Comparative Studies of Heavy Metals in Wheat Growing in Different Environmental Conditions

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(Received on 9th April 2009, accepted in revised form 28th October 2010)

Summary: In the present investigations, we screened wheat crops, collected from different areas of Peshawar and found that the level of heavy metals like Zn, Cu, Cr, Mn Cd, Ni, Pb and Fe in crop increases parallel to the extent of pollution. Wheat crop irrigated with industrial effluents accommodate high levels of heavy metals than those irrigated with municipal sewage and irrigated with tube well water. The aim of the study is to aware the public of the possible contamination and ensure that they avoid consumption of crops if grown near industrial dumps or other heavily contaminated places.

Introduction

Environmental pollution is a matter of great concern and has been accepted as global problem because of its adverse effects on human health, animals and plants .soil ecosystem through the world has been contaminated with heavy metals by various human activities .recent study has been focused on the metals content in food due to detrimental consequences to human health; as well as the availability of metals as enzyme activators or inhibitor. Knowledge of the oligoelemental composition of wheat crop is important from nutritional point of view, as wheat is the major part of diet in the world and particularly in Pakistan.

Heavy metals are the components of the earth crust. They cannot be degraded or destroyed, metals like Cu, Se, Zn and Fe are essential to maintain the metabolism of human body .there is a general agreement that metals may react directly with DNS, and the most serious interaction is probably cross linking between DNA strands as was notices after exposure to Cu^{+2}, Zn^{+2}, Co^{+2} and Mn^{+2} [1].

The large number nucleophilic centers in nucleic acids provide a high affinity for metals. Nickel has been shown to inhibit DNA synthesis either vitro or vivo exposure [2].

Control quantities of sodium and fixed potassium/sodium ratio are recommended in some cases for heart dieses and assimilation of Zn is thought to be helpful in the treatment of some liver dieses [3].

Metals like Zinc, iron, Copper, Chromium and Cobalt are essential nutrients and becomes toxic at high concentration. Lead and cadmium have no known beneficial properties and thus are exclusively toxic [4]. However all elements including essential elements in high concentration becomes toxic to organisms.

Studies on contamination of metals and soil and plants have so for restricted to highly industrialized region, while in the present investigation sample were collected from three different selected soils of Peshawar.

1. Soil irrigated with industrial effluents due shortage of irrigation water. Spot 1.
2. Soil irrigated with sewage slug. Spot 2.
3. Soil irrigated with tube well water free from all sort of contamination. Spot 3.

In view of the toxicity of selected metals to the human health through the food chain it is necessary to record the impact of metals in wheat crop grown in different soil of Peshawar.

In this study the contamination of selected metals in the whole plant including soil, root, stem, leaves and seed were recorded and evaluated.

Results and Discussion

It is an established fact the soil and plants under waste water irrigation from various industries contain high level of heavy metals than those irrigated with tube well water [5]. The concentration standard deviation and ranges of heavy metals are listed in Table-4, while maximum intake levels in crops and soil from literature are listed in Table-1 and 2 respectively. The level of different heavy metals ranges from Zn = 3.15 - 0.42, Cu = 0.95 -0.13, Cr = 1026-0.01, Mn = 28.76 – 0.37, Cd = 0.02-0.00, Ni = 2.03-0.01, Pb = 0.47-0.02, Se = 25.74-2.44 mg/kg. The accumulation of heavy metals from soil to plant parts did not follow any particular pattern and varied with respect to metals and plant parts.

Interestingly the concentration of heavy metals and plants growing of polluted soil as a whole was higher than the plants grown on unpolluted soil. Table-4.

Zinc

The content of zinc in all the tested samples occurred in the range of 0.42-3.25 mg/kg. The maximum level of zinc is found in the soil of spot-1 (3.25 mg/kg). This high level followed by its concentration 3.15 mg/kg in the roots of spot 1. In the rest of sample zinc was in lower concentration. The lowest level of Zn was found the stem of spot 2 (0.42 mg/kg). The level of zinc in all tested sample of spot-1 is higher than spot 2 and 3 respectively. This indicated that wheat crop grown on soil irrigated with industrial effluents have high level of Zinc. The level of zinc in all the tested samples of spot-2 was also significant indicating that wheat crop irrigated with municipal waste water will also raise the level of zinc in crops.

