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INFLUENCE OF SEWAGE EFFLUENT ON SOIL ORGANIC MATTER AND EXCHANGEABLE CATIONS

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Irrigating the soil with municipal sewage effluent over a period of 25 years and 15 years found to accumulate higher amount of organic matter and higher concentration of cations like calcium, magnesium, sodium and potassium. The concentration of exchangeable cations decreased with the increase in depth in both sewage irrigated and sewage unirrigated fields.

In India more than 100 cities and towns have complete or partial sewage system in addition to about 700 towns with open drain sewage system. Sewage available from these areas is estimated to be about 800 million gallons per day. This works out to 1456 tonnes per day or about 5,30,000 tonnes of organic matter per year. In addition, large amounts of exchangeable cations are also found in the sewage effluent. Hence with a view to assess the status and distribution pattern of organic matter and exchangeable cations in the soil after several years of sewage water irrigation, this present investigation was undertaken in a sewage farm belonging to Coimbatore Municipality which was established in the year 1955.

MATERIAL AND METHODS

Nine profile pits up to a depth of 105 cm i.e. three pits each in 25 years, 15 years, sewage irrigated fields and in the farmer's fields (without sewage irrigation) surrounding the sewage farm (Coimbatore Municipality) were dug and soil samples at the rate of seven samples per pit (0-15, 15-30, 30-45, 45-60 60-75, 75-90 and 90-105 cm) were collected.

Organic carbon was estimated by the chromic acid wet digestion method of Walkley and Black (1934) and organic matter was computed from the values of organic carbon. The cation exchange capacity was estimated by using normal ammonium acetate and expressed as milli equivalents per 100 g of soil (Schollenberger and Driebelbis, 1930). Exchangeable calcium and magnesium were estimated in a known volume of ammonium acetate leachate by titration (Jackson, 1973). Exchangeable potassium and sodium were estimated in the ammonium acetate leachate using flame photometer (Toth and Prince, 1949).

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The sewage water samples were collected separately in the polythene container and analysed for EC, pH, total solids, total cations and the results are presented in Table 1.

RESULTS AND DISCUSSION

Organic matter (Table 2)

The different periods of sewage irrigation significantly increased the organic matter content in the soil when compared to unirrigated plots. The 25 years and 15 years sewage irrigated fields increased the build up of organic matter by 52 and 24 per cent respectively over the farmer's fields (sewage unirrigated). Hence it is concluded that irrigation with sewage water had increased the organic matter content in the sewage amended soils and this is supported by the findings of Lunt (1953), Subbiah (1976) and Rajarajan (1978). The build up of organic matter content was from 20 to 50 per cent in the sewage irrigated soil.

The effect of different depths on organic matter content was well pronounced. The highest organic matter content was observed in the surface layer and the same decreased as the depth increased This may be due to the resistance of sewage sludge for further decomposition by the micro-organisms at lower zones-resulting in the higher accumulation of organic matter at top surfaces. Miller (1974) stated that the application of anaerobically digested sewage sludge to soil resulted in favourable accumulation of organic mctter content because of its resistance to further biological decomposition. A higher degree of positive and significant associations were established between organic matter and macro and micro nutrients under the influence of sewage irrigation. The interaction between depth and period was also significant among various periods of sewage irrigation. The organic matter build up was highest at 0-15 cm and the lowest at 90-105 cm. On the other hand, among various depths the effect of period of sewage irrigation in 0-15 cm and 15-30 cm in increasing the organic matter was similar to the individual effect. However, in depths 45-60, 60-75 and 75-90 cm, 25 years sewage irrigated fields registered the highest organic matter accumulation and 15 years sewage irrigated fields recorded the lowest value. At 90-105 cm the influence of sewage irrigation in increasing the organic matter, though significant did not show any perceptible difference.

