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EFFECT OF SEWAGE AND GROUND WATER IRRIGATION ON PHYSICO CHEMICAL PROPERTIES OF MUSI RIVER BASIN SOILS

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ABSTRACT

The present study was conducted to assess the influence of sewage and ground water irrigation on soil physico-chemical characteristics of surface and subsurface soils in Musi river basin, Hyderabad, Andhra Pradesh. Soil samples (100 surface and 100 subsurface) collected from different sites were analysed for their physico chemical properties, nutrients and heavy metals. The pH of the surface and sub surface soils irrigated with sewage and ground water was relatively higher compared to control (no irrigation). The organic carbon content in the surface and sub surface soils treated with sewage water was higher compared to ground water irrigated soils and control. In general, surface soils contained relatively higher amounts of organic carbon than those of sub surface soils. The available concentration of N,P and K ranged from 133.0 to 702.6 kg ha-^{1}, 11.6 to 347.7 kg ha-^{1} and 152.5 to 653.8 kg ha-^{1}. Respectively irrespective to depth of soils. The concentration of Cu, Fe, Mn and Zn extracted in DTPA extractant solution ranged from 0.63 to 2.85, 6.10 to 57.2, 1.17 to 21.72 and 0.38 to 2.15 mgkg-^{1}, respectively. The concentration of Cd was low compared to other heavt metals and occurred between 0.64 and 3.62 mgkg-^{1}. Surface soils had higher content of DTPA-extractable micronutrient cations and heavy metals as compared to sub surface soils.

Key words: soil physico chemical properties, chemical properties, sewage water, ground water.

INTRODUCTION

`With the increase in population, the magnitude of waste is multiplying enormously and is beyond the recycling capacity of local ecosystems. Consequently, it is posing a serious threat to the environment and human health. The sewage water may contain nitrate and other harmful chemicals, which contaminate the ground waters. In India, approximately 3500 million liters of sewage is generated in the cities alone. It is estimated that of the 150 L per capita per day of drinking water pumped by Indian municipalities, 80% returns as waste water in the drains. With the increasing scarcity of fresh water resources that are available to agriculture, the use of wastewater in agriculture will increase, especially in arid and semiarid conditions. In order to optimize the benefits of wastewater as a source of both the water and the nutrients, it is inevitable to minimize the negative impacts of its use on human health. Before, it is used for irrigation in agricultural lands, it is absolutely necessary to give due consideration towards its environmentally negative and positive aspects. There are various guidelines set for quality standards of wastewater in agriculture (Mara and Cairncross, 1989). These standards can be achieved if the wastewater is appropriately treated. However, while the use of untreated wastewater has become a routine practice in cities of developing countries, the policies on its use have not taken the cognizance of these facts. More than 20 million ha area is irrigated with urban wastewater, and that wastewater has important impact on agricultural productivity and livelihoods/human health. Several reports revealed accumulation of organic matter and soil available nutrients in soils irrigated with sewage waste water. Organic matter content in sewage irrigated soils was found to be higher in soils irrigated with sewage water compared to ground water (Singh etal 2012). Bao et al (2013) observed the enrichment of Cd, Cu, and Zn in deeper soil layers (40-70 cm) irrigated with sewage water. Therefore, the present study was conducted to quantify the long term effects of sewage and ground water irrigation on soil properties under Musi river basin of Hyderabad.

MATERIALS AND METHODS

Soil samples from five villages practicing sewage irrigation (Peerjadiguda, Parvathpur, Kachavani singaram, Muthawaliguda, Pratapsingaram), four villages practicing ground water irrigation and one village as control (no irrigation i.e rainfed from Annojiguda village),were collected. The study area geographically falls between $17^{0} – 19^{1}$ to 17^{0} - 30^{1} N latitude and 78^{0} – 23^{1} to 78^{0} –30^{1} E longitude. A total of 100 surface (0-15 cm depth) and 100 sub surface (15-30 cm depth) samples were collected. Out of the 100 soil samples collected, 50 samples were from sewage irrigated land, 40 samples from groundwater-irrigated land and 10 from un irrigated land. Standard methods were followed to determine the physico chemical characteristics of soils (Jackson 1973). Available nitrogen was determined by alkaline $KMnO_4$ method (Subbliah and Asija, 1956), phosphorus by Olsen et al (1954) and K in 1 N NH_4 OA_C (pH-7) extract by flame photometer. Available micronutrients and heavy metals were extracted with DTPA (Londsay and Norvell (1978) and determined on atomic absorption speetrophotometer.

