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Impact of city effluents on soil and vegetables in Pakistan

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Key words: Heavy metals; waste water; City effluents; cadmium; cobalt.

Abstract

Waste water irrigation accumulating heavy toxic metals in soil and in plant grown posing a serious threat to biotic life. The represent research was aimed to assess city effluents on soil and vegetables in three different location of Faisalabad district in Pakistan. Samples of irrigation water, field soils and leafy vegetables were taken from random sites ABC road (City effluents), Judgewali (Normal water + city effluents) and Rasalewala (Normal water irrigated) in Faisalabad region. Maximum pH (7.53) was recorded in city effluents (ABC road). Cadmium and cobalt concentrations were measured from root and leaves samples of cabbage, coriander and spinach taken from city effluents irrigated (ABC road) and normal water + city effluent irrigated (Judgewali) soils. No significant difference in Electrical Conductivity (EC) was noted between ABC road and Judgewali sites. No significant difference in cadmium (Cd) and Manganese (Mn) was found between irrigation water samples taken from ABC road and Judgewali. Samples taken from ABC road and Judgewali were significantly same in pH butElectrical conductivity (EC) varied regardless to the soil depth. Maximum (14.100) Sodium Absorption Ratio (SAR) was noted at Judgewali location at 0-20 cm depth soil samples. Judgewali was found to be significantly high (0.8167) in organic matter (OG) contents. Cadmium (Cd) was found highly significant at 80-100 cm depth samples taken from ABC road (city effluents). No cadmium and cobalt was found in soils where normal irrigation water (Rasalawali) was applied. Samples of three vegetables (cabbage, coriander and spinach) from Rasalawali (Normal water irrigated) were found to be free from cobalt, cadmium and manganese.

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Introduction

Population explosion is a continuous alarming threat to the environment. Producing more to meet human needs, industries have been tremendously increased since last decades. Despite coming up with human needs, waste products are posing a serious menace to biotic and abiotic environment directly or indirectly(Misra and Mani, 2004). Emitting gasses from factories and automobiles are the major fact of global warming(Satterthwaite, 2008). Continuous deposition of waste in environment especially heavy metal in soil is an alarming threat for biotic life. Producing more from small land encouraged pesticide and fertilizers application resulting into soil toxicity(Conway and Barbier, 2013).

Having unique nutritional importance, vegetables are consumed throughout the world. Being a good source of carbohydrates, proteins, vitamins, minerals and trace elements gradually increasing consumption since recent years, particularly among the urban community(Kearney, 2010). Heavy metals contaminated soils particularly near industrial areas are more toxic as compared to others(Bai *et al.*, 2011). Vegetables grown in these areas having more residual metals effects entering in food web. Specific precautions like frequent heavy irrigation required to run off or leach down these toxic elements from root zone(Okieimen, 2011). Unfortunately, in Pakistan, vegetables are irrigated from waste water considering a rich sources of organic matter but contains heavy metals as well. Despite this, prior to bring in market, formers wash them by waste water. Vegetables from such areas having high metallic contents deposits in adipose tissues in human body when consumed(Shi *et al.*, 2011). Hazardous effects have been recorded in humans feeding on waste irrigated vegetables and suffer from a number of fatal diseases like cancer, hepatitis and kidney failure(Chong, 2012).

In Faisalabad, being an industrial city, textile factories have developed largely producing tons of waste material every day. Poor drainage and seepage waste water containing heavy metal ions continuously deploying underground water resources and depositing toxic residues in cultivatable lands. Keeping in view the facts, the present study was proposed to assess the effect of effluents on soils and vegetables of three different sites of Faisalabad district in Pakistan.

Materials and methods

Three random sites "ABC road (City effluents), Judgewali (Normal water + city effluents) and Rasalewala (Normal water irrigated)" were selected in Faisalabad and its nearby regions. Grid sampling method was adopted to collect samples from each site. Soil samples were taken from different depths (0-20, 20-40, 40-60, 60-80 and 80-100 cm) from randomly selected three sites (ABC road, Judgewali and Rasalewala) per selected field with the help of an auger.

The samples were air dried ground with wooden articles mixed and sieved. Saturated soil paste of each sample was prepared by adding distilled water in 250g soil and stirred thoroughly using spatula.

