

Effect of Long Term Continuous Application of Sewage Irrigation on Soil Characteristics and Heavy Metal Contents

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Abstract

A study on impact of long-term application of sewage irrigation on soil characteristics and heavy metal content was carried out in south-western part of Haryana state comprising Sirsa, Fatehabad, Hisar, Rohtak and Bhiwani districts. Raw sewer, soil and plant samples were collected both from sewage and non-sewage irrigated soils. The sewer water and soil samples were analyzed for their physico-chemical properties and heavy metal content. All the sewer water were found to be neutral to slightly acidic in reaction and low in their salt content along with appreciable amount of micronutrient and toxic metals. The sewage irrigated soils were high in EC, OC, CEC, DTPA-extractable and total Zn, Cu, Fe and Mn and potentially toxic metals (Cd, Pb, Ni, Cr, Co). Low in pH and high accumulation of salts were common in all the sewage irrigated soils.

Key words : Soil, Sewage irrigation, Physico-chemical properties, Toxic metals.

Effluent utilization of water resource is crucial to agricultural production for meeting the challenge of feeding the ever increasing population in the third world countries. Irrigation with sewage water not only meet the water requirement but also fulfill partial nutrient need of the crop as the effluents from municipal origin also contain appreciable amount of essential plant nutrients. In India about 2,600 Mm³ sewage generated per day and out of which this only 30% is treated and remaining 70% is discharged into land without any treatment. In Haryana also about 485 million liters of sewage water is produced every day which can irrigate 650 ha land/day by entering into the fields as a potential source of irrigation (1). However, continuous long term application of raw sewage for irrigation may adversely affect soil physico-chemical properties and resulted and accumulation of potentially toxic metal into soil and plant system to such an extent that they may cause toxic effect to plant growth. Therefore, the present study was planned to assess the effect of long-term application of sewage water on soil health and heavy metal status in the study area.

Methods

Sewer water, soil and plant samples were collected from the disposal sites and field of Sirsa,

Fatehabad, Hisar, Rohtak and Bhiwani cities peri-urban areas. To assess the impact of long term application of sewage water change in on soil characteristics and heavy metal status reference samples from non-sewage irrigated field were also collected. The soil and sewer water samples were analyzed for cations, anions pH, EC, OC, CaCO₃ and texture by following standard methods as described by Richard (2). The DTPA (soluble) and total heavy metal content in soil and plant samples were estimated using methods suggested by Lindsay and Norvell (3) using atomic absorption spectrophotometer.

Results and Discussion

Sewer Water Characteristics

The physico-chemical characteristics of the sewer water collected from the sewer outlet in the study area reveals that pH, EC, organic carbon, suspended solids, BOD and sodium adsorption ratio (SAR) ranged from 3.10 to 7.35, 2.0 to 3.2 dS/m, 37.50 to 322.50 mg/liter, 196 to 2120 mg/liter, 45.97 to 395.38 mg/liter and 2.93 to 10.09 mg/liter respectively (Table 1). The sewer water of Rohtak-I site was having lower pH (3.10) and highest EC, OC and BOD as compared to that of sewer water of Bhiwani, Hisar-I and Hisar-II. At the same time the sewer waters of

Table 1. Composition of raw-sewage in some cities of Haryana.

Locations	pH	EC (dS/m)	OC (mg/l)	TDS (mg/l)	BOD (mg/l)	Na (meq/l)
Sirsa-I	6.90	2.7	205.00	1648	251.33	12.10
Sirsa-II	6.85	3.1	195.00	2070	239.07	17.58
Fatehabad	7.05	2.0	273.75	196	335.61	6.06
Rohtak-I	3.10	3.2	322.50	1755	395.38	8.70
Rohtak-II	4.10	3.1	172.50	2120	211.48	11.21
Bhiwani	5.30	2.7	135.00	1758	165.51	10.09
Hisar-I	7.35	2.5	37.50	966	45.97	10.32
Hisar-II	6.90	2.2	52.50	928	64.36	11.19
Range	3.10-7.35	2.0-3.2	37.50-322.50	196-2120	45.97-395.38	6.06-17.58
Mean	5.94	2.7	174.22	1430.15	213.58	11.28

Table 1. Continued.

