Original Research Article

Characterization of wastewater irrigated soils of district Kota of Rajasthan

ABSTRACT: This study was conducted in Kota district for characterization of wastewater irrigated soils of *Haroti* region of Rajasthan in India. In kota district of *Haroti* region, most of the fields of urban and peri-urban agriculture depends on wastewater up to a certain extent as a source of irrigation water and nutrients. The quality of water and conditions under this water is used vary significantly. A quarterly survey was conducted and different characteristics of wastewater irrigated soils were determined. The irrigation effects of wastewater on soil properties were observed. The observed sand content, pH and dehydrogenase activity were decreased and Porosity, EC, BOD, COD, OC, available-NPK, SO_4, Cl and heavy metals *viz.* Mn, Fe, Zn, Cu, Ni, Cd, Pb and Cr were higher in wastewater irrigated soils as compared to reference tube well water irrigated soils collected from ten source points in district urban site. A slight decrease was observed during monsoon, it might be due to dilution effect of monsoon. Highest values were observed in summer of all study sites. Some parameters found above as the prescribed permission limits of Indian standards. The aim of this research is to determine the effects of wastewater irrigation on EC, pH, available- NPK, dehydrogenase and physical, chemical and biological properties of soils of Kota district of Rajasthan state in India.

Key words: Characterization of soil, Wastewater, NPK, Heavy metal,

1 INTRODUCTION

A huge amount of wastewater is generated daily in urban areas by different sources and has increased along with the increasing population, urbanization, improved living conditions, and economic development (Qadir *et al*., 2010). In most of the countries, urban and peri-urban agriculture depends on wastewater as a source of irrigation water and nutrients up to a certain extent. The quality of water and conditions under this water is used vary significantly. In many cities of our country, much of the wastewater from different sources tends to be untreated, whereas in big cities, treated wastewater is used (Minhas *et al.,* 2015). Wastewater irrigation is known to contribute significantly to the heavy metal content of soils (Mapanda *et al*., 2005) and plant species have a variety of capacities to remove and accumulate heavy metals.

Heavy metal accumulation in soils, and subsequently, in vegetation by long-term wastewater irrigation has a potentially detrimental effect on humans via their transfer along the food chain. In this reconnaissance study the effects of wastewater irrigation on the accumulation of heavy metals (Co, Cr, Cu, Mn, Ni, Pb and Zn) in soils and vegetables (Mohanty *et.al.,* 2021).

The wastewater and industrial waste disposal is worldwide problem and are often drained to agricultural lands where they are used for growing different crops including vegetables. It is considered a rich source of organic matter and other nutrients, but it increases the levels of heavy metals, such as Fe, Mn, Cu, Zn, Pb, Cr, Ni, Cd and Co, in the receiving soils (Rattan *et al*., 2005), many of which are non-essential and are toxic to plants, animals and human beings (Kanwar and Sandha, 2000). The long-term application of treated and untreated wastewater has resulted in a significant buildup of heavy metals in the soil (Khan *et al*., 2008; Ullah *et al*., 2012 and Minhas *et al.,* 2015) and in vegetables, which are subsequently transfers to the food chain and causing a potential health risk to consumers (Kumar Sharma *et al.,* 2007).

2 MATERIALS AND METHODS

2.1 SURVEY WORK

A quarterly survey was conducted in kota district at ten different study sites along with reference site. The samples of wastewater and soil were taken from the 10 randomly selected points, where both wastewater and reference tube well water irrigation were used for vegetable cultivation.

The soil properties were evaluated by the standard methods according to the USDA. All soil samples were analyzed for texture, BD, Porosity, EC, pH, OC, dehydrogenase activity, available-NPK and Mn, Fe, Zn, Cu, Ni, Cd, Pb and Cr *etc*.

2.2 SAMPLING

Soil samples were collected at the surface depths of 0-15cm using stainless steel auger sampling tools and plastic buckets to avoid any contamination of samples with traces of elements from the tools. At each sampling site, scrape away surface debris and collect the soil samples. The collected soil samples were immediately analysed for dehydrogenase activity than air dried, grounded with wooden mortar and pestle, passed through 2 mm sieve and stored in plastic bags for further analysis.

2.3 DIGESTION OF THE VEGETABLE AND SOILS SAMPLES

The soil samples were digested with perchloric acid and nitric acid (1:4) solution. The samples were left to cool and contents were filtered through Whitman filter paper No. 40. Each sample solution was made up to a final volume of 50 ml with distilled water and concentration of heavy metals were analyzed by atomic absorption spectrophotometer (ASS: model AA6300, Shimadzu).

3 RESULTS AND DISCUSSION

3.1 Physical characterization of soils

The observed soil texture of Kota was clay; soil bulk density (gcc^{-1}) of wastewater and tubewell irrigated soils were 1.38 and 1.45 of Kota; 1.41. The wastewater irrigated soils has lower BD as compared to tube well water irrigated soils. This can be attributed due increase in total porosity and aggregate stability in wastewater irrigated soils due to addition of organic matter.

