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Effect of Different Levels of Sewage Water on Accumulation of Heavy Metals in Soil, Plants and Bulbs of Onion Crop *(Allium Cepa L.)*

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Abstract

The field experiments were conducted at the crop growing farm in the south east part of northern region of India during Rabi season 2006-07 and 2007-08 to study the "Effect of deferent levels of sewage water on accumulation of heavy metals in soil, plants and bulbs of onion crop (A*llium cepa* L.). The study site is located between 25 ̊24'08.71"N latitude and 81 ̊50'16.95" E longitude, along the Yamuna River and 98 meter above the mean sea level. The mean temperature during the growing period was 37.2 to 4.7 ^{0}C due to subtropical and semi arid climate. The soil of experimental area falls in order Inceptisol and the experimental field is alluvial in nature. The Ni, Pb, Cd, Cr and Cu mg kg^{-1} of post harvest soil of onion grown plot was found to be significant in both the experiments. The Ni, Pb, Cd, Cr and Cu mg kg^{-1} of post harvest soil of onion grown plot were recorded in order of T_0, <T_1, <T_2, <T_3 during the entire growth and development. The afore mention heavy metals in T_3 treatment tended to be significantly greater than the remaining treatments and decreased with increase in depth in both tubewell and sewage irrigated soil. Plant samples of onion crop were collected at 60 days after transplanting, from field, irrigated with sewage as well as with tubewell water and the data on Ni, Pb, Cd, Cr and Cu mg kg^{-1} in plants and bulbs of onion crop was found to be significant at 60 days after transplanting in both the experimental years

Key word: Sewage water, Tubewell water, Heavy metals, Soil and Plant.

Introduction:

Water is an indispensable for the growth and development of agricultural crops. It is a measure constituent of plant protoplasm, essential for photosynthesis and conversion of starches to sugars. About 300-1000 liter of water is necessary for production of a kilo of plant dry matter. Infect, soil water is the great regulator of physical, chemical and biological activity of soil. Water and nutrients are only the major inputs for crop production. Rapid industrialization, mushrooming population and greater urbanization in the last five decade have resulted in utilization of significant quantities of fresh water available and as such the quantum of water available for agriculture is dwindling. It is predicted that most of the Asian countries will face a severe problem related to water availability in the coming future and is also becoming an increasingly scarce resource for agriculture (Singh 199).

Wherever good quality water is limited, water of marginal quality like sewage and other waste water are used to supplement irrigation needs (Bhise *et al*. 2007). It will not only reduced disposal problem of sewage but also contributes towards the up gradation of soil fertility as it contain appreciable amount of macro and several micro nutrients ((Tiwari *et al*. 2003; Mitra and Gupta 1999; Sreeramulu 1994) however, a long term and indiscriminate use of raw sewage water may prove hazardous to human health since it contain a variable amounts of metallic cations (Anderson & Nilssion 1972)

Efficient utilization of water resources is crucial to agricultural production for meeting the ever increasing demand of irrigation water for producing more and more food. Since resources are limited and a large gap exists between available water supply and the amount required for intensive cropping, appropriate use of waste water of domestic origin can help in meeting a part of the increased demand of water. Industrial and domestic effluents with solid and liquid components are being used partially for irrigation (Tiwari *et al*. 2003).

Onion being important crop needs proper attention for producing better quality and yield of bulb. Merely go on applying the fertilizer to crop is not bound to produce increased yield because at certain level either it may be constant or start declining. Therefore to achieve the higher yield and better quality from one unit area of land new cultural practices are to be adopted. Among the cultural practices, application of sewage water on found to be helpful in maximum yield production but another side it is harmful due to contamination of soil by heavy metals (Kausal, *et al.*1993).

Increasing interest in the agricultural application of sewage water is due to the possibility of recycling valuable components such as organic matter, N, P, K, and other plant nutrients to increase the crop yields (Mitra and Gupta 1999). On other hand, since sewage water contains higher concentration of potentially toxic elements the accumulation of heavy metals in soils and their subsequent uptake by plants is major concern (Kausal, *et al.*1993; Anderson & Nilssion 1972). The uptake and accumulation of heavy metals in the edible part of green tissue represent a direct path way of incorporation of heavy metals into the human food chain. Application of sewage water to soil affect the metal content of edible crops directly by serving as a source of trace metals and indirectly by altering the soil chemistry which in tern changes the solubility and mobility of trace elements.

