



## ABSTRACT

Information on mineral levels of forages are very important to identify what measures should be taken to improve the nutritional status of grazing livestock. Seasonal variation affects livestock seasonal production in different regions of the world by affecting forage dry matter accumulation. The study was aimed to evaluate the concentration of minerals in

# MINERALS CONCENTRATION OF SOIL IN RELATION TO THE PASTURE REQUIREMENTS IN MAIDUGURI METROPOLITAN AREA

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## Introduction

Plants absorb minerals from soil as well as from surface deposits on parts of plants exposed to polluted areas. In Nigeria, no information is available so far with reference to the nutritive value, particularly mineral concentrations of different forages in relation to different seasons. Therefore, there is a need to evaluate the mineral concentrations during the summer and winter seasons in relation to pasture requirements. Information on mineral levels of forages are very important to identify what measures should be taken to improve the nutritional status of grazing livestock. Seasonal variation affects livestock seasonal production in different regions of the world by affecting forage dry matter accumulation (Arizmendi-Maldonado *et al.* 2001; Khan *et al.*, 2004, 2005). Seasonal forage nutrient contents stability may be achieved through successful breeding programs (Mislevy *et al.*, 1999). It is important to know the mineral-nutrient concentration of new varieties, because



*relation to pasture requirement of ruminants. The study was conducted in two successive phases. The Soil was collected daily within the vicinity of Maiduguri metropolitan; each wards five different sample was collected at random following the grazing Animal on grazing field. The samples were allowed to dry using hot oven (Model 30GC lab oven) and then ground into fine powder by using a porcelain mortar and pestle. The study discovered that soil minerals are concentrated in 6 local government areas of the 12 studied. These soil minerals relatively complement the growth of forages for ruminant nutrition in those areas.*

**Keywords:** Soil; Mineral Concentrations; Farm Animals; Pasture; Nutrients

forage is the primary source of nutrients for livestock consuming pastures (McDowell, 1992) because mineral-nutrients to the feed.

The northern savannah region of Nigeria suffers the most in terms of the impact of climate change on vegetation. The most abundant vegetation within the region which are mostly grasses to provide the ruminant animals with the necessary nutrition required.

Mineral uptake by plants is greatly influenced by soil pH: the effects in a grass and are even more striking in legumes. Molybdenum uptake increases as soil pH rises. Pasture molybdenum can rise sufficiently on alkaline or calcareous soils (clays, shales and limestones) to induce copper responsive disorders in livestock by impairing copper absorption. By contrast, plant uptake can be sufficiently poor on acidic soils to cause molybdenum deficiency in leguminous plants. The application of lime and sulfur can raise or lower soil pH, respectively, and so change the availability of particular minerals to plants. Liming is occasionally needed to maintain or improve soil fertility, but the associated increase in pasture molybdenum can induce copper deprivation in grazing sheep (Suttle and Jones, 1986). The absorption of nickel, cobalt and manganese by plants is favoured by acid soil conditions (Underwood and Suttle, 1999). The cobalt, molybdenum and manganese concentrations in pasture plants are all greatly increased by soil waterlogging (BurrIDGE et



*al.*, 1983). Thus, soil conditions greatly influence the mineral composition of crops and forages and the efficacy of fertilizer applications. However, the use of soil extractants to measure 'plant-available' minerals frequently fail to predict plant mineral concentrations (Jumba *et al.*, 1996), although soil extractants may be good predictors of plant yields in some cases (e.g. iron, manganese and zinc).

This study was aimed to evaluate the concentration of minerals in relation to pasture requirement of ruminants.

## **Materials and Methods**

### **Experimental Site:**

This experiment was conducted at twelve wards of Maiduguri Metropolitan Council (MMC) Local Government of Borno State, (Bolori, Mafoni, Fezzan, Hausari, Gwange I, Gwange II, Bolori I, Bolori II, Gwange II, Limanti, Lamisula, Gomboru)

### **Methodology**

This study was conducted in two successive phases. The soil samples were collected daily within the vicinity of Maiduguri Metropolitan Council (MMC); each wards five different sample was harvested at random following the grazing Animal on grazing field.

### **Heavy Metals analysis**

The equipment and instruments was used in this study were all calibrated to check their status before and in the middle of the experiments. Apparatus such as volumetric flasks, measuring cylinder and digestion flasks was thoroughly washed with detergents and tap water and then will be rinsed with deionized water. All Glass was cleaned with 10% concentrated Nitric acid ( $\text{HNO}_3$ ) in order to clear out any heavy metal on their surfaces and then rinsed with distilled-deionised water. The digestion tubes were soaked with 1% (w/v) potassium dichromate in 98% (v/v)  $\text{H}_2\text{SO}_4$  and the volumetric flasks in 10% (v/v)  $\text{HNO}_3$  for 24 hours followed by rinsing with deionized water and then dried in oven and will be kept in dust free place until analysis began. Prior to each use, the apparatus was soaked and rinsed in deionized water.



