APPROVAL SHEET

Carl Williams Kelley,   Doctor of Philosophy, 1942.

Major: Soils, Department of Agronomy

Title of Thesis: A Study of the Chemical and Physical Changes Produced
in a Soil by the Formation of the Organic Colloidal
Complex.

Thesis and Abstract approved: _____
Professor in Charge of Thesis

Date

ABSTRACT

Carl Williams Kelley, Doctor of Philosophy, 1942.
Major: Soils, Department of Agronomy
Title of Thesis: A Study of the Chemical and Physical Changes Produced
in a Soil by the Formation of the Organic Colloidal
Complex.
Directed by Dr. R. P. Thomas
Pages in Thesis, 23   Words in abstract, 243

Ten Maryland soils having various amounts of organic matter and

being representative of all the soils of Maryland were oxidized by

nine different methods to get an indication of the amount of organic

matter present. The soils treated were Elkton silt loam, Sassafras

silt loam, Portsmouth loam, Sassafras sandy loam, Chester loam, Mahor

loam, Hagerstown silt loam, Congaree silt loam, Ash gravelly loam, and

Penn silt loam. The methods used were, hypoiodite, ammonia extraction,

potassium permanganate, ceric sulphate, Walkley-Black, Thomas-Williams,

sulfato cerate, perchlorato cerate and total carbon.

One soil was incubated in the greenhouse with varying amounts of

organic matter, lime and fertilizer. The Thomas - Williams and Walkley-

Black methods were run on all these samples. Also the base exchange

capacity was determined before and after oxidation on these samples as

well as on the ten soils mentioned above. From this the organic base

exchange capacity was calculated. Oxidation was performed with 6%

H_2O_2.

From the relationship of the various factors there is an indication

that a rapid oxidation may be set up to give a very close approximation

of the organic exchange capacity of the soil. Also, in the treatment

of the soil samples with organic matter, lime and fertilizer, it was seen

that organic materials in themselves may actually decrease the organic

exchange capacity. From these observations it is concluded that the

best method of increasing organic base exchange capacity is by the use of nitrogeneous material and lime.

VITA

Name	Carl Williams Kelley
Degree and date	Doctor of Philosophy. 1942.
Date of birth	January 10,1908
Place of birth	Durham, North Carolina
Secondary education	Durham High school, Durham, N. C.

Collegiate Institutions	Dates	Degree	Date
University of North Carolina	Sept.1924-June 1928	B.S.	June 1928
	Sept.1933-June 1935	M.S.	June 1935
University of Maryland	Feb. 1939-Sept. 1941	Ph.D.	May 1942

Publications   None

Positions held

Chemist, Sanitorium, Charlotte, N. C. September 1929 to September 1931.

Graduate Assistant, University of North Carolina September 1934 until June 1937.

Chemist, North Carolina Department of Agriculture, September 1937 until February 1939.

Research Fellow, University of Maryland from November 1940 until September 1941.

At present, Assistant Chemist, Cooperative Research, Bureau of Mines, College Park, Maryland.

A STUDY OF THE CHEMICAL AND PHYSICAL CHANGES PRODUCED
IN A SOIL BY THE FORMATION OF THE
ORGANIC COLLOIDAL COMPLEX

By
Carl Williams Kelley

UMI Number: DP70426

UMI

Dissertation Publishing

UMI DP70426

ProQuest

ACKNOWLEDGMENT

LIST OF TABLES

TABLE OF CONTENTS

INTRODUCTION

It has long been known that organic matter plays an important part in soil fertility. It serves to improve soils from several standpoints. Among these are improved water holding power, biological conditions, capacity to hold plant nutrients and in other ways improve soil as a medium for plant growth.

The ability to hold plant nutrients and to deliver these nutrients to growing plants is closely associated with the property of base exchange. Since base exchange plays such a prominent part in soil economy, much emphasis has been placed on this topic by soil investigators during the last two decades. The general features of the exchange properties have long been known, but the intensified research of recent years has added much to the practical interpretation of the processes involved.

