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Assessment ofmacrominerals and their distribution and concentration in soil-plant-animal systems in Shor Kot, Pakistan

Abstract

The status of differentmacrominerals was appraised in soils, forages and blood plasma of two buffalo groups (lactating, non-lactating). Soilmg+ and K+ remained below their respective critical values, while Na+ and Ca+ exceeded their critical values in soil. Forage had high Ca andmg whereas, K and N concentrations stayed within prescribed limit. Blood plasma hadmean values higher than critical concentrations for Na, Ca, andmg. The observations recorded in current study implied thatmetals in toxic concentrations have been built up in animals through consuming forage contaminated withmetals both in tissues and at exposed plant parts.

Keywords: ruminant, pasture,mineral, nutrition,milk

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Introduction

One of themajor contributory sectors of agriculture in Pakistan is livestock sector. Contribution of livestock in GDP of the country is 12%.[1] Several products likemeat,milk,manure and leather hide are obtained from livestock.[2] Plants are the primary source of food for ruminants. Apart from fulfilling food needs, plants also provide adequate amounts ofminerals to the animals. Plants acquire theseminerals from soil. A complex interactive relationship occurs between soil, plants and animals. Hence,mineral status in these interdependent entitiesmust be ascertained for provision of balanced diet.[3] Biomonitoring is necessary for regulating environmental stress triggered by upheavals inmineral concentrations.[4]

Macrominerals like calcium (Ca),magnesium (Mg), sodium (Na) and Potassium (K) are required in animals and plants for variousmetabolic processes.[5,6] Excess and dearth of theseminerals cause various physiological and cellular defects. High calcium levels cause slow bone growth and heart failure;[7] elevated potassium level results inmembrane damage, tissue necrosis and hyperleukemia.[8,9]magnesium shortage implicates in hypomagnesia.[s] Forage digestibility is reduced deficiency of sodium.[11] An approach to devise a possible relationship ofmetal flow among soil, forages and blood plasma is the question of this study. Ascertainingmineral level in forages and their consumers was taken under consideration.

Materials andmethods

Study area

Livestock station at Shorkot city, district Jhang was taken as study area. Temperature of the area varies according to season withmean winter and summer temperatures dwindling between 12-35°C.

Soil and forage sampling

Various forages including some dominant plants like *Sorghum bicolor, Zeamays, Pennisetum glaucum* were grown in pasture at the time of sampling. Different sampling intervals like 5m, 10m, 15m and 20m were kept for collection of soil and forage. Forages were taken from 3-6cm at the feeding level of grazing animals from predefined sampling intervals. A total of 36 samples of soil and forages each were collected.

Blood sampling

Twenty buffaloes were grouped in two categories i.e. lactating (n=10) and non-lactating (n=10). Non-lactating buffaloes were below 4-5years and weighed between 70-100kg while lactating buffaloes were above 4-5years and weighed between 80-102kg. 15ml blood sample from jugular vein was collected in heparin containing syringes and plasma was separated via centrifugation.[12]

Sample preparation and analysis

After air drying, the forages and soil were oven dried for 3days to evademoisture. After grinding, the samples were passed through fine sieve. 1gm of each sample was taken for digestion with the help of H_2O_2 and H_2SO_4 using ratios defined by Vidovic et al.[13] Themixture was heated for 3-4hours till transparency was achieved. The samples were diluted up to 50ml after filtration. H_2SO_4 (2ml) was added in 2ml of blood plasma and themixture was kept overnight; digestion was carried out till the dissolution of organicmatter. Final volume of 50ml wasmade using distilled water.

Analysis ofmetals

Atomic absorption spectrophotometer (Model #AA-6300, Shimadzu, Japan) was used for estimation of sodium, potassium,magnesium and calcium.

Statistical analysis

Metalmean values and statistical significant differences

betweenmetal concentrations of all samples were determined using SPSS (version 21).

Results and discussion

Soil potassium

ANOVA depicted significant ($p \leq 0.05$) Kmean concentration differences with respect to sampling intervals for soil (Table 1). The concentration ranged between 83.40-106.20mg/kg (Figure 1). Samples obtained from 15m distance from road side had highest Kmean levels.

Forage potassium

Significant ($p \leq 0.05$) variation in K forage concentration was exhibited at different sites (Table 1). Highest K level was found at the 20m distance while the range stayed between 0.088-0.102% (Figure 2).