Regular monitoring of the heavy metal content of sewage water, industrial effluents and soils is the need of time. There is also urgent need to identify hyper accumulators with high biomass among crop plants especially vegetable crops for phytoremediation of heavy metals. Keeping in view the importance of vegetables in India and the extent to which there are consumed in so many forms by the human beings and the utilization of sewage water to reduces the load of fresh water. Therefore an attempt has been made in the present investigation to determine the "Effect of deferent levels of sewage water on accumulation of heavy metals in soil, plants and bulbs of onion crop (A*llium cepa* L.)".

Materials and Methods

Description of Site:

The field experiments were conducted at the crop growing farm at Tignota Village, of Chaka Block, Naini, Allahabad, India (Figure 1). The study site is located between 25 ̊24'08.71"N latitude and 81 ̊50'16.95" E longitude, along the Yamuna River and 98 meter above the mean sea level. The mean temperature during the growing period was 37.2 to 4.7 ^{0}C. Due to subtropical climate prevailing in the south east part of northern region of India with the extremes in temperature dropping to 1-2 ^{o}C in December and January and very hot in summer with temperature ranging between 46-48 ^{o}C in the month of May-June. The average rainfall is around 1013.4 mm with maximum concentration during July to September and occasional frost in winter and hot wind (Loo) in summer. The climatic condition of the investigation area is most suitable for the cultivation of Bulb crops.

The soil of experimental area falls in order Inceptisol and the experimental field is alluvial in nature and the soil is irrigated with sewage water for more than about 20 years along with an unirrigated control. The experiments were conducted during Rabi season 2006-07 and 2007-08 to study the "Effect of deferent levels of sewage water on accumulation of heavy metals in soil, plants and bulbs of onion crop (A*llium cepa* L.)".

