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Research Article

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Influence of Sewage Water Irrigation on Soil Properties in Different Districts of Haryana

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ABSTRACT

In this study, samples were collected from sewage and tube well water irrigated soil of various sites like Kaithal, Narwana and Jind district of Haryana state 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 chemical properties due to sewage irrigation. The mean value of pH (8.38) was found highest in the soils irrigated with sewage water of Jind. The mean value of EC (0.46 dSm^{-1}) was found highest in the soils irrigated with sewage water of Jind. The mean value of SOC (0.91%) was found highest in soils irrigated with sewage water of Kaithal. The mean value of $CaCO_3$ (3.57%) was found highest in the soils irrigated with sewage water of Narwana. The mean value of CEC (14.89 cmol (+) kg^{-1}) was found highest in the soils irrigated with sewage water of Kaithal. The mean value of Ca^{2+} (7.69) was found highest in the soils irrigated with sewage water of Jind. The mean value of Mg^{2+} (3.89) and Na^{+} (1.82) was found highest in the soils irrigated with sewage water of Kaithal. The mean value of K^{+} (0.94) was found highest in the soils irrigated with sewage water of Narwana.

Keywords: *$CaCO_3$, CEC, EC, OC, pH and Sewage water*

INTRODUCTION

Water is essential component of environment and it sustains life of the earth. It serves as a raw material for photosynthesis and therefore, it is important for crop production. Obviously, an optimum agricultural production depends on water and soil quantity. India supports more than 16% of the world's population with only 4% of the world's fresh water resources (Singh, 2003). Agriculture sector is the major user (89%) of this resource but the estimates showed that the growing demands from municipalities, industry and energy generation will claim about 23% (24.3 mha-m $year^{-1}$) of the total water resources (105 mha-m $year^{-1}$) by the year 2025AD, thereby, further reduce the good quality water supply for irrigation (Minhas & Tyagi, 1998, Bhat et al., 2018). In this changing scenario, reuse of domestic and industrial waste water in agriculture for irrigating crops appears to be a lucrative option. Increasing urbanization and industrialization has result the increased production of effluents worldwide.

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In particular, wastes of agro-industrial origin are expected to be high in organic matter and plant nutrients and low in toxic elements. As there is a gradual decline in availability of fresh water for irrigation in India, the use of sewage and other industrial effluents for irrigating agricultural lands is on the rise (Ratan et al., 2005). For the farmers, opportunities exist as sewage effluents from domestic origin are rich in organic matter and also contain appreciable amounts of major and micronutrients. Wastewater induced improvements in soil fertility status and thus nutrient uptake and the crop yields have been reported widely (Saha et al., 2010 & Singh et al., 2012).

The use of waste water for irrigating agricultural soil has been shown to be associated with a number of potential beneficial changes such as an increase in organic carbon, available nitrogen, phosphorus, potassium, and magnesium contents in soil as compared to the clean ground water-irrigated soil (Rai et al., 2011). Irrigation with waste water has been shown to result in increased growth, yield and plant constituents (Aghtape et al., 2011). With the demand for food increasing day by day, more and more land is to be brought under cultivation. Thus increasing the demand for inorganic fertilizers as well as irrigated water. Hence, the focus is shifting towards various non-conventional sources of irrigation available easily. Among others, one of the important irrigation as well as nutrient source is municipal sewage water. The long-term application of treated and untreated wastewater has resulted in a significant build-up of heavy metals in the soil (Khan et al. 2008). Farmers prefer the sewage irrigation for saving the cost of fertilizers and irrigation water. Besides nutrients, heavy metals are also present in the sewage water and leads to bio-accumulation of heavy metals in the cultivated crops there in (Rattan et al., 2002).

In recent years a lot of work has been done by several researchers worldwide on the use of sewage and industrial effluents as a source of irrigation and their effect on soil properties, accumulation of toxic metals and crop yields. Use of waste or sewage water had been found in historical literate and due to increasing demand of water in the present scenario, it was made legal to use the waste water directly to the agricultural land in many parts of the world. Paris was the first large city which started to irrigate the peri-urban fields with waste water (Jaramillo & Restrepo, 2017). Developing countries, like India require reliable and low cost technology methods for acquiring new water supplies and protection against the contamination of water to be used for agricultural purposes (Asano, 1996). Keeping in view of the aforementioned facts, the present study was undertaken to verify the effect of sewage water on existing state of the soil properties.

