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Estimation of some heavy metals in the wheat varieties of Balochistan

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Abstract

Heavy metals are present in our environment and they are also absorbed by plants. Their bioaccumulation is harmful for all life forms. Plants are found to absorb heavy metals like Cu, Zn, Ni, Cr and Pb which when cross their desired level has adverse effects on plants. Wheat is one of the main foods which is consumed by the most of the world's population. In the present study, some heavy metals like chromium, zinc, copper, nickel and lead were determined by Atomic Absorption Spectroscopy in twenty wheat samples. The average chromium was 0.12 ± 0.01 mg/kg, Lead 0.25 ± 0.05 mg/kg, Zinc 9.20 ± 0.38 mg/kg, Copper 2.82 ± 0.34 mg/kg, Nickel 3.17 ± 0.24 mg/kg. The heavy metals lead, chromium and nickel were found slightly higher than the permissible limits. However zinc and copper were within the permissible limits. Significant differences existed among all the five heavy metals at P< 0.05. Principal component analysis (PCA) was applied to identify spatial variation in elemental composition of wheat varieties, in which 86.8% of the total variance in whole set of data was found. PCA of metal profile divided wheat varieties into two main groups Raskoh, Abdul Sattar, Sehar, L-3, Shalkot, Benazir, TD-1, Faisalabad 2008, AZRI-1, Zardana, AZRC-1 and Taijban10 correlated with lead whereas Umeed, Ujala-2015, Zargoon, Shahkar, Galaxi and Zarlashta correlated with chromium, nickel and zinc.

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Introduction

Presence of heavy metals, like nickel, cobalt, cadmium, copper, lead, chromium and mercury in air, soil and water can cause bioaccumulation affecting the entire ecosystem and pose harmful health consequences in all life forms. The plants can absorb these metals. It has been experimentally proved that heavy metals like copper, lead, mercury and zinc are easily absorbed by the plants. Plants absorb toxicants either directly from the atmosphere through the leaves, or from soil or water through the roots.

Wheat is main staple food of Pakistan grown on area of 8.41 m/ha with annual production of 21.83 million tones and the average yield of 2596 kg/ha. Wheat is one of the main crops and an integral constituent of the national diet. It plays a vital role in human growth by providing carbohydrates, proteins and certain minerals. Consumption of grain is safe when accumulation of metals is under the permissible limits. However, when accumulations exceed the permissible limit, it exerts toxic effects and may produce a variety of diseases in human (Al-Othman *et al.*, 2012).

In developing countries, the rapid use of industrialization has increased the addition of heavy metals in to the soil. The pollution of heavy metals is a major problem and its contamination is harmful for agriculture, wild life and humans. In maize, wheat, potato, peas and radish the effect of hexavalent chromium (Cr-VI) was studied. The decrease of root growth, biomass, photosynthetic impairment and finally death of plant occurred when chromium interferes with several metabolic activities (Sangwan *et al.,* 2016). Lead (Pb) is one of the most common heavy metal contaminants in both aquatic and terrestrial ecosystem and can have adverse effect on metabolic and growth of plant, according to the US Environmental Protection Agency, Owing to its direct release into the atmosphere. Lead is toxic to plants and human beings (Lamhamdi *et al.*, 2011). Wheat is the staple food for 40 % of the world's population and is grown on 17 % of all crop areas which is primary food staple in the North Africa (Maccaferri *et al.,* 2009). Spinach has significant antioxidant activity and important dietary crop, which constitute its major water- soluble polyphenols, mainly related to the presence of flavonoids. So, it appeared to be of interest to compare the effects of lead exposure on these two important agricultural species wheat and spinach (Lamhamdi *et al.*, 2011).

It is estimated that about 10 % of all the protein in the human body that reaches 300 % proteins are all Zinc (Zn) dependent. Zn has diverse physiological functions in biological systems. It interacts with large number of protein and enzymes in the body which perform critical structural, functional and regulatory rules (Cakmak and Kutman. 2018).

The required proper growth and development of plant is predictable by Nickel (Mazzafera *et al.*, 2013). The requirements of nickel are the lowest of all essential elements which is below 0.5 mg/kg dry weight (FAO and WHO. 2011). The effect of Ni is observed at multiple levels in which one of them is observed that is disrupting the nutritional status of plant. Ni interferes with uptake, distribution and transport of macro and micronutrients (Sreekanth *et al.* 2013). This study has been designed to analyze heavy metals in some wheat varieties that are commonly grown in Balochistan, particularly in Quetta. Quetta is the provincial capital of Balochistan, which is also ninth largest city of Pakistan. Quetta is a valley with less industrialization, therefore rare chances of heavy metal pollutions.