### ***Equipment and Apparatus***

1. Analytical balance, 250-g capacity, resolution 0.0001g, OHAUS, PA214 pioneer USA
2. Glass ware: Borosilicate volumetric flasks (25, 50 ml, 100 ml & 1000 ml), Measuring cylinders,
3. Micropipettes (1-10 ml, 100-1000 ml)
4. Atomic absorption spectrophotometer (Buck scientific model 210VGP AAS, USA; equipped with hollow cathode lamps and air-acetylene flame)
5. Microwave digester (Master 40 serial No: 40G106M)

### ***Reagents and Chemicals***

Reagents and chemicals used for the laboratory works were all analytical grade: Deionized water (chemically pure with conductivity 1.5  $\mu\text{s}/\text{cm}$  and below was prepared in the laboratory) and was used for dilution of sample and intermediate metal standard solutions prior to analysis and rinsing glassware and sample bottles.

### ***Sample Pre-Treatment/Digestion (soil samples)***

The samples were allowed to dry using hot oven (Model 30GC lab oven) and then ground into fine powder by using a porcelain mortar and pestle. About 200mg of each sample was weighed in to thoroughly clean plastic container (microwave tube) and 6ml of 65%  $\text{HNO}_3$  and 2ml of  $\text{H}_2\text{O}_2$  (and 2mL of HF for soil samples only) was added and allowed to stand for a while. The plastic container (microwave tube) was then covered and placed in to microwave digester (Master 40 serial No: 40G106M) and digested.

The digestion was carried out at a temperature of (75°C) for 10 min and then ramped at 10°C per min to 95°C and hold for 30mins. The digestion followed by a cooling to room temperature in the microwave. Potential presences of metal/elements in chemicals used in digestion were determined. Blanks was used simultaneously in each batch of the analysis to authenticate the analytical quality. The digested samples were diluted with deionized water to a total volume of 100ml.



### **Sample Pre-Treatment (Water)**

The samples were filtered through whatman no 1 filter paper. About 1mL of HNO<sub>3</sub> was added to each 90mL of sample (to make 1.0%). The presence of heavy metals in the samples was determined using AAS. Blank was used simultaneously in each batch of the analysis to authenticate the analytical quality.

### **Preparation of 1000mg/Litre stock AAS standard solution for selected heavy metals (such as Pb, Cr and Cd and other metals)**

The determination of a given metal concentration in the experimental solution was based on its respective calibration curve. In plotting the calibration curves for lead, cadmium, zinc and other metals, a stock solution of each metal ion of (1000ppm) supplied by manufacturers company was used, from which a standard working solution of 100ppm was prepared.

**Standard working solution:** 100ppm was prepared as working solution from the 1000ppm already prepared. A simple dilution formula ( $C_1V_1 = C_2V_2$ ) was used to calculate the volume of the stock solution to be diluted to the new desired concentration. 1mL of concentrated HNO<sub>3</sub> was added to each working standard and finally diluted to the desired volume with deionised water.

To prepare 100ppm, 10ml of the standards and other stock solutions were pipetted and added in to 100 ml calibrated flasks finally diluted with deionized water and the solution was mixed thoroughly. The other standard working solutions was prepared from 1000ppm by pipetting out appropriate volume in to calibrated flasks and made up to volume with deionized water.

### **Determination of metal content by AAS**

#### **Preparation of calibration curve**

Calibration curves were prepared to determine the concentration of the metals in the sample solution. The instrument was calibrated using series of working standards. The working standard solutions of each metal will be prepared from standard solutions of their respective metals and their absorbencies will be taken using the AAS. Calibration curve for each



metal ion to be analyzed will be prepared by plotting the absorbance as a function of metal ion standard concentration.

### ***Determination of metal contents of each sample***

Concentration of the metal ions present in the sample was determined by reading their absorbance using AAS (Buck scientific model 210GP) and comparing it on the respective standard calibration curve. Three replicate determinations were carried out on each sample. The metals was determined by absorption/concentration mode and the instrument readout was recorded for each solution manually. The same analytical procedure was employed for the determination of elements in digested blank solutions and for the spiked samples.

