THE EFFECT OF AERATION AND OTHER FACTORS ON THE LIME REQUIREMENT OF A MUCK SOIL

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INTRODUCTION

After the work reported in this paper had been practically completed the attention of the author was called to a much more elaborate investigation by Conner (1) along the same line. In view of Conner's paper it might almost seem that the present one is superfluous. However, the methods and conditions of the two investigations differed sufficiently to justify publication of the results of both as supplemental to each other.

METHODS USED AND EXPERIMENTAL RESULTS

In April, 1919, the writer had occasion to determine the lime requirement of some muck soil from the shore of Lake Pontchartrain, Louisiana, and was impressed by the fact that the long time required for air-drying, together with the frequent stirring, probably brought about chemical changes which would affect the determination. Such oxidation changes would presumably reduce the acidity. To test this point some of the soil was air-dried in the usual way and ground to pass a 2-mm. sieve. Another portion was kept in the original moist condition in a sealed jar. Moisture was then determined in both the air-dried and the moist portions and the lime requirement of each was determined by the Johnson method (2). The equivalent of 10 gm. of dry soil was weighed in each case and enough water added to the air-dried soil and to the blanks to make the total amount of water the same in all cases. The mixtures of soil and bicarbonate solution and also the blanks were shaken 10 minutes before filtering.

It is recognized that the Johnson method for lime requirement is rather new and has not yet been generally adopted. However, it is rapid, simple, and concise in its results, and is believed to be eminently suited to an investigation like the present one where comparative results only are desired.

Contrary to expectation, the air-dried sample gave a higher result than the undried sample. In other words, it appeared that aeration had increased the acidity.

The question then arose as to whether a drained and cultivated muck soil would actually tend to become more sour than if it were left undisturbed in its original overflowed, water-logged condition. Incidentally, it was desired to know how much effect lime, in the quantity indicated by the Johnson method, would have in reducing acidity through a considerable period of time, and what changes might take place during storage of the moist and air-dried soil, respectively.

TABLE 1
Lime requirement of muck soil after various treatments
(Expressed in per cent of calcium carbonate on the basis of oven-dry soil)

TREATMENT	APRIL		DECEMBER (COMPARE WITH APRIL)	DECEMBER	
	Moisture	Lime requirement	Lime re- quirement	Moisture	Lime requirement
	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>
A. None.....	76.4	$\left\{ \begin{smallmatrix} 0.501 \\ 0.471 \end{smallmatrix} \right\} 0.486$	0.615	76.1	0.540
B. Air-drying.....	19.1	$\left\{ \begin{smallmatrix} 0.559 \\ 0.536 \end{smallmatrix} \right\} 0.547$	0.418	18.3	0.456
C. Aerobic..... $\left\{ \begin{smallmatrix} 1 \\ 2 \end{smallmatrix} \right\}$				60.7 66.6	$\left\{ \begin{smallmatrix} 0.489 \\ 0.514 \end{smallmatrix} \right\} 0.501$
D. Anaerobic..... $\left\{ \begin{smallmatrix} 1 \\ 2 \end{smallmatrix} \right\}$				78.6 83.1	$\left\{ \begin{smallmatrix} 0.598 \\ 0.617 \end{smallmatrix} \right\} 0.608$
E. Lime plus aerobic.... $\left\{ \begin{smallmatrix} 1 \\ 2 \end{smallmatrix} \right\}$				63.7 58.9	$\left\{ \begin{smallmatrix} 0.411 \\ 0.418 \end{smallmatrix} \right\} 0.414$
F. Lime plus anaerobic... $\left\{ \begin{smallmatrix} 1 \\ 2 \end{smallmatrix} \right\}$				85.0 85.2	$\left\{ \begin{smallmatrix} 0.553 \\ 0.534 \end{smallmatrix} \right\} 0.543$

Different portions of the soil were lettered and preserved as follows:

- A. The original moist soil (76.4 per cent moisture), sealed in a glass jar.
- B. Same as A, only air-dried and ground to pass a 2-mm. sieve. Kept in an ordinary screw-top sample jar.
- C. Same soil as A; 150 gm. in each of two glass jars, 1 and 2. Jars kept uncovered. Soil kept moistened with distilled water and stirred occasionally.
- D. Same soil as A; 150 gm. in each of two glass jars, 1 and 2. Soil covered with distilled water and jars kept tightly sealed.
- E. Same as C except for addition of calcium carbonate in the amount indicated by the original determination on A.
- F. Same as D except for the addition of calcium carbonate as in E.

