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Heavy metals contamination of different water sources, soils and vegetables in Rawalpindi area

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Abstract

Two main sources of soil and water pollution are domestic sewage and untreated industrial discharge. These waste waters though contain large amount of organic material and inorganic elements essential for crop growth, also contain those heavy metals which when present in large amount may be fatal for animals and human beings. Similarly, if these heavy metals leach out through the soil, they may contaminate ground-water as well. Present study was conducted to determine the contamination of heavy metals in soils, waters and vegetables of Rawalpindi area. For this purpose, a study was conducted in which eighty water samples from different water sources such as tubewell (40), sewage (21) and industrial effluents (19) and same number of samples were collected from soils and vegetable plants irrigated with these waters and analysed for heavy metals as lead, cadmium, chromium and nickel. The heavy metals of different waters were compared with maximum permissible limits of FAO (1985) for irrigation water. All water samples for lead were safe, whereas, concentration of other heavy metals showed quite variation even some of the tubewell waters were unsafe for irrigation. Heavy metals in soil samples were found below the critical levels as prescribed by Mclean et al. (1987). Heavy metals in tubewell-irrigated vegetables were below the critical levels of WHO (1996) and Asaolu (1995). Heavy metals in sewage and industrial effluents-irrigated vegetables were above the critical levels.

Key words: Heavy metals, sewage, industrial effluents, soil, water, vegetables

Introduction

Water is important for survival and existence of life. It is being used intensively for domestic (6%), industrial (3%) and agricultural purposes (90%). Fortunately, Pakistan has one of the biggest networks of canal irrigation system, but still there is shortage of surface water supplies. Surface water supplies doesn't meet crop water requirements as net deliveries of surface water supplies are 1.80 acre feet per cropped area, which does not meet optimum water requirements estimated to be 4-5 acre feet (Tarar, 1997). This shortage is being met by the conjunctive use of ground water for growing cereals and use of urban waste water (sewage and industrial effluents) for raising vegetables especially in city conurbations (Lone, 1995). Such irrigation practices give very good crop yields as it contains large amount of organic material and inorganic elements essential for crop growth (Mitra and Gupta, 1999). But it may also contain those heavy metals which when present in large amount may be phytotoxic or transferred to animal and human beings through food chain and thus harmful for them (Ghafoor *et al*., 1995).

Industrial effluents are the most potential water pollutants (Aslam, 1998). The effluents discharged by different industries contain higher values of physico-chemical parameters like temperature, pH, conductivity, hardness, alkalinity, chemical oxygen demand, total soluble salts, nitrates, nitrites and cations (Na, K, Ca and Mg). Sewage water may also contain significant amount of heavy metals such as zinc, iron, copper, manganese, lead, cadmium, chromium, nickel, cobalt etc. Some of the heavy metals are even not essential for plant growth but after accumulating in the soil could be transferred to food chain (Malla *et al.*, 2007). These metal ions are either themselves toxic to biological organisms or induce deficiency of others. The metals like iron, manganese, cobalt, copper and nickel are also essential nutrients; however, their permissible limits are quite low and show toxic effects on biological system above their permissible limits. The elements, which have been identified from different industrial effluents, are heavy metals and trace metals including chromium, cadmium, copper, lead, nickel, zinc, cobalt, magnesium, iron and arsenic (Ali *et al*., 1996). Generally, the growers are not aware of the metal ion toxicity being introduced into food chain by vegetables grown with effluents. If these heavy metals leach out through the soil, they may contaminate ground-water as well (Qadir *et al*., 1999).

Heavy metal toxicity is the result of complex interaction of major toxic ions with other essential or non-essential ions. These metals reduce the activity of hydrolysis viz., α amylase, phosphatase, RNAse and proteins. They interfere in the enzyme action by replacing metal ions from the metaloenzymes. Among heavy metals cadmium shows severe effect on seedling length, dry weight, reduces photosystem II activity,

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causes structural change in chloroplast and thus reduces photosynthesis, availability of carbon dioxide, lowers stomatal conductance, reduces total lipids, glycolipids and neutral lipids, interfere with membrane permeability and reduces respiration in leaves (Agarwal, 2002). Toxic level of lead inhibits germination, reduces rate of photosynthesis, reduces transpiration, causes reduction in total chlorophyll production, alters relative proportion of chlorophyll a and chlorophyll b and reduces gaseous exchange in leaves. Similarly, toxic levels of nickel and chromium show drastic effect on dry matter production and yield (Agarwal, 2002). Now it is our responsibility to advocate the proper use of sewage effluents in order to avoid soil contamination because soil is more valuable natural resource for mankind. So the present study was conducted to determine the heavy metals pollution in soils, waters and plants of Rawalpindi area.

