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THE EFFECT OF REPLACING BASES WITH HYDROGEN ON MICROBIOLOGICAL ACTION IN SOILS

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The activities of microorganisms in the soil are affected by a large number of factors and one of the principal ones is the hydrogen ion concentration of the soil. The decomposition of organic matter may take place at a low pH as well as at a high pH; however, the type of organisms responsible for decomposition varies at different pH values and the rate and character if the decomposition may also change considerably.

Pierre (1) found a high correlation between the percentage base saturation of acid soils and plant growth, and suggested that the degree of saturation is one of the most important factors determining the growth of plants on acid soils. He also suggested that the relative proportion of the various bases present in the exchange complex and in the soil solution may be contributing factors to the poor plant growth obtained on acid soils.

A study of the decomposition of humus forming materials in the soil is of large practical as well as technical value. Many investigations have shown that a fairly close relationship exists between the rate of decomposition of organic matter in soils, the rate of carbon dioxide production, and the numbers of bacteria. Comparisons of the rate of decomposition of some plant materials have been made but only a small number of materals have been studied in detail.

Millar, Smith and Brown (2, 3) found that certain plant materials high in nitrogen decomposed more rapidly during the first few days of decomposition than other materials low in nitrogen, but after the initial period of decomposition this relation was reversed. The decomposition of plant materials high in nitrogen resulted in a greater fixation of carbon in the soil than was the case with materials with a low nitrogen content. They also showed in laboratory experiments that decomposing plant materials increased the base exchange capacity of the soil. In general, the leguminous materials increased the exchange capacity of the soil more than the non-leguminous materials.

The purpose of the work reported here was to determine the rate of decomposition of organic matter in an electrodialyzed soil where bases are replaced with hydrogen and in a non-electrodialyzed soil, and to observe the effects of the decomposing organic matter on pH, exchange capacity, and carbon content of the soil.

METHODS OF PROCEDURE

A quantity of acid Tama silt loam was electrodialyzed in a Mattson type of electrodialyzed cell. Bases were drawn off at 3, 3, 6, and 12-hour intervals. An average of 13.8 milliequivalents of bases were removed from the soil by electrodialysis and a similar amount of hydrogen was thus substituted for the bases.

Two hundred grams each of the electrodialyzed and the non-electrodialyzed soil were treated in duplicate with 3 per cent dry weight of green sweet clover in one-liter Erlenmeyer flasks. The moisture content of the soil was adjusted to 20 per cent and maintained at this amount throughout the experiment. The flasks were kept in the incubator at a temperature of 25°C. The rate of decomposition was determined by measuring the amount of carbon dioxide evolved. The carbon dioxide evolved was absorbed in KOH, and the excess KOH was titrated with standard acid after precipitating the carbonate with $BaCl_2$. Carbon

Table I — Rate of Carbon Dioxide Evolution from Electrodialyzed and Non-electrodialyzed Soil

Days After Beginning	MILLIGRAMS OF CARBON DIOXIDE			
	Electrodialyzed Soil		Non-electrodialyzed	
	Accumulative	Daily	Accumulative	Daily
9	280	280	368	368
10	504	224	656	288
11	664	160	976	320
12	793	129	1238	262
13	894	101	1361	123
14	985	91	1610	249
15	1077	92	1758	148
16	1164	87	1874	116
17	1253	89	1996	122
18	1313	60	2065	69
19	1388	75	2130	65
20	1455	67	2168	38
21	1522	67	2252	84
22	1583	61	2317	65
23	1638	55	2367	50
24	1681	43	2396	29
25	1724	43	2431	35
26	1791	67	2482	51
27	1848	57	2521	39
28	1903	55	2581	60
29	1958	55	2631	50
30	2002	44	2667	36
31	2030	28	2707	40

dioxide determinations were made at 24-hour intervals for 23 days, beginning 8 days after the treatment of the soil. The total amounts of carbon dioxide evolved from the electrodialyzed and the non-electrodialyzed soil, expressed as milligrams, are given in Table I and in Fig. 1. After the decomposition had

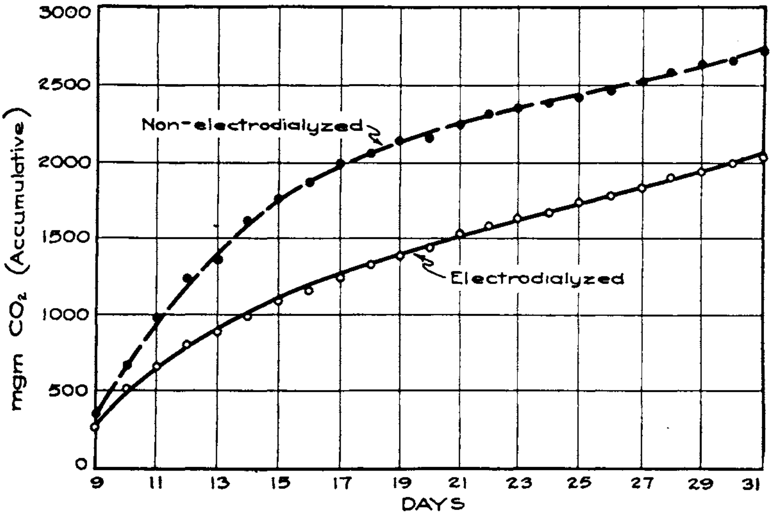

Fig. 1. The decomposition of organic matter in electrodialyzed and non-electrodialyzed soils.

