

Research Article

Contamination Level of Chromium, Iron, Nickel, Lead and Cobalt in Soil from an Agricultural area of Urmar Bala, Peshawar Pakistan

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Abstract | The contamination level of Chromium (Cr), Iron (Fe), Nickel (Ni), Lead (Pb) and Cobalt (Co) was evaluated in the soil samples of agricultural area of the Urmar Bala, district Peshawar, Khyber Pakhtunkhwa, Pakistan. To solubilize the targeted metals from selected soil samples, a wet digestion procedure was adopted. The targeted metals in selected soil samples were in the ranges of: 1.37-2.00, 28.91-29.50, 1.62-1.82, 1.22-1.179 and 0.07-0.112 mg/kg for Cr, Fe, Ni, Pb and Co, respectively. Increasing order of these heavy metals in soil samples were found as: Plum's farm soil Co < Cr < Ni < Pb < Fe, Peach's farm soil as Co < Cr < Pb < Ni < Fe, Tomato's farm soil as Co < Pb < Cr < Ni < Fe, soil of the ridge gourd farm as Co < Pb < Cr = Ni < Fe, soil of the lady fingers farm as Co < Pb < Ni < Cr < Fe while soil of the wheat farm was found in the order of Co < Cr < Pb < Ni < Fe. The concentration of Fe in all soil sample was found in the maximum ranges while those of Co in the minimum ranges.

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1. Introduction

The pollution of our adjacent environment with heavy metals is becoming a big monster in many regions of the world especially industrial zones, metropolises and modern agricultural centres due to their non-biodegradable nature, toxicity, bioaccumulation and subsequent bio-magnifications (Rahim and Mas Haris, 2019; Huihui *et al.*, 2020). Any metallic element having a density greater than 5 g/cm³ is referred to as a heavy metal. Rapid industrialization, anthropogenic lifestyle and the wide use of man-made chemicals are the major sources of metal toxicity in environment (do Carmo Ramos *et al.*, 2016; Rahim *et al.*, 2016). Elements such as Fe,

Zn, Mn, Cu, Co and Ni play a crucial role in the normal growth and some vital functions of living organisms if present in trace amount as micronutrients, however, becomes a matter of concern if exceed their permissible levels (Rahim *et al.*, 2014; Zhang *et al.*, 2020; Ilieva *et al.*, 2020). Such metals become severely toxic beyond the threshold levels and can lead to various problems due to over-doses. Another list of metals including Pb, As, Cd, Cr and Hg also find their way into the surrounding environment through various anthropogenic activities and finally seep into living tissues through food chain (Ahmad *et al.*, 2014; Krishna and Mohan, 2014). Such metals are of great concern for humanity since their long time exposure causes acute toxicities.

Soil constitutes an essential component of mother nature for life. The minerals and organic materials constituting the soil play a vital role in plant growth and other developmental activities (Ahluwalia and Goyal, 2007; Nwaogu *et al.*, 2014). Heavy metals occur in soil naturally because of geological processes like erosion of underground materials (Chishti *et al.*, 2011). Soil may also have contaminated by heavy metals through effluents from rapidly expanding industrial zones, leaded gasoline and paints, spillage of crude oils, disposal of municipal wastes having high metal contents and modern farming practices such as extensive application of inorganic fertilizers, animal manures and pesticides for greater agricultural outputs (Irmak *et al.*, 2008; Liu *et al.*, 2020). Pollution of agricultural soil with heavy metals have far reaching consequences for the vegetables and crops grown on such soil in two ways, firstly in relation to the very growth and secondly in relation to their consumption as food (Arif *et al.*, 2020; Kim *et al.*, 2020). From the soil through food chain, heavy metals may accumulate in living bodies including humans and their excess in hosts may become ultimately toxic (Rahim *et al.*, 2016; Rahim and Mas Haris, 2019; Khan *et al.*, 2020; Saqib *et al.*, 2020). The exposure of humans and higher animals to various heavy metals for longer duration may ultimately leads to mental lapse, kidney failure, gastrointestinal colic, lung cancer and central nervous system disorder (Rahim *et al.*, 2016). The present study provides a base-line data for the levels of five metals in targeted soil samples in relation to human health.

