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Heavy metals in wheat grains of Haryana (India) and their health implications

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ABSTRACT

Soil and wheat grain (Triticum aestivum) samples were collected from selected locations of southern Haryana. The trace analysis was made for heavy metals (Zn, Cu, Ni and Cr) present in soils of the agricultural lands of these locations and subsequently in the wheat grains (collected from same sites). The soil physiochemical parameters like pH, electric conductivity etc were also estimated. Cu and Zn metals were estimated using atomic absorption spectrophotometer (AAS) while Ni and Cr metals were analyzed by inductively coupled plasma-atomic emission spectrophotometer (ICP-AES). Individual metal concentration levels in soils and wheat grains from selected sites are discussed separately. The health risk analysis of these metals is carried out in terms of Bio-concentration factor (BCF), Hazard Quotient (HQ) and Hazard Index (HI).

Keywords: Trace Analysis, Heavy Metals, Soil, Wheat (Triticum aestivum), ICP-AES, AAS.

INTRODUCTION

In current perspectives of environmental pollution, heavy metal contamination of the environment is most burning issue for pollution control agencies. Rapid industrialization and urbanization leads to a constant and rapid input of these heavy metals in the surrounding environment of human concern. Role of heavy metals in plant and human biology is now quite understood. Trace metals such as copper and zinc are classified as essential to life due to their involvement in certain physiological process. Elevated level of these metals has however been found to be toxic [1]. The criteria for essentiality of elements for plant growth and development were first established by Arnon and Scott & Meyer and Anderson & Bennett [2-4].

Plants are considered as intermediate reservoirs through which heavy metals/ elements/ nutrients are transferred from soil to other organisms via a food chain. Several heavy metals are toxic to human beings [5-7]. Although some of the heavy metals such as Zn, Mn, Ni, and Cu act as micronutrient at lower concentrations, they become toxic at higher concentrations [8]. The metals are not toxic as the condensed free elements but are dangerous in the form of cations and when bonded to short chains of carbon atoms [9]. Potential toxicity of trace metals result from the fact that they are transitional elements able to form stable coordinated compounds with a range of both organic and inorganic ligands [10] and [11]. Many metals act as biological poisons even at parts of per billion (ppb) levels. The toxic elements accumulated in organic matter in soils are taken up by growing plants [12]. In studying the heavy metal interrelationships in natural systems i.e between soil, vegetation and animals, in general, there is a greater correlation for the certain elements (Cu and Zn) between soil and vegetation than between vegetation and animals or between soil and animals. Excellent reviews on the food chain or soil plant animal aspects of heavy metals have been conducted by Underwood [13] and Nicholas and Egan [14]. The toxicity of these metals may result in blocking the essential biological functional groups of the biomolecules, displacing the essential metal ion present in biomolecules or and modifying the active confirmation of the biomolecules like polypeptides etc. The polypeptides store genetic information and their disruption can have serious results such as cancer or congenital deformation [15] and [16].

The determination of heavy metals in soil may be carried out for various reasons. These include firstly the measurement of the total elementary content, which provides base line knowledge of soil components with respect to which changes in soil composition produced by pollution; plant uptake or agricultural manipulation can be assessed. In addition, total metal concentration analysis may be designed to assess the availability of elements to agricultural crops and hence the likelihood of their entry into the food chain of animals and man. In continuation of analysis of selenium status in soils and food grains [17] and [18], present research work deals with study of various heavy metals (Cu, Zn, Ni and Cr) concentration levels in soils as well as in wheat grains produced in selected locations of Southern Haryana and then their health implications on the humans dependent on the food products prepared from the wheat grains.

EXPERIMENTAL SECTION

Geography of Haryana

The state of Haryana lies between 27°39' -30° 55' N latitude and 74°27' -77°36' E longitudes. Though Haryana lies in the sub-tropical belt but in the state as a whole there are three types of climate: (i) Arid (ii) Semi-arid and (iii) Sub-humid. The normal annual rainfall varies from 300 mm in the south-western parts of Bhiwani and Sirsa locations to about 1560 mm in the north-eastern hilly tract of Ambala location. Wind velocity is maximum in May and June (8-11 km/hr). Minimum temperature becomes close to freezing in December/ January and the maximum daily temperature is above 40°C in May/June. The mean annual temperature ranges from 23°C to 26°C. Saline soils occur in parts of Gurgaon, Mahendragarh, Sonipat, Rohtak, Hissar and Jind locations of Haryana where as alkali soils occur in parts of Karnal, Kurukshetra locations [19].

