Shabbir A. Shahid
Samira A. S. Omar

Kuwait Soil Taxonomy

Springer

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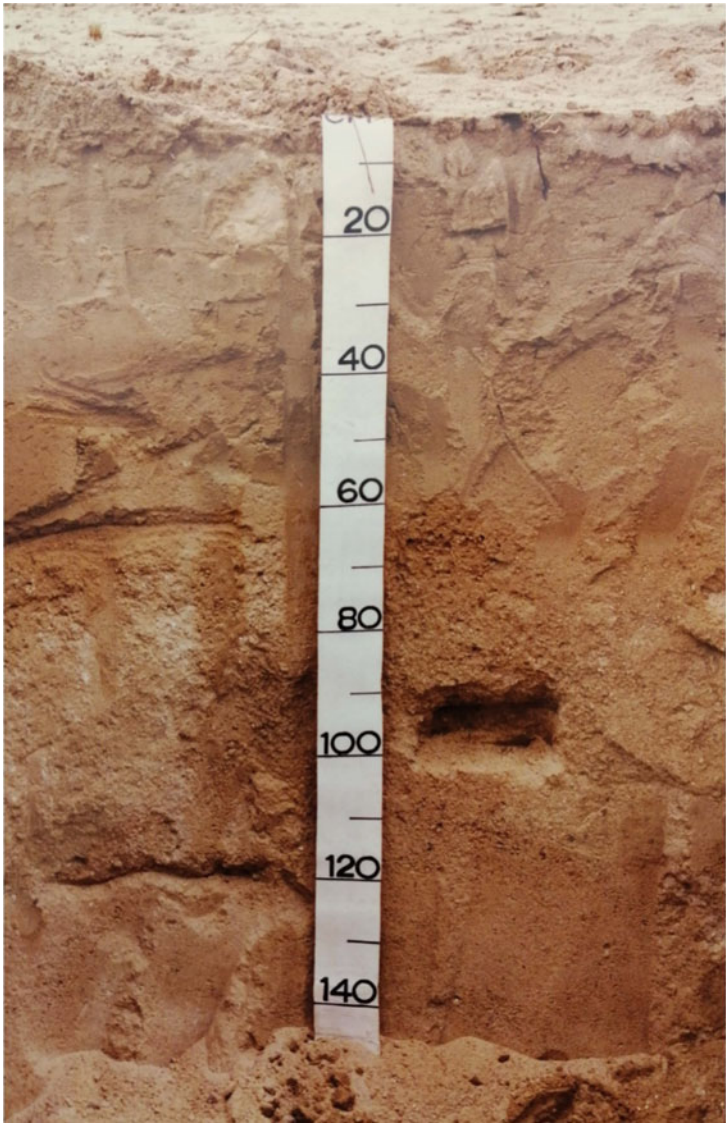

A typical sandy soil of Kuwait “Entisols” covering 30 percent of the surveyed area

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Kuwait Soil Taxonomy

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ISBN 978-3-030-95296-9 ISBN 978-3-030-95297-6 (eBook)
https://doi.org/10.1007/978-3-030-95297-6

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Photos of plants are the courtesy of Dr. Samira A. S. Omar

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Rhanterium epapposum is the national plant of Kuwait. Rhanterium grows well in calcigypsids, torripsammts and petrocalcids soils

Foreword

Rationale uses of soils require their potential to be scientifically assessed. This is essential as misuse of soils can compromise their quality without achieving the targeted benefits. In this context, national soil classification becomes more important in the current situation, where, in 2050, it is likely that the agrifood sector will face a momentous challenge to produce high–quality and nutritious food to feed 9 billion people, while dealing with the impact of climate change on natural resources. Keeping in mind that 95% of our food is directly or indirectly coming from land-based agriculture, and to feed 9 billion people by 2050, the UN Food and Agriculture Organization (UNFAO) expects an increase of 60% food globally and 100% in developing countries, where it is also indicated that currently 33% of global soils are moderately to highly degraded, and 21% of the irrigated lands are affected by soil salinization. However, if the soils are properly understood and managed sustainably, it could be possible to produce up to 58% more food.