The pH of saturated soil paste was recorded by a Jenco Model 671, pH meter. Electrical conductivity (EC) was measured by Jenway EC meter. Sodium Absorption ratio (SAR), Residual Sodium Carbonate (RSC), Organic matter (OG), Soil Texture and Cadmium (Cd), Cobalt (Co) and Manganese (Mn) concentrations were measured by following international standard protocols (Ryan *et al.*, 2007)in soil and water testing laboratory, Lahore.

Samples of three leafy vegetables (Cabbage, Coriander and Spinach) taken from three sites (ABC road, Judgewali and Rasalewala) were thoroughly washed in running tap water to remove dust particles. Samples were excised from separately into roots, stem and leaves by sterilized knife and dehydrated at 80 ^{o}C for 3 days and oven dried at 100 ^{o}C. Dried samples of each parts (root, stem and leaves) of vegetables were ground into a fine powder (80 mesh) using a commercial blender (TSK- West point, France) and acid digested using standard protocols (Sahito *et al.*, 2002). Cadmium (Cd), Cobalt (Co) and Manganese (Mn) concentrations were measured from root and leave samples of each vegetable grown in three tested locations (ABC road, Judgewali and Rasalewala).

Data analysis

Analysis of Variance (ANOVA) was performed to statistically analyze experimental data and means were compared by Fisher's Least Significance Difference (LSD) test at 5% level of significance(Steel and Torrie, 1980). Statistical analysis was performed using SAS (9.3) and graphical approach was made by using Microsoft excel (2013).

Results and discussion

Significant difference in pH of irrigation water samples were noted among ABC road (City effluents), Judgewali (Normal water + city effluents) and Rasalewala (Normal water irrigated) locations. Maximum pH (7.53) was recorded in city effluents (ABC road) water. No significant difference in Electrical Conductivity (EC) was noted between ABC road (City effluents irrigated) and Judgewali (Normal water + city effluents irrigated) sites.

Table 1. Irrigation quality at three sites receiving city effluents, normal water plus city effluent and normal water of Faisalabad.

	ABC Road (city effluents)	Judgewali (normal water plus city effluent)	Rasalawali (Normal water)	LSD Value
pH	7.53 A	7.34 B	7.04 C	0.0941
EC	1.24 A	1.22 A	0.90 B	0.1591
SAR	9.80 A	9.32 A	6.12 B	1.6828
RSC	1.70 A	1.70 A	1.30 B	0.3328
Cadmium (Cd)	0.05 A	0.03 A	0.00 B	0.0258
Cobalt (Co)	0.06 A	0.02 B	0.00 C	0.0211
Manganese (Mn)	0.37 A	0.31 A	0.00 B	0.0656

Means values sharing similar latters do not differ significantly.

Table 2. Soil pH of three sampling locations receiving city effluents (ABC road), normal water plus city effluent (Judgewali) and normal water (Rasalawali).

Soil Depth	ABC Road	Judgewali	Rasalawali
0-20	7.8000 A	7.6333 A	7.0833 B
20-40	7.6667 A	7.6833 A	7.0833 B
40-60	7.7833 A	7.6333 A	7.0000 B
60-80	7.6667 A	7.6833 A	7.0333 B
80-100	7.6833 A	7.6667 A	7.0000 B
LSD=0.3211			

Means values sharing similar latters do not differ significantly.

In Rasalewala (Normal water irrigated) Electrical Conductivity (EC) was lower as compared to ABC road (City effluents), Judgewali (Normal water + city effluents) locations. Lower concentrations of Sodium Absorption Ratio (SAR) and Residual Sodium Carbonates (RSC) were recorded in Rasalewala (Normal water irrigated) with respect to City effluents (ABC road) irrigated and Normal water + city effluents (Judgewali) irrigated regions of Faisalabad. No significant difference in Cadmium (Cd) and Manganese (Mn) concentrations was found between samples taken from ABC road (City effluents), Judgewali (Normal water + city effluents). No metal (Cd, Co and Mn) concentration was recorded in irrigation water samples taken from Rasalewala (Normal water irrigated)(Table 1).

No significant difference in soil pH was recorded at different soil depths (0-20, 20-40, 40-60, 60-80 and 80-100 cm) regardless to the sampling locations. Samples taken from ABC road (City effluents) and Judgewali (Normal water + city effluents) was significantly same in pH regardless to the soil depth. In Rasalewala (Normal water irrigated), soil pH was significantly low as compared to ABC road (City effluents) and Judgewali (Normal water + city effluents) (Table 2).