RESULTS AND DISCUSSIONS

Physico chemical properties

The p^H of surface soils under sewage water and ground water irrigation ranged from 7.2 to 8.6 and 7.4 to 8.7 respectively (Table 1). In control, p^H 8.1 and 8.2 in surface and sub-surface soils respectively (Table 1) indicating relatively higher p^H in sub-surface soils. The relatively higher pH values under no irrigation conditions could be due to less or no leaching of salts or due to more accumulation of salts following evaporation under high temperature conditions. The EC of sewage water irrigated surface and subsurface soils ranged from 0.25 to 1.13dS m^{-1} and 0.22 to 0.91 dS m^{-1} respectively (Table 1). In groundwater irrigated soils, EC varied from 0.29 to 1.78 and 0.23 to 1.70dS m^{-1} respectively. In the control soils, the EC was 0.13 and 0.12 dSm^{-1} in surface and sub-surface soil, respectively. The results of Ahmed Usman *et al.*, (2006) showed that the EC of sewage irrigated soil was 200% higher compared to that of the non-irrigated soil**.** In the present study also, the sewage treated soils had considerably higher EC values compared to unirrigated soils. But the soils which were irrigated with ground water maintained higher EC even than the sewage treated soils. The increase in total soluble salt content in soils irrigated with ground water was due to presence of high content of salts such as bicarbonates in ground water. Similar results were reported by Tiwari *et al.,* (1996) for sewage irrigated soils of Varanasi, (U.P.) and Maiti *et al.,* (1992) for the sewage irrigated soils of Kolkata, (West Bengal). In general, soluble salt concentration tended to decrease with depth.

Table1: Mean content of physic-chemical properties and available nutrients (kg $ha^{-1)}$ in sewage and groundwater irrigated soils of Musi river Basin

Village	pH		EC (dS m^{-1})		OC (g kg^{-1})		Avail. N (kg ha^{-1})		Avail. P (kg ha^{-1})		Avail. K (kg ha^{-1})	
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
Sewage water												
Peerjadiguda (10)	7.8	8.1	0.35	0.29	12.4	8.0	702.6	659.5	287.1	185.9	219.4	240.5
Parvathapur (10)	7.2	7.4	0.73	0.44	15.2	16.5	513.8	389.2	332.2	281.2	394.4	300.7
Kachavani (10) singaram	8.1	8.2	1.13	0.91	14.7	14.2	239.5	386.3	314.2	347.7	653.8	610.8
Pratap (10) singaram	7.3	7.6	0.32	0.25	14.3	11.8	285.9	235.4	342.1	343.6	152.5	176.5
Muthawaliguda (10)	8.6	8.7	0.25	0.22	6.4	5.2	139.7	147.3	27.4	26.3	248.7	199.4
Ground water												
Sadat Ali Guda (10)	8.3	8.2	1.78	1.70	9.1	9.0	154.8	156.7	89.4	91.4	250.7	267.4
Korremula (10)	7.7	7.6	0.39	0.40	8.9	8.2	204.4	207.8	200.4	207.6	190.3	183.0
Chowdarguda (10)	8.4	8.	0.35	0.40	9.7	9.3	227.4	240.4	27.8	39.5	171.8	183.0
Narapally (10)	8.2	8.2	0.29	0.23	8.5	8.8	207.5	190.7	80.5	63.7	210.1	169.5
Annojiguda (10	8.1	8.2	0.13	0.12	4.4	4.6	138.1	133.0	14.5	11.6	189.6	186.3

Figures in parentheses indicate number of soil samples

The organic carbon content in surface and sub-surface under sewage water irrigated condition varied from 6.4 to 15.2g kg'^{1} and 5.2 to 16.5 g kg-^{1} (Table 1) which was higher compared to groundwater irrigated soils (8.5 to 9.7 and 8.8 to 9.3 g kg^{-1}) . In control soils, the surface and subsurface contained 4.4 and 4.6 g kg-^{1} organic carbon respectively. Higher buildup of soil organic matter was observed in soils irrigated with sewage water followed by groundwater irrigated soils. Though, buildup of organic matter in soils, in general, is considered as a desirable feature, organic matter loaded with toxic pollutants is not desirable. The organic C content of sewage and ground water irrigated soils was considerably higher than that under unirrigated condition. This may be due to higher content of suspended and soluble organic matter in the sewage water. Similar results were reported by Tiwari *et al.*, (1996) for the sewage irrigated soils of Varanasi and Bhupal Raj *et al.*, (1997) for the sewage affected soils of Hyderabad. Brar *et al.*, (2006) also stated that the soils irrigated with sewage contaminated water had higher organic carbon compared to soils irrigated with deep underground water. Organic carbon content decreased with depth under sewage water, ground water and unirrigated soils.

