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HEAVY METALS CONTAMINATION OF SOIL AND FODDER: A POSSIBLE RISK TO LIVESTOCK

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Abstract

Heavy metals are significant ecological pollutant, principally in areas with sky-scraping anthropogenic stress. Their existence in the environment, soil and water, still in traces can cause severe tribulations to all organisms; heavy metal bioaccumulation in the food chain particularly can be extremely hazardous to animal and human health. Heavy metals generally come into the body by breathing and eating, ingestion being the most important route of contact to these elements in animals. The current study was conducted to examine lead (Pb), cadmium (Cd) and chromium (Cr) in the soil and fodders. Representative samples of soil were collected during two different seasons from two different sites, known as feeding sites for ruminants and analysed for heavy metals after wet digestion, using Atomic Absorption Spectrophotometer. The results showed that location and season had a significant effect ($P>0.001$) on soil and heavy metal concentrations. Soil and forage Pb, Cd, and Cr concentrations were higher in summer than in winter. From the results of the current study, it was determined that all the metals in soil were lower than deadly levels, posing no probable threat to both plant and animal life. There is an incessant need for monitoring the bioavailability of these heavy metals to grazing livestock, principally in summer season when these metals were found in relatively elevated concentrations, so that their possible toxic consequence to the grazing livestock can not be permitted. Agronomic practices, such as, manure and water managements as well as crop alternation system, can affect bioavailability and crop accretion of heavy metals, thus influencing the thresholds for assessing nutritional toxicity of heavy metals in the foodstuff. This study would be important for livestock owners and scientists working in extension services in Pakistan and other countries with same ecological condition.

Keywords: Soil, Lead, Chromium, Cadmium, Pakistan.

Introduction

Environmental pollution is caused due to increased human population. Speedy augment of industrialisation and urbanisation all over the world as well as in Pakistan has ended in the release of noxious effluents, which is inappropriate for soil, water and eventually for crop acquiesce (Sheikh and Irshad, 1980; Wahid et al., 1999, 2000). Thus, the majority of agro-industrial wastes are polluted with a diversity of metals (Al-Nakshabandi et al., 1997; Faryal et al., 2007; Khan et al., 2008) which, if functional to crops may cause inhibitory sound effects on enlargement and acquiesce. Chen and Chia (2002) reported that toxicity in vegetables is dangerously exaggerated by city contaminated water than additional crops and forages and this contaminated water exerts immense economic stress on growers. Azmat and Khanum (2005) indicated that pollution of soil and water by chromium (Cr) is of immense apprehension. Chromium also causes harmful effects on plant physiological processes such as photosynthesis, water relationships and mineral nourishment. Cr hassle is one of the urgent factors that manipulate photosynthesis and respiration in plants (Clijsters and Van Assche, 1985). Forages increasing in polluted environment can congregate heavy metals at elevated concentrations, posing grave danger to animals and human physical state. Moreover, heavy metals are hazardous because they have a propensity to mount up in living

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systems, thereby causing detrimental effects and transport in human food chain (Alloway, 1990). Similar special effects of cadmium and lead on forages have been reported somewhere else (Akinola and Ekiyoyo, 2006; Vousta et al., 1996).

In sight of the above information, it is extremely probable that the industrial effluent from Sargodha may hold substantial amounts of heavy metals together with Pb, Cd and Cr. Thus, the precise purpose of the current study was to scrutinise the levels of three key heavy metals, viz. Pb, Cd and Cr, in the soil and forages to encompass the acquaintance of their overload or undersupplied levels for adopting prophylactic procedures to prevent livestock from harms caused by the disproportion of these metals in the nutritional sources. The objective of this study was to investigate the accretion of lead, cadmium and chromium in soil and fodders at a particular arable farm for the duration of meadow condition during two different seasons to know the deficiency and toxicity anticipation for grazing ruminants in that area and to suggest prophylactic measures to avoid various disorders caused by imbalance of the metals.