Cation Exchangeable capacity (Table 2)

The influence of periods of sewage irrigation on cation exchange capacity was found to be significant. 25 years and 15 years sewage irrigation recorded higher values of cation exchange capacity by 35.3 and 22.9 per cent increase respectively over farmer's fields (without sewage irrigation) This is in conformity with the findings of Lunt (1953), Epstein *et al.* (1976). The values of CEC decreased steeply with depth from 52.4 to 27 3 me/100 g of soil. The depth 0-15 cm registered an increased value of CEC of about 48 per cent over the lower most depth (90-105 cm). This may be attributed to its high organic matter accumulation in the surface layers. Similar observation was also made by Sidle and Kardos (1977) who reported that CEC of the 0-7.5 cm depth was 18.4 me/100 g soil, while that of 7.5-15 cm depth was 8.4 me/100 g soil in the sludge treated forest soil.

CEC was correlated positively with available N (r= 0.91**) for 25 years and 0.94** for 15 years). It was also found that CEC of the soil was also significantly and positively associated with other nutrients and clay content, when sewage irrigation was given (available P-r = 0.93** for 25 years; exchangeable calcium — r = 0.93** for 15 years; exchangeable magnesium — r = 0.87** for 15 years; clay content — r = 0.92** for 15 years and total N — r = 0.85** for 25 years) (Table 4).

Exchangeable calcium (Table 3)

Twenty five years sewage irrigated fields registered increase in exchangeable calcium content significantly over the other treatments. The varied depths clearly manifested difference in values of exchangeable calcium indicating that higher values of exchangeable calcium were being associated with surface horizon and the same value markedly reduced to 50 per cent of its original at the lower depth. Further, it was learnt from the interaction of depth and periods of sewage irrigation, the treatment 25 years sewage irrigation continued to be superior over its counterparts at all depths.

Exchangeable magnesium (Table 3)

The exchangeable magnesium showed a clear cut variation due to different periods of sewage and non-sewage irrigation. The treatments 25 years and 15 years recorded increased values of exchangeable magnesium in the order of 56 and 50 per cent respectively over the treatment without sewage irrigation. The exchangeable magnesium values got reduced as the depth increased from surface to subsurface horizons.

Exchangeable sodium (Table 3)

The surface soil depths (0 15 cm and 15-30 cm) could accumulate more exchangeable sodium than the subsurface soil depths. Such accumulation of exchangeable sodium did not vary much in depths 30-45 to 90-105 cm. However, the general trend indicated that the exchangeable sodium status showed a decrease with increase in depths as in the case of exchangeable calcium and magnesium. The above finding was further affirmed by the significant interaction between the different depths and periods of sewage irrigation.

Exchangeable potassium (Table 3)

The values of exchangeable potassium varied significantly among the periods of sewage and non-sewage irrigation where the treatments T_1 and T_2 were found to increase the values of exchangeable potassium It was also observed that as the depth increased, the exchangeable potassium decreased.

Sewage irrigated soils were definitely superior and found to accumulate higher amount of organic matter and higher concentration of cations like calcium, magenesium, sodium and potassium than the sewage unirrigated fields. The concentration of exchangeable cations decreased with the increase in depth in both sewage irrigated and unirrigated fields. The increased concetration of exchangeable cations in the surface layer may be probably due to the large addition of cations that are present in the sewage effluent. This is in close agreement with the results expressed by Sessing (1961), Bennett *et al.* (1973) and Gaynor and Halstead (1976) who reported that application of sewage effluent to the land caused extensive addition of calcium, magnesium and sodium.

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le 1 Composition of Sewage water

Particulars	December 1979		May 1980	
	Influent to sewage farm after settlement & digestion	Effluent from the sewage farm	Influent to sewage farm after settlement & digestion	Effluent from the sewage farm
Total solids (mg/lit)	2110	1570	2010	1360
pH	7.5	7.8	7.2	7.5
Electrical conductivity (m mhos/cm)	1.2	0.65	1.0	0.70
Total N (mg/lit)	91.8	58.8	81.4	59.3
Ammonical N (mg/lit)	76.3	43.0	69.3	41.7
Nitrate N (mg/lit)	0.8	—	1.0	—
Total p (mg/lit)	37 5	25	41.5	20.1
Total K (mg/lit)	17.0	5.5	21.3	6.5
Total Ca (mg/lit)	183	105	165	110
Total Mg (mg/lit)	83	47	91	48
Total Na (mg/lit)	149	91	173	97

Table 2 Effect of sewage on organic matter and cation exchange capacity (Mean values of three replications)

