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## The Soil

### Rothamsted Research

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## THE SOIL

(Departments of Chemistry and Physics.)

### (a) SOIL CLASSIFICATION.

XXXIII. E. M. CROWTHER. "*Some Inductive Methods in Pedology.*" Transactions of the Third International Congress of Soil Science, 1935, Vol. I, pp. 339-343.

Three supplementary methods of collecting and analysing soil data are proposed with the object of placing soil classification on a firmer inductive basis.

The collection of local soil names would reveal many natural units which must be accommodated in any general soil classification, and might also show the dominant pedogenic factors. Thus in Great Britain the traditional names emphasise the parent material or the recent geological history, whilst there is a conspicuous absence of names for soils now recognised as belonging to the major world groups.

The genetic interpretation of typical soils might be expressed in terms of a logarithmic time scale analogous to the  $pH$  scale (i.e. negative logarithms to the base 10 of time in years). Empirical methods of classification and mapping for advisory purposes tend to emphasise local differences and obscure the common factors which become important when the soils are to be linked up with those of other regions. In partially surveyed countries there is a danger that valuable observations may be missed by non-specialists working from crude statements of too restricted genetic theories.

An analysis of the distribution of the soils of the European U.S.S.R. in relation to rainfall and temperature brought out the major characteristics of the Russian soil zones and showed which ones were sufficiently widely and regularly spread to be regarded as in substantial equilibrium with climatic factors, and which were not.

### (b) PHYSICAL PROPERTIES.

XXXIV. R. K. SCHOFIELD. "*The  $pF$  of the Water in Soil.*" Transactions of the Third International Congress of Soil Science, 1935, Vol. II, pp. 37-48.

A treatment of soil moisture relationships based on energy considerations has the advantage that the results obtained are true regardless of the mechanisms at work.

Buckingham's assumption that there is an equilibrium suction for each moisture content does not provide a satisfactory practical basis.

The suction needed to withdraw water from a moist soil is, in general, greater than that against which water will enter the soil at the same moisture content.

In order to deal conveniently with the whole range of suction, use is made of the logarithm of the height in centimetres of the equivalent water (or other liquid) column. The symbol  $pF$  is used for this quantity.

The determination of  $pF$  by direct suction, freezing point, vapour pressure, vertical columns, centrifuge and absorbent materials is considered.

It is shown that by carefully distinguishing wetting from drying conditions the results of investigations on plant wilting and field moisture capacity receive a rational interpretation.

It is suggested that in ordinary soils the difference between the behaviour on wetting and drying is due more to micro-plastic resistance to swelling and shrinking, than to surface-tension effects.

Further lines of enquiry are indicated.

XXXV. R. K. SCHOFIELD and J. V. BOTELHO DA COSTA. "*The Determination of the  $pF$  at Permanent Wilting and at the Moisture Equivalent by the Freezing Point Method.*" Transactions of the Third International Congress of Soil Science, 1935, Vol. I, pp. 6-10.

Attention is drawn to two defects in the technique of Bouyoucos and McCool for determining the freezing point of moist soil which lead to serious errors.

Results obtained, when due regard is paid to these points, agree well with the best determinations by vapour pressure and seed adsorption, and give the "wetness" of soil at permanent wilting as approximately  $pF$  4.2.

Determinations of the freezing point at the moisture equivalent give values between  $pF$  2.5 and  $pF$  3.0. A truly constant figure for all soils is not to be expected.

XXXVI. E. W. RUSSELL. "*The Adsorption of Liquids by Clays.*" Transaction of the Third International Congress of Soil Science, 1935, Vol. I, pp. 48-50.

An analysis is made of the factors on which the apparent specific volume (or density) of a clay in different liquids depends.

The results of this analysis are in accord with the hypothesis that clays adsorb non-polar liquids only weakly, if at all; but that the adsorption of polar liquids is due to the orientation of the electric dipoles in their molecules in the electrostatic fields around the exchangeable ions held by the clay and around the negative charges on the clay substrate.

