Arabian Journal of Chemistry (2014) 7, 91–99

King Saud University

Arabian Journal of Chemistry

www.ksu.edu.sa
www.sciencedirect.com

SPECIAL ISSUE: ENVIRONMENTAL CHEMISTRY

Human health risk assessment of heavy metals via consumption of contaminated vegetables collected from different irrigation sources in Lahore, Pakistan

Adeel Mahmood [a,*], **Riffat Naseem Malik** [b]

[a] *Environmental Biology and Ecotoxicology Laboratory, Department of Plant Sciences, Faculty of Biological Sciences, Quaid-I-Azam University, PO 45320, Islamabad, Pakistan*
[b] *Environmental Biology and Ecotoxicology Laboratory, Department of Environmental Sciences, Faculty of Biological Sciences, Quaid-I-Azam University, PO 45320, Islamabad, Pakistan*

Received 1 March 2013; accepted 4 July 2013
Available online 12 July 2013

KEYWORDS

Risk assessment;
Human health;
Metal accumulation;
Vegetables;
Lahore;
Daily intake of metals

Abstract Soil pollution with heavy metals due to discharge of untreated urban and industrial wastewater is a major threat to ecological integrity and human well-being. The presenting study aimed to determine human health risks associated via food chain contamination of heavy metals routing from irrigation of urban and industrial wastewater. Irrigated water, soil and vegetables were analyzed for Cr^{2+}, Co^{2+}, Ni^{2+}, Cu^{2+}, Pb^{2+}, Cd^{2+}, Mn^{2+} and Zn^{2+}; transfer factor (TF), daily intake of metals (DIM) and health risk index (HRI) were also calculated. Cr^{2+}, Pb^{2+} and Cd^{2+} in vegetables cultivated by wastewater exceeded the permissible limits (European Union, 2002) while TF was lower for all metals except Co^{2+} and HRI was found to be maximum for *Spinacia oleracea* (2.42 mg/kg) and *Brassica campestris* (2.22 mg/kg) cultivated by wastewater. *S. oleracea*, *B. campestris*, *Coriandrum sativum* posed a severe health risk with respect to Cd and Mn.

1. Introduction

World's urban communities are increasing faster than global population as the urbanization progresses in the least-developed regions (UN-HABITAT, 2004). Urban development caused momentous alteration to the environment by increasing the waste material accumulation through anthropogenic activities (Chen, 2007). Urban expansion is promoting a concern for farmers to use contaminated land for food crop's production (Nabulo, 2009). In urban and peri urban areas, land contamination with toxic metals is common as a result of industrial and municipal activity. Wastewater irrigation to increase the yield of food crops (vegetables) is the principal source of contamination in urban agricultural lands (Qadir et al., 2000). These effluents are rich in toxic metals and are a chief contributor to metals loading in waste irrigated and amended soils (Singh et al., 2004; Mapanda et al., 2005).

* Corresponding author. Tel.: +92 333 5805776.
E-mail address: adilqau5@gmail.com (A. Mahmood).

Peer review under responsibility of King Saud University.

ELSEVIER Production and hosting by Elsevier

1878-5352 © 2013 Production and hosting by Elsevier B.V. on behalf of King Saud University.
http://dx.doi.org/10.1016/j.arabjc.2013.07.002

Soil contaminated with metals is a primary route of toxic element exposure to humans. Toxic metals can enter the human body by consumption of contaminated food crops, water or inhalation of dust (Cambra et al., 1999). It has been estimated that more than 70% of dietary intake of cadmium is contributed via food chain (Wagner, 1993). Vegetables grown on contaminated land may accumulate toxic metals. Prolonged consumption of contaminated foodstuff may lead to the unceasing accumulation of toxic metals in the liver and kidney of humans resulting in the disturbance of biochemical processes, such as, liver, kidney, cardiovascular, nervous and bone disorders (WHO, 1992; Jarup, 2003).

Health risk assessment of heavy metals in contaminated vegetables is being carried out in developed countries (Milacic and Kralj, 2003); however, little is explored in developing countries (Lock and de Zeeuw, 2001). In Pakistan very few published data on heavy metal contamination in vegetables is available (Jan et al., 2010; Khan et al., 2010; Jamali et al., 2009; Akbar et al., 2009). Environmental abetment practice is almost missing due to the lack of environmental management and un-operational environmental pollution laws.

