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Mineral Composition of Feed and Mineral Soil Utilization in Haramaya District, East Hararghe Zone, Ethiopia

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ABSTRACT

This study was carried out to assess feed resources mineral composition and utilization of mineral soil in the Haramaya district of the East Hararghe Zone, Ethiopia. The survey data was collected from four kebeles using a semi-structured questionnaire from 80 respondents (20 from each kebele) selected randomly. Two natural pasture samples across the wet and dry seasons were collected using a quadrant from each season. Two maize and sorghum stover samples were collected for analysis at the end of harvesting seasons. Two mineral soil samples were collected from Lake Adelle and Small Abaya. Table salt (50%), mineral water (30%), and mineral soil (20%) were used as mineral supplements for livestock. Farmers obtain mineral soil from the licking area of the mineral soil and feed animals by hiking them in the licking area and taking the mineral soil into the home. Maize stover was deficient in Ca, P, Na, Zn, and Cu, while sorghum stover was deficient in P, Na, Mg, and Cu. During the wet season, natural pasture consists of higher ($p<0.05$) P, K, Cu, Zn, and Mn while Ca and Fe were higher ($p<0.05$) in the dry season. During wet and dry seasons, the Ca, P, Na, Mg, and K content were 14.53 vs 20.47, 1.51 vs 0.82, 0.38 vs 0.45, 4.01 vs 3.84, and 16.50 vs 6.40 g/kg, respectively. The Mn, Fe, Cu, and Zn contents were 365.14 vs 415.22, 477.78 vs 336.11, 8.48 vs 7.38 and 42.74 vs 16.94 mg/kg in wet and dry seasons, respectively. The mineral soil of both lakes was deficient in P and K, but high in Na and Fe. Supplementation of animals with deficient minerals in their feed is necessary in the study area and the mineral soil can be used as a mineral supplement for ruminants. However, an extension service is essential to improve mineral soil utilization in the study area.

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Introduction

Ethiopia is home to a diverse range of Indigenous ruminant populations, contributing to food security and poverty alleviation. However, the livestock sector's potential remains underutilized, primarily due to inadequate forage supply in quality and quantity (Adugna & Aster, 2007), which is essential for providing necessary nutrients, including minerals. The mineral levels in the animals' bodies are influenced by the mineral levels in their feed (Tiwari et al., 2014). In tropical regions, low productivity and reproductive performance in grazing ruminants have been linked to mineral imbalances in soil and forage (McDowell, 1997).

In Ethiopia, many feed sources lack essential macro and micro minerals such as sodium (Na), phosphorus (P), zinc (Zn), and copper (Cu) (Fekede et al., 2013), with deficiencies often being location-specific (Tiwari et al., 2014). Consequently, the mineral content in the feed is inadequate to support optimal ruminant productivity (Aschalew et al., 2006). Despite this, mineral nutrition has received limited attention, resulting in significant gaps in the nutritional profiles of local feed resources (Tikabo & Shumuye, 2021). The mineral composition of forages can vary based on factors such as plant age, soil type, fertilization practices, species, variety, seasonal changes, and grazing pressure (Aregheore, 2002). Minerals are supplied through feed, and their concentrations in body fluids are influenced by the mineral content of the feed, dietary intake levels, and mineral availability (Suttle, 2010). Therefore, conducting chemical analyses of forages is crucial to assess the adequacy of essential minerals in the major diets of grazing animals (Shakira et al., 2011). In the present study area, natural pastures, maize stover, and sorghum stover are the primary feed sources for grazing animals (Freweini et al., 2015). However, there is a lack of information regarding the mineral composition of these feeds in the region. A comprehensive study of feed quality is necessary to document the nutritional values of available feed resources (Tikabo & Shumuye, 2021). Additionally, determining the mineral composition of these feeds is essential to address mineral deficiencies in animal diets.