Major Nutrients

The available nitrogen in surface and subsurface soils ranged from 139.7 to702.6 and 147.3 to 659.5 kg ha^{-1} (Table 1) respectively when irrigated with sewage water. Whereas, the corresponding values in groundwater irrigated soils varied from 154.8 to 227.4 and 156.4 to 240.4 kg ha^{-1}. The available nitrogen in un irrigated (control) conditions was 138.1 and 133.0 kg ha-^{1}. Buildup of available N in soil under sewage water irrigated conditions is beneficial for improving soil fertility. The higher content of available nitrogen in sewage treated soils was due to continuous addition of sewage water having higher amounts of organic matter. The NH_4^+-N and NO_3^--N were formed due to mineralization of organic nitrogen. Similar results were reported by Azad *et al.*, (1987) for the sewage-irrigated soils of Ludhiana. In general, available N content decreased with depth. Surprisingly, in sewage water irrigated soils, available phosphorus content in surface and subsurface soils across the villages significantly varied from 27.4 to 342.1and 26.3 to 347.7 kg ha^{-1} (Table 1). In case of groundwater irrigated soils, the corresponding surface and subsurface P values varied from 27.8 to 200.4 and 39.5 to 207.6 kg P ha^{-1}. In the control soils, the surface and subsurface soils contained 14.5 and 11.6 kg P ha^{-1}. These levels were considerably higher than the critical values set for P availability in soils (higher if >25 kg P ha^{-1}). There was an increase in available phosphorus content in sewage fed soils over groundwater treated and control soils which may be due to the reason that considerable amount of phosphorus accumulates in the sewage water due to organic matter, detergents and soap mixed water coming from wash rooms from urban localities and industrial effluents. Dubey *et al.*, (2006) reported that the content of available P (58 kg ha^{-1}) in soil improved with the use of domestic sewage in Kurukshetra district of Haryana.

Table 2: Mean content of micronutrients (mg kg^{-1}) in sewage and groundwater treated soils of Musi river basin

Villages	Cu		Fe		Mn		Zn	
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
Sewage water								
Peerjadiguda	2.34	1.99	23.67	20.64	10.29	7.09	2.12	2.15
Parvathapur	1.81	1.70	54.82	57.2	11.28	8.427	2.08	1.56
Kachavani singaram	1.62	1.42	23.69	25.24	7.00	6.729	1.65	1.6
Pratap singaram	2.85	2.45	56.55	52.59	10.95	9.732	2.05	1.85
MTHG	0.68	0.63	6.43	6.11	10.18	10.40	1.82	1.53
Ground water								
Sadat Ali Guda	2.67	2.90	45.45	50.55	17.31	21.72	1.87	1.81
Korremula	1.03	1.03	9.02	11.82	3.86	4.069	0.48	0.38
Chowdarguda	2.01	2.84	18.46	21.46	1.35	1.172	1.50	1.47
Narapally	1.24	1.14	11.16	10.02	6.48	6.354	1.19	1.13
nnojiguda	1.24	1.1	6.4	6.1	4.14	4.29	1.18	1.09

MTHG-Muthawaliguda

In surface and subsurface soils treated with sewage and groundwater, K content ranged between 152.5 and 653.8 and 176.5 and 610.8 kg ha^{-1} (Table 1) respectively. Available K content was 189.6 and 186.3 kg ha^{-1} in surface and subsurface soils respectively Tiwari, *et al.*, (2003) stated that the treated sewage irrigated soil samples showed relatively higher organic carbon, available N, P and K in comparison to tube well irrigated soils. Azad *et al.* (1987) reported that the sub-soil layers generally contained higher amounts of potassium than the surface layers.

Heavy metals

Data indicating heavy metal levels of soils irrigated with sewage water and ground water are presented in Table 3. The levels of available metals in SW surface soils ranged from 1.52 to 3.62 mg Cd, 2.24 to 2.69 mg Ni and 56.7 to 94.1 mg kg-^{1} Pb whereas in ground water soils these ranged from 1.13 to 3.00 mg Cd, 3.62 to 4.22 mg Ni and 54.7 to 92.0 mg kg-^{1} Pb. The quantities of DTPA-extractable metals in SW sub surface ranged from 0.76 to 3.42 mg Cd. 2.17 to 9.12 mg Ni and 57.9 to 94.6 mg Pb and in ground water subsurface soils these ranged from 1.08 to 2.63 mg Cd, 33.3 to 4.27 mg Ni and 49.9 to 89.2 mg Pb. In unirrigated soils the amounts of Cd, Ni and Pb in surface and sub-surface soils were 0.64 and 0.97, 1.5 and 2.31 and 14.3 to 26.9 mg kg-^{1}, respectively. The concentration of the heavy metals was relatively higher in subsurface soils than surface soils. In general SW soils contained greater amount of heavy metals followed by ground water soils. Since the soils are formed from the same parent material, considerably higher concentrations of Cd, Ni and Pb detected in SW soils have resulted from external addition of these metals. Thus, continuous application of sewage water could be considered the only source responsible for their enrichment. The results are in consistent with the findings of Bhat *et al.* (2011).