Materials and Methods

A field survey of Rawalpindi field area was carried out to assess the heavy metal status of different water sources such as tubewell, sewage, industrial effluents and agricultural soils and vegetables irrigated by these sources. For this purpose, Taxilla, Adiyala, Swan, Gujar Khan and Rawalpindi city were surveyed and forty samples were collected from Tubewells and 21 and 19 samples were collected from sewage and untreated industrial effluents, respectively. Same numbers of samples were collected from fields and vegetables irrigated with these sources, during winter, 2003 and summer, 2004. Soil samples were collected from 0-30 cm depth only. Vegetable leaves samples of commonly grown vegetables in the area were collected (Table 1-3). Soil, water and plant samples were analysed for heavy metals; lead, cadmium, chromium and nickel. The soil samples were analysed by the method given by Soltanpour and Workman (1979), water samples by the method of AOAC (1984) and plant samples by the method of Rashid (1986).

Results and Discussion

Heavy metals contents of different water sources

The heavy metal contents of different water sources were classified into safe and unsafe classes for irrigation (Figure 1) using maximum permissible concentrations of FAO (1985) for lead (5.0 mg L^{-1}), cadmium (0.01 mg L^{-1}), chromium (0.10 mg L^{-1}) and nickel (0.20 mg L^{-1}).

Lead concentration of tubewell waters ranged from 0.01 to 0.40 mg L^{-1} and all the forty samples were safe for irrigation as they were below the maximum permissible concentration of FAO (1985). Cadmium concentration ranged from 0.001 to 0.030 mg L^{-1}. Twenty-nine (72.5%) samples were safe whereas, 11 (27.5%) tubewell waters were unsafe for irrigation. Chromium concentration was from 0.01 to 0.43 mg L^{-1}. Twenty-six (65%) were safe and 14 (35%) were unsafe. However, nickel concentration varied from 0.01 to 0.30 mg L^{-1} and 37 (92.5%) tubewell waters were safe for irrigation regarding nickel concentration.

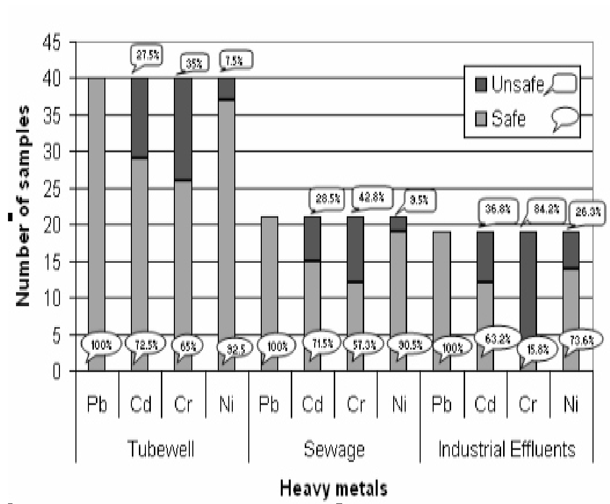

Figure 1. Classification of water samples from different sources

Lead concentration of sewage ranged from 0.01 to 0.79 mg L^{-1} and all the forty samples were safe within the permissible limit of FAO (1985). Whereas, the cadmium concentration of sewage varied from 0.001 to 0.031 mg L^{-1} and 15 (71.5%) samples were safe and 6 (28.5%) sewage samples were unsafe for irrigation. Chromium concentration was in the range of 0.01 to 0.84 mg L^{-1} and 12 (57.3%) samples were safe and 9 (42.8%) were unsafe. However, Nickel concentration varied from 0.01 to 2.08 mg L^{-1} and 19 (90.5%) samples were safe.

