

# Table of contents

|  |            |
|--|------------|
| <b>PREFACE</b>   | <b>I</b>   |
| <b>EDITORS</b>   | <b>III</b> |
| <b>CONTRIBUTORS</b>  | <b>V</b>   |
| <b>1 INTRODUCTION</b>  | <b>1</b>   |
| <b>2 BASIC ELEMENTS OF GROUNDWATER<br/>MANAGEMENT IN LARGE RIVER BASINS</b>        | <b>6</b>   |
| 2.1 Definitions and scope of this chapter  | 6          |
| 2.2 Status of groundwater as a natural resource                                    | 9          |
| 2.3 Climate change and its potential impact on<br>groundwater management           | 28         |
| 2.4 Economic and social environment for<br>groundwater management                  | 31         |
| 2.5 Groundwater legislation  | 36         |
| 2.6 Basic functions of groundwater management                                      | 43         |
| 2.7 Basic groundwater management activities  | 47         |
| 2.8 Implementation   | 71         |
| 2.9 Groundwater management in the large river basins                               | 77         |
| 2.10 Groundwater management in selected countries                                  | 87         |
| 2.11 Local groundwater management  | 109        |
| 2.12 Concluding remarks  | 117        |
| <b>3 THE SELF-PURIFYING POTENTIAL<br/>OF AN AQUIFER</b>                            | <b>129</b> |
| 3.1 Definition of the self-purifying potential of an aquifer                       | 129        |
| 3.2 An aquifer in clastic sediments, as a medium<br>for purification processes     | 136        |
| 3.3 Hydrodynamic dispersion  | 150        |
| 3.4 Relevance of soil particle sorption to purification<br>processes in an aquifer | 153        |

|          |  |            |
|----------|--|------------|
| 3.5      | Biochemical processes  | 170        |
| 3.6      | The effect of layering on the definition of aquifer dispersivity   | 188        |
| 3.7      | “In situ” investigations to define the degradation of phenols in groundwater   | 194        |
| 3.8      | Revitalization of an artificially-recharged groundwater source: “Mediana” in the city of Niš   | 202        |
| <b>4</b> | <b>PROBLEMS OF GROUNDWATER SOURCE MANAGEMENT AND MAINTENANCE</b>   | <b>216</b> |
| 4.1      | Introduction   | 216        |
| 4.2      | The origin of groundwater  | 218        |
| 4.3      | Quality of groundwater resources   | 247        |
| 4.4      | Utilization of self-purification potential in the definition of production lines and protection zones of intergranular-aquifer groundwater sources | 286        |
| 4.5      | Benefits of riverbank filtration and artificial groundwater recharge: The German experience  | 310        |
| 4.6      | Characteristics of natural attenuation processes for organic micropollutant removal during riverbank filtration                                    | 332        |
| 4.7      | Well-ageing indicators, with special reference to Belgrade groundwater source  | 353        |
| 4.8      | Groundwater and nitrogen   | 388        |
| 4.9      | Examples of groundwater management in Austria  | 431        |
| <b>5</b> | <b>MATHEMATICAL MODELING, A TOOL FOR GROUNDWATER REGIME MANAGEMENT</b>   | <b>457</b> |
| 5.1      | Introduction   | 457        |
| 5.2      | Groundwater modeling and types of groundwater models   | 459        |
| 5.3      | Circumstances which affect the formulation of a mathematical model   | 465        |
| 5.4      | Model scale  | 472        |
| 5.5      | Model calibration  | 476        |
| 5.6      | Model and investigations   | 478        |
| 5.7      | Hydrodynamic problems of a groundwater source  | 480        |
| 5.8      | Regional models of deep aquifers   | 483        |
| 5.9      | Regional and local models (case study of Belgrade groundwater source)  | 492        |

|          |  |            |
|----------|--|------------|
| 5.10     | Management tools for a sustainable resource: groundwater models of the Mississippi River valley alluvial aquifer | 498        |
| 5.11     | Pseudo 2d model for groundwater regime monitoring and management in riparian lands of the Danube River           | 504<br>506 |
| 5.12     | Karst models   |            |
| <b>6</b> | <b>LARGE URBAN GROUNDWATER BASINS: WATER QUALITY THREATS AND AQUIFER RESTORATION</b>                             | <b>520</b> |
| 6.1      | Introduction   | 520        |
| 6.2      | Background and problem statement   | 523        |
| 6.3      | Groundwater contamination  | 528        |
| 6.4      | Regulatory and liability drivers for restoration   | 540        |
| 6.5      | Conceptual model of groundwater restoration  | 546        |
| 6.6      | Technical options for groundwater restoration  | 555        |
| 6.7      | Technical limitations of groundwater restoration   | 580        |
| 6.8      | Implications for groundwater basin management  | 600        |
| <b>7</b> | <b>APPENDIX: SELECTED INFORMATION AND STUDIES WHICH WOULD BE USEFUL TO A GROUNDWATER ENGINEER</b>                | <b>614</b> |
| 7.1      | The Planet Earth and its crust   | 614        |
| 7.2      | Determination of hydraulic conductivity using grain-size distribution data                                       | 622        |
| 7.3      | Selected physico-chemical properties of groundwater  | 630        |
| 7.4      | Monitoring of groundwater  | 633        |
| 7.5      | Overview on organic contaminants in groundwater resources  | 638        |
| 7.6      | Remarks on some solutions of the one-dimensional dispersion equation   | 690        |
|          | <b>FINAL REMARKS</b>   | <b>705</b> |