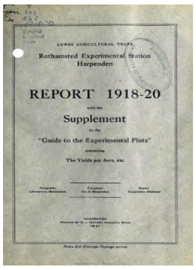
Report 1918-20 With the Supplement to the Guide to the Experimental Plots Containing the Yields per Acre Etc.



Full Table of Content

Chemical Department - Soil Changes IX-xiii

Rothamsted Research

Rothamsted Research (1921) *Chemical Department - Soil Changes IX-xiii ;* Report 1918-20 With The Supplement To The Guide To The Experimental Plots Containing The Yields Per Acre Etc., pp 35 - 38 **- DOI: https://doi.org/10.23637/ERADOC-1-109**

by year and month by month in the same way as the ammoniacal nitrogen and the rainfall until 1910, since when there has been no simple relationship.

Reasons are adduced for supposing that the ammonia arises from several sources. The sea, the soil and city pollution may all contribute. Neither the sea nor city pollution seems able to account for all the phenomena : the soil is indicated as an important source by the fact that the ammonia content is high during periods of high biochemical activity in the soil, and low during periods of low biochemical activity.

The close relationship between the amounts of ammoniacal and nitric nitrogen suggests either a common origin or the production of nitric compounds from ammonia.

The average amount of chlorine is 2.43 parts per million, bringing down 16lbs. per acre per annum. The fluctuations closely follow the rainfall both month by month and year by year, but the general level is much higher during the months September to April than during the summer months. It seems probable that the chlorine comes from the sea, but some may come from fuel.

Since 1888, when the experiments began, to 1916, when they terminated, there has been a rise in the amounts of nitric nitrogen and of chlorine in the rain. In the case of chlorine a parallel series of determinations made at Cirencester over the same period shows a similar rise. There is no rise of ammonia, but on the contrary a tendency to drop : the sum of ammoniacal and nitric nitrogen shows little change over the period. This seems to suggest that a former source of ammonia is now turning out nitric acid : it is possible that modern gas burners and grates tend to the formation of nitric oxides rather than of ammonia.

Rain contains on an average 10 parts of dissolved oxygen per million, the amount being higher in winter than in summer : 66.4lbs. per acre per annum were brought down during the two years over which the determinations extended.

The marked difference in composition between summer and winter rainfall suggests that these may differ in their origin. The winter rain resembles Atlantic rain in its high chlorine and low ammonia and nitrate content : the summer rain is characterised by low chlorine but high ammonia and nitrate content, suggesting that it arises by evaporation of water from the soil and condensation at higher altitudes than in the case of winter rain.

CHANGES OCCURRING IN THE SOIL.

IX. E. J. Russell and E. H. Richards. *"The Washing Out of Nitrates by Drainage Water from Uncropped and Unmanured Land."* (Based on analyses made by the late N. H. J. Miller.) Journal of Agricultural Science, 1920. Vol. X. pp. 22-43.

An investigation of the results obtained by the drain gauges set up by Lawes and Gilbert in 1870.

At the beginning of the experiment the soil contained 0.146% of nitrogen, or about 3,500lb. per acre in the top 9 inches; it yielded up to about 40lb. of nitrogen per acre per annum to the drainage water. At the end of nearly 50 years it still contains 0.099% of nitrogen, or 2,380lb. in the top 9 inches, and it still gives up to the drainage water 21lb. of nitric nitrogen per acre per annum, enough to produce a 15 bushel crop of wheat, although neither manure nor crop residues have been added during the whole of the period. If the curve showing the rate of fall continued its present course and without further slowing down, no less than 150 years would be needed for exhaustion of the nitrogen.

So far as can be ascertained, the nitrogen lost from the soil appears wholly as nitrate in the drainage water. From the top 9 inches of the 20in. and 60in. gauges, the nitrogen lost has been respectively 1,124 and 1,172lb. per acre. The nitric nitrogen in the drainage water amounts to 1,247 and 1,200lb. per acre in the two gauges. These figures are arrived at by adding together the whole of the nitrate found and such estimated amounts as are possible for the first seven years before regular determinations were made, deducting nitrogen introduced by rain. The subsoil is left out of account, but evidence is adduced to show that it contributed little, if anything, to the nitrate in the drainage water.