XXXVII. E. W. RUSSELL. "*The Binding Forces between Clay Particles in a Soil Crumb.*" Transactions of the Third International Congress of Soil Science, 1935, Vol. I, pp. 26-29.

The hypothesis is put forward that clay particles are held together in a crumb by orientated molecules of a polar liquid, which was the dispersion medium in the paste from which the crumb was formed. These polar molecules lie between the negative charges on the clay surface and the exchangeable cations that have dissociated from the clay, and they are strongly orientated in the electrostatic field between these charges. The binding link postulated between two clay particles consists of three units: orientated molecules, an exchangeable cation, orientated molecules, and it binds a negative

charge on the surface of one clay particle to a negative charge on the surface of a second. This hypothesis accounts satisfactorily for the main experimental facts concerning the hardness of crumbs and the conditions under which they are found.

(c) PHYSICAL CHEMISTRY.

XXXVIII. G. NAGELSCHMIDT. "On the Lattice Shrinkage and Structure of Montmorillonite." *Zeitschrift für Kristallographie, A*, 1936, Vol. XCIII, pp. 481-487.

A detailed investigation was made of the lattice shrinkage upon dehydration and the structure of montmorillonite, described by Hofmann, Endell and Wilm. The  $d_{(001)}$  spacing shows a proportional increase from 10.5 Å to nearly 15 Å during the uptake of the first four molecules of water per  $\text{Al}_4\text{Si}_8(\text{OH})_4\text{O}_{20}$ , and a slight increase of 0.6 Å during the uptake of the next ten molecules of water. At still higher moisture contents this spacing rises to nearly 19 Å.

These results can be explained by assuming that the first four molecules of water per unit cell enter between the layers of the structure and thus change their distance, whereas the bulk of the next ten molecules of water remains at the surfaces of the crystals.

When water is replaced by methylene iodide or by methyl iodide there is no indication that the liquid takes up definite positions within the lattice.

Some difficulties of explaining these results quantitatively by the detailed structure of montmorillonite are pointed out.

XXXIX. E. M. CROWTHER and S. G. HEINTZE, (with D. J. HISSINK, CHAIRMAN.) "Report of the Soil Reaction Committee on the Investigation of the Glass Electrode Method." *Transactions of the Third International Congress of Soil Science*, 1935, Vol. I, pp. 128-132.

The glass electrode method was tested on 21 soils at six laboratories and proved satisfactory.

The agreement between the quinhydrone and the glass electrode methods is satisfactory for soils without quinhydrone drift, i.e., for soils which give closely similar potentials about 10 seconds and 60 seconds after adding the quinhydrone. For soils with quinhydrone drift the glass electrode results are similar to those measured by quinhydrone after about 10 seconds. Such rapid measurements by quinhydrone are not reproducible and for soils with large quinhydrone drifts the  $p\text{H}$  values should be measured by the glass electrode.

In order to decide whether the quinhydrone method is appropriate, determinations should always be made rapidly (preferably within 10 seconds) and again after 60 seconds, and the latter readings used when the drift is small.

XL. S. G. HEINTZE. "Soil Oxidation-Reduction Potentials and  $p\text{H}$  Values." *Soil Research*, 1935, Vol. IV, pp. 351-355.

The oxidation-reduction potentials (EH) of the majority of a

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large number of widely differing soils, measured by four independent workers, tend to follow the  $pH$  values of the soils. The relationship is similar to that between platinum electrode potentials and  $pH$  values in buffer solutions. It is suggested that the EH values for most soil-water suspensions are essentially rough  $pH$  measurements made by a platinum-platinum oxide electrode. EH values may be used to detect acutely reducing conditions in soils but otherwise appear to have little value. A proposal to use EH measurements on acid-treated soils for diagnostic purposes was criticised on the grounds that they include several independent factors which could be separated and measured accurately.

