

Soil Biology

Erika Kothe
Ajit Varma *Editors*

Bio-Geo Interactions in Metal-Contaminated Soils

 Springer

Soil Biology

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Ajit Varma, Amity Institute of Microbial Technology,
Amity University Uttar Pradesh, Noida, UP, India

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Erika Kothe • Ajit Varma
Editors

Bio-Geo Interactions in Metal-Contaminated Soils

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Editors

Erika Kothe
Friedrich Schiller Universität Jena
Institute of Microbiology
Neugasse 25
07745 Jena
Germany
erika.kothe@uni-jena.de

Dr. Ajit Varma
Amity University Uttar Pradesh
Amity Institute of Microbial Sciences
Noida Uttar Pradesh
Block A, Ground Floor, Sector 125
India
ajitvarma@aihmr.amity.edu

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Preface

The book aims at interdisciplinary research between geosciences and biology with major input from microbiology. The view on geoactive principles of bacteria and fungi in soil comprises the ecological understanding of habitat formation as well as modeling of matter fluxes. The combination of geological and biological methodology brings forward a general understanding of processes at the interfaces of the microbial cell and the plant root at soil particles in specifically metal-contaminated land. Since metal contamination is an increasing ecological and ecotoxicological risk, the basic understanding of processes involved in metal mobilization as well as sorption and mineralization are the key features for remediation actions in the field of heavy metal-contaminated land management. This is also reflected in the growing interest in bio-geo-interactions by a number of new periodicals as well as study courses, like biogeosciences, geomicrobiology, or geoecology.

Researchers and graduate students working in the field of biogeosciences and ecology, consulting companies which now become aware of the potential lying in the use of biology and look for biological means to manage schemes of soil remediation, or small- and medium-sized enterprises involved in bioremediation are the groups targeted with this book. We intended to provide state-of-the-art knowledge of phytostabilization and phytoextraction for their use. Since many of the sites in question are former mining sites, the federal and state governments might be interested in finding new solutions to the risk management of heavy metal-contaminated sites. For their use, specifically, the chapters on bioremediation or phytoremediation were added.

The chapters of the book start from a general overview on contaminated soil with a description of the role of physical, chemical, and biological compartments and their interaction with organic and inorganic contaminants which is followed by an introduction to biogeosciences in heavy metal-contaminated soils. After introducing the different mechanisms at play in the interactions of soil, microorganisms, plants, and the water phase necessary to transfer metals to biological systems, the mineralogy and geochemistry basics in assessing potential hazards at mining sites are addressed.

As mineralogy might also contain natural tracer elements for following processes between biotic and abiotic systems, rare earth elements are introduced as a means to follow the patterns of distribution between bios and geos in acidic systems. The direct impact of microorganisms on the substrate is specifically shown in an example of geomicrobial manganese redox reactions for metal release from manganese (hydr)oxides forming a biogeochemical barrier in a contaminated soil substrate. A potential for microbially induced biomineralization to natural attenuation is presented in the contaminated system at an abandoned mining site in Sardinia. Biomineralization investigated, in particular, at post-mining area is discussed regarding its potential to reduce the bioavailability of toxic heavy metals such as cadmium or lead. Since metal speciation plays a major role in element behavior, uranium speciation is investigated in seepage water and pore water of heavy metal-contaminated soil. In the context of uranium speciation and complexation, sophisticated methods like time-resolved laser-induced fluorescence spectroscopy or X-ray absorption spectroscopy are explained as suitable tools to study uranium in acidic and metal-rich waters.

The next chapters then move to plant–microbe interactions and their role in sustaining plant growth at heavy metal-contaminated sites, with heavy metal resistance of soil bacteria, the role of mycorrhiza in reforestation programs, and the occurrence of adapted plants at historical copper spoil heaps in Austria. Occurrence and capabilities of heavy metal-resistant plant growth promoting bacteria dwelling in the rhizosphere are presented with regard to bioaugmentation strategies. The examination of natural vegetation on heavy metal rich soils is necessary to find hyperaccumulator plants, which leads to the topic of phytoremediation of metal-contaminated soils. One such example is the nickel hyperaccumulating plant *Alyssum bertolonii*, which is presented as a model system for studying biogeochemical interactions.

