

## Comparison of Heavy Metals in Food Grains of Tribal, Rural and Urban Areas in India

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### Abstract

It is well known that general population of India is dependent on rice, wheat and pulses as a staple food for daily life. Lead (Pb) and cadmium (Cd) are well known toxic elements while iron, nickel, manganese, cobalt, chromium, copper and magnesium are essential micronutrients. Some of them form an integral part of several enzymes and biological activity for both plants and humans. Cereals and pulses are also a major sources of exposure of metals to human. The level of metals namely Pb, Cd, Fe, Ni, Mn, Co, Cr, Cu and Mg were measured in rice, wheat and pulses. Cereal and pulse samples were collected from urban, rural and tribal areas of different states, namely Madhya Pradesh, Uttar Pradesh, Orissa, Karnataka and Gujarat of India and were analyzed by atomic absorption spectrophotometer. The samples were processed following sample dissolution followed by acid digestion. Pulses from urban and rural areas showed significantly higher concentration of Pb deposition than tribal areas, Ni and Mn were found to be significantly in higher concentration in tribal areas than rural areas while Fe content was significantly lower in rural areas as compared to tribal and urban areas. Cobalt level was significantly lower in pulses of tribal areas than rural areas while in rice it was significantly lower in tribal area than rural area. There were no significant changes observed in other elements among cereals and pulses of urban, rural and tribal areas. It might be concluded that the grain particularly pulses grown in tribal areas have lesser accumulation of Pb and rich in micronutrient (Fe). It may be due to the reason that tribal areas are still having less environmental pollution compared to rural and urban areas.

**Key words :** Heavy metals, Cereals, Pulses, Urban, Rural.

Cereals particularly rice, wheat and pulses constitute primary source of food in Indian subcontinent. They are the staple food for general Indian population. Metals are naturally occurring elements in the environment with both beneficial and toxic properties. Some of them form an integral part of several enzymes. Although they are essential, if they are taken beyond a certain limit they may become harmful to health, so the toxicity and beneficial effects depend upon the level of their intake which will be governed by their presence in food. The health effect of metals on human varies from metal to metal. Some are essential micronutrient like Cu, Mn, and Zn, however Ni and Sn are likely to be essential micronutrient but their beneficial role towards human health is yet to be ascertained (1). Some elements like Cd and Pb are well known for their adverse effects on human health. Sometimes chemical forms or speciation also changes

their role from toxic to beneficial (Cr III is trace element while Cr VI is toxic). Metal concentration present in cereals and pulses depends on nature of soil and their bioavailability to the plant. Environmental pollution, human developmental activities, use of fertilizers, fungicides, insecticides, and herbicides to crop also affect the metal uptake in agricultural produce. The physical and chemical form of their application can enhance metal content in plants and vegetables (2, 3). The rapid industrialization and developmental activities have resulted in environmental pollution and some of the chemical contaminants are not biodegradable and thus they are biomagnified in food chain (4). The chronic exposure of the heavy metals through cereals even at low level may be harmful to the population consuming these cereals. Cereals are also a rich source of dietary fibers, which prevent diseases like colon cancer, obesity and cardiovascular disease

**Table 1.** Instrument conditions for the analysis of different metals on atomic absorption spectrophotometer (AAS). \*The lower limit of each working range is approximately 10 × of detection limit. The upper limit of each working range gives approximately 0.8 absorbance.

Metal	Lamp current (mA)	Wave length (nm)	Slit width (nm)	Working range (ppm)*
Cu	3	228.8	0.5	0.01—4
Pb	3	327.7	0.5	0.1—12
Cr	6	240.7	0.2	0.03—10
Cd	6	357.9	0.2	0.004—1.8
Fe	5	279.0	0.2	0.05—8
Ni	3	285.0	0.5	0.09—8
Co	4	232.0	0.2	0.04—10
Mn	7	248.0	0.2	0.015—4
Mg	5	217.0	0.2	0.003—0.6

(5). The present study was undertaken to evaluate the presence of heavy metals in cereals particularly in rice, wheat and pulses and find out if there is any difference among tribal, rural and urban areas from different states of India viz. MP, Orissa, Karnataka, Gujarat and UP.

