

Table of contents

- **Preface** (p. v)
- **Contributors** (p. xix)
- **1 Screening and Comminution** (p. 1)
- **1 Function of Screens and Comminutors** (p. 1)
- **2 Types of Screens** (p. 2)
- **2.1 Coarse Screens** (p. 2)
- **2.2 Fine Screens** (p. 2)
- **3 Physical Characteristics and Hydraulic Considerations of Screens** (p. 3)
- **4 Cleaning Methods for Screens** (p. 5)
- **5 Quality and Disposal for Screens** (p. 6)
- **6 Comminutors** (p. 7)
- **7 Engineering Specifications and Experience** (p. 8)
- **7.1 Professional Association Specifications** (p. 8)
- **7.2 Engineering Experience** (p. 11)
- **8 Engineering Design** (p. 12)
- **8.1 Summary of Screening Design Considerations** (p. 12)
- **8.2 Summary of Comminution Design Considerations** (p. 14)
- **9 Design Examples** (p. 15)
- **9.1 Example 1: Bar Screen Design** (p. 15)
- **9.2 Example 2: Bar Screen Head Loss** (p. 16)
- **9.3 Example 3: Plugged Bar Screen Head Loss** (p. 17)
- **9.4 Example 4: Screen System Design** (p. 17)
- **Nomenclature** (p. 18)
- **References** (p. 18)
- **2 Flow Equalization and Neutralization** (p. 21)
- **1 Introduction** (p. 21)
- **2 Flow Equalization** (p. 21)
- **2.1 Flow Equalization Basin Calculations** (p. 23)
- **2.2 Mixing and Aeration Requirements** (p. 25)
- **2.3 Mixer Unit** (p. 26)
- **3 Neutralization** (p. 28)
- **3.1 pH** (p. 28)
- **3.2 Acidity and Alkalinity** (p. 29)
- **3.3 Buffer Capacity** (p. 30)
- **3.4 Hardness** (p. 31)
- **4 Neutralization Practices** (p. 32)
- **4.1 Neutralization of Acidity** (p. 32)
- **4.2 Neutralization of Alkalinity** (p. 33)
- **4.3 Common Neutralization Treatments** (p. 34)
- **5 pH Neutralization Practices** (p. 36)
- **5.1 Passive Neutralization** (p. 36)
- **5.2 In-Plant Neutralization** (p. 36)
- **5.3 Influent pH Neutralization** (p. 36)
- **5.4 In-Process Neutralization** (p. 37)

- **5.5 Effluent Neutralization** (p. 38)
- **5.6 Chemicals for Neutralization** (p. 38)
- **5.7 Encapsulated Phosphate Buffers for In Situ Bioremediation** (p. 39)
- **6 Design of a Neutralization System** (p. 39)
- **7 Design Examples** (p. 40)
- **Nomenclature** (p. 43)
- **References** (p. 44)
- **3 Mixing** (p. 47)
 - **1 Introduction** (p. 47)
 - **2 Basic Concepts** (p. 48)
 - **2.1 Criteria for Mixing** (p. 50)
 - **2.2 Mixing Efficiency** (p. 52)
 - **2.3 Fluid Shear** (p. 54)
 - **3 Mixing Processes and Equipment** (p. 55)
 - **3.1 Mixing in Turbulent Fields** (p. 55)
 - **3.2 Mechanical Mixing Equipment** (p. 58)
 - **3.3 Impeller Discharge** (p. 69)
 - **3.4 Motionless Mixers** (p. 71)
 - **3.5 Mixing in Batch and Continuous Flow Systems** (p. 73)
 - **3.6 Suspension of Solids** (p. 77)
 - **3.7 Static Mixer** (p. 84)
- **4 Design of Facilities** (p. 86)
 - **4.1 Pipes, Ducts, and Channels** (p. 86)
 - **4.2 Self-Induced and Baffled Basins** (p. 89)
 - **4.3 Mechanically Mixed Systems** (p. 90)
 - **Nomenclature** (p. 99)
 - **References** (p. 100)
- **4 Coagulation and Flocculation** (p. 103)
 - **1 Introduction** (p. 103)
 - **2 Applications of Coagulation** (p. 104)
 - **2.1 Water Treatment** (p. 104)
 - **2.2 Municipal Wastewater Treatment** (p. 104)
 - **2.3 Industrial Waste Treatment** (p. 104)
 - **2.4 Combined Sewer Overflow** (p. 104)
 - **2.5 Factors to be Considered in Process Selection** (p. 105)
 - **3 Properties of Colloidal Systems** (p. 105)
 - **3.1 Electrokinetic Properties** (p. 105)
 - **3.2 Hydration** (p. 106)
 - **3.3 Brownian Movement** (p. 106)
 - **3.4 Tyndall Effect** (p. 106)
 - **3.5 Filterability** (p. 107)
 - **4 Colloidal Structure and Stability** (p. 107)
 - **5 Destabilization of Colloids** (p. 109)
 - **5.1 Double-Layer Compression** (p. 110)
 - **5.2 Adsorption and Charge Neutralization** (p. 110)
 - **5.3 Entrapment of Particles in Precipitate** (p. 111)

