Reverse Osmosis Process And System Design Desalination | fc3936cb62b61cd2804cc0430f6733


This textbook covers the fundamentals of fouling and scaling in reverse osmosis systems. It includes theory and practice of pre-treatment, fouling and scaling in reverse osmosis applied for drinking and industrial water production. The impact of the water source – seawater, river water, brackish groundwater and (treated domestic) waste water – will be discussed in depth. The book presents the knowledge and experience gained at IHE Delft over the last 25 years during the implementation of the master programme in Water Supply Engineering and during the implementation of state-of-the-art research in understanding and solving operational problems in full scale desalination plants. It presents the expert knowledge of IHE Delft in the areas of pre-treatment for reverse osmosis systems, assessment of water quality with respect to fouling potential, development of methods for quality assessment, modified fouling index ultrafiltration at constant flux, transparent exoploymer particles, antiscalant dose optimization, biological growth potential, algal blooms, scaling control. The book will be used in the annual master programme at IHE Delft and is of interest for students, academics, engineers and managers in drinking water facilities all over the world. A growing proportion of the world’s population is dependent on Seawater Desalination as a source of fresh water for both potable and civil use. One of the main drawbacks of conventional desalination technologies is the substantial energy requirement, which is facing costs increases in the global energy market. “Seawater Desalination” presents an overview of conventional and non-conventional technologies, with a particular focus on the coupling of renewable energies with desalination processes. The first section of this book presents, in a technical but reader-friendly way, an overview of currently-used desalination processes, from thermal to membrane processes, highlighting the relevant technical issues, advantages and disadvantages, and highlighting a rapid increase in the development of energy aspects of fresh water production from seawater. The second section of the book presents novel processes which use Renewable Energies for fresh water production. From the solar still evaporators, which artificially reproduced the natural cycle of water, technology has progressed to develop complex systems to harness energy from the sun, wind, tides, waves, etc. and then to use this energy to power conventional or novel desalination processes. Most of these processes are still at a preliminary stage of development, but some are already being cited as examples in remote areas, where they are proving to be valuable in solving the problems of water scarcity. A rapid growth in these technologies is foreseen in the coming years. This book provides a unique foundation, within the context of present and future sustainability, for professionals, technicians, managers, and private and public institutions operating in the area of fresh water supply. For this, the term “desalination” is used in the broadest sense of the removal of dissolved, suspended, visible and invisible impurities in seawater, brackish water and wastewater, to make them drinkable, or pure enough for industrial applications like in the processes for the production of steam, power, pharmaceuticals and microelectronics, or simply for discharge back into the environment. This book is a companion volume to “Desalination, Trends and Technologies”, IENTECH, 2011, expanding on the extension of seawater desalination to brackish and wastewater desalination applications, and associated technical issues. For students and workers in the field of desalination, this book provides a summary of key concepts and keywords with which detailed information may be gathered through internet search engines. Papers and reviews collected in this volume covers the spectrum of topics on the desalination of seawater, to broadly delve into in depth. The literature citations in these papers serve to fill in gaps in the coverage of this book. Contributions to the knowledge-base of desalination is expected to continue to grow exponentially in the coming years. This book describes in depth knowledge of designing and operating reverse osmosis (RO) systems for water desalination, and covers issues which will effect the probability for the long-standing success of the application. It also provides guidelines that will increase the performance of seawater RO desalination systems by avoiding errors in the design and operation and suggest corrective measures and troubleshooting of the problems encountered during operation. This book also provides guidelines for the best RO desalination system design. In the introductory section, the book covers the history of RO along with the fundamentals, principles, transport models, and equations. Following sections cover the practical aspects such as pretreatment processes, design parameters, design software programs (WAVE, IMSDesign, TORAYDS2, Lewaplus, ROAM Ver. 2.0, Winflows etc.), RO performance monitoring, normalisation software programs (RODataXL and TorayTrak), troubleshooting as well as system engineering. Simplified methods to use the design software programs are also properly illustrated and the screenshots of the results, methods etc. are also given here along with a video tutorial. The final section of the book includes questions along with answers. Moreover, various case studies carried out and recent developments related to RO