Table 3. Electric Conductivity (EC) of three sampling locations receiving city effluents (ABC road), normal water plus city effluent (Judgewali) and normal water (Rasalawali).

	Electric Conductivity (EC) dS m^{-1}		
Soil Depth	ABC Road (city effluents)	Judgewali (normal water plus city effluent)	Rasalawali (Normal water)
0-20	2.9333 B	3.8667 A	1.1500 D
20-40	2.4000 BC	2.9167 B	1.4167 D
40-60	2.0167 BCD	2.7500 BC	1.3000 D
60-80	1.9333 CD	2.7333 BC	1.1667 D
80-100	1.8833 CD	2.8833 B	1.1167 D
LSD=0.9263			

Means values sharing similar latters do not differ significantly.

Table 4. Sodium Absorption Ratio (SAR) of three sampling locations receiving city effluents (ABC road), normal water plus city effluent (Judgewali) and normal water (Rasalawali).

	Sodium Absorption Ratio (SAR)		
Soil Depth	ABC Road (city effluents)	Judgewali (normal water plus city effluent)	Rasalawali (Normal water)
0-20	9.817 CDEF	14.100 A	9.300 DEF
20-40	8.200 EF	13.233 AB	7.617 EF
40-60	8.300 EF	11.900 ABC	8.317 EF
60-80	8.300 EF	11.117 BCD	8.650 DEF
80-100	7.833 EF	9.883 CDE	7.283 F
LSD=2.5698			

Means values sharing similar latters do not differ significantly.

Significant variation in Electrical conductivity (EC) was recorded at different soil depths in case of ABC Road and Judgewali not from Rasalawali. Decrease in EC was observed with increase of soil depth. Maximum Electrical conductivity (3.8667dS m^{-1}) was recorded where soil was irrigated by Normal water + city effluents (Judgewali) at 0-20 cm soil depth. At 20-40 cm sampling depth, No significant difference was measured ABC road (2.40 dS m^{-1}) and Judgewali (2.91 dS m^{-1}). Significant lower EC was recorded at 60-80 cm depth at ABC road samples as compared to Judgewali (Normal water + city effluents). Electrical conductance (EC) of normal water irrigated samples was significantly low comparing to Judgewali and ABC road sampling locations. No significant change in EC was recorded regardless to soil depth from where sample was taken (Table 3).

Maximum (14.100) Sodium Absorption Ratio (SAR) was noted at Judgewali location at 0-20 cm depth samples. No significant difference in SAR was recorded at 0-20 cm soil depth samples taken from any location ABC road (City effluents), Judgewali (Normal water + city effluents) and Rasalewala (Normal water irrigated).At 20-40 cm depth, samples from Normal water + city effluents irrigated areas were significantly high in SAR as compared to areas of city effluents. Significant decrease in SAR value was noticed at 80-100 cm depth as compared to 0-20 cm depth samples irrespective to sampling locations. Minimum ratio (7.283) was found where irrigation water was normal (Rasalawali) (Table 4).

Table 5. Organic matter (OG) contents of three sampling locations soils receiving city effluents (ABC road), normal water plus city effluent (Judgewali) and normal water (Rasalawali).

	Organic Matter (OG)		
Soil Depth	ABC Road	Judgewali	Rasalawali
0-20	0.6833 B	0.8167 A	0.5000 C
20-40	0.6167 B	0.4833 CD	0.4167 CDE
40-60	0.4833 CD	0.4500 CDE	0.4333 CDE
60-80	0.4500 CDE	0.4000 CDE	0.4167 CDE
80-100	0.4000 CDE	0.3667 E	0.3833 DE
LSD=0.1076			

Means values sharing similar latters do not differ significantly.

Table 6. Soil texture of three sampling sites receiving city effluents (ABC road), normal water plus city effluent (Judgewali) and normal water (Rasalawali).

	Soil Depth	ABC Road	Judgewali	Rasalawali
Clay (%)	0-20	16.097 DEF	18.200 D	17.033 DEF
	20-40	16.547 DEF	16.527 DEF	17.927 DE
Silt (%)	0-20	15.807 DEF	14.317 F	14.697 EF
	20-40	16.980 DEF	14.340 F	14.340 F
Sand (%)	0-20	68.097 AB	69.667 A	65.767 BC
	20-40	66.640 AB	68.203 AB	62.717 C
LSD = 3.4387				

Means values sharing similar latters do not differ significantly.

