METHODS OF SOIL ANALYSIS

Part 2
AGRONOMY

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METHODS OF SOIL ANALYSIS

Part 2

Chemical and Microbiological Properties

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Sponsored jointly by the
AMERICAN SOCIETY OF AGRONOMY
and
AMERICAN SOCIETY FOR TESTING AND MATERIALS

Number 9 in the series
AGRONOMY

American Society of Agronomy, Inc., Publisher
Madison, Wisconsin, USA
1965
GENERAL FOREWORD

AGRONOMY—An ASA Monograph Series

The need for comprehensive treatments of specific subject matter areas was realized by members of the American Society of Agronomy several years ago. As a result, the first monograph of a series entitled “Agronomy” was published in 1949. Dr. A. G. Norman, an eminent member of the Society, was appointed general editor and served in this capacity for the first six publications. Since the Society, a nonprofit organization, was not initially able to finance the project, arrangements were made with Academic Press, Inc., of New York to publish the monographs. This procedure was used for the first six monographs. This fact explains why these six publications are not available at the Society Headquarters Office but instead from Academic Press, Inc.

By 1957, the Society had developed considerably and had in operation a Headquarters Office with a competent editorial staff which made it possible to editorially manage its publications. Also, the financial stability of the Society now enabled it to pursue independently the monograph project, including complete financing and publishing of the series.

The ASA now presents its ninth contribution, with several more in preparation. In contrast to the first eight “volumes,” the ninth and succeeding issues will be referred to as “numbers.” As reported in the Preface, the project which was to become this monograph on Methods of Soil Analysis was conceived and initiated in 1957 by the Soil Science Society of America. During the course of development of the project it became apparent that the publication would be a particularly large and expensive one. The American Society of Agronomy had in its organization a Monographs Committee to which was assigned the responsibility to decide on the appropriateness of subject-matter for ASA monographs while at the same time taking note of the financial obligations related to this project. With the agreement of the SSSA, the Monographs Committee recommended the sponsorship and complete financing of this monograph to the ASA. Approval to proceed was given by the American Society of Agronomy.

It may interest readers to know that members of the SSSA are members of the ASA and that members of the Crop Science Society of America are also members of the ASA. The three societies, while administratively separate, autonomous, and individually incorporated organizations in Wisconsin, are closely associated, work harmoniously together, and share a Headquarters Office and staff in Madison, Wisconsin. The readiness of the ASA to sponsor a project initiated and successfully carried through by an SSSA committee, the members of which are also ASA members, is a further indication of the desirability and practicality of the existing favorable inter-relationship among these associated societies.

December 1964

Matthias Stelly
Executive Secretary-Treasurer
American Society of Agronomy
Crop Science Society of America
Soil Science Society of America
Cooperation on a project like this monograph on soil analysis is appropriate for the American Society of Agronomy and the American Society for Testing and Materials. The American Society of Agronomy has primary concern for efficient agricultural production while ASTM interest covers standards and test methods used in engineering and industrial applications. Numerous soil characteristics are significant and important to both, and both societies subscribe to full use of applicable science in making soil of maximum benefit to man.

Historically the processes of testing and analyzing soil have relied heavily on standardized apparatus and standardized procedures. With a complex, heterogeneous and reactive material like soil, we have been fortunate when the purpose of a measurement has been sufficiently understood that a realistic and useful testing procedure could be devised.

As knowledge increases of the components, principles and mechanisms represented in soil, soil scientists can deal increasingly with properties that can be defined, ideally, in such a way that measured values are independent of apparatus or method and can be expressed in standard units. There are some who would restrict the technical meaning of the term “property” to such “qualities” of matter. For soil it is not always possible to define such properties that will serve our needs. The reader will be interested to see how far we have progressed in this direction.

For ASTM, standardization of specifications and methods of testing is an important consideration. Even though there are properties for which different methods may yield similar results, the ultimate objective would be to establish a single standard method.

Skill is required in the definition of useful soil properties, in devising suitable measuring methods and in making the determinations. It is the purpose of this intersociety monograph to assemble and disseminate these skills for the analysis of soil. We are much indebted to the Editor, to his staff, and to the many contributing authors.

December 1964

Lorenzo A. Richards, President
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PREFACE

The need for authoritative information on soil analysis is shared by most soil scientists, whether or not they are actively engaged personally in making analyses. Comprehensive and authoritative coverage of a range of subject matter as great as that of soil analysis, however, is hardly possible for a single individual and may be accomplished more readily by cooperation of specialists in the different areas of work. This monograph is a result of the cooperative endeavor of many specialists.

In January 1957, L. B. Nelson, then president of the Soil Science Society of America, appointed a committee to study and recommend whether or not the SSSA should prepare a book on methods of soil analysis and to consider the fields to be covered and the method of organization, selection of methods, and editing. This committee included W. H. Gardner, E. R. Graham, J. J. Hanway, M. L. Jackson, R. F. Reitemeier, R. L. Starkey, and L. V. Wilcox, with C. I. Rich as chairman. The committee recommended that the SSSA prepare such a book. The committee recommended further that the standing committees on methods of soil analysis already existing in the Society, with the addition of a committee on microbiological properties, be given the responsibility of selecting and editing the methods; and that the chairmen of these committees, together with an individual elected by them to be the editor-in-chief, should comprise the editorial board. The recommendations were approved by the executive subcommittee of the SSSA in August 1957 and by the entire executive committee at the annual meeting held in November 1957 in Atlanta, Georgia.