Materials and Methods

The investigational location, Sial Morr, District Sargodha, Punjab, Pakistan, was preferred to demeanour current study. The least and highest temperature array in Sargodha is 4°C to 25°C in winter and 25 to 48°C in summer, correspondingly. The yearly precipitation in this district is 180 to 200mm which is typically restricted to the months of July and August. The coordinates of Sial Morr are 32°08′00″N and 73°7′00″E. Samples of soil and fodders were taken from two grazing sites known as feeding sites, located at a distance of 1km from each other in summer and winter seasons of the year 2010-2011. Four replications of each soil and fodder samples were taken haphazardly. These soil samples were air dried, stored in labelled, sealed paper bags and placed in an oven for 7 days at a temperature of 60°C. The forage samples were cleaned with distilled water to bathe soil particles and other impurities. These samples were dried in air and placed in an oven at 60°C temperature for 5 to 7 days. These soil and forage samples were subjected to wet digestion in nitric acid and perchloric acid (1:2). After digestion, samples were analysed for lead cadmium and chromium using Atomic Absorption Spectrophotometer according to standard methods described by Anonymous (1980) and by Rhue and Kidder (1983).

Statistical Analysis

Data was subjected to statistical examination, following Steel et al. (1997), to determine considerable differences at dissimilar levels (0.01, 0.001, 0.15) with the help of SPSS statistical software.

Results and Discussion

Soil Lead: Analysis of variance showed noteworthy consequence of all sampling intervals on Pb concentration in soil (Table 1). The concentration of Pb in soil was approximately equivalent in both sampling periods but decreased abruptly at 3rd sampling time with incoherent trends of depression and elevation (Fig. 1). The mean soil Pb level varied from 34.9 to 46.1mg/kg at Site 1 while the levels on Site 2 varied from 4.4 to 7.04 mg/kg. On the whole, concentrations of Pb were elevated in summer at Site 1 as compared to winter at Site 2. The levels of Pb observed in current study were greatly higher than standards of soil Pb (5 to 25mg/kg) as reported by Hayashi et al. (1985). These concentrations of soil Pb were lesser than those previously reported (Perez et al., 2000; Oluokun et al., 2007) in Nigeria but more than those reported by Aksoy et al. (1999) in Turkey which investigated on bio monitoring of heavy metal contamination in that region. According to Ross (1994), the Pb levels in soil were lower than the deadly intensity, divulging no hazard to life of plants and animals. The trace amount of soil Pb may probably be due to nonexistence of pollution by biosolids, manure slush because these grazing lands were irrigated with canal water having no hazard of Pb toxicity.

Fodder Lead: Noteworthy ($P<0.001$) variations were found in fodder Pb concentrations with respect to harvesting periods (Table 1). Lead concentration varied from 0.63 to 1.59mg/kg in all plant species explored. Levels of Pb in summer varied from 1.02-1.59mg/kg and from 0.63-1.45mg/kg in winter (Fig. 2). Elevated concentrations of Pb were found in *Calotropis procera* and *Eragrosti spilosa*. Lesser levels were observed in *Dactyloctenium aegyptium*. Average level of lead was larger than the decisive concentration 0.05mg/kg recommended by Tokalioglu et al. (2000). Pb level of 80mg/kg in forages caused injurious effects to horses but for cattle, the amount was allowable. Some forage species have high amount of Pb as reported by Ahmad et al. (2009) and Sobukola et al. (2010). The average Pb level in forage samples was lower than those recognised earlier (Oluokun et al., 2007). It has been suggested that Pb decreases root expansion by restricting cell division and cell elongation (Eun et al., 2000). The decisive Pb border was 3mg/kg according to Allen (1989) and our study exhibited that Pb value is lesser than the decisive level and have no prospective intimidation for grazing ruminants in the investigated region.

Table 1: Analysis of variance for lead concentrations in soil and forages at different sampling intervals

Source of variation (SOV)	Degree of freedom (df)	Mean Squares					
		Soil		Forages			
		Site 1	Site 2	Species 1	Species 2	Species 3	Species 4
Sampling periods (Summer)	2	92.252***	116.808***	1.058*	0.150ns	0.171**	0.199ns
Error	11	0.294	0.153	0.095	0.116	0.024	0.084
Sampling periods (Winter)	2	3.349***	1.483***	0.019ns	0.65***	0.001ns	0.072*
Error	11	0.022	0.045	0.085	0.009	0.002	0.017

Data is expressed as mean squares significant at (p<0.05-p<0.001), vs. control, where *=0.05, **=0.01, *=0.001, ns = non-significant**

Species 1 = *Dactyloctenium aegyptium*
Species 2 = *Calotropis procera*
Species 3 = *Parthenium hysterophorus*
Species 4 = *Eragrosti spilosa*