The particle density (gcc^{-1})) of the districts of wastewater and tubewell irrigated soils were 2.51 and 2.56. The wastewater irrigated soils has lower particle density as compared to tube well water irrigated soils. The porosity (%) of wastewater and tubewell irrigated soils were 44.87 and 43.55 of Kota. The wastewater irrigated soils has higher porosity as compared to tube well water irrigated soils. This can be attributed due increase in total porosity and aggregate stability in wastewater irrigated soils due to addition of organic matter (Mathan *et al.,*1984; Kharche *et al.,* 2011 and Khan *et al.,* 2011, Singh, 2012 and Mohanty *et.al.,* 2021).

3.2 Chemical characterization of soils

The pH of wastewater and tube-well water irrigated soils during I^{st}, II^{nd}, III^{rd} and IV^{th} survey were 8.12, 7.47, 7.54, 7.69 and 8.55, 7.80, 7.88, 8.35 of Kota.

The EC (dSm^{-1}) of wastewater and tube-well water irrigated soils of kota urban sites was determined. The observed EC mean values of wastewater irrigated soils during I^{st}, II^{nd}, III^{rd} and IV^{th} survey were 2.14, 1.93, 2.09, 2.12 and 1.21, 1.04, 1.26, 1.20 of Kota. The organic carbon (gkg^{-1}) of the soil of wastewater and tube-well water irrigated fields during I^{st}, II^{nd}, III^{rd} and IV^{th} survey were 12.8, 10.9, 11.2, 11.27 and 4.62, 3.45, 4.35, 4.51 of Kota.

Available nitrogen ($kgha^{-1}$) status of soil of wastewater and tube-well water irrigated fields during I^{st}, II^{nd}, III^{rd} and IV^{th} survey were 478.4, 366.5, 367.9, 451.5 and 151.2, 130.4, 141.7, 143.0 of Kota.

The available phosphorus (kgha^{-1}) of soil of wastewater and tube-well water irrigated fields during I^{st}, II^{nd}, III^{rd} and IV^{th} survey were 52.0, 47.8, 36.0, 36.39 and 19.3, 19.0, 19.2, 19.43 of Kota.

The available potassium (kgha^{-1}) of soil of wastewater and tube-well water irrigated fields during I^{st}, II^{nd}, III^{rd} and IV^{th} survey were 383.5, 364.4, 376.1, 379.2 and 206.6, 202.1, 216.0, 217.9 of Kota.

The observed pH, EC, NPK in wastewater and tube-well water irrigated soils were differed as per time and location. A slight decrease was observed during monsoon, it might be due to dilution effect of monsoon. Highest values were observed in summer at all four study sites. The pH of tube well water irrigated soils was higher than wastewater. Decrease of pH of wastewater irrigated soils are perhaps due to the effect of acidic nature of wastewater used for irrigation and EC, OC and NPK of wastewater irrigated soils were higher than tube-well water irrigated soils due to higher load of soluble salts and metallic ions in wastewater.

A slight decrease in EC, OC and NPK was observed during monsoon, it might be due to dilution of water and transportation of OM, NPK and soluble salts with rain water. Highest values were observed in summer. The increase in EC, OC, available NPK of wastewater irrigated soils are perhaps due to higher amount of OM, available NPK and soluble salts in wastewater used for irrigation (Totawat, 1991; Totawat *et al.,* 1994, Baddesha *et al.,* 1997; Saha and Mandal, 1998; Mitra and Gupta, 1999; Brar *et al.,* 2000; Khurana *et al.*, 2004; Minhas and Samra, 2004; Bhat *et al.,* 2011; Singh *et al.,* 2011 and Khurana, Singh, 2012 and Mohanty *et.al.,* 2021).

3.3 Biological characterization of soils

The activity of dehydrogenase enzyme (µgTPFd^{-1}g^{-1}) of soils from wastewater and tube-well water irrigated vegetable fields during I^{st}, II^{nd}, III^{rd} and IV^{th} survey were 1.10, 1.01, 0.91, 0.92 and 0.55, 0.54, 0.54, 0.55 of Kota. The DHA of wastewater irrigated soils were higher than tube-well water irrigated soils. The increase in DHA of wastewater irrigated soils was perhaps due to higher amount of organic matter in wastewater used for irrigation.

The DHA of wastewater and tube-well water irrigated soils were differed as per time and location. Decrease in DHA was observed during summer and monsoon that might be due high temperature and toxic concentration of heavy metals in summer and dilution effect of monsoon. Highest values were observed in winter and spring season that might be due to favourable environmental conditions for microbes. The reduction in DHA in soils in summer season might be due to the build- up of heavy metal toxicity in soils irrigated with wastewater (Casida *et al*., 1964; Rao *et al*., 1993; Tripathi *et al*., 2007; Salazar *et al*., 2011; Subhani *et al*., 2011; Cirilli *et al*., 2012; Yuan and Yue, 2012).

