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LEAD, CADMIUM AND CHROMIUM CONTENTS OF CANOLA IRRIGATED WITH SEWAGE WATER

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Abstract

The present research was conducted in Sargodha, Punjab, Pakistan to determine the effect of sewage water treatments on accumulation of some heavy metals (Pb, Cd and Cr) in cv. Dunkeld of canola (*Brassica napus* L.). The results showed that each metal treatment had its own specific effects on the growth of the canola cultivar. Sewage water application had a significant effect on number of leaves and leaf area, whereas root length remained unchanged. There was a decline in yield and yield related attributes in the treated crop. Soil, forage and seed Pb, Cd, and Cr concentrations increased consistently with increase in the treatment level of sewage water. From the results of the present study, it was concluded that municipal sewage water of cities containing high levels of metals has inhibitory effect on growth and seed yield of canola.

Introduction

Rapid growth in human population is one of the major causes of environmental pollution. Increased industrialization and urbanization throughout the world including Pakistan has resulted in consistent release of toxic effluents, which render both soil and water unfit for crop production (Sheikh & Irshad, 1980; Wahid *et al*., 1999, 2000). Thus, most agro-industrial wastes are contaminated with a variety of metals (Al-Nakshabandi *et al*., 1997; Faryal *et al*., 2007; Khan *et al*., 2008) which, if applied to crops, may cause inhibitory effects on growth and yield.

Khedkar & Dixit, (2003) have reported that municipal sewage water of cities has inhibitory effect on seed setting and it can directly affect crop yield. Chen & Chia (2002) reported that vegetables are more seriously affected by the city polluted water than other crops, and this polluted water exerts great financial pressure on growers. In view of some researchers (Kakar *et al*., 2006; Al-Makhdoom 2006) it is evident that the principal impurities in polluted waters are organic materials and inorganic nutrients, but domestic sewage is also not free from contaminants and is very likely to contain disease causing microbes which may enter in animal or even human bodies and cause serious diseases to them. Azmat & Khanum (2005) indicated that contamination of soil and water by chromium (Cr) is of great concern. Chromium also causes deleterious effects on plant physiological processes such as photosynthesis, water relations and mineral nutrition.Cr stress is one of the imperative factors that influence photosynthesis and respiration in plants (Clijsters &Van Assche, 1985). Plants growing in contaminated surroundings can gather heavy metals at higher contents posing grave hazard to human health. Moreover, heavy metals are dangerous because they tend to accumulate in living systems thereby causing injurious effects and accumulate in food chain (Alloway, 1990) Similar effects of cadmium and lead on plants have been reported elsewhere (Akinola *et al*., 2006; Vousta *et al*., 1996).

In view of the above reports it is highly likely that the sewage water from the Sargodha city contains considerable amounts of heavy metals including lead, cadmium and chromium. Thus, the premier objective of the present investigation was to examine the levels of three key metals, Pb, Cd and Cr in the sewage water of Sargodha City and their effects on growth and accumulation of these metals in canola, a very popular oilseed crop of the region.

Materials and Methods

Collection of sewage water: Sewage water used in the present investigation was collected from a disposal pump in the main Sargodha City residential area near the Society colony. It was analysed for Pb, Cd and Cr. The growth experiment was conducted in the Botanical Garden, University of Sargodha during 2010.

Soil samples: Soil for planting canola was collected from the Botanical Garden, University of Sargodha. After mixing well the soil was added to pots. Three soil samples were taken from each pot to analyse soil characteristics.

Seeds: Seeds of cv. Dunkeld of canola (*Brassica napus* L.) were obtained from the Ayub Agricultural Research Institute (AARI), Faisalabad. The experiment was laid out in a Completely Randomized Design. Fifteen seeds were sown in each pot containing air-dried 5 kg field soil. Hundred percent germination was recorded within 14 days after sowing in all treatments. Thinning was done 25 days after sowing and 9 plants were kept in each pot.

Treatment: Different concentrations of sewage water diluted with tap water were used for irrigation throughout the crop period. Different treatments (1000 ml water each time) were applied from pre-emergence to maturity stage. Different treatments applied are as under: T_0 (100% tap water only), T_1 (10% sewage water + 90% tap water), T_2 (20% sewage water + 80% tap water), T_3 (30% sewage water + 70% tap water), T_4 (40% sewage water + 60% tap water), T_5 (50% sewage water + 50% tap water), T_6 (60% sewage water + 40% tap water), T_7 (70% sewage water + 30% tap water), T_8 (80% sewage water + 20% tap water), T_9 (90% sewage water + 10% tap water) and T_{10} (100% sewage water only).