2. Materials and Methods

2.1 Study area

The current study was conducted in Urmar Bala of district Peshawar, Khyber Pakhtunkhwa, Pakistan. Geographical coordinates of this area are: 33° 57' 0" North, and 71° 41' 0" East. It is a popular agricultural area and many vegetables and fruits are grown here which are consumed locally and marketed other parts of the region. Google map of the study area is shown in Figure 1.

2.2 Chemicals and instruments

Hydrochloric Acid (35-38 % Purity), Nitric Acid (65-68 % Purity), Water (Double Distilled), Polyethylene Containers for sampling, Atomic Absorption Spectrometer (AAS), model AAS 700, Perkin Elmer, USA.



Figure 1: Google map of the study area.

2.3 Collection of soil samples and pretreatment

Soil samples for cultivation of selected fruits and vegetables were obtained from various farm houses in Urmar Bala, district Peshawar in summer 2019. Soil samples weighing approximately 1 kg each were taken with the help of soil auger from the upper layer at a depth of 0-15 cm for each targeted location. Each soil sample was labelled on the spot and coordinates were inscribed on it. The samples were then shifted to the chemistry lab. of Government College Peshawar for experimental work. Each soil sample was air dried and then grinded with porcelain Mortar and Pestle. The grinded materials were passed through 0.5 mm sieve and then stored in good quality clear Polythene bags for further analysis. The flowchart diagram is shown in Figure 2.

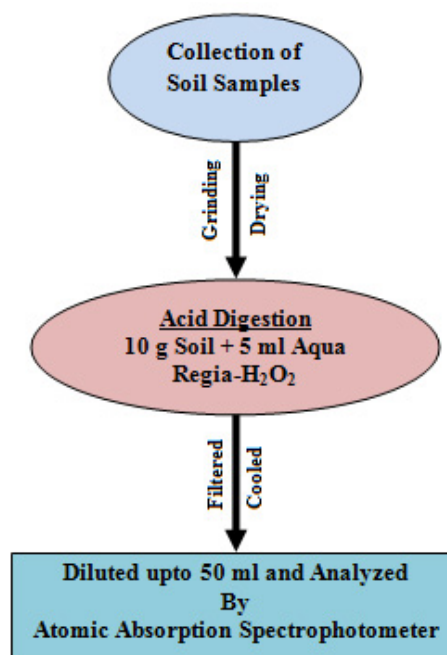


Figure 2: Flowchart of the experimental work.

Table 1: Average concentration (mg/kg) of Cr, Fe, Ni, Pb and Co in the soil of selected agricultural farms.

Sampling site	Selected heavy metals				
	Cr	Fe	Ni	Pb	Co
Plum farm soil	1.47±0.002	295.01±3.782	1.69±0.030	1.79±0.000	0.49±0.006
Peach farm soil	1.52±0.014	294.00±5.720	1.82±0.033	1.56±0.025	0.07±0.001
Tomato farm soil	1.42±0.007	294.11±11.092	1.73±0.000	1.22±0.000	0.49±0.000
Ridge gourd farm soil	1.62±0.025	291.73±0.382	1.62±0.000	1.17±0.009	0.60±0.002
Lady fingers farm soil	2.00±0.040	290.20±1.094	1.63±0.007	1.49±0.045	0.47±0.000
Wheat farm soil	1.37±0.008	289.09±0.555	1.64±0.018	1.57±0.003	1.12±0.017
FAO/WHO (Safe limit)	100	50000	50	100	50

2.4 Digestion of soil samples

Wet digestion procedure was adopted for solubilizing the targeted metals from selected soil samples. In this method, 10 g each of the already processed soil sample was accurately weighed and taken turn by turn into the digestion tube. 5 ml Aqua regia (3:1 of HCl and HNO₃) and 1.6 ml H₂O₂ were poured into the digestive tube. The digestion tube was kept in furnace for 150 minutes to facilitate the solubility of metals in Aqua regia-H₂O₂ solution. The process was repeated for all soil samples. After completion of digestion process, samples were cooled and filtered. The filtrate of all soil samples were then diluted to 50 mL by adding distilled water and analyzed by Atomic Absorption Spectrophotometer (AAS 700, Perkin Elmer, USA) installed at Centralized Resource Laboratory (CRL), University of Peshawar, Pakistan.

