

Health Risk Assessment due to Heavy Metals in Cow Pea Cultivated in Sanganer using Textile Waste Water

Jaishree¹, T. I. Khan²

Indira Gandhi Centre for H.E.E.P.S., University of Rajasthan Jaipur, India

Abstract: *The present study was carried out to estimate the concentration of heavy metals (Zn, Cu, Ni, Cd, Cr, Pb and Co) in Cow pea (Vigna unguiculata) collected from different agricultural fields located in Sanganer, Jaipur. Atomic absorption spectrophotometer was used to determine the concentrations of heavy metals. The present study aims at determining human health risks associated with food chain contamination by heavy metals caused by industrial effluent water used in irrigation. The plants accumulated Zn concentration as high as 15.708 mg/gm, Cu 8.878 mg/gm, Ni 6.186 mg/gm, Cd 5.446 mg/gm, Cr 7.505 mg/gm, Pb 6.595 mg/gm and Co 5.858 mg/gm. Results revealed that the average concentrations of all metals in the cow pea was found in order of their abundance as Zn > Cu > Cr > Pb > Ni > Co > Cd.*

Keywords: Textile waste water, Heavy metals, Health risk, Transfer Factor

1. Introduction

Heavy metals enter into food from natural sources like soil, air and water through wastewater irrigation, solid waste disposal, mining, smelting, sludge applications, vehicular exhaust, fertilizers, fungicides and industrial activities. (Muhammad et al, 2008, Radwan and Salama, 2006). Consumption of food crops contaminated with heavy metals is a major food chain route for human exposure. (Khan et al, 2008). The absorption of heavy metals in the system varies to certain extent depending on various factors. Heavy metals, in general, are non-biodegradable, have long biological half-lives and have the potential for accumulation in the different body organs leading to acute as well as chronic toxic effects. (Radwan and Salama, 2006). The problem of heavy metal contamination is getting serious all in different countries of the world especially in developing countries. Moreover as heavy metal bio-accumulation increases in nutrition deprived state, developing countries with higher prevalence of under nutrition are at a greater risk of heavy metal toxicity. The contamination of heavy metals in agricultural soils can pose health problems which is a matter of concern. Therefore, there is the need to investigate the possible risks in the population due to the chronic exposure of heavy metal contamination in vegetables and fruits. Vegetables are common diet taken by populations throughout the world, being sources of essential nutrients, antioxidants and metabolites. (Thomsan and Kelly, 1990). Both essential and

toxic elements are present in vegetables over a wide range of concentrations as they are said to be good absorber of metals from the soil (Lokeshwari and Chandrappa, 2006 and Eslami et.al. 2007). Vegetables absorb these metals from contaminated soils as well as from polluted environmental deposits through the roots and incorporate them into the edible part of plant tissues or deposit on the surface of vegetables. (Haiyan and Stuanes, 2003, Nawaeji, 2009).

In the present study Sanganer, Jaipur has been selected as study area where textile waste water drains into Amanishah nalla. The waste water is drawn through pumps and agricultural fields are irrigated with this untreated waste water.

2. Study Area

Sanganer, Jaipur was selected as study area. It is famous for Tie, dye and printing, waste paper recycling and blue pottery industries. Sanganer is located between 26° 49' to 26° 51' N latitude and 75° 46' to 75° 51' E longitude. (Fig 1). These industries discharge untreated waste water in Amanishah Nala (Earstwhile Dravyawati river) in Sanganer. (Fig 2). A large number of small, medium and large scale textile industrial units are located in Sanganer. The untreated waste water which contains chemicals like anelin, caustic soda, acids, bleaching powder and heavy metals is lifted through pumps and utilized in irrigating agricultural fields for growing vegetables and other crop plants. (Fig 3).