Lead concentration in untreated industrial effluents ranged from 0.03 to 0.27 mg L^{-1} and all samples were safe for irrigation, whereas, cadmium concentration varied from 0.001 to 0.040 mg L^{-1} and 12 (63.2%) samples were safe and 7 (36.8%) samples were unsafe. Chromium concentration was within the range of 0.07 to 1.15 mg L^{-1} and 3 (15.8%) were safe and 16 (84.2%) were unsafe. Nickel concentration varied from 0.01 to 0.60 mg L^{-1} and 14 (73.7%) effluents samples were safe and 5 (26.3%) samples were unsafe for irrigation.

Heavy metals especially cadmium, chromium and nickel contents in some of the tubewell water samples were observed above the maximum permissible limits, due to the reason that some of the farmers have installed their tubewells on the banks of sewage drains, resulting in elevated levels of heavy metal in tubewell waters due to seepage as elevated levels of heavy metals were

Table 1. Collections of well/ tube well water samples

Sample No	Site	Source	Vegetable	Village	Name of Farmer
1	**Rawalpindi**	Tube well	Cauli Flower	Gorakhpur	M. Asif
2		Tube well	Cauli Flower	Gorakhpur	Fazal Hussain
3		Tube well	Cauli Flower	Dhoke Syedan	Atif Mehmood
4		Well	Corriander	Kamal abad	M. Kamran
5		Tube well	Squash	Tench Bhata	Kabir Hussain
6		Tube well	Spinach	Waris Khan	Anwar-ul-Haq
7		Tube well	Cauli Flower	Muslim Town	Haji Ilyas Ahmad
8		Tube well	Spinach	Satellite Town	Altaf Hussain
9		Tube well	Cauli Flower	Chak Shahzad	Arshad Mehmood
10		Tube well	Cauli Flower	Dhok Ratta	Jamil Akhtar
11		Tube well	Cauli Flower	Dhok Ratta	Jamil Akhtar
12		Tube well	Peas	Dhoke Khabba	Khan Zaman
13		Well	Bitter Gold	Misrial	Fazal Hussain
14		Tube well	Pepper	Haji Camp	Manzoor Hussain
15		Tube well	Coriander	Peer Wadhai	Tariq Mehmood
16		Tube well	Onion	I-8/2	Abdul Majid
17		Tube well	Spinach	G-9/4	Abdul Hameed
18		Tube well	Squash	I-10/2	Shakoor Ahmad
19		Tube Well	Tomato	Sihala	M. Afroz Khan
20		Tube well	Squash	Sihala	M. Khan
21	**Kotli Sattian**	Chashma	Onion	Kotli Sattian	
22	**Kahuta**	Mini Dam	Tomato	Dhoke Maira	Tariq Mehmood
23		Well	Potato	Lehtrar	
24	**Taxila**	Tube well	Potato	Sunjani	M. Zaheer
25		Tube well	Onion	Taxila city	Malik Noor Elahi
26		Tube well	Lehsan	Chachi Mohalla	M. Ishaq
27		Tube Well	Spinach	Pind Gondal	Maqbool Ahmad
28		Tube Well	Spinach	Pind Gondal	Malik Afsar Gujjar
29		Tube well	Spinach	Dhoke Awan	Shoukat Ali
30		Tube well	Coriander	Dhoke Awan	Abdul Malik
31		Well	Onion	Taxila City	Malik Rafique
32	**Gujjar Khan**	Tube Well	White Lehsan	Jand Nijjar	Naseem Khan
33		Tube Well	Red Lehsan	Gujjar Khan	Khalid Mehmood
34		Tube Well	Squash	Gujjar Khan	Ghulam Mustafa
35		Tube Well	Spinach	Gujjar Khan	Wajid Khan
36		Tube Well	Cauli Flower	Malala	Anwar Malik
37		Well	Cauli Flower	Mandra	Ghulam Nabi
38		Tube Well	Cauli Flower	Rawat	Abdul Rehman
39		Tube well	Peas	Gujjar Khan	Riaz Ahmed
40		Tube Well	Squash	Gujjar Khan	Ch. Zulfiqar

present in sewage and untreated industrial effluents. Elevated levels of heavy metals in sewage and industrial effluents have also been reported by various scientists in Pakistan. Dewani *et al*. (1997) reported the elevated levels of heavy metals in sewage samples of Hyderabad city. Ensink *et al*. (2007) reported the same in industrial effluents of Faisalabad and sewage of Haroonabad areas, Farid (2003) in Faisalabad city effluents and Lone *et al*. (2003) in sewage samples of Attock area. In Rawalpindi/ Islamabad areas, the same was reported by Mohammad *et al*. (1997) in CDA tubewells of Islamabad, Mian *et al*. (1998) in Soan river water being polluted due to industrial estate, Model Town, Humak, Islamabad. Same