Numerous studies have identified mineral soil as a significant mineral supplement for livestock (Muluken et al., 2015; Nderi et al., 2015; Wondewsen et al., 2019), particularly in developing countries. Mineral soil could serve as a viable intervention to mitigate mineral deficiencies in animal feed due to its availability and accessibility. In Ethiopia, similar to other regions, mineral soil is utilized for animal supplementation, especially in the study area. However, existing knowledge about mineral soil is largely based on indigenous practices. Therefore, it is essential to obtain comprehensive information about the mineral composition and uses of mineral soil to effectively integrate it into livestock diets for enhanced animal production. This study aims to assess the mineral soil utilization practices and to evaluate the mineral composition of the major feed resources and mineral soil in the study area.

Materials and Methods

Study Area

The survey was conducted in Haramaya districts in the East Hararghe zone of the National Regional State of Oromiya. The capital of the East Hararghe zone is Harar City, located 526 km east of the Ethiopian capital, Addis Ababa. The Haramaya district with a total area of 55,000 ha is located at a latitude of 9°9’ to 9°32’ N, at a longitude of 41°50’ to 42°05’E, and at an altitude of 1600-2100 meters above sea level. Minimum and maximum temperatures are 10.8 and 24.62°C, respectively. The mean annual rainfall is 698 mm, ranging from 291 to 1104.2 mm. The area has a bimodal rainfall pattern, with small rains occurring from March to May and main rains from June to September (Shame, 2021).

Sample Size and Data Collection

Among districts of East Hararghe Zone, Haramaya district was purposively selected based on the availability of mineral soil. Accordingly, four kebeles (Adele, Iffaa Oromiya, Haroadii and Biftu Gedaa) were selected purposefully based on mineral soil availability and utilization practices. A total of 80 households from the four kebeles (20 households from each kebele) were selected randomly for survey data collection. A preliminary questionnaire was prepared, pretested, adjusted based on the feedback and used to collect data by interviewing individual farmers at their farm gates. The interview questions consist of demographic characteristics, types of mineral supplements used, methods and sources of mineral soil feeding, seasons of mineral supplement, reasons for mineral supplements, perceived mineral deficiency signs and use of mineral soil and other mineral sources as livestock feed. The data was also supplemented with information obtained from key informant interviews, focus group discussions and secondary data derived from the zonal and district offices of livestock production and health agencies.

Feed and Mineral Soil Samples Collection

Feed samples were collected from the selected kebeles of the study district. Based on their importance and contribution as reported by Freweini et al. (2015), three different feed samples (natural pasture, maize stover, and sorghum stover) were collected among the available feed resources. Natural pasture samples were collected during the dry (mid-February) and wet seasons (Mid-August). Natural pasture samples were collected from each selected representative site of the grazing lands by harvesting from 5 randomly positioned quadrants, spaced 20 meters apart, using stainless steel sickles. All harvested subsamples were thoroughly mixed to make a composite sample, from which a subsample of 1 kg was taken into labelled paper bags and transported to Haramaya University nutrition laboratory. On arrival, the samples were air-dried under shade to prevent spoilage of the samples before being placed into the oven. Maize and sorghum stover samples were collected at the end of harvesting seasons from each of the representative kebele, chopped, and thoroughly mixed to make a composite sample. For chemical analysis, three duplicate sub-composite samples were collected from the composite samples of each feed type. A mineral soil sample was collected from mineral soil licking areas of lakes Adele and Small Abaya located in Adele *Kebele* of Haramaya district and Gebribere *Kebele* of the Silte Zone, respectively. The samples were taken from three different points within the two lakes and each was placed into a polyethylene bag and transported to Haramaya University, stored in the open air on a bench at the nutrition laboratory until used for chemical analysis.

Chemical Analysis

The samples were ground in a Willey mill to pass through a 1mm sieve after drying in an oven at 60^0C for 48 hours. The Ca, Mg, Mn, Zn, Cu, and Fe contents of the mineral soil and feed samples were determined by using an atomic absorption spectrometer (AOAC, 2000). The concentrations of Na and K were determined using a flame photometer (Black, 1965) and P was determined following the standard Olsen extraction method (Baruah, 1997). All chemical analysis were carried out at Haramaya University laboratories.

