Revista de Chimie
https://revistadechimie.ro
https://doi.org/10.37358/Rev. Chim.1949

Does the Chromium Element in Forages and Fodders Grown In Contaminated Pasture Lands Cause Toxicity in Livestock: Assessing the Potential Risk

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Abstract: *Contamination of the ecosystem is a highly concerning issue as various types of pollutants get released into the environment which ultimately enter the food chain and create disturbance there. This study reported the chromium concentrations in the buffalo blood, soil and forages. The heavy metals from the toxic smoke get accumulated in the forage and the buffalos consuming this contaminated forage. This study was carried out in Sargodha during December 2015 to January 2016 (winter) and May 2016 to June 2016 (summer). Five road sites (Mateela, Faisalabad roadside, Shaheenabad roadside, Bhalwal roadside and 50 chak were selected from sampling of forages, soil and buffalo blood sample. In order to find out chromium in the soil, forages and blood samples, the atomic absorption spectrophotometer was used. The values of chromium in soil and forage samples were found highest at Site-II, while the amount of chromium in buffalo blood samples was highest collected from Site- III. The bio-concentration factor for forage and soil was found highest at Site-III. The bio-concentration factor for blood and forage was highest at Site-VI. The correlation was found positive and significant when soil-forage was correlated. On the other hand, negative significant was found for chromium when blood-forage was correlated. The pollution load index, daily intake and health risk index was highest in the samples collected from Site-IV.*

Keywords*: Chromium, Pollution load index, forage, automobile smoke*

1. Introduction

The source of entry of heavy metals into the environment is through contamination of food crops. On consumption of the contaminated forages by buffalos, the heavy metals from these forages get entered into their living bodies. As the heavy metals could not be removed out of the body so they get on accumulating in the body of living organisms like blood and other living organs. The heavy metals from the automobile smoke get entered into the soil from which the plants absorb these heavy metals through their roots. The fertilizer practice also adds up the heavy metals to the soil. Being highly toxic, heavy metals are a real threat to the living bodies in the environment [1, 2]. The heavy metal in the environment might be due to any other reason, cause hazards to the ecosystem and biosphere particularly in developing countries [3, 4]. The significant toxicity is caused by heavy metals in any form [5]. The discharge of heavy metal-rich smoke from the automobiles causes severe soil and air pollution. Roadside plants are severely affected by the heavy traffic smoke, and as the smoke is replete with the heavy metals so from the smoke, heavy metals get entered into the plant bodies [6]. In the

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area rich in metals, there is an increased risk of the contamination of human bodies by contaminated crops [7, 8]. Chromium has been found to be more accumulated in the legumes unlike in other foods. Chromium affects the structure of the nucleic acids, immune response, growth and lipid metabolism etc. [9]. It helps in the increased growth in various ruminants if taken in lower concentrations [10]. This aim of the present study was to appraise the extent of accumulation of chromium in roadside soil, forages and buffalo blood.

2. Materials and methods

Various forages in different parts of the Sargodha city were collected. The sampling sites were Shaheenabad Road, Faisalabad Road, Mateela, 50 Chak, Bhalwal road and Dera Saudi, respectively. Sampling of forages (*Triticum aestivum, Sorghum bicolor, Trifolium alexandrinum, Pennisetum glaucum*) was done in various intervals during December 2015 and January 2016 in winter while during the period of May 2016 and June 2016 in summer.

The samples of forage (4 types) were collected from 3-6 cm at the feeding levels of the grazing animals. 30 samples (each type of forage) were collected from each site (30×4=120 samples). Sample of the soil (2g) and forages were saved after the air drying and oven drying at 70-75^{o}C till constant weight. The buffalo blood sampling was done (12×5=60 samples) from each site in 16×150 mm sealed test tubes (Na-citrate vials) to save the blood from clotting.

The blood serum was separated and was saved in labelled vials for further analysis. Soil (0.5g) and forage (1g) was digested by using 10ml of Aqua regia (HNO_3 and HCl, ratio 1:3) in digestion flask at 460°C for about 24 h. The result of this procedure was the clear solution which was then filtered and diluted up to 50mL [11]. Blood sample (1g) was taken in a digestion flask in which 20ml of nitric acid was added. Heating was done at 150^{o}C on a hot plate until the clear solution was obtained. This solution was diluted up to 50mL and saved in a plastic bottle [12].

The specific procedure of chromium analysis in all samples was carried out by Atomic Absorption Spectrophotometer (AA-6300 Shimadzu Japan).

