IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 8, Issue 10 Ver. I (Oct. 2015), PP 45-53
www.iosrjournals.org

Determination of Essential Minerals and Toxic Elements Composition of the Natural Licks Consumed By Livestock in Tharaka-Nithi County, Kenya

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Abstract: *The aim of this study was to determine the quantities of essential and toxic elements in the natural licks consumed by livestock in Igambang'ombe Division in Tharaka-Nithi County, Kenya. Ten highly used licks, five moderately used licks and one abandoned lick were randomly selected. Mineral elements were determined using TXRF, atomic absorption and U-V visible spectrometry methods. Normal averaging and ratio sacle were used to determine the differences in quantities of mineral elements in the licks and control. Results indicated that, Kimenyi lick had the highest quantities of calcium (44,445±425 mg/kg) and magnesium (26,640±85 mg/kg), whereas Kigwanga, Kibuuri and Kieroo licks showed higher levels of sodium (11,279±35 mg/kg), potassium (1,800±12 mg/kg) and phosphorus (67 mg/kg) than control respectively. Levels of iron ranged between 15,252±166 to 67,717±351 mg/kg. Among the toxic elements only vanadium in Riankui lick site was above the globally accepted median range and the rest were below. The study revealed that natural licks had higher levels of essential elements than control sample, and there was no lick that contained high levels of all the minerals than in other licks. Mineral supplementation could be the major reason why livestock consume natural licks in Igambang'ombe Division.*

Keywords: *Essential minerals, Geophagy, Livestock, Natural licks, Toxic elements*

I. Introduction

Geophagy or soil ingestion by animals has numerous benefits which include: mineral supplementation, detoxification of plant secondary metabolites and alleviation of digestive disorders [1]. Causes of this behaviour vary with the soil type of the area, seasons and among groups of animal species [2]. Geophagy is common in both wild and domestic species, and animals have been reported to travel long distances away from their natural habitats to consume the naturally occurring minerals in the natural lick sites [3].

Particularly, natural licks are an important source of sodium since this mineral is not naturally accumulated in terrestrial plants to meet the animals demand especially in areas far from the ocean [4]. Animals use the taste of sodium chloride to detect the sites with greater quantities of minerals because of their inherent ability to explore chemicals in the environment by use of the tongue [5]. Natural licks are also important sources of other essential minerals such as magnesium, calcium and iodine [6]. Sodium plays a critical role of maintaining acid-base balance and osmolarity in the body, and its deficiency in the diet leads to a low osmotic pressure and consequently dehydration of the animal [7]. Magnesium is a major enzyme activator and an essential element for metabolism of carbohydrates and lipids in the body. However, lush forage at the onset of rains contains higher levels of potassium that interferes with retention of magnesium when consumed by ruminants, and this leads to a condition known as grass tetany that is common in lactating dairy cows [8]. Calcium is important in nerve transmission and muscle contraction in animals and a deficiency of this mineral in the animal diet leads to low levels in blood serum which results into milk fever in dairy cows [9].

Natural licks play a crucial role in the health of animals. For example, pregnant Moose cows visit natural licks more than males, a fact that is associated with high mineral demand during pregnancy and succeeding lactation period [10]. Elephants in Aberdares National park in Kenya were reported to visit natural licks in search of Iodine, a trace element that is necessary in synthesis of thyroxin hormone which is required for metabolism and growth of mammals [11].

One of the challenges facing many smallholder livestock producers is inability to satisfy mineral requirement of their animals leading to reduced productivity [12]. It is universally known that animals require certain essential minerals for maintenance and production, but most livestock in the tropics hardly receive mineral supplements [13]. Livestock are, therefore, expected to obtain most minerals from the feeds and forages that they consume, whose concentration largely depends on the soil characteristics among other factors [14].

Reports in the literature have indicated presence of higher levels of sodium in natural licks consumed by livestock than in the ordinary soils in Northern Ghana [15]. Similar studies have showed significant levels of essential micronutrients, Selenium (4.7mg/kg), Co (107mg/kg) and Mo (7.4mg/kg) in Ngorongoro area in

Tanzania, suggesting the reasons why animals have preference for the natural licks than in the ordinary soils [16].