Statistical Analysis

The data was analyzed using the statistical package for social sciences (SPSS version 20) for Windows (SPSS, 2007). The mean mineral concentration of maize and sorghum stover, natural pasture and mineral soil were statistically analyzed by using the SAS general linear model procedure (SAS, 2007). The mean values were compared by using a list significant difference test ($p<0.05$).

Results and Discussion

Demographic Characteristics of Households

The households’ hhs average family size and age were 7.5 persons/hh and 48 years, respectively. This family size is greater than the national average value of 5.2 persons/hh reported by CSA (2007). The family size in the present study area is consistent with the previous report of 7.65 persons/hh in the Sekota district of the Amhara Regional State of Ethiopia (Zinash, 2015) and 7.5 persons/hh in the

Jimma zone of the Oromiya Regional State, Ethiopia (Zewdie, 2010). This large family size could be due to the relative labor-intensive diversified farming activities and weak family planning services (Zewdie, 2010). Most of the interviewed hhs were illiterate, which could be a gap for increased use of improved feeding practices such as knowledge-based extensive use of soil mineral lick. The proportion of male-headed households was about 85.0%. Most hhs relied on mixed agricultural practices for income (livestock rearing, and crop production (sorghum, maize, and khat), while the rest depend on off-farm income sources like the sale of khat (*Catha edulis*), which is considered as the major cash crop in the study area.

Types of Mineral Supplement

According to the result of the present study, table salt, mineral soil, and mineral water were popularly used as a mineral supplement (Table 1). Nearly, 50%, 30%, and 20% of the respondents used table salt, mineral water, and mineral soil, respectively. Consistent with this finding, table salt supplementation is common in other parts of Ethiopia (Bosenu et al., 2019; Wondewsen et al., 2019). Furthermore, 69.3% of the pastoralists used mineral soil as a mineral supplement for camels in the Somali region of Ethiopia (Bosenu et al., 2019). Moreover, mineral soil (bole) supplementation to dairy animals is common in the East Shoa Zone of Ethiopia (Wondewsen et al., 2019). In the study area, around 80% of the hhs were not providing mineral soils as supplements to their animals, which could be due to a lack of awareness of the importance of mineral soil.

Sources and Feeding Methods of Mineral Soils

Most hhs obtain mineral soil from the licking areas near Adele Lake (Table 2). Most (87.5%) farmers supplemented their animals by hiking them to the licking area, while the rest (12.5%) brought mineral soil in to the home. Similar to this result, pastoralists fetch mineral water and soil to the nearby fields when the licking and watering areas are inaccessible to the camels (Temesgen, 2012; Bosenu et al., 2019). Studies have shown that salt licks are a natural gathering place for grazing animals to ingest as part of their feed and consume directly (Lameed & Adetola, 2012).

Seasons of Mineral Supplementation

The study showed that most of the respondents (87.5%) supplement mineral soil during the dry season, while the rest provide it during the wet season (Table 3). Although the intensity varies between seasons, the results show that livestock owners almost supplement table salt and mineral water throughout the year. Presence of seasonal variation in the frequency of mineral soil use was also indicated in a previous study (Muluken et al., 2016). Higher intensity of mineral supplementation during the dry season could be related to the better mineral content of forages and other feed resources available during the wet season and as a result of the lack of pronounced mineral deficiency in animals (Lameed and Adetola, 2012; Lengarite et al., 2013; Endale et al., 2015). Moreover, there is a greater loss of Na in hot weather due to respiration and perspiration (Shamat et al., 2009), hence animals show signs of need for salt to which owners respond by providing salt supplements frequently in dry than wet season. Mineral soil could supply adequate minerals for animals, especially when the mineral content of the forage is inadequate (Muluken et al., 2016), as tropical forages showed lower mineral content during the dry season (McDowell, 1997). The soil lick could provide the sodium, calcium, iron, phosphorus, and zinc necessary for the growth of animals (Lameed and Adetola, 2012). Therefore, mineral licks supplement minerals that are deficient in animal diets and maintain mineral equilibrium in the body of animals (Eksteen & Bornmann, 1990). About 60% of farmers supplement mineral soil in direct soil form and the rest (40%) mix with feed in the morning. Mixing mineral soil with feed increases fibrous feed intake and feeding mineral soil before grazing increases appetite and improves feed intake during grazing (Muluken et al., 2016).