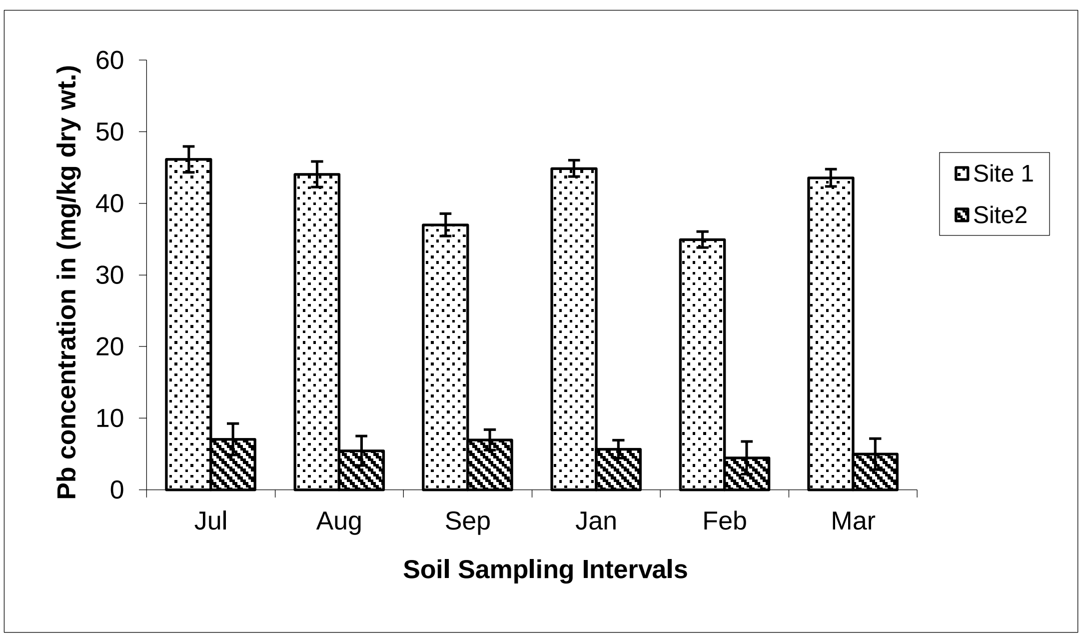

Fig. 1. Lead levels in soil at different sampling intervals

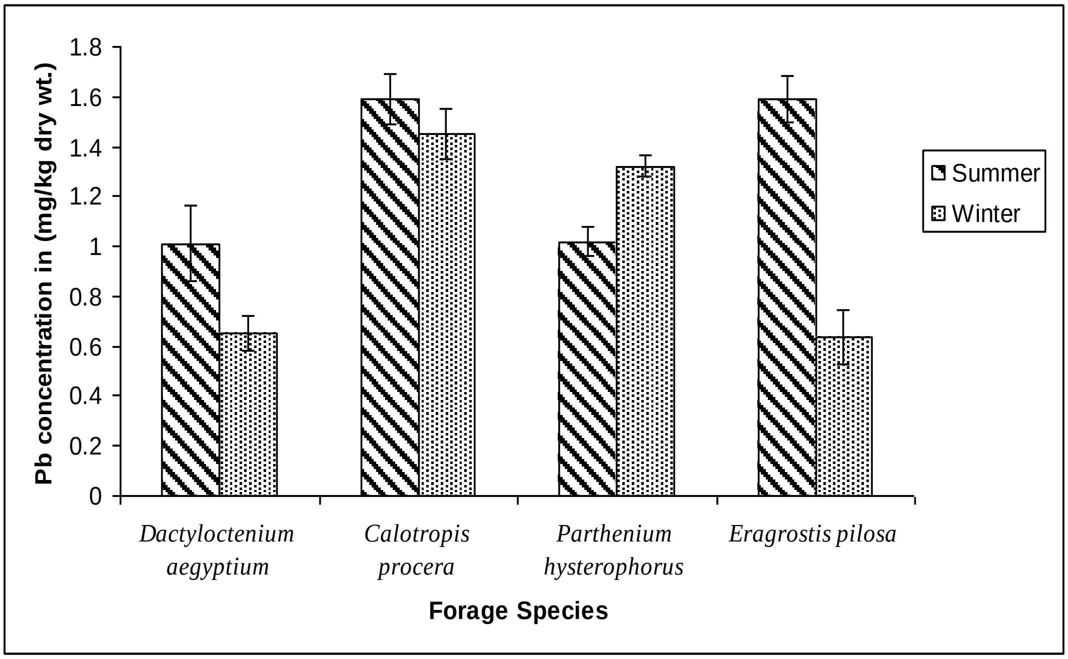

Fig. 2. Lead concentration in forages at different sampling intervals

Soil Cadmium: Cadmium (Cd) echelon here in soil ranged considerably (P<0.001) throughout different sampling periods (Table 2). The amounts of Cd in soil varied from 15.2 to 49.8mg/kg through all sampling periods with sudden tendency of augmentation or dwindling. Cd level varied from 15.26 to 49.89mg/kg at Site 1 and 17.04 to 44.9mg/kg at Site 2. The soil Cd was elevated in summer season than winter (Fig.3). Pinnacle stratum of soil has an average Cd amount numerous times elevated than the highest obtainable perimeter of 3mg/kg (Kloke, 1980). The suggested levels of Cd in soil are 3-8mg/kg (Ross, 1994) and also 0-1mg/kg (Fay et al., 2007). Then, according to this decisive factor, the concentration of soil Cd in our results was elevated than the lethal level. Those areas underlying industries have the greatest echelon of metals level such as Pb and Cd. Elevated level of heavy metals was observed in previous investigation in India (Anuratha, 2006). In present results, on the whole Cd in soil was elevated in summer as compared to winter. It might be owing to the amassing of deadly substance from the pollution of soil by filter cake and other waste matters from sugarcane industry in that vicinity.

Fodder Cadmium: Analysis of variance for Cd level exhibited non-significant effect (P>0.05) on fodder species of all samples harvesting intervals (Table 2). Average forage Cd varied from 0.88 to 5.23mg/kg in all the forage plants. There was sudden augment and decline of Cd level