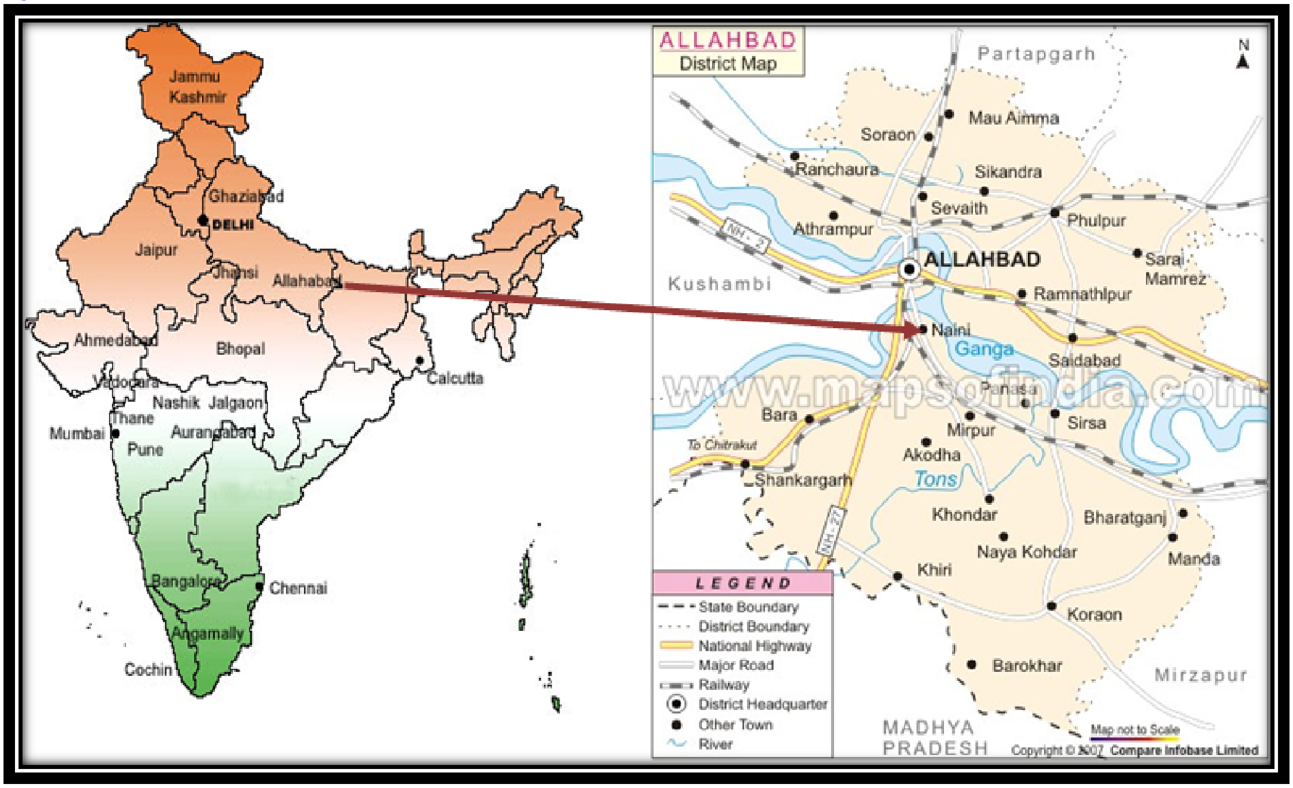

Figure 1: Site layout of Naini Allahabad, India.

Plan of Experiment:

The treatments were allocated in randomized block design with three replications and four levels of sewage and tubewell irrigation water for onion crop (T_0 = 200 liters of tubewell irrigation water), (T_1 = 100 liters of sewage water + 100 liters of tubewell irrigation water), (T_2 = 150 liters sewage water + 50 liters tubewell irrigation water) and (T_3 = 200 liters of sewage irrigation water). Each plot size was of 2m x 2m (4m^2). Crop was irrigated 10-12 times at 10-12 days intervals @ 200 liters water per irrigation. A water requirement was calculated by formula reported by D. M. Dennis and R. B. Lal (2002).

Rooting Depth in (cm) = Rooting depth (d) m X plant available water (mm/m) X Readily available water fraction.

Quantity of water $= \frac{\text{2m length of plot X 2m width of plot X rooting depth in mm}}{1000} = m^3$

m^3 X 1000 = water quantity in liters.

Analysis of Heavy Metals in Soil, Plant and Water Samples:

The chemical analysis of soil was done before starting the experiment to ascertain the initial level of heavy metals in the soil. The soil samples were collected randomly from 0-15, 15-30, 30-45, 45-60 cm depths prior to tillage operations. The samples were mixed depth viz. and its weight was reduced by air drying, conning, quartering and passing it through 2mm sieve. To obtain composite soil sample in respective to different depth viz. the soil samples was stored for analysis of heavy metal. The heavy metals accumulation in soil is determined by Black (1965), Lindsay and Norvell (1978) Atomic Absorption Spectrophotemetric Method.

Several parameters of sewage and tubewell irrigation water were analysed separately, pH and EC the procedure described by M. L Jackson (1958), DO, BOD, COD, TSS, Cations- Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, anions Cl^{-} and SO_4^{2+} and NH_4-N and P as per the method given by Trivedy and Goel (1984) and APHA-AWWA-WPCF (1975). Heavy metals like Cu, Pb, Cd, Cr, and Ni were estimated after wet digestion with 1:4 mixtures of $HClO_4$ and HNO_3, followed by measurement of respective concentrations with the help of Atomic Absorption Spectrophotometer.

Plant samples of onion crop were collected at 60 days after transplanting, from field, irrigated with sewage water as well as with tubewell water. Plant samples were washed successively with tap water; acidified water, distilled water and double distilled water. These samples were then dried first at room air temperature for several days and then in hot (60 ± 5^{0}C) air oven for 48 hours to constant dry weight. Dried samples were crushed and powdered separately in mortar and pestle to pass through 0.3 mm sieve. The powdered plant samples were then put separately in well washed, dried and suitably labeled flasks and these samples were then ready for digestion and then analyzed for heavy metals accumulation.

