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Characterization of Wastewater Irrigated Soils of District Kota of Rajasthan

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study was conducted in Kota district for characterization of wastewater irrigated soils of Kota district of Rajasthan. In Kota, urban and peri urban agriculture fields depends on particularly during summer season. The water quality significantly varies according to varies conditions. A quarterly survey was conducted and different characteristics of wastewater and source of waste water irrigated soils were determined. The irrigation effects of wastewater on soil properties were observed. The observation of sand content, pH and dehydrogenase activity were decreased and the other properties like Porosity, EC, BOD, COD, OC, available-NPK, SO_4, Cl and heavy metals *viz.* Mn, Fe, Zn, Cu, Ni, Cd, Pb and Cr were increased. Observation of the impact of waste water on soil properties were studied in comparison with the 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. Present investigation aim to determine the irrigation effects of wastewater on soil EC, pH, available- NPK, dehydrogenase activity and micronutrient content of Kota district of Rajasthan in India.

Keywords: Characterization of soil; wastewater; NPK; heavy metal.

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1. INTRODUCTION

The Discharge of untreated municipal and industrial wastewater to waterways and soils resulting in degradation of water and soil quality and becomes a major environmental concern in many (semi) urban areas of several countries [1]. 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 [2]. 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 [3]. Wastewater irrigation is known to contribute significantly to the heavy metal content of soils [4] and plant species have a variety of capacities to remove and accumulate heavy metals.

Accumulation of Heavy metal in soils, and subsequently, in vegetation by long-term wastewater irrigation has a potential to determine the effect on humans via their transfer along the food chain [1]. The wastewater and industrial waste disposal is worldwide problem which are often drained to agricultural lands and 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 [5], many of which are non-essential and have toxic effect to plants, animals and human beings [6].

The long-term application of treated and untreated wastewater has resulted in a significant buildup of heavy metals in the soil [7, 8,3] and in vegetables. Such heavy metals are subsequently transfers to the food chain and causing a potential health risk to consumers [9].

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 heavy metals such as 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 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 study site was clay; soil bulk density (gcc^{-1}) of wastewater and tubewell irrigated soils were 1.38 and 1.45. The wastewater irrigated soils has lower BD with reference to tube well water irrigated soils. This is due to increase in total porosity. The aggregate stability in wastewater irrigated soils due to addition of organic matter.

The particle density (gcc^{-1})) of the study sites of wastewater and tubewell irrigated soils were 2.51 and 2.56. The wastewater irrigated soils has lower particle density with reference to tube well water irrigated soils. The porosity (%) of wastewater and tubewell irrigated soils were 44.87 and 43.55.

The wastewater irrigated soils has higher porosity as compared to tube well water irrigated soils. This is due to increase in total porosity and aggregate stability in wastewater irrigated soils due to addition of organic matter [10,11,12,13].

3.2 Chemical Characterization of Soils

The observed mean value of pH of wastewater and tube-well water irrigated soils during Ist, IInd, IIIrd and IVth survey were 8.12, 7.47, 7.54, 7.69 and 8.55, 7.80, 7.88, 8.35 of Kota study site.

The observed mean value of 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 Ist, IInd, IIIrd and IVth 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 Ist, IInd, IIIrd and IVth survey were 12.8, 10.9, 11.2, 11.27 and 4.62, 3.45, 4.35, 4.51 of Kota.

The observed mean value of available nitrogen (kgha^{-1}) status of soil of wastewater and tube-well water irrigated fields during Ist, IInd, IIIrd and IVth survey were 478.4, 366.5, 367.9, 451.5 and 151.2, 130.4, 141.7, 143.0 of Kota.

The observed mean value of available phosphorus (kgha^{-1}) of soil of wastewater and tube-well water irrigated fields during Ist, IInd, IIIrd and IVth survey were 52.0, 47.8, 36.0, 36.39 and 19.3, 19.0, 19.2, 19.43 of Kota.

The observed mean value of available potassium (kgha^{-1}) of soil of wastewater and tube-well water irrigated fields during Ist, IInd, IIIrd and IVth 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.

The observed mean Mn content value in soils of waste water irrigated vegetable fields during I, II, III and IV survey were 5.15, 4.85, 5.54, 6.07 and tube well water irrigated soils were 2.69, 2.09, 2.12, 2.27.The Fe contents in soils of waste water irrigated vegetable fields during I, II, III and IV survey were 17.9, 15.30, 16.37, 17.19 as compared to tube well water irrigated soils were 4.61, 3.48, 3.59, 4.29.

