Heavy metals in soil and vegetables grown with municipal wastewater in Lahore

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Abstract

Heavy metals contamination of fruits and vegetables as a consequence of wastewater irrigation is most important concern today. Present study measures heavy metals concentration (Cr, Cu and Pb) in soil and vegetable samples collected from agriculture area around four major drains of Lahore (Hudia drain, BabuSabu drain, Chota Ravi drain and Kharak drain). Results show that concentration of Cu, Cr and Pb in soil samples were in compliance with WHO and EU standards, with an average of 2.221 ± 1.184, 5.314 ± 1.0511 and 3.864 ± 1.6095 mg/kg respectively. Cu content in vegetables ranged from 0.4-18.9 mg/Kg (average of 4.11 ± 6.639 mg/kg), was within limits while Cr in Lady Finger, from Chota Ravi drain area, was 13.2 mg/Kg which is higher than permissible limit (2.4 mg/Kg). While Pb concentration in vegetables samples varied between 0.7 -8.1 mg/Kg (Mean 2.329 ± 2.592 mg/kg), which was also higher than the standard (0.3 mg/Kg).

Keywords: Heavy metals; Drains; Contamination; Soil; Vegetables

Introduction

Industrial and municipal wastewater application for agricultural produce contaminates soil and crops with heavy metals and subsequently poses risk to humans and animals. According to an estimate about 20 million hectares of land worldwide is utilizing wastewater for irrigation with 10% of the total world’s population being dependent upon wastewater irrigated food (Corcoran et al., 2010). Likewise, in Pakistan increased demand of food, coupled with scarcity of water, has compelled a greater reliance on use of wastewater for agriculture purposes, with only 2% water undergoing some treatment before use in irrigation.

The Lahore district drainage system, comprising eight main and 75 tributary drains, has become ultimate disposal locations for industrial and municipal effluents. Two hundred and seventy one industrial units release an estimated 281.6 cusec untreated effluent into the irrigation canals and drains (IPD, 2008) which is ultimately released into River Ravi, within a stretch of nearly 65 km (WASA, 2007) with the consequence that River Ravi quality has been termed as detrimental for fish and other aquatic life propagation (Akhtar and Mohammad, 2012). Characterization of wastewater samples of drains of Lahore indicates varied concentrations of important parameters of special concern as regards irrigation water quality (Hamid et al., 2013). Earlier, Afzal et al. (2000) has carried out similar study to demonstrate the high pollution levels of Hudia drain. Discharge of untreated industrial effluents without treatment and its subsequent use in agriculture results in contamination of soil and vegetation and cause toxic effects on crops and vegetables imparting major detrimental impacts on human health. A large number of industries discharge heavy metals as a significant part of their effluents and wastes that enter into surface water sources with the consequence that their manifold; these pose severe impacts and persist in the ecosystem for years (Khattak, 2014). Metals like cadmium (Cd), mercury (Hg), cobalt (Co), lead (Pb), copper (Cu), nickel (Ni), chromium (Cr), and zinc (Zn) are recognized as metals of immediate concern (WHO, 2010). Estimates reveal that heavy metal pollution has produced adverse impacts on soil, fruits and vegetable quality and requires utmost attention (Abii and Okorie, 2011; Sobukola et al., 2010; Sharma et al., 2007; Ismail et al., 2011; Khan et al., 2008;
Jimoh et al., 2012; Nazemi, 2012; Perveen et al., 2012; Tasrina et al., 2015; Delbari and Kulkarni, 2013; Najam et al., 2015). Vegetables are an important constituent of diet. Comparison of vegetables, fruits and other grain crops shows that heavy metals are largely accumulated in the edible parts of vegetables (Mapanda et al., 2005). Vegetables absorb and store high quantity of these harmful metals and become source of health problems when ingested by humans and animals (Alam et al., 2003; Sobukola et al., 2010). Elevated concentrations of Cd, Cu, Co and Pb in food stuff are basis of diseases such as bone cancer, high prevalence of upper intestinal cancer, reproductive effects, hypertension and renal failure (Turkdogan et al., 2003). Long term exposure with these toxic elements, even at insignificant levels, causes noxious effects for humans and other living beings. Being nonbiodegradable in nature, persistent in environment and potential bioaccumulation, these metals lead to severe hazards once these enter the bodies of living organisms (Shahid et al., 2015a). Many reports suggest that the continued ingestion of food contaminated with heavy metals can damage liver, nervous, cardiovascular, kidney and/or causing cancers (Jarup, 2003). Extensive evidence of health hazards due to intake of vegetables grown in sewage irrigated water has been reported (Avci, 2012; Ghosh et al., 2012; Wang et al., 2012; Weldegebriel et al., 2012; Xue et al., 2012). Iqbal et al. (2016) carried out a study in Pakistan to assess the concentrations of heavy metals in irrigation water, soil and vegetables, their transfer factors and human health risk. Similar study was conducted by Khan et al. (2013) to evaluate heavy metals in and around Lahore district and analysis revealed that metal concentration were higher when compared with WHO applicable limits. Similarly, Hamid et al. (2016) studied heavy metal contamination of vegetables and soil of Ruhidrain area and their likely health hazards and concluded that Pb Cd, Fe, Cu, Zn and Cr were found in higher concentrations in selected samples.

