TASKS FOR VEGETATION SCIENCE – 48

Sabkha Ecosystems

Volume V: The Americas

edited by M. Ajmal Khan, Benno Boër, Münir Özturk,
Miguel Clüsener-Godt, Bilquees Gul
and Siegmar-W. Breckle

EXTRAS ONLINE

Springer

Tasks for Vegetation Science 48

Series editor

H. Lieth, University of Osnabrück, Germany

More information about this series at http://www.springer.com/series/6613

M. Ajmal Khan • Benno Boër
Münir Özturk • Miguel Clüsener-Godt
Bilquees Gul • Siegmar-W. Breckle
Editors

Sabkha Ecosystems
Volume V: The Americas

Springer

EXTRAS ONLINE

Editors
M. Ajmal Khan
Qatar Shell Chair in Sustainable Development, Centre for Sustainable Development
Qatar University
Doha, Qatar

Münir Özturk
Ege University
Izmir, Turkey

Bilquees Gul
Institute of Sustainable Halophyte Utilization
University of Karachi
Karachi, Pakistan

Benno Boër
UNESCO Liaison Office in Addis Ababa with the AU and UNECA
Addis Abeba, Ethiopia

Miguel Clüsener-Godt
Division of Ecological & Earth Science
UNESCO Headquarters, Natural Science
Paris Cedex 15, France

Siegmar-W. Breckle
Bielefeld, Germany

ISSN 0167-9406 ISSN 1875-130X (electronic)
Tasks for Vegetation Science
ISBN 978-3-319-27091-3 ISBN 978-3-319-27093-7 (eBook)
DOI 10.1007/978-3-319-27093-7

Library of Congress Control Number: 2002024322

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG Switzerland

Foreword

The *Sabkha Ecosystems Series is the most comprehensive scientific documentation dealing with hypersaline coastal and inland ecosystems and with numerous scientific and development aspects. The series started in 2002 with Volume I, on the "Sabkha Ecosystems of the Arabian Peninsula and Adjacent Countries"; Volume II, on "West and Central Asia (2006)"; Volume III, on "Africa and Southern Europe (2011)"; and Volume IV, on "Biodiversity Conservation and Cash Crop Halophyte Development (2014)." Sabkha Ecosystems of the Americas* is the fifth volume of the series, and one additional volume on the *Sabkha of Asia – Pacific* is expected to conclude this global documentation in Springer's *Tasks for Vegetation Science*.

UNESCO is the only United Nations body with a specialized science sector and with the word *science* clearly stated in its name. UNESCO has the needed intellectual capacity and the leading role advancing the scientific bases for water management, ecosystem research, and biodiversity conservation, as well as education for sustainable development. The series was inspired and supported by UNESCO's Natural Sciences Sector.

Our planet's human life support system has reached and partly exceeded its limits, especially with a view to food and water security in the dry land areas.

Considering globally dwindling freshwater resources, increasing demand for freshwater for irrigation, considering the fact that we know approximately 2200 halophytic plant species, and considering that we have reached a total number exceeding 7.2 billion human beings living on Earth, it is surely in the best interest for mankind to continue the process of scientific research into halophyte development. There is an abundance of saline water resources available, including saline groundwater, saline wastewater, and full-strength seawater. The long process of scientific research and development needs to be accompanied with good ecosystem management practices, based on science and under consideration of ethics, biodiversity conservation, and numerous other aspects as required under the new United Nations Sustainable Development Goals.

It is also of importance for the scientific and development community to reach out to those who can provide the necessary financial resources to support halophyte research and development, until visible and profitable products become available for farmers and investors.

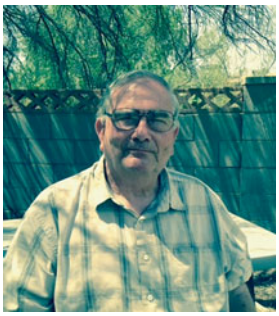
The current volume includes scientific contributions on biochemistry, biodiversity issues, biofuel production, botany, climate change, coastal ecosystem

management, ecosystem restoration, ecophysiology, fodder production for sheep, genetics, germination strategies, grain production, halophyte-bacteria interaction, landscaping, morphophysiology, seed banks, soil-plant relationships, as well as halophyte farm development in hyper-ari coastal zones.