In view of the great importance attached to soil organic matter in general and to that entering into base exchange capacity in particular, this investigation was undertaken. The investigation involves two important factors. One, a comparison of different methods for the determination of organic matter that enters into the exchange capacity. The other, a study of base exchange in soil as affected by the presence of organic matter.

The bodies of dead organisms (10) and the residues of living matter deposited on and within the soil form the material known as soil organic matter. Soil organic matter theoretically comprises only the dead residue of organisms and the various products of their decomposition. It is practically impossible, however, to separate this material from the living micro-organisms that live in the soil and carry on the task of decomposing the residues. The bulk of the bodies of micro-organisms, together with their own residues, is therefore regarded as a part of soil organic matter.

Chemically, soil organic matter comprises a mixture of a great many substances that may be classified into three groups: (1) carbohydrates, (2) proteins, (3) lignin, and (4) fats, resins, waxes and similar compounds.

The term "humus" (20) is sometimes used to designate soil organic matter. "Humus" is a name given to a group of black, sticky, or waxy, complex compounds that are derived from organic matter originating from substances that the plants have synthesized.

Much of the material that constitutes humus is derived from lignin of plant residues. It has been found that lignin and lignin-like substances have base exchange properties.

McGeorge (6) has shown that the exchange capacity of organic matter is in largest part due to ligneous compounds, and that lignin possesses a chemically equivalent exchange property. As for lignin itself, he says that the exchange capacity depends upon the methods used in preparing or separating it from the mother substance, and that

it may be subject to further increase in exchange capacity by hydrolysis or fractionation. The theory is advanced that a protein linkage is in most part responsible for the exchange property of ligneous material.

Miller (9) has proved that there is an increase in base exchange capacity of organic matter with decomposition.

Miller, Smith and Brown (8) in carrying out base exchange studies on oat straw, wheat straw, etc. found that with decomposition of these materials there was an increase in base exchange capacity, although the increase was not in the same relation to one another. Also they found that mature plants differ greatly in base exchange capacity.

Meyer (7) in exchange capacity studies on mixed organic-inorganic systems determined that the resulting mixture in every case had a lower exchange capacity than the sum of the individual exchange capacities.

In consideration of the important part played by organic matter in base exchange process, it seems that investigations dealing with this phenomena would be more profitable. Possibly the reason is the lack of a definite method for making such determinations. The few determinations of the organic base exchange capacity have been made in one of the following ways (12): (a) the organic portion of the soil is removed by an alkaline extracting solution and reprecipitated by the addition of a mineral acid, and the determination of the base exchange capacity of the organic matter is made directly; (b) the organic matter of the soil is destroyed by gentle ignition, and the base exchange capacity is determined before and after treatment, the difference representing the exchange capacity of the organic matter; (c) the organic matter of the soil is destroyed by treatment with hydrogen peroxide, and the base exchange capacity is determined as in (b).

In any of the foregoing procedures, serious objections may arise.
The chief objection to (a) is that this procedure requires considerable
time. Also, the exchange capacity of the organic matter depends upon
the method used in preparing or separating it from the mother substance.

In (b) there is a serious threat of dehydrating the soil minerals
by ignition and thus reducing the base exchange capacity of the in-
organic complex. A second serious threat to the procedure is that
7 or 8 hours of ignition are required to bring about the destruction of
the organic matter.

In (c) there is a possibility that the peroxide treatment might
effect the inorganic base exchange capacity in a manner similar to
that of ignition. McGeorge (6), however, showed that digestion with
H₂O₂ does not effect the exchange capacity of synthetic zeolites. The
principal objection to the use of this procedure is the inconsistency
in the manner in which the oxidations have been carried out. Also,
there is a lack of definite information concerning the effects of
various concentrations of peroxide in making such determinations.

Broadfoot and Tyner (3) point out that the exchange capacity of
organic residues varies with the cation used for saturation of the ex-
change complex. For instance, the absorptive capacity for ammonium was
found in all cases to be considerably less than that for the divalent
cations.

Bartlett, Ruble and Thomas (2) found, in using the hydrogen per-
oxide method of determining organic exchange capacity, that this reagent
increased the inorganic exchange capacity in some of the soils.

