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Organic Matter Contribution to Cation Exchange Capacity in Soils

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The average cation exchange capacity contribution of organic matter alone was 242.61 m.e./100g and that of clay alone was 123.30 m.e./100g Organic matter and clay together accounted for 182.95 m.e./100g organic matter and clay as an exchange complex had cation exchange capacity of 132.46 m.e./100g. The average organic matter content of the soils was 3.59 per cent and its contribution to cation exchange capacity averaged 8.76 m.e./100g soil. Similarly the average clay content was 42.62 per cent and the average of its contribution to cation exchange capacity was 46.70 m.e./100g soil. The percentage reductions in cation exchange capacity on account of the formation of organic matter - clay complex as in the soils of Parbhani, Ambagogai, Mukhed, Vaijapur and Tuljapur were 47.15, 45.10, 11.40, 16.46 and 21.17 respectively. The average cation exchange capacity contribution of organic matter was about 15.56 per cent while clay accounted 84.40 per cent. It appeared that in tropical ecosystem as of Marathwada, clay largely constitutes the bulk of cation exchange properties of soils.

It has been demonstrated that the exchange capacity of soil organic matter preparations is much higher than those of clays (Bremner, 1956). Broadbent (1955) found that the organic fraction was responsible for 58 to 83 per cent of the sum of the exchange capacities. Although organic matter contributes a larger share to cation exchange capacity, the role of organic matter in regard to absolute contribution to cation exchange capacity of soil may very much depend on the build-up of organic matter in soils. In tropical arable soils where decomposition rates are greater than build-up because of high temperatures, cation exchange capacity of soil mainly will depend upon inorganic colloids of soils, i.e. clay proportion (Jenny *et al*., 1949).

It is with this view, laboratory studies were conducted to determine the contribution of soil organic matter to cation exchange capacity of same soils of Marathwada.

MATERIALS AND METHODS

The soil samples were collected from farmers' fields from 0-20 cm depth representing all the soil characteristics of soil. The physico-chemical properties of these soils are presented in Table I.

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TABLE I. Physico-chemical properties of soils (Depth of sampling - 0-20 cm)

Legend	Parbhani	Ambajogai	Mukhed	Vaijapur	Tuljapur
Mechanical analysis					
Course sand %	2.15	6.10	1.70	6.17	24.65
Fine sand %	6.34	18.40	13.14	25.62	35.65
Silt %	18.23	18.75	37.50	35.75	15 00
Clay %	69.14	54.75	35.00	26.25	28.00
Texture	Clay	Clay	Clay loam	loam	Sandy loam
pH	8.25	8.30	8.55	8.55	8.70
$CaCO_3$	10.5	10.0	11.5	7.5	7.0

Cation exchange capacity (C.E.C.) and organic matter (O.M.) content of the soils were determined before and after removal of organic matter with 30 per cent w/v H_2O_2 (Jaffries and Jackson, 1949). Organic matter was determined with chromic acid titration method of Walkley and Black (1934). The cation exchange capacity was measured with N ammonium acetate solution adjusted to pH 7.0 as discribed by Piper (1966). The pH was determined using Beckman glass electrode pH meter in 1:2.5 soil water suspension, and mechanical analysis was done by international pipette method (Piper, 1966).

The difference between the organic matter content of the soil before and after H_2O_2 treatment showed the amount of organic matter lost by 100g of the soil.

The difference between the cation exchange capacity of soil before and after H_2O_2 treatment gave the cation exchange capacity of the soil due to removal of organic matter. Since not all the organic matter was removed by the H_2O_2 treatment, the portion removed was used to calculate the over all cation exchange capacity due to the total organic matter content of the soil. This contribution by organic matter was deducted from the cation exchange capacity of the soil to get the cation exchange capacity due to mineral colloid (clay).

RESULTS AND DISCUSSION

There is a general reduction in cation exchange capacity of the soil after destruction of organic matter using hydrogen peroxide (30 per cent). This shows definite contribution of organic matter to cation exchange capacity of soil comparing the organic matter contribution to cation exchange capacity of various soils (Table II). It could be seen that higher percentage of organic matter does not necessarily give high cation exchange capacity value. e.g. Parbhani and Ambajogai soils having 4.83 and 4.06 per cent of organic matter contributing respectively 250.51 and 280.29 m.e./100 g of organic matter alone, similarly Mukhed and Vaijapur soils having 3.57 and 2.87 per cent of organic matter contributing respectively 180.11 and 253.65 m.e./100 g of organic matter. This trend is observed in all soils. It follows that soil type and probably different organic matter origins and their stage of decomposition have pronounced effect on the organic matter contribution to cation exchange capacity.