in all forage species in both seasons (Fig. 4). The maximum level was seen in *Calotropis procera* while the lowly value was observed in *Parthenium hysterophorus*. Cd value was much elevated than the decisive rank recommended by NRC (1980) as 0.5-0.005mg/kg and also elevated than those recommended formerly (Aksoy et al., 1999).Our standards were lower than the conclusion of Gowda et al. (2003) who premeditated the effect of contamination from industrial area and found 0.50-10mg/kg of Cd level. All average forage Cd concentration was analogous in forage species to the decisive value 2-3mg/kg suggested by Abbasi et al. (1998) and by Cicek and Koparal (2004). The toxicity of Cd in animals owing to its elevated levels in forage may be predictable at this particular premeditated area. Consequently, supplementation of livestock with minerals antagonistic to Cd is the alarming need to avoid toxicosis in ruminants.

Table 2. Analysis of variance for Cadmium concentrations in soil and forages at different sampling intervals.

Source of variation (SOV)	Degree of freedom (df)	Mean Squares					
		Soil		Forages			
		Site 1	Site 2	Species 1	Species 2	Species 3	Species 4
Sampling periods (Summer)	2	200.381***	127.940***	4.866ns	1.372ns	0.019ns	1.390ns
Error	11	0.088	0.269	3.441	1.039	0.072	0.570
Sampling periods (Winter)	2	44.903***	37.322***	3.558ns	5.754ns	0.154ns	0.008ns
Error	11	0.088	0.419	2.892	1.873	0.104	0.071

Data is expressed as mean squares significant at ($p<0.05$-$p<0.001$), vs. control where *=0.05, **=0.01, *=0.001, ns= non-significant**

Species 1= *Dactyloctenium aegyptium*
Species 2= *Calotropis procera*
Species 3= *Parthenium hysterophorus*
Species 4= *Eragrosti spilosa*