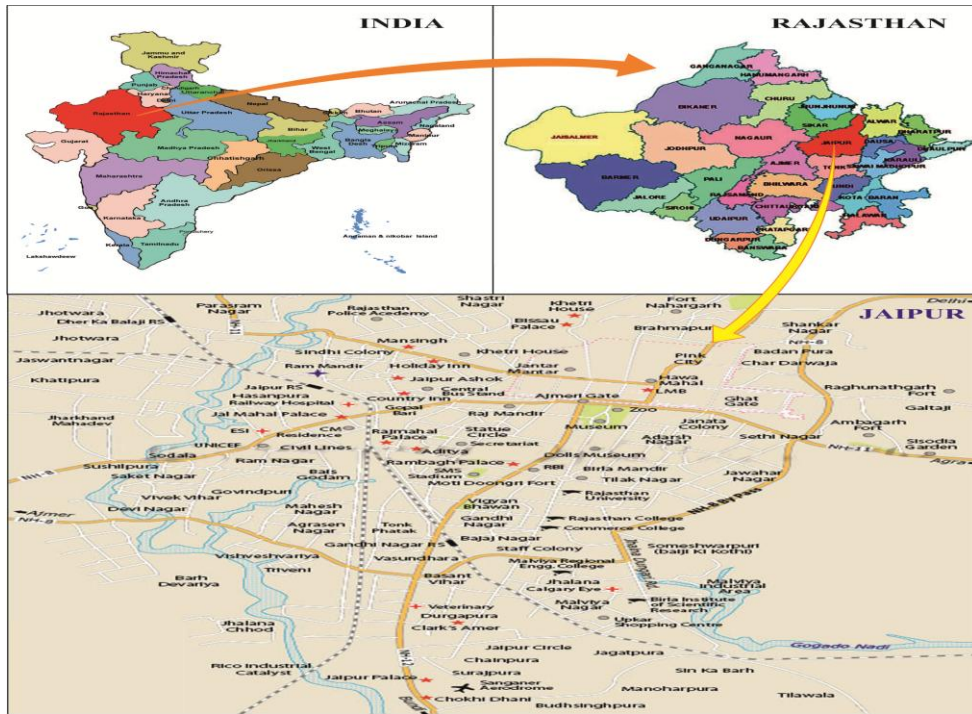
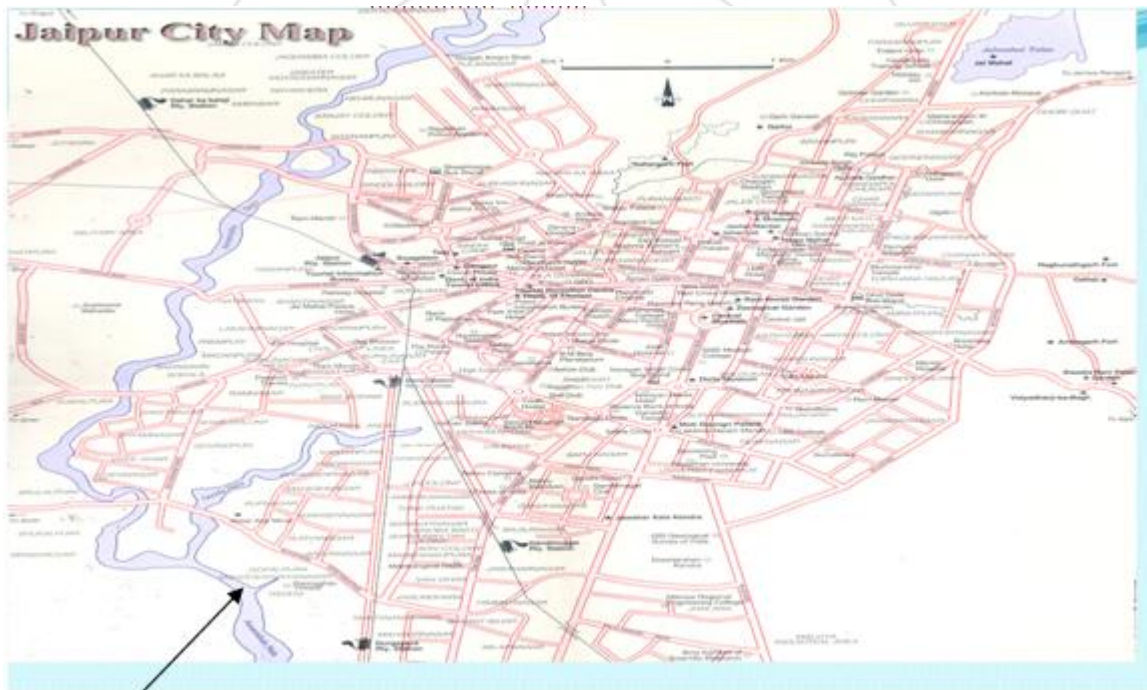