Materials and methods

The varieties of wheat (*Triticum aestivum* L.) that are popular and grown in Balochistan due to their tolerance of cold, water and drought were chosen and collected from Balochistan Agriculture Research and Development center, Quetta. Twenty wheat samples were analyzed for this study (Table 1). These samples were washed and then dried in oven. For heavy metal analysis these grains were grinded to form flour by using electrical grinder. Lead, Chromium, Zinc, Copper and Nickel were determined after wet

digestion of grains according to the method of Wolf (1982). In digestion tube, wheat sample (grain's flour) was taken and 1 ml concentrated sulphuric acid was added. The sample were kept overnight and then digested for 30 min at 300 degree centigrade. After digestion 1 ml hydrogen peroxide was added for the transparency of the material. The clear extract obtained was use for analysis of heavy metals by Atomic Absorption Spectroscopy. Three replicates of each variety were analyzed for the heavy metals and their average was taken for accuracy. The significance value was analyzed at $P \leq 0.05$ by SPSS (Version 20). For variability among different species of wheat, principal component analysis (PCA) was also done.

Results and discussion

The mean values of heavy metals for triplicates of each wheat variety has been presented in Table 2.

The statistical analysis of all the heavy metals (Table 3) has shown significant differences among the analyzed heavy metals in the wheat varieties.

Table 1. Different wheat varieties grown in Balochistan.

No	Variety name	No	Variety name
1	Umeed	11	Raskoh
2	Pirsabaq	12	Faisalabad 2008
3	Ujala-2015	13	AZRI-1
4	Abdul Sattar	14	Shalkot
5	L-3	15	Zardana
6	Zarghoon	16	Galaxi
7	Shahkar	17	Benazir
8	Sariab	18	Zarlasta
9	TD-1	19	AZRC-1
10	Sehar	20	Taijban-10

Chromium

The concentration of Cr in twenty wheat varieties are presented in Fig.1. The higher concentrations of chromium was found in Ujala-2015, Zarghoon, Sahakar, TD-1, Galaxi and Zarlashta (0.19, 0.19, 0.12, 0.17, 0.17 and 0.18 mg/kg) followed by Umeed, Pirsabaq, Abdul Sattar, L-3, Saraib, Sehar, Raskoh, Faisalabad 2008, AZRI-1, Shahkot and Banezir (0.10, 0.11, 0.09, 0.11, 0.11, 0.12, 0.13, 0.09, 0.08, 0.10 and 0.10 mg/kg) respectively. Whereas Zardana, AZRC-1 and Taijban-10 (0.07, 0.07, and 0.07 mg/kg) had least concentration of chromium (Table 2).

Table 2. Heavy metals concentration in various wheat varieties of Quetta.

No	Varieties	Lead	Chromium	Zinc	Nickel	Copper
1	Umeed	0.11*	0.10*	9.55**	3.91**	3.22**
2	Pirsabaq	0.13*	0.11*	9.50**	3.89**	2.24*
3	Ujala-2015	0.20**	0.19**	12.2**	4.42**	6.00**
4	Abdul Sattar	0.70**	0.09*	7.98*	3.10*	2.10*
5	L-3	0.70**	0.11*	8.00*	3.08*	2.16*
6	Zarghoon	0.16*	0.19**	11.5**	4.22**	5.91**
7	Shahkar	0.18**	0.17**	13.5**	4.00**	4.10**
8	Sariab	0.14*	0.11	9.45**	3.82**	2.21*
9	TD-1	0.40**	0.17**	7.99*	2.82*	1.90*
10	Sehar	0.12*	0.12*	8.98**	3.06*	2.20*
11	Raskoh	0.11*	0.13*	8.76**	2.92*	2.19*
12	Faisalabad 2008	0.40**	0.09*	7.97*	2.42*	1.55*
13	AZRI-1	0.50**	0.08*	7.96*	2.22*	1.86*
14	Shalkot	0.09*	0.10*	8.83**	3.93**	1.92*
15	Zardana	0.04*	0.07*	7.55*	1.24*	1.86*
16	Galaxi	0.16**	0.17**	10.9**	4.10**	5.88**
17	Benazir	0.60**	0.10*	8.79**	3.94*	1.43*
18	Zarlashta	0.15**	0.18**	10.2**	4.00**	4.08**
19	AZRC-1	0.05*	0.07*	7.25*	1.24*	1.77*
20	Taijban-10	0.05*	0.07*	7.12*	1.00*	1.82*

** Higher concentration of ions in grain.

*Lower concentration of ions in grain.

