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Effect of sewage water on physical properties of cultivated soils of Peri-urban Areas of Haryana

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Abstract
Raw sewer and tube well water samples were collected from various sewer disposal sites and nearby fields in Haryana where these waters are directly used for irrigating the crops. Soil samples (0-15 and 15-30 cm) were also collected from fields irrigated with these waters and from nearby fields irrigated with non-sewage waters to determine the changes in soil physical properties due to sewage irrigation. All the physical properties except texture varied according to the composition of the sewer water and duration of irrigation. The bulk density was found highest in Narwana (1.56 Mg m^{-3}) at 0-15 cm in sewage water irrigated soil while at 15-30 cm depth it was highest in Charkhi Dadri (1.54 Mg m^{-3}). The infiltration rate decreased with the application of sewage water. However, the highest infiltration rate was observed in Jind district (25.0 mm h^{-1}) under the non-sewage water as compared to the sewage water (17.6 mm h^{-1}). The highest water retention (26.22%) was observed in the soils irrigated with sewage water at 0.03 bar in district Jind while it was lowest (14.84%) in the soils of Charkhi Dadri at 0-15 cm. Highest available water capacity was recorded in the soils irrigated with sewage water at 0-15 cm depth in district Kaithal (21.15%) while it was lowest (9.23%) in the soils of Charkhi Dadri. Therefore, sewage water can be used for irrigation but continuous monitoring is necessary to check its long term effect.

Keywords: Available water capacity, bulk density, infiltration rate, texture, water retention

1. Introduction

Farmers are dependent of irrigated water for the successful production of agricultural crops which is available by canal water as a primary source given on *barabandi* system (a distribution system of canal water in India, where, the farmers irrigated their fields based on their turn). The farmers which have the fields near the canal head, get sufficient amount of water, sometimes face water logging conditions due to leakage etc., but the farmers having the fields at the tail of the canal receive insufficient amount of water during the peak demand of the agricultural crops. So, they use tube well water as a source of irrigation to their thirsty crops. This happens generally among the medium farmers (4.00 - 10.00 ha land) who were 4.25 per cent and large farmers (10.00 ha and above land) 0.70 per cent of number of operational holdings to total. But the marginal (below 1.00 ha) and small farmers (1.00 and 2.00 ha) who are 67.10 and 17.91 per cent of operational holdings to total received no water or very less water. They even cannot afford the tubewells and search for alternate of canal water. Sewage water is one of the better and easy options to use in their lands without any competition in the rural system.

Water bodies in India are discharged with 62 per cent of total sewage water without any treatment and it is nearly 38791 millions of liters per day (MLD) and the capacity of the sewage treatment is only 22963 MLD against the total sewage generation of 61754 MLD during 2015. Maharashtra is the leading state in sewage generation of 8143 MLD (13%) with an installed treatment capacity of 5160.36 MLD. In contrast to this the situation of sewage generation in urban areas of Haryana is 1413 MLD with an installed treatment capacity of 852.7 MLD (Anonymous, 2018) [2]. It is worth mentioning here that Himachal Pradesh and Sikkim are the only two states having sufficient capacity of the installed treatment plants for their generated sewage.

In Haryana, 41 sewage treatment plants were installed up to 2016 (Anonymous, 2016).

Due to continuous use of raw sewage water the agricultural lands, particularly in peri-urban areas often exhibit elevated levels of trace elements (Rattan *et al.* 2002; 2005) [10, 11]. The increased competition for fresh water among urban and semi-urban centers, industries and agriculture has put agriculture, particularly irrigated agriculture under severe pressure as irrigation has been the largest user of water (Van der Hoek *et al.* 2002) [16]. Therefore, the use of treated, partially-treated or untreated wastewater has received more attention. Sewage is a major load on water bodies and its incorrect disposal promotes growth of toxic algal blooms which hampers aquatic life. The practice of reuse is the necessity of the present time. Sewage has affected adversely both soil health and crop productivity. Sewage has resulted in improved physiochemical characteristics of soil. In the agricultural practices, the irrigation quality of water is believed to have an effect on the soil characteristics, crops production and proper management of water (Shainberg and Oster 1978) [13]. Particularly, application of saline/sodic water results in the reduction of crop yield and deterioration of the physical and chemical properties of soil. Therefore, it has more concern to the farmers when being used as an irrigant, which may contain constituents capable of creating adverse effects on the soil media and the agriculture produce. Therefore, the present study has been planned to see the effect of sewage water on physical properties of soil in peri-urban areas of five districts of Haryana namely Kurukshetra, Kaithal, CharkhiDadri, Jind and Narwana.

