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Determination of Essential Mineral Contents in Salty Soils Used for Supplementary Food to Ruminants in Wolaita Zone

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Abstract
Minerals are essential for life to fulfil the needs of growth and production and to replace cells lost during the course of normal metabolism. On this account, they need to be replenished continuously through food, water or supplements. Although not well studied, rural people in Ethiopia have been using soil supplements for ruminants with the assumption to improve livestock production. Therefore, this study was conducted to examine the mineral content in red and brown salty soils used for supplementary food to ruminants in Wolaita Zone and to compare the findings against the national standards, and forward appropriate recommendation. Representative samples of minerals were taken from different sites of SNNPR around Wolaita Zone, Humbo worada, near Lake Abaya to test the contents and concentration of elements. Sixteen Aduwaa(salty soil) samples were collected, air dried, any visible external particles were removed crashed, homogenized, sieved by using 2 mm mesh, accurately weighed, labelled in plastic bags and sent to mechanical and chemical laboratory and tested using XRF spectroscopy in South Africa and Ethiopian Conformity Assessment Enterprise, in Addis Ababa. One way ANOVA was used for test significance. The findings of XRF spectrometry test showed that there are more than forty six (46) elements in the soil sample. Among them Na (1.790 - 7.562%), Mg (0.461- 0.832%), P (0.023 - 0.092%), S (0.014 – 0.084%), K (2.722 – 3.186%), and Ca (0.404 – 0.844%) are essential macronutrients and Mn (0.190 – 0.216%), Fe (4.908 – 7.292%), Cu (0.00026 – 0.00062%), Co (0.00064 – 0.00089%) and Zn (0.016 - 0.032%), are essential micronutrients which can become toxic when the threshold limits for normal growth are exceeded. The study also showed Aduwaa did not contain heavy metals such as Ir and Hg which have; so far, unknown roles in living organisms, and are toxic even at very low concentrations. However, it contained Pb (0.00048 – 0.00076%), Cd (0.00025 – 0.00128%) and As (0.00425 – 0.00528%) in relatively at very low concentration. The sample contained Fe at extremely high concentration which have antagonistic role in copper absorption and metabolism.
Keywords: Supplementation, macro and micro minerals, XRF spectrometer, ANOVA, Aduwaa, Boole, Ruminants, Calcinations.

1. INTRODUCTION

Mineral is valuable or useful chemical substance that is formed naturally in the ground or a chemical that animal body needs to stay healthy. A healthy diet should supply all necessary vitamins and minerals. Minerals are essential for life, to fulfil the needs of growth and production and to replace cells lost during the course of normal metabolism. Minerals participate in a range of biochemical reactions as components of enzymes and fulfil a structural and osmotic role in a number of animal tissues.[1]Adequate mineral-vitamin nutrition is vital in optimizing animal growth, lactation, reproductive function and immune response. Mineral deficiencies can cause metabolic problems that bring about reductions in productivity, and in extreme cases, death. Mineral deficiencies are often difficult to detect since their only manifestation could be reduced productivity, which can also be to the result of poor nutrition or parasite infestation. The clinical signs of mineral deficiencies may be obvious only after the mineral status of the animal has fallen below threshold levels that may have affected response to vaccination. Maintenance, growth, lactation, reproduction and animal health cannot be optimized where mineral intake is not properly balanced.[2] However; severe deficiencies are more readily perceptible and can be recognized from specific symptoms. Mineral deficiencies are best confirmed by the analysis of blood samples.[3]

Mineral deficiencies vary, depending on soil factors, forage quality, region of the country, time of year and even type of animal. As an example, plants don't require several of the trace minerals (selenium) for growth, but cattle do. So, unless the soil has some selenium in it that the plant will capture, the cattle will likely be deficient in that trace mineral. Moreover, as cattle are bred for better performance: higher reproductive rates, increased weaning weights, growth, carcass characteristics, etc..., their nutritional requirements also increase.[4]

Ethiopia has the largest livestock population and the highest draft animal population in the continent. Central Statistical Authority (CSA) estimated that there are approximately 35 million cattle, 39 million sheep and goats, and 1 million camels in Ethiopia.[5] Despite the large number of livestock, there has been a declined national and per capita production of livestock and livestock products, export earnings from livestock, and per capita consumption of food from livestock origin since 1974, in comparison to other African countries.[6]