Figure 2: Showing Study area, Sanganer, Jaipur, Rajasthan, India.



Waste water drained into Amanishah Nalla (Dravaywati river)

Figure 2: Showing Amanishah nalla



Figure 3: Series of pump sets, which is used to pump waste water for irrigating agricultural fields shown in the background.



Figure 4: Shows the effect of waste water on hands and feet of workers using chemicals without gloves

3. Material and Methods

Heavy Metal Analysis By Atomic Absorption Spectrophotometer

Atomic absorption Spectrophotometer (AAS Model GBC 932) was used for analysis of heavy metals in water. The 25ml of the sample was digested in di acid mixture of HNO₃ and per chloric acid in the ratio of (10:1). The digestion was performed in 100 ml conical flasks and to facilitate complete digestion the samples in di acid mixture were kept overnight at room temperature. These flasks containing samples and di acid mixture were heated at hot plate until a clear solution was obtained. This was followed by a slow but complete evaporation of acids. Then, the volume of the digested samples was made up to 100 ml with the help of the double distilled water. Finally these solutions were analyzed by Atomic Absorption Spectrophotometer.

4. Data Analysis

1. Transfer Factor (TF)

Soil to plant metal transfer was computed as transfer factor (TF), which was calculated by using the equation $TF = C_{PLANT} / C_{SOIL}$ where, C Plant is the concentration of heavy metals in plants and C Soil is the concentration of heavy metals in soil.

2. Daily Intake of Metals (DIM)

Daily intake of vegetables in adult was calculated by data obtained during the survey through a questionnaire. DIM was calculated by the following equation suggested by Chary et al., (2008).

$$DIM = C_{metal} \times C_{factor} \times D_{food\ intake} / B_{average\ weight}$$

where, C_{metal}, C_{factor}, D_{food intake}, B_{average weight} represent the heavy metal concentrations in plants (mg kg⁻¹), conversion factor (0.085), daily intake of vegetables and average body weight, respectively. The average vegetable intake was

calculated by conducting a survey where about 200 people (males and females) having an average body weight of 48 kg were asked for their daily intake of particular vegetables from sampling sites.

Health Risk Index (HRI)

To assess the human health risk of heavy metals, it is necessary to calculate the level of human exposure to that metal by tracing the route of exposure of pollutant to human body. There subsist many exposures routes for heavy metals that depend upon a contaminated media of soil and vegetables on the recipients. Receptor population use the vegetables enriched with higher concentration of heavy metals which enters the human body leading to health risks (Khan et.al. 2008). In the present research work vegetables grown at the wastewater were collected from the study area and their metal concentration was used to calculate the health risk index (HRI). The health risk index of the present research work was compared with the one reported by Khan et al. (2008) and Jan et al.(2010). Results of HRI were found to be lower than those of Khan et al.(2008) and Jan et al.(2010). Value of HRI depends upon the daily intake of metals (DIM) and oral reference dose (R_{fd}). R_{fd} is an estimated per day exposure of metal to the human body that has no hazardous effect during life time [USEPA 2006]. The health risk index for Cr, Ni, Cu, Pb, Cd, Mn and Zn by consumption of contaminated vegetables was calculated by following equation -

$$HRI = DIM / R_{fd}$$

where DIM represents the daily intake of metals and R_{fd} represents reference oral dose. R_{fd} for Cr, Ni, Cu, Pb, Cd, Co and Zn is 1.5, 0.02, 0.04, 0.004, 0.001, 0.033 and 0.30 (mg/kg bw/day) respectively .

