

# The Guidebook to Membrane Technology for Wastewater Reclamation

**Wastewater treatment, Pollutants, Membrane filtration, Membrane bioreactors, Reverse osmosis, Fouling, UV oxidation, Process control, Implementation, Economics, Commercial plants design**

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This is the second guidebook on commercial membrane technology written by a team of membrane technology professionals and published by Balaban Desalination Publications. The material included in the first guidebook (published in 2007) covers mainly brackish and seawater desalination technology and applications. This guidebook is dedicated to the membrane technologies applied in wastewater reclamation processes. The reasons for a separate book on wastewater reclamation technology are related to the unique treatment challenges, potential of sufficient availability and affordable economics of utilizing this water source: The water sources, used for wastewater reclamation, are highly contaminated with constituents that embody conditions of environmental and health concern.

Therefore, specialized and highly reliable treatment technologies are required for applications that involve water reuse; Wastewater is available in abundant quantities at locations that allow convenient conveyance to the treatment facilities and distribution of treated effluent to potential users; Energy requirement of the treatment process is low compared to other alternatives of augmentation of water supply; Advances in membrane technology for wastewater reclamation contributed to its increasing recognition as a reliable technology for cost effective production of high quality effluents.

The objective of this book is to describe commercial treatment technologies and explain in simple engineering terms modern membrane applications in wastewater reclamation processes. Examples of design and process calculations and case studies are provided to illustrate methods of system design, calculation of process parameters and evaluation of process economics.

The book content was formulated to serve as a reference for configuration and design processes of membrane systems in wastewater reclamation and reuse applications for project engineers, plant designers, planners, utility directors and operations managers, involved in municipal and industrial reclamation projects. It is also anticipated that the book will provide information on practical approaches of these technologies and processes to scientists and academics interested in commercial wastewater reclamation applications.



## *The Guidebook to Membrane Technology for Wastewater Reclamation*

### **1 Introduction**

### **2 Wastewater**

Introduction/ Characteristics of wastewater feed streams/ Water quality required for reuse/ Wastewater treatment process/ Legislation

### **3 Introduction to membranes in wastewater treatment**

Background/ Why use membranes?/ Markets/ Cost analysis

### **4 Fundamentals of membrane filtration**

Membrane filtration basics/ Membrane characteristics/ Transport and fouling phenomena/ Effect of temperature/ Flux and permeability/ Filtrate quality/ Advantages of membrane pre-treatment for RO/ Integrity

### **5 Membrane filtration – commercial membranes & modules**

History of UF/MF membrane development/ UF/MF products / Manufacture of UF/MF products / Module format and system configuration

### **6 Membrane filtration system design**

Background/ Flux selection/ System configuration/ Selection and sizing of system components/ Indicative capital and operating costs/ Case studies: Orange County, California, USA, Public Utilities Board (PUB), Singapore, Benidorm and Rincon de Leon, Spain, Sulaibiya, Kuwait, Western Corridor, Brisbane, Australia

### **7 Membrane bioreactors – commercial membranes and modules**

Membrane materials and properties/ Modules configuration/ Effluent quality/ Modes of operation

### **8 Fundamentals of membrane bioreactors**

Comparison of MBR with the conventional activated sludge process/ Hydraulic terms

### **9 Membrane bioreactors system design**

System configuration and operating sequence/ Process components/ Process alternatives/ Footprint/ System operating parameters/ Influent design parameters/ Biological process/ Phosphorous reduction process/ System hydraulics/ Sludge management/ Membrane permeability restoration/ Usage of chemicals/ Energy requirement/ Membrane replacement rate/ Selection and sizing of system components/ Membrane unit/ Major system components/ Auxiliary equipment/ Materials of construction/ System layout

### **10 Operation of the MBR systems**

Monitoring of membrane performance/ Monitoring of biological process/ Equipment maintenances/ MBR equipment procurement

### **11 Fundamentals of reverse osmosis**

Osmotic pressure of water solution/ Salt-water separation in reverse osmosis process/ Water salinity / Permeate recovery rate/ Average feed salinity/ Net driving pressure / Salt passage and salt rejection/ Temperature effect on transport rate/ Average permeate flux/ Specific water permeability / Concentration polarization

### **12 Commercial RO membranes and modules**

Manufacturing of composite polyamide membranes/ Other membrane materials/ Plate and frame membrane elements/ Hollow fiber membrane elements/ Spiral wound membrane elements/ Spiral wound elements categories

### **13 RO unit configuration**

Pressure vessels/ Membrane assembly unit/ Concentrate staging / Permeate flux and flow distribution/ Permeate staging (two pass system)

### **14 Calculation of system performance**

Manual method of membrane system performance calculations / Use of computer programs for projection of membrane performance

### **15 Parameters of RO process design**

Feed water composition/ Indicators of RO feed water quality/ Membrane fouling/ Permeate flux rate/ Recovery rate/ Membrane replacement rate

### **16 RO system design**

System configuration/ Configuration of the pretreatment process/ Membrane unit/ Membrane cleaning unit/ Permeate processing/ Energy requirement in RO applications/ Process flow diagram and system layout

### **17 System operation**

Monitoring system operation / Normalization of membrane performance

**18 UV disinfection and reduction of micropollutants**

UV disinfection fundamentals/ UV lamp types and radiation sources configuration/ UV system components and typical layouts/ UV system sizing considerations and design parameters/ UV operating parameters/ UV oxidation in potable reuse applications/ Design and optimization of UV oxidation system/ Designing UV oxidation system for indirect potable reuse (IPR)/ Application examples

**19 Restoration of membrane performance**

Introduction/ Fouling phenomena/ Evaluation of fouled membranes/ Cleaning procedures

**20 Project implementation**

Project Feasibility/Planning/ Pilot Testing/ Design stages/ Permitting/ Procurement methods/ Start-up and testing/ Training

**21 Economics of membrane treatment projects**

Cost components/ Calculation of components of product water cost/ Present worth value

**22 Examples of commercial plant data and design**

Ground water reclamation/ Singapore wastewater reclamation plants/ US wastewater reclamation plants/ Wastewater reclamation at other locations/ Case studies: Singapore, Dow Corporation – Filmtec, Terneuzen

**23 Process control**

Introduction/ Designing of instrumentation and control system/ Access levels/ Specification of scope of work/ Performance optimization through process optimization/ Control system redundancy/ Implementation of control system

**24 Appendixes**

Representative configuration of membrane filtration unit/ Representative configuration of membrane bioreactor unit / Representative configuration of RO membrane unit / Example of calculation of operating cost of membrane filtration systems/ Example of calculation of operating cost of membrane bioreactor/ Example of calculation of operating cost of RO systems/ Units conversion table