It is well known that some areas of Ethiopia are deficient in one or more minerals, e.g., copper in the

Rift Valley region. The minerals deficient in ruminant diets are sodium (as salt), calcium, phosphorus, and magnesium. Iodine may be deficient in diets for pregnant cows; likewise, several trace minerals, including copper, cobalt, and selenium probably reflecting soil deficiencies. An earlier mineral study in Ethiopia indicated that widespread Cu and Zn deficiencies, and although much more information on the supplies of essential minerals for livestock were required. [7]

Certain mineral elements which are essential for normal body functions are often deficient in the feeds offered to ruminant livestock. Na deficiency is probably the most common and salt (NaCl) should be provided as a matter of routine. Ca and P are most appropriate to be deficient in ruminant diets.[8] Attempts have been made to correct natural soil deficiencies for trace minerals by soil fertilization practices. Thus, it is implied that a beef producer needs to know the mineral and trace mineral content of the feedstuffs used in cattle rations. A general approach to prevent such deficiencies is to feed trace mineralized salt, along with a mixture of calcium and phosphorus supplementation.[9]

There are possible raw materials to be utilized in the production of mixtures that could be applied in animal supplementation, in most of the territories, Wolaita Zone of the Southern, Nations, Nationalities and Peoples' Region of Ethiopia is not an exception. A number of mineral soils that can be obtained from different parts of Ethiopian Rift Valley lakes and other areas contain adequate amount of most of the essential minerals with the exception of phosphorus.[10] These include Bole (Lake Abaya, Abijata, Zeway and Shala), Addo or Makadua (Lake Abaya) and Red Soil. From these, Aduwaa is abundantly and locally available in the Central Rift Valley than the other kinds of mineral soil and is used by local farmers as a mineral source for their cattle.

Previous work showed that Boole (Aduwaa) soil improves milk yield and feed intake of dairy cows.[11] However; there was no documented information on the level of intake and corresponding productivity. Therefore, this study was conducted with the objective to compare different levels of essential minerals in Aduwaa for supplementary feed intake in ruminants. Aduwaa has been given two names depending on its colour and presumed functions it offers: 'Gassaara' for red Aduwaa and 'Maqaddauwaa' for brown Aduwaa. Gassaara Aduwaa is used by local people to increase the productivity of milk and Maqaddauwaa is for optimal growth, beef production and reproduction. Around Rift Valley some rural areas such as Wolaita, Sidama, Hadiya, Kambata, Gurage and Silte Zone farmers used to supplement salty soil (Aduwaa) to their livestock as free choice supplement only,[13] but this is not a balanced supplementation to enhance their nutritive efficiency and adequate production.

Aduwaa is a salty soil which people used to supplementary spice for their livestock's, when added in grass and water, cattle's feed and drink over than as usual. But there is no adequate information available in scientific literature on its mineral content, whether it may contain toxic heavy elements (Hg, Cd, As, Pb etc…) or essential macro and micro nutrients (Na, K, Mg, Ca, Cu, Fe, Zn, Mn, etc…), in how much level comparing with National Research Council (NRC) standard. Therefore, this study was conducted to come with solution for such questions raised by scientific society and community. Therefore the aim of this study is to which is potentially used as supplementary food to ruminants,

The study will generate knowledge on the mineral composition of Aduwaa that is widely used by the local community and determine the locally available, essential macro and micro nutrients in Red and Brown salty soil mineral in Aduwaa in Wolaita Zone by using different instrumental techniques which assist in formulating supplementary mixtures for ruminants. The findings of the study will be used as a baseline material to assist decision makers and resource allocators for interventions and future studies on the subject. Also the mineral content of the analyzed sample may indicate mineral requirements i.e. deficiencies/ shortages or excess presence which will assist designing mineral supplementation mixtures and save resources. Therefore, the livestock producers, the scientific society and the community as whole will be beneficiaries from this study. The study will forward recommendations that will indicate the need for intervention or further studies based on the findings.