Table 2. Collection of sewage samples

Sample No	Site	Source	Vegetable	Village	Name of Farmer
41	**Gujar Khan**	City Sewage	Tomato	Gujar Khan	Ch. Zulfiqar
42		City Sewage	Squash	Gujar Khan	Amanat Khan
43		Malala Nala	Onion	Gujar Khan	M. Rashid
44		Malala Nala	Tomato	Gujar Khan	M. Munawar
45		City Sewage	Potato	Rawat	M. Younis
46		City Sewage	Potato	Mandra	M. Rafiq
47	**Rawalpindi**	Nala Lai	Onion	Peer Wadhai	M. Zulfiqar
48		Korang Nala	Lehsan	Chak Shahzad	Arshad Mehmood
49		Swan River	Cauli Flower	Sihala	Maqbool Ahmad
50		City Sewage	Peas	Waris Khan	Muzammal Hussain
51		Swan River	Bitter Gourd	Adiyala	Tayyab Iqbal
52		City Sewage	Pepper	Kamal Abad	Tanveer Ahmad
53		Nala Lai	Coriander	Dhoke Matkiyal	Walliullah
54		Nala Lai	Onion	Moti Mahal	Abdul rehman
55		Nala Lai	Spinach	Chaklala	Shahid Mahmood
56	**Taxila**	City Sewage	Squash	Chachi Mohalla	M. Ansar
57		City Sewage	Spinach	Dhoke Awan	Allah Ditta
58		City Sewage	Cauliflower	Dhoke Awan	Rizwan Iqbal
59		City Sewage	Spinach	Taxila City	Abdul Rahim
60		City Sewage	Cauliflower	Wah City	Rehan Arif
61		City Sewage	Cauliflower	Wah Cantt	Riaz Ahmad

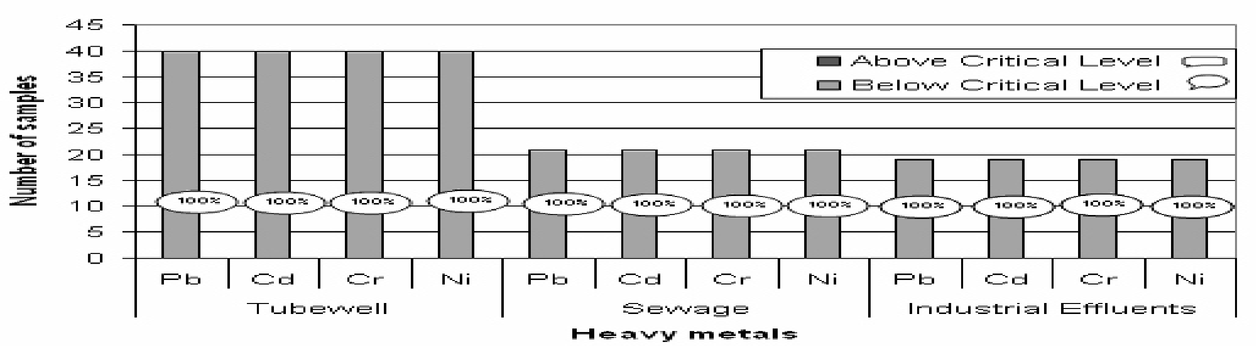

Figure 2. Classification of vegetable fields irrigated with different water sources

