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Investigation of cadmium (Cd) and lead (Pb) contents in soil, orange fruit and its accumulation in human blood

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Abstract

Heavy metals are among the most environmentally toxic substances. Cadmium (Cd) and Lead (Pb) are extremely toxic heavy metals and their presence in the soil poses severe danger to the food security and consequently human health. Present study was carried out to investigate the concentration of Cd and Pb in soil, Orange and human blood. Soil and orange fruit samples were collected from same garden. Blood samples were taken from 6 volunteers at two stages before consumption and 4 hours after orange fruit consumption. Cadmium concentration in soil samples were found to be higher than the permissible limit of Cd set by the World Health Organization (WHO). It was noted that Pb concentration in soil was within safe limit of WHO. Orange fruit exceed the safe limit for concentration of both the metals. The cadmium concentration in blood sample before (2.7 ± 0.3ppm) and after eating orange fruit (2.75 ± 0.3ppm) were found different. The difference between cadmium concentration before and after consumption is 0.05ppm. The lead concentration in blood before consumption of orange fruit was (5.05 ± 1.15ppm) while after consumption was (5.88 ± 1.25ppm). The difference found between before and after treatment is 0.83ppm. Further investigation is suggested to find the effect of toxic metals like Cadmium and lead on human physiology and biochemistry.

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Introduction

Heavy metals like Cadmium Cd and Lead Pb are inorganic in nature and have relatively high density and specific gravity (5 times greater when contrast with water). These high atomic number and weight elements is naturally present in earth crust mostly and individuals' anthropogenic activity led to their accumulation in the atmosphere above their permissible level (Sharma B, *et al.,* 2014). They are not degradable and therefore persevere for long time in environment. Heavy metals are potentially harmful to all living organisms. Excessive accumulation of heavy metals in agriculture soils may results in soil contamination of plants and adversely affect the quality food. It is essential to monitor the uptake and accumulation of heavy metals in fruits that results in entrance of hazardous metals into food chain. From the soil and water plants absorbs heavy metals and then accumulate it in their edible and non-edible parts. Intake of contaminated food results in various clinical problems in humans and even death. Cadmium and lead are among the highly toxic heavy metals (Yoon, J., *et al.*, 2006). Cadmium occurs in air, water, soil as well as in tissue of plants and animals, it is not found in free state. Cadmium is present primarily in ores of zinc, cooper or lead, the extraction and processing of which releases large quantities of cadmium into atmosphere, water and soil. It is toxic, non-essential and classified as a human carcinogen by the North Carolina national toxicology program (sarkari *et al.,* 2013). Cadmium is highly toxic metal and can cause severe health problems in humans. Cadmium affect the expression of gene, inhibit DNA damage repair mechanism, and inhibit apoptosis, at molecular level (Joseph P., 2009). Lead (Pb) have great effects on children by lowering the nervous system response, IQ and gestor-intestinal effects (Murata, K., *et al.,* 2008). Lead is toxic to virtually all the body's organs and has significant nervous, renal, hepatic, and hematopoietic debilitating effects. Lead also results in the lowering of antioxidant activity, especially glutathione with respect to the brain (Hsiang, J and Diaz, E., 2011). The toxic effect of lead is well studied in cardiovascular system. Studies done on hypertension patients showed a positive relation between associated blood levels and blood pressure (Alghasham AA, *et al.,* 2011).

The major sources of lead are the use of herbicides and insecticides on plants (Wuana RA and Okieimen FE, 2011). While the sources of cadmium include phosphate fertilizers, batteries paints and pigments (Pulford ID and Watson C, 2003).

The focus of our study is to analyze the concentration of cadmium and lead contents in orange from selected area, in the human blood samples who are fed with orange and in soil from selected area.

Materials and methods

Study design

This cross-sectional study was carried out in Rabbat Khall distract lower Dir, KPK Pakistan in the month of April 2019. In this study we use Nitic Acid and Sulphuric Acid for analytical grade and were obtained from Sigma-Aldrich (Germany).

Collection of Soil samples

All the soil samples were collected from orange gardens. Soil near the base of orang trees at 15-20cm depth were collected in clean plastic bags. Furthermore, the collected soil was dried in sunlight.

Collection of Fruit

Orange fruits were collected from different gardens. The fruits were than dried in oven at 48°C. The dried samples were than grinded into powdered form and were stored in clean and dry plastic envelopes.

Collection of Blood Samples

Blood samples were collected from six volunteers having mean age 24 ±3 years. Blood was taken from each individual at two stages; before eating of orange and 4 hours after eating 2kg of Orange. 4cc blood was taken from every individual at each stage. Blood samples were dried and convert into powder form and then storied in sterile plastic envelops.

Acid Digestion of Samples

All the dried Samples (soil, fruit and blood) were than acid digested by using the method of Allen (Allen, S.E. *et al.,* 1974). Each powder sample were digested separately by taking 0.25-gram powdered sample in 50ml flasks and 6.5ml of mixed acid solution (Nitric acid, Sulfuric acid, Perchloric acid) in the ratio of (5: 1: 0.5) was added and were than kept on an electric hot plat until fumes formation. Samples were then transferred into 50ml volumetric flasks and the volume was made up to 50ml with distilled water. The samples were filtered, and the filters were kept in plastic bottles for further analysis. The filtered samples were analyzed for cadmium (Cd) and lead (Pb) by using Atomic absorption/Flam Spectrophotometer at Centralize Resources Laboratory of Peshawar KPK, Pakistan.

Statistical Analysis

All the data was statistically analyzed and tabulated by using MS excel (2007) and SPSS version 10.0.