Base exchange, (10) whether organic or inorganic, is a property

of soils that has very important practical applications. When a
simple salt, such as KCl, is added to a soil, some potassium changes
places in the colloidal particle with calcium, sodium and other mineral
base elements, and these in turn enter into the soil solution. The
result is that only a part of the potassium which was added in solu-
tion remains water soluble.

"Base exchange capacity" is a term that is used to denote the
measure of the relative ability of a soil to retain basic elements.
"Exchangeable cations" would possibly be a better term, for then
hydrogen which also plays an important part in base exchange reactions
would be included.

Ion exchange (base exchange) (19) may be defined as a reversible
interchange of ions between a liquid phase and a solid body which does
not involve any radical change in the solid structure. It was first
observed in soil by Way in 1850. He passed a solution of KCl through
a bed of soil, and found that all the potassium was removed from the
solution and replaced by an equivalent amount of calcium and sodium
from the soil.

Gedroiz and Hissink (20) have shown that base exchange obeys the
chemical law of mass action and equilibrium. According to Gedroiz,
the law of soil base exchange may be stated as follows: "Absorbed
ions of soil compounds are displaced by other ions in equivalent
ratio."

Only a limited quantity of an exchangeable basic element of a
soil material can be brought into solution by the single addition of
a displacing agent; but under leaching conditions, the displacement

can finally be made complete, as Gedroiz and Hissink have shown.

From the foregoing review of literature it can be seen that the methods used for the determination of organic matter as well as those used for determining the organic matter that enters into the exchange complex are far from satisfactory. It is hoped that the material presented in the following pages may throw a little more light on the problem.

A survey was made on ten representative Maryland soils (5) for organic and inorganic base exchange capacity. These soils were used because they varied in organic matter content and genealogy. It was thought that results obtained from these treatments might be applicable to Maryland soils in general. Also, these soils were subjected to determinations for total organic matter as well as the fraction of organic matter that is readily oxidizable. Samples of one soil were brought into the greenhouse and allowed to incubate with various treatments of organic matter, lime and fertilizer. Base exchange capacity and organic matter extractions were determined on these soils.

For the base exchange analysis, the leaching method of Schollenberger and Dreibelbis (13) was used with slight modifications for the soils which were extracted with barium acetate. The pH of this solution was adjusted to 7.0. In this method, ten grams of soil were weighed out and transferred to a leaching tube. However, instead of using tubes having a perforated porcelain disc covered by a filter paper, leaching tubes with sintered glass discs were employed. These speeded up the leaching process considerably. A rubber policeman was placed on the stem of the leaching tubes so that the soil might soak in the 150 m.l. of leaching solution over night. In the morning the policeman was removed and the solution allowed to leach through the soils. Then the leached soils were washed with successive portions of distilled water until the washings showed no tests for barium ions with dilute H_2SO_4. Ninety-five percent alcohol was used in one or two small portions for

leaching in order to decrease hydrolysis. The washed soils were next leached with 150 m.l. of one normal potassium solution in order to displace all of the barium ions present in the exchange complex. The displaced barium was determined by using a slight modification of the method recommended by Scott (14).

The base exchange capacity was determined before and after oxidation of the soils. (For results see Table 2). The oxidation was accomplished with hydrogen peroxide, using six treatments of twenty-five m.l. of six percent hydrogen peroxide. Each portion was allowed to remain on the soil over night and then drained off the following morning by removing the policeman from the stem of the tube.

A pH determination was made on each of the soils by means of the Beckman pH meter.

Organic matter determinations were made on the soils before and after oxidation, using the wet method for total carbon (1). This method involves the oxidation of organic matter with a chromic-phosphoric-sulphuric acid mixture and the absorption of the carbon dioxide in standard sodium hydroxide.