Study area

For our research work, raw wheat grains were collected from the agricultural lands of selected locations of south Haryana viz. Bhiwani, Jind, Gurgaon, Rohtak, Sonepat, Rewari, Hisar, Narnaul and Mahendergarh and the northern capital Chandigarh. Sampling locations and study area are shown in Fig.1. Sampling of soil was carried out before plantation of crop and then, wheat grains were collected from the same field after crop production in order to investigate the distribution and concentration of heavy metals (Cu, Zn, Ni and Cr) in the produced wheat grains.

Soil sampling and pretreatment

Soil sampling was done by collecting the soil at six places in one hectare of area from the depth of 0-15 cm with the help of auger sampler making a ‘V’ shape and collecting slices of soil. All the samples of one site are then mixed in equal to represent the bulk sample of 0-15 cm depth. Digestion procedure is followed as prescribed in previous publications [17].

Collected soil samples were further dried at 60^0C and thoroughly mixed. Each sample was crushed to 200 meshes size with an agate mortar and pestle. 0.5g soil sample were used for digestion. An open acid digestion method using (1:2) conc. HNO_3 and HF as reported by Shapiro and Brannock was followed for solution preparation [20]. Digested samples were recovered with 6M HCl acid. Soil samples which were rich in organic matter, after first digestion the residue were dark or black in color. In such cases, 5-10 mL H_2O_2 (30%) and 1-2 mL HNO_3 were added and evaporated to dryness. Solutions were then recovered with distilled water [17].

Wheat grains sampling and pretreatment

Wheat grains were collected from the crops from where soil samples were collected. A range of 10-15 plants of crops were collected randomly from the selected fields. Wheat grains were washed and dried to reduce effect of environmental depositions and thoroughly mixed, grinded and dried for analysis. Digestion procedure is as described by Yadav et. al [18]. 1g of wheat grains was taken in a flask and 10 mL of nitric acid was added and matter was slowly heated to 90° C. The flask was heated until half of volume disappeared. Then 0.5 mL of perchloric acid ($HClO_4$) and 1mL of sulfuric acid (H_2SO_4) were added. The digestion flask was held for one hour and then temperature was increased slowly to 100°C and held for 30 minutes. Temperature was increased slowly to 120° C and held for 20 minutes when sulfuric acid only left and digestion of acid was finished. Then 5 mL of 6M HCl was added to residue digestion solution and heated the flask at 80° C for 30 minutes. The flask was cooled to room temperature and digestion solution was diluted to 25 mL with distilled water.

Physiochemical Parameters of Soil Analysis

Hydrogen ion concentration (pH)

After rinsing the electrodes with double distilled water the instrument was calibrated with buffer solution of pH 4.0, 7.0 and 9.2. The pH of all the samples was measured by using 1:2 (w/v) soil and water ratio. The mixture was dissolved to get saturated solution and the samples were stirred well during measurement to provide homogeneity. Individual results are reported in Table1.

Electrical conductivity

Electrical conductivity was measured by taking 5gm soil in 10 mL of distilled water to prepare a suspension (1:2w/v). The conductivity meter was calibrated with 0.1 N KCl solution before taking Electrical conductivity. The conductivity was measured in micro mho (µ mho). Individual results are reported in Table 1.

Sodium and Potassium Concentration

Microprocessor based Chemito model 1020 flame photometer, which has sensitivity for sodium and potassium in 1 ppm range and operating in 0 to 100 ppm has been used for sodium and potassium analysis. Individual results are reported in Table 1.

Instrumentation

An atomic absorption spectrophotometer model ECIL, 4129 (PC based) with vapor generation accessory (hydride generator) [HG-AAS] attached with different metal cathodes using Air–acetylene (oxidizing) flame was used for analysis of Cu and Zn. While Nickel and Chromium were analyzed using an Inductive-coupled Plasma-Atomic Emission Spectroscopy (ICP-AES, Model Ultima-2) [17,18].