CONCLUSIONS AND RECOMMENDATIONS

The result reveals that untreated wastewater is the primary source of pollution to the soil and leads to an increase the concentration of metals in soils and vegetables. The wastewater irrigation has importance throughout the world due to limited water sources and wastewater treatment costs for discharge. It contains a high amount of organic matter, nutrients and heavy metals. In our study, the wastewater irrigated vegetables cultivated soil samples taken had increased concentrations of metals in all the soils. A significant accumulation of toxic heavy metals in soils samples is due to the sewage water irrigation in Kota region.

The concentrations of the metals in the soils will provide baseline data and intensive sampling is required for the quantification of the results not only in Kota but throughout the country. To avoid the entrance of metals into the food chain, municipal or industrial waste should not be drained into rivers and farmlands without prior treatment. The continuous monitoring of the soil, plant and water quality are prerequisites for the prevention of potential health hazards to human beings.

An urgent need exists to strictly monitor the wastewater and the groundwater of the study area and to develop different strategies to prevent the accumulation of heavy metals in food crops that may ultimately minimize the chronic health risk to the exposed population.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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Table-1: Impact of wastewater irrigation on soil Physical properties of Kota

Location	Sand	Silt	Clay	Textural	BD	PD	Porosity
Unit	%	%	%	Class	(g cm^{-3})	(g cm^{-3})	%
Wastewater irrigated soils							
WW-1	21.50	26.25	52.25	Clay	1.41	2.53	44.27
WW-2	20.95	26.45	52.60	Clay	1.40	2.52	44.44
WW-3	20.48	26.78	52.74	Clay	1.39	2.52	44.84
WW-4	20.23	26.98	52.79	Clay	1.39	2.51	44.62
WW-5	19.80	27.22	52.98	Clay	1.38	2.51	45.02
WW-6	19.18	27.56	53.26	Clay	1.38	2.50	44.80
WW-7	18.26	27.87	53.87	Clay	1.37	2.50	45.20
WW-8	17.68	27.96	54.36	Clay	1.37	2.49	44.98
WW-9	16.84	28.32	54.84	Clay	1.36	2.49	45.38
WW-10	16.90	28.54	54.56	Clay	1.36	2.48	45.16
Mean	**19.18**	**27.39**	**53.43**	Clay	**1.38**	**2.51**	**44.87**
Tube well water irrigated soils							
TW-1	33.96	16.78	49.26	Clay	1.45	2.57	43.58
TW-2	33.11	16.87	50.02	Clay	1.44	2.55	43.53
Mean	**33.54**	**16.83**	**49.64**	Clay	**1.45**	**2.56**	**43.55**

Table 2 Impact of wastewater irrigation on soil Chemical properties

Survey No.	EC (dS m^{-1})	pH	OC (g kg^{-1})	NO^{-}_3	P_2O_5	K_2O	Mn	Fe	Zn	Cu	Ni	Pb	Cd	Cr
				(kgha^{-1})			(mgkg^{-1})							
Wastewater irrigated soil														
I	2.14	8.12	12.8	478.4	52.0	383.5	5.15	17.69	6.262	6.10	4.94	8.07	1.35	7.88
II	1.93	7.47	10.9	366.5	47.8	364.4	4.85	15.30	6.11	5.96	4.82	7.87	1.32	6.71
III	2.09	7.54	11.2	367.9	36.0	376.1	5.54	16.37	6.53	6.37	5.15	8.42	1.41	7.18
IV	2.12	7.69	11.27	451.5	36.39	379.2	6.07	17.19	6.86	6.69	5.41	8.84	1.48	7.54

Tube well water irrigated soil														
I	1.21	8.55	4.62	151.2	19.3	206.6	2.69	4.61	3.49	3.62	1.67	0.39	0.35	0.86
II	1.04	7.80	3.45	130.4	19.0	202.1	2.09	3.48	2.75	2.56	1.64	0.36	0.32	0.54
III	1.26	7.88	4.35	141.7	19.2	216.0	2.12	3.59	3.71	3.59	1.66	0.39	0.36	0.66
IV	1.20	8.35	4.51	143.0	19.43	217.9	2.27	4.59	3.75	3.60	1.65	0.38	0.37	0.87
MPL*								**3000-5000**	**10-300**	**6.0-60**		**10-70**	**0.07-1.10**	

***MPL-Maximum permissible limit: BIS (IS:10500:1991); ND- Not detected; I-May, 2012; II-August, 2012; III- November, 2012; IV- February, 2013**

Table 3 Impact of wastewater irrigation on soil Biological properties

Survey No.	DHA (µg TPF d^{-1} g-^{1})
Wastewater irrigated soil	
I	1.10
II	1.01
III	0.91
IV	0.92
Tube well water irrigated soil	
I	0.55

II	0.54
III	0.54
IV	0.55