Profile depth (cm)	Organic matter content (%)				Cation exchange capacity (me/100 g soil)			
	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean
0—15	4.62	2 56	1.42	2.86	61.8	52 6	42 7	52 4
15—30	2.02	1.57	0.97	1 52	55.4	48 2	42.8	48.4
30—45	0.87	0.61	0.63	0.70	52.7	41 6	36 0	43.4
45—60	0 65	0.42	0.55	0 54	46 8	35.5	30 4	37.6
60—75	0.55	0.30	0.45	0.43	44 8	31 4	26.2	34.1
75—90	0.55	0 31	0.35	0 40	40.8	26.7	20.9	29.5
90—105	0.52	0.39	0.30	0.40	39.3	23 5	19 0	27.3
Mean	1.40	0.88	0 67		48 8	37.1	31.1	

Comparison of significant effects	CD (P=0.05)	Comparison of significant effects	CD (P=0.05)
Time (P=0.01)	0.09	Time (P=0.01)	0.75
Depth (P=0.01)	0.13	Depth (P=0.01)	1.15
Time X Depth (P=0.01)	0.23	Time X Depth (p=0 01)	1.99

T_1 = 25 years sewage irrigation; T_2 = 15 years sewage irrigation; T_3 = Farmers' fields with out sewage irrigation)

Table 3. Effect of sewage on exchangeable cations (me/100 g soil) (Mean of three replications)

Profile depth (cm)	Sewage irrigation 25 years				Sewage irrigation 15 years				Without sewage irrigation				Mean			
	Ca	Mg	Na	K	Ca	Mg	Na	K	Ca	Mg	Na	K	Ca	Mg	Na	K
0—15	37.57	17.67	2.94	2.54	21.13	22.00	5 37	2 19	24.20	13.33	2.93	1.00	27.63	17.66	3.73	1.91
15—30	31.96	17.33	2.76	2 15	23.78	15.00	4.71	2.03	25.71	12 67	2.51	0.97	27.15	15.00	3.33	1.72
30—45	29.40	17.33	2.66	2.14	16.78	16 67	4.52	1.89	22.40	10.33	2.06	0.80	22 85	14 78	3.08	1.61
45—60	25.29	16.67	2 55	1.91	13.12	14 33	4.27	1.54	20 08	6.33	2.13	0.74	19.49	12.44	2.98	1.40
60—75	24.17	15.67	2.25	1.90	14.25	11.33	2.94	1.86	17.80	5.00	1.59	0.78	18 67	10.68	2.26	1.51
75—90	20 46	15.33	2 07	1 70	11.01	10 67	2 02	1.71	14.85	3.33	1.45	0.60	16.44	9.78	1.84	1.34
90—105	18 82	15.67	1.99	1.47	6.28	11.33	1.45	1.88	12 43	3 66	1.09	0.32	12 61	10.22	1.51	1.16
Mean	26 81	16.52	2 46	1.97	15 19	14.48	3.61	1.84	19.61	7.81	1.96	0.74				

C. D. (P. =0.05)

	Ca	Mg	Na	K
Time (P=0 01)	0.93	0.47	0.14	0.05
Depth (P=0.01)	1.42	0.71	0.22	0.07
Time X Depth (P=0.01)	2.47	1 23	0.38	0.12

Table 4 Results of Statistical Analysis for correlations

Relationship between X	Y	25 years sewage irrigated fields: Correlation Coefficient (r)	25 years sewage irrigated fields: Regression equation	15 years sewage irrigated fields: Correlation Coefficient (r)	15 years sewage irrigated fields: Regression equation
CEC	Available nitrogen	0.91**	y=6.52X — 204.27	0.94**	y=3.25X — 36.84
CEC	Available phosphorus	0.93**	y=3.33X — 108.62	0.79**	y=1.72X — 38.91
CEC	Exchangeable calcium	0.99**	y=0.79X — 12.3	0.93**	y=0.05X — 3.76
CEC	Exchangeable magnesium	0.82**	y=11.07 + 0.11X	0.87**	y=2.21 + 3 31X
CEC	Clay content	0.82**	y=97.73 — 1.31X	0.92**	y=69.33 + 0.9X
CEC	Total nitrogen	0.85**	y= 0.01X — 0.31	0.84**	y= 0.003X — 0.08