Potentially toxic elements exist side by side along with essential ones in bedrock or soils, and these toxic elements may become a direct risk for human and animal health if present in low quantities or excessive quantities in the diet [17]. Examples of these elements include cadmium and lead [18]. Although toxicities are less likely to occur than mineral deficiencies, hidden or direct effects may occur due to accumulation of toxic elements in the body organs especially in the liver and bones following soil ingestion by animals, and through consumption of animal products such as meat and milk by man [19].

Since geophagic soils present in many parts of the world originate from very different bedrock geology, it is necessary to conduct chemical analysis of both essential and toxic elements in specific regions in order to determine the potential benefits and possible health risks to man and animals. This could be a relieve from the high cost of procuring commercial mineral mixtures that is increasing far beyond the affordability of the rural poor farmers considering the critical economic situation in Kenya.

Despite many studies conducted on the relationship between the mineral content in the natural licks and the use by wildlife in Western countries and Kenya, little research efforts have been put in place to explore the essential mineral content of the natural licks found in Tharaka- Nithi County in order to promote its adoption for use in animal feeds. This study was, therefore, designed to determine the essential minerals and toxic element status in various natural licks in Igambang'ombe Division in Tharaka-Nithi County. The elements that were analyzed include: Calcium, Sodium, Potassium, Magnesium, Phosphorus, Iron, Copper, Zinc, Cobalt, Manganese, Chromium, Vanadium and Lead. This information can be useful in inducing further research on how natural licks can be incorporated in feed rations.

II. Materials and methods

2.1 Study Site

The study was performed at Igambang'ombe Division in Meru-South Sub-County, Tharaka-Nithi County, Kenya (Fig. 1). This site was chosen due to the presence of natural licks which are known to have historical use by livestock farmers [20]. Administratively, the Division has five locations namely; Itugururu, Kamwimbi, Kamaindi, Kanjuki and Mutino. Geographically, Igambang'ombe Division is situated between Latitude $0^{o}19'$ 60 South and Longitude 37^{o} 38' 60 East in Tharaka-Nithi County on the Eastern side of Mt. Kenya.

The region has a bimodal rainfall distribution pattern with the long rains falling between March and May and the short rains between October and December. The average rainfall ranges between 200 and 800mm per year. The ambient temperatures range between 22 ^{o}C and 27 ^{o}C, with the lowest temperatures being in July and the highest in January. Geologically, Igambang'ombe is situated on a basement system which is composed of several different landforms such as hills, uplands, plateaus and valleys, and the soils range from moderately deep to shallow with loam to clay textures [21].

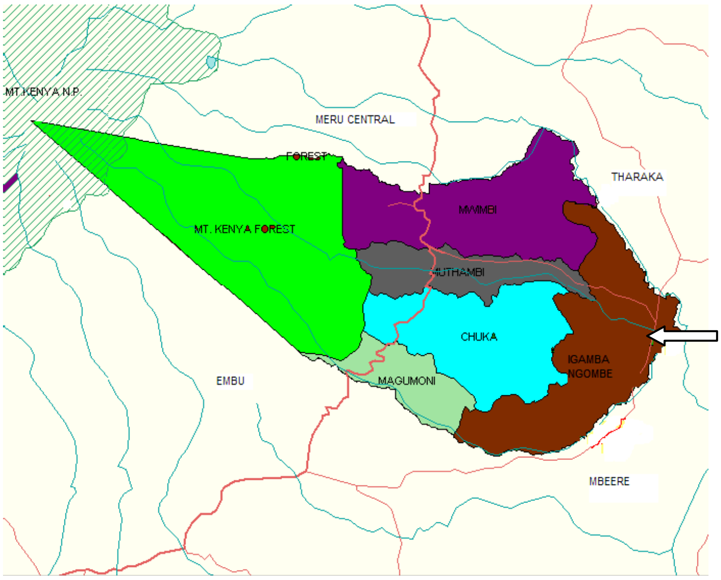

Figure 1: Map of Meru-south in Tharaka-Nithi County, Kenya showing location of Igambang'ombe Division (source: National Environmental Management Authority, 2007)

2.2 Selection of Natural Licks

Locations of the natural licks were purposively selected with the help of village elders in the study area. The establishment of lick use was based on the evidence of animal foot prints, faeces, recent excavations, presence of traditional tools (sharp sticks) that were used to collect licks, and direct observations of animals consuming the lick.