Precision and accuracy of analyses were guaranteed through repetitive samples against National Institute of Standard Technology, Standard reference material (SRM 2709 for soil, CRM-NIST 1567a for forages, NYCO 905 for blood) for chromium.

SPSS software (Version-20) was used to find the mean value of chromium in the samples. Two-way ANOVA was also used. 0.05, 0.001, 0.01 probability levels were used [13].

2.1. Bioconentration factor

The formula of BCF was given by Yoon et al. [14].

BCF= CM/CS

Where CM and CS are the metal concentration in forages and chromium content of the soil.

2.2. Daily intake of metal

The daily consumption of metal as found by Cui et al. [15].

DIM=Daily consumed forage/mean concentration of chromium

12.5 kg was the daily consumption of forage by animals

2.3. Health risk index

It is the exposure of animals to toxic heavy metals. The health risk index was found by Liu et al. [16].

HRI= Daily intake of chromium (Concentration of chromium in forage/Oral reference dose× Animal body weight

From the integrated risk information system, R_fD value waschromium1.5 mg/kg/day [17]. The average body weight of buffalo was taken as 550 kg [18].

2.4. Pollution load index

Pollution load index was determined according to Liu et al. [16].

PLI = Metal concentration in investigated soil ⁄ reference value of the metal in soil.

The reference value for chromium is 0.07mg/kg [19].

3. Results and discussions

3.1. Soil

Seasons affected significantly to chromium, unlike the sites and sites×seasons which affected chromium non-significantly (Table 1). The chromium content in soil samples at six sites of sampling was as: Site-II>Site-IV>Site-VI>Site-I>Site-III>Site-V, respectively (Table 2, Figure 1). The mean values of chromium were found lower than as reported (4.309mg/kg) by Nazir et al. [20]. It was reported by Paschke et al. [21] reported that the concentration of chromium in the soil is affected by different seasons as it increases in the soil during dry seasons due to increased runoff. In addition to this, the soil type also affects the accumulation of chromium in soil and the lower chromium content in these soil samples was due to lesser traffic in the sampling area.

Table 1. ANOVA for chromium content in soil at various sites of sampling

Source of variation	Degree of freedom	Mean square
Sites	5	5.36^{ns}
Season	1	0.07***
Sites×Seasons	5	6.690^{ns}
Error	36	2.55

Ns =non-significant, Significant at 0.001=***

Table 2. Mean concentrations (mg/kg) of the chromium in the soil

Site	Chromium
Site-I	0.371
Site-II	2.363
Site-III	0.408
Site-IV	1.512
Site-V	0.301
Site-VI	0.766

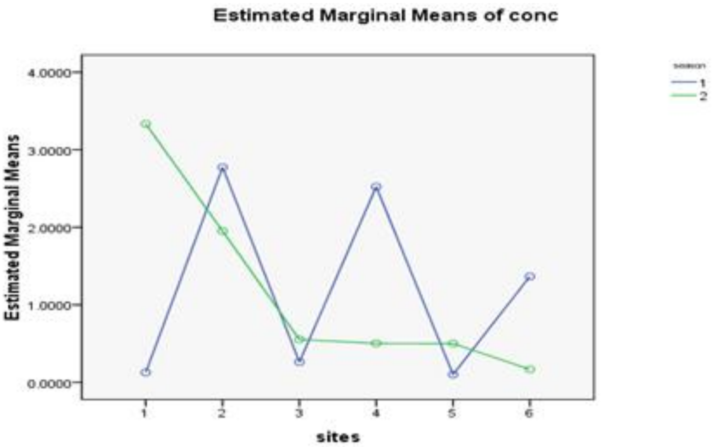

Figure 1. The fluctuations of chromium in the soil at six sites of sampling

3.2. Forage

The concentrations of chromium in forage samples were as: Site-II>Site-III>Site-IV>Site-I>Site-VI>Site-V, respectively (Table 4, Figure 2). The non-significant concentration of chromium was shown by analysis of sites, seasons and sites×seasons (Table 3). The heavy metal levels studied by Moreki *et al*. [22] pointed higher chromium content as compared to that found in this study. Less concentration of chromium in the samples of forage may be the result of considerably lesser traffic on roads from where the samples of forage were collected. Reported by Smith et al. [23] that the formation of carbonates, organic complexes and hydroxides in the soil is due to the increased metal mobility due to less *p*H of soil. More mobility of heavy metals more they move to forages.

