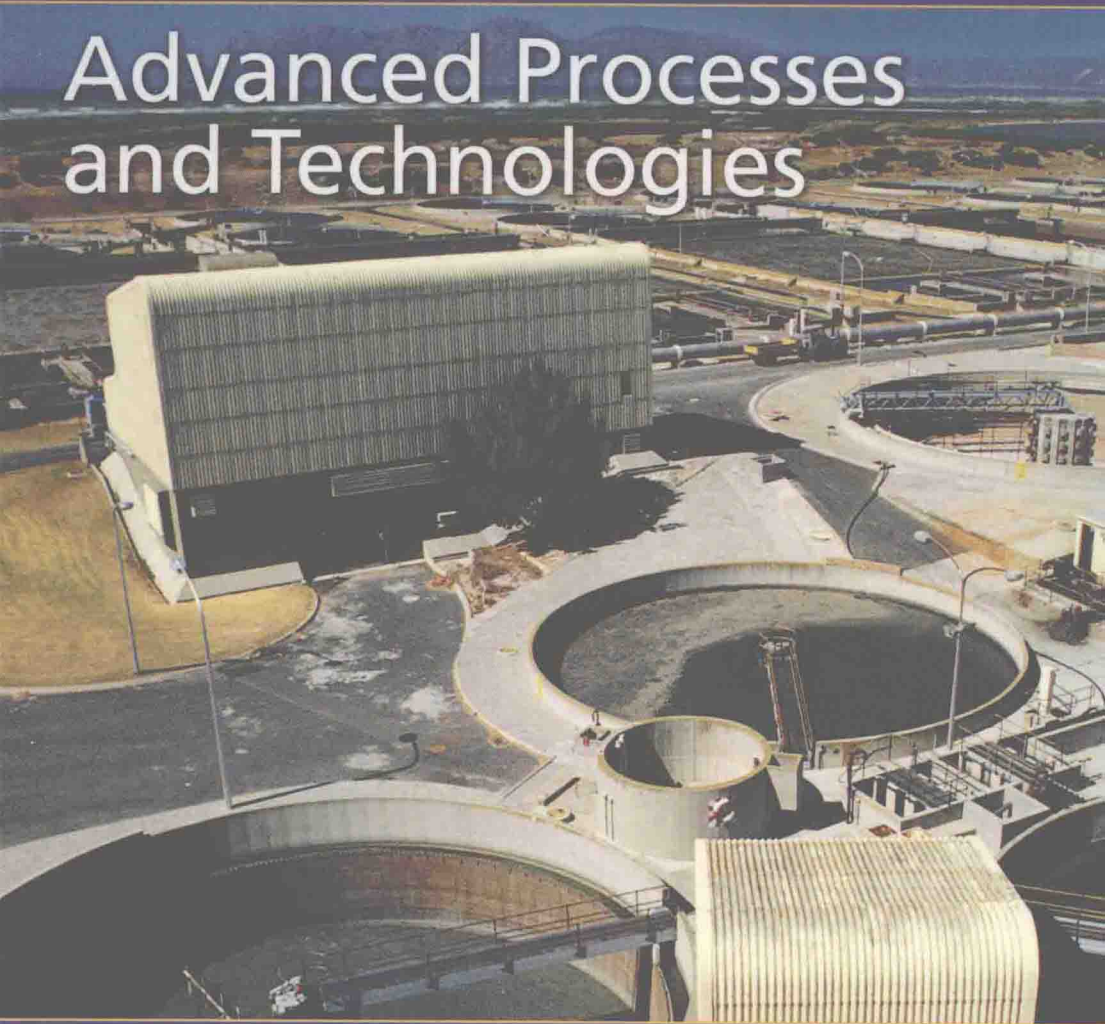
Wastewater Treatment

Advanced Processes and Technologies



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Preface

The importance of wastewater treatment in the modern industrial world is very high in view of the fact that more than 97%, dormant in polar regions, of the available water is saline (in seas and oceans) and 2% of the freshwater is unavailable for human consumption. Thus, very little quantity of water is available for human consumption. The world population is increasing, and the per capita water consumption is also increasing day by day, which lays a heavy burden on science, technology, and engineering to meet the challenges of water treatment and supply in the future. Economic and social growth cannot be ensured without industrialization, which is in turn a culprit in spoiling the available water resources due to the generation of large quantities of wastewater. It is paradoxical but true. To add another dimension to the existing problem is the increased day-by-day legislative restrictions that are being imposed by various governments all over the world in view of the safety and health concerns of the citizens. Urbanization with overconcern for hygiene also generates huge quantities of wastewater that is known as *graywater*. It comes from household kitchens, toilets, and restaurants. The graywater from kitchens and restaurants is not toxic but is not suitable for human consumption. In the present complex scenario, the only alternative is to treat the available wastewater to make it as clean as possible. The treated water may not be exactly suitable for potable purpose, but can at least be used for various other purposes, viz., recycling partly for industrial purposes, steam generation, or gardening and agriculture.