- **5.4 Adsorption and Bridging between Particles** (p. 111)
- **6 Influencing Factors** (p. 112)
 - **6.1 Colloid Concentration** (p. 112)
 - **6.2 Coagulant Dosage** (p. 112)
 - **6.3 Zeta Potential** (p. 112)
 - **6.4 Affinity of Colloids for Water** (p. 113)
 - **6.5 pH Value** (p. 113)
 - **6.6 Anions in Solution** (p. 114)
 - **6.7. Cations in Solution** (p. 114)
 - **6.8. Temperature** (p. 114)
- **7 Coagulants** (p. 114)
 - **7.1 Aluminum Salts** (p. 115)
 - **7.2 Iron Salts** (p. 116)
 - **7.3 Sodium Aluminate** (p. 116)
 - **7.4 Polymeric Inorganic Salts** (p. 117)
 - **7.5 Organic Polymers** (p. 117)
 - **7.6 Coagulation Aids** (p. 118)
- **8 Coagulation Control** (p. 118)
 - **8.1 Jar Test** (p. 119)
 - **8.2 Zetameter** (p. 120)
 - **8.3 Streaming Current Detector** (p. 121)
- **9 Chemical Feeding** (p. 121)
- **10 Mixing** (p. 122)
- **11 Rapid Mix** (p. 124)
- **12 Flocculation** (p. 125)
- **13 Design Examples** (p. 127)
- **Nomenclature** (p. 137)
- **References** (p. 138)
- **5 Chemical Precipitation** (p. 141)
 - **1 Introduction** (p. 141)
 - **2 Process Description** (p. 142)
 - **3 Process Types** (p. 142)
 - **3.1 Hydroxide Precipitation** (p. 142)
 - **3.2 Sulfide Precipitation** (p. 144)
 - **3.3 Cyanide Precipitation** (p. 145)
 - **3.4 Carbonate Precipitation** (p. 145)
 - **3.5 Coprecipitation** (p. 146)
 - **3.6 Technology Status** (p. 146)
- **4 Chemical Precipitation Principles** (p. 146)
 - **4.1 Reaction Equilibria** (p. 146)
 - **4.2 Solubility Equilibria** (p. 147)
 - **4.3 Ionic Strength and Activity** (p. 148)
 - **4.4 Ionic Strength Example** (p. 149)
 - **4.5 Common Ion Effect** (p. 150)
 - **4.6 Common Ion Effect Example** (p. 150)
 - **4.7 Soluble Complex Formation** (p. 151)

