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Comparative study of heavy metals distribution in soil, forage, blood and milk

M. Tahir [a,*], Munawar Iqbal [b,*], Mazhar Abbas [c], M.A. Tahir [d], Arif Nazir [b], Dure N. Iqbal [b], Qudsia Kanwal [b], Faiza Hassan [b], Umer Younas [a,b]

[a] Department of Chemistry, University of Sargodha, Sargodha 40100, Pakistan
[b] Department of Chemistry, The University of Lahore, Lahore, Pakistan
[c] Institute of Molecular Biology and Biotechnology, The University of Lahore, Lahore, Pakistan
[d] Department of Chemistry, University of Agriculture, Faisalabad, Pakistan

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ABSTRACT

Heavy metals contamination is a global issue and is a severe threat to living organisms. Present study was designed to analyze heavy metals distribution in soil, forage, blood and milk from Livestock station, Khizerabad, Sargodha, Pakistan. Statistical analysis was performed to access the variation in metals concernments in different types of samples as well as variation among sampling seasons. The concentration of heavy metals varied significant ($P < 0.05$) seasonally (summer and winter) as well as among sample types (soil, forage, blood and milk). The Ni mean concentration was recorded in the range of 1.6–64.0 mg kg^{-1} in soil, 0.93–10.26 mg L^{-1} in blood and 0.93–10.26 mg L^{-1} in milk sample and similar trend was observed in case of Co, Cd, Cr and Pb. Concentration of Cr in soil, forage, blood and milk was recorded within the permissible limits, whereas Co and Cd contents were beyond the permissible limits. Pb and Ni contents were within the permissible limits in soil and forage samples. In comparison to previous study conducted in adjoining areas, it was observed that the heavy metals in the environment have been increased, which might be serious threat to the soil, environmental and livings organisms.

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1. Introduction

Naturally, metals are present in all matrices either food stuffs or environmental sample and are essential for the regulation of many processes in the body. However, any metal at elevated concentration is harmful. Heavy metals have been reported to be toxic (cytogenetic) to living organisms [1–3], which are non-biodegradable and remain as such in the environment for longer time. Depending on soil type, heavy metal leaches to groundwater and are transferred to food chain and food web. Effects of heavy metals in plants depend upon many factors like plant species, metal concentration, metal nature, soil composition and pH [1,4–6]. Plants are potent source of bioactive compounds [7–15] and contamination of soil affects the distribution of bioactive compounds. Similarly, livestock or ruminants are considered as main source of food for human beings and heavy metals in soil and contaminated feed can disturb heavy metal equilibrium and may cause different dysfunctions in host [16].

Chromium (Cr) affects the growth rate and plays an important role in lipid metabolism and blood cholesterol control [17]. Cr in the range of 0.3 to 1.6 mg kg^{-1} is essential in body and higher concentration is toxic and severely affects the reproductive ability of ruminants [18]. High levels of cobalt (Co) can cause lung problems like asthma, pneumonia and heart failure in human beings [19]. Similarly, high contents of nickel (Ni) can cause heart diseases, thyroid diseases and cancers [20]. Lungs are affected by inhaling high amount of cadmium (Cd). The use of drinking water having high concentration of Cd can cause problems in stomach consequently cause vomiting and diarrhea. The Cd accumulates in the kidney and can cause kidney diseases, if exposes for a long time even in small quantity. Fragile bones and lungs damage are also major effects of long term exposure of Cd [16]. Lead (Pb) accumulates in liver, kidney, bone and other tissues similar as that of calcium and can affects all these parts in living body. Moreover, slow development occurs in children due to Pb deficiency, but at high level it cause weakness in wrists, fingers and ankles. Anemia, problems related to stomach and kidney and high blood pressure are also effects of higher Pb concentration [16]. Heavy metals including non-essential and toxic (As, Cd, Hg and Pb), macronutrients and micronutrients (Cr, Ni, Zn, Mo, Mn, Fe and Cu) as well as different types of nitrates and phosphates is major environmental issue due to indiscriminate discharge of pollutants in the environment [21–38], which affect living organisms adversely.

* Corresponding authors.
E-mail addresses: mtahir307@yahoo.com (M. Tahir), bosalvee@yahoo.com (M. Iqbal).

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Present study was conducted to monitor the heavy metals in soil, forage, milk and blood samples from selected area. Sample of soil, forage, milk and blood were collected for the period of one year and analyzed for heavy metals distribution.

2. Material and methods

2.1. Description of sampling site

Present study was done at Khizerabad Livestock center, Sargodha, Pakistan (Latitude 72°40′ E and Longitude 32°10′ N) for the period of one year. The total center area was 7669 acres including cultivated area (7434 acres). Nature of soil was loamy; subsoil water was fit for irrigation and drinking. Canal and tube-well water was used as irrigation source at this station. Average temperature in winter was ranged from 5 °C to 23 °C and in summer temperature range was 25 °C to 49 °C. Average rainfall in area is 30 mm and fall under semi-arid farming system.

2.2. Sample collection

The soil, forage, milk and blood samples were collected quarterly for one year and subjected to heavy metals detection. Soil samples were obtained at 15–20 cm depth randomly and forage samples of same site were collected and stored in plastic bags. Healthy animals including calves, lactating cows and dry cows were selected for blood sampling. The milk samples taken from lactating cows selected for blood sampling.