The plant samples were digested in a di-acid mixture consisting of HNO_3 and $HClO_4$. To the known amount of plant material (1g) 5ml of conc. HNO_3 was added and kept over night. Next day 12ml of di-acid mixture (Conc. HNO_3+$HClO_4$ in the ratio 3:1) was added and digested on hot plate. The digestion process begins with the evolution of reddish brown fumes (NO_2 gas) and the plant samples slowly begin to dissolve and digested in a di-acid mixture. After few hours the plant samples dissolved completely in the digestion mixture and the solution was then evaporated until only 2ml was left in the flask (Jackson, 1967). The remaining digested material was diluted to 25ml distilled water and was then analyzed for the presence of heavy metals Cd, Cr, Cu, Pb, and Ni by A.A.S (atomic absorption spectrophotometer).

Results and Discussion

Irrigation Quality of Sewage and Tubewell irrigation water:

Irrigation quality of sewage and tubewell water have been analyzed with respect to pH, EC, salinity, sodicity and chloride hazards and concentration of major nutrient in (Table 2) sewage water was slightly alkaline in reaction, Electrical conductivity (EC) was marginally low. Concentration of Ca^{2+}, Mg^{+2}, Na^{+} and K^{+} as expressed in form of per cent sodium and sodium absorption ratio(SAR) indicated no salinity and sodicity hazards. Among the anionic component concentration of Cl^{-} and SO_4^{2-} were much lower in tubewell water as compared to sewage water. Average concentrations of both the anions were much below the maximum tolerance limits (600 and 1000 mg L^{-1}, respectively) for irrigation quality standard Mitra and Gupta (1999). Both macro (NO_3 – N, NH_4 – N, P and K) and micronutrients (SO_4, Mn, Zn, Cu and Co) concentration in sewage water were sufficient to meet the irrigation quality standard.

Effect of sewage and tubewell irrigation water on crop

The statistical analysis of the data on Ni, Pb, Cd, Cr and Cu mg kg^{-1} in plants and bulbs of onion crop was found to be significant at 60 days after transplanting in both the experimental years 2006-07 and 2007-08. The mean Ni, Pb, Cd, Cr and Cu mg kg^{-1} in plants and bulbs of onion crop were recorded at 60 Days after Transplanting (DAT) and after harvesting. The results of the data were found to be presented in the Figure 1. The Ni, Pb, Cd, Cr and Cu mg kg^{-1} in plants and bulbs of onion crop were recorded in order of T_0, <T_1, <T_2, <T_3 during the entire growth and development. The Ni, Pb, Cd, Cr and Cu mg kg^{-1} in plants and bulbs of onion crop in T_3 treatment tended to be significantly greater than the remaining treatments, because sewage water contains higher amount of heavy metals, it brings significant increase in Ni, Pb, Cd, Cr and Cu mg kg^{-1} in plants and bulbs of onion crop. These results are in conformity with the findings of Angin *et al.* (2005); Saif *et al.* (2005); Sharma *et al*. (2005); Chitdeshwari *et al*. (2002); Agah *et al.* (2001)

Effect of sewage and tubewell irrigation water on soil:

The Ni, Pb, Cd, Cr and Cu mg kg^{-1} of post harvest soil of onion grown plot was found to be significant at different depth in both the experimental years 2006-07 and 2007-08. The mean Ni, Pb, Cd, Cr and Cu mg kg^{-1} of post harvest soil of onion grown plot were recorded at 0-15, 15-30, 30-45, 45-60cm depth. The results of the data are presented in the tables 3. The above given heavy metals mg kg^{-1} of post harvest soil of onion grown plot were recorded in order of T_0, <T_1, <T_2, <T_3 during the experimental years. The Ni, Pb, Cd, Cr and Cu mg kg^{-1} of post harvest soil of onion grown plot in T_3 treatment were found to be significantly greater than the remaining treatments and decreased with increase in depth in both tubewell and sewage irrigated soils. This might due to the fact that the concentration of heavy metals in sewage water emanating from different sources is many folds higher than that of tubewell water. However the variation in the extent of Ni, Pb, Cd, Cr and Cu pollution in the soil is due to varying down the soil depth of post harvest soil of onion grown plot. The results are in concurrence with the finding of Hundal *et al.* (2006); Kakar *et al.* (2005); Saif *et al.* (2005); Ghafoor *et al.* (2004); Brar *et al.* (2000); Achari *et al.* (1999)

Table 1: Results of pre-sowing analysis of soil are as depth wise.

