Preface

Compared to the more conventional aerobic process, anaerobic process for waste and wastewater treatment has three intrinsic advantages, i.e., energy saving, reduced sludge yield, and production of biofuel. Because of these advantages, in addition to the technical development in recent years, anaerobic treatment technology has become a cost-effective means for pollution control, resulting in the installations of thousands of full-scale treatment facilities worldwide in the past two decades. These advantages also make anaerobic process a sustainable environmental technology of enormous potential for the years to come.

Full-scale application of anaerobic process was first conducted in about 1860 for the treatment of domestic wastewater by Louis M. Mouras and Abbé Moigno in France, more than 50 years before the invention of aerobic activated sludge process. The first biological treatment of wastewater process was patented by W. D. Scott-Moncrieff in 1891 in Great Britain, in which organic matters were first degraded anaerobically and the products were then further degraded and mineralized aerobically, producing a clear effluent and inoffensive gases. Thereafter, anaerobic process had been continually improved and applied in many cities in Europe and the United States; the value of the generated methane was generally recognized for heating and power generation. Unfortunately, anaerobic process was treated at the time as a black box, with little understanding of its microbiology and biochemistry, and with little improvement in process technology. It was gradually replaced in the 1930s by the aerobic treatment process, which was perceived by many as better understood and more effective in operation.

Anaerobic technology was re-vitalized in the 1960s in the United States by Perry McCarty's pioneering research on the anaerobic filter. However, the first successful full-scale application of anaerobic technology for high-strength industrial wastewater treatment was not demonstrated until the late 1970s by Gatze Lettinga in the Netherlands, using a new reactor design known as upflow anaerobic sludge blanket (UASB). The success of UASB relies on the effective gas–liquid–solid separation by a built-in device at the top of the reactor, resulting in better retention of biomass in the reactor and the formation of granular sludge with superb settleability and bioactivity. Since then, UASB and its modifications, including expanded granular sludge bed (EGSB) and internal circulating (IC) reactors, have been successfully applied worldwide for the treatment of high-strength industrial wastewaters containing readily biodegradable pollutants, such as effluents from food, beverage, brewery, and distillery industries; information related to these reactors and their applications is abundant in literature.

Today, anaerobic technology continues to flourish in many aspects, such as development of new types of reactors, uses of molecular techniques for microbial studies and kinetic modeling, production of bio-hydrogen by fermentation and microbial electrolysis cell, and broadening applications to municipal wastewater, effluents from chemical industry and agricultural wastes with high lignocellulose content. This book compiles state-of-the-art information related to these new developments in anaerobic technology. It consists of 18 chapters contributed by 40 renowned experts from 13 countries/regions. The first chapter is authored by Gatze Lettinga, whose contributions to this technology have won him the Tyler Prize (2007) and the Lee Kuan Yew Water Prize (2009). In this chapter, Lettinga shares with the readers the historic development of anaerobic technology and his concept of de-centralized municipal wastewater treatment in which anaerobic process plays the primary role.

The remaining chapters are divided into three categories: full-scale applications, emerging technologies, and new developments. Discussions of full-scale applications include those in France (Chapter 2) and Japan (Chapter 3), and the treatment of municipal wastewaters in India, Colombia, and Brazil (Chapters 4 and 5). Several new designs of anaerobic reactor (Chapters 2 and 3) and experiences in the design and operations of municipal wastewater treatment (Chapters 3 and 4) are also reviewed. Discussions of emerging technologies include granulation mechanism and reactor systems (Chapter 6), anaerobic membrane bioreactor (AnMBR) (Chapter 7), and anaerobic baffled reactor (ABR) (Chapter 8), along with the applications of anaerobic process for chemical effluents (Chapter 9), the uses of molecular techniques for the identification of crucial microbes and their roles in the treatment process (Chapter 10), and mathematical models for process control (Chapter 11). Discussions of new developments include the pretreatment processes which are required for breaking down the recalcitrant lignocellulosic wastes prior to anaerobic degradation, either chemically (Chapter 12) or enzymatically (Chapter 13). Also discussed are studies of fermentative production of bio-hydrogen in Taiwan (Chapter 14), China (Chapter 15), Korea (Chapter 16), and Thailand (Chapter 17), as well as production of hydrogen by microbial electrolysis cells (Chapter 15), bio-ethanol by fermentation (Chapter 17), and chemicals from synthetic gas fermentation (Chapter 18).

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It is my hope that this book will not only be useful for those engaged in research, development, design, and operation of anaerobic technology, but that it will also arouse interests of postgraduate and undergraduate students to dedicate themselves to this environmental technology of enormous potential for the future.

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