proven technology that can be used to improve all these aspects, which are now consolidated in this book. It is launched at a time of particular interest, in which temperate climate countries (e.g., England) have been carrying out research to better understand and overcome the current limitations associated with the applicability of the anaerobic process under low temperatures.

In *Anaerobic Reactors for Sewage Treatment: Design, Construction and Operation*, a detailed view is provided on the particularities of UASB reactors treating sewage, in which the fundamentals of the anaerobic process are discussed under the typical sewage flows and composition, especially to elucidate occasional limitations. The coordinated set of the 12 chapters, gathering worldwide recognized professionals with different and cross-connected experiences, can effectively contribute to solving almost all problems related to the design, construction, and operation of UASB reactors. Additionally, a simple and ready-to-use spreadsheet for the design of UASB reactors for sewage treatment is available for download through the IWA Publishing website (https://doi.org/10.2166/9781780409238). Such a design tool is based on the concept of standardized gas-liquid-solid (GLS) separators, which is presented and discussed in Chapter 4.

We sincerely believe this book can significantly contribute to the responsible expansion of the anaerobic technology worldwide, and especially for the universalization of sewage treatment in warm climate regions.

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