Judgewali (Normal water + city effluents irrigated) was found to be significantly high (0.8167)in organic matter (OG) at 0-20 cm) depth. No significant difference was recorded from samples taken from city effluents irrigate and normal water irrigated areas ($p \leq 0.05$) at 0-20 cm soil depth. Organic meter contents significantly lowered with increase of soil depth. At 20-40 cm soil depth. ABC road (City effluents) was the significant in high organic matter comparing to Judgewali (Normal water + city effluents irrigated) and Rasalawali (Normal water) (Table 5).

Clay percentage at 0-20 cm and 20-40 cm soil depths was measured significantly same taken from three sampling sites. No significant difference in silt and clay percentage was recorded from samples of ABC road (City effluent irrigated) at 0-20 and 20- 40 cm depths. Silt contents recorded among three sampling locations ABC road (City effluents), Judgewali (Normal water + city effluents) and Rasalewala

(Normal water irrigated) was significantly same at both soil depths (0-20 and 20-40 cm). Samples taken from Rasalawali contained sand was significantly lower as compared to ABC road (City effluents) and Judgewali (Normal water + city effluents). No significant difference in sand percentage was noticed between ABC road (City effluents), and Judgewali (Normal water + city effluents) samples (Table 6).

Cadmium (Cd) was found highly significantat 80-100 cm depth samples taken from ABC road (City effluents). No significant difference was seen between Judgewali and ABC road samples upto 60 cm depth. No cadmium concentration was found in soils where normal irrigatuion water was applied (Rasalawali) (Fig 1).

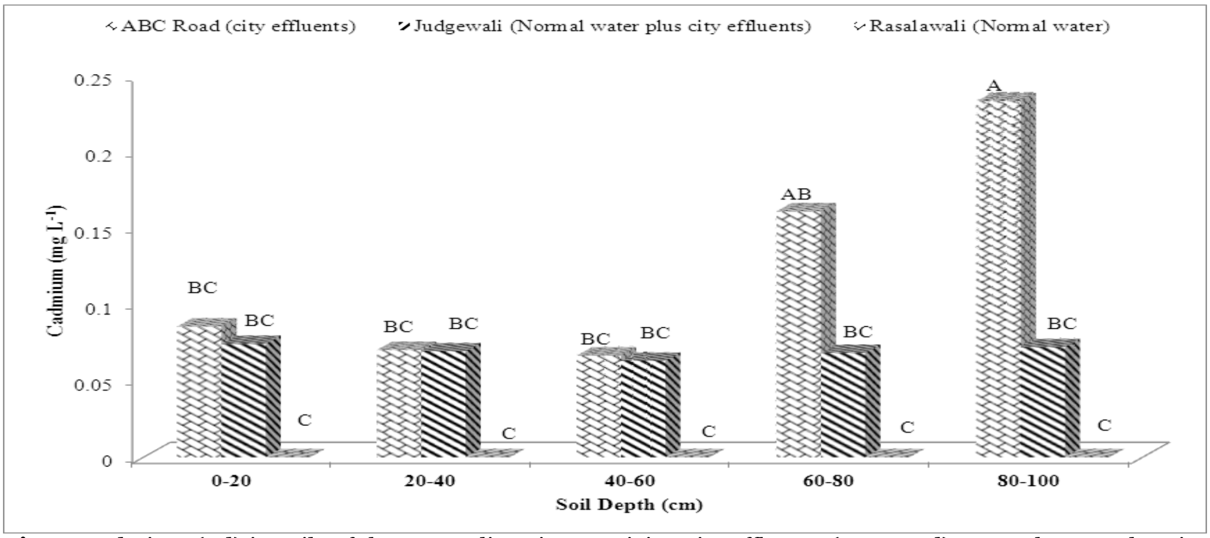

Fig. 1. Cadmium (Cd) in soils of three sampling sites receiving city effluents (ABC road), normal water plus city effluent (Judgewali) and normal water (Rasalawali).

