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(ontinuous application of sewage effluent on soil physical properties

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Abstract: To study the long-term effect of irrigation of raw/primarily treated/secondarily treated sewage on soil physical properties, soil samples were collected from different sewage farms of Tamil Nadu during 1994-'95 with 6 to 100 years of sewage irrigation. The sewage irrigation tended to improve the soil physical properties such as porosity, bulk density, hydraulic conductivity and water holding capacity considerably in both surface and sub-surface soils. The long-term sewage irrigation was not only found to influence the total porosity, but also the proportion of micro pores were found to be increased as the result of sewage irrigation. Long-term sewage irrigation tended to decrease bulk density from 1.60 to 1.50 Mg m^{-3} compared to the adjacent unexposed site. Application of raw sewage for 6 years increased the water holding capacity from 48.68 to 55.63 per cent and hydraulic conductivity from 9.03 to 12.61 cm hr^{-1}.

Key words : Sewage effluent, Porosity, Bulk density, Hydraulic conductivity and Water holding capacity.

(troduction

Among the waste water, sewage ranks (ïst, not only due to high abundance but also (om relatively less hazardous nature coupled (ith high plant nutritive value and also improvement (: soil physical environment. Utilization of the (ewage for agriculture obviously constitutes one (f the ways of meeting the irrigation requirements (f crops. An in depth analysis would reveal (n array of benefits associated with recycling (f sewage for agriculture. These include,

- An excellent and cheap way of disposal.
- Safe guarding of our precious environment.
- Soil fertility improvement.
- Potential source of organic matter to the soils.

(aterials and Methods

In order to investigate the long-term effect (f irrigation with sewage (raw, primarily and (econdarily treated and diluted on soil physical (roperties, soil samples were collected from (ewage irrigated areas during 1994-'95. To relate (he properties of sewage exposed and non-(xposed areas, core soil samples were collected (rom adjacent areas not exposed to sewage (rrigation. Depth wise soil samples were also (ollected to have refined idea on the nature of changes occurring in the properties as a result of sewage irrigation. Soil samples representing three depths (0-15, 15-30 and 30-45 cm) were taken from each of the sewage farms of Tamil Nadu for laboratory investigations. Sewage non-irrigated soil samples were also collected from the adjacent areas of sewage farms. The sample preparation and anaysis were carried out as per standard procedures outlined by Gupta and Dakshinamoorthy (1981).

Results and Discussion

Bulk density

Long-term sewage irrigation tended to decrease bulk density (Table 1). In Tuticorin, raw sewage irrigated area recorded a bulk density of 1.50 as compared to 1.68 Mg m^{-3} in the adjacent unexposed site. With regard to different kinds of sewage irrigations, raw sewage caused more pronounced effect than primarily treated sewage effluent followed by secondarily treated sewage effluent. In Paramagudi, 20 years of raw sewage irrigation recorded 1.31 as against 1.63 Mg m^{-3} in the other case. Whereas in Mannargudi primarily treated sewage effluent, the bulk density was 1.10 as against 1.27 Mg m^{-3} under sewage non-exposed area. In Nesapakkam, for secondarily treated sewage effluent irrigation the bulk density was 1.46 compared to 1.64 Mg m^{-3} in the other case.

Table 1. Influence of long-term sewage irrigation on bulk density

Sl. No.	Location	Years of irrigation	Bulk density ($Mg\ m^{-3}$)					
			Sewage non-irrigated			Sewage irrigated		
			0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
Raw sewage-irrigation								
1.	Tuticorin	6	1.68	1.78	1.86	1.50	1.64	1.75
2.	Paramagudi	20	1.63	1.71	1.81	1.31	1.47	1.64
3.	Virudunagar	52	1.80	1.91	1.97	1.36	1.59	1.72
4.	Madurai	69	1.32	1.48	1.56	0.80	0.90	1.03
5.	Tanjore	100	1.69	1.82	1.86	0.76	0.86	0.90
Primarily treated sewage effluent - irrigation								
6.	Mannargudi	21	1.27	1.32	1.34	1.10	1.19	1.24
7.	Udagamandalam	33	1.02	1.17	1.23	0.80	1.11	1.07
8.	Pudukkottai	67	1.51	1.58	1.62	1.00	1.26	1.36
Secondarily treated sewage effluent - irrigation								
9.	Nesaspakkam	19	1.64	1.73	1.84	1.46	1.59	1.35