Nine different methods for determining organic matter were used on the ten soils. The hypoiodite method used was that of Norman and Peevy (11). In this analysis five grams of soil are used, water added, and iodine and sodium hydroxide placed in the bottle to form NaOI. At intervals portions are withdrawn, HCl added, the iodine titrated with $Na_2S_2O_3$. For the ammonia extraction method, a modification of the method of Cameron and Breazeale (4) was carried out. Instead of using a 3% ammonia solution, as in the method above, the soil was shaken with a 10% ammonia solution, centifuged, the clear extract poured off and

evaporated to dryness on the hot plate. The residue was taken up
with a little distilled water and dilute H_2SO_4, and total carbon
determined. The bleaching powder method made use of was that of
Bradwell and Hall (17). Here five grams of soil were placed in an
evaporating dish along with the bleaching powder. This was made by
weighing out 5 grams, adding water to make 500 m.l. and then taking
out a 20 c.c. aliquot. Ten percent KI and 1 - 1 HCl were added
and the titration made with $Na_2S_2O_3$. Three grams of soil were used
in the $KMnO_4$ method (17). Twenty m.l. of .1093 N $KMnO_4$ were used
and the excess permanganate titrated with Mohr's Salt; ortho-
phenanthroline was used as an indicator. One gram of soil was used
in the Ceric Sulphate Method of analysis. This was put in an 8
inch test tube with 10 m.l. of .1N Ceric Sulphate and heated in
a boiling water bath for 15 minutes. The excess Ceric Sulphate
was titrated with Mohr's Salt. A blank run was made at the same time.
The Walkley-Black Method (18) makes use of only one half gram of
soil. This is mixed with 10 m.l. of $Na_2Cr_2O_7$ and 20 m.l. of con-
centrated H_2SO_4 and heated in a hot water bath for 15 minutes. The
mixture is cooled, diluted, 5 m.l. of H_3PO_4 added and titrated with
Mohr's Salt. This is a modification of the original method. There
is much similarity between the Thomas-Williams method (16) and the
Walkley-Black method. In the former 3 grams of soil are oxidized
with $Na_2Cr_2O_7$ and H_2SO_4, cooled, diluted and an aliquot titrated
with Mohr's Salt. Neither the Sulfato Cerate nor the Perchlorato
Cerate methods (15) have been used before in soil work, but were
employed as described for the determination of glycerol. In the
first method, $(NH_4)_2Ce(NO_3)_6$ was dissolved in 0.5 molar H_2SO_4

added to 1 gram soil and heated on the water bath for 15 minutes. Mohr's salt was used for titration. The second method is very much like the first, except that approximately 35% $HClO_4$ is used instead of the H_2SO_4. Sodium oxalate is used to titrate the excess oxidizing agent. In both of these methods barium diphenylamine sulfonate was used and found to be preferable to any other indicator used so far.

For all the determinations the final calculation was made to give the answer in terms of percent carbon. This was multiplied by the factor 1.724 (4) for conversion to percentage organic matter.

The samples of Beltsville silt loam were collected from the first 6 inches of soil, brought in and well mixed. Thirty-four, two gallon pots were set up, thus giving 17 treatments and checks. Each pot was given treatments as shown in Table 3. The dry organic matter, consisting of wheat straw and soybean straw was added at the rate of 10 grams per kilogram of soil, or 10 tons per acre. The green organic matter used, green wheat and green alfalfa, were added at the rate of 20 grams per kilogram of soil, or 20 tons per acre. The lime added was burnt lime, 40-50% CaO and 9-10% MgO. A 10-6-4 fertilizer was used. It as a neutral mixture, made up of Uramon, 50% muriate of potash and 20% superphosphate, and applied at the rate of $\frac{1}{2}$ gram per kilogram or $\frac{1}{2}$ ton per acre. Also used were 5 pots filled with sand and treated with the same quantities as given above. Each pots was inoculated with soil bacteria. The dry organic material was ground in a Braun Mill, while the green material was ground in a Mixablend Grinder containing water. Moisture determinations were made on the soil by means of the Hilgarde Cups and the pots kept at optimum moisture by adding distilled water at intervals. Every two or three weeks the

contents of the pots were screened, and well mixed. The incubation was carried on for approximately 300 days, at the end of which the contents of the pots were well mixed, samples were taken, air dried and screened.

The determinations made on the pots were as follows: pH value, organic matter determinations by the Thomas-Williams, Walkley-Black and by the total carbon method. Also, base exchange capacity was run before and after oxidation with H_2O_2. All these methods have been described above and the results are given in Table 3.

