
Much of our knowledge of the effects of acidification on lakes has been generated from recent studies of lakes acidified by atmospheric acid. However, there are two other lesser-studied classes of acidic lakes—the lakes of volcanic calderas, and lakes damaged by acidic mining drainage (AMD). As the editors explain in their Introduction, the re-unification of Germany has led to a dramatic increase in understanding of AMD lakes, fostered by a desire to rehabilitate large numbers of AMD lakes in the former East Germany, particularly in the Lusatian lignite district. The many acidified lakes in the region are the unfortunate legacy of reductions in lignite mining. The acid source, and the subject of much of the material of the book, is the oxidation of pyrite (FeS₂). When mining ceased, so did pit de-watering operations. The resultant groundwater movement through the shallow, aerobic, pyrite-rich spoils neighboring the abandoned pits produced lakes with some of the most unusual water chemistries on the planet.

AMD lakes are distinguished from atmospherically acidified lakes in several ways. AMD lakes are 10–100 times more acidic, with pH levels of 2–3. They are buffered by Fe, rather than Al, redox reactions, and they often have extremely high levels of many quite toxic metals. They are also young, neonates on normal limnological time scales, and they are essentially free of higher biota at their inception. As a result there is little reason to presume that the body of limnological acid rain knowledge should be directly transferable to the AMD phenomenon. As we now have many such lakes, this book should be of interest to both limnologists and environmental educators and managers.

The book is based on material presented at an international symposium on the ‘Abatement of geogenic acidification in mining lakes’ held in 1995 at the UFZ Department of Inland Waters in Magdeburg, Germany. It does a good job integrating the recent German work (about half the chapters) with case studies and reviews of knowledge from other AMD waters around the world.

There are two introductory chapters. Geller and colleagues begin the book with a very useful new typology of classes of lakes based on modes in pH distributions linked to Fe, Al and inorganic C buffering systems. There are three modes—lakes of pH ranges of 2–4 (AMD lakes), 4–6 and > 6. They also indicate that the AMD problem is relatively large with, for example, about 100 damaged lakes in the Lusatian mining district alone. Shreck and Gläser review the geology of this mining district in the second chapter, one I suspect will interest mainly geologists.

Part 2 of the book provides five case studies of the limnology of Lusatian AMD lakes. These chapters introduce us to the water and sediment chemistry (Chapter 3), sulphate reduction processes (Chapter 4), novel plankton monitoring tools (Chapter 7), routine limnological assessments (Chapter 8), and the recovery of macrophytes (Chapter 9) in this region. These five chapters provide a good overview of the range of conditions in Lusatian AMD lakes, in particular detailing the degree of biotic impoverishment of the most acidic lakes, and the capacity for recovery of water quality, plankton and macrophytes. However, I had some difficulty in building an overall sense of the current Lusatian situation for a few reasons. First, I missed an introductory overview of the water chemistry and limnology of the entire region, as a complement to the background geology of Chapter 2. I didn’t find the pH panel in Chapter 1 adequately set the Lusatian stage. Secondly, I was a bit confused with the different water quality data presented in each chapter. Thirdly, the numbers of lakes visited varied dramatically among these chapters, from 2 to 200, and as the authors didn’t generally inform us as to why the lakes were selected, generalizations were tough to reach. Fourthly, in most cases, we were given only presence/absence data on the
biota, often in classes of lakes, rather than individual lakes. We were not presented with time trends of ecological recovery, although I suspect these data exist at least for the macrophytes. Finally, except for the zooplankton data in Chapter 7, we were given little sense of spatial or intra-annual variability in biota. Nonetheless, I learned a lot about this region.