In the present study the average Cr concentration was 0.12 ± 0.01 mg/kg (Table 3). The Cr content in wheat grains was found to be higher than the permissible limit of 0.02 mg/kg in this study. Higher values have been reported from Abbottabad in Pakistan and from Uttar Pradesh (8.16 and 8.0 mg/kg) in India (Hassan *et al.*, 2013). The results of the present study were in accordance with some previous reports (Frost and Ketchum, 2000 and Zhu *et al.*, 2011).

Table 3. Descriptive Statistics and Significance values of Heavy metals in various wheat varieties.

Heavy Metals	Permissible Limit mg/kg	Minimum mg/kg	Maximum mg/kg	Mean mg/kg	Std Error	Std. Deviation	P – Value (0.05 level)
Pb	0.24	0.04	0.70	0.25	0.05	0.22	0.00
Cr	0.02	0.07	0.19	0.12	0.01	0.04	0.00
Zn	27.4	7.12	13.50	9.20	0.38	1.71	0.00
Ni	1.63	1.00	4.42	3.17	0.24	1.06	0.00
Cu	3.00	1.43	6.00	2.82	0.34	1.52	0.00

The concentration level of chromium was 0.43 mg kg^{-1} found in wheat reported by (Tegegne *et al.*, 2015) and the content of Cr in the wheat roots was 3.36–5.97 mg kg^{-1}, which was slightly higher than that in rice roots at the same location (Liu *et al.* 2009). The natural levels of As, Cr, and Ni in many Southeast Asian soils is significantly higher than European soils (Khalid *et al.*, 2011). As Balochistan is rich in minerals, and especially chromite is mined here, therefore chromium might be rich in soil and water and that's why higher in wheat in the present study.

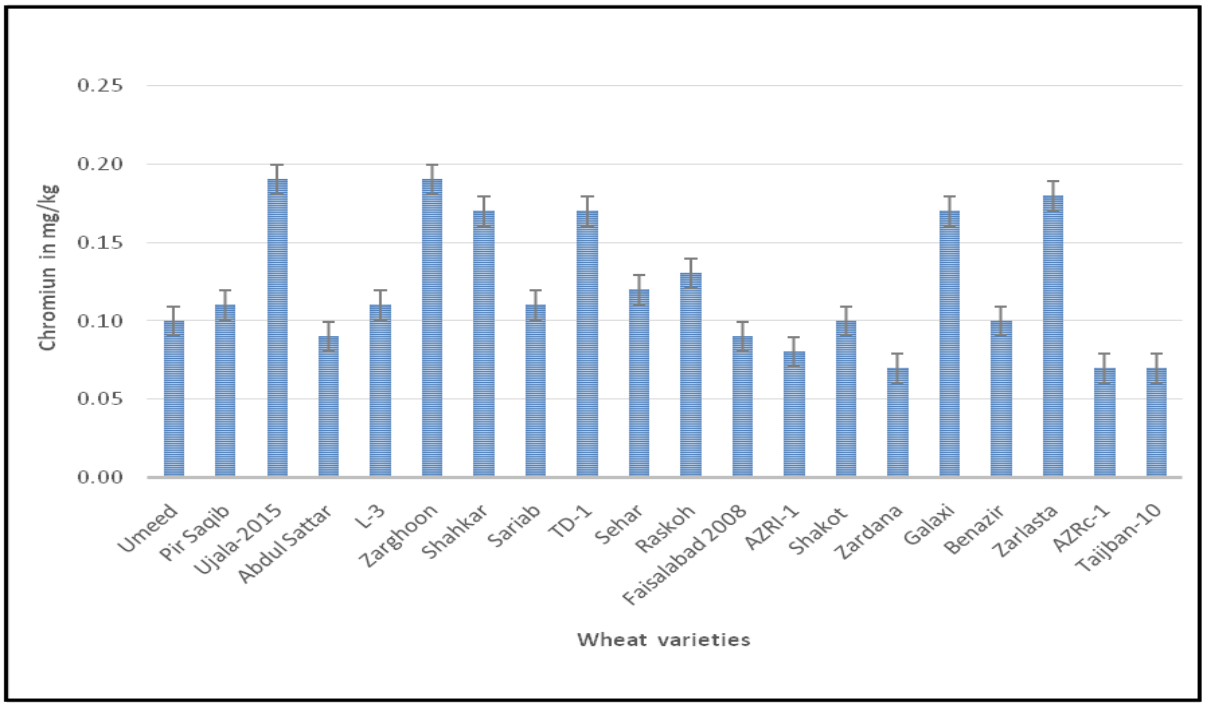

Fig. 1. The mean concentrations of chromium on all the twenty varieties.

