Spoil to Soil

Mine Site Rehabilitation and Revegetation





Edited by **N.S. Bolan • M.B. Kirkham • Y.S. Ok**

CRC Press
Taylor & Francis Group

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CRC Press
Taylor & Francis Group
Boca Raton London New York

CRC Press is an imprint of the
Taylor & Francis Group, an **informa** business

CRC Press
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742

Printed on acid-free paper

International Standard Book Number-13: 978-1-4987-6761-3 (Hardback)

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http://www.taylorandfrancis.com

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http://www.crcpress.com

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Foreword

When we plant trees, we plant the seeds of peace and seeds of hope.

(Wangari Maathai, 2004 Nobel Laureate)

Restoring soils and vegetation on mine-impacted lands is no easy task. Soils possessing site-specific biological, physical, and chemical attributes can be extensively altered during the mining process. Soil microfauna and microflora, plant seeds and rhizomes, earthworms and insects, and even the mineral, clay, and organic carbon fractions of soil can be buried or severely compromised by mining disturbances. Spoil is the material that remains after mining, which provides the foundation for new life post rehabilitation. Unfortunately, spoil is not a universal media that exhibits similar characteristics across the globe. Spoil can be stockpiled topsoil and subsoil from the pre-mining landscape that has been replaced. Spoil can be a topsoil substitute consisting of weathered or unweathered overburden or tailings resulting from mineral extraction. Spoil can be a mixture of all of these and can oftentimes contain amendments that were imported from outside the mining landscape. Regardless, from a pedogenic perspective, spoil represents time zero in the soil formation process in disturbed sites including mine sites.

Rehabilitation, reclamation, restoration, revegetation, and remediation are all terms that have been used to describe the process of transforming spoil to soil and the subsequent recovery of ecosystem processes. In many parts of the world, this process is intended to create a post-mining land use that is equal or better than the pre-mining condition. Unfortunately, this is not always achieved. Even with decades of reclamation research, more information is needed on how to successfully rehabilitate mine-impacted lands. Spoil stabilization and vegetation establishment techniques have been well documented on mined lands, but the return of a landscape for long-term uses and benefits has not always been the goal of many reclamation endeavors.

Mining provided the raw materials needed for global industrialization and development. The legacy of these activities is at the forefront of conversations on climate change, food and water security, and economic sustainability. Mine-impacted lands should have great value even after the resources have been extracted if proper reclamation techniques are employed. Society at large can benefit by restoring ecosystem services and productivity to these lands, as they constitute an "environmental infrastructure" of tangible value to local and global communities. For example, rehabilitated forested landscapes help to maintain clean water and reduce flooding in rivers and streams. Forests are responsible for cleaning air and sequestering carbon, which will help offset emissions from mining activities and burning of fossil fuels. Targeted reforestation can reduce forest fragmentation from mining, as needed to restore habitat for wildlife species that depend on large expanses of unbroken forest. Reforestation with native species can also improve landscape aesthetics, thus enhancing the capacity of communities in mining areas to serve as tourist destinations and to support tourism-related businesses and jobs.

Beyond the forest, former surface mines may also provide opportunities for renewable energy applications (wind, solar, bioenergy including growing energy crops). These lands often contain infrastructure (transmission lines, roads, railroads) that can be utilized for a variety of other industrial and agricultural uses. Opportunities abound to stimulate job creation and economic growth from these types of post-mining land uses. However, we must ensure that this growth is sustainably developed and that the foundation for all of these endeavors to occur, the soil, is healthy and resilient to the many threats it faces. These threats are environmental and biological, such as climate change and exotic invasive pests and diseases, as well as threats associated with benign neglect and exploitive overuse of the land and its related resources.

Successful rehabilitation and revegetation of mine-impacted land are vital for the current and future prosperity of mining regions across the globe. Information in the following chapters outlines the scientific knowledge and best practices for protecting the environment and reestablishing productivity in post-mining landscapes. A commitment to improving conditions on reclaimed mined land for the future seems like a worthwhile investment. By improving our ability to rehabilitate mined land, we create new opportunities for lands that are often considered marginal and we stand a chance of contributing significantly to the development of a sustainable and economically viable future.

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Preface

The need to ensure environmental sustainability for current and future generations is a critical challenge for humanity. The forces driving increased environmental pressure include population growth, increased urbanization, and demand for human consumption. Thus, demands for energy resources, such as coal and base metals (iron and copper) used for industrial products and infrastructure, have been rising.

Mining can cause significant environmental impacts that include soil erosion, formation of mine voids and sinkholes, loss of biodiversity, and contamination of soil, groundwater, and surface water by chemicals from mining processes. Besides creating environmental damage, the contamination resulting from leakage of chemicals also affects the health of the local population. For example, acid mine drainage resulting from mine wastes can cause toxic metal mobilization. Furthermore, conflict can arise at the local level where mining is perceived as competing with agriculture and livestock grazing or other traditional land uses. Displacement and resettlement of land owners and farmers from mining areas also can cause conflict where comparable land cannot be obtained. Mining companies in many countries are required to follow environmental and rehabilitation codes, ensuring the area mined is returned close to its original state through rehabilitation and revegetation.

This book covers both the fundamental and practical aspects of remediation and revegetation of mine sites. It includes three major themes: (1) characterization of mine site spoils; (2) remediation of chemical, physical, and biological constraints of mine site spoils, including post mine site land-use practices; and (3) revegetation of remediated mine site spoils. Each theme includes chapters covering case studies involving mine sites around the world. The last section focuses specifically on case studies with successful mine site rehabilitation. This book provides a narrative of *how inert spoil can be converted to live soil.* The purpose of this book is to give students, scientists, and professional personnel in the mining industry sensible, science-based information needed to rehabilitate sustainably areas disturbed by mining activities. The key features of this book include the following:

- It provides a fundamental understanding of mine site spoil properties.
- It provides various approaches for remediation of mine site contaminants.
- It outlines the potential value of risk-based approaches for remediation.
- It includes case studies of revegetation of mine sites for various land-use practices.
- It is suitable for undergraduate and graduate students majoring in environmental, earth, and soil sciences; environmental and soil scientists; and mine site environmental engineers and regulators.

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