2.1 Ruminants and Non Ruminants

A ruminant is a mammal that digests plant-based food by initially softening it within the animal's first compartment of the stomach, principally through bacterial actions, then regurgitating the semi-digested mass, now known as cud, and chewing it again. The process of re-chewing the cud to further break down plant matter and stimulate digestion is called "ruminating". There are about 150 species of ruminants which include both domestic and wild species. Ruminating mammals include cattle, goats, sheep, giraffes, yaks, deer, camels, antelope and etc. Ruminants have a four-compartment stomach. The four parts of the stomach are rumen, reticulum, omasum, and abomasums.[12]

Non-ruminants are considered monogastrics because they have a simple stomach. They cannot regurgitate partly-digested matter and rechew it because it is not necessary; they do not have a large rumen nor are many such animals herbivorous (except hippos, rhinos, rabbits/hares and equines/horse, for example). Almost all non-ruminant animals are omnivorous or carnivorous. Animals that are herbivorous and are non-ruminants have a functional cecum that is used to ferment the food that they have eaten once it passes through the stomach and small intestine. Such animals are called "hind-gut fermentors," and yet are still considered non-ruminants. Non-ruminants that are not hind-gut fermentors include all primates, canines, bears, pigs, and a number of rodents. The main feature that distinguishes the ruminant animal from other herbivores and monogastric animals is that it has a unique pre-gastric digestive system which uses microorganisms to break down grass and other roughages to provide essential nutrients to the animal.[13]

2.2 Essential and Non essential Nutrients

Essential nutrients are nutrients that are needed by all living things. These nutrients must either be fed or made by the animals from building blocks obtained through eating, drinking, or breathing. Minerals can be divided into two types – Macro and Micro. Macro minerals (Calcium, Potassium, Phosphorus, Sodium, Sulfur, Chloride, Magnesium etc) are needed in grams per day. Micro minerals (Copper, Chromium, Iron, Cobalt, Iodine, Manganese, Selenium Molybdenum, Zinc, Nickel), on the other hand, are needed in milligrams or parts per million (ppm). Micro minerals are often called trace or heavy minerals. Heavy metals are by definition metals having densities higher than 5 g/mL.[14] For example, Fe, Cu, Pb, Cd, Hg, Ni, Zn, and Mn. Approximately fifty three of the ninety naturally occurring elements are called heavy metals[15] and many of these, such as Cu, Mn, Fe, and Zn, are essential micronutrients, but can become toxic at concentrations higher than the amount required for normal growth.[16] Other heavy metals, such as Cd, Hg, and Pb, have so far unknown roles in living organisms, and are toxic even at very low concentrations.[16, 17]

2.3 Heavy metals classification

Heavy metals such as Zn, Cu, Cr, As, Cd and Pb are potential bio-accumulative toxins of the dairy production system as soils tend to act as long term sinks of these metals[18] via sorption onto metal oxides particularly Fe and Mn oxides, clay minerals, soil organic material, and other forms of humified natural organic material.[19] Heavy metals can be classified into four major groups on their health importance. Cu, Zn, Co, Cr, Mn and Fe are said to be essential nutrients. These metals also called micronutrients and are toxic when taken in excess of requirements. Ba, Al, Li and Zr are Non-essential. Sn and Al are less toxic; whereas Hg and Cd are extremely toxic. Heavy metals are also called trace element due to their presence in trace (10 mg kg^{-1}) or in ultra trace (1µg kg^{-1}) quantities in the environmental matrices.[20] Thus, the objectives of this thesis were focus on essential nutrients analysis, to classify them, to look for their amount on dairy feed and dairy products, and their toxicity to ruminants.

2.4 Method of Supplementation

Several methods are commonly used to supplement minerals to ruminants. The most common are: adding minerals to a supplemental feed, mixing minerals into a complete ration, and using free choice mixtures.[21, 22]

***Add minerals to a supplemental feed*:**-in this scenario, minerals should be added to a feed grain supplement at levels that are sufficient to meet requirements for all mineral elements. This approach ignores minerals supplied by the forage. Knowing the level of intake of the supplement is critical to the success of this method.[23]

Mix minerals into complete ration:-the best way to ensure that each animal gets the proper level of minerals in its diet is to mix a good source of the missing or deficient minerals into a complete ration. Some nutritionists recommend that minerals be offered free-choice to cattle even though the ration includes minerals. If this is done, trace-mineralized salt should be fed separately from a mixture of equal parts iodized salt and dicalcium phosphate.[21]