MATERIALS AND METHODS

Location of the study area and sampling

Soil samples irrigated with sewage water and groundwater were selected to compare the impact of water source on the soil from 3 sites across Kaithal, Narwana and Jind district of Haryana. The study area is located in Haryana in northern India, situated between 27°39' to 30°35' N latitude and between 74°28' and 77°36' E longitude. 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 chemical properties, using standard methods.

Samples analysis

Soil pH was determined in a 1:2.5 soil water suspension by glass electrode pH meter (Piper, 1950). Electrical conductivity of supernatant liquid was determined by using conductivity meter (Piper, 1950). Soil organic carbon content was determined by Walkley & Black,

(1934) method. Soil calcium carbonate content was determined by Puri (1949). Exchangeable calcium and magnesium were determined in neutral normal ammonium acetate extract by Versanate titration method (Cheng & Bray, 1951). Sodium was determined by flame photometer with the help of a standard curve outlined by Jackson (1967). Potassium was determined by flame photometer with the help of a standard curve outlined by Jackson (1967). Cation Exchange capacity was determined in the extract obtained by leaching the soil with normal sodium acetate solution (pH 8.2) followed by complete washing with 95 per cent ethanol and final extraction with normal ammonium acetate. Sodium in the resultant extract was determined with the help of flame photometer (Hesse, 1971).

RESULTS AND DISCUSSION

Effect of sewage and non-sewage water on soil chemical properties

The quality of sewage and well waters was assessed for irrigation with respect to their different parameters. The data pertaining to pH, EC, OC, $CaCO_3$ CEC and exchangeable cations of sewage and non-sewage water irrigated soils is presented in Table 1 to 3.

pH

The range of pH values of sewage water irrigated soil were recorded from 8.21 to 8.25, 7.70 to7.82, 8.35 to 8.40 as compare to non-sewage water irrigated soil were recorded from 8.00 to 8.12, 7.46 to 7.50, 8.00 to 8.17 of Kaithal, Narwana, Jind respectively. The value of pH was found highest (8.35 to 8.40) in the sewage water irrigated soil of Jind followed by Kaithal (8.21 to 8.25) and Narwana (7.70 to 7.82). The mean value of pH was found highest (8.38) in the sewage water irrigated soil of Jind as compared to the non-sewage water irrigated soil (7.48) of Narwana. The data clearly indicates that the pH of soil increased with depth. The mean pH values of all sites indicates that the soils irrigated with sewage water had higher pH as compared to soils irrigated with non-sewage water. These results revealed the sewage water applied in soils make the soil alkaline in nature. The results are in confirmation with the results of Gwenzi & Munondo (2008).

EC (dSm^{-1})

The range of EC values of sewage water irrigated soil were recorded from 0.34 to 0.38, 0.22 to 0.44, 0.40 to 0.51 dSm^{-1} as compare to non-sewage water irrigated soil were recorded from 0.21 to 0.24, 0.23 to 0.32, 0.28 to 0.35 dSm^{-1} of Kaithal, Narwana and Jind respectively. The value of EC was found highest (0.40 to 0.51 dSm^{-1}) in the sewage water irrigated soil of Jind followed by Kaithal (0.34 to 0.38 dSm^{-1}) and Narwana (0.22 to 0.44 dSm^{-1}). The mean value of EC was found highest (0.46 dSm^{-1}) in the sewage water irrigated soil of Jind as compared to the non-sewage water irrigated soil (0.23 dSm^{-1}) of Kaithal. The higher value of EC in sewage water irrigated soils may be ascribed due to higher concentration of the soluble salts from the sewage in the soil. Higher EC of the soil indicates the presence of higher levels of anions and cations in the soil. Further the sewage water was rich in the salts mainly of sodium chloride which also increased the EC of the soil. The results are in confirmation with the results of Gwenzi & Munondo (2008) and Oman et al. (2010).