3. Result and Discussion

The average concentrations of the selected heavy metals, Cr, Fe, Ni, Pb and Co in targeted soil samples along with the WHO/FAO maximum permissible limits are shown in Table 1.

3.1 Chromium

Chromium plays an important role in several metabolic activities of humans including those of cholesterol, fat and glucose at optimum levels of presence. Its deficiency in the body is responsible for several disorders such as hyperglycemia, elevation in boy fats levels and a lower sperm count rate. However, at higher concentration levels, it becomes toxic and carcinogenic (Rahim *et al.*, 2014, 2016). Chromium concentration in soil samples was ranged from 1.37 to 2 mg/kg as shown in Figure 3. Highest concentration in the range of 2 mg/kg for chromium was found in the soil of Lady Fingers farm, while lowest level of 1.37 mg/kg observed for wheat farm soil. Level of

chromium in all soil samples is in the order: wheat farm soil < tomato farm soil < plum farm soil < peach farm soil < ridge gourd farm soil < lady fingers farm soil.

3.2 Iron

Iron is an essential element needed by all plants and animals for their diverse metabolic activities. It takes part in DNA synthesis as well as free electrons and oxygen transport to various body parts. However, the presence of iron in human body at higher levels is associated with several disorders including tissues damage and anemia (Rahim *et al.*, 2016). Iron concentration in the current study was found in the range of 289.1 to 295.0 mg/kg and projected graphically in Figure 4. Its highest concentration of 295.0 mg/kg was observed for plum farm soil while lowest (289.1mg/kg) in wheat farm soil. The increasing order of iron in soil samples is: wheat farm soil < lady fingers farm soil < ridge gourd farm soil < peach farm soil < tomato farm soil < plum farm soil.

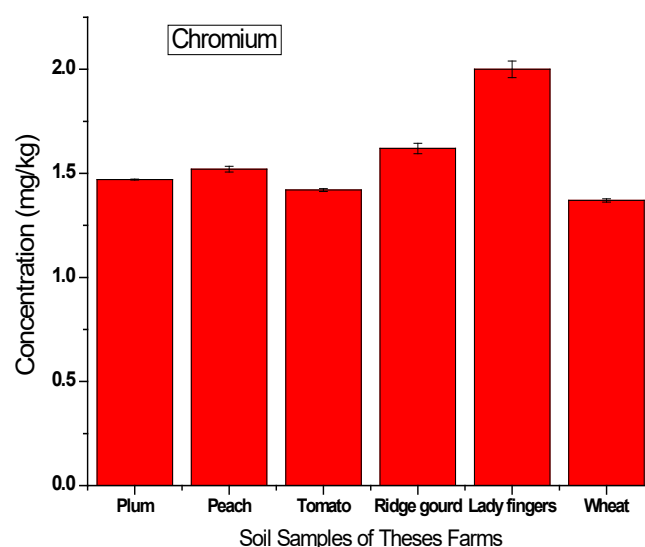


Figure 3: Concentration (mg/kg) of chromium in the soil of selected farms.

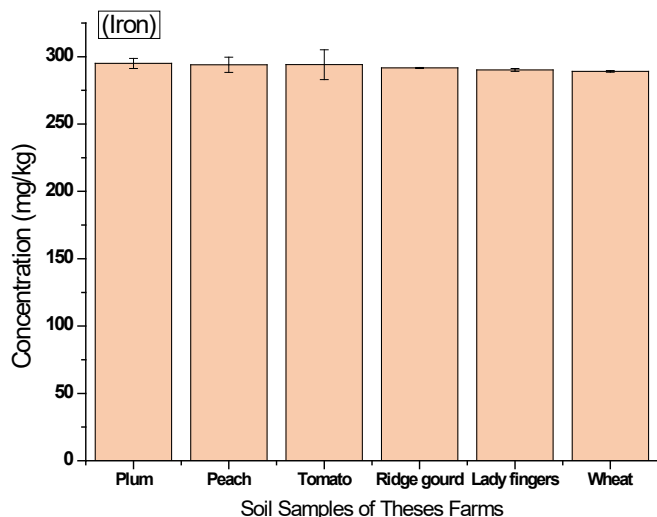


Figure 4: Concentration (mg/kg) of iron in the soil of selected farms.