### **Data Analysis**

Data obtained from the experiment was subjected to ANOVA using statistics 8.1. difference between mean will be tested using the DUNCAN multiple range test

### **Results and Discussion**

The results for soil mineral concentration from the 12 Local Government Areas under studied are given in table 2a and 2b. There was no statistical significant ( $P>0.05$ ) differences in the mean Lead (Pb) distribution across all the LGAs. The mean soil calcium levels varied significantly ( $P>0.05$ ) among the LGAs, soil samples from Fezzan, Hausari, Gwange I and Limanti LGAs recorded the highest soil calcium levels (Table 2a). Soil phosphorus level was significantly ( $P>0.05$ ) higher in Limanti, Bolori I, Mafoni, Fezzan, Hausari, Gwange I and Lamisula (Biu) LGAs, while soil sulphur level was observed to be significantly high in Fezzan, Hausari, Gwange I, II, III, Limanti and Bolori II LGAs (Table 1).

Also, there was significant ( $P>0.05$ ) difference in soil magnesium concentration across all LGAs, Mafoni > Bolori I have highest concentration while Bolori II recorded the lowest. The soil copper concentration is significantly ( $P>0.05$ ) higher in Gwange II, III and Fezzan than all other LGAs. Similarly, soil samples from Limanti and Bolori I showed higher concentration of soil zinc. Finally, only little significant



( $P > 0.05$ ) difference was observed in soil iron, manganese and arsenic across all LGAs understudied. Fezzan, Hausari, and Gwange III have higher soil iron levels, only Bulablin LGA has the highest soil manganese levels and soil arsenic were high in Bulablin, Bolori II and Gamboru LGAs (Table 2).

**Table 1:** Mineral concentration of selected soil samples from 12 Local Government Area of Maiduguri

WARDS	Pb (mg/kg)	Ca (mg/kg)	Ph (mg/kg)	S (mg/kg)	Mg (mg/kg)
LIMANTI	6.09 ± 1.49 (5)	160.6 ± 27.92 (5)bc	1046.65 ± 89.12 (5)c	40.99 ± 3.63 (5)cd	1352.47 ± 124.33 (5)bcd
BOLORI I	3.64 ± 1.68 (5)	124.03 ± 34.34 (5)abc	1039.87 ± 83.48 (5)c	25.19 ± 4.18 (5)ab	1593.67 ± 844.2 (5)d
MAFONI	4.19 ± 1.4 (5)	93.79 ± 34.35 (5)ab	936.27 ± 59.03 (5)c	36.31 ± 4.49 (5)bcd	3643.62 ± 319.94 (5)e
LAMISULA	3.12 ± 1.4 (5)	78.24 ± 31.46 (5)ab	831.97 ± 91.4 (5)bc	28.74 ± 4.66 (5)abc	1955.02 ± 292.41 (5)d
FEZZAN	5.31 ± 1.82 (5)	200.25 ± 23.9 (5)c	1006.93 ± 63.44 (5)c	51.24 ± 5.21 (5)d	482.84 ± 28.82 (5)abc
HAUSARI I	5.84 ± 1.48 (5)	189.79 ± 9.84 (5)c	1108.38 ± 81.95 (5)c	44.71 ± 3.14 (5)d	1429.62 ± 63.69 (5)cd
GWANG E I	4.74 ± 1.57 (5)	196.72 ± 6.32 (5)c	1001.47 ± 24.82 (5)c	50.03 ± 5.49 (5)d	497.12 ± 10.55 (5)abc
GWANG E II	4.49 ± 1.19 (5)	134.91 ± 13.47 (5)abc	928.89 ± 63.87 (5)c	45.66 ± 2.61 (5)d	1478.79 ± 135.66 (5)d
GWANG E III	5.35 ± 1.28 (5)	123.61 ± 35.63 (5)abc	988.18 ± 59.63 (5)c	49.43 ± 3.78 (5)d	475.56 ± 7.12 (5)abc
BOLORI II	4.31 ± 1.2 (5)	92.17 ± 31.69 (5)ab	605.22 ± 119.33 (5)b	40.49 ± 4.83 (5)cd	306.64 ± 63.45 (5)a



BULABLI IN	5.94 ± 1.18 (5)	135.4 ± 31.69 (5)abc	666.79 ± 127.33 (5)b	16.27 ± 4.34 (5)a	394.09 ± 63.58 (5)ab
GAMBO RU	3.89 ± 0.97 (5)	62.18 ± 15.17 (5)a	304.73 ± 98.54 (5)a	26.32 ± 8.22 (5)abc	1307.47 ± 384.13 (5)bcd

**Pb=Lead, Ca=Calcium, Ph=Phosphorus, S=Sulphur, Mg= Magnesium**  
**Group means, standard error and count are presented as; Means ± s. e. m**  
**(n): a, b, c, - means with different superscripts within factor (3 or more**  
**levels) are significantly different.**  
**Significant level = (P>0.05)**