**Methods**

*Chemicals and Glasswares*

Nitric acid and perchloric acid used were of analytical grade and purchased from E. Merck, Mumbai, India. Double distilled water of conductivity less than 1 µs/cm was used for diluting the samples and acid, standards of National Institute of Standard and Technology (NIST) traceability for Cu, Pb, Cr, Cd, Fe, Ni, Co Mn and Mg were procured from E. Merck, Mumbai. Glasswares used were ultraclean and were dipped in 1% nitric acid over night prior to use and washing for metal analysis.

*Sample Collection*

A total number of 77 representative samples of cereals and pulses were collected from local groceries and vendors present in urban, rural and tribal areas of respective states of India viz. MP (Rewa), Orissa (Cuttack), Karnataka (Mangalore), Gujarat (Surat), UP (Agra). Samples were collected by suburban location and it was assumed that the grains col-

**Table 2.** Concentration of different metals concentrations in rice of urban, rural and tribal areas. Values are expressed as mean ± SD ; values given in parentheses denote the number of samples, P < 0, 05 vs rural areas (Student's t-test). ND—Not detectable.

Me-tal	Area	Concentration (ppm)	Range (ppm)
Cu	Urban (12)	0.9712 ± 0.259	0.325—1.258
	Rural (13)	1.6521 ± 1.751	0.207—6.104
	Tribal (4)	1.14 ± 0.248	0.811—1.381
Pb	Urban (12)	0.3946 ± 0.630	0—1.779
	Rural (13)	0.674 ± 0.845	0—1.822
	Tribal (4)	0.305 ± 0.524	0—1.086
Cr	Urban (12)	0.705 ± 1.262	0—4.130
	Rural (13)	1.159 ± 1.500	0—5.310
	Tribal (4)	1.086 ± 1.234	0—2.243
Cd	Urban (12)	0.003 ± 0.013	0—0.004
	Rural (13)	0.012 ± 0.042	0—0.153
	Tribal (4)	ND	ND
Fe	Urban (12)	148.56 ± 102.617	2.775—314.50
	Rural (13)	109.659 ± 73.998	8.730—273.69
	Tribal (4)	166.049 ± 120.757	51.164—336.116
Ni	Urban (12)	0.353 ± 0.502	0—1.429
	Rural (13)	0.342 ± 0.492	0—1.560
	Tribal (4)	0.251 ± 0.502	0—1.005
Co	Urban (12)	0.034 ± 0.12	0—0.418
	Rural (13)	0.048 ± 0.077	0—0.214
	Tribal (4)	ND	ND
Mn	Urban (12)	6.464 ± 3.750	1.420—15.429
	Rural (13)	5.717 ± 5.632	0.632—27.77
	Tribal (4)	2.476 ± 3.334	0—7.055
Mg	Urban (12)	147.751 ± 118.069	0—438.31
	Rural (13)	268.876 ± 410.674	0—1583.766
	Tribal (4)	219.727 ± 215.435	45.819—521.654

lected were grown locally.

*Metal Analysis*

Samples were cleaned for any extraneous material and washed with distilled water, air dried and grinded with the help of pestle and mortar. Accurately weighed sample of cereal and pulses were wet digested with concentrated nitric acid and mixture of nitric acid and perchloric acid in ratio of 6 : 1 until a clear residue was obtained. Simultaneously reagent blank were prepared for respective batch of samples processed. The residue was redissolved in 1% nitric acid and volume was made up to 10.0 ml. The samples were then analyzed on atomic absorption spectrophotometer (GBC AvantaΣ, Australia) with background correction. The instrument conditions are given in Table 1. Standard stock solutions 1000 µg/ml

**Table 3.** Concentrations of different metal in pulses from urban, rural and tribal areas. Values are expressed as mean  $\pm$  SD ; values given in parentheses denote the number of samples. \*  $P < 0.05$ , \*\*  $P < 0.001$  significantly different vs urban areas. # $P < 0$ , ##  $P < 0.001$  significantly different vs rural areas (Students  $t$ -test). ND—Not detected.