Soil sodium

No significant difference in Na soil concentration was observed at different distances (Table 1). The range of Na level was 58.15-64.46mg/kg (Figure 3). Farthest distance of 20m had highest Na level.

Forage sodium

Non-significant difference in Na forage concentration was observed at different distances (Table 1). A range of 401.98-428.24 % was observed (Figure 4). Highest Na level was found at the 20m distance.

Soil calcium

ANOVA depicted significant ($p \leq 0.05$) Camean concentration differences with respect to sampling intervals for soil (Table 1). The concentration ranged between 63.35-82.22mg/kg (Figure 5). Samples obtained from 15m roadside distance had highest Camean levels.

Forage calcium

Variation in Ca forage level was not significant (Table 1). Farthest distance of 20m had highest Ca level with range between 2163.47-2416.87% at all sampling distances (Figure 6).

Soilmagnesium

ANOVA yielded significant ($p \leq 0.05$)mgmean concentration differences with respect to sampling intervals for soil (Table 1). A range of 9.92-11.41mg/kg was obtained whilemaximum level was found at 20m site (Figure 7).

Table 1 ANOVA for K, Na, Ca and Mg mean levels in soil and forage of livestock station, Shorkot

S.o.v	df	Mean square							
		Soil				Forage			
		K	Na	Ca	Mg	K	Na	Ca	Mg
Distance	3	1022.685***	61.045^{ns}	1000.191***	4.155**	0.0001**	1331.554^{ns}	108622.475^{ns}	25773.14^{ns}
Error	32	157.406	91.471	144.874	0.812	0.0001	660.089	75490.222	100498.36

Significant at 0.001, ***; 0.01, **; 0.05, *; ns, non-significant

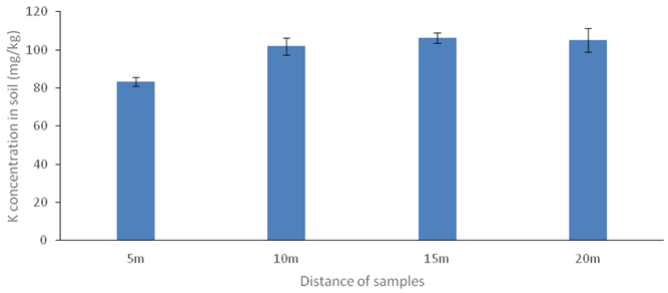

Figure 1 Variation in K mean concentration in soil at different sampling intervals.

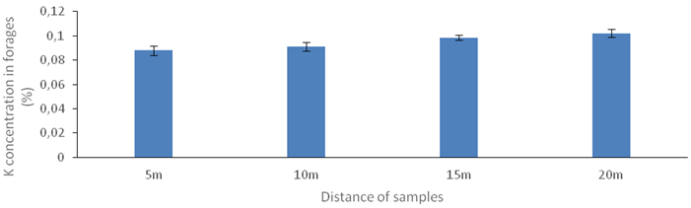

Figure 2 Variation in K mean concentration in forage at different sampling intervals.

Foragesmagnesium

An insignificant difference inmg forage level was observed at different distances (Table 1). Sampling point of 20m had highest level ofmg in plants (Figure 8).

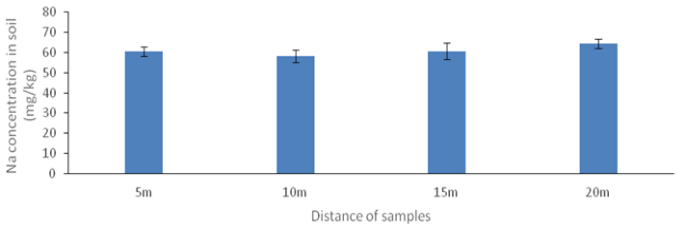

Figure 3 Variation in Na mean concentration in soil at different sampling intervals.

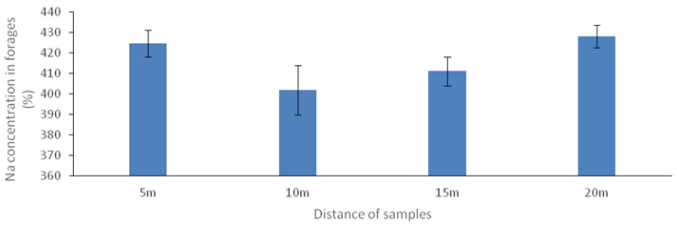

Figure 4 Variation in Na mean concentration in forage at different sampling intervals.