Particular	Rabi Season 2006-2007				Rabi Season 2007-2008			
	0-15	**15-30**	**30-45**	**45-60**	**0-15**	**15-30**	**30-45**	45-60
Pb	5.27	2.78	1.36	0.86	4.58	2.84	1.49	**0.89**
Ni	1.81	1.04	0.81	0.32	1.76	1.53	0.84	**0.35**
Cd	1.17	0.59	0.45	0.31	0.89	0.84	0.51	**0.34**
Cr	2.17	1.00	0.95	0.49	1.93	1.09	1.03	**0.56**
Cu	**5.73**	**3.86**	**1.72**	**0.80**	**5.61**	**4.13**	**1.84**	**0.89**

Table 2: Average chemical characteristics of sewage and tubewell irrigation water 2006- 07 & 2007-08.

Properties	Tubewell water				Sewage water			
	Sample 1	**Sample 2**	**Sample3**	**Average Values**	**Sample 1**	**Sample 2**	**Sample3**	Average Values
pH	7.40	7.60	7.50	**7.50**	7.70	7.60	7.80	7.70
EC dSm^{-1}	0.46	0.52	0.49	**0.49**	0.98	1.66	1.20	1.28
$NO_3 - N$ (mgL^{-1})	0.01	0.03	0.02	**0.02**	1.87	2.10	1.97	1.98
$NH_4 - N$ (mgL^{-1})	0.02	0.04	0.06	**0.04**	10.27	11.42	9.61	10.43
P (mgL^{-1})	0.03	0.02	0.04	**0.03**	0.92	1.74	2.62	1.76
K^+ (me L^{-1})	0.70	0.50	0.90	**0.70**	0.30	0.50	0.70	0.50
Na (me L^{-1})	1.30	1.45	1.60	**1.45**	4.93	5.80	5.05	5.26
Ca (me L^{-1})	2.76	1.80	1.32	**1.96**	3.72	7.68	5.60	5.65
Mg (me L^{-1})	1.39	1.26	1.58	**1.41**	2.87	5.59	3.70	4.05
SO_4 (mgL^{-1})	3.15	3.28	3.47	**3.30**	56.11	78.29	87.46	73.95
Mn (mg L^{-1})	12.71	9.18	16.24	**12.71**	45.2	56.75	68.3	56.75
Cl^- (mgL^{-1})	37.9	40.3	42.4	**40.5**	155.0	212.0	183.5	183.5
Zn (mg L^{-1})	12.36	10.60	12.47	**11.81**	271.34	256.72	238.48	255.51

Co (mg L^{-1})	0.02	0.07	0.06	**0.05**	6.03	4.50	8.25	6.26
SAR (mg L^{-1})	1.60	1.43	1.25	**1.43**	2.37	5.16	4.65	4.04
DO (mg L^{-1})	5.90	6.58	8.16	**6.88**	2.14	1.29	1.35	1.59
BOD (mgL^{-1})	1.1	1.13	1.31	**1.18**	78.00	57.0	84.5	73.17
COD (mgL^{-1})	7.83	7.15	6.97	**7.31**	164.19	132.74	211.93	169.62
TSS (mg L^{-1})	**6.23**	**6.81**	**4.84**	5.96	**256.37**	**216.74**	**196.81**	223.31

Table 3: Effect of sewage and tubewell irrigation water on Cd, Cr, Cu, Ni and Pb mg kg^{-1} of post-harvest soil at different depth (cm) of onion grown plot in 2006-07 and 2007-08.