5. Result and Discussion

Concentration of heavy metals in soil obtained from different agricultural sites of Sanagner was found to be significantly high. The concentration of heavy metals in soil were above the safe limits set by USEPA , WHO and Indian standards. (Awashthi 2000). The concentrations of heavy metals(mg/g) in agricultural soil collected from different crop production sites .Zn concentration varied from 11.758 mg/gm to 16.495 mg/gm , Cu concentration was from 11.013 mg/gm to 11.589 mg/gm, Ni was from 4.623 mg/gm to 5.011 mg/gm, Cd varied from 4.586 mg/gm to 5.234 mg/gm , Cr concentration varied from 6.189 mg/gm to 6.998 mg/gm ,Pb was from 5.286 mg/gm to 5.896 mg/gm and Co varied from 3.684 mg/gm to 3.912 mg/gm. (Table 1).

Concentration of heavy metals in cow pea on a dry weight basis grown in wastewater. Concentration of heavy metals in Cow pea samples collected from different agricultural field sites. Results revealed that the heavy metal concentration was significantly higher in cow pea. The heavy metals were estimated in mg/gm dry weight. The plants accumulated Zn concentration varied from 15.684 mg/gm to 15.708 mg/gm, Cu concentration varied from 8.348 m/gm to 8.878 mg/gm, Ni varied from 6.098 mg/gm to 6.186 mg/gm, Cd concentration varied from 5.264 mg/gm to 5.446 mg/gm, Cr was varied from 7.475 mg/gm to 7.505 mg/gm , Pb concentration varied from 6.567 mg/gm to 6.595

mg/gm and Co concentration was varied from 5.538 mg/gm to 5.858 mg/gm .(Table 2).

Transfer Factor (TF), daily intake of metal(DIM) and health risk index(HRI) were also calculated

Transfer factor for cow pea in different heavy metals Zn was 1.097,Cu was 0.764, Ni was 1.251, Cd was 1.082, Cr was 1.157, Co was 1.481 and Pb was 1.179. Plants uptake the heavy metals from soil and then it accumulate in different parts of plant.(Table 3).

Values of DIM calculated for adults (average age 48 years), are presented in this. These data revealed that the values of daily intake of metal were high for vegetables grown at different five agricultural sites. The trend for DIM in vegetables grown was in the order of $Zn^{2+} > Cu^{2+} > Cr^{3+} > Pb^{2+} > Cu^{2+} > Zn^{2+} > Mn^{2+}$. The highest value of DIM for Zn was 0.061 mg/kg/day and lowest value of DIM for Cd was 0.009 mg/kg/day.(Table 3).

To assess the health risk associated with heavy metal contamination of plants grown locally, estimated exposure and risk index were calculated. The results showed that Cd, Pb and Ni contamination in plants had greatest potential to pose health risk to the consumers. HRI was maximum for Cd^{2+} in cow pea and minimum or out of danger for Cr^{2+} . (Table 3).