There is no indication of fixation of nitrogen or loss of gaseous nitrogen. The soil is, however, now very poor in organic matter.

The amount of nitrate washed out is closely related to the rainfall and to a less extent to the sunshine of the preceding summer.

It is difficult to account for the slow rate of removal of nitrogen from the soil unless one introduces into the ordinary cycle some new element acting as a kind of immobiliser, absorbing nitrates or ammonia as they are produced and giving them up again later on. The case would be met if one supposed that some of the soil organisms, such as algæ, bacteria, fungi, etc., assimilated nitrates or ammonia and on their death were themselves decomposed, giving rise ultimately to nitrates again. On this view the nitrogen compounds of the soil would be supposed to break down with formation of ammonia and then nitrate, but only a portion, and not the whole, of this nitrate is liable to loss or assimilation by plants: the remainder would be taken up by organisms, temporarily immobilised, but re-formed on the death and dissolution of the organisms, when again part would be thrown out of the cycle and reabsorbed.

X. D. J. MATTHEWS. "*The Determination of Ammonia in Soil.*" Journal of Agricultural Science, 1920. Vol. X. pp. 72-85.

An aeration method for determining the quantity of ammonia in the soil with more accuracy and in shorter time that hitherto, it being possible to recover 99.5% of added ammonia as against a recovery of 50-60% by the older methods. For details the paper must be consulted.*

The results of application to natural soils is to confirm the older conclusion that ammonia is present in minimal quantities only, but it now becomes possible to follow accurately the changes that occur when stubble or green manure are ploughed in, or when ammoniacal fertilisers are added to the soil.

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*Or Soil Conditions and Plant Growth. 4th. ed. 1921. p. 349.

XI. G. A. Cowie. *"The Mechanism of the Decomposition of Cyanamide in the Soil."* Journal of Agricultural Science, 1920. Vol. X. pp. 163-176.

This paper is of interest as showing the occurrence in the soil of changes which apparently are not brought about by micro-organisms, but by active chemical agents not yet clearly recognised.

It is known (see p. 55) that cyanamide undergoes decomposition in the soil before it can be utilised by the crop as a fertiliser. It is now shown that the decomposition proceeds in three stages: (1) cyanamide gives rise to urea; (2) urea gives rise to ammonia; (3) the ammonia is oxidised to nitrate. The first stage, the formation of urea, seems to be brought about by a chemical agent and not by micro-organisms, but the agent has not yet been discovered. The change proceeds more rapidly in clay than in sandy soils, and it does not take place at all in pure sand, in peat, or in fen soils. There is some indication that the decomposition agent may be a zeolite or active silicate. A sample of Thanet sand taken from a boring through the London Clay near Chelmsford was found, even after ignition, to be active in decomposing cyanamide into urea. This particular sand has been shown to contain a constituent resembling a zeolite in being reactive and possessing the property of softening hard water by the substitution of sodium salts and possibly potassium for those of calcium and magnesium. In following up this clue it was found that the addition of a definite zeolite prehnite to ordinary inert sand produces a mixture capable of converting cyanamide into urea.

The decomposition of urea and the oxidation of ammonia are then brought about by micro-organisms in the usual way.

XII. V. A. Beckley. *"The Formation of Humus."* Journal of Agricultural Science, 1921. Vol. XI. pp. 69-77.

Setting out from an observation by Fenton it is shown that sugars, on treatment with acids, give rise to hydroxymethylfurfuraldehyde, which readily condenses to form a substance closely resembling humus. The author found indications of hydroxymethylfurfuraldehyde in a dunged soil and in rotting straw in which humus was being produced. He suggests, therefore, that the formation of humus in the soil proceeds in two stages:—

1.—Carbohydrates react with acids to produce hydroxymethylfurfural.