Collection of data

Growth parameters: Nine plants were tagged at the beginning of experiment in each pot and the data for the following parameters were taken at different time intervals (one month) till maturity of the crop. Three plants were selected randomly with their roots from each treatment. The plant roots were washed with gentle flow of distilled water and then air-dried. The data of the following parameters were recorded:

Plant height (cm): From selected plants, plant height was measured in cm with the help of meter -rod from base to top of shoot and average was determined for each harvest.

Number of leaves: Number of leaves was counted from selected plants and average was determined for each harvest.

Leaf area (cm^2): Total leaf area per plant was determined by the following formula: Length x width x c.f., where c.f. (correction factor) = 0.68.

Shoot and root length (cm): Shoot length was measured from the base to top of the plant. Root length was measured from stem base to root tip and mean values were calculated.

Yield attributes: Number of siliquae per plant, siliqua length (cm), seeds per siliqua, seeds per plant, 100-seed weight (g) and seed weight per plant were calculated and mean values determined for each parameter.

Chemical analysis: At maturity shoots, roots and seeds of plants were used for chemical analysis. Samples of root, shoot and seed were collected at maturity stage. The root, shoot and seed samples were dried at 70^{o}C for 72 h in an oven and ground in a Wiley micro mill, so as to pass through 2 mm sieve. The dried material (0.5 g) was digested with the sulphuric acid (H_2SO_4) and hydrogen peroxide (H_2O_2). Lead, cadmium and chromium levels in the extracts were determined using an atomic absorption spectrophotometer.

Results and Discussion

Morphological parameters: Plant height (Table 1) was significantly affected by sewage water treatment as there was a consistent decrease in this growth attribute with increase in the level of sewage water. The same trend was observed for number of leaves, leaf area per plant, and root length of canola plants. Decreased growth in different plants due to metal contaminated waters has been earlier reported by other researchers (Saxena, 1987; Meagher, 2000; Andaleeb *et al*., 2008).

Yield attributes: A marked reduction was observed in the number of siliquae per plant, number of seeds per siliqua, seeds per plant and seed weight per plant due to sewage water treatment (Table 2). Effects of sewage water in reducing the crop yield have been reported earlier by some workers (Bazai & Achakzai, 2006; Farid, 2006; Kang *et al.*, 2007; Khan *et al.*, 2009). Tamoutsidis *et al*., (2002) reported that application of increasing doses of municipal wastewater reduces the overall yield of some vegetable crops e.g., lettuce, endive, spinach, radish, carrot and sugar beet.

Soil lead: From analysis of variance of data for soil Pb it is evident that soil Pb levels varied significantly in varying treatments of sewage water (Table 3). The mean soil Pb levels varied from 0.38 to 0.84 mg/kg d.wt in the sewage water treatments. The soil Pb levels observed in our investigation were much lower than those reported by (Hayashi, 1985), which were in the range of 5 to 25 mg/kg.

Soil Cadmium: Soil Cd levels also varied significantly (p<0.05) after treatment with sewage water. The values of Cd in soil ranged from 1.67 to 3.05 mg/kg during all treatments (Fig. 2a). The mean soil Cd found in our investigation was lower than the critical level of 3.0 mg/kg as reported by Kloke (1980). Thus, according to this criterion the soil Cd levels in our investigation were below the toxic level of Cd. However, the Cd values were higher than those reported by Oluokun *et al*., (2007) in Nigeria, but lower than those earlier reported López & Grau (2004).

Table 1. Effect of sewage water on plant height, No. of leaves, leaf area, root length, shoot length in *Brassica napus* L., (Canola), cultivar Dunkeld.

Treatments	Physical parameters				
	Plant height (cm)	No. of leaves	Leaf area/ plants (cm^2)	Root length (cm)	Shoot length (cm)
T_0	21.43	13.30	110.47	18.934	80.861
T_1	19.36	12.72	102.72	18.372	81.372
T_2	20.56	12.34	112.34	17.534	79.865
T_3	18.39	11.37	91.37	17.764	82.463
T_4	17.72	10.75	80.75	16.375	72.667
T_5	15.62	10.62	86.68	16.821	73.843
T_6	13.28	09.28	76.21	15.291	70.217
T_7	13.37	10.37	69.42	14.953	68.329
T_8	11.36	08.36	67.52	13.452	67.476
T_9	12.61	08.61	63.94	12.535	66.535
T_{10}	11.65	07.65	54.62	12.000	62.903

Table 2. Effects of sewage water on yield attributes of cv. Dunkeld of canola.