Results and discussion

The concentration of heavy metals (Cadmium and lead) in the soil samples were noted in which the concentration of cadmium was noted (2.53 ±0.39ppm) while the concentration of lead was (12.67 ±0.85ppm). The concentration of cadmium in Orange fruit were found (2.15 ±0.1ppm) while the concentration of lead was (5.25 ±1.3ppm). During the analysis of blood samples before treatment we found the concentration of cadmium (2.7 ±0.3ppm) while concentration of lead was noted (5.05 ±1.15ppm). After the consumption of orange fruit by volunteers we found the concentration of cadmium in their blood were (2.75 ±0.3ppm) while the concentration of lead was (5.88 ±1.25ppm). As shown in the (Table-1 and Fig-1).

The increase in the blood metals concentration after consumption of orange fruit were cadmium (0.05ppm) and lead (0.83ppm) respectively. lead concentration in the blood samples after treatment was found much higher than Cadmium. As shown in the (Table-1 and Fig-1).

Table 1. shows the total samples of (soil, orange fruit and blood before and after consumption of orange fruit). This shows the mean concentration of Cadmium and Lead in the mentioned tested components in ppm.

Sr. no	Tested Components	Total samples= n	Cadmium= Mean ± SD	Lead= Mean ± SD
1	Soil sample	06	2.53 ±0.39	12.67 ±0.85
2	Fruit sample	06	2.15 ±0.1	5.25 ±1.30
3	Blood before consumption	06	2.70 ±0.3	5.05 ±1.15
4	Blood after consumption	06	2.75 ±0.3	5.88 ±1.25

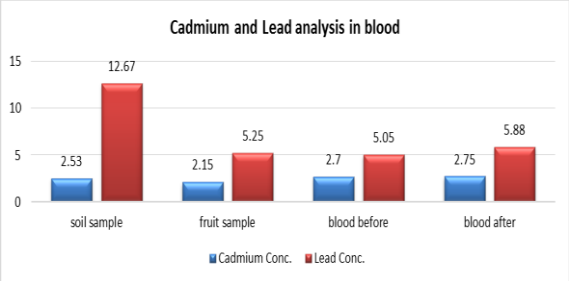

Fig 1. Shows the Mean Concentration in ppm of heavy metals (Cadmium and Lead) in the samples of soil, Orange fruit and in blood before and after consumption of fruit.

Presence of toxic heavy metals in soil not only reduce plant growth and yield but also have negative impact on the quality of food (Steffan, J.J, *et al.,* 2018). Cadmium and lead are among the most hazardous and carcinogenic heavy metals. The international agency for research on cancer (IARC) classify the cadmium in group-1 carcinogens which have higher risk for lung cancer while Lead was classified as probably group-2A carcinogen to humans having high risk of stomach, kidney and lungs cancer (IARC Working Group 2006), (IARC, 2012). Present results showed that soil collected from orange garden contain high concentration of Cadmium and Lead. Presence of these metals in soil results in their absorption by plants and subsequent accumulation in their edible parts such as fruits. The concentration of cadmium exceeds the WHO permissible limit (1ppm) in soil while lead concentration was within safe permissible limit (50ppm) (De Temmerman, L. O., *et al.*, 1984).

In the present investigation we evaluated the concentration of cadmium and lead in orange fruit [2.15±0.1] and [5.25±1.30] ppm which was greater than the standard set by WHO and FAO (WHO/FAO, 2007). A study reported in Iraq showed that the cadmium level in orange fruit was 0.22 ppm while lead was 26ppm (Ibraheen, L.H. and Abed, S.A. 2017). This shows that the cadmium concentration in fruit was relatively greater in Pakistan as compared with Iraq while lead was observed less. Our results are compatible with those of Razieh Saleh *et al.,* that their studies conducted on citrus in Tehran concentration of cadmium and lead was found more than standard level set by WHO/FAO (Saleh, R., *et al.,* 2017). Also studied conducted by Kalagbor *et al.,* on sweet orange in Khanaand reveal that the concentration of lead in peel and pulp of orange are more than standard level (Kalagbor, I.A., *et al.,* 2014). The findings of Mausi *et al.,* in study conducted in Eldoret of Kenya on the concentration of heavy metals like Chromium and Lead in fresh orange reported more than standard level (Mausi, G., *et al.,* 2014). Also, the study reported by Kalagbor and Diriin on a form in Kaani Bori and Rivers states in Nigeria showed the concentration of lead in orange is more than standard level set by WHO/FAO (Ihesinachi K. and Eresiya D., 2014). It was found that consumption of contaminated orange has increased concentration of cadmium and lead in human blood. The assessment of metals content in fruits like oranges represents on of the factors in the evaluation of their quality taking into consideration that some plants may accumulate metals, especially cadmium and lead. In present study we find that soil contain great amount of heavy metals like cadmium and lead which is consumed by fruit plants. That these contaminants come in the soil due to pesticides, chemical fertilized, animal fertilizers and waste water (Mohajer R, *et al.,* 2011). These metals are hazardous and may affect the health of humans (adults and children). The children have more susceptibility to the exposure of heavy metals (Hegazy, A.A., *et al.,* 2010). To reduce the risk of heavy metals exposure to humans the farmers must reduce the use of pesticides, insecticides and heavy amount of fertilizers to their crops and fruit plants. The awareness must be needed in the studied area to reduce the use of cadmium and lead containing ingredients.

Cadmium concentration in soil was found to exceed the World Health Organization (WHO) permissible limit while concentration of lead in soil was found to be approximately within safe limit set by WHO. Increase in concentration of Cadmium and lead in human blood was recorded after orange meal. Further investigation is suggested to find why this concentration range is increased from the set point and to find the effect of toxic metals like Cd and Pb on human Physiology and biochemistry.

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Conflict of interest

This paper has no conflict of interest.

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