Treatment Combination	2006-07				2007– 08			
	Cadmium (Cd)							
Depth	**0-15**	**15-30**	**30-45**	**45-60**	**0-15**	**15-30**	**30-45**	**45-60**
T_0	0.76	0.60	0.42	0.30	0.84	0.82	0.45	**0.33**
T_1	1.32	0.89	0.64	0.41	1.59	0.95	0.69	**0.48**
T_2	1.87	1.22	0.92	0.52	2.10	1.38	0.89	**0.57**
T_3	2.62	1.79	1.02	0.59	2.74	1.88	1.11	**0.62**
S. Em (±)	0.022	0.048	0.034	0.032	0.040	0.019	0.028	**0.021**
C. D. (P = 0.05)	0.054	0.117	0.082	0.079	0.098	0.046	0.067	**0.050**
Treatment Combination	2006-07				**2007– 08**			
	Chromium (Cr)							
T0	1.78	0.98	0.93	0.48	1.85	1.07	1.02	**0.57**
T1	2.40	1.94	1.27	0.62	2.47	2.02	1.39	**0.69**
T2	3.25	2.11	1.63	0.80	3.52	2.21	1.79	**0.84**
T3	4.12	2.28	1.82	0.92	4.86	2.45	1.93	**0.96**
S. Em (±)	0.035	0.034	0.027	0.030	0.025	0.032	0.033	**0.029**
C. D. (P = 0.05)	0.084	0.083	0.066	0.073	0.061	0.079	0.079	**0.071**
Treatment Combination	2006-07				**2007– 08**			
	Copper (Cu)							
T0	5.34	3.73	1.44	0.71	5.19	4.15	1.65	**0.75**
T1	10.01	5.48	2.37	1.39	10.53	6.01	2.62	**1.52**
T2	11.24	7.18	3.19	2.10	12.02	7.92	3.54	**2.16**
T3	14.01	9.03	5.30	3.36	14.32	9.21	5.38	**2.72**
S. Em (±)	0.056	0.036	0.050	0.037	0.072	0.035	0.042	**0.047**
C. D. (P = 0.05)	0.137	0.088	0.122	0.091	0.175	0.085	0.104	**0.115**
Treatment Combination	2006-07				**2007– 08**			
	Nikel (Ni)							
T0	1.03	0.94	0.83	0.32	1.08	0.99	0.88	**0.33**
T1	2.73	2.00	1.11	0.39	2.84	2.06	1.21	**0.40**
T2	3.26	2.24	1.63	0.46	3.32	2.39	1.69	**0.49**
T3	3.77	2.76	1.80	0.53	3.82	3.02	1.92	**0.56**
S. Em (±)	0.032	0.103	0.035	0.038	0.031	0.038	0.032	**0.027**
C. D. (P = 0.05)	0.077	0.251	0.084	0.092	0.075	0.092	0.078	**0.066**
Treatment Combination	2006-07				**2007– 08**			
	Lead (Pb)							
T0	3.97	2.62	1.97	0.76	4.06	2.78	2.06	**0.83**
T1	7.22	6.03	3.82	1.75	7.49	6.22	4.19	**1.81**
T2	8.96	7.64	4.98	2.59	9.39	7.96	5.39	**2.73**
T3	11.12	9.37	6.12	3.39	11.98	9.89	6.78	**3.71**
S. Em (±)	0.029	0.047	0.039	0.038	0.037	0.017	0.042	**0.023**
C. D. (P = 0.05)	**0.070**	**0.115**	**0.094**	**0.092**	**0.090**	**0.042**	**0.103**	**0.055**