system performance, membrane fouling, scaling, and degradation studies have been analyzed. The book also has several work out examples, which are detailed in a carefull manner as simple example that help the reader to understand and follow it properly. The information presented in some of the case studies are obtained from existing commercial RO desalination plants. These topics enable the book to become a perfect tool for engineers and plant operators/technicians, who are responsible for RO system design, operation, maintenance, and troubleshooting. With the right system design, proper operation, and maintenance program, the RO system can offer high purity water for several years. Provides guidelines for the optimum design and operational performance of reverse osmosis desalination plants. Presents step-by-step procedure to design reverse osmosis system with the latest design software programs along with a video tutorial Analyses some of the issues faced during the design process and the operation of the reverse osmosis desalination systems, suggest corrective measures and its troubleshooting. Discusses reverse osmosis desalination pretreatment processes, design parameters, system performance monitoring, and normalisation software programs Examines recent developments related to system performance, membrane fouling, and scaling studies Presents case studies related to commercial reverse osmosis desalination plants Perfect training guide for engineers and plant operators, who are responsible for reverse osmosis system design, operation and maintenancePretreatment for Reverse Osmosis Desalination is a comprehensive reference on all existing and emerging seawater pretreatment technologies used for desalination. The book focuses on reverse osmosis membrane desalination, which at present is the most widely applied technology for the production of fresh drinking water from highly saline water sources (seawater, brackish water and wastewater). Each chapter contains examples illustrating various pretreatment technologies and their practical implementation. Provides an in-depth overview of the key theoretical concepts associated with desalination pretreatment. Gives insight into the latest trends in the separation technology. Incorporates analytical methods and guidelines for monitoring pretreatment systems. Seawater desalination is increasingly being used as a means to augment freshwater supplies in regions with high water stress, and reverse osmosis is increasingly the technology of choice because of the low energy consumption. However, seawater reverse osmosis (SWRO) systems suffer from various types of fouling, which can increase energy consumption and the use of chemicals during SWRO operation. In practice, pretreatment systems are put in place to reduce the particulate and biological fouling potential of SWRO feed water. However, simple, reliable and accurate methods to assess the extent to which biological fouling potential is reduced during pre-treatment are not available for seawater. This research developed a new method to measure bacterial growth potential (BGP) using the native bacterial consortium in seawater. New reagents to extract and detect ATP in microbial cells were specifically developed for seawater. The new lysin and detection reagents overcame the salt interference in seawater and allow low detection of total ATP, free ATP and microbial ATP in seawater. Incorporation of the method six fold, enabling ATP detection of ultra-low levels of microbial ATP in seawater. The newly developed ATP-based BGP method was applied to monitor and assess the pre-treatment of five full-scale seawater desalination plants around the world. A good correlation was observed between BGP measured in SWRO feed water and the pressure drop increase in the SWRO systems, suggesting the applicability of using the ATP-based BGP method as a biofouling indicator in SWRO. Furthermore, a safe level of BGP (in the future, on-line monitoring of BGP in SWRO feed water may further reduce the consumption of chemicals and energy and improve the overall sustainability of desalination by reducing the risk of increasingly thick, prolific and toxic algal blooms. Depending on the severity of algal blooms, desalination systems may be forced to shut down because of clogging and/or poor feed water quality. To maintain stable operation and provide good feed water quality to seawater reverse osmosis (SWRO) systems, ultrafiltration (UF) pre-treatment is proposed. This
research focused on assessing the ability of UF and other pre-treatment technologies to reduce biofouling in SWRO systems. An improved method to measure bacterial regrowth potential (BRP) was developed and applied at laboratory, pilot and full scale to assess the ability of conventional UF (150 kDa) and tight UF (10 kDa) alone and in combination with a phosphate adsorbent to reduce regrowth potential and delay the onset of biofouling in SWRO. The improved bacterial regrowth test method employs a native bacterial consortium and determination of the number of bacterial colony forming units (CFU) and flow cytometry. The number of bacteria is lowered to 43,000 ± 12,000 cells/mL, which is equivalent to 9.3 ± 2.6 g-C glucose/L. The reduction in bacterial regrowth potential after tight UF (10 kDa) was 3 to 4 times higher than with conventional UF (150 kDa). It was further reduced after the application of a phosphate adsorbent, independent of pore size of the UF membrane. Pilot studies demonstrated that the application of tight UF (10 kDa) coupled with a phosphate adsorbent consistently lowered the bacterial