RESEARCH ARTICLE

IMPACT OF APPLICATION OF SEWAGE WATER ON SOIL PHYSICAL PROPERTIES OF HARYANA

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Abstract: Nowadays, the water demand has increased considerably due to the increasing population, resulting in domestic sewage water. Due to the constraint in freshwater availability for irrigation, sewage water is being used for irrigation of agriculture fields. A survey was undertaken during 2019-20 and 2020-21 to study the physical properties of sewage water irrigated soils in different locations of Haryana, namely Karnal, Panipat and Hisar.Soil samples were collected at depths of 0-15, 15-30 and 30-45 cm from sewage and non-sewage irrigated fields. In this study,it was found that sewage water application improves the physical properties like bulk density, infiltration rate and field capacity of the soil compared to non-sewage water. All the physical properties except texture varied according to the composition of the sewage water and irrigation duration. The mean value of bulk density was reduced (1.35Mg m^{-3}) in the soils irrigated with sewage water compared to non-sewage water(1.38Mg m^{-3}). The mean value of infiltration rate under the study decreased(20.83mm h^{-1}) with sewage water as compared to non-sewage water (23.60mm h^{-1}). The available water content at field capacity of the soils irrigated with sewage water was found to be higher(18.49%)as compare to the soils irrigated with non-sewage water(17.51%). The overall result is that use of the sewage water improves the physical properties of the soil as compared to the application of non-sewage water.

Keywords: Available water content, Bulk density, Infiltration rate, Sewage water, Texture

INTRODUCTION

The growth of towns, cities and development of industries by 19th century leads to the problem of disposal of sewage, which encouraged the use of sewage wastewater in irrigation. The use of domestic sewage in farming is becoming prevalent as the water demand is increasing. Due to fast industrial development and population growth, the availability of water decreases day to day (Mojiri*et al*, 2013). In addition to this, cities are challenged by climate change impacts such as extreme rainfall events that affect conventional urban water management systems via increased sewage water overflows resulting in water quality deterioration and urban floods causing infrastructure damage (Wilbers*et a*, 2022). The increase in the population has led to increased demand for water and the increased generation of wastewater.

With increasing demand for food day by day, more and more land is brought under cultivation. Thus increasing the need for inorganic fertilizers and irrigated water (Singh *et al*, 2018). Hence the focus is shifting towards various nonconventional easily available sources of irrigation. Among others, one of the important irrigation anda nutrient sources is municipal sewage water. Nowadays, in some areas around urban cities, the, untreated wastewater or sewage water is directly used for irrigation in different crops, which may raise some public health hazards like the outbreaks of dangerous epidemics (Jaramillo and Restrepo, 2017). In developing countries like India, there has not been much emphasis on the installation of sewage treatment plants and all the industrial effluents are generally discharged into the domestic sewer system. In India, 16625 million litres of sewage water are generated daily. Out of which, only 24 per cent is treated and the remaining 76 per cent of sewage is discharged into the land without any treatment. In Haryana also about 485.2 million litres of sewage water is produced per day and could be utilized directly, without pre-treatment for irrigation purposes.

This study aimed to investigate how long-term sewage water irrigation affects soil physical properties like texture, bulk density, penetration rate, and available water content in Haryana locations, namely Karnal, Panipat and Hisar.

MATERIALS AND METHODS

The present study was conducted during 2019-20 and 2020-21 in Haryana in northern India, situated between 27°39' to 30°35' N latitude and between 74°28' and 77°36' E longitude. Three sites were selected, namely Karnal, Panipat and Hisar. From each district sewage and non-sewage irrigated samples were selected at depths0-15, 15-30 and 30-45 cm. The collected soil samples wereair-dried, ground and screened through a 2 mm stainless steel sieve. After mixing thoroughly, the processed samples were stored in polythene covers for further

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analysis. All the samples were analyzed for various physical properties like texture, bulk density, infiltration rate and available water content as per the standard procedures.

Determination of physical properties

The mechanical composition of the soil was determined by International Pipette Method. To determine bulk density at different depths, soil cores (5 cm inner diameter and 5 cm in height) were obtained from various depths (0-15,15-30 and 30-45 cm). Samples were oven-dried at 105 ^{0}C for 24 hours. The bulk density of soil samples was determined from the soil mass and the volume of the soil cores. Infiltration rate was measured in the field using a close top double-ring infiltrometer as described in the laboratory manual for physical soil analysis (Malik *et al*, 1985). The moisture content at field capacity and a permanent wilting point was determined using pressure plate apparatus at 0.33 and 15 bar suction, respectively (Richards, 1954).