Blood plasma potassium

Relatively similar concentrations of K were present in plasma of two buffalo categories (Table 2). Obtained range for samples was 17.24-17.27mmol/L (Figure 9) and the highest level was ascertained in non-lactating buffaloes lower than the critical limit (2.20mmol/L) established by Grace.[14]

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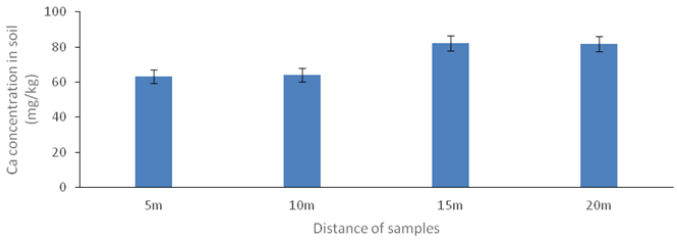

Figure 5 Variation in Ca mean concentration in soil at different sampling intervals.

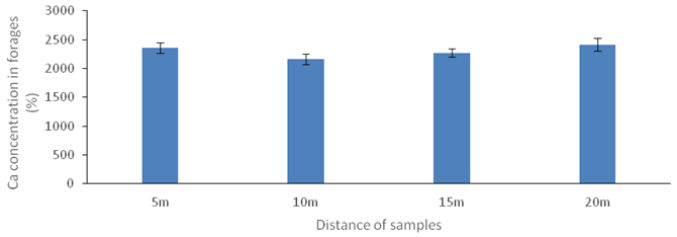

Figure 6 Variation in Ca mean concentration in forage at different sampling intervals.

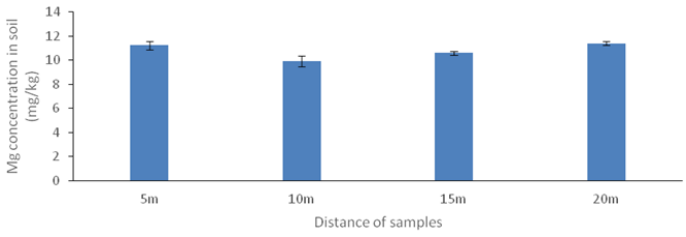

Figure 7 Variation in Mg mean concentration in soil at different sampling intervals.

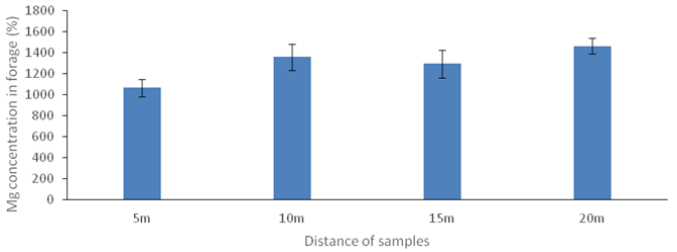

Figure 8 Variation in Mg mean concentration in forage at different sampling intervals.

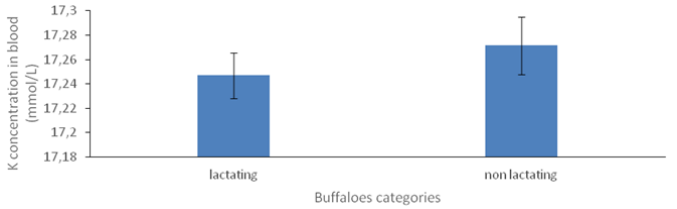

Figure 9 Variation in K mean concentration in blood plasma.

Blood plasma sodium

Almost similar Na concentration was present in whole buffalo lot under study (Table 2). Non-lactating buffaloes, however, had somewhat higher Namean level and the overall range was 1220.33-1311.65mmol/L (Figure 10).

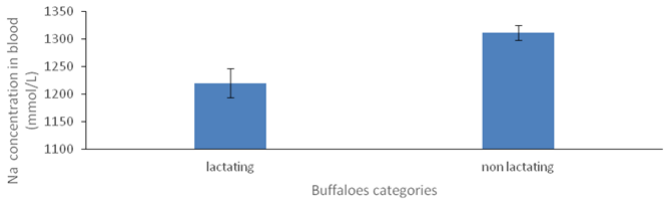

Figure 10 Variation in Na mean concentration in blood plasma.

Blood plasma calcium

Relatively similar concentrations of Ca were present in plasma of two buffalo categories (Table 2). Obtained range for samples was83.70-90.92mmol/L (Figure 11) and the highest level was ascertained in non-lactating buffaloes.