Quality assurance and Quality Control

Appropriate quality assurance procedures were carried out to ensure the reliability of results. Double distilled water was used throughout the experimental work. Glassware were properly cleaned with nitric acid and kept in oven till use. Reagents used were of analytical grade. Reagents blank determinations were used to correct the instrumental readings. The analytical precision and the accuracy were better than 5% for the analyzed elements. This was indicated by the results of duplicate measurements on ten soil samples.

RESULTS AND DISCUSSION

Total metal concentration analysis of soil and food grains plays a vital role in prediction and diagnosis of deficiency related disease and environmental toxicity problems in living systems. Since the projections show the dependence of largest population of India upon the growth of coarse grains production, the monitoring of their quality standards become utmost important. This study is also a step in the direction of monitoring of some heavy metal contents in soil and then in coarse wheat grains produced in the area (ten locations) of Haryana.

Heavy metals in Soil

The values of some selected soil parameters in respect of all the ten soil profiles are given in Table 1. In these soils pH value ranges from 7.72 to 8.73, EC values ranges from 0.114 to 0.394 µmho while sodium and potassium values ranges from 27.77 to 35.52 and 1.20 to 21.84 mg/Kg respectively. The heavy metal concentration levels (Cu, Zn, Ni and Cr) found in soils (used for agricultural purposes) of selected locations in Haryana along with the legally permissible levels of heavy metals as described by Rowell; by European Community Commission (ECC); Permissible limits of Indian Standards by Awasthi, WHO/FAO ; Pilc et al. have been summarized in Table 2 [21-25].

Concentration level of all the metals in selected soil samples has been tabulated in Table 2. Zn concentration of 90 µg/g has been reported for world soil by Bowen [26]. However, Berrow and Reaves measured a mean Zn concentration level of 40 µg/g for world soil [27]. In the present study, among the locations of Haryana state, average concentration of zinc is found comparatively high in Mahendergarh soil having 41.1±9.09 µg/g and Narnaul soil having 35.33±9.18 µg/g respectively. First reason may be that soils of that particular area have zinc related ores so zinc is found more in that area. Secondly use of phosphate fertilizers increase level of zinc in soil. Minimum level of zinc is found in soil of Bhiwani having 17.4±3.74 µg/g and Jind having 17.7±5.78 µg/g respectively. This may be due to reverse effects of above said reasons.

The total Cu content of world soil is 30 µg/g ranging from 2 to 250 µg/g [26] and [28] (Bowen, 1979). The permissible limit of Cu metal in soil as defined by US EPA 1989 is 60 µg/g [28]. In the present study, Cu contents in soil of selected sites of Haryana vary from 19.93 µg/g to 60.07 µg/g. Cu levels are found to be lowest in the soil of Mahendergarh location with a value of 19.93±5.24 µg/g while a quite high level of copper is measured for the soil of Narnaul location with average concentration of 60.07±13.82µg/g and in Rewari it is 44.2±8.62µg/g. Enrichment of Cu metal in the soil of Narnaul may be correlated with the influence of copper mine present in 'Khetri' - nearby to Narnaul and Rewari.

Ni contents in the soils of selected sites is observed to vary between 46.47 µg/g to 73.80 µg/g. Minimum Ni level is observed for Chandigarh soil with a value of 46.47±8.23 µg/g and maximum for Rewari soil having a concentration of 73.80±4.86 µg/g. This may be because of the fact that this area comes under the dry zone of Haryana where the rain fall is very low and thus metal contents mainly remain in the upper soil area.

Brown et al. were the first who determined in the late 1980s that Ni is an essential nutrient for plant growth [29]. It is the seventeenth element recognized as essential for plant growth and development [30]. Plants' Ni requirement is the lowest of all essential elements at < 0.5 mg per kg of dry weight, making it an essential plant micronutrient. Soils for crop production contain 3–1,000 mg kg-1. However total Ni concentration is not a useful measure for Ni bioavailability because Ni^{2+} is the available form of Ni for plants, Positive 2-valence Ni ion (Ni^{2+}) readily oxidizes and becomes unavailable. Thus, plants grown in high pH soils are vulnerable to Ni deficiency. Additionally, excessive use of Zn and Cu may induce Ni deficiency in soil because these three elements share a common uptake system. Over-liming, which raises pH excessively, also causes soil to be deficient in plant-available Ni [31].