2. Materials and Methods

The study was conducted in Haryana in northern India, situated between 27°39' to 30°35' N latitude and between 74°28' and 77°36' E longitude. Five sites were selected namely Kurukshetra, Kaithal, Narwana, Jind and Charkhi Dadri. Under each districts, four sites were selected for the sampling of sewage and non-sewage source of water for irrigation at 0-15 and 15-30 cm depth. From each site, two samples were taken from each depth and the mean values of the soil properties estimated in laboratory were presented in tabulated form. The soil samples were first air dried ground with wooden pestle and mortar and passed through 2 mm stainless steel sieve. After mixing thoroughly, the processed samples were stored in cloth bags and used for various physical properties, using standard methods.

2.1 Determination of physical properties

Mechanical composition of soil was determined by International Pipette Method (Piper, 1966) [9]. For determination of bulk density at different depths, soil cores (5 cm inner diameter and 5 cm in height) were obtained from various depths (0-15 and15-30 cm). Samples were oven dried at 105 ^{0}C for 24 hours. Bulk density of soil samples was determined from the mass of soil and volume of the soil cores. Infiltration rate was measured in the field by using double ring close top infiltrometer as described in laboratory manual for soil physical analysis (Phogat *et al.*, 1999) [8]. Moisture content at field capacity and permanent wilting point was determined using pressure plate apparatus at 0.33 and 15 bar suction, respectively (Richards, 1954) [12].

3. Results and Discussion

3.1 Texture

The texture of the soils samples from the Peri-urban area were Analyzed in the laboratory and it was found that under both the condition of sewage and non-sewage water application, the texture was not affected. The texture of soil sample from peri-urban area of Kurukshetrawas sandy clay loam; Kaithal (clay loam), Narwana (sandy loam), Jind (sandy clay loam) and CharkhiDadri (sandy loam). In nutshell, it can be said that the application of sewage water had not altered the texture of the soils in comparison with the textures of the soils irrigated with non-sewage water. Similar results were reported by Dhaliwal *et al.* (2003) [5] and Kharche *et al.* (2011) [6].

3.2 Bulk density

The bulk density was found highest among the districts under study in Narwana (1.56 Mg m^{-3}) at 0-15 cm in sewage water irrigated soil while the bulk density was found highest in Charkhi Dadry (1.54 Mg m^{-3}) at 15-30 cm. However, the bulk density of the non-sewage water at both the depths was found higher in the non-sewage water irrigation. The reduction in the bulk density in the soils irrigated with sewage water may be attributed to the fact that sewage water resulted into increase in the organic matter.

The bulk density under the influence of sewage water reduced by the accumulation of organic carban which increase porosity of ultimately reduced the bulk density of the soil. Similar results have been reported by Mathan (1994) [7], Kharche *et al.* (2011) [6] and Subramani *et al.* (2014) [15].

3.3 Infiltration rate

The infiltration rate under the study got decreased with the application of sewage water and where applied. However, the highest infiltration rate was observed in Jind district (25.0 mm/h) under the non-sewage water as compared to the sewage water (17.6 mm/h). Likewise under sewage water highest infiltration rate was observed in district Charkhi Dadri (24.3 mm/h). Lowest infiltration rate was observed in district Narwana (10.5 mm/h) under sewage water application.

Some of the properties of soils are affected by the irrigated water. In the present study, infiltration rate of water was lower in the soils irrigated with sewage water. It was evident from the study that water infiltration rate was found lower in the soils which were irrigated with sewage water as compared to the soils irrigated with non-sewage water. The presence of higher quantity of sodium ions and lower quantity of calcium ions in the sewage water reduced the water infiltration rate of the soils under study (Ayers and Wescott, 1985) [3].

3.4 Water retention

The highest water retention (26.22%) was found in the soils irrigated with sewage water at 0.03 bar in district Jind while it was lowest (14.84%) in the soils of Charkhi Dadri at 0-15 cm under the influence of sewage water. Higher water retention at 0.15 bar was observed in the soils irrigated with sewage water at 0-15 cm in district Jind (8.08%) and lowest in Kaithal district (3.36%).

Water retention refers to the actual amount of water retained in the soil for crop use. In the present study, water content of the soils irrigated with sewage water was found 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 as compared to soils irrigated with non-sewage water. In addition to this, the water retention capacity of the soil depends upon the quantity of organic carbon and thereby the different profiles of a soil have varying water retention capacity (Viville *et al.* 1986) [17].

3.5 Available water

The available water content were found maximum in the samples taken from the sewage water irrigated soils of Kaithal district (21.15%) at 0-15 cm as compared to non sewage water from the same sites (16.45%) followed by Narwana (17.14%). Likewise at 15-30 cm depth sampling, maximum available water was observed under the sewage water irrigated soils of the same district i.e. Kaithal (21.86%) as compared to 17.19 % from the non-sewage water irrigated soil. Overall, the available water content was foun higher where the sewage water was applied as the source of water as compared to the sites where wage water. Also the available water got decreased with increase in the depth under both the condition but was found higher in the soil irrigated with sewage water. This might be due to the texture of soils which was sandy loam in Kaithal and sandy clay loam in Kurukshetra. This type of textures responds well to the available water percentage due to the effect of higher organic contents i.e. 0.91 per cent in Kaithal and 1.01 per cent in Kurukshetra. Similar reasoning was quoted by Bauer and Black (1981) [4].