The tests were started in April, 1919, and continued approximately 8 months. At the end of the period (December, 1919) the contents of jars D and F were transferred to large porcelain dishes and exposed to the air, with occasional stirring, for a few days until the excess of water had evaporated. Moisture was then determined in all of the samples, including the original A and B, and the lime requirement was determined by the Johnson method, distilled water being added to all samples (except the wettest one—F2) and to the blanks in quantity to make the relation of dry soil to total liquid the same in all cases.

Also, determinations were made on A and B using the same quantity of dry soil and total liquid as was used for the original determinations on these samples in April, in order to afford direct comparison between the two dates.

The results obtained, expressed in percentage of calcium carbonate required to neutralize the oven-dry soil, are shown in table 1.

DISCUSSION OF RESULTS

The figures given in table 1 plainly indicate that more acidity was developed under water-soaked, anaerobic conditions than when the moist soil was kept aerated by stirring. Comparing C with D and E with F it will be seen that the lime requirement of the anaerobic soil exceeds that of the aerobic soil by more than 0.1 per cent in each case. However, in view of Conner's results (1) showing that the acidity developed by a peat soil is greater the more water it contains, it cannot be considered as proved that aeration was the controlling factor in the experiments here reported. D and F were much wetter than C and E, respectively, and therefore would probably have developed more acidity even if C and E had not been mechanically aerated. But of course the logical interpretation of Conner's results, as he himself recognizes, is that the drier soils are better aerated by diffusion than are the wetter soils, and that the oxidation thus accomplished is at least one factor which tends to decrease acidity.

If the Johnson method furnishes a true or even approximate measure of soil acidity, then it appears that the addition of lime to this soil has greatly increased the rate of formation of acids. Thus sample E, which was supposed to be exactly neutral at the beginning of the experiment, developed during the 8 months a lime requirement of 0.414 per cent, while sample C, which started with a requirement of 0.486 per cent, showed 0.501 per cent at the finish—or a difference of only 0.015 per cent developed during the 8-month period. Similarly, sample F, which was neutralized with lime at the beginning, developed an acidity of 0.543 per cent, while sample D, without lime, developed only the difference between 0.608 and 0.486 per cent, or 0.122 per cent. This accelerated rate of acid formation is probably not to be explained by the presence of the calcium, but by the Law of Mass Action. The exactly neutralized soil would naturally develop acidity much more rapidly than one already containing much acid.

However this may be, it is evident that in liming a muck soil for permanent results one should apply much more lime than is indicated by the lime-requirement determination, in order to take care of subsequently developed acidity.

As already noted in the first part of the paper, sample B, air-dried, showed a higher lime requirement than sample A, undried. Conner also found that air-drying increased the acidity in many cases, though not in the case of an organic soil containing much water, such as sample A.

But when samples A and B were kept in storage for 8 months some notable changes took place. Sample A, containing 76 per cent of water, developed a considerable increase of acidity (changing from 0.486 to 0.615 per cent) while the air-dried sample (19 per cent moisture) changed in the other direction, from 0.547 to 0.418 per cent.

Some light is thrown on the nature of the Johnson method for lime requirement, and all similar methods, by a consideration of the two sets of values found for A and B in December. In the first case, where the same ratio of dry soil to total liquid was used as had been used in the April determinations, somewhat different results were obtained than in the second case where a greater amount of total liquid was used in order to make the results comparable with those of C, D, E and F. This, of course, merely emphasizes the well known fact that all such methods are only comparative, not absolute, and that conditions must be rigidly controlled in using them.

SUMMARY

A typical black muck soil was treated in various ways in order to study the effect of aeration and other factors on lime requirement as determined by the Johnson method.

It was found:

That the lime requirement of this soil was increased by air-drying.

That when the soil was kept moist and frequently stirred for a period of 8 months the increase of acidity was decidedly less than when it was kept covered with water in a sealed jar.

That soil which was first neutralized with calcium carbonate and then kept for a period of 8 months, under either aerobic or anaerobic conditions, developed a great deal more acidity than did unneutralized soil under the same conditions. This is explained by the Law of Mass Action.

That the lime requirement of all samples stored in a moist condition was increased, but that the air-dried sample decreased in acidity during storage.

It was emphasized that results obtained by the Johnson and similar methods are comparative rather than absolute, and that rigid conditions must be adhered to in using such methods.

REFERENCES

- (1) CONNER, S. D. 1918 Soil acidity as affected by moisture conditions in the soil. *In* Jour. Agr. Res., v. 15, no. 6, p. 321.
- (2) JOHNSON, M. O. 1918 Reaction of Hawaiian soils with calcium bicarbonate solutions, its relation to the determination of lime requirements of soils, and a rapid approximate method for the determination of lime requirements of soils. *In* Jour. Indus. Engin. Chem., v. 10, no. 1, p. 31.