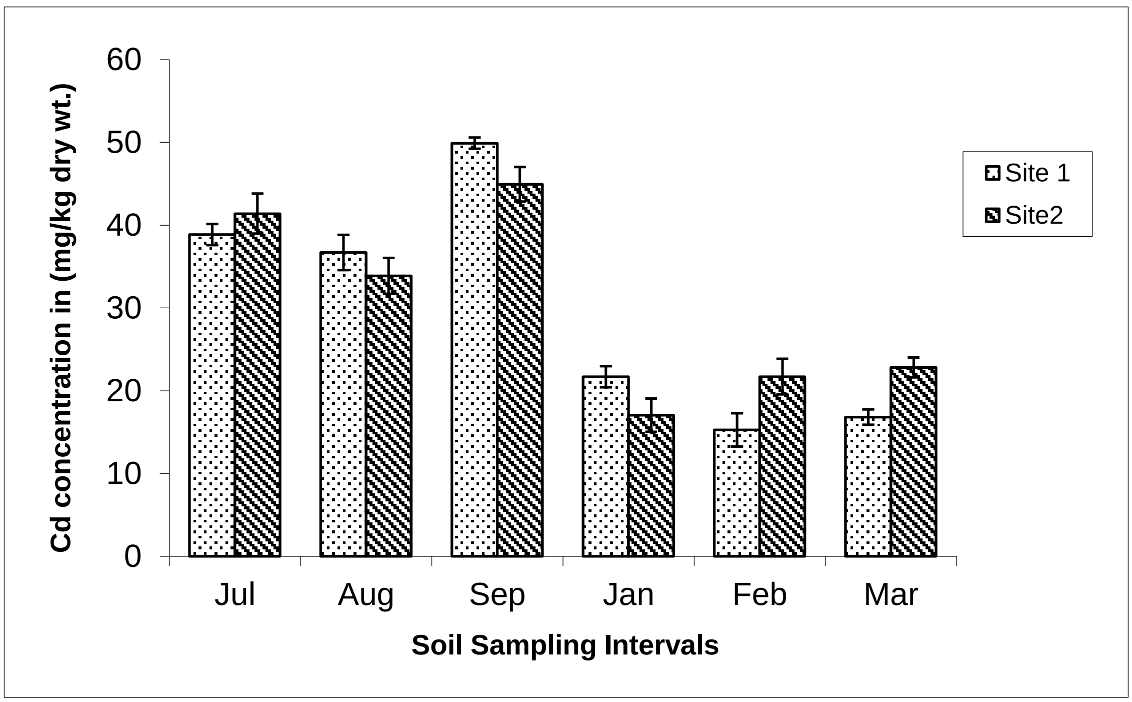

Fig. 3. Cadmium level fluctuations in soil at different sampling intervals.