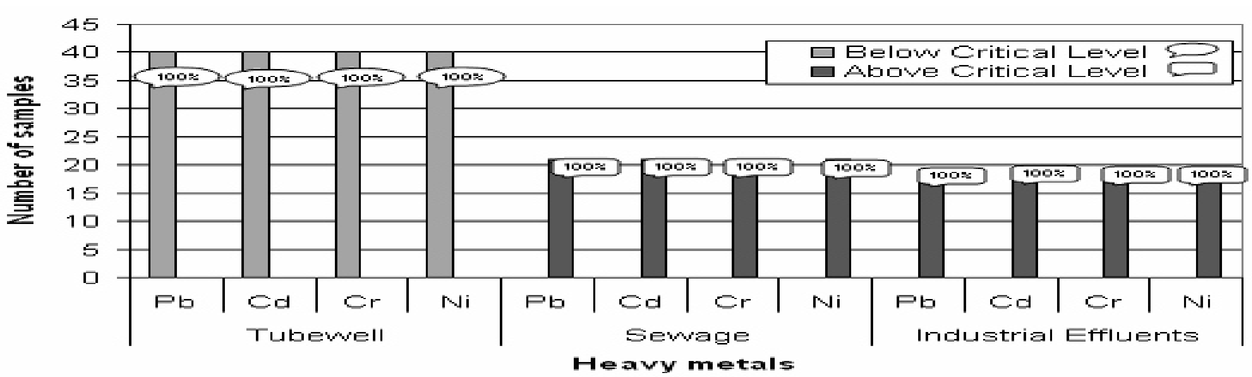

Figure 3. Classification of vegetable irrigated with different water sources

Table 3. Collection of industrial effluents

Sample No	Site	Source	Vegetable	Type of effluents	Name of Farmer
62	**Gujar Khan**	Industrial effluents	Cauliflower	Flour Mill	Sagheer Ahmad
63	**Rawalpindi**	Industrial effluents	Peas	Ghee factory	M. Umar
64		Industrial effluents	Bitter Gold	Oil Refinery	Zamir Khan
65		Industrial effluents	Pepper	Soap & Detergent	Rasib Khan
66		Industrial effluents	Tomato	Ghee Factory	M. Akmal
67		Industrial effluents	Onion	Flour Mill	Gulzar Ahmad
68		Industrial effluents	Spinach	Ghee factory	Subah Khan
69		Industrial effluents	Squash	Plastic Factory	Noor Muhammad
70		Industrial effluents	Tomato	Marbell factory	M. Hayyat
71		Industrial effluents	Squash	Plastic Factory	Safdar
72		Industrial effluents	Onion	Garments Factory	Saleem
73		Industrial effluents	Tomato	Briefcase Factory	Ghazanfar Iqbal
74	**Taxila**	Industrial effluents	Potato	Cement	Hamid Mehmood
75		Industrial effluents	Potato	Arm Factory	Shaban
76		Industrial effluents	Onion	Pak Ordinance Factory	Zabiullah
77		Industrial effluents	Coriander	Ghee Mill	Peeran Ditta
78		Industrial effluents	Onion	Marbell factory	Touqeer Abbas
79		Industrial effluents	Spinach	Explosive factory	Zaheer Ahmad
80		Industrial effluents	Squash	Gun making Factory	Subhan Ali

was also reported by Khan *et al*. (2001) in sewage samples of Rawalpindi area.

Heavy metals accumulation in different vegetable fields

Heavy metals accumulation in vegetable fields irrigated with different sources (Figures 2) was classified using critical levels described by Maclean *et al*. (1987) for lead (13.0 mg kg^{-1}), cadmium (0.31 mg kg^{-1}), chromium (8.0 mg kg^{-1}) and nickel (8.10 mg kg^{-1}).

Lead accumulation in tubewell irrigated vegetable fields in Rawalpindi area ranged from 0.50 to 0.75 mg kg^{-1}. Cadmium accumulation varied from 0.01 to 0.04 mg kg^{-1}, whereas, Chromium accumulation ranged from 0.13 to 0.22 mg kg^{-1}. Nickel accumulation was observed from 0.04 to 0.22 mg kg^{-1}. All samples in tubewell irrigated vegetable fields in Rawalpindi area were less than the critical levels with respect to lead, cadmium, chromium and nickel contents.

Lead accumulation in sewage irrigated vegetable fields in Rawalpindi area varied from 0.15 to 3.00 mg kg^{-1}. Cadmium accumulation ranged from 0.09 to 0.14 mg kg^{-1}, whereas, chromium accumulation ranged from 0.43 to 0.49 mg kg^{-1}. Nickel accumulation was observed from 0.42 to 0.44 mg kg^{-1}. All samples were less than the critical levels for lead, cadmium, chromium and nickel.