Organic carbon

The range of OC values of sewage water irrigated soil were recorded from 0.89 to 0.92, 0.65 to 0.86, 0.81 to 0.95 % as compare to non-sewage water irrigated soil were recorded from 0.52 to 0.66,0.48 to 0.54, 0.45 to 0.56 % of Kaithal, Narwana band Jind respectively. The value of OC was found highest (0.81 to 0.95 in the sewage water irrigated soil of Jind followed by Kaithal (0.89 to 0.92 %) and Narwana (0.65 to 0.86 %). The mean value of OC was found highest (0.91 %) in the sewage water irrigated soil of Kaithal as compared to the non-sewage water irrigated soil (0.59 %) of Kaithal. The organic carbon in the sewage water irrigated soil was found to be higher which ultimately improved the infiltration rate, CEC and decreased the bulk density. All these properties are helped to improve the crop productivity point of view. Similar results were reported by Datta et al. (2000), Kesba et al. (2010) and Subramani et al. (2014).

$CaCO_3$

The range of $CaCO_3$ values of sewage water irrigated soil were recorded from 0.65 to 1.38, 3.21 to 3.93, 1.24 to 1.45 % as compare to non-sewage water irrigated soil were recorded from 0.52 to 0.80, 2.4 to 2.6, 0.68 to 0.74 % of Kaithal, Narwana and Jind respectively. The value of $CaCO_3$ was found highest (3.21 to 3.93 %) in the sewage water irrigated soil of Narwana followed by Kaithal (0.65 to 1.38 %) and Jind (1.24 to 1.45 %). The mean value of $CaCO_3$ was found highest (3.57 %) in the sewage water irrigated soil of Kaithal as compared to the non-sewage water irrigated soil (2.50 %) of Kaithal. It envisaged that sewage water resulted into more calcium carbonate content in the soils as compared to non-sewage water. In a nut shell, it can be inferred that calcium carbonate content increased in the sewage water irrigated sites with increase in depth also as compared to the sites irrigated with non-sewage water. The increase in calcium carbonate content in sewage water irrigated soil might be due to precipitation of Ca^{2+} exchanged from the soil complex by Na^+, present in sewage water as reported by Narwal & Gupta (1989).

CEC

The range of CEC values of sewage water irrigated soil were recorded from 12.23 to 17.54, 13.90 to 14.68, 14.18 to15.38 cmol (p+) kg^{-1} as compare to non-sewage water irrigated soil were recorded from 8.33 to 8.72, 7.40 to 9.07, 11.34 to 12.06 cmol (p+) kg^{-1} of Kaithal, Narwana and Jind respectively. The value of CEC was found highest (12.23 to 17.54 cmol (p+) kg^{-1}) in the sewage water irrigated soil of Kaithal followed by Narwana (13.90 to 14.68 cmol (p+) kg^{-1}) and Jind (14.18 to15.38 cmol (p+) kg^{-1}). The mean value of CEC was found highest (14.89 cmol (p+) kg^{-1}) in the sewage water irrigated soil of Kaithal as compared to the non-sewage water irrigated soil (11.70 cmol (p+) kg^{-1}) of Jind. Cation exchange capacity of the sewage water irrigated soils was higher as compared to the soils irrigated with non-sewage water. Also the mean values of CEC of the soils irrigated with sewage water at 15-30 cm depth was found higher as compared to the CEC of the soils irrigated with non-sewage water. Further, an increase in soil organic matter resulted into increase the CEC of soil irrigated with sewage water as compared to lower organic matter in the soils irrigated with non-sewage water. The results are in confirmation with Datta et al. (2000), Reddy & Rao (2000) and Malla & Totawat (2006).