Similarly Cr contents are observed to encompassing the range between 78.07 µg/g to 109.33 µg/g. Minimum Cr contents were observed for the soil of Gurgaon (with a value of 78.07±10.96 µg/g) whereas the soil of Bhiwani location represent maximum Cr level with a value of 109.33±9.70 µg/g.

Total heavy metal contents in the analyzed soils were compared with the critical levels described by Rowell, ECC, Indian Standards by Awasthi, WHO and Pilc et al. [21-25] (Table 2). Measured Zn concentration levels when compared with the permissible limits of Rowell was much lower (Range=17.4 to 41.3 µg/g) in the soils of selected locations of Haryana. However, Zn contents were observed to lie very low when compared with the critical limits given by ECC (150-300 µg/g) and Indian standards (300-600 µg/g). Total Zn contents in the sampling sites was in the order of Bhiwani<~Jind<Gurgaon<Chandigarh<Rohtak<~Sonepat~Rewari=Hisar<Narnaul<Mahendergarh. Measured Cu contents in the soils of selected sites lie in the range of 19.93 to 60.07 µg/g, which is high compared to the permissible limits by Rowel (20 µg/g) [21] but lie within the safe range given by ECC [22] (50-140 µg/g) and quite low compared to the limits of Indian standards (135-270). Total Zn contents in the sampling sites was in the order of Mahendergarh< Hisar <~Bhiwani<~ Chandigarh< Jind<Rohtak<Sonepat< Rewari< Gurgaon< Narnaul. Soil samples of selected sites of Haryana showed total Cr concentration lie(78.07 to 109.33) within the permissible limits of ECC [22] (100 µg/g). Total Cr contents in the sampling sites was in the order of Gurgaon<Narnaul<Sonepat<~ Jind<~ Chandigarh< Mahendergarh< Rewari<~ Rohtak< Hisar <Bhiwani. Ni contents of selected soil samples (46.47-73.8 µg/g) are observed to possess a Ni level higher than the critical limits proposed by Rowel (25.0 µg/g) while lie within the safe range of ECC (30-75 µg/g) whereas fell quite low compared to permissible limits of Indian Standards (75-150 µg/g). Total Ni contents in the sampling sites was in the order of Chandigarh< Hisar< Jind< Gurgaon< Bhiwani< Mahendergarh< Narnaul< Sonepat< Rohtak< Rewari.

Heavy metals in wheat grains

Concentration level for different metals in wheat grains from the selected locations and descriptive analysis of each metal is tabulated in the table-3 and discussed here separately.

Ni contents in the wheat grains of selected locations ranged between 1.92 to 3.57 µg/g. Grains from Chandigarh were observed to have lowest Ni contents (1.92±0.47 µg/g) which seems to be in accordance of Ni concentration in the soil of Chandigarh (Table 2). Highest Ni contents (3.57±0.33 μg/g) were measured in the wheat grains of Rewari. This is again in accordance of Ni profile of soil of Rewari indicating the highest Ni contents in its soil. In a similar study, made by Roychowdhury et al. [32] in West Bengal of India, a Ni level of 0.76(<0.0002-1.52) mg/Kg and 1.24 (0.48-2.22) mg/Kg is reported in wheat and wheat flour respectively.

Zn contents, as analyzed in the wheat grains from selected locations of Haryana, ranged between 0.85 to 2.46 μg/g. Grains from Gurgaon were found to possess lowest Zn contents (0.85 ±0.51) and the highest Zn level (2.46±0.65 μg/g) was for the grains of Mahendergarh. During literature survey, Zinc levels in wheat grains are also reported by (Salama and Radwan, 2005) [33] in Egypt as being 12.02 mg/Kg and by Conti et al., 2000 in Italy being 32-33 mg/Kg. A Zn level of 24.3 (24.2-24.4)mg/Kg and 22.1 (17.1-27.2) mg/Kg is also reported in the wheat and wheat flour of West Bengal of India by Roychowdhury et al [32].