- **4.8 pH Effect** (p. 152)
- **4.9 Solubility Diagrams** (p. 152)
- **5 Chemical Precipitation Kinetics** (p. 152)
- **5.1 Nucleation** (p. 153)
- **5.2 Crystal Growth** (p. 153)
- **5.3 Aging** (p. 154)
- **5.4 Adsorption and Coprecipitation** (p. 154)
- **6 Design Considerations** (p. 155)
- **6.1 General** (p. 155)
- **6.2 Chemical Handling** (p. 155)
- **6.3 Mixing, Flocculation, and Contact Equipment** (p. 156)
- **6.4 Solids Separation** (p. 157)
- **6.5 Design Criteria Summary** (p. 157)
- **7 Process Applications** (p. 158)
- **7.1 Hydroxide Precipitation** (p. 158)
- **7.2 Carbonate Precipitation** (p. 159)
- **7.3 Sulfide Precipitation** (p. 160)
- **7.4 Cyanide Precipitation** (p. 161)
- **7.5 Magnesium Oxide Precipitation** (p. 162)
- **7.6 Chemical Oxidation-Reduction Precipitation** (p. 162)
- **7.7 Lime/Soda-Ash Softening** (p. 162)
- **7.8 Phosphorus Precipitation** (p. 162)
- **7.9 Other Chemical Precipitation Processes** (p. 163)
- **8 Process Evaluation** (p. 163)
- **8.1 Advantages and Limitations** (p. 163)
- **8.2 Reliability** (p. 164)
- **8.3 Chemicals Required** (p. 165)
- **8.4 Residuals Generated** (p. 165)
- **8.5 Process Performance** (p. 165)
- **9 Application Examples** (p. 165)
- **Nomenclature** (p. 169)
- **References** (p. 170)
- **Appendices** (p. 174)
- **6 Recarbonation and Softening** (p. 199)
- **1 Introduction** (p. 199)
- **2 Process Description** (p. 199)
- **3 Softening and Recarbonation Process Chemistry** (p. 201)
- **4 Lime/Soda Ash Softening Process** (p. 203)
- **5 Water Stabilization** (p. 205)
- **6 Other Related Process Applications** (p. 206)
- **6.1 Chemical Coagulation Using Magnesium Carbonate as a Coagulant** (p. 206)
- **6.2 Recovery of Magnesium as Magnesium Carbonate** (p. 207)
- **6.3 Recovery of Calcium Carbonate as Lime** (p. 207)
- **6.4 Recarbonation of Chemically Treated Wastewaters** (p. 208)
- **7 Process Design** (p. 208)

- **7.1 Sources of Carbon Dioxide** (p. 208)
- **7.2 Distribution Systems** (p. 210)
- **7.3 Carbon Dioxide Quantities** (p. 212)
- **7.4 Step-by-Step Design Approach** (p. 212)
- **8 Design and Application Examples** (p. 215)
- **Nomenclature** (p. 226)
- **Acknowledgments** (p. 227)
- **References** (p. 227)
- **7 Chemical Oxidation** (p. 229)
- **1 Introduction** (p. 229)
- **1.1 Dissolved Oxygen and Concept of Oxidation** (p. 230)
- **1.2 The Definition of Oxidation State** (p. 231)
- **2 Theory and Principles** (p. 233)
- **2.1 Stoichiometry of Oxidation-Reduction Processes** (p. 234)
- **2.2 Thermodynamics of Chemical Oxidation** (p. 236)
- **2.3 Kinetic Aspects of Chemical Oxidation** (p. 240)
- **3 Oxygenated Reagent Systems** (p. 243)
- **3.1 Aeration in Water Purification and Waste Treatment** (p. 243)
- **3.2 Hydrogen Peroxide and Peroxygen Reagents** (p. 246)
- **3.3 High-Temperature Wet Oxidation** (p. 248)
- **4 Transition-Metal Ion Oxidation Systems** (p. 256)
- **4.1 Chromic Acid Oxidation** (p. 256)
- **4.2 Permanganate Oxidation** (p. 258)
- **5 Recent Developments in Chemical Oxidation** (p. 261)
- **5.1 Ozone (O₃) Processes** (p. 261)
- **5.2 Ultraviolet (UV) Processes** (p. 262)
- **5.3 Wet Oxidation** (p. 263)
- **5.4 Supercritical Water Oxidation** (p. 264)
- **5.5 Biological Oxidation** (p. 264)
- **6 Examples** (p. 264)
- **Nomenclature** (p. 268)
- **References** (p. 269)
- **8 Halogenation and Disinfection** (p. 271)
- **1 Introduction** (p. 271)
- **2 Chemistry of Halogenation** (p. 274)
- **2.1 Chlorine Hydrolysis** (p. 274)
- **2.2 Chlorine Dissociation** (p. 275)
- **2.3 Chlorine Reactions with Nitrogenous Matter** (p. 275)
- **2.4 Chlorine Reactions with Other Inorganics** (p. 279)
- **2.5 Chlorine Dioxide (ClO₂) Applications** (p. 281)
- **2.6 Chlorine Dioxide Generation** (p. 281)
- **2.7 Chlorine Dioxide Reaction with Nitrogenous Matter** (p. 282)
- **2.8 Chlorine Dioxide Reactions with Phenolic Compounds and Other Substances** (p. 283)
- **2.9 Bromine Hydrolysis** (p. 283)
- **2.10 Bromine Dissociation** (p. 283)