Table 1. Mineral supplements used in the study area

Mineral Supplements	Frequency	Percentage
Table salt	40	50
Mineral water	24	30
Mineral soil	16	20
Total	80	100

Table 2. Sources and methods of feeding mineral soil in the study area

Mineral soil	Frequency	Percentage
Sources		
Soil lick area	16	100
Methods of feeding		
Trekking animals	14	87.5
Taking soil to home	2	12.5
Overall	16	100

Table 3. Season of mineral supplementation in the study area

Mineral type	Season	Frequency	Percentage
Mineral soil	Dry	14	87.5
	Wet	2	12.5
Table salt	All year round	80	100
Mineral water	Wet	14	58.3
	All year round	10	41.7

Table 4. Reasons of mineral supplementation in the study area

Variable	Frequency	Percentage
Increase intake	29	36.3
Increase weight gain	11	13.8
Clear and shiny hair coat	11	13.8
Increase milk yield	11	13.8
Increase disease resistance	10	12.5
Improve body condition	6	7.5
Increase conception rate	2	2.5
Overall	80	100

Table 5. Perceived mineral deficiency signs in the study area

Variable	Frequency	Percentage
Decrease intake	27	33.8
Abnormal skin color	15	18.8
Decrease weight gain	13	16.3
Decrease milk yield	13	16.3
Low disease resistance	7	8.8
Delayed estrus	3	3.8
Delayed maturity	2	2.5
Overall	80	100

Importance of Mineral Soil Supplementation

Almost all respondents believed that mineral soil supplementation provides better appetite, greater weight gain, good body condition score, greater resistance to disease, clear and shiny hair coat, higher conception rate, and higher milk production (Table 4). Similarly, farmers across different regions of Ethiopia use mineral soil to improve feed intake, induce heat in cows, promote weight gain and a shiny coat, and enhance milk production (Minyahel & Alemayehu, 2019). Additionally, pastoralists believe that supplementing with mineral soil leads to rapid weight gain in livestock, increases milk yield, encourages reproductive activity in cows, and possesses medicinal properties (Teshome, 2016). The consumption of mineral-rich soils is viewed as a method to address mineral deficiencies or imbalances in animal diets (Montenegro, 2004). The minerals found in lick soil can meet the seasonal nutritional needs associated with lactation, calving, and the growth of bones, horns, or tusks (Tracy & McNaughton, 1995), while also helping to mitigate gastrointestinal diseases in animals (Minyahel & Alemayehu, 2019).

Signs of Mineral Deficiency

Farmers observed that animals lacking essential minerals exhibited various symptoms, including reduced feed intake, unusual skin coloration, slower weight gain, decreased milk production, lower disease resistance, and abnormal behaviors like soil licking (Table 5). Supporting this observation, other studies revealed that farmers recognized mineral deficiency diseases and their associated symptoms, such as licking human urine, soil licking, delayed puberty, and extended calving intervals (Wondewsen et al., 2019). Research has demonstrated that mineral deficiencies can result in lower milk output, decreased water consumption, increased foraging for salty plants, bone chewing, and soil ingestion (Shah & Hussain, 2014). Sodium deficiency, in particular, can lead animals to develop unusual appetites, prompting them to consume soil, trees, stones, and even feces and urine (Robbins, 1993). To address this sodium deficiency, animals often seek out areas rich in sodium or salt licks (Staaland & White, 2001).

Mineral Composition of the Feeds

In the present study, the maize stover had sufficient Mg, K, Mn, and Fe content to meet the mineral requirements of ruminants (NRC, 1996; McDowell, 1997) (Table 6). The Ca content in the maize stover (MS) was lower than the 3.3 g/kg value while the P content was comparable with a report from the highlands of Ethiopia (Kabaija & Little, 1988). The mean Na content of maize stover was lower than the previous reports which were 2.2 g/kg (Garg et al., 2009) and 0.5 g/kg (Kabaija and Little, 1988). The Mg content in maize stover was lower than 2.5 g/kg (Kabaija & Little, 1988). The mean K content in the present study was lower than the values of 17.8 g/kg (Kabaija & Little, 1988) and 22.7 g/kg (Garg et al., 2009). Differences in Na, Mg, and K content among studies could be due to differences in cultivars, stage of harvest, soil, and climatic conditions in which plants are grown (Abarghani et al., 2013).