regrowth potential in pre-treatment processes. Flow cytometry was observed in membrane washing after 28 days. The study showed that non-backwashable fouling of UF membranes varied strongly with the type of algal species and the algal organic matter (AOM) they release. The presence of polysaccharide (stretching -OH) and sugar ester groups (stretching S=O) was the main cause of non-backwashable fouling. In conclusion, this study showed that an improved BRP method is suitable for the assessment of SWRO pre-treatment systems and it can be a useful tool to develop potential strategies to mitigate biofouling and to improve the sustainability of SWRO systems. Membrane Contactors: Fundamentals, Applications and Potentials, Volume 11 covers new operating concepts that efficiently used a variety of industrial production cycles from fine chemical production to agrofood. This book focuses on the basic principles of work: required membrane materials and properties, major operating parameters, the importance of module configuration and design; and the performance of membrane contactors in specific processes. The authors’ dynamic approach to this subject makes Membrane Contactors: Fundamentals, Applications and Potentials, Volume 11 the most comprehensive book currently available on all aspects related to the membrane contactor world. * Describes new unit operations in process engineering, opens up a wide variety of industrial applications, from biotechnology to agrofood. * Applicable to process intensification and sustainable growth strategies. For the Nonengineering Professional Perfect for anyone without a background in science or engineering who wants to take a closer look at how water is processed and treated, Reverse Osmosis: A Guide for the Nonengineering Professional relates reverse osmosis to its most basic form and addresses growing concerns about the quality of tap water. What is reverse osmosis? Not to be confused with filtration—which involves straining or size exclusion—reverse osmosis involves a diffusive mechanism and separation process that is dependent on solute concentration, pressure, and the water flux rate. This book describes all of the basic processes involved in reverse osmosis operations. Presented in a conversational style—using jargon-free language—it discusses in detail the drinking water purification, wastewater reuse, desalination processes, and other freshwater applications used to ensure the safe consumption of water. The book also places special emphasis on pharmaceuticals and personal care products (PPCP) contaminants, which are not typically removed from wastewater by conventional treatment processes, however, they can be removed by processes using sophisticated membrane filtration. The author provides a basic understanding of membrane technology and how it fits together with the membrane separation process. He details how the processes are used in water purification to concentrate or recover valuable materials or to process wastewater treatment system and presents concepts that make up water and wastewater treatment processes as a whole. He also highlights advances in reverse osmosis technology and discusses relevant applications. Presents a comprehensive coverage of reverse osmosis Discusses fundamental processes and equipment used in reverse osmosis Provides technical terminology in simplified form Reverse Osmosis: A Guide for the Nonengineering Professional explains how reverse osmosis for water purification works, and provides readers with step-by-step instruction on the pre-treatment, system design, and post-treatment methods used in the purification of drinking water. Osmosis Engineering provides a comprehensive overview of the state-of-the-art surrounding osmosis-based research and industrial applications. The book covers the underpinning theories, technology developments and commercial applications. Sections discuss innovative and advanced membranes and modules for osmosis separation processes (e.g., reverse osmosis, forward osmosis, pressure retarded osmosis, osmotic membrane distillation), different application of these osmosis separation processes for energy and water separation, such as the treatment of radioactive waste, oily wastewater and heavy metal removal, draw solution reverse osmosis, osmocatalytic reactions, the use of renewable energies, driver osmotic processes, computational, environmental and economic studies, and more. Covers state-of-the-art osmotic engineering technologies and applications. Presents multidisciplinary topics in engineered osmosis, including both fundamental and applied EO concepts. Includes major challenges such as fouling mitigation, membrane development, pre-treatment and energy usage. This book is a companion volume to two published in 2011 by INTECH titled “Desalination, Trends and Technologies” and “Environmental Protection and Desalination”. This book is the broadest sense of “desalination” used in this book, that is, the removal of invisible impurities in seawater, brackish water and wastewater. The purpose of desalination is to make water drinkable, or pure enough for industrial applications like in the processes for the production of steam, power, pharmaceuticals and microelectronics, or simply for attaining acceptable qualities for discharge back into the environment. This volume touches on Membranes and Systems, Solar Desalination, Reverse Osmosis Process Chemistry and Control, Drinking Water Quality, and Selective Waste Product Removal. The value of these volumes on the vast topic of desalination is to present the landscape to students, teachers