3.3 Nickel

Nickel is an important metal required by human body for lipid regulation inside tissues and production of haematids. However its presence in the body beyond permissible levels can lead to several ailments such as loss in body weight, loss of eye sight, failure of heart liver dysfunction and irritation of skin (Poonkothai and Vijayavathi, 2012). Nickel concentrations in current study were observed in the range of 1.62 to 1.82 mg/kg. Comparison of various soil sample reveals that the level of nickel (1.83 mg/kg) is highest for peach farm soil while lowest (1.62 mg/kg) for ridge gourd farm soil as graphically displayed in Figure 5. The increasing order of nickel in soil samples is: ridge gourd farm soil < lady fingers farm soil < wheat farm soil < plum farm soil < tomato farm soil < peach farm soil.

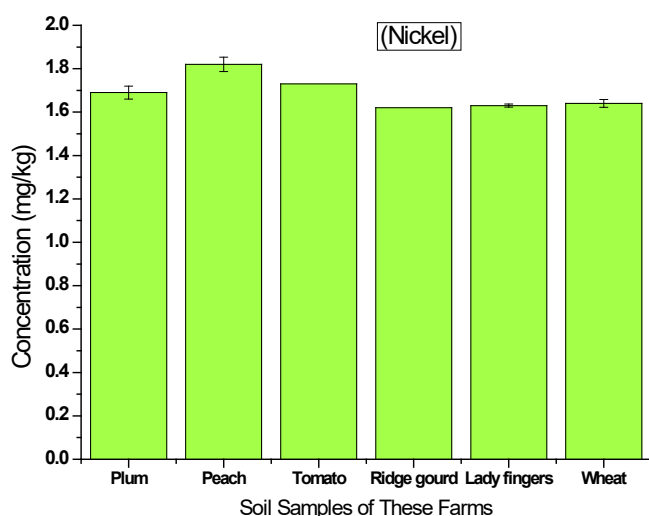


Figure 5: Concentration (mg/kg) of nickel in the soil of selected farms.

3.4 Lead

Lead is non-essential heavy metal and its accumulation in body at an elevated level and can cause headache, anaemia, damage of brain and central nervous system (Nas and Ali, 2018). Lead contents in present investigation were found in the range of 1.17 to 1.79 mg/kg. The concentrations of lead in various soil samples are: ridge gourd farm soil is 1.17 mg/kg, tomato farm soil, 1.22 mg/kg; lady fingers farm soil, 1.49 mg/kg; peach farm soil, 1.56 mg/kg; wheat farm soil, 1.57 mg/kg while that in plum farm soil is 1.79 mg/kg. The highest concentration of lead was reported for plum farm soil while lowest for tomato farm soil. The average concentrations are shown in Figure 6.

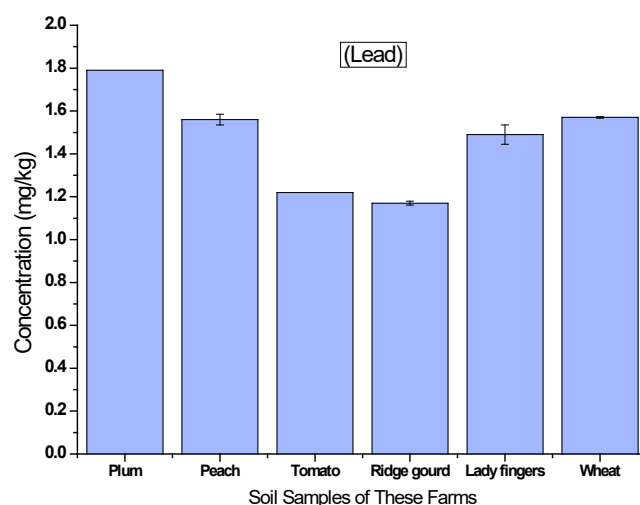


Figure 6: Concentration (mg/kg) of lead in the soil of selected farms.