The sites were divided into highly used, moderately used and abandoned licks. Thereafter, random sampling technique was employed to obtain sites that were used for soil sampling. Ten highly used licks (Kibuuri, Kang'au, Kandondo, Gikurwe, Mikame, Maara, Nagundu, Kabariange, Kabuai and Kigwanga), five moderately used (Rainkui, Kanduga, Kimenyi, Kieroo and Ikindu), and one abandoned lick (Thuci) were sampled. A control of uneaten earths was obtained from the surrounding farms at a distance extending about five kilometers from the lick edges in order to avoid seepage influences [22]. Sampling was done during the dry season.

III. Data collection and analysis

3.1 Collection of Soil Samples

At each lick site, soil samples were collected using soil auger and trowel from 5 sampling points where geophagical behavior was evident. The samples were collected at depths of 0 to 15 cm, 15 to 30 cm and 30 to 60 cm in order to take care of the water soluble elements such as sodium which are subject to leaching [23]. The three sub-samples collected from each sampling point were mixed to form a composite sample and put in a bag [24]; hence five samples were collected from each natural lick site. A total of 85 soil samples, weighing 250 grams each were collected for laboratory analyses: 50, 25, 5 and 5 samples from highly used, moderately used, abandoned and control respectively.

The collected samples were transported to the laboratory in a cool box and kept under refrigeration to minimize chemical reaction in preparation for chemical analysis [25].

3.2 Preparation of test soil sample

Soil samples from the field were transferred into a plastic tray and air dried for three days. During drying, the samples were properly labeled for identification purposes. Large clods were broken down in order to speed up drying. Roots, stems, leaves and animal faeces were removed from the samples. After drying, the samples were ground using a motor and pestle and sieved through a 2 mm sieve [26]. The clods which did not pass through the sieve were taken back to the motor and pestle for further grinding. This process continued until all samples passed though the sieve. Thereafter, coning and quartering technique was employed to come up with analyte samples [27].

3.3 Extraction of macro elements

Reagent grade chemicals sourced from Sigma, Aldrich Cheme, USA and de-ionised double distilled water were used. The extraction of calcium, magnesium, sodium, potassium, iron and manganese was achieved by a method of cold dissolution using hydrofluoric acid-boric acid solution. A 0.1000 g of the powdered soil sample was weighed and transferred into a 100 ml plastic bottle. Then 0.5 ml of hydrochloric acid and 0.5 ml of nitric acid were added, mixed, and the slurry left to stand overnight. Hydrofluoric acid (3 ml) was added with stirring, and the bottles were tightly stoppered and placed in a water bath set at 100 ^{o}C for overnight. Using an automatic dispenser, 50 mls of boric acid solution and 46 mls of water was added respectively. Thorough mixing was done, and the solution was filtered through Whatman No.42 filter paper into plastic vials and stored at 4 ^{o}C.

3.4 Extraction of micro elements

The extraction of trace elements, zinc, copper, cobalt and molybdenum was done using Aqua regia solution. A 2.500 grams sample was weighed into a 50 ml volumetric flask and little water added to make slurry. Then15 ml of HCL and 5 ml HNO_3 was added, and the slurry heated on a sand bath to near boiling point for 1 hour while agitating from time to time. The solution was allowed to cool and then topped up to the mark using water with uniform mixing, and then left to stand for about 30 minutes before filtration using a Whatman No.42 filter into plastic vials.

3.5 Extraction of Phosphorus

A 10 grams sample of air dry soil was weighed into a plastic flask and 200 ml of prepared sulphuric acid/ammonium sulphate mixture was added. The slurry was then shaken for 30 minutes using Dragon Lab SK-180-Pro Mechanical shaker. Thereafter, the solution was filtered using Whatman No.42 filter paper into plastic vials.