Even though the data shown in the tables are more or less self explanatory, the discussion is given to emphasize certain important points and to point out the relation of the various factors. For instance, in Table 1, there can be seen the effectiveness of the methods for determining the organic matter content of the various soils. The total carbon determinations is taken as the standard.

The ammonia took out about 20% of the organic material. There seemed to be no relation between the organic matter dissolved and either the total organic matter or organic base exchange capacity. It is possible that if dilute HCl had been used prior to the ammonia treatment, higher and more significant values would have been obtained. Hypoiodite removed 25-50% of organic material. The $KMnO_4$ method was much less effective, giving values a little less than half of the hypoiodite. The Thomas-Williams method is similar in principle to the Walkley-Black procedure but employs a weaker oxidizing solution. It is presumable that this method evaluates the organic matter that may be expected to be well incorporated in the soil. These two methods appeared to give better and more significant values.

The three oxidizing solutions involving cerate as an oxidizing medium bear a certain relationship to one another but vary in their effectiveness. The perchlorato cerate being the mildest oxidizing medium of the group. These three methods removed the organic matter more in proportion to the organic exchange capacity than the other methods.

Bleaching powder was also used as an oxidizing agent but the results

were not included in the table. This method needs further investigation in view of the fact that only slight variations were shown in the results for highly varying soils. The values obtained ranged from 2.03 to 2.35 percent organic matter.

There is shown in Table 2 the base exchange capacity of the un-oxidized and oxidized soils and the base exchange capacity due to the organic matter alone. If the organic exchange capacity for each soil is divided by the percentage organic matter found by the different methods it is believed a relationship will be obtained. If the same numerical value is obtained for all ten soils then there is a definite relationship. This was done as is shown by the results in Table 4. A casual survey of those data indicate that for some of the methods there does seem to be a relationship between the oxidized organic matter and the organic exchange capacity. In order to check this, the standard deviation as well as the coefficient of variation were calculated for these values as well as those in Table 3. In Table 4 the smallest coefficient of variation appears in the Sulfato Cerate method where it is 0.160, and 0.195 for the Perchlorato Cerate method. The latter is not as good a value as the Sulfato Cerate method. However, when the eight soils that have the least variation are subjected to such a statistical analysis the coefficient of variation is 0.091 for the Perchlorato Cerate method and 0.118 for the Sulfato Cerate method.

The coefficient of variation value of 0.091 is considered to be very significant. The coefficient of variation values obtained for the other values which were secured by dividing the organic exchange capacity by the soluble organic matter are not considered to be significant. It would appear that the values obtained for the eight soils by the Per-

chlorate Cerate method is approximately one-tenth that of the organic
exchange capacity. This would indicate that this rapid method might
be used as a means of evaluating the organic exchange capacity. Al-
though more data will have to be obtained before this can be justified.
It appears as if one can estimate fairly closely the organic exchange
capacity by multiplying the amount of organic matter oxidized by the
Perchlorate Cerate procedure by ten.

In Table 3 it can be seen that the treatment definitely influences
the organic exchange capacity. In order that the effects of this
treatment can be more clearly seen the results of Table 3 are summerized
in Table 5. Of the green material, green wheat very definitely decreases
the base exchange capacity while green alfalfa did not lower it quite
so much. In dry material the high nitrogen content had little effect
on the organic exchange capacity while low nitrogen material decreased
it. Organic material alone and fertilizer alone decreased the organic
base exchange capacity. Also lime and fertilizer together did about
the same thing. Lime alone did not decrease the values, but gave even
a little higher ones. Then from these data it would seem that the or-
ganic exchange capacity can only be built up by the use of organic
residues high in nitrogen that do not decompose too readily along with
the judicious use of lime.

In the past the difficulty experienced in attempting to oxidize
organic matter has probably been due to its close association with in-
organic and mineral matter. Since a great deal of both organic and
inorganic active matter is in the colloidal form this means that the
organic and inorganic colloids are very closely related. The impression
acquired from the literature bears out this observation as well as those

data assembled in this investigation. In the latter case the Sulfato Cerate and Perchlorate Cerate probably oxidize the organic matter in the relation in which it exists in the organic exchange complex.