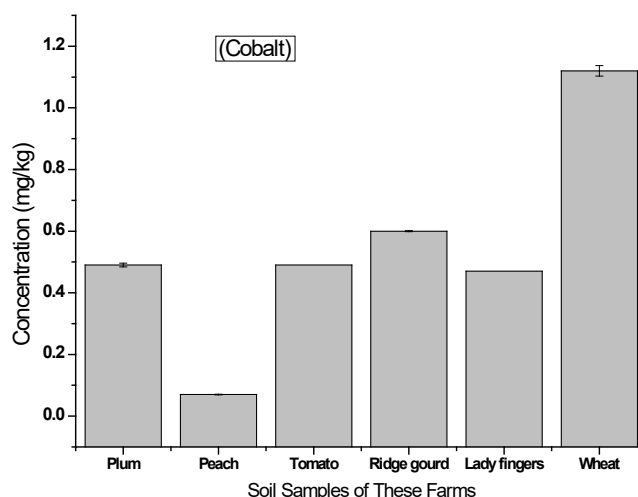


Figure 7: Concentration (mg/kg) of cobalt in the soil of selected farms.

3.5 Cobalt

Cobalt is useful to human for its utility in production

of Cobalamine (vitamin B₁₂), however at high levels, cobalt is responsible for dermatitis, lungs and heart diseases (Gavrilenko *et al.*, 2015). In the present study, cobalt concentrations in various soil samples were observed in the range of 0.07 to 0.112 mg/kg and these are shown graphically in Figure 7. The level of cobalt in various soil samples are: Peach farm soil, 0.07 mg/kg; lady fingers farm soil, 0.47 mg/kg; plum farm soil, 0.49 mg/kg; tomato farm soil, 0.49 mg/kg; ridge gourd farm soil, 0.60 mg/kg; wheat farm soil, 0.112 mg/kg.

Conclusions and Recommendations

Various research findings reveal that the presence of heavy metals at an elevated level in irrigation water and soil is responsible for penetration and concentration of these in vegetables, fruits and cereal crops. Such food staples when consumed on regular basis causes adverse effect on human health. The health concerns necessitated the assessment of Cr, Fe, Ni, Pb and Co in soil samples collected from the agricultural farms of the selected fruits and vegetables in the area of Urmar, Peshawar, Northwest Pakistan. Soil samples were collected from the selected fruits and vegetables farms in summer 2019. Acid digestion method was used in order to extract metal ions from the soil samples. The concentration was ranged from 1.37 to 2.00, 28.91 to 29.50, 1.62 to 1.82 and 1.22 to 1.179 and 0.07 to 0.112 mg/kg for Cr, Fe, Ni, Pb and Co, respectively. The study revealed that the average concentration of Fe was highest and that of cobalt lowest among all soil samples. Moreover, the results that observed concentrations of all five metals were well below their maximum safe limit set by FAO/WHO. It might be due to limited industries and less use of pesticides. Although, the observed values are below the WHO standards, but presence of heavy metals in water, fruits and other food commodities should be monitored in the studied area.

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Novelty Statement

This investigation highlights the occurrence of Cr, Fe, Ni, Pb and Co at the lower levels than the WHO/

FAO guidelines in agricultural soil samples. The lower levels of Cr, Fe, Ni, Pb and Co indicated that the soil is safe for agricultural activities.

Author's Contribution

WF, AAU conceptualized the study. DF, KN recorded the data. RM and US statistically analyzed the data. AY and SSAA wrote Introduction section of the manuscript. WF and SAU wrote methodology and results. RM edited the format of the graphs and tables. RM and SSAA reviewed the manuscript. The final draft was approved for submission by all the authors.

Conflict of interest

The authors have declared no conflict of interest.

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