and practitioners, with key concepts and keywords useful in gathering publications through internet search engines. The technologies of desalination of water are advancing as rapidly as the cry of human kind for more availability of quality water supply while minimizing environmental pollution. Contributions to the knowledge-base of desalination are expected to continue to grow exponentially in the coming years. The book assembles the latest research on new design techniques in water supplies using desalinated seawater. The authors examine the diverse issues related to the intakes and outfalls of these facilities. They clarify how and why these key components of the facilities impact the cost of operation and subsequently the cost of water supplied to the consumers. The book consists of contributed articles from a number of experts in the field who presented their findings at the “Desalination Intakes and Outfalls” workshop held at King Abdullah University of Science and Technology (KAUST) in Saudi Arabia in October, 2013. The book integrates coverage relevant to a wide variety of researchers and professionals in the general fields of environmental engineering and sustainable development. This book describes in depth knowledge of designing and operating reverse osmosis (RO) systems for water desalination, and covers issues which will effect the probability for the long-standing success of the application. It also presents new innovation and design by avoiding of seawater RO by producing clean water using one of the most effective solutions to reverse of our fresh water shortage. New methodologies, measures and troubleshooting of the problems encountered during RO operation. This book also provides guidelines for the best RO design and operational performance. In the introductory section, the book covers the history of RO along with the fundamentals, principles, transport models, and equations. Following sections cover the practical areas such as pre-treatment processes, design parameters, design software programs (WAVE, IMSDesign, TORAYDS, Lewlupis, ROAM Ver. 2.0, Winflows etc.), RO performance monitoring, normalization software programs (RODataXL and TorayTeak), troubleshooting as well as system engineering. Simplified methods to use the design software programs are also properly illustrated and the screenshots of the results, methods etc. are also given here along with a video tutorial. The final section of the book includes the frequently asked questions along with their answers. Moreover, various case studies carried out and recent developments related to RO system performance, membrane fouling, scaling, and degradation studies have been analyzed. The book also has several work out examples, which are detailed in a careful as well as simple manner that help the reader to understand and follow it properly. The information presented in such a comprehensive manner surely adds value to researchers. Case studies obtained are commercial RO desalination plants. These topics enable the book to become a perfect tool for engineers and plant operators/technicians, who are responsible for RO system design, operation, maintenance, and troubleshooting. With the right system design, proper operation, and maintenance program, the RO system can offer high purity water for several years. Provides guidelines for the optimum design and operational performance of reverse osmosis desalination plants. Presents step-by-step procedure to design reverse osmosis system with the latest design software programs along with comprehensive analysis of the desalination system. Analyzes some of the major issues faced during the design and operation of the reverse osmosis systems, covering important system performance measures and its troubleshooting. Discusses reverse osmosis desalination pretreatment processes, design parameters, system performance monitoring, and normalization software programs Examines recent developments related to system performance, membrane fouling, and scaling studies. Presents case studies related to commercial reverse osmosis desalination plants Perfect training guide for engineers and plant operators, who are responsible for reverse osmosis system design, operation and maintenance.Reverse Osmosis starts with an overview of the historic development of the RO membrane, the RO process, and its effect on other membrane technologies. The reader then explores a thorough understanding of membrane formation techniques, particulates, contaminants, and the role each plays in the desalination process. The book then moves to the various applications of RO membranes, such as TFC membrane, NF/UF membranes, RO membrane for wastewater treatment, RO membrane for seawater desalination and other membrane processes. This book also describes, in detail, experimental methods and details the performance of RO membranes in specific applications. The book concludes with a comprehensive overview of the various applications of RO membranes in cross-flow filtration, ultrafiltration, microfiltration, and nanofiltration. Provides an in-depth discussion of the role of RO membrane materials and their properties, major operating parameters, the importance of module configuration and design; and the performance of membrane contactors in specific processes. The authors’ dynamic approach to this subject makes Membrane Contactors: Fundamentals, Applications and Potentials, Volume 11 the most comprehensive book currently available on all aspects related to the membrane contactor world. The second edition is an enhanced version of the original bestseller.
