Annals of Plant and Soil Research 17(2): 129-132 (2015)

EFFECT OF SEWAGE WATER IRRIGATION ON ACCUMULATION OF MICRONUTRIENTS AND HEAVY METALS IN SOILS AND VEGETABLE CROPS

SANDEEP SINGH, VINAY SINGH, JAGPAL SINGH, ANIL KUMAR[1] AND HARVENDRA SINGH[2]

Department of Agricultural Chemistry and Soil Science, Raja Balwant Singh College Bichpuri, Agra (U.P.) – 283 105
Received: October, 2014; Revised accepted: April, 2015

ABSTRACT

The samples of soils and leaves f brinjal (Solanum melongena) as well as radish (Rhapanus sativus L.) crops were collected from the farmers fields along a sewage water nullah in which the treated sewage waters are poured when irrigation in crops is needed. The soil and plant samples were also collected from the same areas irrigated with ground water. Quality of sewage water and ground water from tubewell was found suitable for irrigation purpose but differed widely in their chemical characteristics. Enrichment with organic carbon N, P and K was relatively higher in sewage water irrigated soils as compared tube well water irrigated soils. The sewage water irrigated soils had mean values of available Fe, Mn. Cu and Zn as 13.8, 9.9, 2.1 and 2.75 mg kg^{-1} respectively whereas adjoining soils irrigated with tube well water contained 5.2, 3.0, 0.32 and 0.60 mg kg^{-1} respectively. The concentrations of micronutrients and heavy metals in vegetables irrigated with sewage water were higher than those irrigated with tube well water. Brinjal showed higher level of Zn. Fe and Cd than in radish, whereas Cu, Ni and Pb concentrations were higher in radish samples.

Keywords: Sewage water, accumulation, heavy metals soil, plant

INTRODUC TION

Efficient utilization of water resource is crucial to agricultural production for meeting the challenge of feeding the ever-increasing human population in India. Industrial and domestic effluents with solid (sludge) and liquid (sewage) components are often used for irrigation purposes due to non-availability of fresh water to take advantage of organic matter and plant nutrients. Sewage effluents of municipal origin contain appreciable amounts of major essential plant nutrients like N, P, K, S and several micronutrients such as Zn, Cu, Mn and Fe. Ni and Cr (Saha et al, 2010).Accordingly the nutrient levels of the soils are expected to improve considerably with continuous application of sewage effluent t. Again sewage effluents contain variable amounts of heavy metals like Pb, Cd, Cr, and Ni etc. A limiting factor in the long-term application of sewage effluent to agricultural land is the likelihood of accumulation of heavy metals in the soils and their transmission to crops grown. The presence of these heavy metals in the soil affects the environment in several ways; contamination of food because of the plants grown in polluted soil, as well as a decrease in crop productivity and soil microbial activity (Saha *et al*. 2013). Although partial and sporadic information on the characteristics of the sewer water S is available, yet, no systematic study has been conducted so far in Agra, (Uttar Pradesh) to assess the relative availability of heavy metals in soil irrigated with waste water. The present investigation was initiated to collect information regarding status of nutrients and heavy metals in surface soils and their contents in vegetable crops grown on treated sewage water irrigated command area around sewage treatment plant at Dhandupura (Agra) Uttar Pradesh.

MATERIALS AND METHODS

The sewage water and ground water samples of the tube well were collected in winter season from the sewage water irrigated areas. The sewage effluent and ground water samples were analyzed for pH and EC following the standard methods. For the determination of micronutrients and heavy metals, 100 ml treated sewage water sample was digested with 5 ml of di acid (HNO_3:$HClO_4$ 4:1) and the mixture was concentrated by drying and made up to 50 ml. Surface (0-15 cm) samples of soils irrigated last 7-8 years with sewage water were collected from 50 locations. Soil samples (15) were also collected from an adjoining area where only tube well water was used for irrigation. The samples thus collected were brought to the laboratory, dried, processed and analyzed. Organic carbon, available N, available P, and available K were determined by adopting standard procedures (Jackson 1973). DTPA-extractable (Lindsay and Norvell, 1978) Fe, Mn, Cu, Zn, Ni, Cd, Pb, Co were determined on atomic absorption spectrophotometere. Plant samples of vegetable crops collected from the same sites were digested with diacid mixture (HNO_3:$HClO_4$) and analyzed for the heavy metals and micronutrients on atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

