

Contents

1	Introduction	1
2	Terrestrial Environment of Pit Lakes	11
2.1	Morphology, Age, and Development of Pit Lakes	11
2.2	Influence of Groundwater on Pit Lakes	17
3	Limnology of Pit Lakes	23
3.1	Physical Properties of Acidic Pit Lakes	23
3.1.1	Electrical Conductivity	23
3.1.2	Density	26
3.1.3	Optical Properties of Lake Water	29
3.1.4	Stratification and Circulation	32
3.1.5	Waves and Currents in Mining Lakes	37
3.1.6	Mixing and Vertical Transport	40
3.1.7	Concluding Remarks	42
3.2	Limnochemistry of Water and Sediments of Acidic Pit Lakes	42
3.2.1	Pit Lakes from Coal and Lignite Mining	42
3.2.1.1	Water, Sediment, and Pore Water	42
3.2.1.2	The Role of Iron Minerals in the Biogeochemistry of Acidic Pit Lakes	57
3.2.1.3	Phosphorus in Acidic Mining Lakes: Importance and Biogeochemical Cycling	62
3.2.2	Hardrock Metal Mine Pit Lakes: Occurrence and Geochemical Characteristics	75
3.3	The Biology and Ecosystems of Acidic Pit Lakes	107
3.3.1	Plankton	107
3.3.1.1	Phytoplankton	107
3.3.1.2	Zooplankton	117
3.3.1.3	Prokaryotic Micro-organisms and Fungi	126
3.3.1.4	Trophic Interactions and Flow of Energy	135

3.3.2	Littoral, Benthic and Sediment Zone	149
3.3.2.1	Macrophytes and Neophyte Invasions	149
3.3.2.2	Zygnematalean Green Algae (Streptophyta, Zygnematales) in Lakes Impacted by Acidic Precipitation, Experimental Acidification and Acid Mine Drainage	159
3.3.2.3	Benthic Primary Production	172
3.3.2.4	Benthic and Sediment Community and Processes	176
3.4	Modeling of Pit Lakes	186
4	Remediation and Management of Acidified Pit Lakes and Outflowing Waters	225
4.1	Goals and Conditions of Remediation and Management	225
4.2	Hydrological Management and Chemical In-Lake Treatments	228
4.3	Biological In-lake Treatment	236
4.4	Treatments of In- and Out-Flows	243
4.5	Conclusions and Lessons Learned	256
4.6	Avoidance and Source Treatment	258
5	Case Studies and Regional Surveys	265
5.1	Pit Lakes in Germany: Hydrography, Water Chemistry, and Management	265
5.2	Lakes in Large Scale Open-Pits in Poland	291
5.3	Mine Pit Lakes of the Iberian Pyrite Belt: Some Basic Limnological, Hydrogeochemical, and Microbiological Considerations	315
5.4	Pit Lakes in Australia	342
5.5	The Berkeley Pit Lake, Butte, Montana	362
5.6	Mining Lake 111: A German Reference Lignite Pit Lake	376
5.7	Biological Polishing of Arsenic, Nickel, and Zinc in an Acidic Lake and Two Alkaline Pit Lakes	387
5.8	Acid Inventories and their Impact on Groundwater in the Rhineland Lignite Mining District (Germany)	408
5.9	The Economics of Mine Pit Restoration: The Case of Pit Lakes in Lusatia, Germany	421
6	Lessons Learned, Open Questions, and Concluding Remarks	437
6.1	Physical Limnology	437
6.2	Geo-Environmental and Hydrochemistry	438
6.3	Predictive Modeling of Lakes	439
6.4	Biology and Ecology of Acidic Pit Lakes	440
6.5	Treatment Methods to Remediate Acidic Pit Lakes	445
6.6	Economical Assessments: The Value of Pit Lakes	448

References	451
Index	513
General Terms	513
Mines, Lakes and Streams	522
Organisms and Taxa	523