Table 1: Effect of sewage water on bulk density and infiltration rate

Locations	Bulk density (Mg m^{-3})			
	0-15 cm		15-30 cm	
	Sewage	Non-sewage	Sewage	Non-sewage
Kurukshetra	1.32	1.35	1.30	1.38
Kaithal	1.31	1.33	1.29	1.44
Narwana	1.46	1.51	1.43	1.53
Jind	1.38	1.41	1.36	1.43
Charkhi Dadri	1.56	1.57	1.54	1.59

Table 2: Water retention of sewage and non-sewage water irrigated soils of peri-urban area of different districts

Location	Water retention (0.03 bar)				Water retention (0.15 bar)			
	0-15 cm		15-30 cm		0-15 cm		15-30 cm	
	Sewage	Non-sewage	Sewage	Non-sewage	Sewage	Non-sewage	Sewage	Non-sewage
Kurukshetra	18.91	22.04	22.67	21.38	3.83	3.21	4.07	3.77
Kaithal	24.51	21.81	21.25	20.37	3.36	4.06	3.71	4.18
Narwana	23.67	21.02	12.76	20.53	5.91	4.70	3.34	5.56
Jind	26.22	21.02	22.54	18.99	8.08	6.27	6.95	5.48
CharkhiDadri	14.84	13.14	13.30	13.60	4.63	6.89	4.07	4.26

Table 3: Available water at field capacity of sewage and non-sewage water irrigated soils of peri-urban area of Haryana

Location	Water retention content (%)			
	0-15 cm		15-30 cm	
	Sewage	Non-sewage	Sewage	Non-sewage
Kurukshetra	15.08	18.83	20.43	19.06
Kaithal	21.15	16.45	21.86	17.49
Narwana	17.14	14.32	19.20	14.98
Jind	15.60	12.70	18.15	13.87
CharkhiDadri	9.23	6.26	10.21	9.34

Table 4: Correlation between organic carbon and bulk density of soils irrigated with sewage and non-sewage water

Variable	Condition	Bulk density (mg m^{-3})	
		0-15 cm	15-30 cm
Organic carbon (%)	Sewage water	-0.705*	-0.800**
	Non-sewage water	-0.050	-0.350

*Significant at P = 0.05 levels
**Significant at P = 0.01 level

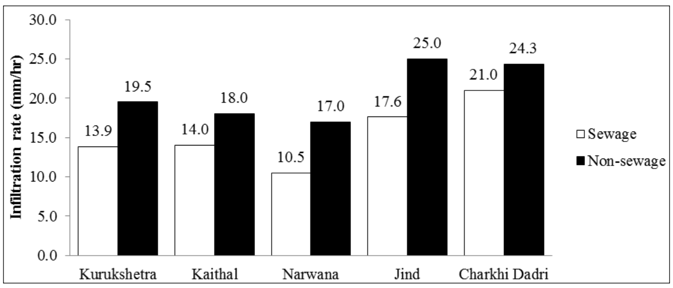

Fig 1: Effect of sewage water on infilteration rate

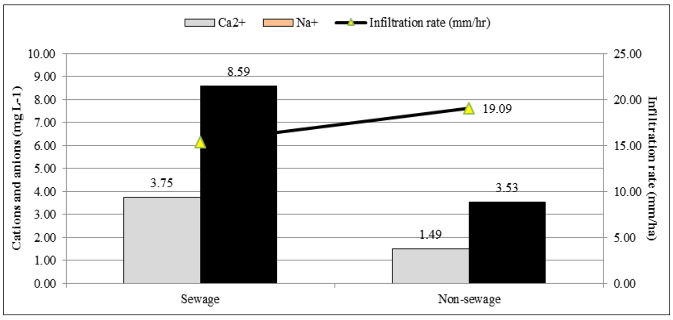

Fig 2: Effect of Calcium and sodium in sewage and non-sewage water on infiltration rate

Conclusion

From the above study it can be concluded that when sewage water was applied as a source of irrigation, the infiltration rate got decreased with the application of sewage water as source of irrigation. However, the available water content and water retention got increased while the bulk density decreased. The texture of the soils of Narwana and Charkhi Dadri irrigated with sewage and non-sewage water was found as sandy loam while it was sandy clay loam for Kurukshetra and Jind.The texture of the soils ot Kaithal irrigated with sewage and non-sewage water was found as Clay loam.

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