Treatments	Siliquae per plant	Siliqua length (cm)	Seeds per siliqua	Seeds per plant	100-seed weight (g)	Seeds weight per plant (g)
T_0	260	7.8	19.3	4832.4	1.52	73.54
T_1	275	7.9	18.1	4673.3	1.56	75.83
T_2	254	7.4	19.3	4194.7	1.48	67.21
T_3	230	7.2	17.8	3754.8	1.43	45.28
T_4	203	6.8	16.6	3212.1	1.36	54.56
T_5	178	7.1	16.7	2831.6	1.39	43.86
T_6	210	6.6	15.3	2573.2	1.28	38.47
T_7	138	6.3	14.5	2343.6	1.33	32.24
T_8	104	5.8	13.8	2075.5	1.25	28.51
T_9	83	5.7	11.7	1538.4	1.20	29.34
T_{10}	78	5.3	9.4	1243.9	1.28	25.73

Table 3. Analysis of variance of data for Pb, Cd and Cr levels in soil, root, shoot and seed of canola (*Brassica napus* L.) cultivar Dunkeld at different doses of sewage water levels.

SOV	df	Mean squares					
		Soil			Forage		
		Pb	Cd	Cr	Pb	Cd	Cr
Treatments	10	0.099***	1144.417***	1.199***	0.420**	1.007**	.727**
Treatments	22	0.012	1165.432	0.013	0.008	0.038	0.024

SOV= Source of variation; df= Degree of freedom; ***= Significant at 0.001 levels; **= Significant at 0.01 levels

Soil chromium: Soil Cr levels increased consistently with increase in the concentration of sewage water (Fig. 3a), i.e., it ranged from 1.43 to 3.49 mg/kg of soil. The toxic Cr level in soil is in the range of 2-50 mg/kg (Bergmann, 1992). Thus, all the values of soil Cr reported here are within the lower limit of the toxic range reported by Bergmann (1992).

Forage Lead: The mean forage lead levels ranged from 0.08 to 1.52 mg/kg in various sewage water treatments, although there was an inconsistent pattern of increase during different external sewage water doses. The forage lead levels detected in the present investigation were lower than the acceptable Pb limit level, 3.0 ppm reported for plants (Allen, 1989).

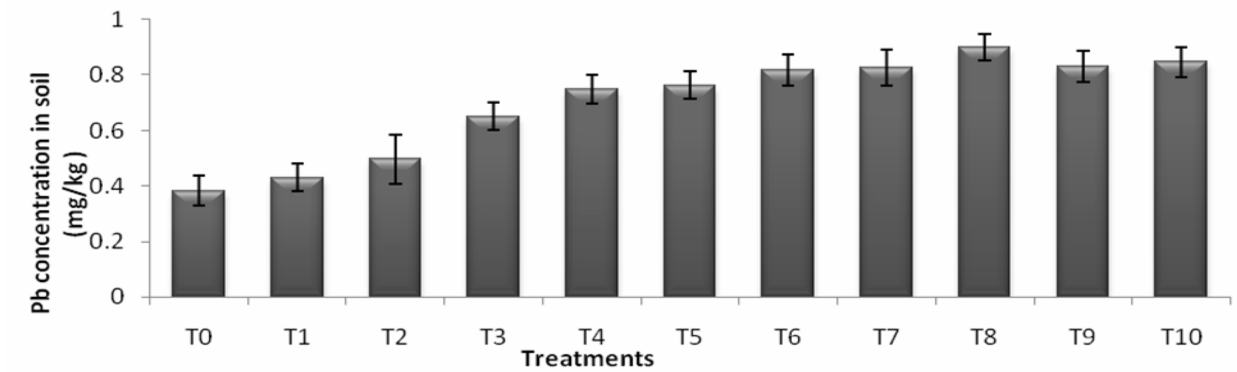

Fig. 1a. Effect of different sewage water levels on the soil Pb levels.