RESULTS AND DISCUSSION

Texture Karnal

The texture of the soils samples from the sewage and non-sewage irrigated site were analyzed in the laboratory. It was found that under both the conditions of water application (i.e., sewage and non-sewage), the soil texture of the soils of respective locations in each district was not affected. The texture of soils samples from the *peri-urban* area of Karnal at location UcchaSimana under sewage water application was clay loam with particle composition of sand (42.54 %), silt (20.06 %) and clay (37.40%). The same texture (clay loam) has been observed in the soils of the second location under sewage water irrigation in Mubarakabad in district Karnal (i.e., sand 41.25%, silt 23.67% and clay 35.08%, respectively).

Under non-sewage water irrigation conditions in Karnal district at location UcchaSimana, the sand particles were slightly higher (44.52 %), while the silt particles were observed lesser (19.46 %), and the clay particles were also lesser (36.02 %), but the texture of the soils remained same *i.e.*, clay loam. The same pattern has been observed in particle composition under non-sewage water irrigation in Karnal at Mubarakabd where the sand, silt and clay particles were 43.27, 22.61 and 34.12 per cent, respectively.

Panipat

Under both the conditions of source of irrigation i.e., sewage and non-sewage at both the locations i.e., Untla and Alupur, the texture was observed as clay loam to loam, showing no effect of sewage water on texture.

Hisar

The texture remained unaffected by sewage and non-sewage water application at both the locations in Hisar i.e., at Kaimri and Ludas the texture of the soils under observation was sandy loam. The sand particles ranged from 60.42 to 66.24 per cent under sewage water irrigation, while it was observed higher under non–sewage water irrigation *i.e.,* 66.92 to 69.75 per cent for Kaimri and Ludas locations. The application of sewage water had not altered the soils' texture compared to irrigated with non-sewage water. Similar results were reported by Dhaliwal*et al*. (2003) and Kharche *et al*. (2011).

Bulk density

The bulk density of sewage irrigated soilswas lesserthan non-sewage irrigated soils during both years. Sewage irrigated soils had a lower bulk density with a range of1.27-1.44 Mg m^{-3} and 1.26-1.45 Mg m^{-3} at 0-15 cm depth than the bulk density of soils under non-sewage irrigated water (*i.e.*,1.31-1.47 and 1.30-1.48 Mg m^{-3} at 0-15 cm depth) during 2019-20 and 2020-21, respectively. Sewage irrigated soils had a lower bulk density with a range of1.31-1.46 Mg m^{-3} and 1.29-1.47 Mg m^{-3} at 15-30 cm depth than the bulk density of soils under non-sewage irrigated water (*i.e.*, 1.34-1.51 and 1.35-1.52 Mg m^{-3} at 15-30 cm depth) during 2019-20 and 2020-21, respectively. Sewage irrigated soils had a lower bulk density with a range of1.35-1.47 Mg m^{-3} and 1.32-1.48 Mg m^{-3} at 30-45 cm depth than the bulk density of soils under non-sewage irrigated water (*i.e.*, 1.36-1.52 and 1.37-1.52 Mg m^{-3} at 30-45 cm depth) during 2019-20 and 2020-21, respectively. Under the influence of sewage water, the bulk densityis reduced by the accumulation of organic carbon, which increases the porosity and ultimately reduces the soil's bulk density. Similar finding was also reported byMathan (1994), Kharche *et al*. (2011) and Subramani*et al*. (2014).

Infiltration rate

The infiltration rate of sewage irrigated soil was less than non-sewage irrigated soil during both the year. Sewage irrigated soil had a lower infiltration rate range (15.8-27.2 and 16.2-28.0 mm h^{-1}) than the non-sewage irrigated soil (17.8-31.0 and 17.2-29.4 mm h^{-1}) during 2019-20 and in 2020-21. The lowest value was recorded in Karnal (15.8 mm h^{-1}) while the highest value (27.2mm h^{-1}) in Hisar of sewage irrigated soil on the surface layer of 0-15cm. The same trend was observed in non-sewage irrigated soil (17.8 and 31.0 mm h^{-1}) during 2019-20. The mean value of infiltration rate (20.83 and 20.9mm h^{-1}) in sewage irrigated soil as while the mean value of non-sewage irrigated soil (23.6 and 23.47mm h^{-1}) during 2019-20 and 2020-21.

In the present study, water infiltration rate was lower in the soils irrigated with sewage water. It was evident from the study that water infiltration rate was found to be lower in the soils irrigated with sewage water compared to the soils irrigated with non-sewage water. The presence of a higher quantity of sodium ions and a lower quantity of calcium ions in the sewage water reduced the water infiltration rate of the soils under study (Koupai*et al*. (2006).