2.2.1. Sample preparation

The soil samples were dried in air for 4–5 days followed by oven drying at 60 °C for 2 days. The grinded soil sample passed through 1 mm mesh size and preserved in plastic bags till analysis. The powdered soil (1.0 g) was taken in a flask, mixed with 5 mL of conc. HNO_3, heated for 20–30 min, 10 mL HNO_3 was added and heated the mixture until the residue turns bright. Finally, 5 mL HCl was added and concentrated the contents up to 1 mL, filtered and stored in glass vials by diluting up to 20 mL with D. water [39]. Accurately weighed 1.0 g of each oven dried forage samples was digested at 200 °C using HNO_3 and $HClO_4$ (3:1). The digested sample was filtered and diluted up to 20 mL with D. water. The digestion of blood and milk samples was carried out at 120 °C in HNO_3 followed by treatment with H_2O_2 to enhance digestion process by oxidization. The digested samples were filtered and diluted up to 20 mL with D. water. Sample was stored in glass vials till further analysis [39–40]. The chemical and reagents used (heavy metal standards, HCl and HNO_3 were of analytical grade and purchased from Sigma-Aldrich).

2.3. Statistical analysis

Triplicate analysis was carried for each sample and data is reported as Mean ± SD and analysis of variance was performed by Minitab Software Package Version 13.0 (Minitab, Inc., State College, PA, USA). A probability level $P < 0.05$ was considered statistically significant difference level.

3. Results and discussion

3.1. Nickel

The soil, forage, blood and milk were analyzed for heavy metals variation. To obtained difference among sample types and duration, data was analyzed statistically. Results revealed that concentration of Ni in soil samples was changed significantly ($P < 0.05$) with time (Table 1). The level of Ni in soil was in the range of 1.6–64.0 mg kg^{-1} (Fig. 1). The concentration of Ni was found to be 6.22 mg kg^{-1}, 1.59 mg kg^{-1}, 25.72 mg kg^{-1} and 63.92 mg kg^{-1} in soil, 3.65 mg kg^{-1}, 0.82 mg kg^{-1}, 18.80 mg kg^{-1} and 39.72 mg kg^{-1} in forage, 2.95 mg kg^{-1}, 0.93 mg kg^{-1}, 6.67 mg kg^{-1} and 10.25 mg kg^{-1} in blood and 1.55 mg kg^{-1}, 0.35 mg kg^{-1}, 2.58 mg kg^{-1} and 2.8 mg kg^{-1} in milk samples (collected in four seasons) (Fig. 2). Overall, it was observed that the Ni concentration in soil, forage, blood and milk samples was high in samples collected during summer season (April–Jun and Jul–Sep) and significantly lower in winter samples (Oct–Dec and Jan–Mar). The Ni contents observed in 4th sampling (Jul–Sep) of present study were found higher than previous study conducted in Pakistan (59 mg kg^{-1}) studied by Malik et al. [41], while the 1st, 2nd and 3rd sampling furnished Ni contents lower than earlier studies in different countries; Serbia [42], India [43], Spain [44] and Mexico [45]. Higher value of Ni may be due to low soil pH, use of synthetic fertilizers and contamination of water used for irrigation.

Statistical analysis showed that level of Ni in blood was highly time dependent and found in the range of 0.93–10.26 mg L^{-1} during whole study period with the lowest value in Jan–Mar and highest in July–Sept. Blood Ni concentration recorded during present study (Oct–Mar) was lower than reported by Ogabiela et al. [46] from Nigeria and higher in Apr–Sep. High amount of Ni in blood may be due to drinking water and feed having high concentration of Ni. The Ni affects the growth

Table 1
Analysis of variance for heavy metals in soil, forage, blood and milk samples.

	SoV	SS	df	MS	*F*	*P*-value
Co	Soil	242.495	3	80.832	176.304	<0.0001
	Forage	83.598	3	27.866	84.701	<0.0001
	Blood	114.418	3	38.139	57.92	0.0001
	Milk	0.558	3	0.186	12.989	0.0001
Ni	Soil	24,130.18	3	8043.392	654.843	0.0001
	Forage	9528.811	3	3176.27	630.077	0.0001
	Blood	1513.953	3	504.651	98.449	0.0001
	Milk	38.889	3	12.963	55.705	0.0001
Cd	Soil	201.548	3	67.183	70.398	0.0001
	Forage	69.011	3	23.004	59.888	0.0001
	Blood	3.497	3	1.116	2.415	0.07
	Milk	0.698	3	0.233	59.016	0.0001
Pb	Soil	140.234	3	46.745	36.753	0.0001
	Forage	55.504	3	18.501	22.813	0.0001
	Blood	41.545	3	13.848	20.906	0.0001
	Milk	0.938	3	0.313	9.524	0.0001
Cr	Soil	0.053	3	0.018	92.257	0.0001
	Forage	0.028	3	0.009	83.421	0.0001
	Blood	0.296	3	0.099	123.651	0.0001
	Milk	0.057	3	0.019	273.275	0.0001

SoV - Source of Variation, SS - sum of square, df - degree of freedom, MS - Mean Square, P - probability.

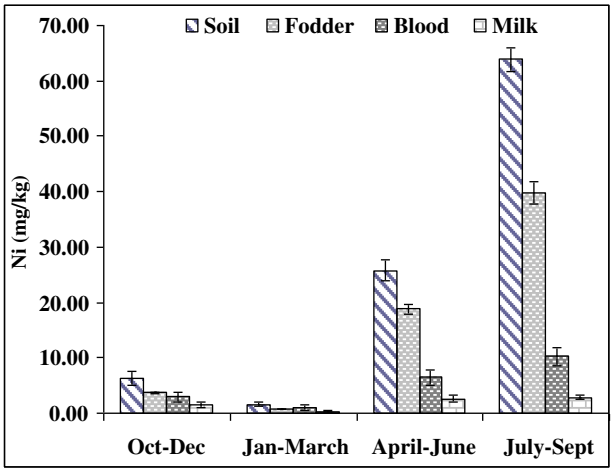

Fig. 1. Variation in Ni concentration in soil, forage, blood and milk samples over the period of one year.

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