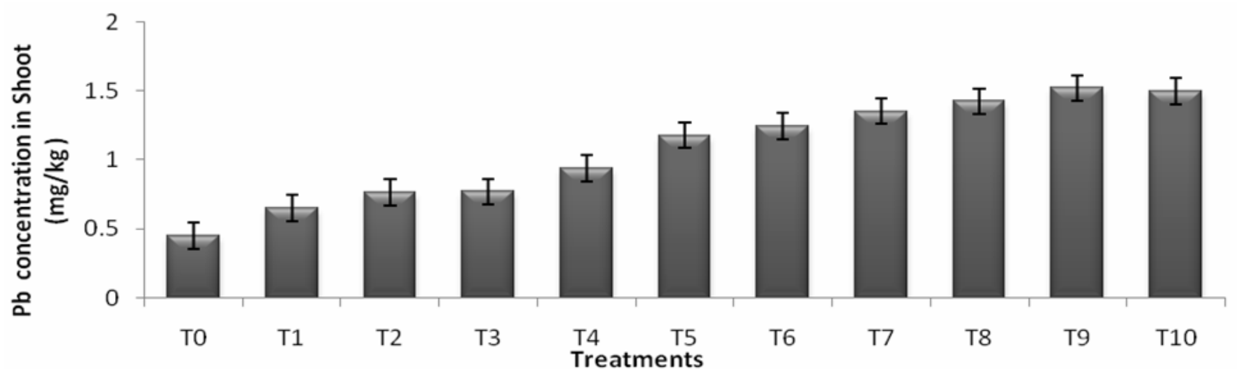

Fig. 1b. Effect of different sewage water levels on canola shoot Pb levels.

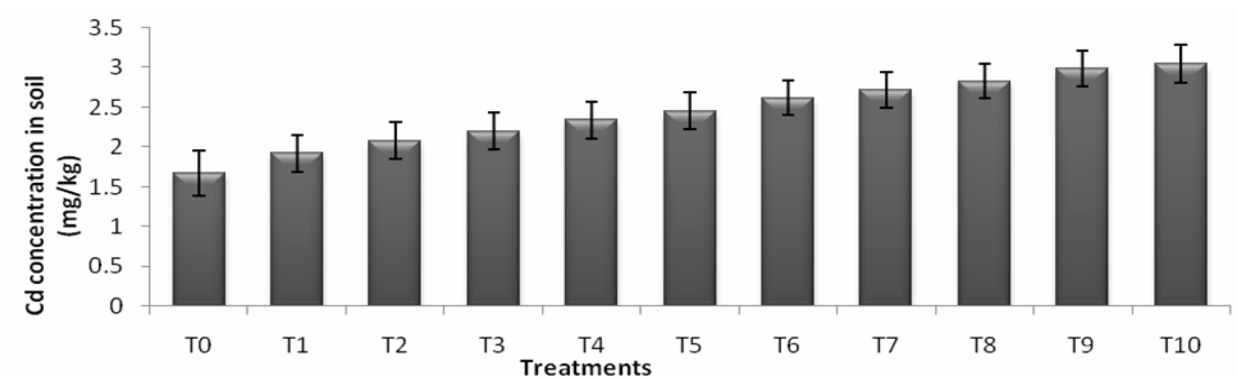

Fig. 2a. Effect of different sewage water levels on soil Cd levels.

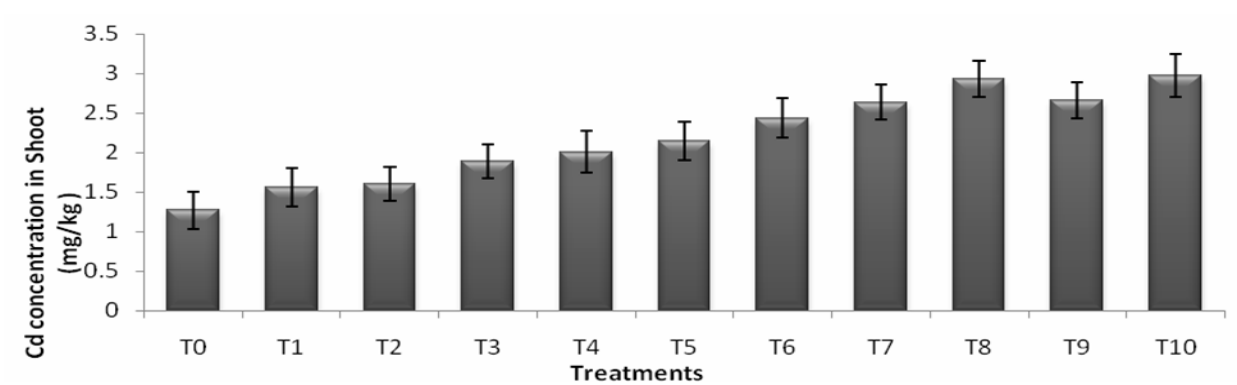

Fig. 2b. Effect of different doses of sewage water on forage (shoot) Cd levels.