progressed to the stage where both soils were giving off carbon dioxide in approximately equal amounts the experiment was discontinued. The soil was removed from the flasks, air-dried and then finely ground in a mortar.

The pH of the soils before and after decomposition was determined electrometrically. The results obtained are given in Table II.

Table II — pH of Soils Before and After Decomposition

Soil	Before Decomposition	After Decomposition	pH Change
Electrodialyzed	4.25	5.11	0.86
Non-electrodialyzed	5.20	6.95	1.75

The base exchange capacity of the two soils was determined by the barium acetate method. The results obtained are given in Table III.

Table III — Base Exchange Capacity of Soils Before and After Decomposition

Soil	Base Exchange Capacity, M.E. per 100 gms. Dry Soil	
	Before Decomposition	After Decomposition
Electrodialyzed	24.55	24.41
Non-electrodialyzed	24.55	26.45

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An attempt was made to characterize the organic matter of the two soils after decomposition by determining total carbon and easily soluble humus-carbon. The procedure recommended by von Nostitz (4) for the determination of humus-carbon was followed.

RESULTS

The measurement of carbon dioxide evolved from decomposing organic matter is a common method for determining biological action in the soil. Buffering, pH and other factors influence this process. The data in Table I show that the rate of decomposition of the organic matter was considerably lower in the electrodialyzed soil than in the non-electrodialyzed soil from the ninth to the eighteenth day. From then on until the experiment was discontinued the average rate of decomposition gradually decreased about the same amount in both soils. It was noted that mold growth was not as pronounced on the electrodialyzed soil as on the non-electrodialyzed soil during the period of decomposition. Nutritional disorders caused by a lack of the bases, Ca, Mg, K, and Na, as well as an increased hydrogen ion concentration in the electrodialyzed soil were probably contributing factors in the decreased mold growth and decomposition in this soil.

Both soils were strongly acid in the beginning of the experiment and the hydrogen ion concentration decreased as the decomposition of the organic matter proceeded (Table II). The pH change in the non-electrodialyzed soil was greater than in the electrodialyzed soil. This pH change was probably brought about by the liberation of bases in the decomposing organic matter and indicates a greater decomposition in the non-electrodialyzed soil than in the electrodialyzed soil.

The organic and the inorganic soil colloids constitute the base absorptive complex and as the added organic matter decomposes this complex may be increased. The increased exchange capacity of the non-electrodialyzed soil, Table III, also indicates a greater decomposition of the organic matter in this soil than in the electrodialyzed soil.

The ratio of humus (easily oxidizable) carbon to total organic

Table IV — Total and Humus Carbon After Decomposition

Soil	Percentage Total Organic Carbon	Percentage Humus Carbon	Ratio $\frac{\text{Humus Carbon}}{\text{Total Organic Carbon}}$
Non-electrodialyzed	3.56	2.69	0.75
Electrodialyzed	3.43	2.61	0.76

carbon was slightly less in the electrodialyzed soil than in the non-electrodialyzed soil, Table IV. The difference is small and probably not significant in this experiment but the amount of total organic carbon is less in the non-electrodialyzed soil than in the electro-dialyzed soil which also indicates more complete decomposition of the organic matter.

Summary

Thirteen and eight-tenths milliequivalents of hydrogen per 100 grams of soil were substituted for bases in an acid Tama silt loam by electrodialysis. The electrodialyzed soil and non-electrodialyzed soil were treated in duplicate with 3 per cent dry weight of green sweet clover. Microbiological action was measured by determining the evolution of carbon dioxide, base exchange capacity, and the ratio of humus carbon to total organic carbon. The results obtained may be summarized briefly as follows:

1. The rate of decomposition was less in the electrodialyzed soil than in the non-electrodialyzed soil.
2. The pH of the two soils was increased but the pH of the non-electrodialyzed soil was increased more than the electrodialyzed soil.
3. The exchange capacity of the electrodialyzed soil remained unchanged, while that of the non-electrodialyzed soil increased materially.
4. The total organic carbon was decreased slightly and the ratio of humus carbon to total organic carbon was increased slightly more in the non-electrodialyzed soil than in the electrodialyzed soil.

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