Use free-choice mixtures:-self-feeding minerals free-choice is a satisfactory method of mineral supplementation under most conditions; however, cattle will not have their mineral needs perfectly met with this system. Some animals will over consume a self-fed mineral supplement while others will eat less than they need. In this system, salt or highly palatable concentrates are used to encourage supplement intake.[24]

3. MATERIALS AND METHODS

3.1 Sampling and Sample Site Description

The study area lies in the south western highlands and West margin of Great Ethiopian Rift valley. The physical feature of the study area is characterized by plain, nearly rising and falling flat topography. Representative samples of minerals were taken from different sites of around near Lake Abaya, Humbo; and Boditi local market from Wolaita where an appropriate resource exists. Therefore, some of the geographical locations of these sampling sites are described in Figure 3.1.

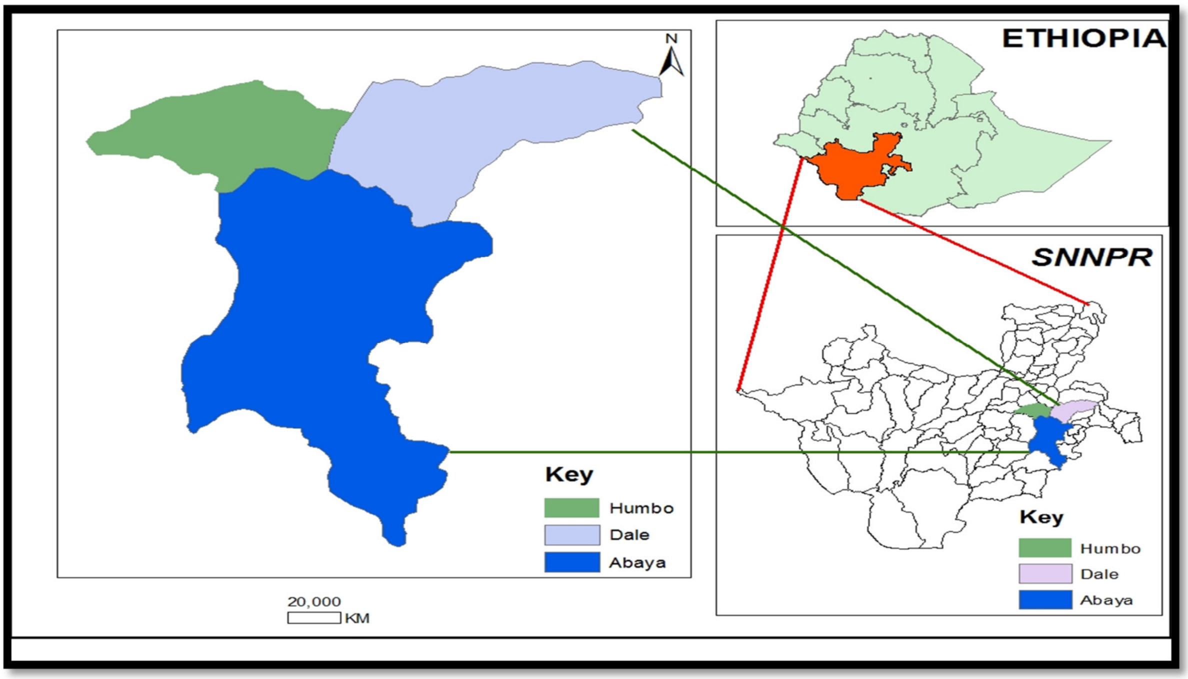

Figure 3-1 Description of Sample Collection Site

A composite samples (about 1 kg) were collected using different sample collection techniques, among them stratified methods for sample taken from Humbo; wolaita Zone, near Lake Abaya and purposive sampling method for Boditi local market. Then samples were air-dried and any visible external particles were removed. The dried samples were crashed, homogenised, sieved by using 2 mm mesh and accurately weighed by electronic balance. The weighed samples were preserved in labelled plastic bags until analysis.

