

# Salinity and Sodicity

A Global Challenge to  
Food Security, Environmental Quality,  
and Soil Resilience

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## **Salinity and Sodicity: A Global Challenge to Food Security, Environmental Quality, and Soil Resilience**

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*David E. Clay, Thomas M. DeSutter, Sharon A. Clay, and Thandiwe Nleya, Editors*



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## Scope

In the past, there has been many educational materials and much salinity research focused on irrigated agricultural systems in dryland soil. One of the more recent publications was, “Agricultural Salinity Assessment and Management” that was published by the Environmental Water Resource Institute (Wallender & Tanji, 2012). This book provides an excellent resource for irrigating systems, and it contains reference information on the effect of salts on soils, sampling and monitoring, diagnosis of salt problems, salinity management options, and reclamation treatment options. However, Wallender and Tanji (2012) only provides limited information on greenhouse gas emissions, flooding from rising sea levels, dryland systems and their remediation, phytoremediation, the use of remote sensing to track salt-affected soils, and how climate change is impacting the expanding soil salinity/sodicity problem. In addition, Wallender & Tanji (2012) does not provide answers to common questions that can be integrated into lesson plans for undergraduate and graduate students. Our book was designed to complement as opposed to replace Wallender & Tanji (2012). Dryland non-irrigated systems are a serious problem in many areas. In many situations it is driven by climate change and the transport of water and salts from buried marine sediments to the soil surface. In many situations, the soil surveys do not provide hints that salinity and sodicity are serious problems.

Our book covers a range of topics that include the origins of dryland salinity and sodicity, assessing the economic potential of remediation, problems with relying on soil mapping to identify problem areas quantification methods and procedures, management strategies, practical calculations, and more. The book also features special items including example problems set out as questions that are answered. These items are intended to empower the reader with new and updated knowledge about the growing problems caused by soil salinity and sodicity. The purpose of this book is to increase the problem-solving abilities of students, soil professionals, certified crop advisors, and other practicing professionals.

## Reference

Wallender, W. W., & Tanji, K. K. (2012). *Agricultural salinity assessment and management*, Second Edition ASCE Manual and Reports on Engineering Practices No. 71. ASCE American Society of Civil Engineers, Reston Virginia.



## 1

## An Introduction to Salinity and Sodicyty

*Shaina Westhoff, David E. Clay, Kristopher Osterloh, Sharon A. Clay, Thomas M. DeSutter, Thandiwe Nleya, Jorge F. S. Ferreira, Donald L. Suarez, and Devinder Sandhu*

### Chapter Overview

Rising sea levels, increasing land use intensification, declining fresh water supplies, and climate variation are accelerating the development of saline and sodic soils worldwide. This chapter defines the issue and discusses the global extent of salt-affected soils. Subsequent chapters are focused on saline/sodic soil economics (Chapter 2), formation and classification (Chapter 3), chemical analysis (Chapter 4), measurement with soil sensors (Chapters 5 and 6), monitoring salinity with models (Chapter 7), remote sensing (Chapter 8), plant responses to salt stress and phytoremediation (Chapters 9–11), chemical amendments (Chapter 12), rising sea levels (Chapter 13), greenhouse gas emissions (Chapter 14), and case studies (15). Chapter 16 provides answers to common questions.

### Introduction

Salinity and sodicity are prevalent worldwide and have severe negative agronomic and environmental ramifications. Soil salinity is an accumulation of dissolved minerals and salts in soil that often includes  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{SO}_4^{2-}$ ,  $\text{Cl}^-$ ,  $\text{HCO}_3^-$ , and  $\text{NO}_3^-$ . The sources of these salts are the dissolution of salt-bearing minerals such as marine shales and halite, or human management that can add salts or accelerate soil genesis or lead to the accumulation of salts in to the surface soil. Salinity risks are generally assessed by measuring soil electrical conductivity (EC). However, because the critical EC levels are soil- and crop-specific, salinity management is closely tied to water, soil, and crop management. Soil sodicity relates to the proportion of clay binding sites specifically filled by  $\text{Na}^+$ . High concentrations of  $\text{Na}^+$  on the soil cation exchange (CEC) sites can contribute to soil dispersion and increase erosion, negatively affecting soil health and plant growth. Erosion not only leads to the loss of soil, but also the loss of any agronomic fertilizers or pesticides applied to the field. Therefore, erosion can be highly detrimental to surrounding ecosystem services while also severely reducing the producer's return on investment for impacted areas.

The management of salinity and sodicity have challenged communities since the beginning of agriculture (Jacobsen & Adams, 1958; Lowdermilk, 1953; Montgomery, 2007). One early challenge to food security was human-induced salinization where the use of salt-laden irrigation water reduced Sumerian harvests in the delta plain of the Tigris and Euphrates Rivers to one-third of original production between 3000 and 1800 BCE (Montgomery, 2007). For these communities, farmers had the choice of abandoning the land or managing the problem. Because early farmers had an abundance of land but limited information/technology, many chose to move to new lands. Today the situation has changed with most of the earth's suitable land already in agricultural production, and with an increasing world population, management and reclamation are the only viable options for most communities.

Research suggests that if we do not mitigate this expanding problem, the combined impact of drought and salinity/sodicity have the potential to reduce yields on over 50% of global arable land by 2050 (Wang et al., 2003). Salt-induced yield decreases are important because agriculture is the world's most essential industry and accounts for 27% of the world's labor force. Globally, between 2013 and 2018, the agricultural industry received almost \$630 billion (US) in annual governmental support. Continued loss of arable lands due to salinity and sodicity will further strain global economies.

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