The mean pH of sewage water was 7.6 whereas that of tubewell water, it was 7.7 the waters could be considered as slightly alkaline. EC was 0.93

Zonal Agriculture Research Station, Morena (M.P.), IARI New Delhi,

dSm^{-1} for sewage water and 0.95 dSm^{-1} for tubewell water. The pH and EC of the effluent were within the permissible limits in respect of its use in agriculture. However, the average TSS (total suspended solids) in sewage water (480 mg L^{-1}) was above the permissible limit (100 mg L^{-1}, EPR 1993) for effluents (Table 1). Heavy metal status of sewage effluent followed the order Pb (0.70 mg L^{-1})>Cd(0.19 mg L^{-1})>Ni (0.19 mg L^{-1}). As per the safe limit of 5 mg L^{-1} of Pb in irrigation waters (Ayers and Westcot 1985), the value was below the safe limit for Pb. The concentration of Ni was within the threshold limits (FAO 1985), however Cd content (0.19 mg M^{-1}) exceeded the threshold;d limit of 0.01 mg L^{-1} set by FAO (1985) and hence it may not be suitable for irrigation. The higher content of Cd might be due to the mixing of industrial effluents with domestic sewage. The concentration of Fe (5.10 mg L^{-1}), Mn (0.65 mg L^{-1}), Cu (0.51 mg L^{-1}) and Zn (0.58 mg L^{-1}) in sewage water were well within the maximum prescribed limits for irrigation quality standards (100 mg L^{-1}, Pratt 1972). Tubewell water was a poor source of these micronutrients (Fe 1.0, Mn 0.20, Cu traces and Zn 0.10 mg L^{-1}) in comparison to sewage water. Since the concentration of Cd in sewage water was present beyond the permissible limits, use of such waters over long period for irrigation with out any remedial measures can possibly lead to accumulation of Cd in soils and thus contammation of food chain through its uptake by plants (Kumar *et al.* 2011).

Table 1: Chemical characteristics of sewage and tubewell water used for irrigation

Sr. No.	Parameters	Sewage water	Tubewell water
1.	pH	7.6	7.8
2	EC (dSm^{-1})	0.93	0.95
3	Total solids (mg L^{-1})	480.0	Nil
4.	Iron (mg L^{-1})	5.10	1.0
5	Manganese (mg L^{-1})	0.65	0.20
6	Copper (mg L^{-1})	0.51	Tr.
7	Zinc (mg L^{-1})	0.58	0.10
8	Cadmium (mg L^{-1})	0.19	0.01
9	Lead (mg L^{-1})	0.70	0.01
10	Nickel (mg L^{-1})	0.19	0.01

Tr=trace

Available N, P, and K status was at higher level in sewage irrigated soils (Table 2). Average amounts of available N at sewage and tube well-irrigated soils were 261.5 and 213.1 kg ha^{-1}, respectively. Available P content in sewage irrigated soils ranged from 14.0 to 30.0 kg ha^{-1} while in tube well water irrigated soils; it ranged between 11.0 and 16.0 kg ha^{-1}. Available K status (174.3 kg ha^{-1}) was higher in sewage water irrigated soils than those irrigated with tube well water (118.1 kg ha^{-1}). The amounts of available N, P and K in the sewage water irrigated soils was higher than the tube well irrigated soils indicating their build-up in the soils due to sewage water irrigation. Higher N, P and K contents in sewage-irrigated soils were also reported by Tiwari *et al.* (2003).