Locations	Ca (meq/l)	CO ₃ (m/l)	HCO ₃ (mg/l)	SAR (mg/l)	RSC (mg/l)
Sirsa-I	1.40	5.6	3.6	5.99	1.2
Sirsa-II	1.55	8.8	5.2	8.37	5.2
Fatehabad	1.50	4.8	1.2	2.93	—
Rohtak-I	—	—	—	8.70	—
Rohtak-II	2.10	—	4.0	4.47	—
Bhiwani	—	—	2.0	10.09	2.0
Hisar-I	2.25	6.4	5.6	4.59	1.8
Hisar-II	1.70	4.0	2.0	6.46	—
Range	1.40-2.25	4.0-8.8	1.2-5.6	2.93-10.09	1.2-5.2
Mean	1.75	5.9	3.4	6.55	2.50

Bhiwani, Hisar-I and II also contained higher amount of soluble salts and hence could not to be used for irrigation as they may deteriorate soil health and increase the concentration of heavy metals of agricultural land in the peri-urban areas of the cities of the study areas.

Effect on Physico-Chemical Characteristics of Soil

The data on impact of sewage irrigation reveals that sewage irrigation considerably decreased soil pH at all location (Table 2). The decrease in pH was found by 1.0, 0.43, 0.73, 0.36, 0.34 and 0.13 units in Sirsa, Fatehabad, Rohtak, Bhiwani, Hisar-I and Hisar-II respectively. The maximum change in pH was observed at Sirsa where the fields have been irrigated with sewer water for the last 34 years. The EC was more under sewage irrigated soil compared to non-sewage irrigated soils at all the sites. The increase in EC of sewage irrigated soil might be due to accumulation of soluble salts in soil receiving irrigation with

water of higher electrolyte concentration and the source of these salts in the sewage is the domestic activity (4).

The organic carbon content of non-sewage irrigated soils was much lower compared to soil irrigated

Table 2. Change in soil characteristics due to sewage irrigation at various locations of Haryana.

Properties	Locations					
	Sirsa (34)	Fate- habad (15— 20)	Roh- tak (40)	Bhi- wani (45)	His- ar-I (40)	His- ar-II (16)
pH (1 : 2)	-1.00	-0.43	-0.73	-0.36	-0.34	-0.13
EC (dS/m)	+0.35	+0.17	+1.38	+0.62	+0.38	+0.04
OC (%)	+1.12	+0.05	+0.67	+0.58	+0.50	+0.42
CaCO ₃ (%)	-0.67	-3.13	-2.33	+1.02	-2.25	+1.13
CEC (Cmol/ kg)	+4.70	+0.46	+3.71	+6.07	+2.16	+4.18

Table 3. Change in available and total toxic metals due to sewage irrigation at various locations of Haryana.

Properties	Locations					
	Sirsa (34)	Fatehabad (15—20)	Rohtak (40)	Bhiwani (45)	Hisar-I (40)	Hisar-II (6)
Available Toxic Metals (mg/kg)						
Cd	+ 2.28	+ 0.20	+ 1.32	+ 2.70	+ 0.36	+ 0.04
Pb	+ 0.14	+ 2.27	+ 4.14	+ 7.40	+ 0.46	+ 4.35
Ni	+ 1.56	+ 0.49	+ 0.96	+ 4.27	+ 0.54	+ 0.73
Cr	+ 0.07	+ 0.05	+ 0.05	+ 0.12	+ 0.03	+ 0.03
Co	+ 0.26	+ 0.32	+ 0.12	+ 0.36	+ 0.16	+ 0.28
Total Toxic Metals (mg/kg)						
Cd	+ 7.72	+ 10.17	+ 8.18	+ 19.85	+ 8.2	+ 6.92
Pb	+ 13.25	+ 9.74	+ 11.88	+ 21.43	+ 6.12	+ 4.34
Ni	+ 23.06	+ 25.63	+ 21.54	+ 36.89	+ 28.03	+ 14.49
Cr	+ 14.59	+ 6.64	+ 9.40	+ 11.83	+ 13.49	+ 8.53
Co	+ 11.68	+ 14.56	+ 15.21	+ 17.65	+ 18.70	+ 26.38