Lead

In the present study, concentration of lead in various varieties of wheat grains is shown in Fig. 2. The higher concentrations were found in Abdul Sattar, L-3, TD-1, Faisalabad 2008, AZRI-1 and Benazir (0.70, 0.70, 0.40, 0.40, 0.50 and 0.60 mg/kg) which were in excess. However, other varieties were within the limits i.e., Umeed, Pirsabaq, Ujala-2015, Zarghoon,

Shahkar, Sariab, Sehar, Raskoh, Shallot, Galaxi and Zarlashta (0.11, 0.13, 0.20, 0.16, 0.18, 0.14, 0.12, 0.11, 0.09, 0.16 and 0.15 mg/kg). While the three varieties were found lower in few samples i.e., Zardana, AZRC-1 and Taijban-10 (0.04, 0.05 and 0.05 mg/kg) as show in Table 2. In our study the average lead content (0.25 ± 0.05) was close to the permissible limit (0.24 mg/ kg), however the maximum value found was 0.7 mg/kg (Table 3). Tegegne *et al.*, 2015 reported that the lead concentration in wheat was found to be 0.05 mg/kg. The limit of 240 µg/kg dry weight (DW) for wheat has been proposed as the maximum Pb level for cereal grains (Joint FAO/WHO, 2011).

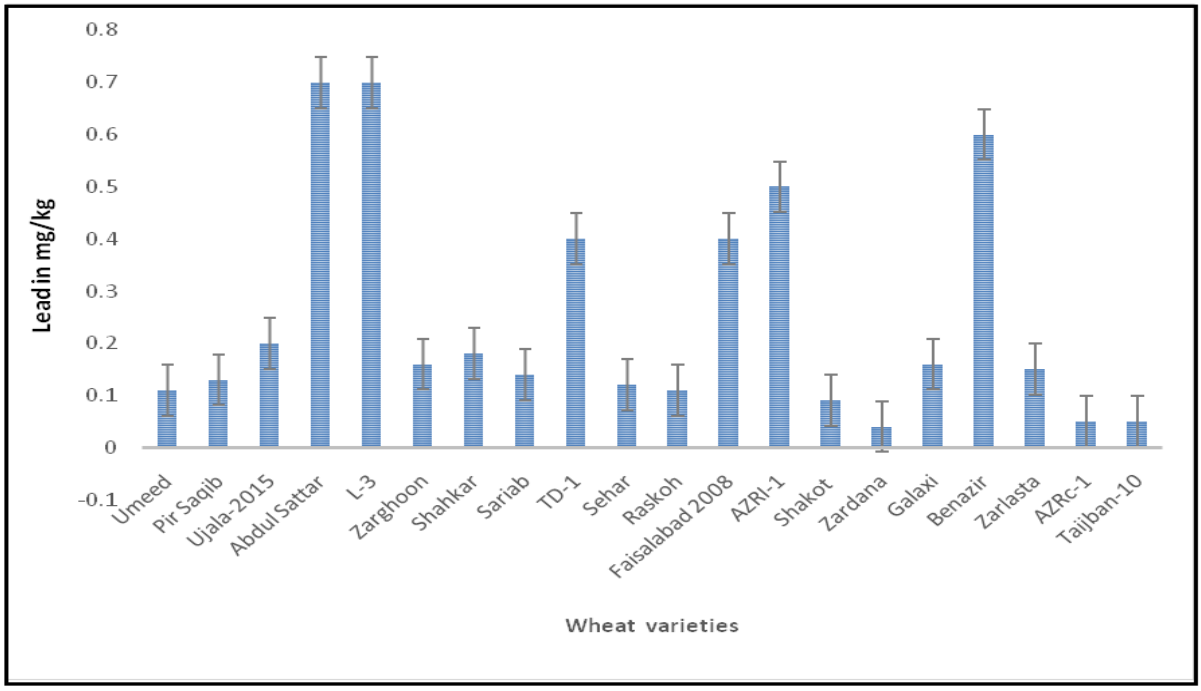

Fig. 2. The concentrations of Lead on all the twenty varieties.

The Pb concentration in wheat grains reported by most authors is high, ranging from 0.015 to 22.6 mg/kg. The concentration value of Pb by Hassan *et al.*, (2013) was found to be 0.35 mg/kg which is similar to Hussain *et al.*, (2011) from the same country (22.6 and 0.12 mg/kg, respectively). The higher concentration of lead in wheat grains may be due to irrigation by wastewater or amended by sludge.