3.2 Soil Sample Analysis

3.2.1 Physical Tests

Determination of soil moisture content

There are two methods (direct and indirect) available for the determination of Aduwaa moisture content. In direct method, the amount of water present in a given soil is directly determined whereas in indirect methods, a soil property or some reaction products relating to soil water content is determined. Now the method used for determination of Aduwaa moisture content is gravimetric (direct) method. The air dried samples were accurately weighed and also dried constantly in an oven at 105 ^{0}C for two hours, cools for 30 minutes and reweighed. From this measurement, the moisture content in dray mass bases was calculated, [25, 26] used the following equations.[27]

$$\frac{(M2-M3)}{(M3-M1)} \text{X } 100 \ldots\ldots \text{(eq.1)}$$

Where M1=mass of empty crucible, M2= mass of empty crucible + mass of moist soil,
M3= mass of empty crucible + Oven dried soil.

3.2.2 Chemical Test

Organic Matter Determination

A 5 g of NCR-13 volumetric scoop of soil was placed into a tared, kimax beaker, and dried for two hours at 105 ^{0}C and weighed were ashed for 2 hour at 360 ^{0}C and reweighed. The percentage of organic matter determination on dry mass bases was used by using the following equation

$$\%OM = \frac{(M2-M4)}{(M4-M1)} X100\ , \ldots\ldots \text{(eq.2)}$$

Where: M_4 = mass of crucible + muffle furnace dried soil.

pH Determination of soil

pH determination is useful for soil classification on the basis of acidity or alkalinity and was done accurately in the laboratory by electrometric method. The change in the potential difference at 25 ^{0}C for 1 pH unit is 59.1 mV. Soil pH was determined on an equal ratio (1:1) of soil water mixture. Ten gram soil was taken and mixed with 10 ml double distilled water sample, were stirred both before and after 15 min equilibration period.[28] The pH electrode was calibrated to standard buffer solutions such as pH 4, 7 and 10. In the supernatant solution the pH was measured potentiometrically on a direct reading pH meter using a glass electrode with a saturated KCl – calomel reference electrode.[29]

Electrical conductivity of the soil

Soil samples were evaluated for salinity by first determining the electrical conductivity (EC) of a 1:1 suspension. Ten gram soil was mixed with 10 mL double distilled water to form slurry, which was stirred intermittently for 30 minute. The EC was determined by the JANWAY model (4310), voltage 9VAC, frequency 50/50 Hz conductivity meter, and is reported in units of millimhos percentimetre (mmohs/cm). Slightly to strongly saline soils (conductivity more than 0.9 millimhos) were subjected to a more precise test. A saturated soil paste was prepared by slowly adding double distilled water to about 50 cc's of soil until the mixture is a thick paste. After an equilibration time of two hours, the saturation paste was filtered under suction.

Determination of Ash Content

Soil samples of 5 g were weighted accurately into a pre-weighted porcelain crucible and gently heated on a muffle furnace. The temperature of the furnace was raised slowly (about 100 ^{0}C in every 15 min) up to 560 ± 5 ^{0}C. This ashing temperature was maintained to give a total ashing time of two hour for soil samples. After muffling the crucible and contents were cooled in a desiccators and the weighed ash content were determined. The ash content was expressed as a percentage of the weight.[27]

$\%\ Ash\ content = 100 - \left(\frac{M2-M3}{M3-M1}\right) + \left(\frac{M2-M4}{M4-M1}\right)$,……………………..…..(eq. 3)

3.3 Instruments and Apparatus

3.3.1 XRF Spectrometers

X-ray fluorescence (XRF) provides one of the simplest, most accurate and most economic analytical methods for the determination of elemental composition of many types of materials. It is an advanced, highly automated, portable analytical tool that can be used by scientists, lab staff, field investigators, and even non-experts to support their job functions. XRF Measure almost any element from Be - U in almost any matrix and its unique advantages is rapid non-destructive quantitative analysis in air. Epsilon 3^X spectrometers which is found in Addis Ababa, Ethiopian Conformity Assessment Enterprise (ECAE) used for Aduwaa analysis.

3.3.2 Sample preparation for XRF analysis

The standards and samples were analysed by using X-ray fluorescence spectrometer operating with a Pd tube. The operating voltages ranged from 5 to 50 kV. Calibration of standards and samples was achieved by using the 'Geology Analytical Program'. The live time required for sample analysis varied from 29.56 -109.40sec. In the process, air at 29.79s and helium (He) at 92.38 to104.65sec speeds were used as fuel sources. The intensity varied for each element at different wave lengths (λ). However, XRF intensity influenced by a size of soil particles and soil moisture content or water percentage in the soils. Therefore, the soil was sieved with 2mm mesh and air dried for two days. Thus, the study investigated how such experimental parameters would influences XRF analysis of soils in the present paper.