Table 2. Influence of long-term sewage irrigation on hydraulic conductivity of the soil

Sl. No.	Location	Years of irrigation	Hydraulic conductivity ($cm\ hr^{-1}$)					
			Sewage non-irrigated			Sewage irrigated		
			0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
Raw sewage-irrigation								
1.	Tuticorin	6	9.03	8.56	7.79	12.61	10.62	8.34
2.	Paramagudi	20	11.30	11.05	10.35	19.32	17.30	15.60
3.	Virudunagar	52	4.38	4.14	4.00	17.56	15.26	14.48
4.	Madurai	69	22.65	22.00	21.65	43.32	38.66	31.74
5.	Tanjore	100	9.25	9.00	8.75	40.27	36.84	34.23
Primarily treated sewage effluent - irrigation								
6.	Mannargudi	21	21.82	21.25	20.84	29.51	28.36	26.77
7.	Udagamandalam	33	20.92	20.44	20.11	32.33	30.75	26.49
8.	Pudukkottai	67	22.38	22.16	21.47	38.64	37.47	36.54
Secondarily treated sewage effluent - irrigation								
9.	Nesaspakkam	19	14.86	14.32	14.06	18.50	17.32	16.68

Influence of sewage irrigation was also nd in the deeper layers. The decrease in k density was more pronounced on the top er followed by subsequent layers. In Tuticorin, bulk density values were progressively easing depth under sewage exposed area e 1.50, 1.64 and 1.75 as against 1.68, 1.78 1.86 Mg m^{-3} for the unexposed situation -15, 15-30 and 30-45 cm depth respectively. : impact of sewage on porosity brought ut concomitant changes in bulk density. The rall effect of sewage irrigation was to decrease bulk density. This effect is the result of er aggregation and other structural indices ught about by organic rich sewage. Such henomena was also earlier evidenced by arkar *et al.* (1990) and Mathan (1994). h positive effect on clay content, porosity icularly micropores supplemented by better regation.

raulic conductivity

Long-term sewage irrigation tended to ease the hydraulic conductivity (Table 2). Tuticorin, 6 years of raw sewage irrigation eased the hydraulic conductivity from 9.03 12.61 cm hr^{-1}. With regard to different s of sewage irrigations, raw sewage caused e effect than the primarily treated followed econdarily treated sewage effluent irrigation. b cite an example, in Paramagudi raw sewage igation for 20 years increased the value from 11.30 to 19.32 cm hr^{-1}. In Mannargudi, 21 ears of primarily treated sewage effluent accounted or an increase from 21.82 to 29.51 cm $^{-1}$. In Nesapakkam where the secondarily treated ewage effluent was used, the relative values ere 14.86 and 18.50 cm hr^{-1}. Long-term pplication of sewage also influenced the hydraulic onductivity at deeper layers. For example in uticorin the hydraulic conductivity for rogressively increasing depth were 10.62 and .34 under sewage irrigated condition in comparison 8.56 and 7.79 cm hr^{-1} under normal irrigation 15-30 and 30-45 cms respectively. The sewage rigation enhanced the water holding power nd also the water transmission characteristics onsiderably. Raw sewage irrigation over a period f 20 years enhanced the water holding power om 48 to 63 per cent. The ability of the oil to hold more moisture and at the same time facilitate better water movement is a matter of betterment in soil-water-plant relationships. The usefulness of sewage addition for increasing the water holding power and enhanced hydraulic conductivity have been reported by Tisdall and Oades (1982), Juwarkar *et al.* (1990) and Mathan (1994).

Porosity

The long-term sewage irrigation was found to influence the porosity characteristics (Table 3). Not only the total porosity but also the proportion of microspores were found to be increased as the result of sewage irrigation. In Paramagudi for example where the site was exposed to 20 years of raw sewage irrigation the porosity values observed were 55.56, 44.86 and 10.72 per cent for total, micro and macro pores respectively. This was against the values of 46.40, 37.30 and 9.10 per cent in adjacent unexposed case. In the case of secondarily treated sewage effluent as well, as could be seen in Nesapakkam, the increase in porosity values could be observed. The point of emphasis is that the sewage in general tend to increase the soil porosity and more particularly the fraction of microspores.