In the present study, the Ca, K, Mn, Fe, and Zn content of sorghum stover (SS) was sufficient to meet the mineral requirements of the ruminants (NRC, 1996; McDowell, 1997). The Ca content of the sorghum stover (SS) was comparable to the reports of Mirzaei (2012) which was 4.60 g/kg. The sorghum stover content of P and Cu were similar to the values of 0.9 g/kg P and 6.41 mg/kg Cu (Garg et al., 2009). The Na content of SS was similar to the value of 0.21 g/kg (Karbo et al., 2008). The K content in this study is lower than the values of 21.3 g/kg (Karbo et al., 2008) and 21.5g/kg (Garg et al., 2009). The contents of Mg and Fe were also lower than the reported values of 3.3g/kg and 434.7g/kg, respectively (Garg et al., 2009). The manganese content of SS was higher than the value of 31.12 mg/kg (Ramana et al., 2011). The differences in the mineral content of sorghum stover in the current study when compared with others could be due to variety, soil type and climate condition of the environment during plant growth (Abarghani et al., 2013).

Table 6. Mineral compositions of maize and sorghum stovers

Variable	Feed Type		SEM	Ruminant requirements †
	Maize Stover	Sorghum Stover		
Macro-minerals (g/kg)				
Ca	1.77^b	4.06^a	0.22	1.8 - 8.2
P	1.58^a	0.93^b	0.02	2.5 - 4.8
Na	0.22^a	0.16^b	4.94	0.6-1.8
Mg	1.56^a	0.60^b	0.04	1-2.5
K	10.23	10.37	0.32	5-10
Micro-minerals (mg/kg)				
Mn	63.5^b	70.20^a	0.62	40
Fe	225^a	177.5^b	9.96	30-50
Cu	5.41^b	6.21^a	0.04	8-14
Zn	16.67^b	41.13^a	2.64	20-40

^{ab} Means within a row with different superscripts differ significantly (P<0.05); Ca= calcium; P= phosphorous; Na= sodium, Mg= magnesium; K= potassium; Mn= manganese; Fe= iron, Cu = copper, Zn = zinc; mg= milligram; kg= kilogram; g=gram; SEM=standard error of mean; † Recommended mineral requirement for all classes of ruminants suggested by the NRC (1996) and summarized by McDowell (1997).

In the present study, maize stover exhibited significantly higher levels (p<0.05) of phosphorus (P), sodium (Na), iron (Fe), and magnesium (Mg) compared to sorghum stover. Conversely, sorghum stover had greater (p<0.05) concentrations of calcium (Ca), manganese (Mn), copper (Cu), and zinc than maize stover. In general, maize stover was deficient in Ca, P, Na, Zn, and Cu, while sorghum stover was deficient in P, Na, Mg, and Cu as compared to the level recommended for ruminants (NRC, 1996; McDowell, 1997). Similar to this finding, Cu, P, and Na deficiency in feed was reported in many parts of Ethiopia (Dermauw et al., 2014; Endale et al., 2015; Martne Sáez, 2015). Minerals are lost with seed shedding and the remaining stem or straw is low in most minerals (Suttle, 2010), which could be the reason for the low mineral content observed in this study. Furthermore, the deficiency of feed minerals in the present study area could be related to the mineral content of the soil, since the concentration of minerals in plants increases with the mineral content in the soil (Blake et al., 2000; Silvanus et al., 2014). Therefore, the main reason for mineral deficiencies in grazing animals is that soils are inherently low in plant-available minerals (Suttle, 2010).