In view of the present issue of contamination of food, the current study was designed to determine the concentration of selected heavy metals (Cu, Cr, and Pb) in soil and vegetables that were cultivated by using waste water of major drains of Lahore city.

Materials and methods

Sampling locations

Four major drains of Lahore were selected. These included Babu Sabu drain (74.250001667, 31.5205556), Hudiara drain (74.350195278, 31.3835308), Chota Ravi (74.296235, 31.605436) and Kharak drain (74.256196, 31.51328). Soil (top soil TS, subsoil SS) and vegetable samples (being grown there) were collected from each site. Figure 1 (a,b) illustrates the sampling locations.

![Map of the Lahore drainage and study area locations](source)

Fig. 1. (a,b) Map of the Lahore drainage and study area locations

Collection of vegetables and soil samples

Six different vegetable samples, which included bottle gourd (Lagenaria siceraria), spinach (Spinacia oleracea), egg plant (Solanum melongena), lady finger (Abelmoschus esculentus), pilak (locally grown vegetation/ a type of fodder), tomato (Solanum lycopersicum), and soil samples
(top soil and sub soil) were collected from selected drains, following sampling protocols and great care to avoid any kind of contamination (Ramteke et al., 2016). Clean air tight plastic bags were used for the collection of these soil and vegetables samples.

**Soil sample preparation**

100g of each collected soil sample (TS, SS) was first air dried followed by oven drying at 120°C for 3-4 hrs. 10g of each dried soil sample was digested using 50 ml of aqua regia solution. The samples’ solution were heated to boiling and allowed to simmer for 5-6 hr. After cooling, samples were filtered using Whatman 1 filter paper. After washing twice with 5 ml distilled water, the filtrate along with washings was transferred to 50 ml measuring flask. The volume of filtrate was made up to mark (Ramteke et al., 2016) and solutions were analyzed for Cu, Cr and Pb (USEPA Method 3050).

**Vegetable samples preparation**

Six different types of vegetable samples were collected from the fields cultivated with drains’ wastewater. The vegetables were washed with distilled water, air dried and chopped into small pieces. Approximately 80-100g of these chopped air dried vegetable samples were taken in petri dishes and oven-dried at 70°C for 3-4hrs. The dried vegetables were then transferred to beaker and digested with 50 ml of aqua regia solution. The samples’ solution were heated to boiling and allowed to simmer for 1-2 hr followed by filtration using Whatman 1 filter paper. In each case, the filter paper was washed twice with 5 ml distilled water and the filtrate along with washings was transferred to 50 ml measuring flask (Taghipour and Mosaferi, 2013; Ramteke et al., 2016). The volume of filtrate was made up to mark and solutions were analyzed to measure concentrations of Cu, Cr and Pb using atomic absorption spectrophotometer (Buck Model 210 VGP).