The treatment of wastewater is complicated because of the heterogeneous nature of the water streams coming from the various domestic and industrial sources. The industrial sources are as diverse as drugs and pharmaceutics, pesticides, food processing, fermentation, vaccines manufacturing nuclear processing, and metallurgical and animal processing industries. The pollutants generated can be physical, chemical, and biological in nature, and they can be toxic or nontoxic. Hence, the treatment methods are also varied in nature in order to process the diverse effluent wastewaters coming from various sources.

This book is an honest attempt to present important concepts, technologies, and issues in this direction by various experts in the field of wastewater treatment. The treatment methods cover various process industries and utilize various technologies for the purpose. Chapters 2–4 deal with advanced oxidation processes including processes based on Fenton and photo-Fenton, ozonolysis, photocatalysis, and sonolysis. Various types of reactors used in wastewater treatment are dealt with in Chapters 5, 9, and 13. Microbial treatment methods, in general, for wastewater treatment are described in Chapter 6, whereas those used in various process industries are covered in Chapter 8.

Effluent treatment methods, usually practiced in food processing industries, are comprehensively dealt with in Chapter 10. Removal of low-molecular-weight substances from wastewater is a challenging task, and hence special methods for their removal are needed, which are all described in Chapter 11. Seaweeds are good adsorbents and may be applied in wastewater treatment for the removal of toxic substances (Chapter 7). The treatment of graywater needs a special attention in view of its increasing magnitude. Chapter 12 describes such treatment methods with a case study of the Muscat municipality. A special concept of central effluent treatment plants (CETPs) is gaining prominence in the treatment and release of wastewater from small-scale processing units into municipal water lines, after meeting the stringent legislative requirements. It is dealt with in the introductory chapter (Chapter 1).

All efforts have been made by the editors and authors to judiciously blend most of the treatment processes and technologies in one single book in order to make the diverse subject matter as comprehensible as possible. It is, indeed, difficult to make it concise with the whole gamut of advanced processes and technologies in a single book of this nature; hence, enthusiastic readers are advised to consult the original references for complete understanding of any process or technology. This book is ideally suited for researchers and professionals working in the area of wastewater treatment. Each chapter is specific in its own way and, hence, may cater to the requirements of professionals interested in that area. The bibliography given at the end of each chapter would act as a guide for comprehensive information in that particular area. Hence, most of the chapters end with a comprehensive list of literature references.

At the very outset, we would like to thank all our contributing authors, who have done an excellent job in drafting and delivering the chapters. The success of this publication is largely due to them. We would also like to extend our sincere thanks to the staff of the editorial and publication department of CRC Press, who have been very helpful and cooperative throughout the preparation of this material and have been largely responsible for the book in its present form. We thank all the authors, publishers, and industries whose works have been referred to and who have extended the copyright permissions to utilize their published information in this book in some form or the other. We would like to extend our sincere thanks to the executives and management of Caledonian College of Engineering, Muscat (Sultanate of Oman), and to the staff of the University of Ulster (United Kingdom), for their encouragement and support for this work. We also thank our families, who had largely extended their moral support during the last 2 years while preparing (editing) this book.

This publication is a sincere effort made by us to put in a nutshell the vast subject matter of wastewater treatment, which is so vital in the twenty-first century. We are aware of the fact that this book may not be holistic in its approach; but still we feel we are richly rewarded if the publication meets at least partly the requirements of researchers, professionals, and young

students working in the area of wastewater treatment. Since this book is an edited version of the works of so many authors in the field, we are afraid that there may be some mistakes or omissions. We request the readers to kindly bring them to the notice of the editors (e-mail addresses enclosed) by contacting us with their views and positive criticisms for the overall improvement of the book.

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FIGURE 1.1
Common Effluent Treatment Plant in Vatva Industrial Estate in Gujarat (India).

FIGURE 1.2
Krofta spiral scooper.

(a)

(b)

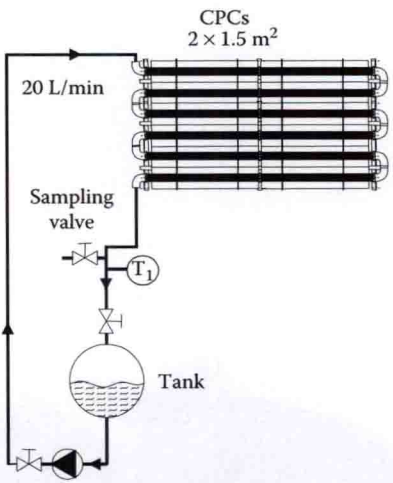

FIGURE 2.2
(a,b) Solar pilot plant: scheme and view of CPCs.