Considering the importance of the soils of Kuwait for agriculture, food security and in the provision of ecosystem services, the Kuwait Institute for Scientific Research (KISR) in collaboration with the Public Authority for Agriculture Affairs and Fish Resources (PAAFR) led the efforts to update the national soil map in 1995 and completed in 1999. The soil map was updated by systematizing and processing information through dedicated soil surveys at the national level (1:100,000 scale) and 200,000 ha area having the potential of irrigated agriculture (1:25,000 scale), using the latest soil survey and classification standards of the United States Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS). We thank the contribution of USDA experts in conducting QA/QC on the soil survey of the State of Kuwait and appreciate the team efforts at KISR and PAAFR for completing the survey successfully.

The publication of Kuwait Soil Taxonomy is a continuity of earlier efforts to understand the quality of soils for diversified uses for national development. The book will be a guide to identify soil classes at unknown places for science-based

land use planning and informed decisions for the implementation of specific projects. I believe the book is a definitive and essential reference for potential stakeholders including but not necessarily limited to students, studying soils as part of their curriculum, earth or environmental sciences, as well as professional soil scientists and land use planners. I congratulate the authors for this unique publication, which will be a reference to use for the next at least 3–4 decades. Last but not least, I would like to thank Dr. Curtis Monger, National Leader, Soil Survey Standards USDA-NRCS National Soil Survey Center, for his approval to extract material from USDA-NRCS publications relevant to Kuwait Soil Taxonomy.

Dr. Afaf Al-Nasser
Acting Executive Director
Environment and Life Sciences Research Center
Kuwait Institute for Scientific Research
Safat, Kuwait

Arnebia decumbens annual herb that is one of the most common of the desert flowers that blooms early in spring

Preface

The soils are an integral part of the terrestrial life to provide food, construction material and ecosystem services. We all know that for centuries, humanity and soils have lived one aside from the other. The rise and fall of civilization have been linked to the use and abuse of soil and water resources. We live on the planet Earth which gives us soils to use and live on. Where the soils are a finite resource and non-renewable. Their sustainable use for diversified functions, such as ecosystem service and food security, is inevitable. The misuse of soil resources reduces resource quality for positive services; therefore, the maintenance of soil quality is essential. The sustainable use of soil resources without compromising the quality suggests its quality is to be assessed and maintained if not improved. This requires the soils in any country to be used rationally based on the potential for a specific use, which is only possible if the soils are described and classified using the internationally recognized soil classification system suiting the country's environment and the soils. Once the soils are classified and soil and diversified thematic maps are published, these become guidelines for informed decisions on land use planning, national development and policy implications.

National soil classification system is established to help the nation to predict soil behavior and to provide a common language for soil scientists. National soil survey is a systematic study of the soil of a country, which includes soil classification using internationally recognized procedures and mapping of soil properties and the distribution of various soil map units. The soil map units are characterized in a systematic way that useful interpretations of the soils can be made for potential uses and response to changes in management. Considering the importance of soil mapping in land use planning and national development, a multi-million-dollar soil survey of Kuwait project was completed jointly by KISR and PAAFR through an international professional contractor AACM International, Adelaide Australia, during 1995–1999. The soil survey of Kuwait has revealed the heterogeneous landscapes including coastal and inland sabkhas, sand sheet and sand dunes and

hence presenting soil diversity in terms of physical, chemical, mineralogical and fertility properties. During the reconnaissance Soil Survey of Kuwait, of 12 Soil Orders covering the entire globe, in Kuwait two soil orders *(Aridisols and Entisols),* seven suborders, eight great groups, 14 subgroups and 24 soil families are identified, and in the semi-detailed soil survey, 39 soil series have been identified. Overall, *Entisols* covered 30% and *Aridisols* covered 70% of the surveyed area of Kuwait. These valuable reports and maps are essential resources; however, there was a gap of readily available guidelines to further classify soils in the deserts of Kuwait for location-specific projects. The Kuwait Soil Taxonomy has filled this gap and is a useful guide to provide a mechanism to update the previous soil surveys conducted in Kuwait and will facilitate the soil correlations from new soil surveys in Kuwait. We believe that the "Kuwait Soil Taxonomy" will also enhance the utilization of national soil information and associated maps for many years to come. In this book, the terms not found in the twelfth edition of US soil taxonomy are added in the Kuwait soil taxonomy by including the criteria and classes for identifying "salidic" subgroup within the great groups of *Petrogypsid*s, *Argigypsids*, *Haplogypsids* and *Torriorthents*.