Metal	Area		Concentration (ppm)	Range (ppm)
Cu	Urban	(24)	3.975 $\pm$ 1.110	2.117—5.793
	Rural	(18)	4.270 $\pm$ 1.044	1.361—5.653
	Tribal	(8)	4.296 $\pm$ 1.249	2.436—5.656
Pb	Urban	(24)	0.821 $\pm$ 0.926	0—2.590
	Rural	(18)	1.091 $\pm$ 0.877	0—2.943
	Tribal	(8)	0.045 $\pm$ 0.084**	0—0.190
Cr	Urban	(24)	0.622 $\pm$ 0.622	0—4.459
	Rural	(18)	0.650 $\pm$ 0.653	0—1.900
	Tribal	(8)	1.674 $\pm$ 1.29	0—3.458
Cd	Urban	(24)	ND	ND
	Rural	(18)	ND	ND
	Tribal	(8)	1.863 $\pm$ 3.740	0—10.166
Fe	Urban	(24)	226.353 $\pm$ 189.214	54.683—836.965
	Rural	(18)	131.930 $\pm$ 99.522*	28.366—482.696
	Tribal	(8)	214.150 $\pm$ 184.861 # #	57.009—517.976
Ni	Urban	(24)	0.864 $\pm$ 0.825	0—2.266
	Rural	(18)	0.520 $\pm$ 0.811	0—2.342
	Tribal	(8)	1.066 $\pm$ 1.203 #	0—2.951
Co	Urban	(24)	0.399 $\pm$ 0.813	0—3.652
	Rural	(18)	0.423 $\pm$ 0.511	0—1.329
	Tribal	(8)	0.102 $\pm$ 0.122 #	0—0.301
Mn	Urban	(24)	8.467 $\pm$ 3.986	4.234—17.189
	Rural	(18)	6.867 $\pm$ 3.322	2.468—15.867
	Tribal	(8)	7.022 $\pm$ 4.186	1.718—12.890
Mg	Urban	(24)	751.139 $\pm$ 397.159	9.722—1706.517
	Rural	(18)	865.959 $\pm$ 292.141	103.570—1241.603
	Tribal	(8)	1085.309 $\pm$ 371.799 #	488.68—1286.08

were purchased from E. Merck Mumbai with NIST traceability and diluted to working standard solution within the linear range for each element. Calibration curves were prepared using least concentration square,  $R$  and  $R^2$  were more than 0.999 and coefficient of variation was not more than 5% at lowest standard range. Standard were also processed simultaneously with each batch of sample analyzed. The detection limit for each metal was measured when signal/noise ratio less than 4 was observed. Recovery experiments were also performed for each metal and each matrix and found greater than 90%. Blank samples were run simultaneously for each set of digestion.

#### Statistical Analysis

Data were presented as mean  $\pm$  SD. Student  $t$ -test was applied to assess the significance of differ-

ence between samples collected from tribal versus urban and rural and urban versus rural areas. Probability value less than 0.05 was considered statistically significant difference.

#### Results and Discussion

A total of nine metals viz. Pb, Cd, Fe, Ni, Mn, Co, Cr, Cu and Mg were analyzed in rice, wheat and pulse samples collected from urban, rural and tribal areas of different states of India i.e. MP, UP, Karna-taka, Gujarat and Orissa. Mean concentration and range of each metal in rice, wheat and pulse are given in Tables 2, 3 and 4, respectively.