The role of soil organic matter on metal mobility as well as the influence of symbiotic associations like different types of mycorrhiza for phytoremediation at different sites is presented. Again, use of metal-resistant bacterial strains as inocula for bioremediation of metal containing soils is presented. The investigation of experiments at laboratory, lysimeter, and field scale leads to the final chapter in which theoretical foundations of integrated modeling approaches in biogeochemistry are presented.

Different tools are discussed and a molecular understanding of dominant and relevant processes in contaminated soils is introduced. The hydrogeology and microbiology of former mining sites, specific microbial communities, and plant–microbe interactions are described with respect to state-of-the-art research.

The presentation of this book within the soil biology series would not have been possible without the help and collaboration of all our partners, specifically from UMRELLA, to whom we are deeply indebted.

Jena, Germany
Noida, Uttar Pradesh, India

Erika Kothe and Götz Haferburg
Ajit Varma

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Contributors

Abate C. M. Universidad Nacional de Tucumán, Tucumán, Argentina

Adlassnig W. Core Facility Cell Imaging and Ultrastructure Research, University of Vienna, Vienna, Austria, wolfram.adlassnig@univie.ac.at

Amoroso M. J. Planta Piloto de Procesos Industriales y Microbiológicos (PROIMI), Avenida Belgrano y Pasaje, Caseros, Tucuman, Argentina

Arnold T. Helmholtz-Zentrum Dresden-Rossendorf, Institut für Radiochemie, Dresden, Germany

Banasova V. Institute of Botany, Slovak Academy of Sciences, Bratislava, Slovakia

Baumann N. Helmholtz-Zentrum Dresden-Rossendorf, Institut für Radiochemie, Dresden, Germany, n.baumann@hzdr.de

Behl R. K. Department of Plant Breeding, CCS Haryana Agricultural University, Hisar, Haryana, India, rkbehlprof@gmail.com

Bodescu F. Research Centre for Ecological Services (CESEC), Faculty of Biology, University of Bucharest, Bucharest, Romania

Buchel G. Institute of Earth Sciences, Friedrich-Schiller-University Jena, Jena, Germany

Cecchi L. Department of Evolutionary Biology, University of Firenze, Firenze, Italy

Ciamporova M. Institute of Botany, Slovak Academy of Sciences, Bratislava, Slovakia, milada.ciamporova@savba.sk

Cidu R. Department of Earth Sciences, University of Cagliari, Cagliari, Italy, cidur@unica.it

Cobzaru I. Institute of Biology Bucharest, Romanian Academy, Bucharest, Romania

Das A. Amity Institute of Microbial Technology (AIMT), Amity University Uttar Pradesh (AUUP), Noida, UP, India, adas@amity.edu

Giudici G. De Department of Earth Sciences, University of Cagliari, Cagliari, Italy, gbgiudic@unica.it

Durisova E. Institute of Botany, Slovak Academy of Sciences, Bratislava, Slovakia

Farcasanu I. C. University of Bucharest, Bucharest, Romania, ileana.farcasanu@g.unibuc.ro

Gawronski S. Institute of Botany, Jagiellonian University, Kraków, Poland, stefangaw@gmail.com

Gherghel Felicia Department of Mycology, Philipps-University of Marburg, Marburg, Germany

Gonnelli C. Department of Evolutionary Biology, University of Firenze, Firenze, Italy

Grawunder Anja Institute of Geosciences, Friedrich Schiller University Jena, Jena, Germany, anja.grawunder@uni-jena.de

Gube Matthias Institute of Microbiology, Friedrich-Schiller-Universität, Jena, Germany, matthias.gube@uni-jena.de

Gurinova E. Institute of Botany, Slovak Academy of Sciences, Bratislava, Slovakia

Haferburg Gotz Institut für Mikrobiologie, Friedrich-Schiller Universität, Jena, Germany, goetz.haferburg@uni-jena.de

Iacob C. Lythos Research Center, Faculty of Geology, University of Bucharest, Bucharest, Romania

