THE NATURE AND PROPERTIES OF SOILS

THE NATURE AND PROPERTIES OF SOILS *8th Edition*

NYLE C. BRADY

Professor of Soil Science
New York State College of Agriculture and Life Science
Cornell University
and Director, International Rice Research Institute,
Philippines

MACMILLAN PUBLISHING CO., INC.
New York
COLLIER MACMILLAN PUBLISHERS
London

PRINTED IN THE UNITED STATES OF AMERICA

MACMILLAN PUBLISHING CO., INC.
866 Third Avenue, New York, New York 10022

COLLIER-MACMILLAN CANADA, LTD.

Library of Congress Cataloging in Publication Data

Brady, Nyle C
The nature and properties of soils.

Sixth-7th ed. by H. O. Buckman and N. C. Brady.
1. Soil science. I. Buckman, Harry Oliver, (date) The nature and properties of soils. II. Title.
S591.B79 1974 631.4 73-1046
ISBN 0-02-313350-3

Printing: 1 2 3 4 5 6 7 8 Year: 4 5 6 7 8

PREFACE

CHANGE is the name of the game in modern soil science. Not only have new discoveries dictated subject matter changes but society has forced changes by demanding solutions to pressing human problems. In addition, teaching methods have become more informal. Students are increasingly involved in independent study, each student being given an opportunity to move at his or her pace. Simultaneously, the science background of college students has broadened, which makes it easier for them to comprehend the constitution of soils and the biological, chemical, and physical processes occurring in soils. The changes made in this eighth edition reflect both increased knowledge of soils and the use of this knowledge to solve emerging societal problems.

Growing knowledge of and concern for environmental pollution have dictated major changes from previous editions. Soil is being used more and more as a recipient of organic and inorganic wastes from both the farm and the city. These wastes include pesticides, animal manures, industrial chemicals, domestic sewage, and nuclear contaminants. Their effects on soil processes and properties and on plants grown in these soils are a public as well as a scientific concern.

This eighth edition responds to the concern for the soil as a recipient of wastes in two ways. First, a new chapter on soil pollutants has been added. This chapter provides a general discussion of the pollutants, their reactions in soils, and their effects on soil organisms including plants. Second, the chapter on animal manures has been rewritten to reflect changes in the concepts of animal wastes in modern agriculture, and other chapters, such as those concerned with the loss of nutrients from soils, have been revised to take into account aspects concerned with environmental quality.

Another marked change over previous editions relates to the treatment of soil water. In recent years, scientists have developed a unified energy concept of water as it enters and moves in soils, is absorbed and translocated through plants, and is finally evaporated from the leaves into the atmosphere. This concept of a soil–plant–atmosphere continuum (SPAC) is the basis for major changes in the three chapters on soil moisture. The energy relations of water as it moves through the SPAC have been presented in terms easily understood by students having their initial exposure to soils.

The introductory chapter has been expanded to include a glimpse of the historical development of soil science. Similarly, some historical perspective of the evolution of current concepts of soil classification is included in Chapter 12. The comprehensive classification system of the U.S. Department of Agriculture is emphasized, only general reference being made to other systems.

Minor revisions have been made in all chapters of the book. The treatment of soil organisms and organic matter has been brought up to date. Chapter 13 has been revised to incorporate the new comprehensive classification system as it relates to organic soils.

The readability of the text has been improved by reducing the number of footnotes and by placing references at the ends of chapters rather than at the bottoms of pages and in figures and tables. Changes were made to reduce the formality of expression throughout the text, and many new figures and tables have been added.

The author is indebted to the many soil scientists who made suggestions for improving the text; to his wife, Martha, for typing, proofreading, and checking references; to Frances Geherin of his office for editing the manuscript; and to Patricia Oplinger, Roberta Reniff, Grace Saatman, and Mildred Townsley for typing it.

N. C. B.

CONTENTS

Chapter 1

THE SOIL IN PERSPECTIVE

MAN is dependent on soils—and to a certain extent good soils are dependent upon man and the use he makes of them. Soils are the natural bodies on which plants grow. Man enjoys and uses these plants because of their beauty and because of their ability to supply fiber and food for himself and his animals. Man's standard of living is often determined by the quality of soils and the kinds and quality of plants and animals grown on them.

But soils have more meaning for man than as a habitat for growing crops. They underlay the foundations of houses and factories and determine whether these foundations are adequate. They are used as beds for roads and highways and definitely influence the length of life of these structures. In rural areas soils are often used to absorb domestic wastes through septic sewage systems. They are being used more and more as recipients of other wastes from municipal, industrial, and animal sources. The deposition of undesirable silt in municipal reservoirs makes the protection of soils in upstream watersheds as important to the city dweller as to his counterpart on the farm or in the forest. Obviously, soils and their management are of broad societal concern.

Great civilizations have almost invariably had good soils as one of their chief natural resources. The ancient dynasties of the Nile were made possible by the food-producing capacity of the fertile soils of the valley and its associated irrigation systems. Likewise, the valley soils of the Tigris and Euphrates rivers in Mesopotamia and of the Indus, Yangtse, and Hwang-Ho rivers in India and China were habitats for flourishing civilizations. Subject to frequent replenishing of their fertility by natural flooding, these soils provided continued abundant food supplies. They made possible stable and organized communities and even cities, in contrast to the nomadic, shifting societies associated with upland soils and with their concomitant animal grazing. It was not until man discovered the value of manures and crop residues that he was able to make extensive use of upland soils for sustained crop culture.

Soil destruction or mismanagement was associated with the downfall of some of the same civilizations which good soils had helped to build. The cutting of timber in the watersheds of these rivers encouraged erosion and topsoil loss. In the Euphrates and Tigris valleys, the elaborate irrigation and drainage systems were not maintained. This resulted in the accumulation of harmful salts, and the once productive soils became barren and useless. The proud cities which had occupied selected sites in the valleys disintegrated and the people migrated elsewhere.

History provides lessons which modern man has not always heeded. The wasteful use of soil resources in the United States during the white man's first century of intensive agricultural production provides such an example. Even today there are many who do not fully recognize the long-term significance of soils. This may be due in part to widespread ignorance as to what soils are, what they have meant to past generations, and what they mean to us and future generations.

1:1. What Is Soil?

CONCEPTS OF SOIL. Part of the lack of concern for soils may be attributed to different concepts and viewpoints concerning this important product of nature. For example, to a mining engineer the soil is the debris covering the rocks or minerals which he must quarry. It is a nuisance and must be removed. To the highway engineer the soil may be the material on which a roadbed is to be placed. If its properties are unsuitable, he must remove it and replace it with rock and gravel.

The average homeowner also has a concept of soil. It is good if the ground is mellow or loamy. The opposite viewpoint is associated with "hard clay" which resists being spaded up into a good seedbed for a flower garden. The homemaker can differentiate among variations in the soil, especially those relating to its stickiness or tendency to cling to shoe soles and eventually to carpets.

The farmer, along with the homeowner, looks upon the soil as a habitat for plants. He makes a living from the soil and is thereby forced to pay more attention to its characteristics. To him the soil is more than useful—it is indispensable.

A prime requisite for learning more about the soil is to have a common concept of what it is. This concept must encompass the viewpoints of the engineer, the homeowner, and the farmer. In developing this concept, brief consideration will be given to the practical and scientific discoveries of the past.

1:2. Evaluation of Modern Concepts of Soil

There are two basic sources of our current knowledge of soils. First, there is the practical knowledge gained by farmers through centuries of trial and error. This was the only information available before the advent of modern science, which now provides a second source of facts about soils and their management.