Exchangeable cations

The highest content of exchangeable cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+) were observed in soils irrigated with sewage water as compared to soils of irrigated with non-sewage water. The value of Ca^{2+} was found highest (4.36 to 8.21 cmol (p+) kg^{-1}) in sewage water irrigated soil of Kaithal followed by Narwana (5.13 to 7.61 cmol (p+) kg^{-1}) and Jind (7.46 to 7 to 92 cmol (p+) kg^{-1}). The mean value of Ca^{2+} was found highest (7.69 cmol (p+) kg^{-1}) in the sewage water irrigated soil of Jind as compared to the non-sewage water irrigated soil (5.66 cmol (p+) kg^{-1}) of Jind. It is inferred from the data that sewage water irrigated soils had higher accumulation of Ca^{2+} than other cations. The value of Mg^{2+} was found highest (3.41 to 4.37 cmol (p+) kg^{-1}) in sewage water irrigated soil of Kaithal followed by Narwana (2.04 to 3.37 cmol (p+) kg^{-1}) and Jind (2.25 to 2.38 cmol (p+) kg^{-1}). The mean value of Mg^{2+} was found highest (3.89 cmol (p+) kg^{-1}) in the sewage water irrigated soil of Kaithal as compared to the non-sewage water irrigated soil (2.32 cmol (p+) kg^{-1}) of Jind. It is inferred from the data that Mg^{2+} content decreased with increased depth under sewage water application in the fields at all the sites. The value of Na^+ was found highest (1.36 to 2.27 cmol (p+) kg^{-1}) in sewage water irrigated soil of Kaithal followed by Narwana (1.52 to 1.73 cmol (p+) kg^{-1}) and Jind (0.24 to 0.35 cmol (p+) kg^{-1}). The mean value of Na^+ was found highest (1.82 cmol (p+) kg^{-1}) in the sewage water irrigated soil of Kaithal as compared to the non-sewage water irrigated soil (1.28 cmol (p+) kg^{-1}) of Narwana. The value of K^+ was found found highest (0.92 to 0.96 cmol (p+) kg^{-1}) in sewage water irrigated soil of Narwana followed by Kaithal (0.64 to 0.87 mg kg^{-1}) and

Jind (0.79 to 0.85 mg kg $^{-1}$). The mean value of K^+ was found highest (0.94 cmol (p+) kg^{-1}) in the sewage water irrigated soil of Narwana as compared to the non-sewage water irrigated soil (0.71 cmol (p+) kg^{-1}) of Jind.

However Na^+ and K^+ content decreased normally with increase in depth. The increase in the exchangeable cations might be due to the fact that these cations are higher in the sewage water which on irrigation simultaneously results into the higher concentration of these cations. Similar results were observed by Krishna & Govil (2008) and Kumar et al. (2011).

Table 1: Effect of sewage and non-sewage water on soil pH, EC, OC, $CaCO_3$, CEC and exchangeable cation of Kaithal

Location	Depth (cm)	pH	EC (dSm^{-1})	OC (%)	$CaCO_3$ (%)	CEC [cmol (p+) kg^{-1}]	Exchangeable cation [cmol (p+) kg^{-1}]			
							Ca^{2+}	Mg^{2+}	Na^+	K^+
SW-1	0-15	8.21	0.38	0.92	0.65	17.54	8.21	4.37	1.36	0.64
	15-30	8.28	0.37	0.85	0.81	11.82	4.14	3.13	1.18	0.44
SW-2	0-15	8.25	0.34	0.89	1.38	12.23	4.36	3.41	2.27	0.87
	15-30	8.27	0.27	0.77	1.73	11.54	3.22	2.36	1.63	0.46
NSW-1	0-15	8.00	0.24	0.52	0.52	8.33	3.18	2.26	1.12	0.18
	15-30	8.11	0.18	0.46	0.73	8.10	2.66	2.21	1.06	0.17
NSW-2	0-15	8.12	0.21	0.66	0.8	8.72	3.14	2.03	1.23	0.22
	15-30	8.16	0.19	0.44	1.05	7.36	2.63	2.10	1.14	0.19
Mean sewage	0-15	8.23	0.36	0.91	1.02	14.89	6.29	3.89	1.82	0.76
	15-30	8.28	0.32	0.81	1.27	11.68	3.68	2.75	1.41	0.45
Mean Non-sewage	0-15	8.06	0.23	0.59	0.66	8.53	3.16	2.15	1.18	0.20
	15-30	8.14	0.19	0.45	0.89	7.73	2.65	2.16	1.10	0.18

SW - Sewage water, NSW - Non-sewage water

Table 2. Effect of sewage and non-sewage water on soil pH, EC, OC, $CaCO_3$, CEC and exchangeable cation of Narwana