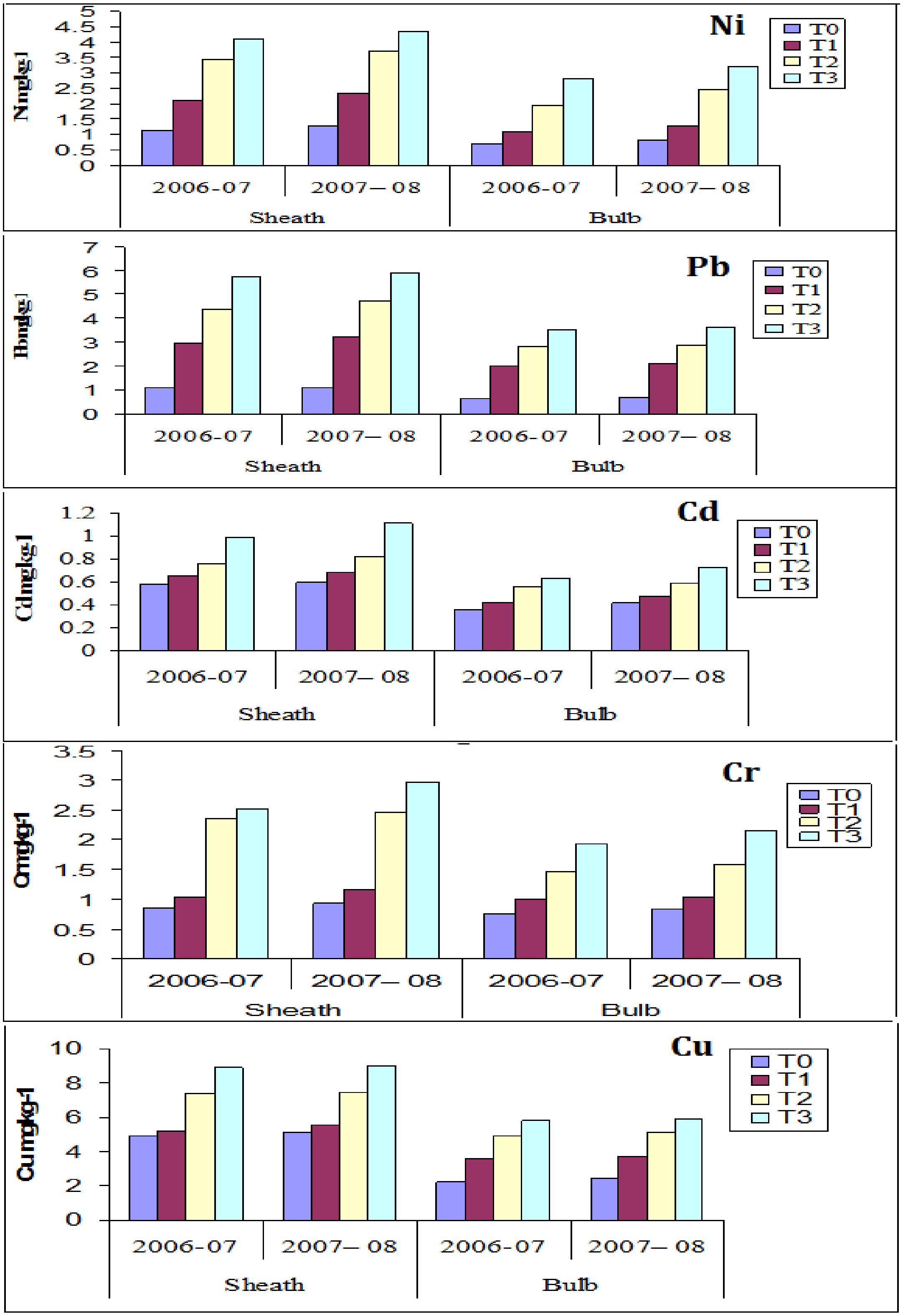

Figure 2: Effect of sewage and tube well irrigation water on Ni, Pb, Cd, Cr and Cu mgkg-1 sheath and bulb of onion at 60 DAT and after harvesting in 2006-07 and 2007-08.

Conclusion:

The statistical analysis of the data on Ni, Pb, Cd, Cr and Cu mg kg^{-1} in plants and bulbs of onion crop was found to be significant at 60 days after transplanting and after harvesting in both the experimental years 2006-07 and 2007-08. The results of the data were shows that the Ni, Pb, Cd, Cr and Cu mg kg^{-1} in plants and bulbs of onion crop in T_3 treatment tended to be significantly greater than the remaining treatments. The mean value of Ni, Pb, Cd, Cr and Cu mg kg^{-1} of post harvest soil of onion grown plot were recorded at 0-15, 15-30, 30-45, 45-60 cm depth and was found to be significant at different depth. The Ni, Pb, Cd, Cr and Cu mg kg^{-1} of post harvest soil of onion grown plot in T_3 treatment were found to be significantly greater than the remaining treatments and decreased with increase in depth in both tubewell and sewage irrigated soils.

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