Copper

The uptake of Cu in all the tested samples occurred in the range of 0.95-0.13 mg/kg. The maximum level of Cu was found in the soil of spot-1 (0.89 mg/kg). The higher level is followed by the soil of spot 3 (0.84 mg/kg). In aerial parts of wheat crop, the highest level was found (0.52 mg/kg) in the stem and seed of spot-1 and 2 respectively. As a whole the level of Cu was higher in spot 1 and found in the order spot -1>spot-2 >spot-3.

Chromium

The level of chromium was found in rang of (0.01-1.26mg/kg).the maximum level of Cu was found 1.26 mg/kg in soil of spot-1. This high level was followed by the soil of spot-2 (1.16 mg/kg). From Table-1 it is clear that the soil of spot 3also has significant level of Cr (1.16 mg/kg). In other samples, the level of Cr is not very significant indicated in the translocation of Cr from soil to plant was lower.

Manganese

The level was found high in all three spots. The level of Mn recorded in the range of 28.76-0.37mg/kg. The high level was found in the soil of spot-1 (28.76 mg/kg) followed by soil of spot-2 (28.28 mg/kg). Significantly different amount of Mn was found in the soil of spot-3 (24.94 mg/kg). The transduction of Mn from soil to crops was small. As a whole, the level of Mn in all the three spots occurred in the order of spot -1>spot-2 >spot-3.

Cadmium

The level of Cd was detected in most of the samples, however its concentration is very low (0.00-0.02 mg/kg) and is below the permissible level of Cd.

Nickel

The level of Ni was found in the range of (0.02-0.47 mg/kg). The high concentration was found in the soil of spot-1 (2.03 mg/kg). This high level was followed by the soil of spot-2 (2.01mg/kg). Significantly different amount was also recorded in the roots of spot-3 (0.25 mg/kg). The level of Ni in all the tested samples was lower than the reported level listed in the Table-1 and 2, respectively.

Lead

The level of lead was found in the range of (0.02-0.47mg/kg). The high concentration was found in the soil of spot-1 (0.47mg/kg). This was followed by soil of spot-2 (0.45 mg/kg). In plant parts high amount of Pb was found in the leaves of spot-2 (0.19 mg/kg). In aerial parts, generally the level of Pb was high in the leaves. as the leaves accommodate high level of Pb.

Iron

The level of Fe was found high after Mn 25.74-2.44 mg/kg. More concentration of Fe was found in the soil of spot-1 (25.74 mg/kg) followed by soil of spot 2 (22.05 mg/kg). In all the plant parts, significant level of Fe was found indicating that the transduction of Fe from soil to plant parts is high.

Table-1: Maximum permissible levels of heavy metals in vegetables/crops in mg/kg.

Parameters	Max. level(mg/kg)	Parameters	Max. level(mg/kg)
Pb	0.30	Cr	2.30
Cd	0.20	Fe	425.50
Cu	73.30	Mn	500
Ni	67.90	Zn	99.40

Sources: [10,11,12]

Experimental

Sampling

Five plants were collected randomly from each sampling spot at maturity stage. Plants samples were thoroughly washed and dried at 70C^{0} for 48 hrs. Composite soil samples were collected from an area

on which the test plants were growing. The soil samples were mixed thoroughly, dried at $105C^0$ in an oven.

Table-2: Maximum permissible levels of heavy metals in soil in mg/kg.

Parameters	Max. level (mg/kg)	arameters	Max.level (mg/kg)
Cd	0.2	Pb	30
Cr	150	Cu	25
Mn	1000	Zn	90
Ni	75		

Source:[13]

Table-3: Percentage ash contents in different parts of wheat crop.

S.NO.	Plant parts	%age ashing
Spot 1		
1	Roots	65.52
2	Stem	92.9
3	Leaves	87.66
4	Seeds	97.53
Spot 2		
5	Roots	81.8
6	Stem	99.65
7	Leaves	89.38
8	Seed	97.65
Spot 3		
9	Roots	90.68
10	Stem	97.38
11	Leaves	86.95
12	Seed	96.87

Acid Digestion of Soil Samples

For heavy metals analysis, all soil samples were sieved to pass through (<0.5mm) mesh. 1g of the soil sample was treated with 10 mL of Conc Nitric acid HNO_3 (68%) for 24 hrs. Then 5 mL of Conc $HCLO_4$ (70%) were added and covered with watch glasses. The contents in the flask were heated to reflux gently on an electric hot plate. The refluxing was continued until the volume of contents in the flask was reduced to 1mL. The contents of the flask were cooled, diluted with distilled water and filtered through whattman (42) filter paper into 25 ml volumetric flask, brought to volume with distilled water and analyzed by flame Atomic Absorption Spectrophotometer (Polarized Zeeman Hitachi 2000) for Mn, Cu, Ni, Fe, Co, Pb and Cr.