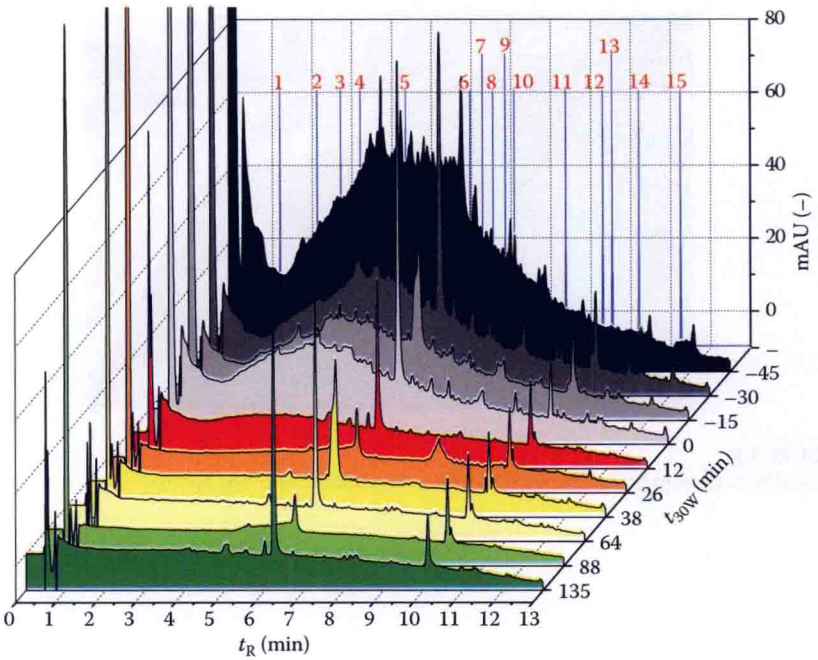

FIGURE 2.4
Degradation profile (HPLC-UV 245 nm chromatograms) of the 15 ECs (5 μg/L each) by photo-Fenton (5 mg/L Fe). 1 Acetaminophen, 2 caffeine, 3 ofloxacin, 4 antipyrine, 5 sulfamethoxazole, 6 carbamazepine, 7 flumequine, 8 ketorolac, 9 atrazine, 10 isoproturon, 11 hydroxybiphenyl, 12 diclofenac, 13 ibuprofen, 14 progesterone, and 15 triclosan.

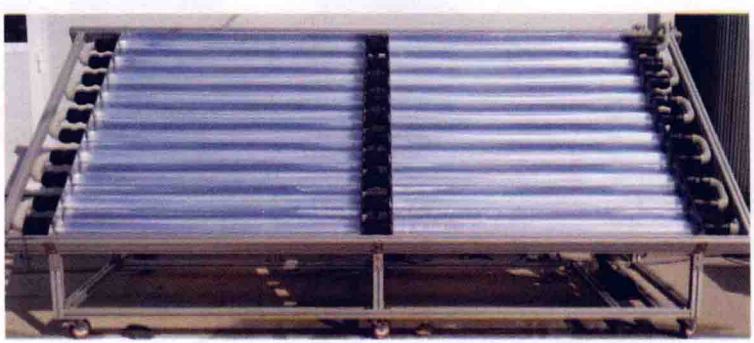

FIGURE 3.7
Photograph of a CPC reactor at PSA, Spain.

FIGURE 3.8
Photograph showing the CPC with borosilicate glass tubes (PSA, Spain).

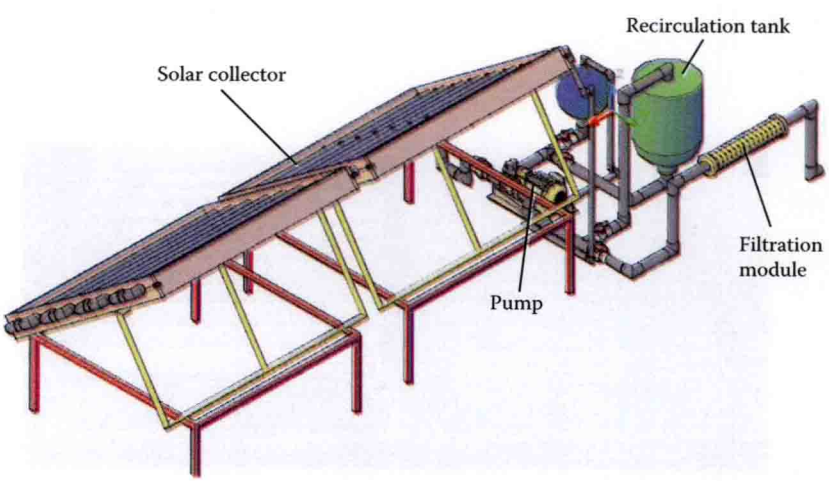

FIGURE 3.9
Schematic of a CPC photocatalytic water treatment system.