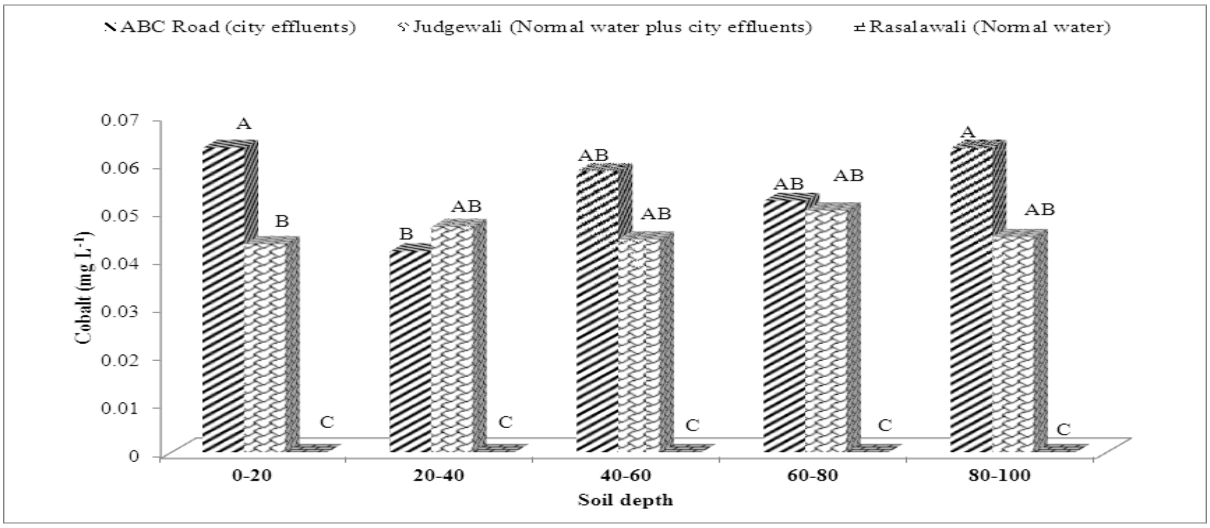

Fig. 2. Cobalt (Co) in soils of three sampling sites receiving city effluents (ABC road), normal water plus city effluent (Judgewali) and normal water (Rasalawali).

Soils of ABC Road were found to be most significant (0.0632) in Cobalt (Co) concentration at 0-20 cm depth samples as compared to Judgewali (0.0432) location. No significant difference in Cobalt was found irrespective to soil depths in Judgewali. Samples from Rasalawali was free from cobalt (Fig 2). Manganese in soils of ABC road samples were found to be significantly high with respect to Judgewali

(Normal water + city effluents) and Rasalewala (Normal water irrigated) at 20 cm depth samples. No significant difference was seen between Judgewali (Normal water + city effluents) and Rasalawali (Normal water irrigated). Samples taken from normal water irrigated soils were found to be relatively low in Manganese but not significant from ABC road and Judgewali samples (Fig 3).

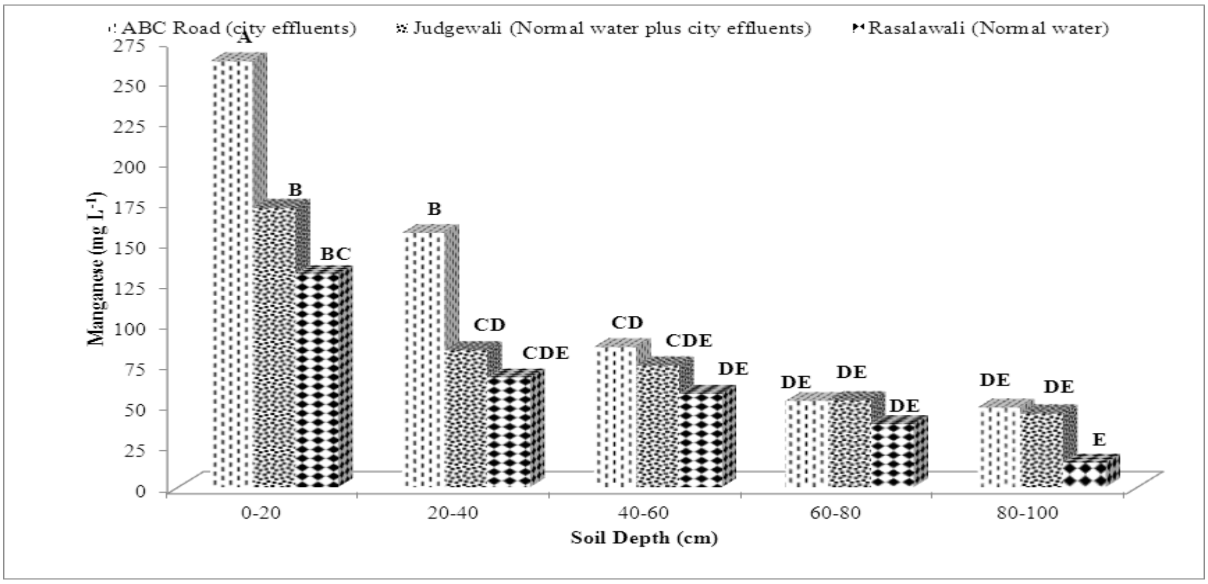

Fig. 3. Manganese (Mn) in soils of three sampling sites receiving city effluents (ABC road), normal water plus city effluent (Judgewali) and normal water (Rasalawali).