TABLE 1. Organic Matter Content of 10 Maryland Soils as Determined by Various Methods

	Percent of Organic Matter Obtained by the Different Methods								
Soil Types Used	Pyrolodite Extraction	Ammonia Extraction	Potassium Permanganate	Ceric Sulphate	Walkley-Black	Thomae-Williams	Sulfato Cerate	Perchlorate Cerate	Total Carbon
	%	%	%	%	%	%	%	%	%
Elkton Silt Loam	1.02	0.67	0.50	1.8	3.44	2.24	1.7	0.67	2.6
Sassafras Silt Loam	1.07	0.08	0.45	1.6	1.92	0.59	1.5	0.72	1.8
Portsmouth Loam	0.89	0.85	0.41	2.5	3.66	2.47	2.5	1.25	4.02
Sassafras Sandy Loam	1.10	0.24	0.57	0.73	0.79	0.11	0.98	0.33	0.75
Chester Loam	1.02	0.45	0.39	1.9	2.16	1.77	2.08	0.94	1.95
Manor Loam	1.05	0.24	0.29	2.1	2.55	1.53	2.2	0.93	2.45
Hagerstown Silt Loam	1.02	0.22	0.27	2.6	3.85	2.00	2.6	1.22	3.22
Congaree Silt Loam	1.02	0.71	0.44	2.1	3.56	2.24	2.3	0.86	1.93
Ash Gravelly Loam	0.97	0.45	0.18	2.5	5.20	3.89	2.6	1.44	5.60
Penn Silt Loam	1.03	0.57	0.56	2.3	2.88	2.00	2.5	1.05	2.56

TABLE 2. The Exchange Capacity, Percentage of Organic Matter and pH Values for the 10 Maryland Soils

Soil Types Used	Base Exchange Capacity		Percentage of Organic Matter				pH Value
	Unoxidized	Oxidized	Organic	Unoxidized	Oxidized	Lost by Oxidation	
	m.e.	m.e.	m.e.	%	%	%	
Elkton Silt Loam	11.45	5.80	5.65	2.60	0.79	1.81	4.08
Sassafras Silt Loam	10.30	3.00	8.30	1.80	0.52	1.28	7.58
Portsmouth Loam	16.62	4.00	12.62	4.02	1.19	2.83	4.57
Sassafras Sandy Loam	6.14	1.40	4.74	0.75	0.23	0.52	5.63
Chester Loam	12.27	2.80	9.47	1.95	0.98	1.37	5.16
Manor Loam	15.09	4.30	10.79	1.21	0.73	0.48	6.57
Hagerstown Silt Loam	18.29	6.90	11.39	1.59	0.95	0.64	6.98
Congaree Silt Loam	12.23	3.30	8.93	0.95	0.56	0.39	4.64
Ash Gravelly Loam	16.80	2.50	14.30	2.73	1.63	1.05	6.78
Penn Silt Loam	14.82	5.20	9.62	1.26	0.77	0.49	5.77

Table 3. The effect of Organic Materials, Lime and Fertilizer on the pH Value, Organic Matter and Exchange Capacity of Beltsville silt loam soil.

