
Contents

Introduction	xi
Authors	xiii

Part I Limnology and Ecology of Inland Waters

1. Overview of Inland Aquatic Ecosystems and Their General Characteristics	3
1.1 Introduction: A Short Overview	3
1.1.1 General Features of the Aquatic Inland Ecosystems	5
1.2 Reservoirs in Brazil: An Example of Large-Scale Construction of Artificial Aquatic Systems	8
1.2.1 Inland Waters as Water Resources	9
References	10
2. Lakes and Reservoirs as Ecosystems	11
2.1 Lakes and Reservoirs Have Many Interactive Factors	11
2.2 Pulse Effects in Lakes and Reservoirs	16
2.3 Vertical and Longitudinal (or Horizontal) Processes in Reservoirs and Their Complexity	17
2.4 Differences between Lakes and Reservoirs	21
2.5 External Nutrient Loading and Nutrient Dynamics	22
2.6 Succession in Lakes and Reservoirs	23
2.7 Lake and Reservoir Sedimentation	24
2.8 Shallow Lakes	26
2.9 Future Research Needs for Lakes and Reservoirs as Tools for Advanced Management of These Ecosystems	27
2.10 Eutrophication Problem	28
2.11 Growth of Phytoplankton	30
2.12 Solutions to the Eutrophication Problem	36
2.13 Reservoirs and Lakes as Complex Systems and They Require an Integrated Management Plan	38
References	40
3. Physical Processes and Circulation in Lakes and Reservoirs	43
3.1 Introduction	43
3.2 Physical Processes	43
3.3 Potential Energy and the Turbulent Kinetic Energy	51
3.4 Transport Process in Lake and Reservoir	52

3.5	Stratification and the Circulation of Lakes and Reservoirs and the Ecological Processes	53
3.6	Classification of Lakes	55
3.7	Reservoirs	55
3.8	Lake Morphometry and Lake Forms	55
	References	58
4.	Rivers as Ecosystems	61
4.1	Physical Characteristics: Horizontal Gradients	61
4.2	Biogeochemical Cycles	62
4.3	Aquatic Biota of Rivers	66
4.4	Energy Flux and Food Chains	68
4.5	Large Rivers	68
4.6	River Fisheries	73
4.7	Small Creeks and Streams	75
4.8	Ecological, Economical, and Social Importance of the Rivers: The Hydrosocial Cycle	75
4.9	Human Impacts on River Ecosystems	76
	References	77
5.	Estuaries and Coastal Lagoons as Ecosystems	83
5.1	Introduction	83
5.2	Classification and Zonation of Estuaries	84
5.3	Environmental Factors	86
5.3.1	Tides	86
5.3.2	Waves	86
5.3.3	Currents	86
5.3.4	Temperature	86
5.3.5	Salinity	86
5.3.6	Oxygen, Carbon Dioxide, pH, and Biogeochemical Cycles	87
5.4	Aquatic Biota of the Estuaries	89
5.5	Freshwater Inflow into Estuaries	92
5.6	Primary Production in Estuaries and Coastal Lagoons	92
5.7	Anthropogenic Impacts on Estuaries	94
	References	95
6.	Wetlands	97
6.1	Introduction: The Importance of Wetlands	97
6.2	Ecosystem Services by Wetlands	97
6.3	Types of Wetlands and Wetland Processes	98
6.4	Constructed Wetlands	100
6.5	Natural Wetlands	105
	References	107

7. Tropical Freshwater Ecosystems	109
7.1 Tropical Lakes and Floodplains of the South American Continent	109
7.1.1 Large Floodplains of the South American Continent	109
7.1.2 Biodiversity in the Amazon Region and Its Floodplains	118
7.1.3 Fish Fauna of the Amazon Region and the Floodplains	121
7.1.4 Biogeochemical Cycles	122
7.1.5 Impact of Human Activities on Neotropical Floodplains at the Amazon Basin	124
7.1.6 High Paraná River Floodplain	124
7.1.7 Biodiversity in the Paraná Floodplain	126
7.1.8 Human Impacts on the Floodplain of the High Paraná River	128
7.1.9 Colonization Patterns of the Reservoirs in the High Paraná River	130
7.1.10 Prognosis for Environmental Impact Assessment of New Reservoirs	133
7.1.11 Pantanal Wetlands	134
7.1.12 Tropical Freshwater Ecosystems of South America and Their Ecological, Economical, and Social Significance	136
7.2 Continental Waters of Tropical Africa	138
7.3 Floodplains and Wetlands in Asia	144
7.4 Tropical Freshwater Environments	145
References	147
8. Freshwater Temperate Lakes and Reservoirs	159
8.1 Introduction	159
8.2 English Lake District	160
8.3 Laurentian Great Lakes in North America	162
8.4 Japanese Lakes	164
8.5 Reservoirs in Temperate Regions	167
References	168
9. Application of the Conservation Principles	173
9.1 Mass Conservation: An Important Basic Principle	173
9.2 Threshold Levels	177
9.3 Steady State and Equilibrium	178
9.4 Basic Concepts of Mass Balances	180
9.5 Mass Conservations in a Food Chain	184
9.6 Hydrological Cycle	188
References	191