The main aim to publish *Kuwait Soil Taxonomy* is to provide easy-to-understand guide for keying out soils of Kuwait into different soil classes and access to associated laboratory soil procedures. The soil survey of Kuwait was completed by using the ninth edition of US Keys to Soil Taxonomy which is upgraded to the twelfth edition of the USDA-NRCS and Soil Survey Manual published in 2017. The Kuwait Soil Taxonomy is a combination of information from Soil Survey of Kuwait reports predominantly extracted and correlated with the twelfth edition of the USDA-NRCS Keys to Soil Taxonomy, and sections relevant to the soils found in Kuwait are included. It provides a useful tool, not only for soil analysts and specialists, but also for decision-makers who seek to promote innovative processes for the development of the country in general, and the agricultural sector in particular.

Safat, Kuwait

Shabbir A. Shahid, Ph.D.

Samira A. S. Omar, Ph.D.

Scrophularia deserti grows on hard rocky ground

Acknowledgements

We greatly acknowledge the vision of the management of both the Kuwait Institute for Scientific Research (KISR) and the Public Authority for Agriculture Affairs and Fish Resources (PAAFR), who took the initiative to jointly complete the Soil Survey and Associated Activities of Kuwait project during 1995–1999. The project was implemented through an internationally reputed professional contractor Australian Agriculture Consultant Management (AACM) Adelaide, Australia. A large team both from KISR and PAAFR joined the AACM to implement various technical tasks of the project. We wish to pay special tribute to KISR Director General, Project Leader of the Soil Survey Project and Dr. Afaf Al-Nasser who was the Manager of the Aridland Agriculture and Greenery Department (AAGD) for their interest in the project from the inception to the completion. Dr. Shabbir Shahid had the opportunity to work with the soil survey team in the capacity of technical coordination to assure the project Terms of Reference are fully complied and the quality of the final reports and the associated maps is met. The report and maps generated through this eminent project are precious resources for broad land use planning and national development. However, Dr. Samira Omar strongly believes there was still a gap of readily available guidelines for those who wish to further explore soil classification in the deserts of Kuwait, which necessitated the development of the *Kuwait Soil Taxonomy* book that will be used as a ready reference by the students at Kuwait University, researchers, professionals, landscape contractors and other potential users as a guide to classify soils in the area of their interest for many years to come. The photos of plants from the deserts of Kuwait are generously provided by Dr. Samira A. S. Omar.

We wish to thank Dr. Curtis Monger, National Leader—Soil Survey Standards USDA-NRCS National Soil Survey Center—for providing the approval to access USDA-NRCS publications and extract relevant parts for the Kuwait Soil Taxonomy. The cooperation of USDA-NRCS during the implementation of Soil Survey Activities and in the finalization of Kuwait Soil Taxonomy is highly acknowledged.

The approval of this book for publication by Sheikh Mohammed Yousif Saud Al-Sabah Director General Public Authority for Agriculture Affairs and Fish Resources (PAAFR), Dr. Mane Alsudairawi Acting Director General KISR, Dr. Afaf Al-Nasser (OD/DD-ELSRC), Dr. Sameer Al-Zenki (DD/STD-ELSRC) and Majda K. Suleiman (Program Manager, Desert Agriculture and Ecosystems Program) is highly acknowledged and appreciated.

Shabbir A. Shahid, Ph.D.

Samira A. S. Omar, Ph.D.

Preamble

Sheikh Mohammed Yousif Saud Al-Sabah

Globally 95% of food is directly or indirectly produced on soils. To have optimum food production from soils and sustaining soil health for long-term services should be taken as a national priority. This requires an understanding of national soils and their rational uses based on their productive capacities for specific projects.

Soils are important for the provision of multiple ecosystem services and the basis for food, feed, fuel and fiber production. Considering the importance of soils of Kuwait for agriculture and food production, Kuwait's Public Authority for Agriculture Affairs and Fish Resources (PAAFR) jointly with Kuwait Institute for Scientific Research (KISR) through international consultant AACM International Australia has completed the Soil Survey of Kuwait in the year 1999. After this completion, it was essential to compile the Kuwait Soil Taxonomy book to enhance the use and application of soil information and maps. PAAFR has been engaged with KISR for decades to enhance applied agricultural research in Kuwait. The joint aim is to promote local food production based on scientific evidence, that

we can achieve economically to reduce dependency on food import, and to avoid disruption in the food supply chain as was the case during the COVID-19 pandemic in many countries. The purpose of the book *Kuwait Soil Taxonomy* is to bridge the knowledge gap about the soils of Kuwait and to help guide potential stakeholders to classify soils and to establish their potentials for national development projects. This is because some soils may be marginal for one use and vital for other uses. The book has come at a time when the world is making significant efforts to double food production by 2030 as a commitment to United Nations-Sustainable Development Goal 2 (End hunger). The book is considered a way forward, well ahead of 2030 to achieve this target in Kuwait. It is believed that the multiple stakeholders of this book, including students, academia, researchers, professionals, decision-makers and land use planners will give this book due consideration in shaping national development in general, and agriculture and food security in specific.