Zinc

The data concentration of zinc in different wheat genotypes are subjected to analyzed and found significant among the wheat varieties. Fig. 3 reveals that maximum zinc concentration in Ujala-2015, Zarghoon, Shahkar, Galaxi and Zarlashta (12.22, 11.54, 13.53, 10.95 and 10.22) varieties. Whereas lower values of zinc in Umeed, PirSabaq, Abdul Sattar, L-3, Sariab, TD-1, Sehar, Raskoh, Faisalabad 2008, AZRI-1, Shahkot, Zardana, Benazir, AZRC-1 and Taijban-10 (9.55, 9.50, 7.98, 8.00, 9.45, 7.99, 8.98, 8.76, 7.97, 7.96, 8.83, 7.55, 8.79, 7.25 and 7.12 mg/kg) as presented in Table 2.

In the current study the average value of zinc obtained was 9.20 ± 0.38 (Table 3). Like copper, Zn is the most studied element in wheat grains, and it ranges from a few milligrams to hundreds of milligrams/kg.

In a previous study, the value of Zn was found to be 35.3 mg/kg, which became higher than the values reported from the same region (3.01 mg/kg) few years ago (Hassan *et al*, 2013). The variation in the values is possibly due to the input of these metals into the soil by different routes. Many heavy metals are entering into the environment by increase in industrialization.

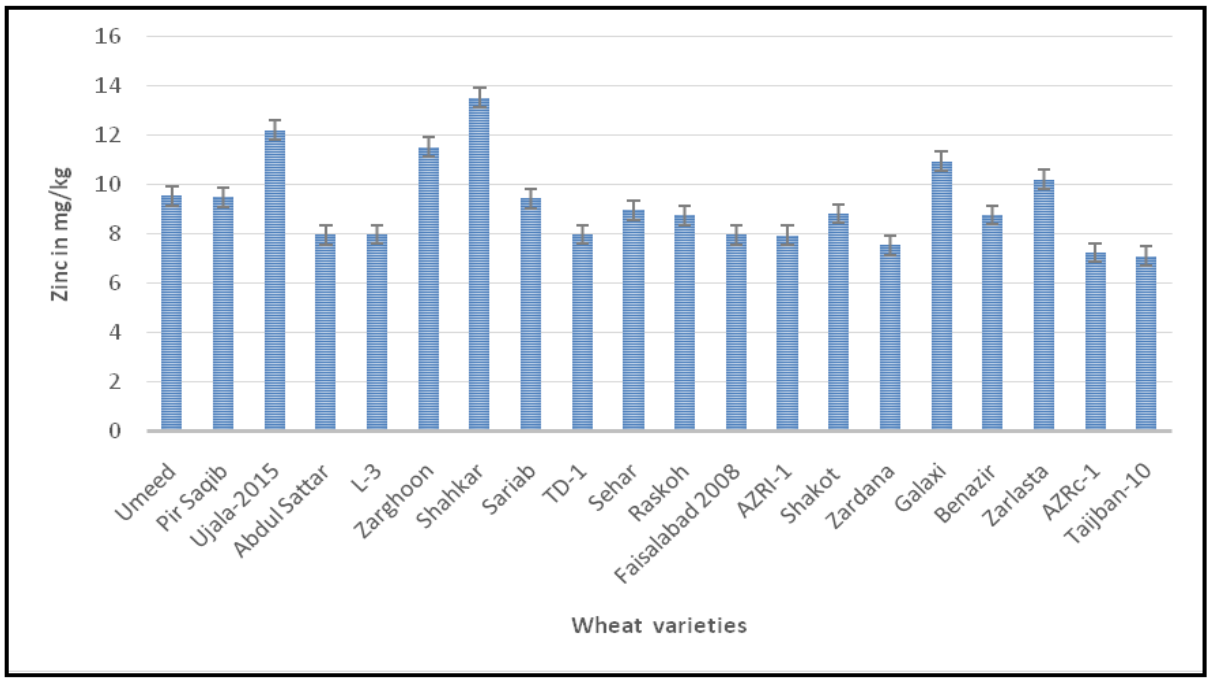

Fig. 3. The concentrations of Zinc on all the twenty varieties.

As Quetta is a less industrialized city therefore, there are less chances of entrance of heavy metals. Tegegne *et al*, 2015 reported the level of zinc 8.54 mg kg in wheat, which are similar to our results.