Copper contents in the wheat grains ranged within the limits of 1.23 to 3.71 μg/g. The highest Cu level was observed for the Narnaul grains (3.71±0.71 μg/g) and lowest being for Hisar grains (1.23 ±0.38 μg/g). The highest Cu contents, as observed, were in the wheat grains from Narnaul. This enrichment of Cu metal in the grains of Narnaul seems to be in accordance of the soil profile of Narnaul which clearly demonstrates a high level of Cu concentration in its soil due to presence of Copper mine in Khetri which lie nearby to Narnaul. Data is also available for Cu levels in wheat grains from other countries. In Egypt a Cu Level of 1.776 mg/Kg is reported in wheat grains [33] while Italy reported a Cu level of 3.2- 3.4 mg/Kg in its wheat grains [34]. However a Cu Level of 3.78 (3.47-4.1) mg/Kg and 4.79 (3.26-6.5)mg/Kg is reported in the wheat and wheat flour of west Bengal (India) respectively

Wheat grains were measured to have Cr contents encompassing a range of 4.69 to 6.15 μg/g. lowest concentration of 4.69±0.69 μg/g being observed for Gurgaon while wheat from Bhiwani were measured to have highest Cr contents of 6.16 ±0.29 μg/g where soil Cr contents are also observed to be highest. In this study, maximum Cr concentration was assessed in the wheat grains from Bhiwani which again reflect a simple correlation with the soil Cr concentration, being maximum for the soil of Bhiwani. Whereas the minimum soil Cr concentration level for the Gurgaon is reflected in the wheat grains of Gurgaon.

Discussion with Statistical Analysis

Soil analysis

Soil Zn concentration is measured to vary within the range of 41.1±9.09 μg/g to 17.4±3.74 μg/g. Comparatively high zinc level was observed for Mahendergarh soil (41.1±9.09 μg/g) while a minimum level of zinc was observed for soils of Bhiwani (17.4±3.74 μg/g) and Jind (17.7±5.78 μg/g). Cu contents in soil of selected sites of Haryana were measured to vary within the range of 19.93 μg/g to 60.07 μg/g lowest being in the soil of Mahendergarh (19.93±5.24 μg/g) while a quite high level of copper is measured for the soil of Narnaul (60.07±13.82μg/g) and in Rewari (44.2±8.62μg/g).Total Cr and Ni contents in the soils of selected sites encompassed a range between 78.07 μg/g to 109.33 μg/g and 46.47 μg/g to 73.80 μg/g respectively. Minimum Ni level was observed for Chandigarh soil (46.47±8.23 μg/g) and maximum for Rewari soil (73.80±4.86 μg/g). Minimum Cr contents were observed for the soil of Gurgaon (78.07±10.96 μg/g) whereas the soil of Bhiwani location represents maximum Cr level (109.33±9.70 μg/g).

Statistical Analysis of Health risk of Wheat grain Consumption

Bio-concentration of metals in wheat grains

Concentration levels for different metal in wheat grains are tabulated in Table 3 and summarized in Table 4 along with their BCF values.

BCF=Cp/Cs

[Where, **Cp**= Concentration of Heavy Metals in Crop; **Cs**= Concentration of Heavy Metals in Soil]

BCF [Bio Concentration factor (median) (mg/kg dry wt.)] is a common parameter used in the study of crop contamination and is calculated as Hung et al. [35]. A high value of BCF for Cu (0.06) and Zn (0.059) indicate a higher mobility of these two metals from soil to plants. BCF of Ni and Cr metals are 0.049 and 0.047. Instead of having a very high soil concentration levels of these two metals, a lower value of BCF for these two metals indicate a quite low tendency of mobility these metals from soil to crop.

Daily Intake of wheat grains

Wheat is a staple food in Haryana state. On an average the consumption of wheat grains by an urban inhabitant is 0.236 Kg/day and by a rural inhabitant it is 0.303 Kg/day (Table-5) [36].

Risk of individual heavy metal

Potential non-carcinogenic risk for individual heavy metal is expressed as Hazard Quotient (HQ) [28], as is used by Huang et al. [35] for calculation of heavy metals in wheat grain and assessment of potential health risk for inhabitants in Kunshan, China. HQ is calculated by equation:

HQ= CDI/RfDo

$$\mathbf{CDI} = \frac{\mathbf{CF \times IR \times EF \times ED}}{\mathbf{BW \times AT}}$$

Where

[RfDo= Oral Reference Dose (mg/Kg/day); RfDo for Cr=1.5; Cu=4 X 10^{-2}; Ni=2 x 10^{-2}, Zn=0.3 mg/Kg/day] [37]

[CDI= Chronic Daily Intake (mg/kg.day) is exposure expressed as mass of a substance contacted per unit body weight averaged over a long period of time.]