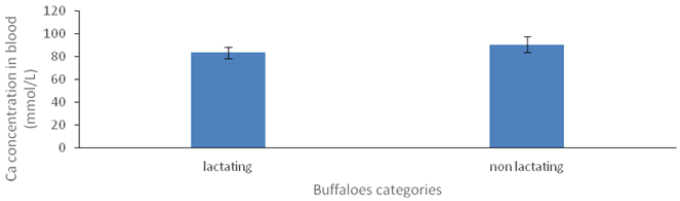

Figure 11 Variation in Ca mean concentration in blood plasma.

Blood plasmamagnesium

ANOVA yielded significant ($p \leq 0.05$)mgmean concentration differences with respect to buffalo cohorts (Table 2). Lactating buffaloes had highermgmean level and the overall range was 6.81-8.09mmol/L (Figure 12).

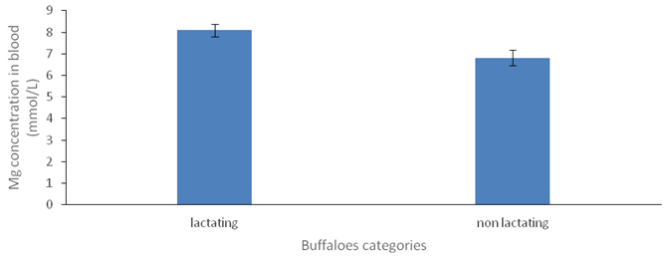

Figure 12 Variation in Mg mean concentration in blood plasma.

Table 2 Analysis of variance for K, Na, Ca and Mg concentrations in blood plasma in two buffalo categories

S.O.V	df	Mean square			
		K	Na	Ca	Mg
Buffalo Categories	1	0.003^{ns}	41698.082^{ns}	260.841^{ns}	8.234*
Error	18	1.342	4412.109	419.411	1.038

Significant at 0.001, ***; 0.01, **; 0.05, *; ns, non-significant

Discussion

The estimated concentration stayed within the critical limit (80mg/kg) described by Warncke & Robertson.[15] Current study estimations were also lower than the other studies carried out in

Florida[16] and Pakistan.[17] Leaching could be the possible reason of low K concentrations.[18] The K levels did not exceed the critical limit of 0.8%.[3] The current study results concurred with findings of Prabowo et al.[19] in Indonesia, Ogebe et al.[20] in Nigeria, Tiffany et al.[21,22] in North Florida and[23] in Pakistan. However, these levels were lower than 8 g/kg, the recommended limit for grazing animals.[6]

Rhue & Kidde[24] estimated the critical level of 62mg/kg and the Na concentration in current study exceeded that. Similar values at other animal ranches were found in various other studies.[17,18,25,26] Optimal level of 0.06%[27] was not crossed in any sample. Several other studies in different parts of the world had reported similar results.[21,22,28] Na supplementation was not needed as the ruminants had adequate supply of Na from the forage. The results of Anon[29] and Khan et al.[30] were below the levels ascertained in current study.

The critical limit (72mg/kg) was surpassed.[23] Contrasting results were obtained by Ruan et al.[31] for calcium in forages. The samples had higher levels than critical limit of 0.3%.[3] Khan et al.[24,32] and Pastrana et al.[33] reportedmuch lower Ca levels than the current study. The level stayed within the critical range of 30mg/kg.[23] Ciećko et al.[34] and Tiffany et al.[22] reported levels higher than the present investigation. The results suggested that soil was deficient ofmg and needed fertilization ormanuring.mineral lossmay occur through excretion[35] and it could be the probable cause of K level being devised asmarginally deficient. Present study levels were, however, higher than the findings of Grunwaldt et al.[36]

Plasma had gathered Na higher than critical limit of 120mmol/L.[37] The values were above the findings of Rahman[28] but similar to Khan et al.[38] The values were above the critical limit of 2mmol/L.[39] Bloodmineral concentrations had been affected by themineral status in soil and forage.[40] The currently calculated values exceeded critical limit of 2.8mmol/L.[14] Pasha et al.[41] had reported similar findings but Gizachew[42] reportedmg levels lower than the current study. Forages have the ability of fulfillment of essential nutrient requirements of the livestock.[38,43–46]

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None.

Conflict of interest

Author declares that there is no conflict of interest.

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