Copper

Data regarding the values of Cu in twenty wheat varieties (Table 2) and their effect on grain responded significantly and shown in Figure-4.

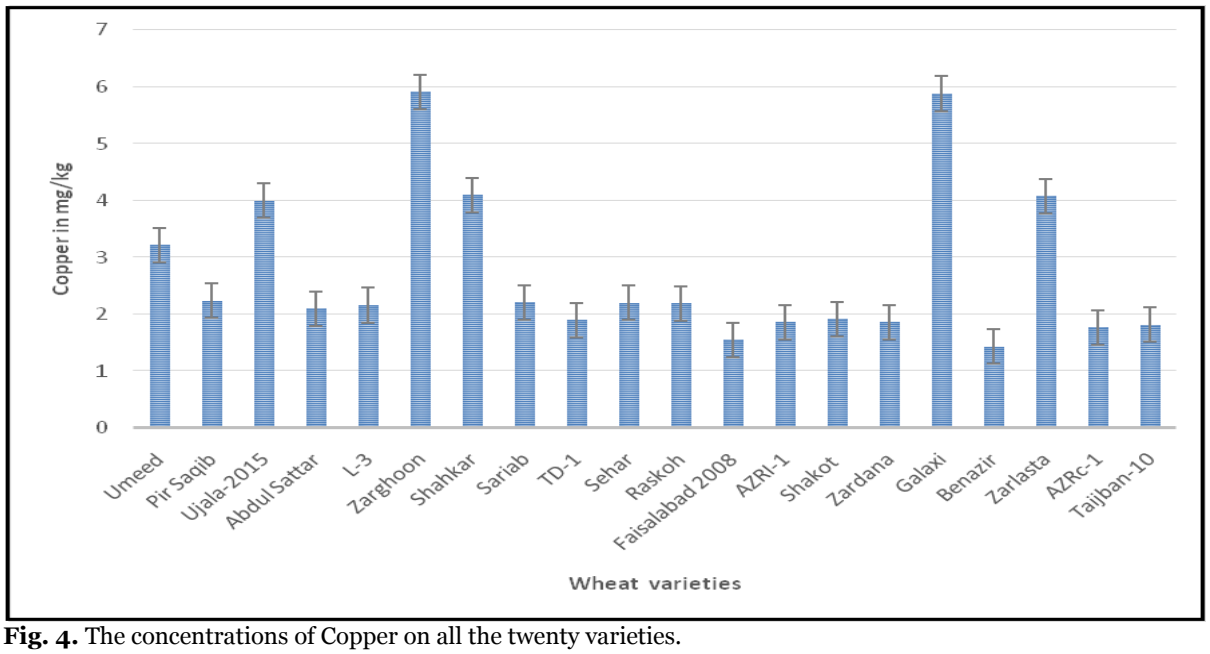

Fig. 4. The concentrations of Copper on all the twenty varieties.

Maximum concentration of copper was found in Ujala-2015, Zarghoon and Galaxi (6.00, 5.91 and 5.88 mg/kg). Which was followed by Umeed, Shahkar and Zarlashta (3.22, 4.10 and 4.08 mg/kg). Whereas, minimum concentration of copper was found in Pirsabaq, Abdul Sattar, L-3, Sariab, TD-1, Sehar, Raskoh, Faisalabad 2008, AZRI-1, Shahkot, Zardana, Benazir, AZRC-1 and Taijban-10 (2.24, 2.10, 2.16, 2.21, 1.90, 2.20, 2.19, 1.55, 1.86, 2.19, 1.86, 1.43, 1.77 and 1.82 mg/kg).

The maximum permissible concentration of Cu should be 3 mg/kg (DW) in wheat set by the EC and FAO/WHO. In the present study the concentration of Cu in wheat grains was found to be in the range of 1.43-6.0 mg/kg (Table 3). The mean concentration of copper 2.82 ± 0.34 is lower than the permissible limit. In a research in Pakistan, the cu concentration raged 3.1-5.1 mg/kg, whereas the mean value of 4.1 mg/Kg was found higher than the permissible limit (Hassan *et al.*, 2013). It was also higher than the value reported (0.42 mg/kg) by Hussain *et al.*, (2011) from the same region, but quite lower than the 11.8 mg/kg, given by Jamali *et al.*, (2009). Cu is the most reported element in elemental analysis of wheat grains. Most of the studies reported higher Cu content in wheat grains, ranging from 4.21-23.73 mg/kg in soils that received a high metal load through the application of contaminated sewage sludge/ wastewater/pond sediments, etc. (Hussain *et al.*, 2011). A fewer samples having higher concentration of cu might be due to irrigation of wheat by sewage wastewater.