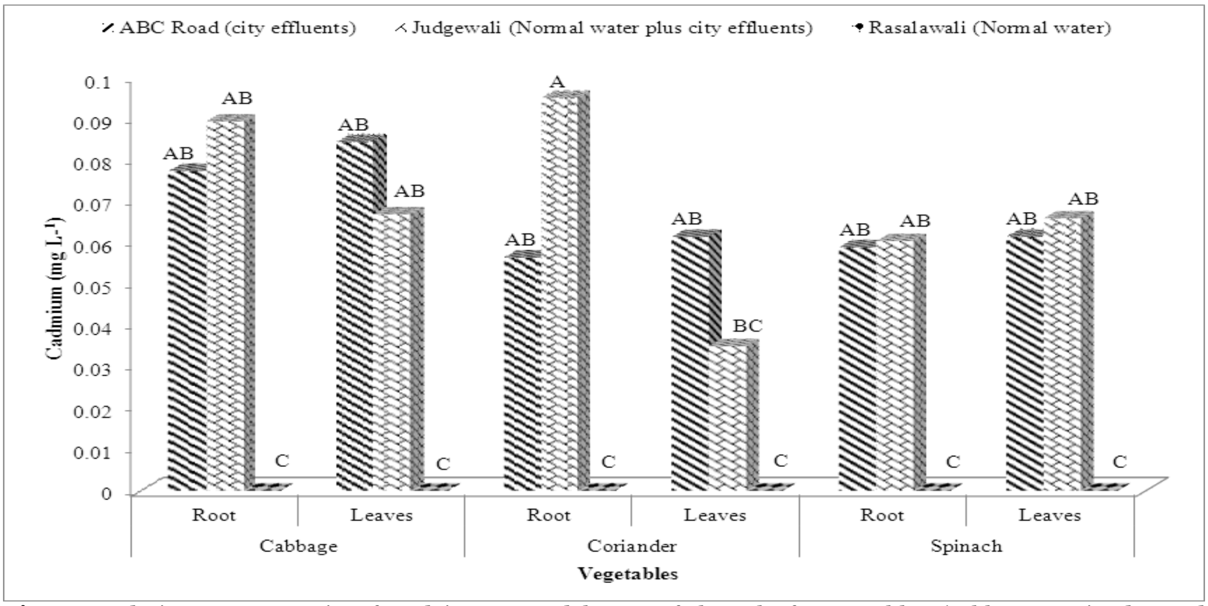

Fig. 4. Cadmium concentration found in root and leaves of three leafy vegetables (cabbage, coriander and spinach) grown in three location receiving city effluents (ABC road), normal water plus city effluent (Judgewali) and normal water (Rasalawali).

Cadmium found in root and leaf samples of cabbage, coriander and spinach taken from ABC road (City effluents) and Judgewali (Normal water + city effluents) was significantly not different. No cadmium was found in leaf and root of any vegetable (cabbage, coriander and spinach) sample taken from soils irrigated with normal water (Fig 4). No significant difference was measured from root and leaves samples of cabbage taken from city effluents irrigated (ABC road) and normal water + city effluent irrigated soils (Judgewali). Similar results were noted in case of coriander and spinach samples (root and leaves). Cobalt was not found in samples of root and leaves of cabbage, coriander and spinach grown in normal water irrigation areas (Rasalawali) (Fig 5).