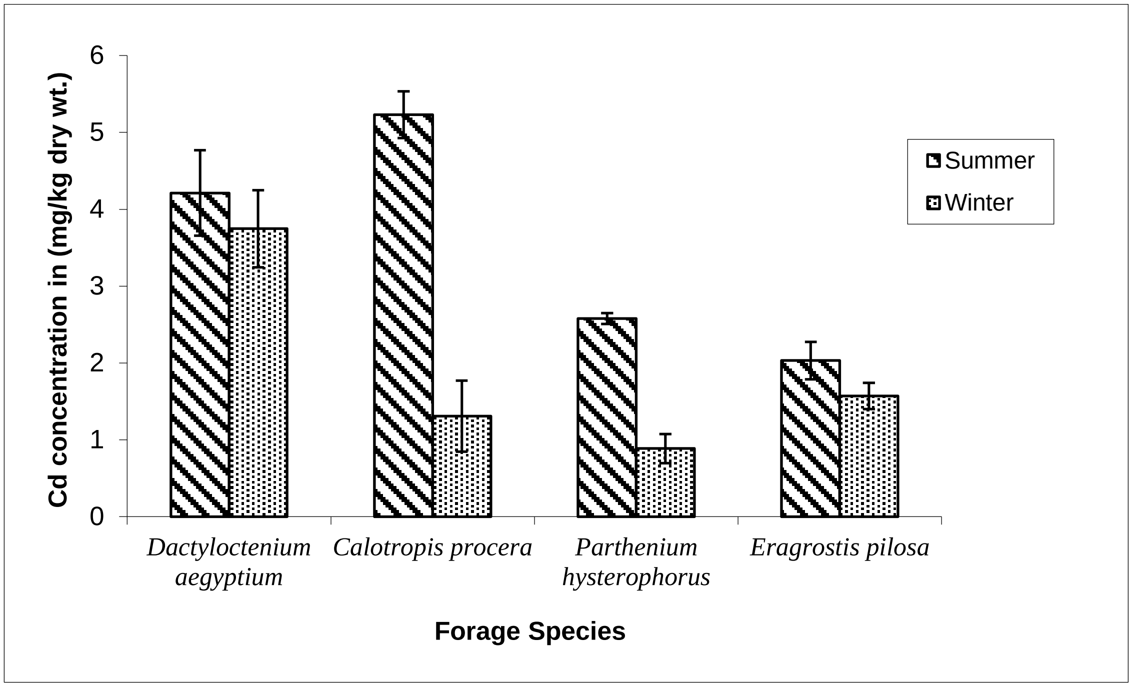

Fig. 4. Cadmium level fluctuations in forages at different sampling intervals.

Soil Chromium: The information on levels of soil chromium showed exceedingly momentous variations ($P<0.001$) on sampling intervals of both sites (Table 3). Average levels varied from 2.6 to 25.9mg/kg. Chromium level varied from 19.9 to 20.79mg/kg in summer season at Site 1 while 3.8 to 4.69mg/kg in winter at Site 1 (Fig.5). Average levels of chromium ranged from 23-25.9mg/kg in summer at Site 2 and 2.6-4.92mg/kg in winter on the same site. On the whole, maximum levels were found in summer rather than in winter. Decisive level investigated by MacLean et al. (1987) was 8µg/g which was lesser than present exploration. Gyawali and Lekhak (2006) reported decreased cultural standard of rice cultivars by application of 10 to 800mg/kg Cr to 0.86-100%. The Cr concentration was similar to the investigation approved by Bergmann (1992) as 2-50mg/kg. So all the mean concentrations were below the deadly limit and no noxious effects are predictable in forage plants being consumed by animals in that particular studied area.

Fodder Chromium: There was a momentous disparity ($P<0.05$, $p<0.001$) of Cr level on all sampling times (Table 3). The average level of chromium in forage varied from 0.22-1.0mg/kg in summer and 0.05-0.61mg/kg in winter season (Fig.6). The maximum values of Cr were found in *Calotropis procera* and the lowest in *Eragrosti spilosa*. It has been suggested that diverse plant parts include changeable quantity of Cr (Anderson et al., 1990). The present forage Cr levels were elevated than the conclusion of Khan et al. (2010). The Pb, Ni and Cr metals were very treacherous for ruminant's health if these were present in the nutritional sources at a larger amount than the allowable levels suggested by the Consumer Regulatory Authority. It has been reported that grazing livestock in meticulous area yields additional amount of metals in their body by consuming forages present in close proximity, which might have accumulated in the bodies of grazing ruminants, thus producing a diversity of health issues, like, hyperkeratosis, colour changes in covering, bone defects, crack and kidney and nervous system harm (McDowell, 2003). Elevated stage of Cr in forage could cause toxicities in livestock. In our current study, Cr intensity was lesser from the toxic level so no hazards of its toxicity can be anticipated in livestock consuming the forages at this particular area of study. Further study is required to come across out the variations in metal uptake by diverse forage plants and the site-specific hazard consideration guiding principle to emphasize and to lessen the probable health risks of ingesting fodders containing elevated concentrations of heavy metals.

Table 3. Analysis of variance for chromium concentrations in soil and forages at different sampling intervals.

Source of variation (SOV)	Degree of freedom (df)	Mean Squares					
		Soil		Forages			
		Site 1	Site 2	Species 1	Species 2	Species 3	Species 4
Sampling periods (Summer)	2	0.012***	0.051***	0.010ns	0.659**	0.335*	0.016ns
Error	11	0.001	0.003	0.051	0.096	0.081	0.008
Sampling periods (Winter)	2	0.037***	0.004*	0.360***	0.058ns	0.147*	0.000ns
Error	11	0.001	0.001	0.015	0.021	0.037	0.000

Data is expressed as mean squares significant at (p<0.05-p<0.001), vs. control, where *=0.05, **=0.01, *=0.001, ns=non significant.**