The impact of sewage on porosity was found to be extending to deeper layers. In the sewage exposed sites in almost all cases there was a progressive decrease in the porosity with depth but for a given depth the values were higher when compared to similar depth of unexposed sites. Citing an example as per the case 20 years raw sewage irrigation in Paramagudi, the porosity values observed for the increasing depth were 55.56, 52.79 and 53.22 per cent respectively in relation to similar values for the unexposed sites. The influence of prolonged sewage irrigation on soil porosity characteristics was another redeeming feature. Not only the total pore volume increased but also the share of micropores enhanced. The possible reason for the above include organic matter enrichment causing micro aggregation, clay enrichment as already described. A positive influence of organic manure on the total porosity was reported by Katile *et al.* (1992) and a positive relationship between clay and porosity was reported earlier by Randhawa (1971). The

Table 3. Influence of long-term sewage irrigation on total porosity

Sl. No.	Location	Years of irrigation	Total porosity (%)					
			Sewage non-irrigated			Sewage irrigated		
			0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-4[illegible] cm
Raw sewage-irrigation								
1.	Tuticorin	6	52.97	53.78	50.95	56.14	54.68	53.9[illegible]
2.	Paramagudi	20	46.40	47.06	47.29	55.56	52.79	53.2[illegible]
3.	Virudunagar	52	61.64	59.94	59.50	76.26	71.75	68.0[illegible]
4.	Madurai	69	35.30	32.94	28.48	58.63	51.79	55.6[illegible]
5.	Tanjore	100	54.52	54.28	51.36	70.92	71.86	73.4[illegible]
Primarily treated sewage effluent - irrigation								
6.	Mannargudi	21	33.14	31.74	27.40	42.34	38.46	35.2[illegible]
7.	Udagamandalam	33	59.62	59.01	56.39	69.56	65.91	67.9[illegible]
8.	Pudukkottai	67	38.92	35.51	31.80	56.79	49.26	51.7[illegible]
Secondarily treated sewage effluent - irrigation								
9.	Nesaspakkam	19	45.79	45.16	45.83	50.94	48.78	47.2[illegible]

Table 4. Influence of long-term sewage irrigation on water holding capacity

Sl. No.	Location	Years of irrigation	Water holding capacity (%)					
			Sewage non-irrigated			Sewage irrigated		
			0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
Raw sewage-irrigation								
1.	Tuticorin	6	48.68	49.12	46.18	55.63	53.22	49.66
2.	Paramagudi	20	48.18	47.65	46.60	63.24	59.36	57.11
3.	Virudunagar	52	51.63	48.26	47.84	72.17	66.72	63.26
4.	Madurai	69	42.60	39.44	35.56	71.24	67.75	66.86
5.	Tanjore	100	60.70	58.42	55.12	80.66	76.68	70.22
Primarily treated sewage effluent - irrigation								
6.	Mannargudi	21	38.62	34.45	30.26	52.25	46.48	40.63
7.	Udagamandalam	33	70.64	69.96	65.50	82.16	74.48	72.66
8.	Pudukkottai	67	37.26	36.16	32.32	70.26	65.50	61.34
Secondarily treated sewage effluent - irrigation								
9.	Nesaspakkam	19	49.92	44.30	43.36	57.60	51.26	49.72

lue of increased porosity in terms of water ention and crop growth need not be over ıphasised. The impact of sewage application soil porosity characteristics have been established several workers (Abd Elnaim *et al.* 1987; ıthan, 1994; Panicker, 1994).

ıter holding capacity

Water holding capacity of soils were found be increased by the influence of sewage gation (Table 4). To cite an example, in ticorin, application of raw sewage for 6 years reased the value from 48.68 to 55.63 per ıt. Among different types of sewage irrigations, raw sewage brought out more pronounced rease than other cases. In Paramagudi, irrigation h raw sewage for 20 years recorded a value 63.24 compared to 48.18 per cent for sewage ı-exposed area. In Mannargudi application primarily treated sewage effluent for 21 ırs the value was 52.25 as against 38.62 cent under sewage non-irrigated site. In e of secondarily treated sewage effluent at sapakkam the relative values were 57.60 and 92 per cent respectively. The influence of vage irrigation was also found in the deeper ers of soil. For example in Tuticorin 6 ırs of raw sewage irrigation caused a water ding capacity of 53.63 and 49.66 in relation 49.12 and 46.18 per cent for sewage non-..posed soil for the lower depths of 15-30 nd 30-45 cms respectively.

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