**Results and discussion**

The average results of metal analysis of soil and vegetable samples are given in Tables I and II respectively. Statistical analysis (maximum, minimum, mean value and standard deviation) for heavy metals concentration in vegetables and soil samples was also calculated (Table III).

A total of 7 (TS and SS) samples were analyzed and found to be within the limits (Table I). It is obvious that the concentration of Cu, Cr and Pb were meeting European Union and WHO’s allowed concentrations for metals in soil. This is similar to other studies carried out at Rawalpindi and Peshawar in which heavy metal concentration in soil was also

**Table I. Heavy metals concentration in soil samples**

| Area               | Soil Sample | Cu mg/Kg | Cr mg/Kg | Pb mg/Kg |
|--------------------|-------------|----------|----------|----------|
| BabuSabu Drain     | TS          | 2.3      | 4.6      | 4.9      |
|                    | SS          | 4.8      | 6.7      | 6.9      |
| Hudiara Drain      | TS          | 1.95     | 6        | 1.95     |
|                    | SS          | 1.3      | 5.6      | 3.4      |
| Chota Ravi Drain   | SS          | 1.5      | 4.3      | 3.4      |
|                    | TS          | 2.0      | 6.1      | 2.8      |
| Kharak Drain       | TS          | 1.7      | 3.9      | 3.7      |
| Safe Limits        | *140        | *150     | *300     |

TS= top soil, SS =sub soil
*EU (2002), **WHO (2006)

**Table II. Heavy metals concentration in vegetables grown by using irrigation water of drains and their comparison with WHO/FAO standards**

| Area             | Sample No. | Vegetable Sample | Cu mg/Kg | Cr mg/Kg | Pb mg/Kg |
|------------------|------------|------------------|----------|----------|----------|
| BabuSabu Drain   | 1          | Spinach          | 0.6      | 0.6      | 1.0      |
|                  | 2          | Egg plant        | 1.2      | 1.2      | 1.6      |
|                  | 3          | Bottle gourd     | 0.4      | 1.7      | 1.0      |
| Hudiara Drain    | 4          | Tomato           | 1.3      | 1.4      | 0.7      |
| Chota Ravi Drain | 5          | Lady finger      | 4.1      | 13.2     | 8.1      |
| Kharak Drain     | 6          | Lady finger      | 2.3      | 1.7      | 1.9      |
|                  | 7          | Pilak            | 18.9     | 0.8      | 2.0      |

*WHO/FAO, **EU standards

* WHO/FAO (2007), **EU (2006)

found to be within safe limits (Latif et al., 2008; Perveen et al., 2012). Lahore soil samples in another study (Khan et al., 2013) showed Cu and Pb concentrations in soil in the range of 1.06-5.42 mg/kg and 2.11-36.88 mg/kg respectively. Although concentrations of Cu, Cr and Pb were below the
Four major drains of Lahore were selected. These included selected heavy metals (Cu, Cr, and Pb) in soil and vegetables. The current study was designed to determine the concentration of these metals. In view of the present issue of contamination of food, the analysis revealed that metal concentration were higher when assessing heavy metals in and around Lahore district and to evaluate heavy metals in irrigation water, and leafy parts of vegetables respectively, with 83% vegetable samples (edible part) contaminated with Pb content higher than EU (2006) limits. The results of present study are also consistent with earlier study by Hamid et al. (2016) which also reported Cu, Cr and Pb at compliance levels in soil samples while elevated concentration were detected in selected vegetables.