Plot Number	Soil Treatment	pH Value	Percent of Organic Matter			Base Exchange Capacity		
			Thomas-Williams %	Walkley-Black %	Total Carbon %	Unoxidized m.e.	Oxidized m.e.	Organic m.e.
1 & 2	None	4.4	2.36	2.18	1.85	12.9	6.6	6.3
3 & 4	Wheat Straw	5.0	1.29	1.94	1.82	11.3	7.5	3.8
5 & 6	Wheat Straw (F)	4.7	1.49	1.85	1.97	10.4	6.7	3.7
7 & 8	Wheat Straw (L) (F)	5.1	1.42	2.04	1.90	12.0	6.3	5.7
9 & 10	Wheat Straw (L)	5.1	2.00	2.46	1.80	13.8	6.3	7.5
11 & 12	Green Wheat	4.5	1.77	2.01	1.85	8.1	6.9	1.2
13 & 14	Green Wheat (F)	4.5	1.48	2.14	1.83	12.0	6.8	5.2
15 & 16	Green Wheat (L) (F)	4.5	1.48	1.61	1.78	8.5	7.4	1.1
17 & 18	Green Wheat (L)	4.9	1.54	2.07	1.83	11.6	6.4	5.2
19 & 20	Soybean Straw	4.9	2.12	2.25	1.82	11.7	6.7	5.0
21 & 22	Soybean Straw (F)	4.7	1.83	1.70	1.76	10.7	5.2	5.5
23 & 24	Soybean Straw (L) (F)	5.5	1.55	1.75	1.83	12.2	4.7	7.5
25 & 26	Soybean Straw (L)	4.2	1.72	1.63	1.83	12.2	4.9	7.3
27 & 28	Green Alfalfa	4.6	1.48	1.78	1.78	12.5	5.8	6.7
29 & 30	Green Alfalfa (F)	4.6	1.24	2.32	1.82	11.5	5.4	6.1
31 & 32	Green Alfalfa (L) (F)	5.6	1.48	1.86	1.82	10.0	5.1	4.9
33 & 34	Green Alfalfa (L)	5.1	1.90	1.91	1.80	9.8	4.7	5.1
35	None (L) (F)	7.0	0	0	2.04	1.0	0	1.0
36	Green Wheat (L) (F)	7.0	0	0	2.37	0	0	0
37	Green Alfalfa (L) (F)	7.0	0	0	2.33	0	0	0
38	Wheat Straw (L) (F)	7.0	0	0.65	2.31	3.0	1.5	1.5

(L). Lime
(F). Fertilizer

TABLE 4. The Value Obtained by Dividing the Milliequivalent of the Organic Exchange Capacity by the Percent of Organic Matter Secured with the Different Methods of Determinations on the 10 Maryland Soils.

Soil Types Used	The Numerical Values for the Different Methods								
	Hypoiodite	Ammonia Extraction	Potassium Permanganate	Ceric Sulphate	Walkley-Black	Thomas-Williams	Sulfato Cerate	Perchlorato Cerate	Total Carbon
Elkton Silt Loam	5.54	8.45	11.30	3.14	1.64	2.52	3.32	6.50	2.18
Sassafras Silt Loam	7.75	10.30	1.84	5.20	4.32	14.00	5.50	11.50	4.60
Portsmouth Loam	14.10	14.90	30.04	6.00	3.44	5.15	5.05	11.01	3.14
Sassafras Sandy Loam	4.30	1.97	8.30	6.50	6.00	47.30	4.82	14.30	6.30
Chester Loam	9.25	9.25	24.20	5.00	4.38	4.35	4.55	10.10	4.85
Manor Loam	10.02	44.50	37.00	5.15	4.22	7.05	0.90	11.60	4.40
Hagerstown Silt Loam	11.01	51.50	42.00	4.36	2.95	5.68	4.35	9.30	3.52
Congaree Silt Loam	8.75	12.50	12.20	3.42	2.50	4.00	3.88	10.04	4.60
Ash Gravelly Loam	14.70	31.80	79.50	5.70	2.75	3.69	5.50	9.90	2.56
Penn Silt Loam	9.35	26.00	26.80	4.18	1.85	4.80	3.82	9.15	3.76
Averages	9.48	30.39	27.32	4.87	3.41	9.95	4.57	10.33	4.00

TABLE 5.   The Effects of Soil Treatments on the Organic
Exchange Capacity of a Soil.

Soil Treatments	Average Organic Exchange Capacity m.e.
Wheat Straw	5.2
Green Wheat	3.2
Soybean Straw	6.4
Green Alfalfa	5.2
Organic Materials Alone	4.2
Fertilizer Alone	4.1
Fertilizer and Lime	4.5
Lime Alone	6.3

SUMMARY

Ten representative Maryland soils were oxidized with nine different methods for determining the organic matter content. Also the base exchange capacity was determined before and after oxidation of the soils. Oxidation was performed by means of 6% H_2O_2.