Table 2: Soil properties as affected by sewage and tubewell water irrigation

Character	Sewage water		Tuberwell water	
	Range	Mean	Range	Mean
pH	7.3-8.1	7.5	7.3-8.2	7.7
EC (dSm^{-1})	0.17-0.40	0.25	0.11-0.22	0.16
Org. carbon (g kg^{-1})	4.9-6.6	5.7	4.8-6.0	5.2
Avail. N (kg ha^{-1})	215.0-290.0	261.5	190.0-240.0	213.1
Avail. P (kg ha^{-1})	14.0-30.0	22.5	11.0-16.0	14.3
Avail. K (kg ha^{-1})	160.0-210.0	174.3	105.0-130.0	118.1
Heavy metals (DTPA-extractable)				
Iron (mg kg^{-1})	7.6-20.2	13.8	4.5-6.5	5.2
Manganese (mg kg^{-1})	4.8-19.0	9.9	2.5-4.0	3.0
Copper (mg kg-1)	0.8-3.6	2.1	0.28-0.40	0.32
Zinc (mg kg^{-1})	0.40-4.60	2.70	0.48-0.70	0.60
Cadmium (mg kg^{-1})	0.06-0.31	0.23	0.04-0.06	0.05
Lead (mg kg^{-1})	0.90-1.55	1.10	0.26-0.40	0.32
Nickel (mg kg^{-1})	1.00-3.30	2.44	0.45-0.66	0.55

The content of DTPA-extractable Fe, Mn, Cu and Zn in soils irrigated with sewage water ranged from 7.6 to 20.2, 4.8 to 19.0, 0.8 to 3.60 and 1.40 to 4.60 mg kg^{-1} soil, respectively (Table 2). The comparatively higher concentration of these micronutrients in comparison to normal soils has resulted from the addition of these elements through the continuous application of sewage water and the maximum concentration was of Fe followed by Mn, Zn and Cu. The amounts of DTPA-extractable Fe, Mn, Cu and Zn were much less in tube well water irrigated soils. On the basis of the limit given by Alloway (1968), concentrations of Cu and Zn were above the normal range as found in agricultural soils. DTPA-extractable Fe was maximum in sewage-irrigated soil and minimum in tube well water irrigated soil. The concentration of DTPA-extractable Cu and Zn were more or less 5 and 4 times higher in the sewage-irrigated soil as compared to tube well water irrigated soil. The results show that sewage irrigation resulted in the increased content of DTPA extractable micronutrients. Saraswat *et al.* (2005) have reported accumulation of DTPA-extractable micronutrients in soils through long term irrigation by treated or untreated sewage effluents. The concentration of DTPA-extractable Cd varied from 0.06 to 0.31 mg kg^{-1} at sewage irrigated site and from 0.04 to 0.06 mg kg^{-1} at tube well water irrigated site. The mean DTPA-extractable Pb and Ni were 1.10 and 2.44 mg kg^{-1}, respectively for sewage irrigated soil.

Table 3: Heavy metals (mg kg^{-1}) in vegetable crops irrigated with sewage water and Tube well water

Heavy Metals	Brinjal				Radish			
	Sewage water		Tube well water		Sewage water		Tubewell water	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Iron	163.0-180	168.5	35.0-40.0	37.6	98.0-115.0	107.5	50.0-60.0	54.2
Manganese	34.0-47.0	39.6	17.0-22.0	19.6	34.0-44.0	39.1	18.0-25.0	21.2
Copper	8.5-11.0	9.7	4.5-6.7	5.4	15.0-25.0	18.6	7.5-9.0	8.3
Zinc	42.0-50.0	46.8	17.0-22.5	19.8	27.5-36.0	31.9	24.0-30.0	27.0
Cadmium	0.27-0.33	0.29	0.12-0.17	0.15	0.17-0.26	0.22	0.11-0.15	0.13
Nickel	0.27-1.25	1.07	0.32-0.39	0.35	1.05-1.22	1.16	0.38-0.42	0.39
Lead	7.5-10.5	8.9	0.10-0.12	0.11	7.5-13.0	10.1	0.13-0.17	0.15