Each chapter has been reviewed and updated. Revised features include more detail on various pretreatment techniques such as greensand and pyrolysate pretreatment media. The design projection chapter has been edited to include up-to-date information on current projection programs. A new section on microbial fouling controlling parameters and alternative techniques is included, addressing the needs of most RO systems. Also, a discussion on forward osmosis is added as an emerging process. The comprehensive structure provides for a basic, in-depth understanding of the membrane process operation, and optimization of reverse osmosis systems.

Earlier chapters cover the basic principles, the history of osmosis, osmotic barriers and definitions, and essential equipment. The book then goes into pretreatment processes and system design, then, finally, operations and troubleshooting. The author includes a section on the impact of other membrane technologies and even includes a "Frequently Asked Questions" chapter.

Annotation A comprehensive guide to the technology understanding and control. The book provides the necessary information for the practical design and operation of membrane processes. The book contains the possibility of integrating different membrane unit operations (microfiltration, ultratitration, nanofiltration, reverse osmosis, electrodialysis and gas separation) in the same industrial cycle or in combination with conventional separation processes. It gives a careful analysis of the technical aspects, and the possible fields of industrial development. The book reviews many original solutions in water desalination, agro-food productions and wastewater treatments, highlighting the advantages achievable in terms of product quality, compactness, rationalization and optimization of productive cycles, reduction of environmental impact and energy saving. Various topics are examined, such as the integration with a fuel cell; polymer membrane gas separation; solar driven membrane processes; combined cycle power plants; integrating a membrane reactor into a solar system; and potential application of membrane integrated systems in the fusion reactor fuel cycle. With detailed analysis and broad coverage, the book is divided into two sections: Bio-applications and Inorganic Applications. The Handbook of Membrane Separations, Chemical, Pharmaceutical, Food, and Biotechnological Applications, Second Edition provides detailed information on membrane separation technologies from an international team of experts. The handbook fills an important gap in the current literature by providing a comprehensive discussion of membrane application.