- XLI. R. K. SCHOFIELD. "*The Interpenetration of the Diffuse Double Layers Surrounding Soil Particles.*" Transactions of the Third International Congress of Soil Science, 1935, Vol. I, pp. 30-33.

Evidence is set out to show that the simple equation,  $x^2=y(y+z)$ , for the Donnan membrane equilibrium is not applicable to soils, because the diffuse double layers surrounding neighbouring particles only interpenetrate to a limited extent.

Freezing point measurements of moist  $Li^+$ ,  $Na^+$ ,  $K^+$ ,  $Mg^{++}$ ,  $Ca^{++}$  and acid-washed soils demonstrate that the interpenetration is less the wetter the soil.

The additional freezing point depression due to ionic dissociation is, broadly speaking, a measure of the repulsive pressure caused by the interpenetration of the diffuse double layers which is liable to destroy the structure of alkali soils.

#### (d) ORGANIC CHEMISTRY

- XLII. E. M. CROWTHER. "*First and Second Reports of the Organic Carbon Committee.*" Transactions of the Third International Congress of Soil Science, 1935, Vol. I, pp. 114-127, Vol. III, pp. 82-83.

The reports summarise co-operative work conducted for the International Society of Soil Science and organised from Rothamsted.

Nine soils were analysed for organic carbon by several methods at eleven laboratories. The dry combustion results by a number of methods gave such concordant results that the choice between these methods is probably to be made on the grounds of laboratory convenience. The removal of carbonates by repeated treatment with sulphurous acid solution gave results agreeing with those from separate determinations of total and inorganic carbon. In wet combustions the recoveries of carbon varied with the details of the technique. A number of rapid chromic acid or dichromate titration methods gave useful approximate results when corrected by appropriate factors. Chloride in two of the soils interfered seriously with many of the analyses.

- XLIII. ALAN WALKLEY. "*An Examination of Methods for Determining Organic Carbon and Nitrogen in Soils.*" *Journal of Agricultural Science*, 1935, Vol. XXV, pp. 598-609.

The details of the Dennstedt dry-combustion method for determining carbon in soils were described, and some simplifications suggested.

The Bangor modified Kjeldahl method for carbon and nitrogen in soils requires carefully standardised heating. Error may arise from contamination of sandy soils by material abraded during grinding in iron or porcelain mills.

For many heavy soils the addition of water before the Kjeldahl digestion is convenient but not essential. For heavy alkaline soils with little organic matter it is advisable to grind the soil very finely and to add water.

The rapid dichromate titration method of Walkley and Black for soil carbon gave satisfactory approximate results. The details of the technique were improved and methods were devised for overcoming disturbances due to chlorides. The method should be useful in advisory and survey work in which the errors of soil sampling in the field are inevitably high.

#### MICROBIOLOGY

(Departments of Bacteriology, Chemistry, Fermentation and General Microbiology)

##### (a) BACTERIA

- XLIV. C. B. TAYLOR. "*Short-period Fluctuations in the Numbers of Bacterial Cells in Soil.*" *Proceedings of the Royal Society of London, B*, 1936, Vol. CXIX, pp. 269-295.

Significant changes in total bacterial numbers, as counted microscopically by the ratio method, have been shown to take place from day to day, in (a) soil freshly taken from the field; (b) soil incubated at constant temperature and moisture conditions; (c) sterilized and re-inoculated soil incubated at constant temperature and moisture conditions.

Using mannite-salts and soil extract media with the plate count method, significant day-to-day changes in bacterial numbers have been recorded in fresh soil.

Significant changes in bacterial numbers at two-hourly intervals have been obtained in fresh soil by both total and plate count methods.

In fresh soil, fluctuations in bacterial numbers have been correlated with moisture on one occasion only, when intermittent rainfall may have been a limiting factor. In the experiment here described fluctuations were at all times independent of soil temperature changes.

By incubating soil under constant conditions of temperature and moisture it has been shown that the bacterial population may change in spite of those conditions being kept uniform.

There is evidence that fluctuations in total numbers are made