One soil was brought into the greenhouse and incubated with varying treatments of organic matter, lime and fertilizer. The base exchange capacity was also determined on these samples before and after oxidation.

From the results of all these treatments it is concluded that:

1. There is an indication that a rapid method can be devised to estimate the organic exchange capacity of the soil.

2. The use of organic materials alone may actually decrease the organic exchange capacity of a soil.

3. The most satisfactory method to increase base exchange capacity is by the use of nitrogeneous organic material and lime.

BIBLIOGRAPHY

1. Association of Official Agricultural Chemist. Offical and Tentative
    Methods of Analysis. 3rd Edition. Washington, D. C. 1930.

2. Bartlett, J. B., Ruble, R. A., and Thomas, R. P. The Influence
    of Hydrogen Peroxide Treatments on the Exchange Capacity of
    Maryland Soils. Soil Science. 44: 123-128. 1037.

3. Broadfoot, W. M., and Tyner, E. H. Studies on Some Factors
    Affecting the Quantitative Estimation of the Exchange Capacity
    of Organic Matter. Proc. Soil. Sci. Soc. of Am. 4: (1939)
    156. 1940.

4. Cameron, F. K., and Breazeale, J. F. The Organic Matter in Soils
    and Subsoils. Jour. Am. Chem. Soc. 26: 29-45. 1904.

5. Gammon, N. A. Base Exchange Study on Some Maryland Soils. Master's
    Thesis at the University of Maryland (unpublished data).

6. McGeorge, W. T. Organic Base Exchange Compounds in Soils. Jour.
    Am. Soc. Agron. 26: 575-579. July 1934.

7. Meyers, H. E. Physico-Chemical Reactions Between Organic and In-
    organic Soil Colloids as Related to Aggregate Formation.
    Proc. Soil Sci. Soc. Am. 2 (1937): 77. 1938.

8. Millar, H. C., Smith, F. B., and Brown, P. E. The Base Exchange
    Capacity of Decomposing Organic Matter. Jour. Am. Soc. Agron.
    28: 753-767. September 1936.

9. Muller, J. F. Some Observations on Base Exchange in Organic
    Materials. Soil Sci. 35: 229-237. 1933.

10. Nikiforoff, C. C. Soil Organic Matter and Soil Humus. Soils
    and Men. U. S. D. A. Yearbook 929. 1938.

11. Norman, A. G., and Peevy, W. J. The Oxidation of Soil Organic
    Matter with Hypoiodite. Proc. Soil Sci. Soc. of Am. 4 (1939):
    183-188. 1940.

12. Olsen, L. C., and Bray, R. H. The Determination of the Organic
    Base Exchange Capacity of Soils. Soil Science 45: 483-495.
    1938.

13. Schollenberger, C. J., and Dreibelbis, F. R. Analytical Methods
    in Base Exchange Investigations on Soils. Soil Sci. 30:
    161-172. 1930.

14. Scott, W. W. Standard Methods of Chemical Analysis. Volume 1.
    New York. D. Van Nostrand Company. 1927.

15. Smith, G. F., and Duke, F. R. Cerate Oxidimetry. Ind. Eng.
    Chem. Anal. Ed. 13: 558-560. August 1941.

16. Thomas, R. P., and Williams, R. C. A Comparison of the Results
    of Rapid Tests with the Amounts of Available Nutrients
    Obtained by Quantitative Methods on Maryland Soils. Proc.
    Soil Sci. Soc. of Am. 1 (1936): 243-254. 1937.

17. Treadwell, F. P., and Hall, W. T. Analytical Chemistry. Vol. 2.
    New York. John Wiley and Sons, Inc. 1930.

18. Walkley, A., and Black, I. A. An Examination of the Degtjareff
    Method for determining Soil Organic Matter, and a Proposed
    Modification of the Chromic Acid Titration Method. Soil
    Sci. 37: 29-38. 1934.

19. Walton, H. F., Ion Exchange Between Solids and Solutions.
    Jour. Franklin Inst. 232: 305-338. October 1941.

20 Weir, W. W. Soil Science. Chicago. J. B. Lippincott Co. 1936.