The content of Fe and Zn in both vegetable crops ranged from 35.0 to 180.0 mg kg^{-1} and 17.0 to 50.0 mg kg^{-1} respectively (Table 3). The concentration of Zn of the order of 50 mg kg^{-1} in the dry matter of plant tissue is considered as toxic (Sauerbeck 1982). The distribution of copper in these vegetable crops varied from 4.5 to 25.0 mg kg^{-1} and for most plant species, the optimum limit of this element is considered 30 mg kg^{-1} in the dry matter. The sewage irrigated vegetables showed higher contents of Fe, Mn, Cu and Zn than the tube well irrigated ones but was within the range of safe limits. The content of lead was found higher in radish followed by brinjal. Lead concentration in these vegetable crops irrigated by sewage water ranged from 7.5 to 13.0 mg kg^{-1}. Both the vegetable crops contained Pb above the permissible limit of 2 mg kg^{-1} as proposed by Asaolu (1995). Hooda and Alloway (1994) and Boon and Soltanpour (1992) have also reported assimilation and accumulation of Pb by plants to hazardous levels. Cadmium was detected in these vegetable crops (0.27 to 0.33 mg kg^{-1}) but the concentration was below the toxicity thresholds of 0.8 mg kg^{-1} (Alloway 1968)/ The concentration of Mn in these vegetable crops ranged from 17.0 to 47.0 mg kg^{-1} dry weight. Findings indicated that the contents of heavy metals in sewage irrigated vegetables was comparatively higher than the tubwell water irrigated vegetables and that was definitely due to larger availability of metals in sewage irrigated soil. By and large, concentration of these metals in crops was below the generalized toxic limits except that of lead (Sauerbeck, 1982).

From this study, it can be concluded that the sewage water of Agra city are slightly alkaline in reaction low in salt content. The sewage water irrigated soils showed the maximum availability of micronutrients and heavy metals than those irrigated with tube well water. The content of micronutrients and heavy metals in vegetable crops was also high in spite of their low level in the soils irrigated with ground water.

Acknowledgement: The authors place on record the financial help from CST, U.P. Lucknow for this research work.

REFERENCES

Alloway, W.H. (1968) Agronomic controls over the environmental cycling of trace elements. *Advances in Agronomy* 20:235.

Asaol, S.S. (1995) Lead content of vegetables and tomatoes at Erekesan market, Ado-E kite. *Journal of Industrial Research* 38:339-401.

Ayers, R.S. and Westcot, D.W. (1995) Water quality of Agriculture. FAO Irrigation and Drainage Paper 29, FAO, Rome, Italy pp 95-97.

Boon, D.Y. and Soltanpour, P.N. (1992) Lead, cadmium and zinc concentration of Aspen

Garden soils and vegetation. *Journal of Environmental Quality* 21:82-86.

EPR (1983) In the Gazette of India, Extraordinary (Part II Sec. 3), Ministry of Environment and Forests, Govt. of India.

FAO (1985) Waste water treatment and use in agriculture. FAO irrigation and dranage Paper 47:16-17.

Hooda, P.S. and Alloway, B.J. (1994) The plant availability and DTPA extractability of trace metals in sludge-amended soils. *Science of Total Environments* 149:39-51.

Lindsay, W.L. and Norvell, W.A. (1978) Developmewnt of a DTPA soil tests for zinc, iron, manganese and copper. *Soil Science Society of America Journal* 42:421-428.

Kumar, D., Malik, R.S. and Narwal, R.P. (2011) Heavy metals in sewage waters and their relative availability in some peri – urban soils of Haryana. *Journal of the Indian Society of Soil Science* 59 (4): 407 – 410.

Pratt, P.F. (1972) Quality criteria for trace elements in irrigation waters. Publication of Universty California Experimental Station Riverside, California, USA.

Saha, J.K., Panwar, N. and Singh, M.V. (2010) An assessment of municipal selid waste compost quality produced in different cities of India in the perspective of developing quality control indices. Waste water Management 30: 092 – 201.

Saha, J.K., Panwar, N. and Singh, M.V. (2013) Risk assessment of heavy metals in soil of a susceptible agro – ecological system a mended with municipal waste compost. *Journal of the Indian Society of Soil Science* 61: 15 – 22.

Saraswat, P.K., Tiwari, R.C., Agrawal, H.P. and Sanjay Kumar (2005) Micronutrient status of soils and vegetable crops irrigated with treated sewage water. *Journal of the Indian Society of Soil Science* 53(1):111-115.

Sauerbeck, D. (1982) which heavy metal concentrations in plants should not be exceeded in order to avail detrimental effects of their growth. *Landw. Frosch. Sondersh*, 39:108-129.

Tiwari, R.C., Saraswat, P.K. and Agrawal, H.P. (2003) Changes in macronutrient status of soils irrigated with treated sewage water and tubewell water. *Journal of the Indian Society of Soil Science* 51(2):150-155.