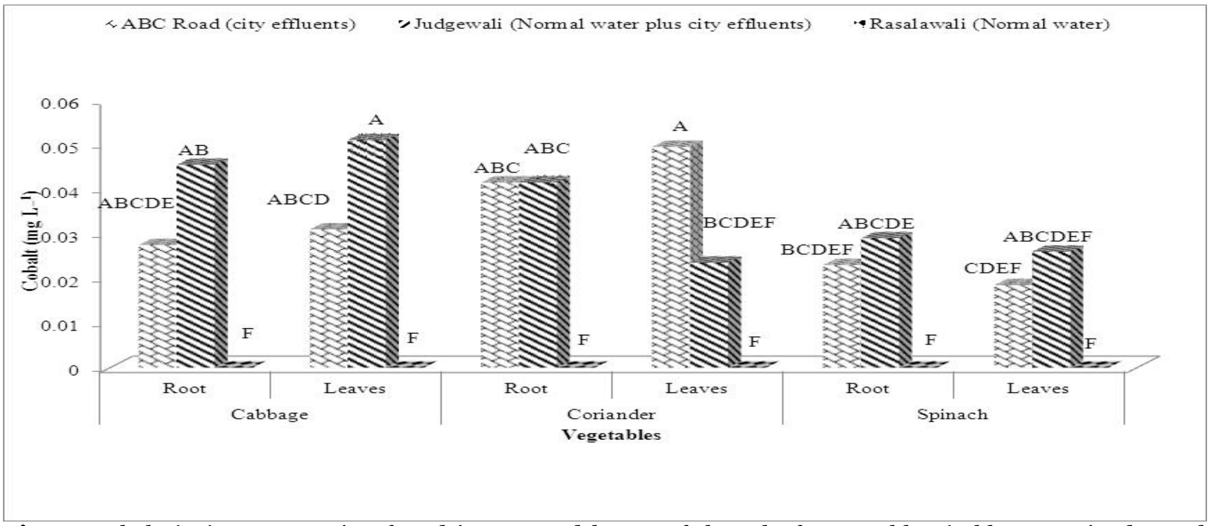

Fig. 5. Cobalt (Co) concentration found in root and leaves of three leafy vegetables (cabbage, coriander and spinach) grown in three location receiving city effluents (ABC road), normal water plus city effluent (Judgewali) and normal water (Rasalawali).

Significant amount of Manganese (Mn) was found in cabbage roots as compared to leaves irrespective to sampling site. No significant difference was recorded comparing to sampling sites either samples of roots or from leaves. Similar results were observed in case of coriander and spinach. Comparing root to root and leave to leave samples of three vegetables grown in city effluents (ABC road) and normal water + city effluents (Judgewali), no significant change in manganese (Mn) was seen. Samples of three vegetables (cabbage, coriander and spinach) from Rasalawali (Norma water irrigated) were found to be free from manganese (Fig 6).

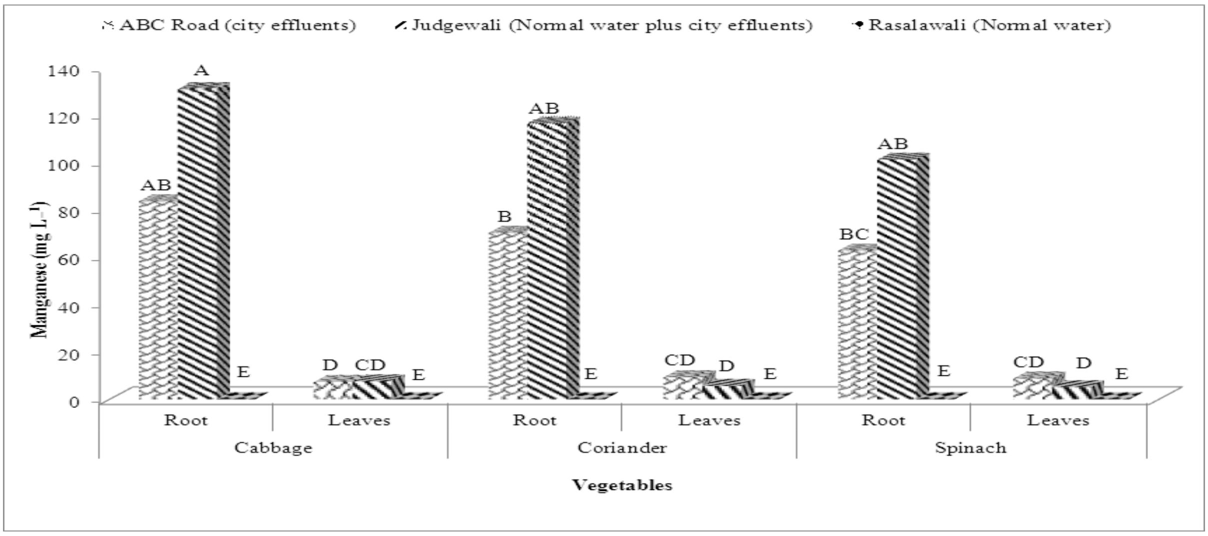

Fig. 6. Manganese (Mn) concentration found in root and leaves of three leafy vegetables (cabbage, coriander and spinach) grown in three location receiving city effluents (ABC road), normal water plus city effluent (Judgewali) and normal water (Rasalawali).