with sewer water. The increase in organic carbon was 1.12, 0.05, 0.67, 0.58, 0.50 and 0.42% over non-sewage irrigated soils of Sirsa, Fatehabad, Rohtak, Bhiwani, Hisar-I and Hisar-II respectively (Table 2). Increase in organic carbon content in sewage irrigated soils could be attributed to intensive cultivation of vegetables through out the year and subsequent addition of organic matter during sewage irrigation (5).

The CaCO_3 content was by 0.67, 3.13, 2.33 and 2.25% in Sirsa, Fatehabad, Rohtak and Hisar-I soils (Table 2). The higher content of CaCO_3 in non-sewage irrigated soil may be due to the arid climate and use of poor quality ground water for irrigation and precipitation of Ca^{++} exchanged from the soil complex by Na^+ present in the sewer water (6). However, there was no specific distribution pattern of CaCO_3 in both the soil.

The increase in CEC values of sewage irrigated soils over non-sewage irrigated was 4.70, 0.46, 0.37, 0.07, 2.16 and 4.18 C ml/kg in Sirsa, Fatehabad, Rohtak, Bhiwani, Hisar-I and Hisar-II soils respectively (Table 2). The maximum variation in CEC was observed in Bhiwani soil and least in Fatehabad soil. Similar results with continuous application of sewage were also observed by Gupta et al. (7).

Effect of Sewage Irrigation on Soluble Heavy Metals

The data on DTPA extractable (soluble) poten-

tially toxic metal (Cd, Pb, Ni, Cr, Co) in sewage and non-sewage irrigated soils are presented in Table 3. The data reveals that the DTPA extractable toxic metals in non-sewage irrigated soil in general were lower than sewage irrigated soil. The increase in soluble Cd was quite variable keeping in view its source and duration of sewage application (Table 3). The increase in DTPA-extractable Pb by sewage application was 0.14, 2.27, 4.14, 7.4, 0.46 and 4.35 mg/kg at Sirsa, Fatehabad, Rohtak, Bhiwani, Hisar-I and Hisar-II, respectively.

Similarly, the application of sewer water also found to enhance the level of soluble Ni by 1.56, 0.49, 0.96, 4.27, 0.54, 0.73 mg/kg, and cobalt (Co) by 0.26, 0.32, 0.12, 0.36, 0.16 and 0.28 mg/kg in Sirsa, Fatehabad, Rohtak, Bhiwani, Hisar-I and Hisar-II soils respectively (Table 3). Although, the concentration of DTPA extractable potentially toxic metals (Cd, Pb, Ni, Cr, Co) under long term application of sewage was high but it was still within the permissible limit based on the critical levels (8). The increase in potentially toxic metal content of these soils might be due to the discharge of industrial effluents into the sewer water and variation in the composition of sewer water used for irrigation (9).

Total Content of Toxic Metal

The data on temporal change in total content of potentially toxic elements (Cd, Pb, Ni, Cr and Co) also

exhibited similar trend as to that of soluble heavy metal (Table 3). At all the sites in the study area, sewage irrigated soils in general were found to contain higher concentration of all the toxic and trace elements compared to non-sewage irrigated soils because of discharge of industrial effluents into the sewer system used for irrigation. Moreover, the increase in total content of toxic metals was also quite variable at all the location which might be due to the variation in the composition of sewer water and inherent variation in the soil properties. These results are in close agreement with findings of Gupta et al. (7).

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