Micronutrients

Average Cu content in surface and sub surface soils irrigated with sewage water ranged from 0.68 to 2.85 and 0.63 to 2.45 mg kg^{-1}, respectively. The corresponding ranges in ground water irrigated soils were from 1.03 to 2.67 and 1.03 to 2.90 mg kg-^{1}. The mean copper content in surface and sub surface unirrigated soils was 1.24 and 1.00 mg kg-^{1}, respectively. Thus, maximum amount of DTPA-Cu was noted in sewage water irrigated soils.

The available Fe content of surface samples treated with sewage water varied from 6.43 to 56.55 mg kg^{-1}. The corresponding values of available Fe in sub surface soils ranged from 6.11 to 52.59 mg kg-^{1}. The highest mean value was found in Pratap singaram soil (56.55 and 52.59 mg kg^{-1}) and lowest in Muthawaligudce (6.49 and 6.11 mg kg^{-1}). Available iron in surface and subsurface soils irrigated with ground water ranged from 9.02 to 5.45 mg kg-^{1} and 10.02 to 50.55 mg kg^{-1}, respectively. The mean value of available Fe in unirrigated surface and sub surface soils was 6.4 and 6.1 mg kg^{-1}, respectively. The maximum values of available iron were noted under sewage water irrigated soils followed by ground water and unirrigated soils. The average available Mn content of surface and sub surface soils treated with sewage water ranged from 7.00 to 11.28 mg kg-^{1} and 6.72 to 10.40 mg kg-^{1}, respectively. The surface and sub-surface soils irrigated with ground water contained from 1.35 to 17.31 mg kg^{-1} and 1.17 to 21.72 mg kg-^{1}, respectively. In unirrigated soils, surface and sub-surface soils had mean value of available Mn 4.14 and 4.29 mg kg^{-1}, respectively. Among these treated soils, sewage water irrigated soils containd higher amounts of available Mn. This might be due to sufficient amount of available Mn in sewage water. Similar results were reported by Brar and Singh (2006) and Tiwari *et al.* (1996). The average DTPA-Zn content of surface and sub-surface soils irrigated with sevage water ranged from 1.65 to 2.12 mg kg^{-1} and 1.53 to 2.15 mg kg^{-1}, respectively. The mean amount of available Zn in surface and sub-surface soils irrigated with ground water ranged from 0.48 to 1.87 mg kg^{-1} and from 0.38 to 1.81 mg kg-^{1}, respectively. The mean amount of available Zn in surface and surface soils without irrigation was 1.18 and 1.09 mg kg^{-1} respectively. In general, sewage water irrigated soils contained relatively higher amount of available zinc followed by ground water treated soils and lowest in unirrigated soils. Tiwari *et al.* (2003) also reported similar results. In general, surface soils had higher DTPA micronutrient cations due to higher organic carbon content and biological activity. Similar results were reported by Tiwari *et al.* (2003).

Table 3: Mean content of heavy metals (mg kg^{-1}) in sewage and ground water treated soils of Musi river bason

Villages	Cd		Ni		Pb	
	0-15	15-30	0-15	15-30	0-15	15-30
Sewage water						
Peerjadiguda	2.62	2.81	2.70	3.19	58.7	70.9
Parvathapur	2.40	0.76	4.03	2.17	62.6	57.9
Kachavani singaram	1.52	2.59	2.24	3.99	56.7	61.2
Pratap singaram	1.76	3.41	5.69	9.12	68.1	77.4
MTHG	3.62	3.42	5.48	5.92	94.1	94.6
Ground water						
Sadat Ali Guda	3.00	2.22	4.22	4.27	55.4	49.9
Korremula	2.47	2.45	4.17	3.93	92.0	89.2
Chowdarguda	2.28	2.63	3.88	3.88	58.0	57.0
Narapally	1.13	1.08	3.62	3.33	54.7	54.6
Annojiguda	0.64	0.97	1.59	2.39	14.3	26.9

The present study revealed that the organic carbon, available N, P and K were observed in higher quantities in the soils, which were irrigated with sewage water than those irrigated with ground water and control soils (without any irrigation). Though the higher contents of organic carbon, available N, P and K in soils irrigated with sewage is a desirable outcome, but at the same time there needs to be a check on other pollutants and toxic heavy metals. Very high build up of available P is also undesirable for the crop plants as it could inhibit the plant uptake of other micro nutrients like zinc. Highest contents of available micronutrients and heavy metals were observed in soils irrigated with sewage water compared to ground water irrigated conditions. Farmers in the Musi river basin will always get tempted to irrigate their crops to get higher yields. Therefore, it is suggested that sewage water should be treated before giving irrigation so that the load of contaminants could be reduced to the safer level and the potential of sewage water could be capitalised to enhance soil fertility in terms of available N, P and K which are very important elements for crop growth which otherwise farmers have to add through costly fertilisers.

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