**Table 2:** Mineral concentration of selected soil samples from 12 Local Government Area of Maiduguri

WARDS	Cu (mg/kg)	Zn (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Ar (mg/kg)
LIMANTI	8.28 ± 2.370 (5)a	40.08 ± 3.25 (5)cd	21.69 ± 3.69 (5)a	14.36 ± 3.65 (5)a	0.14 ± 0.04 (5)a
BOLORI I	5.42 ± 2.460 (5)a	49.1 ± 9.54 (5)d	25.27 ± 4.14 (5)a	11.87 ± 1.03 (5)a	0.16 ± 0.04 (5)a
MAFONI	17.64 ± 3.64 (5)ab	36.08 ± 5.81 (5)c	27.93 ± 5.41 (5)a	8.95 ± 2.18 (5)a	0.37 ± 0.11 (5)a
LAMISUL A	15.94 ± 1.73 (5)ab	9.65 ± 1.33 (5)ab	15.8 ± 3.92 (5)a	6.89 ± 1.41 (5)a	0.4 ± 0.12 (5)a
FEZZAN	25.78 ± 6.84 (5)bc	11.87 ± 2.48 (5)ab	78.9 ± 19.1 (5)b	6.40 ± 1.08 (5)a	000 ± 000 (5)a
HAUSARI	15.03 ± 3.13 (5)ab	8.25 ± 1.73 (5)ab	76.13 ± 13.25 (5)b	5.86 ± 1.48 (5)a	0.98 ± 0.32 (5)a
GWANGE I	18.28 ± 2.21 (5)ab	12.53 ± 1.61 (5)ab	39.84 ± 5.16 (5)a	7.10 ± 0.49 (5)a	0.17 ± 0.17 (5)a
GWANGE II	29.49 ± 11.22 (5)bc	16.21 ± 5.28 (5)ab	40.45 ± 4.29 (5)a	10.15 ± 2.55 (5)a	000 ± 000 (5)a
GWANGE III	37.44 ± 4.29 (5)c	20.44 ± 2.98 (5)b	69.89 ± 14.09 (5)b	9.62 ± 3.13 (5)a	1.2 ± 0.63 (5)a



BOLORI II	20.23 ± 4.71 (5)ab	9.15 ± 1.31 (5)ab	36.35 ± 9.98 (5)a	16.02 ± 9.27 (5)a	4.53 ± 2.99 (5)ab
BULABLI N	13.71 ± 2.82 (5)ab	11 ± 2.65 (5)ab	27.25 ± 4.72 (5)a	96.35 ± 44.09 (5)b	6.9 ± 2.47 (5)b
GAMBOR U	14.43 ± 4.1 (5)ab	6.86 ± 1.17 (5)a	33.09 ± 7.46 (5)a	2.64 ± 0.95 (5)a	3.47 ± 3.23 (5)ab

**Cu=Copper, Zn=Zinc, Fe=Iron, Mn= Manganese, Ar=Arsenic**

**Group means, standard error and count are presented as; Means ± s. e. m (n): a, b, c, - means with different superscripts within factor (3 or more levels) are significantly different.**

**Significant level = (P>0.05)**

The result of this study shows that soil calcium, phosphorus, sulphur, magnesium, copper, and zinc are mostly significantly high in 6 local government areas from the total 12 LGAs studied in Maiduguri metropolis, namely; Limanti, Fezzan, Hausari, Gwange I, Gwange II and Gwange III. However, the mean soil calcium levels were higher than the critical level of 72 mg/kg of soil dry matter suggested by Rhue & Kidder (1983), only Gamboru with 68mg/kg soil calcium has a closer value. Also, there is wide variation in the concentration of soil zinc among all the local government areas. Most of the soil samples collected from all the LGAs had zinc levels higher than the critical level of 2.5 mg/kg reported by Velasquez-Pereira *et al.*, (1997). The lowest level of soil Cu was observed in Limanti and Bolori I LGAs and highest in Gwange III. All soil samples from the 12 LGAs had more than adequate levels of copper. The mean soil copper concentration was much higher than the critical level of 0.3 mg/kg as stated by Rojas *et al.*, (1993).

## Conclusion

The study discovered that soil minerals are concentrated in 6 local government areas of the 12 studied. These soil minerals relatively complement the growth of forages for ruminant nutrition in those areas. Therefore, this study recommends that grazing animals should be concentrated on Fezzan, Hausari, Gwange I, Gwange II and Gwange III, given the amount of forages rich in macro and micro nutrient and soil mineral concentration in those areas.

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