Wastewater irrigation is a common practice in urban and peri-urban areas of district Lahore. Lahore is the capital of Punjab province, Pakistan and is lying along 31.34° N and 74.22° E. The total area of Lahore district is 1772 km^2 and it is 217 m above sea level. The business mart of Pakistan, Lahore is a well suited site for industries. There are various types of industries situated in and around the city. In Lahore metropolitan area 1121 unplanned industries are sited, which include 642 steel re-rolling factories and foundries discharging iron scrap, lead, cadmium and hazardous chemicals, 36 textile industries and 295 other industries like leather tanneries, electroplating miles, pigment factories, etc. (Saleemi, 1990). These industries discharge their wastewater containing various types of hazardous chemicals and toxic metals in the twelve drainages of the city managed by Water and Sanitation authority (WASA). After receiving a huge flux of wastewater and municipal wastes these drainages pass from urban area to sub urban areas and drain into the river Ravi. Cultivation of vegetables with the industrial and sewage effluents of these drains is a common practice in the coinciding agricultural land along the 35 km stretch between the Lahore ring road and the river Ravi. Local farmers across these drainages use surface wastewater to irrigate their agricultural fields for cultivation of vegetables. A large quantity of various vegetables is sold in the supply market of the city. It has been reported that serious health problems can develop as a result of accumulation of dietary heavy metal uptake through food crops irrigated with contaminated wastewater (Saleemi, 1990). Thereby, this study was conducted to assess the heavy metal concentration in soils, resulted uptake by the vegetables and eminent transfer to the food chain which assist in evaluating the related health hazards linked with it.

2. Material and methods

2.1. Site description

Agricultural land to the north and east of Lahore city along river Ravi and Jallo town was selected as the study area (Fig. 1). Two main zones were selected on the basis of industrial wastewater irrigation and ground water irrigation. Ground water from deep bore well is used for irrigation at the ground water irrigated zone, designated as GWZ and it is located near the Wagha (north east of city) and Jallo (east of the city), whereas wastewater from urban drains was used for irrigation at the wastewater irrigated zone; designated as WWZ and it is located between the Lahore Ring Road and the river Ravi along the stretch of 35 km. Each zone was further subdivided into five sites.

2.2. Water sampling

Water samples that were used for irrigation practices were collected from each site in pre cleaned high-density polyethylene bottles. These bottles were rinsed earlier with a metal-free soap and then soaked in 10% HNO_3 overnight, and finally washed with deionized water (Chary et al., 2008). Samples were brought to the Ecotoxicology and Environmental biology laboratory, Quaid-I-Azam University, Islamabad, Pakistan and stored at 4 °C.

2.3. Soil sampling

Soil from agricultural land was collected by digging a monolith of $10 \times 10 \times 15$ size by using a plastic scooper. Non soil particles e.g. stones, wooden pieces, rocks, gravels, organic debris were removed from soil. Soil was oven dried and this dried soil was sieved through a 2 mm sieve and stored in the labeled polythene sampling bags (Lei et al., 2008).

2.4. Plant sampling

A diversity of vegetables are grown in the study area; *Solanum tuberosum* L., *Brassica oleracea capitata*, *Brassica oleracea*, *Brassica campestris* L., *Brassica rapa* L., *Raphanus sativus* L., *Spinacia oleracea* L., *Beta vulgaris* L., *Allium sativum* L., *Daucus carota* L., *Coriandrum sativum* L. were collected from each site of the sampling zone in 3–5 replicates and stored in labeled polythene sampling bags and brought to the Ecotoxicology and Environmental biology laboratory, Quaid-I-Azam University, Islamabad, Pakistan, where they were harvested in edible and non-edible parts, finally washed with tap water to remove any kind of deposition like soil particles. Edible parts of vegetables were then oven dried and ground into powdered form for making the plant digests (Jamali et al., 2009). A complete description of vegetables collected from the study area is given in Table 1.

2.5. Digestion of samples

1 g soil and vegetable samples were digested by 15 ml tri acid mixture i.e. HNO_3, $HClO_4{\cdot}H_2SO_4$ at 5:1:1 ratio at 100 °C until the transparent solution appeared. Water samples were filtered through Whatman No. 42 filter papers and 50 ml of filtrate was stored at 4 °C after adjusting it at pH 2. To determine the suspended metals filter paper was cut into small pieces, digested in HNO_3 and HCl in 3:1 ratio at 180 °C for 15 min (USEPA Method: 3005A). Volume of each digest was adjusted to 50 ml by adding distilled water and stored for further analysis.