10. Application of Aquatic Chemistry in Environmental Management I: Calculations of Equilibria.....	193
10.1 Equilibrium Constant.....	193
10.2 Activities and Activity Coefficients.....	196
10.3 Mixed Equilibrium Constant	197
10.4 Classification of Chemical Processes and Their Equilibrium Constants.....	198
10.5 Many Simultaneous Reactions.....	203
10.6 Henry's Law	204
10.7 Adsorption	206
10.8 Biological Concentration Factor	210
References	211
 11. Application of Aquatic Chemistry in Environmental Management II: Equilibrium Calculations of the Four Types of Reactions	 213
11.1 Double Logarithmic Diagrams Applied on Acid-Base Reactions.....	213
11.2 Molar Fraction, Alkalinity, and Buffer Capacity	217
11.3 Dissolved Carbon Dioxide.....	220
11.4 Precipitation and Dissolution: Solubility of Hydroxides	224
11.5 Solubility of Carbonates in Open Systems	227
11.6 Solubility of Complexes.....	227
11.7 Stability of the Solid Phase	229
11.8 Complex Formation	230
11.9 Environmental Importance of Complex Formation.....	232
11.10 Conditional Constant	232
11.11 Application of Double Logarithmic Diagrams to Determine the Conditional Constants for Complex Formation.....	237
11.12 Redox Equilibria: Electron Activity and Nernst's Law	239
11.13 p_e as Master Variable.....	242
11.14 Examples of Relevant Processes in the Aquatic Environment	243
11.15 Redox Conditions in Natural Waters	245
11.16 Construction of p_e -pH Diagrams	247
11.17 Redox Potential and Complex Formation.....	250
References	253
 12. Future of Limnology and Aquatic Ecology as a Tool for Management of Inland Waters.....	 255
12.1 Our Demand to Limnology and Aquatic Ecology	255
References	256

Part II Holistic, Environmental and Ecological Management

13. Impacts on Watersheds and Inland Aquatic Ecosystems	261
13.1 Environmental Problems, Their Sources, and Evaluation of Impacts	261
13.2 Impacts	262
13.3 Impacts of Climatic Change on Aquatic Ecosystems	266
References	267
14. Integrated Ecological and Environmental Management	269
14.1 Introduction	269
14.2 Ecological and Environmental Management Procedure	270
14.3 Tool Boxes Available Today to Develop an Ecological-Environmental Diagnosis	273
14.4 Tool Boxes Available Today to Solve the Environmental Problems.....	276
14.5 Follow the Recovery Process	279
14.6 Implementation of the Presented Ecological and Environmental Management Procedure in Practice on Inland Water Ecosystems	279
14.7 Conclusions about Integrated Environmental and Ecological Management of Inland Water Ecosystems.....	283
References	283
15. Application of Environmental Technology in the Environmental and Ecological Management	285
15.1 Introduction	285
15.2 Wastewater Treatment: An Overview.....	286
15.3 Municipal Wastewater.....	291
15.4 Combinations of Methods for the Treatment of Municipal Wastewater (Reduction of BOD ₅).....	292
15.5 Methods for the Treatment of Municipal Wastewater (Reduction of Phosphorus Concentration)	297
15.6 Methods for the Treatment of Municipal Wastewater (Reduction of Nitrogen Concentration)	300
15.6.1 Recycling of Municipal Wastewater.....	305
References	305
16. Application of Cleaner Technology in Environmental and Ecological Management	307
16.1 Introduction	307
16.2 Application of Life Cycle Analyses and Cleaner Technology.....	309
16.3 Recycling and Reuse: Green Tax.....	310
References	318

17. Application of Ecotechnology in Ecosystem Management of Inland Waters.....	319
17.1 Ecotechnology: Definition and Classification.....	319
17.2 Application of Class 1 and Class 2 Methods in Ecotechnology.....	322
17.3 Ecotechnology: Restoration Methods	328
17.3.1 Selection of Restoration Methods.....	335
17.4 Selection of the Most Appropriate Methods or Combination of Methods in Environmental and Ecological Management: A Conclusion of Chapters 14 through 17.....	337
17.5 Example to Illustrate the Selection of Pollution Abatement Methods.....	338
17.6 Conclusions.....	339
References	339
18. Application of Ecological Indicators in Environmental Management of Freshwater Ecosystems	341
18.1 Introduction	341
18.2 Tools to Synthesize and Overview: Models and Indicators	342
18.3 Ecological Indicators: Application and Classification	343
18.4 Energy and Exergy	346
18.5 Selection of Ecological Indicator	350
18.6 Case Study.....	352
References	355
19. Application of Ecological Models in Management of Aquatic Inland Ecosystems.....	357
19.1 Models as Tools in Ecological Management	357
19.2 Institutionalized or Mediated Modeling.....	358
19.3 Model Selection	360
19.4 Models as a Strong Management Tool: Problems and Possibilities.....	363
19.5 Eutrophication Models	377
19.6 Toxic Substance Models	385
19.7 Acidification Models.....	388
19.8 Wetland Models	389
19.9 Fisheries Models.....	390
19.10 Structurally Dynamic Models.....	391
References	405
Index.....	411