3.3.3 One way ANOVA test for experiments

Statistical methods can be powerful tools for unlocking the information contained in analytical data. One-way ANOVA would answer the question: Is there a significant difference between the mean values (or levels), given that the means were calculated from a number of replicate observations? Or indicaats an experiment scenario, if there is a significant difference between the samples collected from different site and within sample analysed. From each four samples, more than forty six (46) elements analyzed by XRF, among them ten (10) essential macro and micro elements were taken, as long as the value were not identical from each sample. At first quick look, it may seem like there is a definite difference between these four groups in their elemental concentration. Therefore, an ANOVA is a good test tool to use as it will control for this and determine if there really any difference between the four groups beyond mere random probability.

4. RESULTS AND DISSCUTION

The determination of soil moisture content, soil organic matter, ash content was done by using eq.1, eq. 2 and eq.3 respectably; While that of pH and electrical conductivity was done by direct reading pH meter using a glass electrode with a saturated KCl – calomel reference electrode,[29] and conductivity meter. The obtained results was summarized in table 4.1

Table 4-1 Soil moisture, organic matter, pH, electrical conductivity and ash content of Aduwaa samples determination.

No	Chemical test parameters	Samples			
		L.A1	L.A2	B1	B2
	% of soil moisture	19.904%	17.097%	13.78%	7.52%
	Organic Matter	2.156%	4.959%	5.955%	6.019%
	pH	7.24	9.18	10.15	9.85
	Electrical conductivity (EC)	25.3 m ʃ/cm 25.6 ^{0}C	32.9 m ʃ/cm 25.9 ^{0}C	43.4 m ʃ/cm 25.8 ^{0}C	28.84 m ʃ/cm 25.5 ^{0}C
	% Ash Content	77.94	77.944	80.285	86.461

L.A1=Lake Abaya red Aduwaa, L.A2= Lake Abaya brown Aduwaa, B1= Boditi red Adwuaa, B2= Boditi brown Aduwaa.

The percentage of soil moisture contents of Lake Abaya red Aduwaa (L.A1) is greater than the rest one but the organic matter and the ash content were the reverse. The water holding capacity of the salty soil Aduwaa, (B2 = 7.520%) < (B1= 13.780%) < (L.A2 = 17.097%) < (L.A1 = 19.904%). The organic matter content of samples in ascending order of L.A1, LA2, B1 and B2 was 2.16%, 4.959%, 5.955%, 6.019% respectively, indicates the content of OM of brown Aduwaa in both areas was higher than the red. The pH determination of the soil sample (A.L_1= 7.24, A.L_2= 9.18, B_1=10.15, B_2= 9.85) is slightly alkaline to extremely alkaline. The EC is temperature dependant and the measurement was done at room condition. The result was greater than (0 - 4.5 mS/cm) indicated in Table 4.1 shows that the soil used for supplementary food source of ruminants is saline soil. Table 4.1 also showed that the highest values of ash content were recorded for (B2 = 86.461%) and (B1= 80.285%) soil samples and the lowest values (A.L1 = 77.94%) sample. This result was obtained as expected because the soil moisture contents of (A.L1) and (A.L2) is greater than that of (B1) and (B2). It was known that the mineral content was closely related to the ash content, i.e. the higher the ash content is the higher the mineral content and vice versa.[30]The finding of this study indicated that samples that had high ash percentages manifested the highest mineral content (Table 4.1). The values of ash percentage are important because they permit an indirect estimate of mineral content.

Analysis by X-Ray Fluorescence (XRF) Spectroscopy

To compare the result obtained by XRF with the standard value. The percentage and ppm was converted to g/kg. The conversion of % to ppm and again ppm to g/kg was as follows: 1percentage =10000 mg/L or =10 000 mg/kg, 1 per = 10 g/L or 10 g/kg, 1 kg/L =1 000 000 ppm and 1 g/L or 1 g/kg =1000 ppm by using international conversion method the obtained result by XRF was converted and determined.