Table 3. Analysis of variance for chromium content in forage

Source of variation	Degree of freedom	Mean square
Sites	5	9.20^{ns}
Season	1	9.213^{ns}
Sites×Seasons	5	9.193^{ns}
Error	36	1.840

Ns =non-significant

Table 4. Mean values (mg/kg) of chromium in forage

Site	Chromium
Site-I	0.503
Site-II	3.063
Site-III	1.387
Site-IV	0.529
Site-V	0.112
Site-VI	0.478

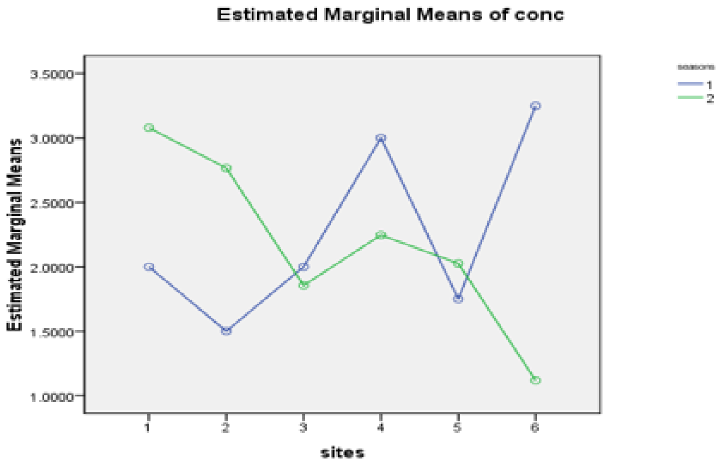

Figure 2. The fluctuation in chromium in forage at six sites of sampling

3.3. Blood

The result of ANOVA was significant at the season, sites and sites×seasons, respectively (Table 5). The chromium content in buffalo blood at six sites of irrigation was: Site-III>Site-VI>Site-IV>Site-V>Site-II>Site-I respectively (Table 6, Figure 3). The results of Nwede et al. [24] were higher than the results of chromium concentration found in this study. The management of roadside smoke is essential to avoid the risk of health by heavy metals in the smoke.

Table 5. Analysis of variance for chromium content in buffalo blood

Source of variation	Degree of freedom	Mean square
Sites	5	7.50^{ns}
Season	1	235.44^{ns}
Sites×seasons	5	4.98^{ns}
Error	36	2.441

Ns =non-significant.

Table 6. Means values (mg/kg) of chromium content in buffalo blood

Site	Chromium
Site-I	2.144
Site-II	2.579
Site-III	4.809
Site-IV	2.842
Site-V	2.590
Site-VI	3.552

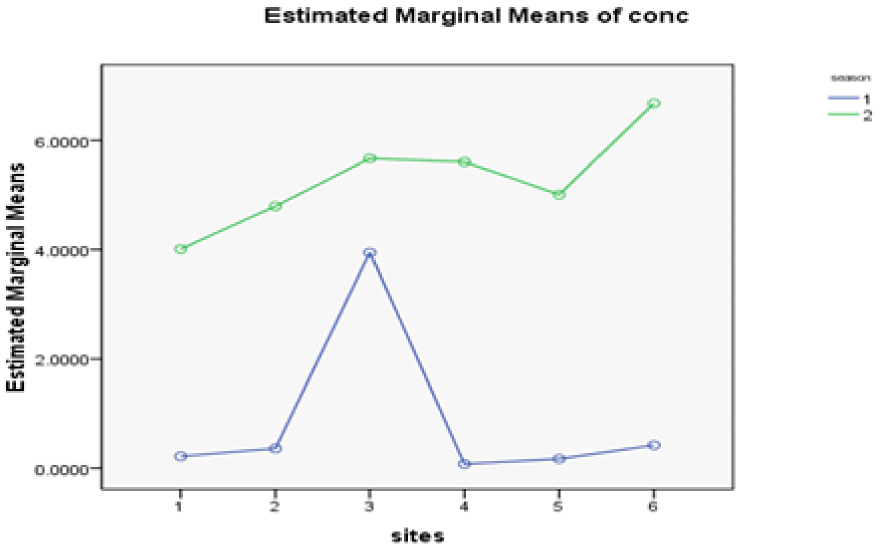

Figure 3. The fluctuation of chromium in blood at six sites of sampling

3.4. Bio-concentration factor for forage and soil

The bio-concentration factor at the six sites of sampling were: Site-III>Site-II>Site-VI>Site-V>Site-IV>Site-I respectively (Table 7). Kamal *et al*. [25] reported higher BCF for chromium, unlike this study indicating that heavy metals get readily transferred. Like the concentration of the chromium in forages as affected by soil *p*H, the BCF is also influenced by soil *p*H [15, 26].