Ion S. Institute of Mathematical Statistics and Applied Mathematics, Romanian Academy, Bucharest, Romania

Iordache Virgil Research Centre for Ecological Services (CESEC), Faculty of Biology, University of Bucharest, Bucharest, Romania, virgil.iordache@g.unibuc.ro

Jianu D. Lythos Research Center, Faculty of Geology, University of Bucharest, Bucharest, Romania, denisa0301@yahoo.com

Kothe Erika Institute of Microbiology, Friedrich-Schiller-Universität, Jena, Germany, erika.kothe@uni-jena.de

Krause Katrin Institute of Microbiology, Friedrich Schiller University, Jena, Germany, katrin.krause@uni-jena.de

Lacatusu R. Research Institute for Soil Science and Agrochemistry (ICPA), Bucharest, Romania

Lattanzi P. Department of Earth Sciences, University of Cagliari, Cagliari, Italy, lattanzp@unica.it

Lichtscheidl Irene K. Core facility Cell Imaging and Ultrastructure Research, University of Vienna, Vienna, Austria

Lonschinski M. Institute of Geosciences, Friedrich-Schiller University, Jena, Germany

Lorenz C. Chair of Environmental Geology, Brandenburg Technical University, Cottbus, Germany, christian.lorenz@tu-cottbus.de

Matache Mihaela University of Bucharest, Bucharest, Romania, mihaela.matache@gmail.com

Medas D. Department of Earth Sciences, University of Cagliari, Cagliari, Italy, dmedas@unica.it

Mengoni A. Department of Evolutionary Biology, University of Firenze, Firenze, Italy, alessio.mengoni@unifi.it

Merten Dirk Institute of Geosciences, Friedrich Schiller University Jena, Jena, Germany, dirk.merten@uni-jena.de

Nadubinská M. Institute of Botany, Slovak Academy of Sciences, Bratislava, Slovakia

Narula N. Department of Microbiology, CCS Haryana Agricultural University, Hisar, Haryana, India, neeru_narula@yahoo.com

Neagoe Aurora Research Centre for Ecological Services (CESEC), Faculty of Biology, University of Bucharest, Bucharest, Romania, aurora.neagoe@unibuc.eu

Onete M. Institute of Biology Bucharest, Romanian Academy, Bucharest, Romania

Orza R. Lythos Research Center, Faculty of Geology, University of Bucharest, Bucharest, Romania

Petrescu L. Laboratory of Geochemistry, Faculty of Geology, University of Bucharest, Bucharest, Romania

Podda F. Department of Earth Sciences, University of Cagliari, Cagliari, Italy, fpodda@unica.it

Purice D. Institute of Biology Bucharest, Romanian Academy, Bucharest, Romania

Reinicke Martin Institut für Mikrobiologie, Friedrich-Schiller Universität, Jena, Germany, martin.reinicke@uni-jena.de

Ryszka P. Institute of Environmental Sciences, Jagiellonian University, Kraków, Poland

Schindler Frank Institute of Microbiology, Friedrich-Schiller-Universität, Jena, Germany, schindler@uni-jena.de

Schutze Eileen Institute of Microbiology, Microbial Phytopathology, Friedrich Schiller University Jena, Jena, Germany, eileen-schuetze@web.de

Scradeanu D. Laboratory of Hydrogeology, Faculty of Geology and Geophysics, University of Bucharest, Bucharest, Romania

Sherameti I. Institute of General Botany and Plant Physiology, Friedrich-Schiller-Universität Jena, Jena, Germany, irenasherameti@yahoo.de

Soare B. Lythos Research Center, Faculty of Geology, University of Bucharest, Bucharest, Romania

Turnau K. Institute of Environmental Sciences, Jagiellonian University, Kraków, Poland, katarzyna.turnau@uj.edu.pl

Varma Ajit Amity Institute of Microbial Technology (AIMT), Amity University Uttar Pradesh (AUUP), Noida, UP, India, ajitvarma@aihmr.amity.edu

Wernitznig S. Core facility Cell Imaging and Ultrastructure Research, University of Vienna, Vienna, Austria

Zook D. Boston University, Boston, MA, USA, dzook@bu.edu