Heavy metals causes different types of diseases Zn causes Stomach cramps, nausea, vomiting, anaemia, damage to the pancreas , Ni causes Stomach cramps, nausea, vomiting, anaemia, damage to the pancreas , Pb causes Haematological and cardiovascular effects (hypertension), kidney damage , Cd damage to kidneys and lungs, fragile bones, anaemia, increased risk of cancer if inhaled , Co affects the respiratory sensitization, asthma, shortness of breath, and decreased pulmonary function , Cr causes Skin rashes ,Upset stomachs and ulcers, Respiratory problems, weakened immune systems, Kidney and liver damage ,Alteration of genetic material ,Lung cancer and Cu causes the hematological manifestations, such as myelodysplasia , ananemia , leukopenia (low white blood cell count) and neutropenia (low count of neutrophils, a type of white blood cell that is often called "the first line of defense" for the immune system) . Vegetables take up metals by absorbing them from contaminated soils, as well as from deposits on different parts of the vegetables exposed to the air from polluted environments (Sobukola et al., 2010). Prolonged human consumption of unsafe concentrations of heavy metals in food stuffs may lead to the disruption of many biological and biochemical processes in the human body (WHO, 1993; Jarup, 2003). Intake of vegetables is an important path of heavy metal toxicity to human being. Dietary intake of heavy metals through contaminated vegetables may lead to various chronic diseases.A number of serious health problems can develop as a result of excessive uptake of dietary heavy metals.(Arora et.al.2008). Furthermore, the consumption of heavy metal-contaminated food can seriously deplete some essential nutrients in the body causing a decrease in immunological defenses, intrauterine growth retardation, impaired psycho- social behaviors,

disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer .

Table 1: Concentration of Heavy metals in soil

SITES	Heavy metals(mg/gm)						
	Zn	Cu	Ni	Cd	Cr	Pb	Co
Site 1	13.289	11.125	5.011	4.586	6.378	5.896	3.684
Site 2	15.236	11.589	4.789	4.865	6.189	5.286	3.712
Site 3	16.495	11.445	4.623	4.912	6.245	5.895	3.776
Site 4	11.758	11.512	5.121	5.019	6.539	5.319	3.845
Site 5	14.698	11.013	4.948	5.234	6.998	5.489	3.912

Table 2: Concentration of Heavy metals in Vigna unguiculata (cow pea)

SITES	Heavy metals(mg/gm)						
	Zn	Cu	Ni	Cd	Cr	Pb	Co
Site 1	15.708	8.742	6.109	5.264	7.475	6.575	5.538
Site 2	15.690	8.348	6.123	5.289	7.487	6.579	5.546
Site 3	15.684	8.568	6.098	5.312	7.490	6.567	5.548
Site 4	15.696	8.796	6.142	5.348	7.501	6.583	5.553
Site 5	15.689	8.878	6.186	5.446	7.505	6.595	5.858

Table 3: Transfer Factor, Daily Intake of Metal and Health Risk Index:-

Heavy metals	Average concentration mg/gm	Transfer Factor	H.R.I	D.I.M (mg/kg/day)
Zn	15.689	1.097	0.203	0.061
Cu	8.666	0.764	0.85	0.034
Ni	6.131	1.251	0.5	0.010
Cd	5.331	1.082	9	0.009
Cr	7.491	1.157	0.019	0.029
Pb	6.579	1.179	3	0.012
Co	5.608	1.481	0.242	0.008

6. Conclusion

In this present study it is conducted that continuous wastewater irrigation in the agricultural land has caused an ample build up of toxic metals. Food items analysis and monitoring should be performed in order to prevent excessive build up of these heavy metals in the food chain. Variations in the heavy metal concentrations between the test vegetables/cereal crops reflect the differences in uptake capabilities and their further translocation to the edible portion of the plants. Heavy metals have a toxic impact, but detrimental impacts become apparent only when long term consumption is done. Consumption of foodstuff with elevated levels of heavy metals may lead to high level of accumulation in the body causing related health disorders. It is suggested that waste water should be used only after adequate treatment.

7. Acknowledgement

The authors are thankful to the Director, Indira Gandhi Centre for Human Ecology, Environment and Population Studies and Dean Faculty of Science, University of Rajasthan for providing necessary facilities. One of the authors (Jaishree) is thankful to University Grant Commission New Delhi for providing financial assistance as Rajiv Gandhi Senior Research Fellowship.

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