Available water contentat field capacity

The available water contentatfield capacityof sewage irrigated soils was higher than non-sewage irrigated soils during both the years. Sewage irrigated soils had higher available water content atfield capacity with a range of12.12-23.36 % and 12.45-23.58 % at 0-15 cm depth than the available water contentatfield capacityof soils under non-sewage irrigated water (*i.e.*,11.14-21.82and 10.70-21.64 % at 0-15 cm depth) during 2019-20 and 2020-21, respectively. Sewage irrigated soils had higher available water content with a range of14.34-25.52 % and 14.48-25.64 % at 15-30 cm depth than the Available water content atfield capacity of soils under non-sewage irrigated water (*i.e.,* 12.42-24.24 and 11.68-24.92 % at 15-30 cm depth) during 2019-20 and 2020-21, respectively. Sewage irrigated soils had higher available water content with a range of14.72-26.08 % and 14.74-25.68 % at 30-45 cm depth than the available water contentat field capacityof soils under non-sewage irrigated water (*i.e.*, 12.78-24.64 and 12.18-24.82 % at 30-45 cm depth) during 2019-20 and 2020-21, respectively. Available water content atfield capacity refers to the amount of water retained in the soil for crop use. In the present study, the water content of the soils irrigated with sewage water was found to be higher than the soils irrigated with non-sewage water. It may be attributed to the higher organic content of the soils irrigated with sewage water than soils irrigated with non-sewage water. In addition to this, the Available water content at the field capacity of the soil depends upon the quantity of organic carbon. Therefore, the different soil profiles have varying available water content at field capacity (Viville*et al*. 1986).Similar finding was also reported by Mathan (1994), Kharche *et al*. (2011), Singh *et al*.(2012), Subramani *et al*. (2014).

Table 1. Effect of sewage and non-sewage water on texture in soil under rice-wheat and pearl millet-wheat cropping systemin*peri-urban* areas of Haryana

Treatment	District	Site	Texture							
			2019-20				2020-21			
			Sand (%)	Silt (%)	Clay (%)	Texture	Sand (%)	Silt (%)	Clay (%)	Texture
Sewage water	Karnal	L1 : UcchaSimana	42.54	20.06	37.4	Clay Loam	42.22	20.18	37.6	Clay Loam
		L2 : Mubarakabad	41.25	23.67	35.08	Clay Loam	41.08	23.74	35.18	Clay Loam
	Panipat	L1 : Untla	44.97	18.16	36.87	Clay Loam	44.85	18.2	36.95	Clay Loam
		L2 : Alupur	45.05	30.4	24.55	Loam	44.97	30.45	24.58	Loam
	Hisar	L1 : Kaimri	60.42	21.54	18.04	Sandy Loam	60.28	21.64	18.08	Sandy Loam
		L2 : Ludas	66.24	16.48	17.28	Sandy Loam	66.04	16.6	17.36	Sandy Loam
Non-sewage water	Karnal	L1 : UcchaSimana	44.52	19.46	36.02	Clay Loam	44.36	19.54	36.1	Clay Loam
		L2 : Mubarakabad	43.27	22.61	34.12	Clay Loam	43.25	22.67	34.1	Clay Loam
	Panipat	L1 : Untla	42.98	28.55	28.47	Clay Loam	42.92	28.58	28.5	Clay Loam
		L2 : Alupur	44.28	31	24.72	Loam	44.30	31.04	24.66	Loam
	Hisar	L1 : Kaimri	66.92	16.64	16.44	Sandy Loam	66.87	16.68	16.45	Sandy Loam
		L2 : Ludas	69.75	13.15	17.1	Sandy Loam	69.76	13.14	17.10	Sandy Loam

Table 2. Effect of sewage and non-sewage water on bulk density in soil under rice-wheat and pearl millet-wheat cropping systemin *peri-urban* areas of Haryana.

