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Human health risk from Heavy metal *via* food crops consumption with wastewater irrigation practices in Pakistan

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HIGHLIGHTS

- Greater Cd, Cr, Ni, Mn, Pb recorded in wastewater irrigated soils and food crops.
- Cd in soil; Pb, Cd, Cr in irrigated water and food crops surpassed permissible limit.
- Wastewater irrigation for food crops is a potential threat to human health.
- Health risk index >1 for Pb, Cd and Mn in food crops cause potential health risk.

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ABSTRACT

The current study was designed to investigate the potential human health risks associated with consumption of food crops contaminated with toxic heavy metals. Cadmium (Cd) concentration in surface soils; Cd, lead (Pb) and chromium (Cr) in the irrigation water and food crops were above permissible limits. The accumulation factor (AF) was >1 for manganese (Mn) and Pb in different food crops. The Health Risk Index (HRI) was >1 for Pb in all food crops irrigated with wastewater and tube well water. HRI >1 was also recorded for Cd in all selected vegetables; and for Mn in *Spinacia oleracea* irrigated with wastewater. All wastewater irrigated samples (soil and food crops) exhibited high relative contamination level as compared to samples irrigated with tube well water. Our results emphasized the need for pretreatment of wastewater and routine monitoring in order to avoid contamination of food crops from the wastewater irrigation system.

1. Introduction

Rapid urbanization and industrialization in 20th century has dramatically increased the discharge of large amount of wastewater accompanied with toxic chemicals. Wastewater finds its way to water channels that are further used for irrigation purposes due to presence of organic matter and nutrients deposition. In contrast, wastewater is a rich source of various toxic metals (Ping et al., 2011). Heavy metals finally become the part of wastewater that originates from various natural (weathering and erosion of bed rock material and ore deposits) and anthropogenic (industrial processes, mining, agricultural practices and waste disposal) activities, atmospheric deposition and emissions related with traffic transported with rain/storm water (Karvelas et al., 2003; khan et al., 2008). Its continuous practice in agricultural lands may cause contamination and adversely affect the safety of the food crops produced (Hua et al., 2013). Wastewater irrigation to food crops is the most familiar practice in the urban, suburban and agricultural areas worldwide, which has gained importance nowadays in water scanty areas. It is posing risk to human via food crops consumption, if it is used for irrigation without prior treatment.

Food crops composed of carbohydrates, minerals, proteins, vitamins and essential metals (macro and micro nutrients) make important components of diet (Khan et al., 2008). Food consumption contaminated with heavy metals is a major contributor pathway (more than 90%) to human exposure than any other pathways such as inhalation and dermal contact (Loutfy et al., 2006). Heavy metal contamination is a known causative of various disorders such as genomic instability, endocrine disruption, neurotoxicity, carcinogenicity, immunological problems and also impaired psycho-social behavior (Dyer, 2007). Heavy metals such as Cd and Pb may cause mutagenesis, teratogenesis and carcinogenesis; high Cd and Pb concentrations in food crops were attributed to prevalence of upper gastrointestinal cancer (Jarup, 2003; Turkdogan et al., 2003). Besides these, Pb is also responsible for elevated blood pressure, renal and tumor infection, improper haemoglobin synthesis and reproductive system. Manganese is accountable for Parkinson's disease as a result of iron oxide deposition (Harmanescu et al., 2011). At high concentration Ni can cause cancer, fatigue, headache, skin rashes, dizziness,

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heart problems and respiratory illness. Dietary Cr intakes studied in different countries were assumed to be directly correlated with breast cancer mortalities (Pasha et al., 2010).

The current study area consists of industrial cities of Sialkot and Wazirabad (Pakistan) known worldwide for their tanneries, pharmaceuticals, surgical, sports and cutlery industries. Nullah Aik and Palkhu streams in these areas receive untreated industrial effluents, urban and domestic sewage, municipal wastes and agricultural runoff. These streams have been categorized among the most polluted streams of Pakistan. The aquatic ecosystem is highly stressed due to release of untreated industrial and urban effluents. It has been predicted that in near future these streams will lose their aquatic integrity if no restoration practices are initiated (Qadir et al., 2008). Agricultural land in a suburb of the aforementioned cities is irrigated with wastewater from these streams and tube well water.

Information about heavy metal accumulation in food crops and their dietary intake is necessary for assessing their risk to human health. Therefore, it is of prime concern to assess the accumulation of toxic heavy metal in food crops, which are irrigated with water diverted from polluted streams (Nullah Aik and Palkhu). Information is lacking on the heavy metal uptake, bioaccumulation, and health risks in terms of wastewater irrigation in Sialkot and Wazirabad. Therefore, the current study aims to quantify heavy metal accumulation in water, soil and subsequent contamination in food crops irrigated with wastewater and tube well water with potential human health risks.