I wish to express my thanks and continuous support to the Springer Publishing House, as well as the editors and numerous authors of this important publication, who worked relentlessly to make this highly important book series a reality.

UNESCO Assistant Director-General for Natural Sciences Flavia Schlegel
Delft, The Netherlands

Preface



This volume is devoted to the sabkha ecosystems of North America. Sabkha is an Arabic word for salt flats, which occur on all continents. The largest area of true coastal sabkhas in North America is along the Sonoran coast of the northern Gulf of California in Mexico. The Gulf of California acts as a tidal funnel, with tidal amplitude increasing as you proceed up the Gulf. At the head of the Gulf where the Colorado River enters the sea, mean tidal amplitudes of 5–10 m prevail. Although now dammed and diverted for human use, the Colorado River historically was known for its summer floods, depositing vast quantities of sediments into the northern Gulf over at least five million years. The Colorado River carved the Grand Canyon from the uplifting Colorado Plateau. The rock that was removed now resides as vast sediment beds in the northern Gulf of California. These sediments have created long, gently sloping shorelines on the eastern side of the northern Gulf. The combination of high tidal amplitudes and gently sloping shorelines has produced about 114,000 ha of coastal salt flats in Sonora with tides penetrating as much as 10 km inland.

On the Pacific coast of Baja California, the Vizcaino Desert supports large natural sabkhas as well as the world's largest salt-making facility at Guererro Negro, Mexico, with over 30,000 ha of evaporation and crystallization ponds where seven million tons of salt are produced from seawater each year. Coastal sabkhas also occur as salt pannes in the extensive coastal salt marshes of the Gulf of Mexico and Atlantic seaboard in the USA and Mexico. If the definition of sabkha is expanded to include inland salt flats, North America supports a variety of other saline ecosystems. These include the salt flats and marshes along the shores of the Great Salt, Big Soda, Mono, Walker, and Pyramid Salt Lakes in the Great Basin Desert, the saline playas of the south-

western USA and northern Mexico, and the salt scalds of the Prairie Pothole region of the northern Great Plains in the USA and Canada.

If we extend the definition of sabkhas still further to include man-made saline ecosystems, they include the saline land and water bodies produced by irrigation districts in the western USA and northern Mexico. An example is the Salton Sea, California's largest inland lake, the salinity of which currently exceeds seawater. It is a below sea-level depression that receives brackish drain water from farms in the Imperial and Mexicali irrigation districts. It has no outlet to the sea, so it has become more saline with time. It has transitioned from a unique ecological asset for birds and marine life in its heyday in the 1950s to a looming environmental disaster for both wildlife and human health. Diversion of water from agriculture to cities in the region has caused the shoreline to contract, exposing decades of toxic chemicals to the atmosphere. Seasonal dust storms expose local residents to these chemicals, and the rotten egg odor of hydrogen sulfide from the exposed seabed triggers health alerts in Los Angeles 200 km away.

Like other volumes in the *Sabkha Ecosystems* series, this volume presents a wide-ranging treatment of the geology, hydrology, and ecology of North America's saline ecosystems. It also presents ideas on how to treat saline soils and water as assets rather than just problems, including using the unique halophytic flora of North America sabkhas as potential crop plants. This volume also includes agriculture, biochemistry, biodiversity conservation, ecophysiology, genetics, livestock production, soil ecology, wastewater recycling, food waste recycling, and food security.

Environmental Research Laboratory Edward P. Glenn
University of Arizona
2601 East Airport Drive, Tucson, AZ 85726, USA

Acknowledgement

The technical and financial support of UNESCO and ISHU (Institute of Sustainable Halophyte Utilization) is gratefully acknowledged for the publication of volume V of the global Sabkha Ecosystem series.

We also thank Dr. Abdul Hameed, Assistant Professor, Institute of Sustainable Halophyte Utilization, University of Karachi, for his help in coordinating the manuscripts.

Moreover, thanks are due to the Springer publishing house for their continuous cooperation and for their patience which is required in times, when authors merely wish to publish in 'index-rated journals' due to the pressure of employers, rather than for their real scientific interests and passion.

Contents