The test results of the samples (A.L1, A.L2, B1 and B2) were related to that of South Africa and Ethiopian Conformity Assessment Enterprise (ECAE) i.e. there were more than 46 (forty six) elements in the soil sample (see Appendix). The test also showed that the heavy elements like, Hg and Ir which are highly toxic in small amount were not reported in Aduwaa samples but lead Pb (0.0048 – 0.0076%), As (0.04250 – 0.05280%) and Cd (0.00250 – 0.0128%) were determined relatively in low concentration. This requires further research how to remove them from supplementary food source of ruminants. Table 4.2 and Figure 4.1 show the concentration of macro and Micro mineral in samples using XRF spectroscopy before calcinations (i.e. heating with high temperature).

From Table 4.2 the results observed that the four soil sample have different mineral concentration. The trace minerals: Fe, Zn, and Mn were highest concentration in the soil sample comparing with macro nutrients. When comparison continued, (A.L1) and (A.L2) soil sample, A.L1 was greater in some macro elements such as Mg (0.0084 g/kg), S (0.0017g/kg) and Fe (879.26 g/kg) whereas (A.L2) have better concentrations in the remaining nutrient elements Na (0.0608 g/kg), P (0.0050 g/kg), K (0.0357 g/kg), Mn (27.50 g/kg), and Zn (10.40 g/kg). The results of this study showed that the mineral content of elements in sample varied with the mineral concentration in which the soil contained.

Among supplementary macro mineral species, Na level before calcinations was significantly high in Wolaita brown (A.L2) soil, because the trend in concentration of Na was different. That is, A.L2 > B2 > A.L1 > B1. Similar to Na, the mineral concentration of K was highest in A.L2 followed by B2. Nevertheless, the lowest concentration of S was obtained in (A.L2) samples as compared to other macro-elements studied such as Na, Mg, K, Ca, and P. The mineral concentration of Mg, P, S, and Ca was highest in (B2) than the rest. The observed concentration of Fe in four supplementary mineral salts was significantly higher than that of other elements studied. On the other hand, the variation of concentration in terms of their micro-mineral composition was also observed for Fe and Cu. However, the content of Cu in all mineral salts was not observed before calcinations and very small quantity after calcinations.

Different surveys were conducted about the mineral status of cattle in the East of Africa including Ethiopia has proven that severe copper deficiency was associated with the pedogeological area of the Rift Valley.[31] Iron, molybdenum and sulfur concentration are higher in the Rift Valley region soil. Since these elements are strong antagonistic of cupper and causes copper deficiencies.[32] Therefore the copper deficiency can still develop in grazing cattle even when grasses have normal copper values. Iron particles are widespread in African soil types, and can easily land on the vegetation whereby the iron content of plants is increasing.[7] The highest and the least concentration of Fe were observed in (B2) and (A.L2) samples before calcinations and the trend of the distribution of the Fe in g/kg was B2 (882.61) > A.L1 (879.26) > B1 (877.69) > A.L2 (850.17).

After calcinations the iron concentration decreased more than tenfold. The variation of concentration among the different mineral soil types studied was summarized in Table 4.2 The concentration of Na, P, S, Mn and Zn in soil sample (A.L2) is greater than (A.L1) but that of Mg and Fe is greater in soil sample (A.L1). The concentration of all the elements for soil sample (B2) is greater than elements analysed in soil sample (B1) except Mn after calcinations. This confirms that the ash content has a direct relationship with the soil mineral concentration[29] that the ash content and soil organic matter of (B1) is less than that of soil sample (B2).

After calcinations the concentration of macro and micro elements were showed a significant change, the mean values of the mineral concentrations were about two up to fourfold greater than the raw or before calcinations of sample. From Table 4.2 again when we compare the mean value of each sample with standard, the result showed that the concentration level of all four sample value obtained before calcinations were almost similar to the maximum value of standards, but the analysis done after calcinations (after proximate analysis) i.e. any solid particles removed, homogenised, oven dried and the result obtained was greater than maximum standard level which implies one fourth (1/4) of any sample (A.L1, A.L2, B1, B2) amount were almost equal mineral concentration than the maximum standard value appropriate for cattle supplementation. Therefore to optimize the mineral supplementation to ruminant's calcinations and mixing the red and brown Aduwaa were advisable.