- **2.11 Bromine Reactions with Nitrogenous Matter** (p. 284)
- **2.12 Iodine Hydrolysis** (p. 284)
- **2.13 Iodine Dissociation** (p. 284)
- **2.14 Iodine Reactions with Nitrogenous Matter** (p. 285)
- **3 Disinfection with Halogens** (p. 285)
 - **3.1 Modes and Rate of Killing in Disinfection Process** (p. 285)
 - **3.2 Disinfection Conditions** (p. 286)
 - **3.3 Disinfection Control with Biological Tests** (p. 287)
 - **3.4 Disinfectant Concentration** (p. 288)
- **4 Chlorine and Chlorination** (p. 288)
 - **4.1 Chlorine Compounds and Elemental Chlorine** (p. 289)
 - **4.2 Chlorine Feeders** (p. 290)
 - **4.3 Chlorine Handling Equipment** (p. 291)
 - **4.4 Measurement of Chlorine Residuals** (p. 291)
 - **4.5 Chlorine Dosages** (p. 292)
 - **4.6 Chlorination By-Products** (p. 293)
- **5 Chlorine Dioxide Disinfection** (p. 294)
- **6 Bromine and Bromination** (p. 294)
- **7 Iodine and Iodination** (p. 295)
- **8 Ozone and Ozonation** (p. 295)
- **9 Cost Data** (p. 295)
- **10 Recent Developments in Halogenation Technology** (p. 296)
 - **10.1 Recent Environmental Concerns and Regulations** (p. 296)
 - **10.2 Chlorine Dioxide** (p. 297)
 - **10.3 Chloramines** (p. 298)
 - **10.4 Coagulant** (p. 298)
 - **10.5 Ozone** (p. 299)
 - **10.6 Organic Disinfectants** (p. 299)
 - **10.7 Ultraviolet (UV)** (p. 300)
- **11 Disinfection System Design** (p. 300)
 - **11.1 Design Considerations Summary** (p. 300)
 - **11.2 Wastewater Disinfection** (p. 301)
 - **11.3 Potable Water Disinfection** (p. 303)
- **12 Design and Application Examples** (p. 305)
 - **12.1 Example 1 (Wastewater Disinfection)** (p. 305)
 - **12.2 Example 2 (Potable Water Disinfection)** (p. 308)
 - **12.3 Example 3 (Glossary of Halogenation, Chlorination, Oxidation, and Disinfection)** (p. 308)
- **Nomenclature** (p. 311)
- **References** (p. 311)
- **9 Ozonation** (p. 315)
 - **1 Introduction** (p. 315)
 - **1.1 General** (p. 315)
 - **1.2 Alternative Disinfectants** (p. 316)
 - **2 Properties and Chemistry of Ozone** (p. 316)
 - **2.1 General** (p. 316)