I am very pleased to learn that finally the important task is accomplished. Further, it is a great honor to learn that Kuwait is among the few countries in the world to publish such a unique book. I congratulate the authors for this significant and unique achievement and fully support such professional efforts in the future which are of mutual interests to both PAAFR and KISR for the development of Kuwait.

Sheikh Mohammed Yousif Saud Al-Sabah
Director General
Public Authority for Agriculture Affairs
and Fish Resources (PAAFR)
State of Kuwait

Cistanche tubulosa growing in sandy desert soil

National Leader Soil Survey Standards

Curtis Monger

The Kuwait Soil Taxonomy is an excellent source of information for use by diversified stakeholders who wish to classify soils in Kuwait to locate suitable sites for new projects and infrastructure development. I found the book with excellent contents is written by experienced scientists actively involved in the implementation of Soil Survey of Kuwait Project. The book is published on the latest USDA-NRCS soil classification standards, relevant to the soils of Kuwait. It establishes soil classification standards of Kuwait that can be used for many years to come. The book was peer-reviewed by USDA-NRCS Scientist Dr. Craig Ditzler,

an experienced soil taxonomist. The authors are congratulated for this significant achievement which will be of interest not only to agricultural scientists but also to the decision-makers in Kuwait.

Curtis Monger, Ph.D.
Professor Emeritus
New Mexico State University
Las Cruces, New Mexico and Former National Leader
Soil Survey Standards, USDA-NRCS (retired)

Phragmites australis growing in wet land soil-marshes

International Reviewer Kuwait Soil Taxonomy

Craig Ditzler

This book, *Kuwait Soil Taxonomy*, is an important resource for understanding the land resources of Kuwait. A soil survey of the state of Kuwait utilizing the same standards as those used in the USA was published in 1999. Perhaps the most important aspect of the soil survey is that it not only identifies the kinds of soil occurring in the country, but the maps provide a geographic context for where each of the soils occurs. This is very important for those wanting to understand the soils at a particular location. The Kuwait soil survey utilized the then-current USDA system of soil classification to classify the soils. Since 1999, the USDA Soil Taxonomy has been improved in a number of ways. This includes some changes to the way arid soils such as those of Kuwait are classified. This publication, while based on the original Kuwaiti soil survey, updates the taxonomic information to reflect the most current revisions to the system. Improvements include the kinds and definitions of diagnostic horizons and features, standard conventions for describing soils in the field, new classes identified at the family level of

classification and updated taxonomic keys for determining the correct classification of the soil based on its' properties. All of these updates and more are included in this new publication.

In addition to providing the most current information on soil classification as it applies to Kuwaiti soils, this publication provides some basic information briefly describing how the USDA classification compares to some other systems used around the world. Another important section provides information about the various procedures for collecting samples in the field and measuring various key properties of the soil in the laboratory. It is very important to not only know what the measured value of a key soil property is, but also to know how it was determined.

Kuwait Soil Taxonomy is an important contribution for anyone wanting to understand the land resources of Kuwait. I congratulate the authors for an important job very well done.

Craig Ditzler, Ph.D.
Retired USDA National Leader for Soil Survey Standards
Lincoln, Nebraska, USA

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Rostaria pumila grass growing in sandy desert

About the Authors

Dr. Shabbir A. Shahid was embraced with prestigious *Sir William Roberts* award to pursue a Ph.D. degree in Soil Science specialization in Soil Micromorphology of Salt-affected Soils at the University of Bangor Wales UK, completed in 1989. He has over 40 years experience as a soil scientist in Pakistan, UK, Australia, United Arab Emirates and Kuwait. Currently, Dr. Shahid is Research Scientist, Desert Agriculture and Ecosystems Program, ELSRC-KISR. He was a technical coordinator in multi-million-dollar national soil surveys of the State of Kuwait and Abu Dhabi Emirate and developed the soil survey action plan for the Northern Emirates of UAE and the Republic of Mauritania. Dr. Shahid, with his co-associates, discovered anhydrite soil which is formally added in the twelfth edition of US Keys to Soil Taxonomy as a diagnostic horizon, mineralogy class and subgroups in the Salids suborder of the order Aridisols. He is also the Principal author of United Arab Emirates Keys to Soil Taxonomy published by Springer. In addition, Dr. Shahid is a creator and co-founder of the Emirates Soil Museum launched in 2016 at the International Center for Biosaline Agriculture, Dubai United Arab Emirates.