The observed mean ZN content value in soils of waste water irrigated vegetable fields during I, II, III and IV survey were 6.26, 6.11, 6.53, 6.86 with reference to tube well water irrigated soils were 3.49, 2.75, 3.71, 3.75. The Cu contents in soils of waste water irrigated vegetable fields during I, II, III and IV survey were 6.10, 5.96, 6.37, 6.69 with reference to tube well water irrigated soils were 3.62, 2.56, 3.59, 3.60.

The observed mean Ni contents value in soils of waste water irrigated vegetable fields during I, II, III and IV survey were 4.94, 4.82, 5.15, 5.41 as compared to tube well water irrigated soils were 1.67, 1.64, 1.66, 1.65. The Cd contents in soils of waste water irrigated vegetable fields during I, II, III and IV survey were 1.35, 1.32, 1.41, 1.48 as compared to tube well water irrigated soils were 0.35, 0.32, 0.32, 0.36, 0.37.

The observed mean Pb contents value in soils of waste water irrigated vegetable fields during I, II, III and IV survey were 8.07, 7.87, 8.42, 8.84 with reference to tube well water irrigated soils were 0.39, 0.36, 0.39, 0.38. The Cr contents in soils of waste water irrigated vegetable fields during I, II, III and IV survey were 7.88, 6.71, 7.18, 7.54 with reference to tube well water irrigated soils were 0.86, 0.54, 0.66, 0.87.

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 [14-20] Singh, 2012 and [1].

3.3 Biological Characterization of Soils

The mean value of activity of dehydrogenase enzyme (µgTPFd^{-1}g^{-1}) of soils from wastewater and tube-well water irrigated vegetable fields during Ist, IInd, IIIrd and IVth 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 with reference to 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 irrigated soils and tube-well water irrigated soils were varied 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 during summer season might be due to the build- up of heavy metal toxicity in soils irrigated with wastewater [23-28].

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 and biological properties

Survey No.	EC (dSm^{-1})	pH	OC (g kg^{-1})	NO^-_3 ($kgha^{-1}$)	P_2O_5 ($kgha^{-1}$)	K_2O ($kgha^{-1}$)	DHA (µg TPF d^{-1} g^{-1})
Wastewater irrigated soils							
I	2.14	8.12	12.8	478.4	52.0	383.5	1.10
II	1.93	7.47	10.9	366.5	47.8	364.4	1.01
III	2.09	7.54	11.2	367.9	36.0	376.1	0.91
IV	2.12	7.69	11.27	451.5	36.39	379.2	0.92
Tube well water irrigated soils							
I	1.21	8.55	4.62	151.2	19.3	206.6	0.55
II	1.04	7.80	3.45	130.4	19.0	202.1	0.54
III	1.26	7.88	4.35	141.7	19.2	216.0	0.54
IV	1.20	8.35	4.51	143.0	19.43	217.9	0.55

Table 3. Concentration of heavy metals (kg/gm) in wastewater and tubewell water irrigated soils of Kota

Survey No.	Mn	Fe	Zn	Cu	Ni	Pb	Cd	Cr
Wastewater irrigated								
I	5.15	17.69	6.26	6.10	4.94	8.07	1.35	7.88
II	4.85	15.30	6.11	5.96	4.82	7.87	1.32	6.71
III	5.54	16.37	6.53	6.37	5.15	8.42	1.41	7.18
IV	6.07	17.19	6.86	6.69	5.41	8.84	1.48	7.54
Tube well water irrigated								
I	0.55	2.69	4.61	3.49	3.62	1.67	0.39	0.35
II	0.54	2.09	3.48	2.75	2.56	1.64	0.36	0.32
III	0.54	2.12	3.59	3.71	3.59	1.66	0.39	0.36
IV	0.55	2.27	4.59	3.75	3.60	1.65	0.38	0.37
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*

4. CONCLUSIONS AND RECOMMENDATIONS

The research concluded that wastewater is the source of organic matter, plant nutrients as well as soil pollution which leads to an increase the concentration of heavy metals in soils and vegetables grown. The wastewater irrigation has immense importance due to limited water sources during summer. In our study, the wastewater irrigated vegetables cultivated soil had reduced pH value, BD and PD, slight increase in total porosity, increased concentrations of NPK, dehydrogenase activity and heavy metals. A significant accumulation of toxic heavy metals in soils samples is due to the waste water irrigation in urban and semi urban areas of Kota district [29-32].

The concentrations of the metals in the soils will provide baseline data. There is a need of intensive sampling for the quantification of the results in Kota. 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 and regulation of the soil, plant and water quality are prerequisites for the prevention of potential health hazards to animals and human beings.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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