Dry Ashing Plant Samples

One gram of crushed powdered parts of plant like roots stem, leaves and seeds were weighed in crucibles and heated in the furnace for five hrs keeping the temperature 550c0. The contents of the crucibles were cooled in the desiccator. Then 2.5 mL ($6MHNO_3$) solution was added to dissolve the contents. The solution was then filtered and transferred to 20 mL flask and was diluted to the mark and analyzed by flame Atomic Absorption Spectrophotometer (Polarized Zeeman Hitachi 2000) for Mn, Cu, Ni, Fe, Cd, Pb and Cr.

Table-4: Concentration of Heavy Metal in Soil and Plant Part mg/kg

S.NO	Plant part	Zn	Cu	Cr	Mn	Cd	Ni	Pb	Fe
Spot-1									
1	Soil	3.25	0.95	1.26	28.76	0.02	2.03	0.47	25.74
		+0.01	+0.00	+0.13	+0.14	+0.01	+0.06	+0.03	+0.05
2	Roots	3.15	0.23	0.04	4.67	0.01	0.11	0.09	17.34
		+0.01	+0.00	+0.02	+0.05	+0.01	+0.06	+0.03	+0.05
3	Stem	0.77	0.52	0.02	0.85	0.01	0.01	0.13	17.63
		+0.01	+0.01	+0.01	+0.05	+0.01	+0.01	+0.01	+0.05
4	Leaves	0.95	0.36	0.05	4.42	0.01	0.05	0.12	17.32
		+0.01	+0.01	+0.01	+0.05	+0.01	+0.01	+0.04	+0.03
5	Seeds	3.01	0.42	0.01	4.15	nd	0.09	0.12	7.82
		+0.01	+0.02	+0.01	+0.04		+0.01	+0.05	+0.04
Spot-2.									
6	Soil	3.09	0.89	1.21	28.28	0.01	2.01	0.45	22.05
		+0.01	+0.01	+0.01	+0.08	+0.00	+0.05	+0.05	+0.07
7	Roots	0.94	0.19	0.04	2.49	nd	0.11	0.12	16.48
		+0.01	+0.00	+0.02	+0.01		+0.01	+0.03	+0.07
8	Stem	0.42	0.18	0.02	0.62	0.01	0.05	0.02	14.98
		+0.01	+0.01	+0.01	+0.01	+0.01	+0.03	+0.01	+0.04
9	Leaves	0.83	0.32	0.05	2.82	0.01	0.04	0.19	8.63
		+0.03	+0.00	+0.01	+0.03	+0.01	+0.03	+0.02	+0.06
10	Seeds	2.88	0.52	0.04	3.63	0.01	0.02	0.02	2.44
		+0.01	+0.00	+0.02	+0.04	+0.01	+0.02	+0.02	+0.05
Spot-3									
11	Soil	2.98	0.84	1.16	24.94	0.01	1.71	0.39	20.25
		+0.01	+0.01	+0.01	+0.04	+0.00	+0.03	+0.05	+0.03
12	Roots	0.74	0.16	0.11	1.96	0.01	0.25	0.06	16.93
		+0.01	+0.01	+0.02	+0.05	+0.00	+0.00	+0.00	+0.07
13	Stem	0.52	0.19	0.04	0.37	0.01	0.04	0.06	14.48
		0.03	+0.00	+0.02	+0.02	+0.00	+0.01	+0.00	+0.04
14	Leaves	0.78	0.13	0.03	2.07	0.01	0.04	0.12	11.66
		+0.00	+0.00	+0.01	+0.03	+0.01	+0.01	+0.02	+0.06
15	Seeds	2.31	0.39	0.04	1.42	0.01	0.05	0.09	2.88
		+0.00	+0.00	+0.02	+0.03	+0.01	+0.03	+0.02	+0.04

Conclusion

The fact from this investigation strongly suggests that the continuous growth on the site could elevate metal contents in the crops, which bring adverse effects on consumers. It is therefore recommended that in order to protect crop from heavy metals, don't discharge industrial effluents and municipal waste in the rivers, streams, or canals etc. The industrialists are asked to established water treatment plants so that the level of metals in industrial effluents could be minimized before their discharge into fresh water resources. Public should be aware of the possibilities of such contaminations and ensure that they avoid consumption of vegetables and crop if grown near industrial dumps of other heavily contaminated places.

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