Macro-Mineral Composition of Natural Pasture

In the current study, natural pastures in wet and dry seasons satisfy the minimum requirement of ruminants for macro-minerals such as Ca, Mg, and K (NRC, 1996; McDowell, 1997) (Table 7). The content of most minerals in natural pastures showed variation with season, with natural pastures having a higher content of minerals in the wet season (Lemma et al., 2002). The calcium (Ca) content of the natural pasture was higher (p<0.05) during the dry season than the wet season. The increased Ca content of natural pasture in the dry season is attributed to the lack of mobility of Ca, which tends to accumulate in old organs and stems as plants mature (Abarghani et al., 2013). Consistent with this finding, a higher Ca was reported in the dry-season natural pasture (Endale et al., 2015). The Ca content of the natural pasture in this study was higher than that obtained in other reports (Lengarite et al., 2013; Martnez Sáez et al., 2015). This difference could be due to higher levels of Ca content in the soil that increase the Ca content of the forage (Desjardins et al., 2018). Factors, such as soil acidity and season affect plant mineral uptake (Soetan et al., 2010). The Ca absorption is impaired with increasing acidity in soils (Soder & Stout, 2003) due to the increases in concentration of hydrogen ions, which interferes with the uptake of Ca by the plant roots (Lawrence et al., 2021) and the availability of Ca in soil and plants were high with alkaline pH (Shisia et al., 2013) since the solubility or availability of Ca is high in neutral or slightly alkaline soils.

The wet season natural pasture had a higher content (p<0.05) of phosphorus (P). Consistent with this study, a higher P content in natural pastures during the wet season was reported in a previous study (Lengarite et al., 2013; Mokolopi, 2019). The P content of the natural pasture was similar to the value of 0.33-1.97 g/kg reported from Asela, Ethiopia (Martne Sáez et al., 2018), and the value of 1.7 g/kg reported from southern Ethiopia (Bezabih et al., 2016). The P content of plants is influenced by the availability of P in soil, soil pH, climate, and stage of plant maturity, and as grasses mature, P is transferred to the grain (Soetan et al., 2010), thus the content of P decreases as the plant increases in size and progresses to maturity (Rahim et al., 2008). With increasing soil pH, the content of P in the soil and the availability of P for forage increases (Soder & Stout, 2003).

The sodium content (Na) of natural pasture was not influenced (p>0.05) by the season. The Na content of the natural pasture was similar to the value of 0.4 g/kg (Márquez-Madrid et al., 2017). Similarly, 0.23-1.1 g/kg Na was reported from Asela, Ethiopia (Martnez Sáez et al., 2018). The Na content of the natural pasture was deficient in both seasons, which could be due to the physiochemical properties of the soil and the climate conditions (Khan et al., 2013). Sodium is generally poor in forage due to soil, plant, and husbandry factors and it is easily leached from soils with low cation exchange capacity (Suttle, 2010). Consistent with this study, all types of feed were deficient in Na in the central and western parts of Ethiopia (Aschalew et al., 2006). Generally, plant species in tropical areas accumulate less Na; therefore, animals grazing on pastures are more prone to sodium deficiencies (Khan et al., 2007) making its supplementation to animals a necessity.

Magnesium (Mg) content was not influenced (p>0.05) by season, which is consistent with previous reports (Lengarite et al., 2013). However, another report indicated that Mg levels in forages showed variation due to month, pasture, and interaction between them (Zafar et al., 2007), which could be due to variations in forage species, climatic factors, and soil types (Mokolopi, 2019). The Mg content found in the current study agrees with the Mg content of 4.22 g/kg (Bimrew et al., 2018). Deficiencies in animals grazing tropical pastures are rare as forage contains sufficient amounts of Mg in these areas (Minson and Norton, 1984).

The potassium (K) content in the natural pasture was high ($p<0.05$) during the wet season, which could be related to the availability of water since the absorption of K is affected by the moisture content of the soil (McDowell, 2003). The decrease in K with increasing forage maturity was also reported in a previous study (Zafar et al., 2007). The loss of K as the plant matured was attributed to the translocation of K into the root system and then to the soil (Blue & Tergas, 1969). Similar to this result, a higher content of K in the wet season pasture was reported in Kenya (Lengarite et al., 2013). The K content was comparable to the value of 14.32-19.44 g/kg, as reported from Asela, Ethiopia (Martnez Sáez et al., 2018).