At the same time a parallel and independent development was taking place in the American Society for Testing and Materials. ASTM Committee D-18 on Soils and Rocks for Engineering Purposes, Subcommittee R-6, with the late D. T. Davidson as chairman, was developing plans for a monograph on methods of soil analysis to supplement the methods of tests already published by ASTM. Because the monograph project of the Soil Science Society of America was further advanced than that of the American Society for Testing and Materials when the duplication of efforts was discovered, the ASTM committee offered their full support and cooperation to the SSSA in completing the project.

Contact was then made with the Monographs Committee of the American Society of Agronomy to determine whether the proposed publication
would be suitable as a number in the series of monographs sponsored by the ASA; and contact was made with the American Society for Testing and Materials to determine whether the ASTM wished to join with the ASA in sponsorship. Approval was obtained, and work on the monograph was completed under the supervision of the SSSA committees and editorial board, with the ASA and ASTM serving as joint sponsors of the publication.

The members of the SSSA and ASTM committees who participated in development of this monograph are as follows:

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Immediately following approval of the project by the SSSA, the committee on physical analysis, then under the chairmanship of W. H. Gardner, prepared an outline of subject matter for the portion of the monograph to deal with physical properties. The other committees on soil analysis soon prepared outlines for their respective areas, and the individual outlines were organized into an over-all outline by the editorial board.
Authors for individual sections were selected by the standing committees, and contacts were made by chairmen of these committees. Authors were selected on the basis of their special knowledge of the subject on which they were asked to write, and the choice of methods to be described was left to them. In some instances authors include several methods for making a particular measurement and, when so, usually provide supplementary information to aid the reader in deciding which method best suits his purpose. Thus, with the exception of some ASTM methods, the methods described have not been included because of any specific official action of the Soil Science Society of America, the American Society of Agronomy, or the American Society for Testing and Materials; hence, they should not be considered to be standard or official methods of any of these Societies.

Most of the sections deal with methods of soil analysis, as the title implies. The few that do not have been included because the methods and related information they contain are of importance to people working with soils and frequently are needed by them.

Although a monograph entitled methods of analysis might be strictly a set of directions for performing the operations required to make the measurements, the editorial board was in unanimous agreement from the beginning that this style of presentation would not fulfill the total need of readers for information about the methods. Authors, therefore, were asked to include not only the specific directions for the measurements but also the principles of the method, comments on such matters as limitations, pitfalls, and precision, and reference to sources in the literature to which the reader might go for further study.

The standard pattern of treatment is followed with most subjects, but it is inapplicable for a few; and, in such instances, departures from the standard format are made. In the subject of analysis of nitrogenous gases, for example, the authors do not consider that proven methods are available; accordingly, they give no methods in detail but instead provide an analysis of the literature to serve as a basis for research to develop suitable methods.

An attempt has been made to produce a treatise that is self-sufficient, so that a reader with good background knowledge of science can obtain what he needs to know of the theory and practice without having to consult other sources, which might not be readily available. This objective has been accomplished to different degrees in the different sections. In some, the breadth of material is so great that a considerable compromise has been necessary. For example, in the subject of petrographic methods, standard techniques may be found in books on optical mineralogy. Be-
cause the material is so extensive, the author does not attempt to repeat it in the form of specific directions. Rather, he confines his remarks principally to the special aspects of petrographic methods that have to do with soils, and he makes reference to sources in the literature where the specific directions may be obtained.

Considerable thought was given to the subject of indexes of availability of plant nutrients. From the standpoint of numbers of analyses performed, such measurements undoubtedly are of first importance. Nevertheless, measurements on soils to obtain indexes of availability of plant nutrients have an empirical aspect that is not so generally present in measurements of other properties. Moreover, the number of methods in use is large, and there is relatively little standardization among different laboratories. Because it was obvious that all methods found to be useful and perhaps satisfactory in one location or another could not be included, a compromise was made, and only a few methods have been given, again at the discretion of the authors.

Manuscripts submitted by authors were reviewed by the committee chairman or by one or more other persons (usually members of the SSSA committees on soil analysis) and sometimes by both, as well as the editor-in-chief; and the comments prepared were transmitted to the authors, as is customary with journal papers. Because a period of several years was required to complete the monograph, authors were given an opportunity, immediately prior to typesetting, to make revisions in their manuscripts. A number of authors made revisions and added new material at that time.

Throughout the monograph, frequent reference is made to specific commercial products and manufacturers. Such information is included for the convenience of the reader and should not be taken as an endorsement of the products or manufacturers to the exclusion of others by the Soil Science Society of America, the American Society of Agronomy, the American Society for Testing and Materials, or the author's employer.

Special recognition is due Oscar Kemphorne for the counsel and assistance he so generously provided in connection with the parts of the monograph dealing with statistics of measurement and sampling. Similar recognition is due Donald T. Davidson, late chairman of ASTM Subcommittee R-6 on physico-chemical properties of soils, and his successor, R. L. Handy, for their contributions to the sections of the monograph dealing with soil mechanics. Thanks are due L. Boersma for his work in an editorial capacity in the area of physical properties during the temporary absence of the chairman of the committee. Thanks are due P. F. Low for his advice on technical matters. And finally, appreciation must be ex-
pressed to the many anonymous reviewers who provided their time and
talents to aid in maintaining high standards in the technical subject matter
of the monograph and to R. C. Dinauer, of the Headquarters Staff of the
American Society of Agronomy, for his painstaking job of editing the final
copy for publication.

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Ames, Iowa
September 1964

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**Francis E. Clark**

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**Francis E. Clark**

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**Torrence H. MacDonald**

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**G. R. Blake**

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**R. C. Reeve**

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#### 43 Particle Fractionation and Particle-Size Analysis

Paul R. Day

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G. W. Kunze

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M. L. Jackson

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