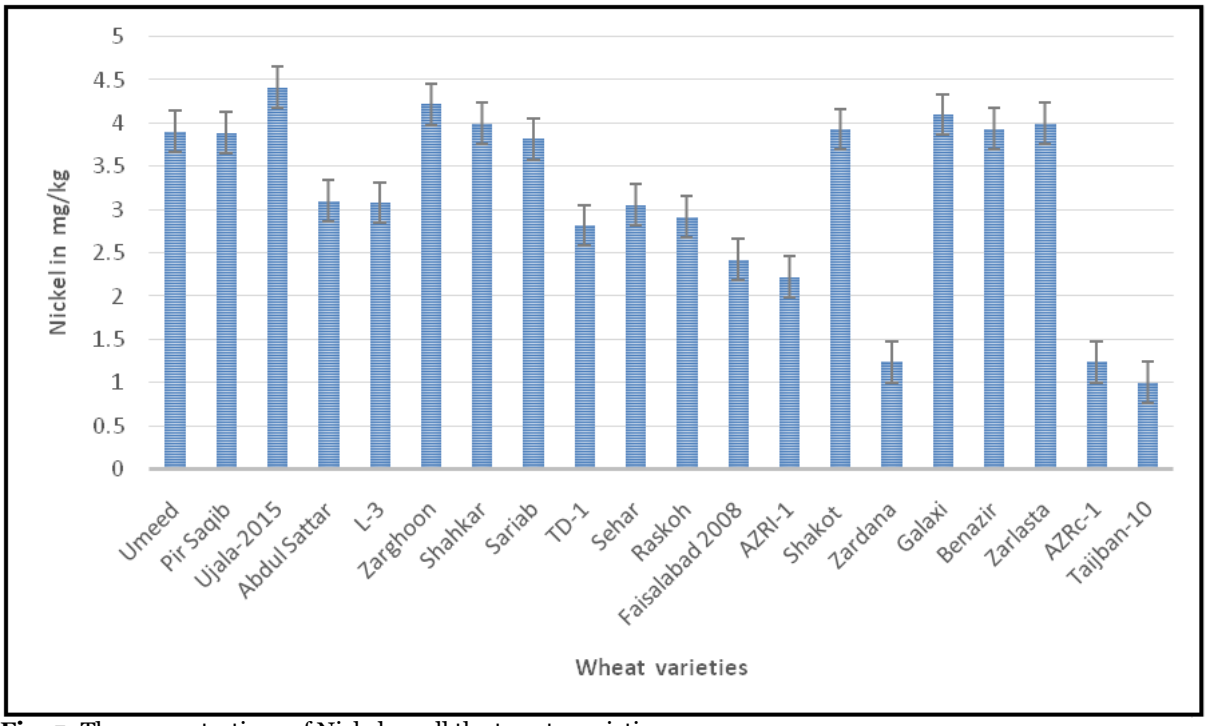

Fig. 5. The concentrations of Nickel on all the twenty varieties.

Nickel

The concentration of nickel response on wheat different genotypes in (Figure-5) varied significantly. The higher nickel concentration was observed in varieties (Table 2) Umeed, Pirsabaq, Ujala-2005, Zarghoon, Shahkar, Sariab, Shahkot, Galaxi, Benazir and Zarlashta (3.91, 2.24, 4.42, 4.22, 4.00, 3.82, 3.93, 4.10, 3.94 and 4.00 mg/kg). Whereas, the lower concertation of nickel was recorded in the following wheat varieties Abdul Sattar, L-3, TD-1, Sehar, Raskoh, Faisalabad 2008 and AZRI-1 (3.10, 3.08, 2.82, 3.06, 2.92, 2.42 and 2.22 mg/kg). The lowest concentrations of nickel appeared in three wheat varieties i.e., Zardana, AZRC-1 and Taijban-10 (1.24, 1.24 and 1.00 mg/kg). There is not much available information on the effects of nickel upon organisms other than humans. Wheat and wheat products and many vegetables contain intermediate levels of Ni (0.2-2.0 µg/g dry basis).