- **2.2 Physical Properties** (p. 316)
- **2.3 Chemical Properties** (p. 317)
- **2.4 Advantages and Disadvantages** (p. 319)
- **3 Applications of Ozone** (p. 319)
 - **3.1 Disinfection Against Pathogens** (p. 319)
 - **3.2 Zebra Mussel Abatement** (p. 320)
 - **3.3 Iron and Manganese Removal** (p. 320)
 - **3.4 Color Removal** (p. 320)
 - **3.5 Control of Taste and Odor** (p. 321)
 - **3.6 Elimination of Organic Chemicals** (p. 321)
 - **3.7 Control of Algae** (p. 321)
 - **3.8 Aid in Coagulation and Destabilization of Turbidity** (p. 321)
- **4 Process and Design Considerations** (p. 321)
 - **4.1 Oxygen and Ozone** (p. 321)
 - **4.2 Disinfection of Water by Ozone** (p. 322)
 - **4.3 Disinfection of Wastewater by Ozone** (p. 324)
 - **4.4 Disinfection By-Products** (p. 333)
 - **4.5 Oxygenation by Ozone** (p. 334)
 - **4.6 Advanced Oxidation Processes** (p. 337)
- **5 Ozonation System** (p. 340)
 - **5.1 Air Preparation** (p. 341)
 - **5.2 Electrical Power Supply** (p. 344)
 - **5.3 Ozone Generation** (p. 344)
 - **5.4 Ozone Contacting** (p. 345)
 - **5.5 Destruction of Ozone Contactor Exhaust Gas** (p. 348)
 - **5.6 Monitors and Controllers** (p. 349)
- **6 Costs of Ozonation Systems** (p. 349)
 - **6.1 Equipment Costs** (p. 349)
 - **6.2 Installation Costs** (p. 352)
 - **6.3 Housing Costs** (p. 353)
 - **6.4 Operating and Maintenance Costs** (p. 353)
- **7 Safety** (p. 353)
- **Nomenclature** (p. 354)
- **References** (p. 355)
- **10 Electrolysis** (p. 359)
 - **1 Introduction** (p. 359)
 - **2 Mechanisms of Electrolysis** (p. 362)
 - **3 Organic and Suspended Solids Removal** (p. 363)
 - **3.1. Organic and Suspended Solids Removal by Regular Electrolysis** (p. 363)
 - **3.2. Organic and Suspended Solids Removal by Electrocoagulation** (p. 364)
 - **4 Disinfection** (p. 366)
 - **5 Phosphate Removal** (p. 368)
 - **6 Ammonium Removal** (p. 369)
 - **7 Cyanide Destruction** (p. 369)
 - **8 Metal Removal** (p. 370)

- **9 Remediation of Nitroaromatic Explosives-Contaminated Groundwater** (p. 372)
- **10 Electrolysis-Stimulated Biological Treatment** (p. 374)
- **10.1 Nitrogen Removal** (p. 375)
- **10.2 Electrolytic Oxygen Generation** (p. 374)
- **References** (p. 376)
- **11 Sedimentation** (p. 379)
- **1 Introduction** (p. 379)
- **1.1 Historical** (p. 379)
- **1.2 Definition and Objective of Sedimentation** (p. 380)
- **1.3 Significance of Sedimentation in Water and Wastewater Treatment** (p. 380)
- **2 Types of Clarification** (p. 380)
- **3 Theory of Sedimentation** (p. 381)
- **3.1 Class 1 Clarification** (p. 382)
- **3.2 Class 2 Clarification** (p. 386)
- **3.3 Zone Settling** (p. 387)
- **3.4 Compression Settling** (p. 390)
- **4 Sedimentation Tanks in Water Treatment** (p. 390)
- **4.1 General Consideration** (p. 390)
- **4.2 Inlet and Outlet Control** (p. 391)
- **4.3 Tank Geometry** (p. 392)
- **4.4 Short Circuiting** (p. 392)
- **4.5 Detention Time** (p. 392)
- **4.6 Tank Design** (p. 393)
- **5 Sedimentation Tanks in Wastewater Treatment** (p. 394)
- **5.1 General Consideration and Basis of Design** (p. 394)
- **5.2 Regulatory Standards** (p. 395)
- **5.3 Tank Types** (p. 395)
- **6 Grit Chamber** (p. 398)
- **6.1 General** (p. 398)
- **6.2 Types of Grit Chambers** (p. 399)
- **6.3 Velocity Control Devices** (p. 400)
- **6.4 Design of Grit Chamber** (p. 402)
- **7 Gravity Thickening in Sludge Treatment** (p. 403)
- **7.1 Design of Sludge Thickeners** (p. 405)
- **8 Recent Developments** (p. 406)
- **8.1 Theory of Shallow Depth Settling** (p. 407)
- **8.2 Tube Settlers** (p. 409)
- **8.3 Lamella Separator** (p. 410)
- **8.4 Other Improvements** (p. 411)
- **9 Sedimentation in Air Streams** (p. 412)
- **9.1 General** (p. 412)
- **9.2 Gravity Settlers** (p. 413)
- **10 Costs** (p. 414)
- **10.1 General** (p. 414)

