Bioremediation of Salt Affected Soils: An Indian Perspective

Sanjay Arora • Atul K. Singh • Y.P. Singh
Editors

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Springer

Editors
Sanjay Arora
Regional Research Station
ICAR-Central Soil Salinity Research Institute
Lucknow, UP, India

Atul K. Singh
Regional Research Station
ICAR-Central Soil Salinity Research Institute
Lucknow, UP, India

Y.P. Singh
Regional Research Station
ICAR-Central Soil Salinity Research Institute
Lucknow, UP, India

ISBN 978-3-319-48256-9 ISBN 978-3-319-48257-6 (eBook)
DOI 10.1007/978-3-319-48257-6

Library of Congress Control Number: 2017931077

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Foreword

Salinity and sodicity of soil is a global problem that extends across all continents in more than 100 countries of the world, presenting a major threat to farm agricultural production, leading to adverse implications for food security, environmental health, and economic welfare. The remediation of salt-affected lands and their management will go a long way in meeting the desired 57% increase in global food production by the year 2050. Amelioration of saline and sodic soils has been predominantly achieved through the application of chemical amendments. However, amendment costs have increased prohibitively over the past two decades due to competing demands from industry and reductions in government subsidies for their agricultural use in several developing countries. Also, the availability of chemical amendments, such as gypsum, that come from minerals is a problem. Saline soil improvement needs excessive amounts of good quality water to wash salts as an ameliorative measure. In many countries in arid and semiarid regions where rainfall is scanty and the availability of good quality waters is a problem, this method of reclamation does not seem to be feasible. However, alternate biological methods such as planting the soil with salt-tolerant plants where salts are taken up by these plants and removed from the soil or exchanged through biological processes can be used. Bioremediation is considered as a promising option as it requires low initial investments and improves the soil quality and the crop produce. Halophilic microorganisms are organisms that grow optimally in the presence of high salt concentrations. These have high potential for bioremediation applications and have been reported by several workers. The applications of halophilic bacteria trigger recovery of salt-affected soils by directly supporting the establishment and growth of vegetation in soils stressed with salts.

The biotic approach ("plant-microbe interaction") for overcoming salinity/sodicity problems has recently received considerable attention throughout the world. Bacteria are most commonly used in the bioremediation of soils. Vesicular-arbuscular mycorrhiza or VAM fungi is also found to be effective in alleviating salt stress and increasing availability of nutrients to the plants. Bioremediation, including phytoremediation approaches for management of saline, sodic and coastal

saline, and waterlogged soils, seems needed. Bioremediation and management of vast areas of salt-affected soils involve considerations of economic viability, environmental sustainability, and social acceptability of different approaches. Phytoremediation strategies can be economically beneficial if there is market demand for the selected crops, grasses, or trees, or if they are useful locally at the farm level. However, in any economic analysis of sodic soil amelioration, it is also important to consider the long-term benefits of improvements made to the soil and the environment. This all will help in bioremediation of saline soil and improvement of crop yields, and in turn will help in uplifting the socioeconomic status of the farming community. However, there are several opportunities and challenges for the future of bioremediation techniques for the effective reclamation of salt-affected soils. In this book, the information and technologies developed for bioremediation and management of salt-affected soils are compiled with an emphasis on characterization, reclamation, microbial and vegetative bioremediation, and management technologies for salt-affected and waterlogged sodic soils.

In this book, attempts have been made to address a wide range of issues related to principles and practices for rehabilitation of inland and coastal salt-affected soils as well as waterlogged saline and sodic soils. Several site-specific case studies typical to the saline and sodic environment, including coastal ecologies, sustaining productivity, rendering environmental services, conserving biodiversity, and mitigating climate change, are included and described in detail. Written by leading researchers and experts of their specialized fields, this book, though in an Indian context, will serve as a knowledge center for experts in management of salt-affected soils but also for researchers, policy makers, environmentalists, students, and academics from all parts of the world. Further, it will also help reverse salinity development to ensure the livelihoods of resource-poor farming families living in harsh ecologies including coastal areas which are more vulnerable to climate change.

I congratulate and extend my appreciation to the editors for conceptualizing and developing the framework of this publication, and the authors for summarizing their wealth of knowledge and experiences. I sincerely hope and believe that the information contained in this book will provide new insight to researchers, extension workers, field officers, and others involved in reclamation and management of salt-affected soils.

Gurbachan Singh
Chairman, ICAR-Agricultural Scientists Recruitment Board, India
Krishi Anusandhan Bhavan – 1, New Delhi, India

Preface

In the past, the increasing needs of a growing population for food, fuel and fiber were met by cultivating progressively larger areas of land and by intensifying the use of existing cultivated land. Under circumstances with diminishing good-quality lands and stagnating crop yields, the food demands of an increasing population must be met through the reclamation and management of degraded lands, including salt affected lands. Salt-affected soils cover about 6 % of the world's lands, which is mainly due to either natural causes or human-induced causes that affect about 2 % (32 million ha) of dryland farmed areas and 20 % (45 million ha) of irrigated lands globally. In India, about 6.73 million ha of land are affected by salts. To overcome this problem, several researchers have advocated the biological approach to improve these lands for cultivation. Innovative technologies in managing marginal salt affected lands merit immediate attention in view of climate change and its impact on crop productivity and the environment. The management of degraded land on a sustainable basis offers an opportunity for the horizontal expansion of agricultural areas in the India. During the last three decades, a number of strategies to ameliorate different kinds of marginal lands, including salt affected areas, have been developed. Adequate knowledge in diagnosis and management technologies for saline and alkali lands is essential to obtain maximum crop production from these resources. Bioremediation is one of the eco-friendly approaches for improving the productivity of salt affected soils.

This book attempts to gather and discuss the information and technologies developed for the bioremediation and management of salt affected soils. The emphasis in this endeavour was on characterization, reclamation, microbial and vegetative bioremediation and management technologies for salt affected and waterlogged sodic soils. This book contains 14 chapters that highlight the significant environmental and social impacts of different ameliorative techniques for salt affected soils. Bioremediation, including phytoremediation approaches for managing saline, sodic and coastal waterlogged soils, is the major emphasis. Agronomic practices, including agroforestry at different scales, with case studies in India are also part of the book. The book summarizes and updates information about the distribution,

reactions, changes in bio-chemical properties and microbial ecology of salt affected soils in India that can be useful globally. Furthermore, it addresses the environmental and socio-economic impacts of reclamation programs with particular emphasis on the impacts on agricultural production and rehabilitation of degraded lands, vis-a-vis the economics of farmers. The decision-making process related to the reclamation and management of vast areas of salt affected soils involves considerations of the economic viability, environmental sustainability, and social acceptability of different approaches. The book contains the latest case studies and applied techniques of bioremediation of salt affected soils.

Overall, we hope the book facilitates future examinations of large scale adoptions of effective techniques by providing summaries of existing data and research related to the restoration of degraded lands through halophyte plant species, diversification of crops, and introduction of microbes for remediation of salt affected soils, and offering a framework for better understanding and identifying the future challenges.

We are thankful to the authors who are experts in their respective fields, and have written a comprehensive and valuable resource for researchers, academicians and students interested in the fields of soil science, environmental science, microbiology, remediation technology, and plant and soil stresses.

Lucknow, India

Sanjay Arora
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