Micro-Mineral Composition of Natural Pasture

In the present study, the wet-season natural pasture had sufficient Mn, Fe, Cu, and Zn (Table 7), while the dry-season pasture had adequate Mn and Fe to meet the requirements of ruminant animals (NRC, 1996; McDowell, 1997). In the current study, the dry season natural pasture had higher manganese (Mn) ($p<0.05$) than the wet season, which could be due to plant maturity (Rahim et al., 2008). In agreement with the present study, Khan et al. (2009) showed influence of season on the content of Mn. The Mn content in this study was comparable to 369.77-417.72 mg/kg value (Endale et al., 2015). In contrast to this result, a higher Mn (753 mg/kg) was reported in natural pastures (Bezabih et al., 2016), which could be attributed to the mineral content of the soil.

The iron (Fe) content of the pasture was higher ($p<0.05$) during the dry season, which could be due to contamination of the forage with soil (Lemma et al., 2002), which is most likely to occur in soils prone to waterlogging (Suttle, 2010). Similar to the present finding, the Fe content of the natural pasture during the dry season was higher than in the wet season (Shamat et al., 2009). The Fe content of the natural pasture was comparable to the values of 225-812 mg/kg (Khan et al., 2009) reported from Pakistan. The higher Fe content in the pasture in this study could be due to the higher Fe content of the soil in the area (Khan et al., 2006) as the Fe content in the soil influences the Fe content in the forage.

The wet-season natural pasture had a higher copper (Cu) content ($p<0.05$) than the dry-season pasture. The Cu content of the forage decreases with the maturity of the forage and is higher in the leaf than in the stem (McDowell, 1996). Cu is associated with a plant's new tissues and is translocated to the root system as plants mature (Sousa, 1978). Consistent with the present finding, forages in the highlands of Ethiopia were adequate in Cu during the wet season and deficient during the dry season (Lemma et al., 2004). The Cu content of the natural pasture from Southern Ethiopia consisted of 8.3 mg/kg (Bezabih et al., 2016) and it is similar to the amount reported in the present study.

The wet-season natural pasture had a higher ($p<0.05$) Zn content than the dry-season forage. This difference could be due to the maturity of the forage. Consistent with this result, a higher Zn content from the wet season forage was reported in a previous study (Shamat et al., 2009). The natural pasture reported from Pakistan contain Zn in the range of 25.88-42.24 mg/kg (Khan et al., 2009). The soil pH, soil texture, soil mineral content, and botanical composition are factors that mainly influence the content of Zn in herbage (Espen et al., 2005).

Mineral Composition of Mineral Soil

In the current study, the content of magnesium (Mg), sodium (Na), iron (Fe), and zinc (Zn) of the Lake Small Abaya mineral soil (bole) was higher ($p<0.05$) than that of the Lake Adele mineral soil (Table 8). However, the mineral soil of Lake Adele has higher ($p<0.05$) manganese (Mn) and copper (Cu) ($p<0.05$) than that of Lake Small Abaya mineral soil. The composition of the macro minerals such as Na, P, and K of Lake Small Abaya mineral soil was similar to other previous reports (Sisay et al., 2007). It was noted that mineral soil has a high content of Na (Holdo et al., 2002) and other elements, including Ca, Mg, P, and K (Lameed and Adetola, 2012). The presence of these essential minerals is the reason for livestock seeking natural licks for mineral supplementation (Nderi et al., 2015). Phosphorus and sodium are believed to be the main trace elements that cause animals to use salt licking (Cowan et al., 1949).