- **10.2 Sedimentation Tanks** (p. 414)
- **10.3 Gravity Thickeners** (p. 416)
- **10.4 Tube Settlers** (p. 416)
- **11 Design Examples** (p. 418)
- **Nomenclature** (p. 426)
- **References** (p. 427)
- **Appendix: US Yearly Average Cost Index for Utilities** (p. 429)
- **12 Dissolved Air Flotation** (p. 431)
 - **1 Introduction** (p. 431)
 - **1.1 Adsorptive Bubble Separation Processes** (p. 431)
 - **1.2 Content and Objectives** (p. 434)
 - **2 Historical Development of Clarification Processes** (p. 435)
 - **2.1 Conventional Sedimentation Clarifiers** (p. 435)
 - **2.2 Innovative Flotation Clarifiers** (p. 437)
 - **3 Dissolved Air Flotation Process** (p. 440)
 - **3.1 Process Description** (p. 440)
 - **3.2 Process Configurations** (p. 441)
 - **3.3 Factors Affecting Dissolved Air Flotation** (p. 443)
 - **4 Dissolved Air Flotation Theory** (p. 444)
 - **4.1 Gas-to-Solids Ratio of Full Flow Pressurization System** (p. 444)
 - **4.2 Gas-to-Solids Ratio of Partial Flow Pressurization System** (p. 446)
 - **4.3 Gas-to-Solids Ratio of Recycle Flow Pressurization** (p. 447)
 - **4.4 Air Solubility in Water at 1 Atm** (p. 448)
 - **4.5 Pressure Calculations** (p. 449)
 - **4.6 Hydraulic Loading Rate** (p. 449)
 - **4.7 Solids Loading Rate** (p. 451)
 - **5 Design, Operation, and Performance** (p. 453)
 - **5.1 Operational Parameters** (p. 455)
 - **5.2 Performance and Reliability** (p. 455)
 - **6 Chemical Treatment** (p. 455)
 - **7 Sampling, Tests, and Monitoring** (p. 457)
 - **7.1 Sampling** (p. 457)
 - **7.2 Laboratory and Field Tests** (p. 457)
 - **8 Procedures and Apparatus for Chemical Coagulation Experiments** (p. 457)
 - **9 Procedures and Apparatus for Laboratory Dissolved Air Flotation Experiments** (p. 459)
 - **9.1 Full Flow Pressurization System** (p. 459)
 - **9.2 Partial Flow Pressurization System** (p. 460)
 - **9.3 Recycle Flow Pressurization System** (p. 461)
 - **10 Normal Operating Procedures** (p. 462)
 - **10.1 Physical Control** (p. 462)
 - **10.2 Startup** (p. 463)
 - **10.3 Routine Operations** (p. 464)
 - **10.4 Shutdown** (p. 464)
 - **11 Emergency Operating Procedures** (p. 464)

- **11.1 Loss of Power** (p. 464)
- **11.2 Loss of Other Treatment Units** (p. 465)
- **12 Operation and Maintenance** (p. 465)
- **12.1 Troubleshooting** (p. 465)
- **12.2 Labor Requirements** (p. 465)
- **12.3 Construction and O&M Costs** (p. 465)
- **12.4 Energy Consumption** (p. 465)
- **12.5 Maintenance Considerations** (p. 466)
- **12.6 Environmental Impact and Safety Considerations** (p. 468)
- **13 Recent Developments in Dissolved Air Flotation Technology** (p. 468)
- **13.1 General Recent Developments** (p. 468)
- **13.2 Physicochemical SBR-DAF Process for Industrial and Municipal Applications** (p. 470)
- **13.3 Adsorption Flotation Processes** (p. 471)
- **13.4 Dissolved Gas Flotation** (p. 471)
- **13.5 Combined Sedimentation and Flotation** (p. 472)
- **14 Application and Design Examples** (p. 472)
- **Nomenclature** (p. 491)
- **Acknowledgments** (p. 492)
- **References** (p. 493)
- **13 Gravity Filtration** (p. 501)
- **1 Introduction** (p. 501)
- **2 Physical Nature of Gravity Filtration** (p. 502)
- **2.1 Transport Mechanism** (p. 502)
- **2.2 Attachment Mechanisms** (p. 504)
- **2.3 Detachment Mechanisms** (p. 504)
- **3 Mathematical Models** (p. 504)
- **3.1 Idealized Models** (p. 505)
- **3.2 Empirical Models** (p. 509)
- **4 Design Considerations of Gravity Filters** (p. 510)
- **4.1 Water Variables** (p. 510)
- **4.2 Filter Physical Variables** (p. 511)
- **4.3 Filter Operating Variables** (p. 517)
- **5 Applications** (p. 522)
- **5.1 Potable Water Filtration** (p. 522)
- **5.2 Reclamation of Wastewater** (p. 522)
- **6 Design Examples** (p. 527)
- **Nomenclature** (p. 539)
- **References** (p. 540)
- **14 Polymeric Adsorption and Regenerant Distillation** (p. 545)
- **1 Introduction** (p. 545)
- **2 Polymeric Adsorption Process Description** (p. 547)
- **2.1 Process System** (p. 547)
- **2.2 Process Steps** (p. 547)
- **2.3 Regeneration Issues** (p. 547)
- **3 Polymeric Adsorption Applications and Evaluation** (p. 548)