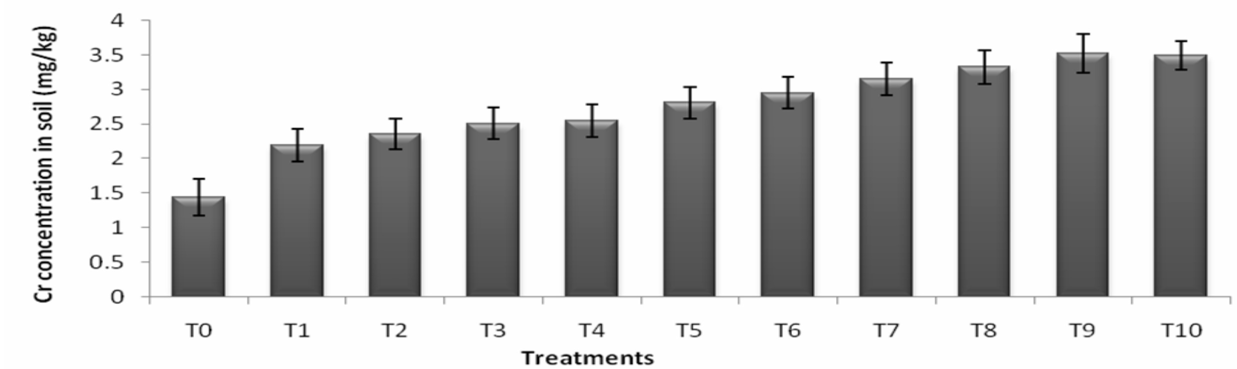

Fig. 3a. Effect of different doses of sewage water on soil Cr levels.

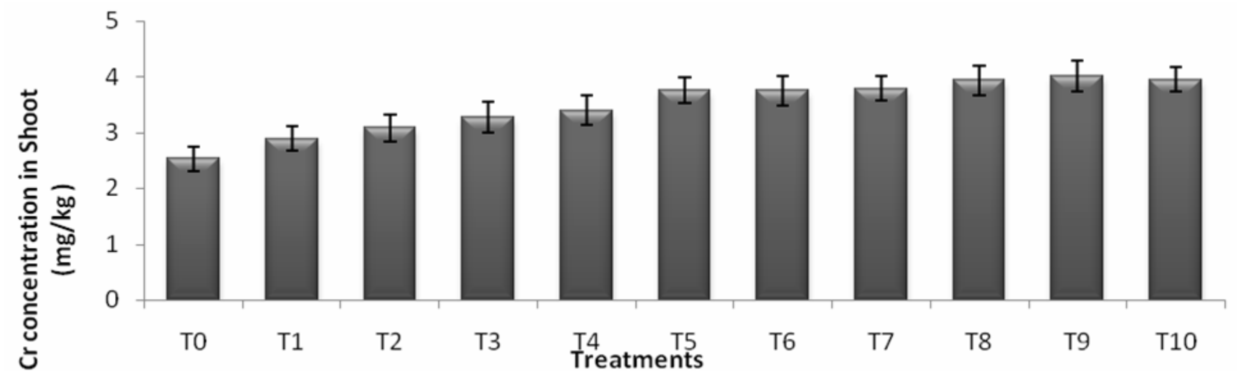

Fig. 3b. Effect of different doses of sewage water on forage (shoot) Cr levels.

Forage cadmium: Forage Cd levels ranged from 1.26 to 3.15 mg/kg in the present study. The adequate level of Cd in plants has been suggested to be around 3 mg/kg (Cicek, 2004). So the forage Cd levels reported in the present study show no potential threat for livestock if such sewage water treated forages are fed to it.

Forage chromium: In the present study the forage Cr concentrations were equally increased during all the sewage water treatments (Fig. 3b). The forage Cr levels ranged from 2.16 to 4.12 mg/kg. The Cr levels found in our study were in the range of forage Cr level previously reported by Deya *et al*., (2005) in Vieques, Puerto Rico, while forage Cr found in our study was far higher than that values reported by Khan *et al*., (2010) in Pakistan.The forage Cr level is less than the toxic level so it is safe for livestock use. Based on findings of our investigation, the significant reduction in yield and yield related parameters in the Canola crop treated with municipal sewage water was found. Soil, forage and seed Pb, Cd, and Cr levels augmented constantly with amplifying the level of treatment with sewage effluents. Municipal sewage water of cities having high concentrations of heavy metals proved to have a potential retarding effect on growth, development and yield affecting parameters of Canola crop.

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