Treatment	District	Crop	Bulk density (Mg m^{-3})					
			2019-20			2020-21		
			0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
Sewage water	Karnal	Rice	1.27	1.32	1.34	1.26	1.29	1.32
		Wheat	1.32	1.34	1.36	1.3	1.32	1.35
	Panipat	Rice	1.28	1.31	1.35	1.31	1.34	1.36
		Wheat	1.34	1.36	1.37	1.35	1.38	1.4
	Hisar	Pearl millet	1.44	1.46	1.47	1.43	1.47	1.48
		Wheat	1.43	1.45	1.46	1.45	1.46	1.47
		Mean	**1.35**	**1.37**	**1.39**	**1.35**	**1.38**	**1.4**
		Range	**1.27-1.44**	**1.31-1.461**	**1.35-1.47**	**1.26-1.45**	**1.29-1.47**	**1.32-1.48**
Non sewage water	Karnal	Rice	1.31	1.34	1.36	1.3	1.35	1.36
		Wheat	1.35	1.37	1.38	1.37	1.38	1.38
	Panipat	Rice	1.33	1.37	1.38	1. 31	1.36	1.38

		Wheat	1.38	1.41	1.43	1.4	1.42	1.44
	Hisar	Pearl millet	1.47	1.51	1.52	1.48	1.52	1.52
		Wheat	1.45	1.48	1.5	1.47	1.48	1.5
		Mean	**1.38**	**1.41**	**1.43**	**1.39**	**1.42**	**1.43**
		Range	**1.31-1.47**	**1.34-1.51**	**1.36-1.52**	**1.30-1.48**	**1.35-1.52**	**1.37-1.52**

Table 3. Effect of sewage and non-sewage water on infiltration rate in soil under rice-wheat and pearl millet-wheat cropping system in *peri-urban* areas of Haryana.

Treatment	**District**	**Crop**	**Infiltration rate(mm h^{-1})**	
			2019-20	**2020-21**
Sewage water	Karnal	Rice	15.8	16.2
		Wheat	17.1	19.2
	Panipat	Rice	18.9	16.4
		Wheat	19.6	18.9
	Hisar	Pearl millet	27.2	28
		Wheat	26.4	26.7
		Mean	**20.83**	**20.9**
		Range	**15.8-27.2**	**16.2-28.0**
Non-sewage water	Karnal	Rice	17.8	17.2
		Wheat	20.5	21
	Panipat	Rice	20.7	19.9
		Wheat	23.1	25.1
	Hisar	Pearl millet	31	29.4
		Wheat	28.5	28.2
		Mean	**23.6**	**23.47**
		Range	**17.8-31.0**	**17.2-29.4**

Table 4. Effect of sewage and non-sewage water on available water content (AWC) at field capacity in soil under rice-wheat and pearl millet-wheat cropping system in *peri-urban* areas of Haryana

Treatment	**District**	**Crop**	**AWC (%)**					
			2019-20			**2020-21**		
			0-15 cm	**15-30 cm**	**30-45 cm**	**0-15 cm**	**15-30 cm**	**30-45 cm**
Sewage water	Karnal	Rice	23.36	25.52	26.08	23.58	25.64	25.68
		Wheat	20.52	23.76	24.12	19.54	23.70	24.96
	Panipat	Rice	21.14	23.32	24.54	20.86	23.92	24.62
		Wheat	19.42	21.56	22.04	19.65	21.60	22.26
	Hisar	Pearl millet	12.12	14.34	14.72	12.45	14.48	14.74
		Wheat	14.38	16.24	17.76	14.70	16.10	17.65
		Mean	**18.49**	**20.79**	**21.54**	**18.46**	**20.91**	**21.65**
		Range	**12.12-23.36**	**14.34-25.52**	**14.72-26.08**	**12.45-23.58**	**14.48-25.64**	**14.74-25.68**
Non - sewage water	Karnal	Rice	21.82	24.24	24.64	21.64	24.92	24.82
		Wheat	20.64	22.80	23.29	19.75	22.48	23.90
	Panipat	Rice	20.48	21.54	22.76	20.72	22.53	22.90
		Wheat	18.45	20.18	20.82	18.48	19.52	20.38
	Hisar	Pearl millet	11.14	12.42	12.78	10.70	11.68	12.18
		Wheat	12.52	13.58	15.18	13.14	14.20	14.62
		Mean	**17.51**	**19.13**	**19.91**	**17.41**	**19.22**	**19.80**
		Range	**11.14-21.82**	**12.42-24.24**	**12.78-24.64**	**10.70-21.64**	**11.68-24.92**	**12.18-24.82**

CONCLUSION

After evaluating the data collected from the experiment, it is clear that both types of irrigation e.g., sewage water and non-sewage water play an important role in soil and physical properties for long time irrigation. The specific conclusionswere that soil texture remained unaffected by the application of sewage water irrigation. The sewage water irrigation caused a reduction in the soil porosity, so the infiltration rate of water is reduced as compared to non-sewage irrigation application. The soil irrigated by sewage water decreased the BD and the available water content at field capacityincreased compared with non-sewage water irrigated soil. Considering these results, we can conclude that using sewage water sources without adequate safeguards is better for soil's physical properties.

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