The sources of high EC in Faisalabad city effluent could be the use of subsoil water, detergents in industries, cosmetics, textile, ashes and factory wastes (Ibrahim and Salmon, 1992).Since the city of well-known for textile industry. Overall, the samples taken from ABC Road which is considered useable unfit for irrigation purposes. Earlier Ghafoor *et al.* (1994) reported this much high EC of effluents from various industrial establishments and collector drain in Faisalabad city.

The SAR of this range is considered moderate hazard to most of the soil textures and plants. The ABC Road effluent was marginal while Judgewali effluent was hazardous for irrigation according to standers set by U.S. Salinity lab. Staff (1954). There is no pattern of increasing or decreasing concentration with the change of seasons, while there is a slight higher values in Judgewali samples than those of ABC Road. Long and continues use of effluent for irrigation may cause accumulation of these metals in soil which may reach to toxic levels for plants and animals health. Qdir & Ghafoor (1996) possible strategy could be mixing of effluent with canal or other good quality water. Higher EC_e at the upper depths (0-20 cm) than the lower ones might be due to salts in effluents applied for growing crops, as well as accumulation through capillary action under the agro climatic conditions of Faisalabad.

All the other fields were non saline. The lower values of EC in these fields seem partly due to monsoon rains (Ghafoor *et al.*, 1997). Those affected flushing as well as extensive and heavy irrigation practiced by farmers to grow vegetables which are implicitly maintaining leaching fraction (LF) high enough to take off the salt build up in these well drained medium textured soils. The soil SAR at Judgewali fields have become higher than ABC Road fields. It was natural since the EC, SAR and RSC of the effluents of the former sampling site were higher. It is proposed that for such irrigation waters quality, the former should follow some management practices, like use of Ca^{2+}source organic manures and or other suitable management as described by (Qadir and Ghafoor, 1996) and Robinson *et al.* (1995). The higher OM in the study fields appears due to its addition through sewage irrigation water as Qadir *et al.* (1999) reported 0.20% OM in such effluents at Faisalabad. Moreover, the intensive cropping adding plant residues in soils which is universally accepted a good and reasonable source of soil OM. Cadmium was detected three sites, ABC Road, Judgewali and Rasalewala around Faisalabad where fields were irrigated with industrial effluent, normal plus industrial effluents and normal water respectively is below the permissible limit of 0.31mg Kg-1. This could be due to low mobility of bioavailability of Cd+2 in neutral to alkaline soils (Murtaza *et al.*, 2003). There is no pattern of distribution of Cd+2 in the soil profile but in all samples. Cd+2 is higher in topsoil and decreases with depth in some cases. Similar results were found in the soils irrigated with city effluents at Faisalabad (Ghafoor *et al.*, 1996, Murtaza *et al.*, 2008). Okra (*Abelmoschus esculentus*) and spinach (*Spinacea oleracea*) were planted in spring and winter respectively. Both vegetables were given a basal dose of 100 and 50 kg ha^{-1} N and P respectively. The heavy metal and micronutrient contents in both vegetables were present in significantly higher amount in order of sewage>sewage and tube well water>tube well water except Cu and Fe which showed variation for both the crops. Spinach leaves showed higher accumulation of heavy metals and micronutrients as compared to okra fruit (Lone *et al.*, 2003).

Conclusion

The present research was aimed to assess the comparative concentrations of toxic metals (Cadmium, Cobalt and Manganese) in filed soils and vegetables at three different location preferably selected based on the irrigation water i.e. city effluents (ABC Road), Normal water + city effluents (Judgewali) and Normal irrigated water (Rasalewala). The present study revealed that heavy metals (Cadmium, Cobalt and Manganese) concentrations were found same in filed soils and in vegetable samples at ABC Road (city effluents) and Judgewali (Normal water + city effluents), however, no heavy metals were found where normal water was irrigated. So, it has been concluded that vegetable grown by irrigating the city effluents and Normal water + city effluents may be fatal for human and animal life upon consuming and may cause serious chronic diseases.

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