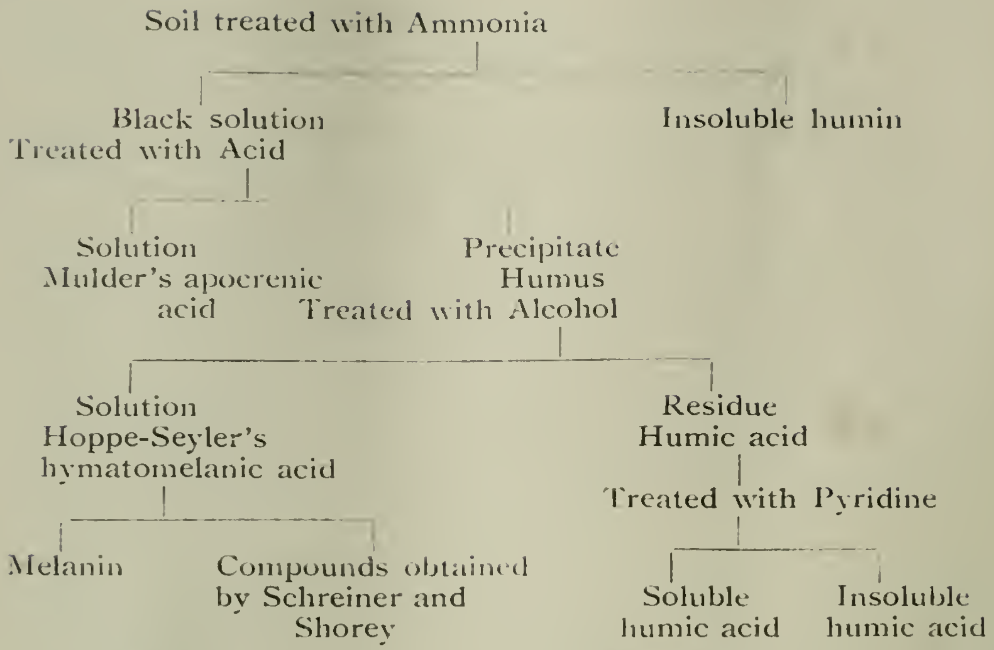
2.—Hydroxymethylfurfural condenses to form humus.

In addition, in the laboratory, there is produced some furfural and lævulinic acid.

No evidence of the formation of hydroxymethylfurfural during the decomposition of cellulose by *Spirochæta cytophaga* could be obtained.

XIII. V. A. Beckley. *"The Preparation and Fractionation of Humic Acid."* Journal of Agricultural Science, 1921. Vol. XI. pp. 66-68.

The author finds that humus may be fractionated according to the following scheme:—



The above procedure has been repeated with rotted straw and with sugar humus, and in both cases similar fractions were obtained. The residue after pyridine extraction of sugar humus was, however, only slowly soluble in ammonia, probably having been converted into humin.

SOIL ORGANISMS.

XIV. L. M. CRUMP. "*Numbers of Protozoa in certain Rothamsted Soils.*" Journal of Agricultural Science, 1920. Vol. X. pp. 182-198.

The method used was an improvement on that previously adopted in this laboratory, but it did not discriminate between active and encysted forms. Determinations were made at intervals of about seven days of the numbers of total protozoa and bacteria in the soil of Broadbalk Plot 2, which receives 14 tons of farmyard manure in each year, and of Harpenden Field, which is typical of poor arable land. The results are plotted on curves from a study of which the following conclusions are drawn :—

1.—Flagellates, amœbæ and thecamœbæ are usually present in these soils in the trophic condition and in comparatively large numbers, so that there is an extensive population actively in search of food.

2.—The protozoan fauna is practically confined to the top six inches of the soil.

3.—There is a definite inverse relation between the numbers of bacteria and amœbæ.

4.—The amœbæ are uninfluenced by variations in the water content and temperature of the soil and by the rainfall.

5.—The richer the soil is in organic matter the richer it is in protozoa, especially in amœbæ and thecamœbæ.

These conclusions are at variance with those arrived at by the American investigators, but it is believed that the methods employed are better than those used in America.