FIGURE 10.10
An activated sludge treatment plant. (Courtesy ARTES Ingegneria, Cannon, Italy.)

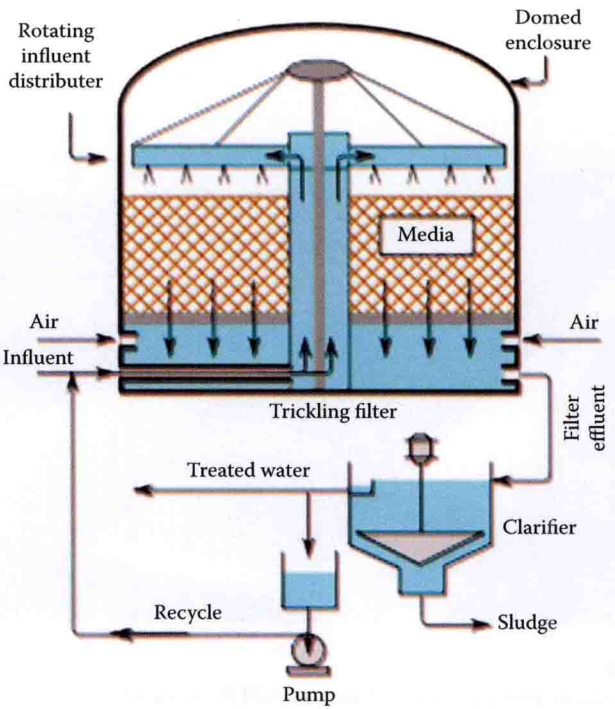

FIGURE 10.11
A trickling filter bed.

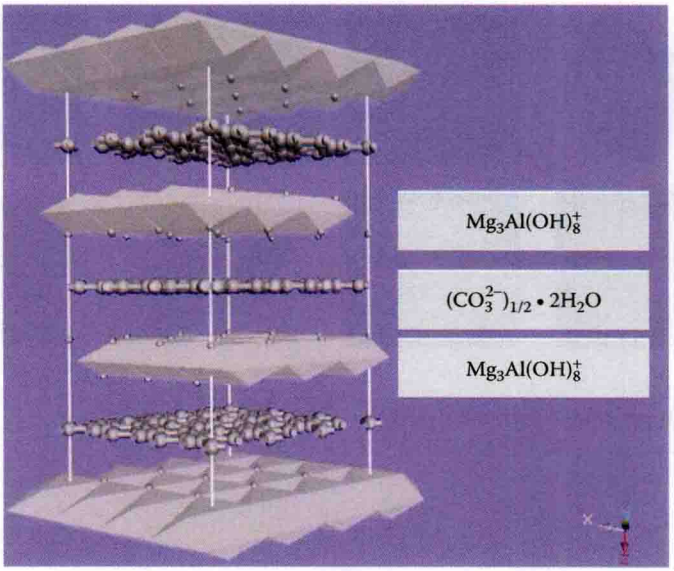

FIGURE 11.7
Schematized interlayer structure of an LDH.

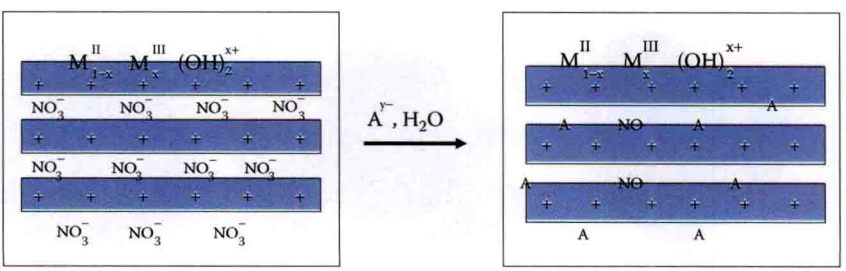

FIGURE 11.8
Anion exchange of LDH where the anion to be intercalated is denoted as A^{y-}.

FIGURE 13.2
Different types of inert carriers.

FIGURE 13.11
Photographs of biological solids attached to the anaerobic fixed bed media. (a) Noncolonized support, (b) colonized support, and (c) support after heat drying.