2. Materials and methods

2.1. Sampling strategy and digestion procedure

The study was conducted in the industrial cities of Sialkot and Wazirabad, located between 32°24′N–32°37′N latitude and 73°59′E and 75°20′E longitude in the east of Pakistan and 32°27′0″N and 74°7′0″E of Punjab, respectively. The study area is divided into two main irrigation zones, i.e. wastewater and tube well water. Nullah Aik and Palkhu are the most polluted streams used for irrigation purposes of agricultural land in this area. Total of four sampling sites of wastewater ($n = 2$ sites from each study area, Nullah Aik and Palkhu) and four tube well water sites in the vicinity of the same area ($n = 2$ sites from each study area) were selected for collection of soil, water and food crops samples (Fig. 1).

Water and soil samples were collected in triplicate from each study area. Total of 24 samples of water ($n = 12$ each for wastewater and tube well water) and 24 soil samples (12 each for wastewater and tube well water irrigated soil) were collected randomly from surface soil (0–20 cm). Water samples were preserved in pre-rinsed plastic bottles with 10% solution of HNO_3 and placed at 4 °C for further process. Air dried soil samples were grounded into fine powder, passed through 2 mm mesh sieve and stored in polythene bags till further analysis.

Twelve food crops species (*Coriandrum sativum* L. (Coriander), *Allium cepa* L. (Onion), *Abelmoschus esculentus* L. (Okra), *Allium sativum* L. (Garlic), *Capsicum annum* L. (Capsicum), *Daucus carota* L. (Carrot), *Solanum melongena* L. (Brinjal), *Spinacia oleracea* L. (Spinach), *Raphanus sativus* L. (Radish), *Mentha spicata* L. (Mint), *Lycopersicum esculentum* L. (Tomato) and *Triticum aestivum* L. (Wheat)) irrigated with wastewater (Nullah Aik and Palkhu) and tube well water in the same vicinity were collected from agricultural field in Sialkot and Wazirabad. A total of eight sites (four sites each of wastewaters and tube well water) were selected for random sampling. All the collected food crops sample were sectioned into edible and non-edible parts. The edible parts were washed with deionized distilled water to remove all observable dust particles, and blotted with tissue paper. The edible portion was dried in oven for 24 h at 70–80 °C, ground into fine powder, sieved through

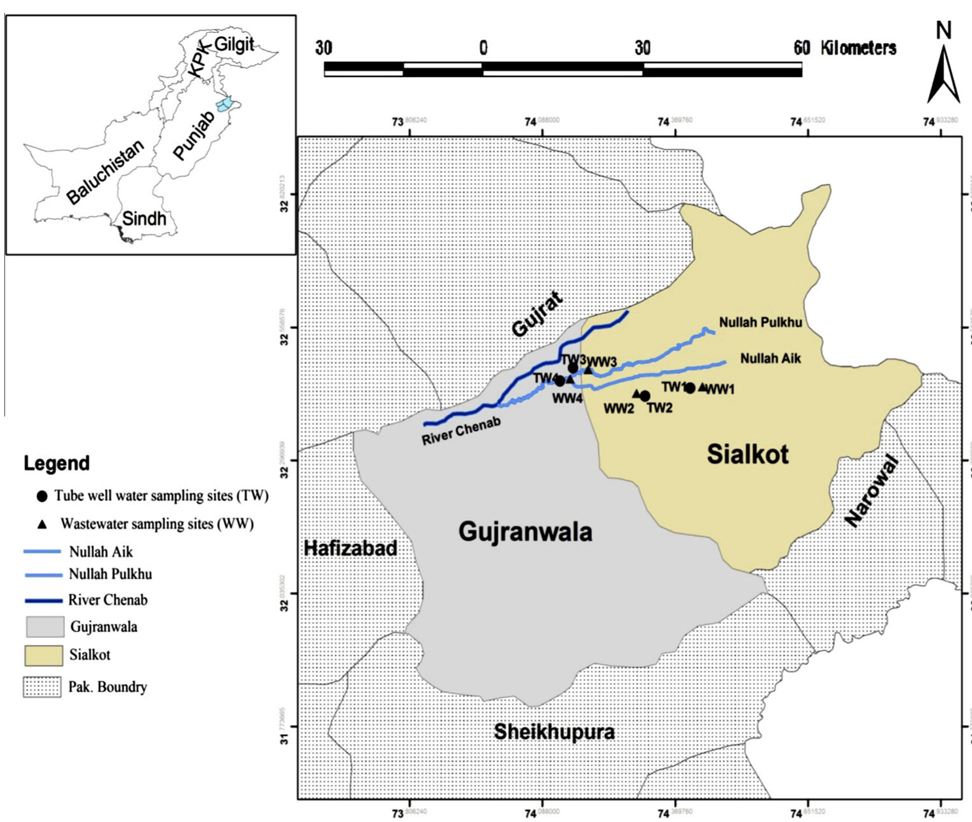

Fig. 1. Map of the study area showing sampling sites irrigated with wastewater and tube well water.