He is a prolific author of over 160 scientific papers published in peer-reviewed scientific journals, book chapters, conference proceedings and newsletters. As Editor/Co-editor/Principal author, he

Erodium glaucophyllum a perennial herb grows on rocky terrain on shallow sandy soil

published seven books by professional publisher Springer. At the time of book preparation, Dr. Shahid $\mathbf{R}^{\mathbf{G}}$ score was 26.44, h-index 20 with 1,610 citations, 1,880 research interests and over 127,000 reads globally. His $\mathbf{R}^{\mathbf{G}}$ score of 26.44 is higher than 82.5% of all Research Gate members' scores.

Dr. Samira A. S. Omar was appointed by the Kuwait Council of Ministers as the Director General of KISR from 2016–2021. She was responsible for the Science, Technology and Innovation (STI) development and promotion in the country. Currently, Dr. Omar is Principal Research Scientist conducting full-time Research & Development (R&D) at KISR. She has led many projects to conserve biodiversity, restore ecosystems and promote sustainable agricultural development in Kuwait. Dr. Samira also led the Soil Survey for the State of Kuwait Project from 1995–1999 and the Kuwait Environmental Remediation Program (KERP) for the United Nations Compensation Commission (UNCC) from 2011–2014. Dr. Samira is affiliated with many international organizations, such as the International Union for Conservation of Nature (IUCN) and the Society for Ecological Restoration (SER). Dr. Omar is a Research Fellow at The World Academy of Sciences (TWAS) and has received many awards for her scientific achievements. Recently, she received the Decoration of OSI (Order of the Star of Italy) at the very high rank of Grand Officer for her collaboration with the Government of Italy in Research & Development (R&D) in 2021. She was also honored with the Theodore M. Sperry Award 2019 by SER in September 2019. Dr. Samira holds a Ph.D. degree in wild land resource science from the University of California, Berkeley. She is a prolific author of many peer-reviewed research papers, conference proceedings and book chapters. She published many books on the vegetation of Kuwait, protected areas and remediation of environmental pollution.

Tamarix aucheriana growing in the saline coastal flat

Acronyms and Abbreviations

AACM	Australian Agriculture Consultant Management
AAGD	Aridland Agriculture and Greenery Department
AAS	Atomic Absorption Spectrophotometer
AASHTO	American Association of State Highway and Transportation Officials
°C	Degree centigrade
CEC	Cation-Exchange-Capacity
COVID 19	Coronavirus Disease 2019
DAEP	Desert Agriculture and Ecosystems Program
dS/m	deci Siemens per meter
DTA	Differential Thermal Analysis
EAD	Environment Agency Abu Dhabi
EC	Electrical Conductivity
ECe	Electrical conductivity of soil saturation extract
ELSRC	Environment and Life Sciences Research Center
ESP	Exchangeable Sodium Percentage
°F	Degree Fahrenheit
FAO	Food and Agriculture Organization
HCl	Hydrochloric acid
ICP	Inductively Coupled Plasma
IRA	Infrared Analysis
IUSS	International Union of Soil Sciences
KISR	Kuwait Institute for Scientific Research
kPa	Kilo Pascal
MAF	Ministry of Agriculture and Fisheries
MAW	Ministry of Agriculture and Water
MoEW	Ministry of Environment and Water

PAAFR	Public Authority for Agriculture Affairs and Fish Resources
SAR	Sodium Adsorption Ratio
SI System	International System of Units
TWAS	The World Academy of Sciences
UNESCO	United Nations Educational, Scientific and Cultural Organization
USA	United States of America
USDA-NRCS	United States Department of Agriculture-Natural Resources Conservation Service
WRB	World Reference Base
XRDA	X-Ray Diffraction Analysis
XRF	X-Ray Fluorescence

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