Lead content in pulses from tribal area was found to be significantly lower than that in rural and urban areas. The Fe concentration in pulses from tribal and urban areas was significantly higher as compared to samples from rural areas. However, there was no sig-

**Table 4.** Concentrations of different metals in wheat\* of urban and rural areas. Values are expressed as mean  $\pm$ SD, values given in parentheses denote the number of samples. \*Samples could not be collected from tribal areas.

Metal	Area	Concentration (ppm)	Range (ppm)
Cu	Urban (4)	2.068 $\pm$ 0.201	1.836—2.327
	Rural (4)	1.609 $\pm$ 0.825	0.910—2.663
Pb	Urban (4)	0.816 $\pm$ 1.117	0—2.368
	Rural (4)	0.716 $\pm$ 0.573	0—1.267
Cr	Urban (4)	0.051 $\pm$ 0.103	0—0.207
	Rural (4)	0.412 $\pm$ 0.791	0—1.598
Cd	Urban (4)	0.004 $\pm$ 0.009	0—0.019
	Rural (4)	0.593 $\pm$ 1.187	0—2.374
Fe	Urban (4)	191.292 $\pm$ 89.606	70.023—269.32
	Rural (4)	216.368 $\pm$ 106.471	105.652—345.581
Ni	Urban (4)	0.244 $\pm$ 0.241	0—0.563
	Rural (4)	0.377 $\pm$ 0.191	0.205—0.593
Co	Urban (4)	0.080 $\pm$ 0.095	0—0.187
	Rural (4)	0.020 $\pm$ 0.04	0—0.080
Mn	Urban (4)	12.760 $\pm$ 2.712	9.760—15.223
	Rural (4)	14.975 $\pm$ 3.477	11.904—19.880
Mg	Urban (4)	811.262 $\pm$ 195.954	632.53—998.05
	Rural (4)	531.587 $\pm$ 488.686	0—1136.99

nificant difference found between tribal and urban areas. The level of nickel in pulses from tribal area was significantly higher as compared to rural area. Cobalt concentration was significantly lower in pulses from tribal areas as compared to that of rural areas. Magnesium contents in pulses from tribal areas were significantly higher compared to samples from rural areas (Table 3).

In the rice samples from tribal areas cobalt was not detected (Table 2). No significant difference was observed in concentration of Cu, Cr, Cd and Mn among pulses of tribal, urban and rural areas. Metals examined in wheat and rice showed no significant difference except cobalt in rice of rural areas (Tables 3 and 4).

Lead is categorized as a potentially toxic element. It is present in general environment (6—11) and once absorbed it persists in human body for a longer period and get accumulated in bones (7, 9). It is well documented that the general population is exposed to chemical pollutants by non-occupational exposure and through foods besides atmospheric air (12—14). The lower Pb content in pulses from tribal areas when compared with samples from rural and urban areas may be attributed to the reason that tribal areas

are still not exposed to industrial and human developmental activities and they are more clean and natural. Iron content in pulses from tribal areas was higher compared to the samples from rural areas; which might be due to higher uptake/deposition of iron in pulses of tribal areas while in urban and rural areas, the uptake/deposition of iron might be influenced by human developmental activities which are minimum in tribal areas. However, higher level of nickel in pulses from tribal areas compared to samples from rural areas could not be logically explained. The level of cobalt in rice and pulses were lower in tribal area compared to samples from rural areas that might be due to the micronutrient deficient soil, which needs to be further investigated or due to lower uptake of cobalt in rice and pulses crops as there might be some environmental factors and chemicals used. The level of magnesium in cereals and pulses was present in higher proportion compared to other elements analyzed. It is a constituent of chlorophyll and plays a major role in many biochemical reactions. Higher level of magnesium in pulses from tribal areas may be attributed to greater uptake from soil. It may be concluded that the level of toxic elements like lead is lower and some essential elements are higher in pulses from tribal areas while no significant changes were observed in rice and wheat.

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