With a detailed analysis of the mass transport through membrane layers and its effect on different separation processes, this book provides a comprehensive look at the theoretical and practical aspects of membrane transport properties and functions. Basic equations for every membrane are provided to predict the mass transfer rate, the concentration distribution, the convective velocity, the separation efficiency, and the effect of chemical or biochemical reaction taking into account the heterogeneity of the membrane layer to help better understand the mechanisms of the separation processes. The reader will be able to describe membrane separation processes and the membrane reactors as well as choose the most suitable membrane structure for separation and for membrane reactor. Containing detailed discussion of the latest results in transport processes and separation processes, this book is essential for chemists and practitioners of chemical engineering and process engineering. Detailed survey of the theoretical and practical aspects of every membrane process with specific equations. Practical examples discussed in detail with clear steps. Will assist in planning and preparation of more efficient membrane structure separation in various applications. The book provides a full description of the RO process, a comprehensive review of membrane technology and system design, and describes the economic application in water desalination and wastewater treatment. Emphasizes economic aspects of RO processes for wastewater treatment. This handbook provides a comprehensive look at the theoretical and practical aspects of membrane transport properties and functions. Basic equations for every membrane. Provides an overview of membrane processes, focuses on different types of membrane processes for water treatment and explains characteristics of membrane modules. Introduces the importance and challenges of process modelling for simulation, design, and optimization and offers examples across various industries. Describes the concept of different types of genetic algorithms for process optimisation and provides the state-of-the-art of the GA method in terms of its application and wastewater treatment. Emphasizes the practical implications of RO processes in the water industry. Includes a range of techniques that are characterised by a huge variety of information on how membrane processes are applied to a vast array of applications. The book provides a comprehensive look at the theoretical and practical aspects of membrane transport properties and functions. Basic equations for every membrane. Provides an overview of membrane processes, focuses on different types of membrane processes for wastewater treatment and explains characteristics of membrane modules. A comprehensive guide to the technology understanding and control. The book provides the necessary information for the practical design and operation of membrane processes. The book contains the possibility of integrating different membrane unit operations (microfiltration, ultrafiltration, nanofiltration, reverse osmosis, electrodialysis and gas separation) in the same industrial cycle or in combination with conventional separation processes. It gives a careful analysis of the technical aspects, and the possible fields of industrial development. The book reviews many original solutions in water desalination, agro-food productions and wastewater treatments, highlighting the advantages achievable in terms of product quality, compactness, rationalization and optimization of productive cycles, reduction of environmental impact and energy saving. Various topics are examined, such as the integration with a fuel cell; polymer membrane gas separation; solar driven membrane processes; combined cycle power plants; integrating a membrane reactor into a solar system; and potential application of membrane integrated systems in the fusion reactor fuel cycle. With detailed analysis and broad coverage, the book is divided into two sections: Bio-applications and Inorganic Applications. The Handbook of Membrane Separations, Chemical, Pharmaceutical, Food, and Biotechnological Applications, Second Edition provides detailed information on membrane separation technologies from an international team of experts.
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up-to-date coverage of both theory and practice of water treatment system design. The Third Edition brings the field up to date, addressing new regulatory requirements, ongoing environmental concerns, and the emergence of pharmacological agents and other new chemical constituents in water. Written by some of the foremost experts in the field of public water supply, Water Treatment, Third Edition maintains the book's broad scope and reach, while reorganizing the material for even greater clarity and readability. Topics span from the fundamentals of water chemistry and microbiology to the latest methods for detecting contaminants in water, leading-edge technologies for implementing water treatment processes, and the increasingly important topic of managing residuals from water treatment plants. Along with hundreds of illustrations, photographs, and extensive tables listing chemical properties and design data, this volume: Introduces a number of new topics such as advanced oxidation and enhanced coagulation Discusses treatment strategies for removing pharmaceuticals and personal care products Examines advanced treatment technologies such as membrane filtration, reverse osmosis, and ozone addition Details reverse osmosis applications for brackish groundwater, wastewater, and other water sources Provides new case studies demonstrating the synthesis of full-scale treatment trains A must-have resource for engineers designing or operating water treatment plants. Water Treatment, Third Edition is also useful for students of civil, environmental, and water resources engineering. Desalination Sustainability: A Technical, Socioeconomic, and Environmental Approach presents a technical, socioeconomic, and environmental approach that guides