Location	Depth	pH	EC (dSm^{-1})	OC (%)	$CaCO_3$ (%)	CEC [cmol (p+) kg^{-1}]	Exchangeable cation [cmol (p+) kg^{-1}]			
							Ca^{2+}	Mg^{2+}	Na^+	K^+
SW-1	0-15	7.82	0.44	0.86	3.21	14.68	7.61	2.04	1.73	0.92
	15-30	7.9	0.33	0.63	3.57	13.22	6.12	1.55	1.93	0.74
SW-2	0-15	7.7	0.22	0.65	3.93	13.90	5.13	3.37	1.52	0.96
	15-30	7.75	0.17	0.51	4.6	12.74	4.54	3.25	1.48	0.48
NSW-1	0-15	7.46	0.23	0.54	2.6	9.07	2.50	1.91	1.29	0.27
	15-30	7.51	0.16	0.39	2.6	7.88	2.25	0.88	1.26	0.11
NSW-2	0-15	7.5	0.32	0.48	2.4	7.40	2.10	1.67	1.27	0.18
	15-30	7.58	0.27	0.3	2.76	6.24	2.00	0.91	1.18	0.11
Mean sewage	0-15	7.76	0.33	0.76	3.57	14.29	6.37	2.71	1.63	0.94
	15-30	7.83	0.25	0.57	4.09	12.98	5.33	2.40	1.71	0.61
Mean Non-sewage	0-15	7.48	0.28	0.51	2.50	8.24	2.30	1.79	1.28	0.23
	15-30	7.55	0.22	0.35	2.68	7.06	2.13	0.90	1.22	0.11

SW - Sewage water, NSW - Non-sewage water

Table 3: Effect of sewage and non-sewage water on soil pH, EC, OC, $CaCO_3$, CEC and exchangeable cation of Jind

Location	Depth (cm)	pH	EC (dSm^{-1})	OC (%)	$CaCO_3$ (%)	CEC [cmol (p+) kg^{-1}]	Exchangeable cation [cmol (p+) kg^{-1}]			
							Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}
SW-1	0-15	8.4	0.51	0.95	1.24	15.38	7.92	3.52	0.35	0.85
	15-30	8.7	0.35	0.79	1.32	14.66	6.37	3.10	0.28	0.95
SW-2	0-15	8.35	0.4	0.81	1.45	14.18	7.46	3.63	0.24	0.79
	15-30	8.5	0.24	0.75	1.64	13.16	6.01	3.15	0.29	0.84
NSW-1	0-15	8	0.35	0.45	0.74	12.06	5.80	2.25	0.14	0.67
	15-30	8.16	0.22	0.38	0.98	10.91	4.24	2.08	0.18	0.75
NSW-2	0-15	8.17	0.28	0.56	0.68	11.34	5.52	2.38	0.15	0.75
	15-30	8.4	0.21	0.44	0.92	10.14	5.58	1.65	0.14	0.87
Mean sewage	0-15	8.38	0.46	0.88	1.35	14.78	7.69	3.58	0.30	0.82
	15-30	8.60	0.30	0.77	1.48	13.91	6.19	3.13	0.29	0.90
Mean Non-sewage	0-15	8.09	0.32	0.51	0.71	11.70	5.66	2.32	0.15	0.71
	15-30	8.28	0.22	0.41	0.95	10.53	4.91	1.87	0.16	0.81

SW - Sewage water, NSW - Non-sewage water

CONCLUSION

From the above study it can be concluded that use of sewage water for irrigation in Kaithal, Narwana and Jind was found to improve the chemical properties of the soils without pre-treatment and found below the permissible limit without causing any harmful effect on the soil. The results from the sites under study where sewage water is being used for about some decades showed the enrichment of soils with organic carbon and nutrients status of soil. Thus, the efficient application of sewage and industrial effluents can effectively increase water resource for irrigation and may help increase for agriculture production. When the sewage and industrial effluents are used in agriculture, certain chemicals may cause hazards to human health by exposure through different sources. These exposure sources are mainly contact with sewage and industrial effluents (farmers, field workers and nearby communities) and consumption of sewage and industrial effluents-grown produce. So the regular monitoring of heavy metal concentration in effluents and their possible effect on soil and plant health is very necessary

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