- **3.1 Applications** (p. 548)
- **3.2 Process Evaluation** (p. 550)
- **4 Polymeric Adsorbents** (p. 550)
- **4.1 Chemical Structure** (p. 550)
- **4.2 Physical Properties** (p. 552)
- **4.3 Adsorption Properties** (p. 552)
- **5 Design Considerations** (p. 552)
- **5.1 Adsorption Bed, Adsorbents, and Regenerants** (p. 552)
- **5.2 Generated Residuals** (p. 555)
- **6 Distillation** (p. 557)
- **6.1 Distillation Process Description** (p. 557)
- **6.2 Distillation Types and Modifications** (p. 557)
- **6.3 Distillation Process Evaluation** (p. 560)
- **7 Design and Application Examples** (p. 560)
- **Acknowledgments** (p. 570)
- **References** (p. 571)
- **15 Granular Activated Carbon Adsorption** (p. 573)
- **1 Introduction** (p. 573)
- **2 Process Flow Diagrams for GAC Process** (p. 576)
- **3 Adsorption Column Models** (p. 577)
- **4 Design of Granular Activated Carbon Columns** (p. 585)
- **4.1 Design of GAC Columns** (p. 585)
- **4.2 Pilot Plant and Laboratory Column Tests** (p. 590)
- **5 Regeneration** (p. 591)
- **6 Factors Affecting GAC Adsorption** (p. 592)
- **6.1 Adsorbent Characteristics** (p. 592)
- **6.2 Adsorbate Characteristics** (p. 592)
- **7 Performance and Case Studies** (p. 593)
- **8 Economics of Granular Activated Carbon System** (p. 595)
- **9 Design Examples** (p. 602)
- **10 Historical and Recent Developments in Granular Activated Carbon Adsorption** (p. 623)
- **10.1 Adsorption Technology Milestones** (p. 623)
- **10.2 Downflow Conventional Biological GAC Systems** (p. 625)
- **10.3 Upflow Fluidized Bed Biological GAC System** (p. 627)
- **Nomenclature** (p. 628)
- **References** (p. 630)
- **16 Physicochemical Treatment Processes for Water Reuse** (p. 635)
- **1 Introduction** (p. 635)
- **2 Conventional Physicochemical Treatment Processes** (p. 636)
- **2.1 Principle** (p. 636)
- **2.2 Application of the Physicochemical Processes in Wastewater Treatment and Reuse** (p. 651)
- **3 Membrane Processes** (p. 658)
- **3.1 Principle** (p. 658)
- **3.2 Application of Membrane Processes** (p. 661)

- **References** (p. 675)
- **17 Introduction to Sludge Treatment** (p. 677)
- **1 The Origin of Sludge** (p. 677)
- **2 Conditioning Processes** (p. 678)
 - **2.1 Coagulation** (p. 678)
 - **2.2 Flocculation** (p. 681)
 - **2.3 Conditioner Choice** (p. 681)
 - **2.4 Optimal Dose** (p. 682)
- **3 Dewatering Processes** (p. 684)
 - **3.1 Dewatering Processes** (p. 684)
 - **3.2 Sludge Thickening** (p. 685)
 - **3.3 Sludge Dewatering** (p. 687)
- **4 Stabilization Processes** (p. 691)
 - **4.1 Hydrolysis Processes** (p. 691)
 - **4.2 Digestion Processes** (p. 695)
- **5 Thermal Processes** (p. 699)
 - **5.1 Sludge Incineration** (p. 699)
 - **5.2 Sludge Drying** (p. 701)
 - **5.3 Other Thermal Processes** (p. 702)
- **References** (p. 703)
- **Index** (p. 705)