researchers and technology developers on how to quantify the energy efficiency of a proposed desalination process using thermodynamics-based tools. The book offers the technical reader an understanding of the issues related to desalination sustainability. For example, technology users, such as public utility managers will gain the ability and tools to assess whether or not desalination is a good choice for a city or country. Readers will learn new insights on a clear and practical methodology on how to probe the economic feasibility of desalination using simple and effective tools, such as levelized cost of water (LCOW) calculation. Decision-makers will find this book to be a valuable resource for the preliminary assessment of whether renewable-powered desalination is a good choice for their particular setting. Presents the issues related to desalination sustainability. Guides researchers and technology developers on how to quantify the energy efficiency of a proposed desalination process using thermodynamics-based tools. Outlines a clear and practical methodology on how to probe the economic feasibility of desalination using simple and effective tools. Provides a roadmap for decision-makers on the applicability of a desalination process at a particular setting. Ostensively driven membrane processes (ODMPs) including forward osmosis (FO) and pressure-retarded osmosis (PRO) have attracted increasing attention in fields such as water treatment, desalination, power generation, and life science. In contrast to pressure-driven membrane processes, e.g., reverse osmosis, which typically employs applied high pressure as driving force, ODMPs take advantages of naturally generated osmotic pressure as the sole source of driving force. In light of this, ODMPs possess many advantages over pressure-driven membrane processes. The advantages include low energy consumption, ease of equipment maintenance, low capital investment, high salt rejection, and high water flux. In the past decade, over 300 academic papers on ODMPs have been published in a variety of application fields. The number of such publications is still rapidly growing. The ODMPs' approach, fabrications, recent development and applications in wastewater treatment, power generation, seawater desalination, and gas absorption are presented in this book. This comprehensive reference work describes in an instructive manner the combination of different membrane operations such as enzyme membrane reactors (EMRs), microfiltration (MF), ultrafiltration (UF), reverse osmosis (RO), nanofiltration (NF) and osmotic distillation (OD) is studied in order to identify their synergistic effects on the optimization of processes in agro-food productions (fruit juices, wines, milk and vegetable beverages) and wastewater treatments within the process intensification strategy. The introduction to integrated membrane operations is followed by applications in the several industries of the food sector, such as valorization of food processing streams, biocatalytic membrane reactors, and membrane emulsification. The past thirty years have witnessed a growing worldwide desire that po-tive actions be taken to restore and protect the environment from the degr- ing effects of all forms of pollution—air, water, soil, and noise. Because pollution is a direct or indirect consequence of waste, the seemingly idealistic demand for “zero discharge” can be construed as an unrealistic demand for zero waste. However, as long as waste continues to exist, we can only attempt to abate the subsequent pollution by converting it to a less noxious form. Three major questions usually arise when a particular type of pollution has been id- tified: (1) How serious is the pollution? (2) Is the technology to abate it ava- able? and (3) Do the costs of abatement justify the degree of abatement achieved? This book is one of the volumes of the Handbook of Environmental Engineering series. The principal intention of this series is to help readers formulate answers to the last two questions above. The traditional approach of applying tried-and-true solutions to specific pollution problems has been a major contributing factor to the success of en- ronnemental engineering, and has accounted in large measure for the establi- ment of a “methodology of pollution control. ” However, the realization of the ever-increasing complexity and interleaved nature of current environmental problems renders it imperative that intelligent planning of pollution abatement systems be undertaken. Industrial desalination of sea and brackish water is becoming an essential part in providing sustainable sources of fresh water for a larger number of communities around the world. Desalination is a main source of fresh water in the Gulf countries, a number of the Caribbean and Mediterranean Islands, and several municipalities in a large number of countries. As the industry expands there is a pressing need to have a clear and well-written textbook that focuses on desalination fundamentals and other industrial aspects. This book focuses on the processes widely used in industry, which include multistage flash desalination and reverse osmosis. Also, other desalination processes with attractive features and high potential are featured. It includes a large number of solved examples, which are explained in simple and careful matter that allow the reader to follow and understand the development. The data used in the development of the examples and case studies are extracted from existing desalination plants. This title also includes comparisons of model predictions against results reported in literature as well as available experimental and industrial data. Several industries include similar unit operation processes, i.e., evaporators, condensers, flashing units, membrane separation, and chemical treatment. Examples of such industries include wastewater treatment, food, petroleum, petrochemical, power generation, and pulp and paper. Process fundamentals and design procedures of such unit processes follow the same procedures given in this textbook.