Table 7. Bio-concentration factor in forage and soil obtained from six sites

Site	Chromium
Site-I	0.29
Site-II	1.29
Site-III	3.39
Site-IV	0.34
Site-V	0.37
Site-VI	0.62

3.5. Bio-concentration factor for blood and forage

Site-VI>Site-IV>Site-III>Site-V>Site-I>Site-II was the order of the BCF that come out after the analysis (Table 8). The movement of the heavy metals was restricted by the high value of *p*H, unlike in case of low *p*H heavy metals mobility from soil to plants [27]. It may be possible that the *p*H of examined soil affects the BCF of chromium. According to Liu *et al*. [7], the BCF if found >1 suggest that the plants can accumulate heavy metals in them. Alloway and Ayres [28] analysed that the extent of the heavy metal uptake by forages depends upon their age, edaphic factors and the climatic factors.

Table 8. Bio-concentration factor in forage and blood obtained from six sites of Sargodha

Site	Chromium
Site-I	1.04
Site-II	0.84
Site-III	3.46
Site-IV	5.37
Site-V	2.30
Site-VI	7.43

3.6. Correlation

The correlation results after the statistical analysis of data obtained from heavy metal concentrations by Atomic Absorption Spectrophotometer were positive significant for forage-soil unlike the result of blood-forage, which was non-significant (Table 9).

In the current study, the soil-forage and blood-forage heavy metal concentrations were correlated separately. The highest positive non-significant correlation found for chromium depicts the equal concentration of chromium in soil and forages. More convoluted relationship of heavy metals suggesting an imbalance of the heavy metals between soils was one of the reasons behind the negative non-significant correlation. Effective translocation of heavy metals from soil was one of the reasons behind the positive correlation found for chromium [29].

Table 9. Metal correlation between soil-forage at three sites

Correlation	Soil-forage	Blood-forage
Chromium	0.079	-0.581

3.7. Daily intake of metal

The order of the daily intake of chromium was Site-IV>Site-II>Site-V>Site-III>Site-I>Site-VI, respectively (Table 10). Lente *et al*. [30] found lower values of DIM, unlike the DIM found in this study. When the daily intake of metal is lower than 1 as in this study than risk is not linked with the use of such type of forages [31].

Table 10. Daily intake of metal via the consumption of forage from six different sites

Site	Chromium
Site-I	0.0175
Site-II	0.052
Site-III	0.03
Site-IV	0.056
Site-V	0.045
Site-VI	0.01

3.8. Health risk index

The health risk index due to chromium at six sites of sampling was in the order: Site-III>Site-V>Site-II>Site-IV>Site-I>Site-VI, respectively (Table 11). According to Sajjad et al. [32] if the health risk index is found higher than 1, then severe health risk might be linked with the use of roadside contaminated forages. Health risk index depends on the chemical composition and the physical characteristics of soil, type of forage being consumed and the rate of the consumption of forages.

Table 11. Health risk index via the consumption of forage from six sites of Sargodha

Site	Chromium
Site-I	0.11
Site-II	0.034
Site-III	0.02
Site-IV	0.037
Site-V	0.03
Site-VI	0.006

3.9. Pollution load index

The pollution load index due to chromium at the six sites of sampling were: Site-VI>Site-IV>Site-V>Site-IV>Site-III>Site-I>Site-II respectively (Table 12). In the same way as HRI the pollution load index >1 means that the environment is highly polluted, unlike PLI<1. Ashfaq *et al*. [33] reported lower chromium concentration, unlike this study. The lower PLI at Site-IV means the less rush of industries in Sargodha. The pollution load index greater than 1 suggests deterioration of soil quality, While PLI<1 means denote perfection. On the other hand, PLI equal to 1 means the baseline level of pollutant present [34].

Table 12. The pollution load index in the soil of forage obtained from six sites of sampling

Site	Chromium
Site-I	0.28
Site-II	0.21
Site-III	0.36
Site-IV	0.344
Site-V	0.346
Site-VI	0.348

4. Conclusions

Contamination of the food chain due to heavy metals is an emerging issue now a days. These heavy metals come from different sources. Vehicular emission is also the major source of heavy metals. The current study was performed to observe the effect of vehicular emission on metal accumulation in roadside soil, forages and blood of buffaloes that consume these forages. The results of the parameters found in this study like bio-concentration factor, health risk index, daily intake of metal, correlation and pollution load index at various sites of Sargodha suggested the smoke of the automobiles was replete with dangerous toxic heavy metals which pose toxic effects on the health of living bodies. This study recommends the need for a plan in order to be safe from the toxic effects of heavy metals.

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Manuscript receied: 25.03.2020