There were two Canadian case studies (Chapters 5 and 6) in Part II. Kwong and Lawrence described the biogeochemistry of Clear Lake in the Yukon, a fascinating lake with a pH of 2.8 attributable to pyrite oxidation, but in an undisturbed landscape. This case study gives us the opportunity to witness the long-term consequences of chronic severe acidification. Salivating paleolimnologists should note, however, that the sediments of the lake were continuously covered with a 1.5 m-thick blanket of moss, which rendered core collections next to impossible! I would have preferred it if the authors had not somewhat cavalierly suggested this lake might best be used as a disposal site for reactive mine wastes. However, in Chapter 6, Pedersen and colleagues do indicate this is a relatively safe method of disposal for pyrite-rich tailings, as evidenced from a retrospective look at long-term water and sediment quality assessments in Anderson and Buttle lakes in Canada.

Part III, perhaps the strongest section of the book, provides four chapters on pyrite chemistry. Evangelou (Chapter 10) provides an excellent introduction of the mechanisms and regulators of pyrite oxidation. In Chapter 11, Wisozk focuses the previous chapter’s mainly laboratory-based discussion on the realities of the fate of acidity and S when waters from pyrite oxidation zones interact with alkaline groundwater in waste dumps. The limiting step in pyrite oxidation is the oxidation of Fe\(^{2+}\) by oxygen, a bacterially-catalyzed reaction. In Chapter 12, Prein and Mull build a model of bacterially-mediated pyrite oxidation which is limited by oxygen supply, and parameterize it so as to mimic actual overburden spoil heaps in Germany. The model output provides a convincing rationale for managing ADM production by minimizing oxygen influx into pyrite-rich spoils. In Chapter 13, Katzur and Liebner continue the examination of Lausatian overburden dumps, here focusing on groundwater quality following various soil amendments. Their experiments provide convincing evidence of the difficulty of managing groundwater quality in AMD regions without managing rates of oxygen supply.

Remediation studies are the sole focus of Part IV of the book. In Chapter 14, Wendt-Potthoff and News review the various microbially-mediated processes that raise pH (photosynthesis, methanogenesis) and/or generate alkalinity (the reduction of nitrate, sulphate, iron and manganese). Johnson (Chapter 15) provides a fascinating account of microbial foodwebs of natural pyrite, indicating which of these linkages might be exploited to remediate AMD. In Chapter 16 Kleinmann and colleagues introduce us to the need for site specificity in managing AMD by passive means in variously-constructed wetlands and/or anoxic limestone drains. This is the first of several “how-to” chapters, which should please those with an engineering bent. In Chapter 17, Kalin describes her approach to lower Zn discharge from an abandoned Canadian mine using periphytic colonies on submerged brush cuttings. This is a satisfying case study, moving from theory, to pilot scale testing, then to the successful implementation; however, Kalin and Kleinmann both stress the lack of long-term remediation data. In Chapter 18, Lamb and colleagues explore the needs for such long-term treatment at an abandoned English tin mine. The chemical and engineering knowledge required to manage AMD is clearly evident in this chapter. Treatment involved first, an engineered aerobic reed-bed wetland for ferrous iron oxidation, hydrolysis and precipitation, followed by an anaerobic cell of hay, sawdust and manure, for metal sulphide precipitation. The final cell was a high-pH, aerobic rock filter for precipitation of Mn. Unfortunately, no long-term data are available for this site, so the chapter’s title was a bit misleading. In Chapter 19, Phillips and Bender provide compelling evidence of the need for such long-term study given the limited longevity evident in the advancing front of effective Mn removal in engineered, microbial mats. George and Davison then demonstrate the possibility of raising the pH of mildly acidic soft-water lakes by promoting nitrate reduction with small additions of phosphate. Their results, from an English whole-lake experiment, will be of interest to a broad limnological audience, not just students of AMD. The next two chapters provide watershed-level overviews of geochemical model (Chapter 21) and ecological approaches (Chapter 22) that can be applied to managing AMD-damaged lakes in the Germany.

The book concludes with three brief overviews (respectively, on controlling pyrite oxidation, limnological fundamentals of AMD lakes, and restoration methodology) which are reports of summary conference discussions. For me, the most interesting points in this synopsis of nagging uncertainties were: (1) that depending on the time of year and its composition,