Table 7. Mean macro and micro mineral compositions of natural pasture in the study area

Variable	Season		SEM	Ruminant requirements †
	Wet	Dry		
Macro-minerals (g/kg)				
Ca	14.53^{b}	20.47^{a}	1.39	1.8 - 8.2
P	1.51^{a}	0.82^{b}	0.02	2.5 - 4.8
Na	0.39	0.45	0.50	0.6-1.8
Mg	4.01	3.84	0.39	1-2.5
K	16.50^{a}	6.40^{b}	0.17	5-10
Micro-minerals (mg/kg)				
Mn	365.15^{b}	415.22^{a}	1.35	40
Fe	336.11^{b}	477.78^{a}	8.79	30-50
Cu	8.34^{a}	7.38^{b}	0.05	8-14
Zn	42.74^{a}	16.94^{b}	2.08	20-40

^{ab} Means within a row with different superscripts differ significantly ($P<0.05$); Ca = calcium; P= phosphorous; Na= sodium, Mg= magnesium; K= potassium; Mn= manganese; Fe= iron, Cu = copper, Zn = zinc; mg= milligram; kg= kilogram; g=gram; SEM=standard error of mean; † Recommended mineral requirement for all classes of ruminants suggested by the NRC (1996) and summarized by McDowell (1997).

Table 8. Mean mineral concentrations in the mineral soil

Variable	Mineral soil type		SEM	Ruminant requirements †
	Mineral soil (Adele Lake)	Mineral soil (Lake Small Abaya)		
Macro-minerals (g/kg)				
Na	33.53^{b}	41.87^{a}	0.64	0.6 -1.8
P	0.21	0.25	8.61	2.5 - 4.8
Ca	5.57	5.84	0.17	1.8 - 8.2
Mg	1.51^{b}	2.89^{a}	0.07	1-2.5
K	3.13	3.23	0.07	5-10
Micro-minerals (mg/kg)				
Cu	12.53^{a}	10.35^{b}	0.04	8-14
Zn	23.23^{b}	52.68^{a}	0.55	20-40
Fe	647.22^{b}	819.4^{a}	79.9	30-50
Mn	461.77^{a}	450.29^{b}	0.76	40

^{ab} Means within a row with different superscripts differ significantly (P<0.05); Ca= calcium; P= phosphorous; Na= sodium, Mg= magnesium; K= potassium; Mn= manganese; Fe= iron, Cu = copper, Zn = zinc; mg= milligram; kg= kilogram; g=gram; SEM=standard error of mean; † Recommended mineral requirement for all classes of ruminants suggested by the NRC (1996) and summarized by McDowell (1997).

This study showed that Na and Fe were the main minerals. Similar to the present finding, a higher Na in mineral soils was reported from the Somali region (Sisay et al., 2007). Mineral soils with a high Fe content could have an antagonistic effect on P and Cu (Kabaija, 1989), which could be the reason for the low P content observed in the mineral soil of the present study. In the present study, the mineral soils of both areas could not satisfy the phosphorus and potassium requirements for ruminants (NRC, 1996; McDowell, 1997), as they contain a lower amount of P and K. This agrees with another report (Sisay et al., 2007), in which mineral soils were low in phosphorus. The P deficiency in natural lick was also observed in Kenya (Nderi et al., 2015), and suggests that animals require phosphorus sources when fed on low-quality feed supplemented with mineral soil.

Conclusions

In the present study area, table salt, mineral soil, and mineral water were mineral supplements utilized for different ruminant animals. The soil mineral areas were one of the main sources of mineral soil for animals and farmers fed animals by hiking their animals to the licking area and taking the mineral soil in to the home. The current study revealed that the major feed's chemical composition of minerals was deficient and could not meet animal requirements. Maize stover was deficient in Ca, P, Na, Zn, and Cu, while sorghum stover was deficient in P, Na, Mg, and Cu. The content of minerals in the natural pasture varied with seasons. The wet season pasture was deficient in P and Na, while the dry season pasture was deficient in P, Na, Zn, and Cu. It is, therefore, concluded that animals in this area require the supplementation of deficient minerals in their diet, and mineral soil can mitigate this problem, as it contains adequate amounts of some essential minerals, except P and K.

Declarations

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Ethical Approval Certificate

This study was approved by the Haramaya University School of Animal and Range Science Research and Ethics Committee with decision number SARS/SGC180520185 and date of May 18, 2018

Conflict of Interest

The author(s) declare no conflict of interest concerning this article's research, authorship, and publication.

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Data Availability

Data used to support the findings of this study are available from the corresponding author upon request.

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