Table 4-2 Soil mineral analysis result by XRF after calcinations and before calcinations in g/Kg

Minerals	W1 After	W1Before	W2 After	W2 Before	H1 After	H1 Before	H2 After	H2 Before	Stand in g/Kg	
									min	max
Na	29.9	0.0113	75.62	0.0608	17.9	0.0099	52.25	0.028	0.8	1.2
Mg	5.62	0.0084	4.92	0.0068	4.61	0.007	8.32	0.022	5	5
P	3.1	0.0038	0.92	0.005	0.23	0.032	0.71	0.005	1	3.8
S	0.53	0.0017	0.73	0.0009	0.14	0.0079	0.84	0.021	1.5	2
K	31.86	0.0137	29.94	0.0357	22.91	0.0174	27.22	0.036	1.3	2.2
Ca	4.84	0.0195	6.55	0.0132	4.04	0.0118	8.44	0.036	2	11
Mn	1.95	17.05	1.83	27.53	2.16	17.5	1.9	18.44	0.02	1
Zn	0.32	8.36	0.16	10.37	0.31	8.95	0.3	9.04	0.09	0.2
Cr	N.D	N.D	N.D	N.D	N.D	N.D	0.22	0.314	0.5	0.5
Mean	8.68	2.8298	13.48	4.2256	5.811	2.9484	11.13	3.105	1.357	2.99

N.D = Not detected.

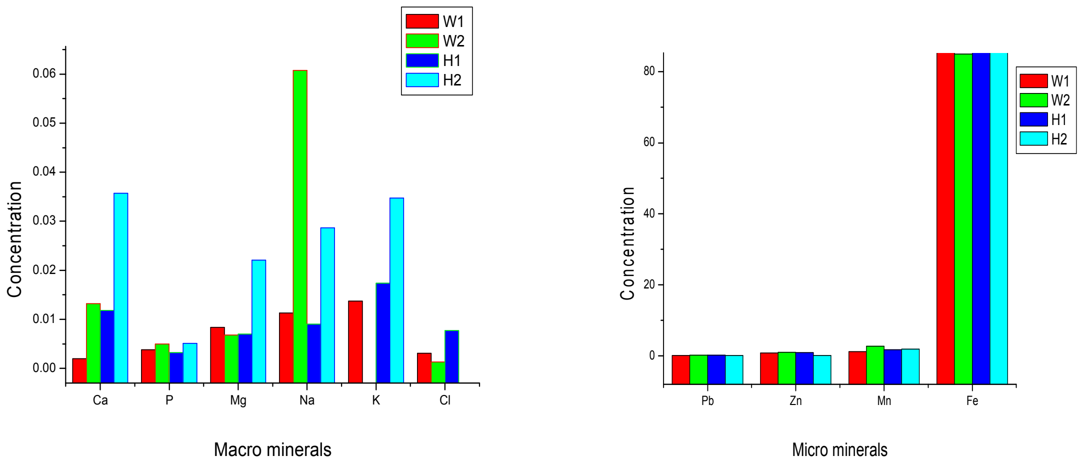

Figure 4-1 Concentration of essential elements in g/kg before calcinations

5. Conclusions

The study findings are concluded as follows. The determination of macro and micro elements done in this study using different parameters, one way ANOVA test and XRF spectroscopy indicated that there were more than forty six elements in Aduwaa. Most of them are essential supplementary food source to ruminants although the high concentration of Fe, Zn and Mn, and low concentration of the toxic Pb demonstrated are causes to concern.

Given the limited geographical coverage of Aduwa samples collected, tested and analysed, generalization of the results needs to be made with caution. However; the optimization of the concentration of Cu, Fe and Mn to improve livestock production through the use of Aduwaa requires further investigation. Accordingly, the study indicated that the XRF spectroscopy was influenced by moisture contents and the ash content of minerals implying the direct relation, that is the higher the ash content the higher the mineral content of the samples. The study also confirmed that there was high copper deficiency in samples and higher iron mineral concentration in Aduwaa, the later showing antagonism against the former. Despite these weaknesses demonstrated, Aduwaa contained essential minerals for livestock growth and other metabolic functions. Therefore, the study concludes that Aduwaa is an important supplementary soil for ruminants and can increase livestock production, although caution should be taken before wide range use and marketing.

6. References

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