Species 1= ***Dactyloctenium aegyptium***
Species 2= ***Calotropis procera***
Species 3= ***Parthenium hysterophorus***
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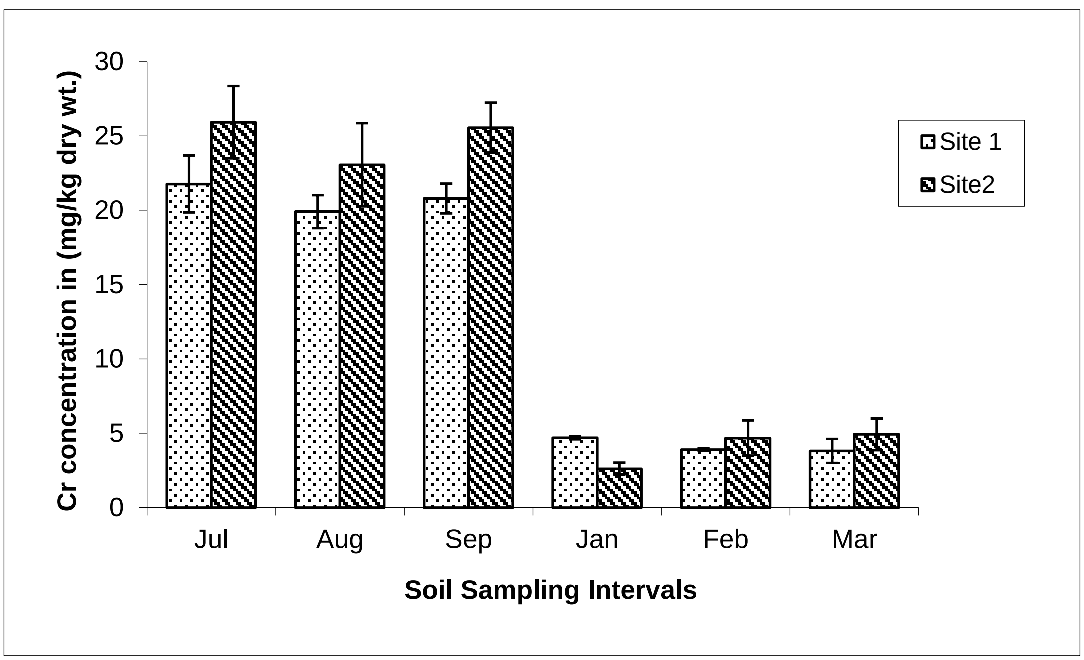

Fig. 5. Chromium level fluctuations in soil at different sampling intervals.

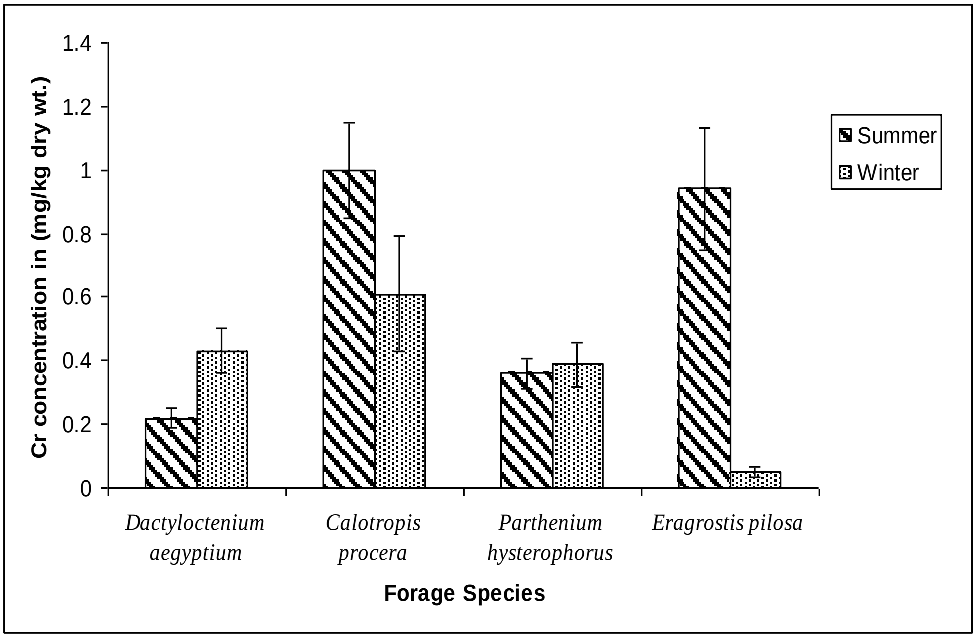

Fig. 6. Chromium level fluctuations in forages at different sampling intervals.

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