According to FAO/WHO, the Ni tolerance limit in wheat grains is 1.6 mg/kg. Our current finding of Ni in wheat grain is 3.17 ± 0.24 mg/kg (Table 3), which is higher than the permissible limit; however, this value is far lower than the 6.2 mg/kg in previous reports from the same country (Hassan *et al.*, 2013). To evaluate the variability among different species of wheat, principal component analysis (PCA) was

applied. The elucidation biplot obtained from PCA is mentioned in Fig. 6, which explain the effect of different varieties on metal composition. Two principal component with significant value were identified. The first component (PC1) showed the highest Eigen value (3.28) followed by PC2 (1.05). The two principal components showed a contribution of 86.8 % to its total variance. PC1 showed maximum variance with 65.7 % followed by PC2 21.1%.

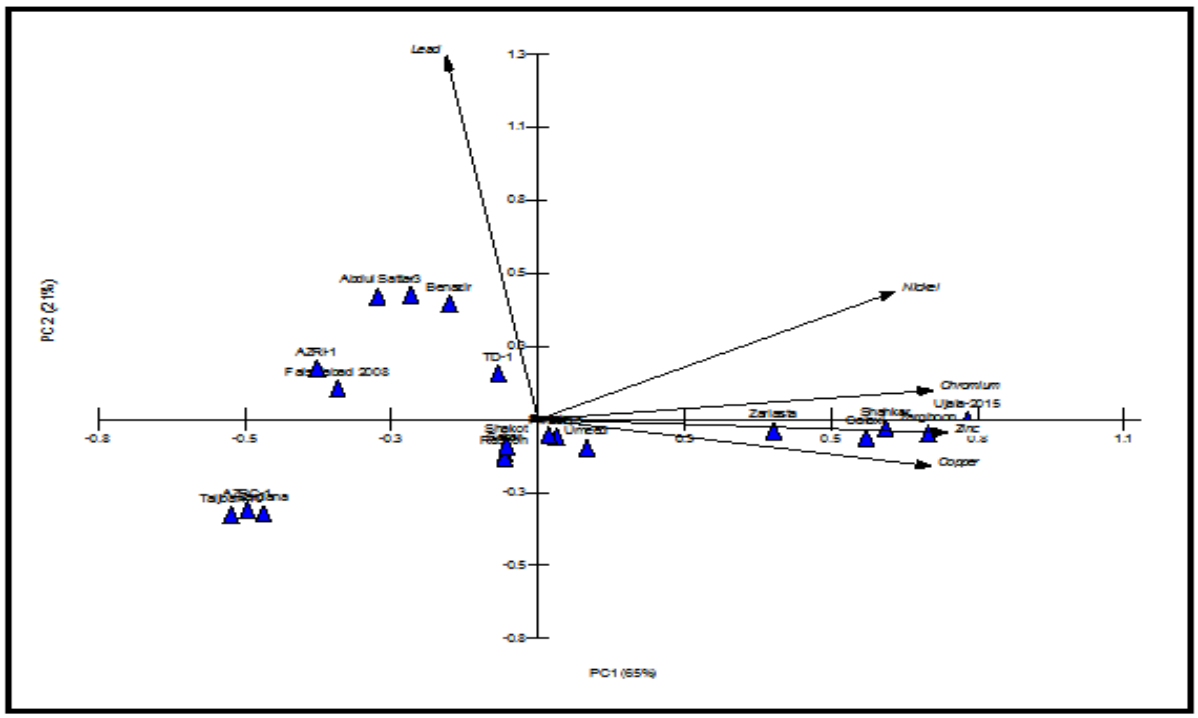

Fig. 6. PCA of wheat varieties of Balochistan.

The first component PC1 was positively correlated with chromium, zinc, nickel and copper and negatively correlated with lead.

The second component PC2 is positively correlated with lead, chromium and nickel, whereas negatively correlated with zinc and copper. As mentioned in Fig. 6, PCA of metal profile divided wheat varieties into two main groups Raskoh, Abdul Sattar, Sehar, L-3, Shahkot, Benazir, TD-1, Faisalabad 2008, AZRI-1, Zardana, AZRC-1 and Taijban10 correlated with lead whereas Umeed, Ujala-2015, Zargoon, Shahkar, Galaxi and Zarlashta correlated with chromium, nickel and zinc.

So it is concluded from PCA results that different varieties have different metal profile. These results are in agreement with previous studies in which varieties may have impact on biochemical composition (Anjum *et al.*, 2019).

Conclusion

The heavy metals lead, chromium and nickel were found slightly higher than the permissible limits.

However zinc and copper were within the permissible limits. Balochistan is ales industrialized city therefore more chances of heavy metal entrance can be from mining or irrigation by waste water.

Since wheat plants tend to accumulate heavy metals in their aerial parts, and in view of their important role in the food chain, it is recommended that this type of plant should not be cultivated in farms and fields contaminated by heavy metals.

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