Lead accumulation in untreated industrial effluents irrigated vegetable fields in Rawalpindi area varied from 2.67 to 9.35 mg kg^{-1}. Cadmium accumulation ranged from 0.09 to 0.16 mg kg^{-1}, whereas, Chromium accumulation ranged from 0.53 to 0.90 mg kg^{-1} and Nickel accumulation was observed from 0.50 to 0.87 mg kg^{-1}. All samples of untreated industrial effluents irrigated vegetable fields of Rawalpindi area were below the critical levels with respect to lead, cadmium, chromium and nickel contents.

Elevated levels of heavy metals in vegetable fields irrigated with sewage and untreated industrial effluents were observed due to the reason that these waste water effluents some times are rich in heavy metals, thus polluting soil. Elevated levels of heavy metals in sewage and untreated industrial effluents irrigated soils have been reported by various scientists in Pakistan. Khalid *et al*. (1990) reported the elevated levels of heavy metals in soils at 0-30 cm depth. Khan *et al*. (1992) and Butt *et al.* (2005) reported the elevated levels of heavy metals in Faisalabad city effluents-irrigated soils upto 90 cm soil depth, whereas, Jawahar and Javed (1997) reported the same in Lahore, Sheikhupura and Muridke area till 120 cm soil depth and Mian and Ahmed (1997) reported the same in Humak industrial effluents-irrigated soils of Rawalpindi/ Islamabad area.

Heavy metals accumulation in vegetables

The heavy metals accumulation in vegetable leaves irrigated with different water sources (Figure 3) was classified using critical levels described by Asaolu

(1995) for lead (2.0 mg kg^{-1}) and chromium (1.30 mg kg^{-1}) and by WHO (1996) for cadmium (0.02 mg kg^{-1}) and nickel (10.0 mg kg^{-1}).

Lead accumulation in vegetable leaves irrigated with tubewell water in Rawalpindi area ranged from 0.10 to 0.29 mg kg^{-1}. Cadmium accumulation ranged from 0.001 to 0.006 mg kg^{-1}, chromium accumulation ranged from 0.004 to 0.007 mg kg^{-1} and nickel accumulation was observed from 0.09 to 0.13 mg kg^{-1}. All samples of vegetables irrigated with tubewell water were less than the critical levels for heavy metals.

Lead accumulation in vegetable leaves irrigated with sewage in Rawalpindi area ranged from 2.05 to 4.62 mg kg^{-1}. Cadmium accumulation ranged from 0.39 to 0.89 mg kg^{-1}, Chromium accumulation ranged from 1.93 to 2.23 mg kg^{-1}. All vegetable samples irrigated with sewage in Rawalpindi area were above the critical levels of lead, cadmium and chromium. Nickel accumulation was observed from 11.32 to 18.13 mg kg^{-1} and all samples were above the critical level for nickel contents (WHO, 1996).

Lead accumulation in vegetable leaves irrigated with industrial effluents in Rawalpindi area ranged from 8.07 to 10.72 mg kg^{-1}. Cadmium accumulation varied from 3.09 to 4.86 mg kg^{-1}, chromium accumulation ranged from 3.61 to 8.85 mg kg^{-1} and nickel accumulation was observed from 16.32 to 21.84 mg kg^{-1}. All vegetable samples irrigated with untreated industrial effluents were above the critical levels for eating regarding lead, cadmium, chromium and nickel contents as described by WHO (1996) and Asaolu (1995).

Elevated levels of heavy metals in vegetable leaves irrigated with sewage and untreated industrial effluents were observed due to the reason that these waste water effluents some times were rich in heavy metals, thus polluting soil and ultimately our crops and vegetables. Elevated levels of heavy metals in sewage and industrial effluents-irrigated vegetables have been reported by various scientists in Pakistan. Ronaq *et al*. (2005) collected spinach and turnip samples from market and reported that these vegetables were unsafe for eating due to heavy metals pollution. Similarly, Farid (2003) collected samples of spinach, egg plant, okra, bitter gourd and pumpkin from Faisalabad city and reported that these vegetables were unsafe for eating due to heavy metals pollution and Butt *et al*. (2005) observed the same in squash, potato, spinach, turnip, tomato and coriander samples of the same area. Lone *et al*. (2003) revealed the same in sewage irrigated okra and spinach leaves and fruits in Attock area. Zaidi *et al*. (1997) collected vegetables and pulses (caramay, cumin, spices clover, black pepper, coriander, black bean, mung bean) samples from Rawalpindi/ Islamabd markets and reported the same.

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