CF=Median conc. of heavy metal in wheat grains

IR=Ingestion rate of wheat (kg/person/day)

EF=Exposure frequency (365 days/year)

ED=Exposure Duration (70 yrs for adults) [39]

BW=Average Body weight (61.1 Kg for adult)[38]

AT=Average Exposure Time for non-carcinogenic effect (ED X 365 days/yr)

Calculated HQ value for different studied metal is presented graphically in Fig. 2 and tabulated in Table 6. Results of HQ calculation for individual metal indicate that HQ value of individual HM are all below 1 which means that the daily intake of individual metal through the consumption of wheat grain would be unlikely to cause adverse health effects for Haryana inhabitants.

Cumulative risk for all heavy metals

To assess the overall potential for non-carcinogenic effects posed by more than one heavy metal, a Hazard Index approach has been used [40]. It is the sum of Hazard Quotient of individual heavy metal.

$$\mathbf{HI} = \sum \mathbf{HQ}$$

When HI exceeds unity, there may be concern for potential health effects.

Under this study, calculated value for HI came out to be 0.808 for urban inhabitants and 1.036 for rural inhabitants of Haryana state.

Table 1: Physiochemical Parameters of Soil Analysis

Location	pH	Conc. of Na^+ ions (mg/Kg)	Conc. of K^+ ions (mg/Kg)	Conductance (µmho)
Rewari	8.73	32.07	21.84	0.212
Gurgaon	8.20	32.4	2.65	0.114
Bhiwani	8.21	27.77	3.08	0.119
Sonipat	8.01	35.52	1.86	0.120
Chandigarh	7.78	27.77	2.34	0.118
Jind	7.72	29.38	4.49	0.182
Narnaul	7.81	32.80	5.92	0.184
Hisar	7.89	32.30	1.20	0.116
Rohtak	7.77	315.39	4.37	0.394
Mahendergarh	7.73	32.90	3.62	0.182

Table 2: Heavy metal concentration levels (µg/g) in soils of selected sites in Haryana

LOCATION	SOIL							
	Cu		Zn		Ni		Cr	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
Rewari	44.20	8.62	31.67	7.23	73.80	4.86	94.27	32.34
Gurgaon	50.13	6.53	18.40	3.60	51.00	7.74	78.07	10.96
Bhiwani	22.07	7.13	17.40	3.74	56.60	4.91	109.33	9.70
Sonepat	37.20	5.06	31.47	4.50	64.93	8.19	92.00	7.81
Chandigarh	22.20	4.54	19.87	4.07	46.47	8.23	92.60	10.55
Jind	24.20	5.33	17.73	5.78	49.13	5.99	92.47	8.18
Narnaul	60.07	13.82	35.33	9.18	61.27	5.78	88.80	8.87
Hisar	22.00	5.79	31.67	19.11	48.13	5.78	102.87	8.42
Rohtak	34.33	9.15	31.13	10.05	68.33	12.86	94.87	15.30
Mahendergarh	19.93	5.24	41.13	9.09	57.00	8.64	93.07	9.89
Permissible Limits a	20		80		25		n/a	
b	50-140		150-300		30-75		100.00	
c	135-270		300-600		75-150		n/a	
d	10							
e			50					

a=Limits evaluated by Rowell (1994); b=By European Community Commission (ECC) (1986); c=Permissible limits of Indian Standards (Awasthi,2000; Sharma et al.,2006; Gupta et al., 2008); d=WHO (1998); e=Pilc et al. (1994)

Table 3: Heavy metal concentration (µg/g) in wheat grains of selected sites.