Average cation exchange capacity contribution form organic mat-

TABLE II. Cation exchange capacity composition from organic matter and clay (Depth of sampling 0-20 cm)

Soils	Parbhani	Ambajogai	Mukhed	Vaijapur	Tuljapur
O. M. content (per cent)	4.83	4.06	3.57	2.87	2.66
C. E. C. m. e./100 g soil	63.60	59.40	55.40	51.20	47.80
C. E. C. m. e./100 g soil due to total O. M.	12.10	11.38	6.43	7.28	6.61
C. E. C. m. e./100 g soil due to total clay	51.50	48.02	48.97	43.92	41.19
C. E. C. m. e / O. M.+clay as in the soils	85.98	101.00	143.63	175.82	155.90
C. E. C. m. e./100 g O. M.	250.51	280.29	180.11	253.65	248.49
C. E. C. m. e. /100 g Clay	74.48	87.70	139.91	167.31	147.10

ter alone is 242.61 m.e./100 g and that of clay alone is 123.30 m.e./100g organic matter (Table III) and clay contribution amount to exchange capacity of 182.95 m.e./100 g. The soil where the organic matter and clay form the exchange complex showed CEC as 132.46 m.e./100 g. The reduction percentage in CEC on account of the formation of organic matter-clay complex as in the soil of Parbhani, Ambajogai, Mukhed, Vaijapur and Tuljapur were 47.15, 45.10, 11.40, 16.46 and 21.17 respectively (Table IV). The per cent reduction in CEC is higher in soils containing relatively higher proportion of clay. It is striking to observe such a marked reduction in the cation exchange capacity. Organic matter and clay interactions perhaps are responsible for reduction in CEC of the materials. Organic matter during aggregate formation is likely to block exchange sites on clay particles thus effectively causing reduction in

TABLE III. Contributions of O. M. and clay to C. E. C. of soils.

Soils	C. E. C., me./100g O. M.	C. E. C., me./100g Clay	C. E. C., me./100g O. M.+Clay as in the soils
Parbhani	250.51	74.48	85.98
Ambajogai	260.29	87.70	101.00
Mukhed	180.11	139.98	143.63
Vaijapur	253.65	167.31	175.82
Tuljapur	248.49	147.10	155.90
Mean	242.61	123.30	132.46

TABLE IV. Reduction in C. E. C. due to organic matter-clay complex formation.

Soils	C. E. C., m. e./100g O. M. and clay	C. E. C., m. e. /100g O. M.+Clay as in the soil	Per cent reduction in C. E. C. O. M.-clay complex as in soil
Parbhani	162.49	85.98	47.15
Ambajogai	182.99	101.00	45.10
Mukhed	160.01	143.63	11.40
Vaijapur	210.48	175.82	16.46
Tuljapur	197.79	155.90	21.17

CEC of soil colloids. In a number of instances it has been reported that in clay organic matter interactions the total negative charge (cation exchange capacity) is less than the sum of the negative charges of clay and organic compounds (Gaur, 1964; Sen, 1964; Helling, *et al*., 1964). As the exchange sites of organic matter are formed through dissociation of hydrogen of phenolic hydroxyl and carboxyl groups (Meyers, 1937), it is possible that this dissociation will be impaired through association due to formation of hydrogen bonding. The adsorption of fulvic acid (Leaver and Russel, 1957) and humic acid (Okuda and Hori, 1957) reduced the sorption capacity of the soil for phosphate. Besides organic matter may have a critical level in the soil below which it does not block the exchange sites on clay but also can not contribute to cation exchange capacity. Above this critical level, organic matter contributes to cation exchange capacity apart from blocking the exchange sites on clay through aggregation. It is not all the exchange sites on organic matter that are available for retention of cation but only the fraction that is left over after formation of complexes with metallic cations and aggregation of soil particles. If organic exchange sites presently blocked by inert iron and aluminium compounds could be filled with ions more beneficial to plant nutrition, soil productivity might be increased.

The average cation exchange capacity contribution of organic matter as in the soil was 15.56 per cent, similarly that of clay was 84.40 per cent (Table V).

The contribution of organic matter as in the soil to CEC of Parbhani and Ambajogai were relatively high viz. i. e. 19.02 and 19.15 per cent respectively as compared to Mukhed, Vaijapur and Tuljapur.

The contribution of organic matter to exchange capacity of soil by difference method does not fully account the effect of the cation exchange capacity that might be due to organic matter (Schnitzer, 1965). Extraction and purification of the organic matter before the study give better results, but such practice is appropriate for soils where CEC of soils ranges between 200 to 500 m.e. / 100 g organic matter (Bremner, 1956).

TABLE V. Contributions of O. M. and clay to C. E. C. of soils.

Soils	% of C. E. C. due to O. M. as in the soil	% of C. E. C. due to clay as in the soil
Parbhani	19.02	80.98
Ambajogai	19.15	80.85
Mukhed	11.60	88.40
Vaijapur	14.21	85.79
Tuljapur	13.82	86.18
Mean	15.56	84.40

The relatively small proportion of cation exchange capacity of soil being constituted by soil organic matter perhaps is due to very low build-up of organic matter under tropical ecosystem as is prevalent in Marathwada region and high temperatures around 44°C during summer month. In tropical arable soils where decomposition rates are greater than build-up because of high temperature, cation exchange capacity of soils mainly will depend upon inorganic colloids of soils i.e. clay proportion (Jenny *et al*., 1949).

The variations in the proportion of cation exchange capacity contributed by organic matter (Table IV) as observed in the soils studied again reflected the nature of organic matter-clay complex formation. It also appeared that in tropical ecosystem as of Marathwada region, clay largely constitutes the bulk of cation exchange properties of soils.

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