From the results of vegetable samples analysis (Table II), it is observed that concentration of Cu ranged from 0.4 - 18.9 mg/Kg with Mean ± SD value 4.11 ± 6.639mg/ kg which was within safe limit (40 mg/Kg) of EU (2006), in all vegetables samples. Chromium concentration in vegetables ranged from 0.6 - 13.2 mg/Kg (Average 2.943 ± 4.542 mg/kg) and was exceeding the permissible levels given by WHO/FAO and EU (2.3 mg/kg). The maximum chromium content (13.2 mg/Kg) was found in lady finger plant grown at Chota Ravi drain area; other plants such as eggplant, tomato, spinach and pilak also had trace amounts of metals but very high level of chromium in lady finger would be due to absorption capacity and ability of the plant. Chromium absorbs rapidly in soil but retain there for short interval because it goes to the other medium such as plants. Oliveira (2012) reported that the level of heavy metal concentration vary with parts of the plant as most of the plants have higher quantity of heavy metals in roots and stems; however their quantity lowers down in the leaves. Many studies in Pakistan have reported Cr in soil in permissible range of 100-150 mg/Kg with global mean soil concentration of 60 mg/Kg (Waseem et al., 2014).While vegetables grown on soils irrigated with drain water showed Cr concentration above the tolerable ranges (Perveen et al., 2012).

According to the results, Pb in vegetables samples varied between 0.7 - 8.1 mg/kg with mean 2.329 ± 2.592 mg/kg. Lead levels in vegetables were also not in compliance with WHO/FAO and EU limits (0.05-0.3mg/Kg). This is in agreement with other study (Khan et al., 2010) which reports Pb levels in vegetables in Gilgit, Pakistan in the range of 0.03-44 mg/Kg. Similarly, Farooq et al. (2008) also reports Pb concentration as 27.49 mg/kg and 15.58 mg/kg in edible and leafy parts of vegetables respectively, with Pb content higher than EU (2006) limits.

The results of present study are also consistent with earlier study by Hamid et al. (2016) which also reported Cu, Cr and Pb at compliance levels in soil samples while elevated concentration were detected in selected vegetables.

Based on current study results, the trends of Pb in selected vegetables are as follows:

\[
\text{Cu} = \text{Pilak} > \text{Ladyfinger} > \text{Tomato} > \text{Eggplant} > \text{Spinach} > \text{Bottle gourd} \\
\text{Cr} = \text{Ladyfinger} > \text{Bottle gourd} > \text{Tomato} > \text{Eggplant} > \text{Pilak} > \text{Spinach} \\
\text{Pb} = \text{Ladyfinger} > \text{Pilak} > \text{egg plant} > \text{Bottle gourd} = \text{Spinach} > \text{Tomato}
\]

**Conclusion**

It can be concluded that vegetables grown along four major drains are contaminated with metals i.e. Cu, Cr and Pb in varying amounts. In soil samples Cu, Cr and Pb are detected but their concentration are within applicable permissible limits whereas concentration of Cr and Pb is high in vegetables samples. Application of wastewater for irrigation has the potential to accumulate high level of heavy metals in human due to consumption of these vegetables.

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Six different vegetable samples, which included bottle (Solanum lycopersicum), tomato (Solanum lycopersicum), lady finger (Spinacia oleracea), bitter melon (Lagenaria siceraria) and eggplant (Solanum melongena). 

Collection of vegetables and soil samples was also calculated (Table III).

Six different types of vegetable samples were collected from drains (top soil and sub soil) were collected from selected drains, there) were collected from each site. Figure 1 (a,b) illustrates the sampling locations.

Heavy metals goes to plants without retaining in soil (top soil TS, subsoil SS) and vegetable samples (being grown to absorption capacity and ability of the plant. Chromium Pb levels in vegetables in Gilgit, Pakistan in the range of 0.6 - 13.2 mg/Kg (Average 2.943 + 4.542 mg/Kg).

It can be concluded that vegetables grown along four major drains are contaminated with metals i.e. Cu, Cr and Pb in the fields cultivated with drains' wastewater. The results of present study are also consistent with earlier studies by Hamid et al., 2013), Heavy metal status of soil and vegetables contaminated with Municipal Wastewater: A Case Study of Faisalabad, Journal of Environmental and Agricultural Sciences 4: 6-10.

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