LOCATION	WHEAT							
	Cu		Zn		Ni		Cr	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
Rewari	2.32	0.44	1.73	0.44	3.57	0.33	5.13	0.85
Gurgaon	2.24	0.35	0.85	0.51	2.57	0.43	4.69	0.69
Bhiwani	1.53	0.62	1.54	0.52	2.89	0.16	6.15	0.29
Sonepat	2.37	0.30	1.81	0.36	3.14	0.34	5.17	0.80
Chandigarh	2.03	0.78	1.11	0.31	1.92	0.47	5.32	0.71
Jind	1.36	0.35	1.55	0.75	2.14	0.11	5.61	0.51
Narnaul	3.71	0.71	1.99	0.61	3.03	0.24	5.31	0.57
Hisar	1.23	0.38	2.13	0.24	2.62	0.55	5.79	0.57
Rohtak	2.36	0.51	1.89	0.40	3.20	0.60	2.36	0.51
Mahendergarh	1.82	0.55	2.46	0.65	4.10	1.68	5.38	0.55

Table 4: metal concentration (µg/g) in food grains of selected sites in Haryana.

	Cu			Zn			Ni			Cr		
	Range	**Median**	**BCF (Cp/Cs)**	**Range**	**Median**	**BCF (Cp/Cs)**	**Range**	**Median**	**BCF (Cp/Cs)**	**Range**	**Median**	**BCF (Cp/Cs)**
WHEAT	1.23-3.71	2.135	0.06	0.85-2.46	1.77	0.059	1.92-3.57	2.96	0.049	4.69-6.15	5.315	0.057

Cp/Cs =BCF Bio Concentration factor (median) (mg/kg dry wt.)

Table 5: Average quantity of consumption of wheat per person per day for Rural and Urban areas in Haryana [36].

Consumption Rate (Kg) of Wheat per Person per Day		
	URBAN	RURAL
WHEAT	0.236	0.303

Table 6: HQ of individual heavy metals in wheat grains for different population in Haryana.

HEAVY METALS	WHEAT	
	URBAN	**RURAL**
Cu	2.04×10^{-1}	2.62×10^{-1}
Zn	2.3×10^{-2}	2.9×10^{-2}
Ni	5.67×10^{-1}	7.27×10^{-1}
Cr	1.4×10^{-2}	1.7×10^{-2}

Fig. 1: Selected locations of South Haryana from where sampling was done

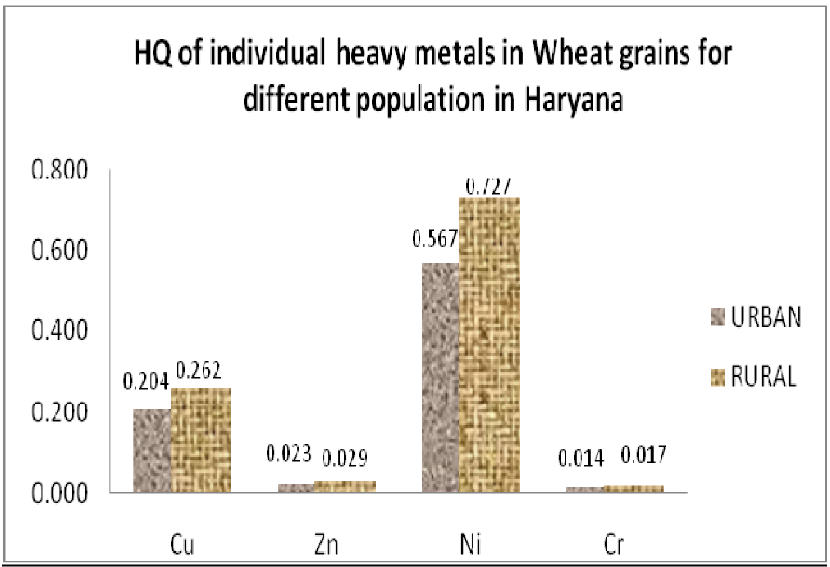

Fig. 2: HQ of individual heavy metals in Wheat grains for different population in Haryana

CONCLUSION

Concentration levels of heavy metals in wheat grains lie in the sequence of Cr(5.315)>Ni(2.96)>Cu(2.135)>Zn(1.77) but BCF sequence is Cr(0.047)<Ni(0.049)<Zn(0.059)<Cu(0.06) indicating that Cr and Ni metals have less mobility from soil to crop.

The possible health risk from individual heavy metal was not notable but the aggregate risks of four heavy metals for urban inhabitants are less (HI<1) while for rural inhabitants it is more (HI>1), indicating a border line health hazard risk via consumption of these wheat grains for rural inhabitants.

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