3.6 Determination of metal ion concentration in the sample

Metal ions analysis of soil samples was conducted using procedures described by Johnson and Maxwell (1981) [28] employing atomic absorption spectrophotometer (PG990).

3.7 Phosphorus Determination

A 10 ml sample was measured and transferred into a 150 ml conical flask and then 20 ml of water was added. The extract was treated with 2 ml of prepared molybdate solution and a spatula of ascorbic acid. The sample solution was heated slowly to form a blue phosphomolybdate complex and then allowed to cool. The intensity of the blue color in the sample was determined by a U-V spectrophotometer (model U-V 1800-Shimadzu) at 690 nm against a set of standards of known phosphorus concentration. The analysis of all soil samples was done in triplicate.

3.8 Data Analysis

Data analysis was done using normal averaging and the ratio sacle to determine the differences in quantities of mineral elements in the natural licks and the control soil sample.

IV. Results and Discussion

4.1 Mineral and Toxic Elements Composition of the Natural Licks

The present study was intended to investigate whether the natural licks that are consumed by livestock in Igambang'ombe contained essential minerals and toxic elements. Initially, a comparison of results from total reflection X-ray fluorescence (TXRF) and atomic absorption spectrophotometer (AAS) methods was made using a few samples in order to establish if the results were comparable (Table 1).

The values from TXRF in mg/kg were as follows; calcium (9393.13-71398.39), magnesium (4625.00-40857.80), manganese (110.97-1106.94), potassium (1507.06-13905.12), iron (14744.03-36468.00), copper (5.6722.24), zinc (12.65-87.72) and lead (0.34-27.63), while values from the AAS in mg/kg were; calcium (6816.80-44445.13), magnesium (4372.33-26640.00), manganese (185.92-1341.87), potassium (392.00-1800.00), iron (15251.67-56733.33), copper (1.82-49.91), zinc (3.91-25.17) and lead (0.91-7.91). A close examination of results obtained through these two methods revealed that the values of TXRF were higher compared to those of AAS which is in agreement with the findings of Marijan *et al.* (2005)[29]. The differences in these values can be attributed to poorer excitation and absorption of their emitted characteristics X-ray in the sample itself and in air especially for lighter elements. Also, the high values could be attributed to the possibility of almost complete overlap in TXRF spectrum between the main peaks of some elements. For example, high concentrations of iron in a sample could overlap with cobalt peak leading to greater cobalt readings because the peaks for these two elements are very close.

The correlation coefficients for calcium, magnesium, manganese, potassium, iron, copper, zinc and lead were, 0.93, 0.94, 0.44, 0.55, 0.93, 0.86, 0.78, and 0.02 respectively. The F calculated values that were obtained are as follows; calcium (84.69), magnesium (161.06), manganese (3.13), potassium (5.65), iron (89.13), copper (37.99), zinc (20.17) and lead (142.05), while the F tabulated value for V1=14 and V2 is 2.949 for all the cases. Molybdenum, cobalt, chromium, vanadium and sodium were below detection limits for the AAS in some sites. Since the correlation values (r) in the two methods were below 0.95, this indicated that there was no excellent linearity in the curves which contradicts the work reported by Radu (2009) [30] on lead, copper and zinc which reported an excellent correlation in these elements between AAS and TXRF methods. Further, the F- calculated values for the same elements were found to be greater than the critical values which imply that there were significant differences in precision of the two methods and hence the t-test was not performed to establish the validity. Based on the above findings, AAS was employed in the present investigation since it is a standard method which is accepted by common regulations and normative-subjected [31]. AAS has also been used for calibration of XRF methods in cases where there are no standard reference materials [32].

Table 1: A comparison between TXRF and AAS in determination of elements

	TXRF					AAS							
	SITES					SITES					Pearson's		
Elements	Kibuuri	Kang'au	Kimenyi	Kieroo	Thuci	Kibuuri	Kang'au	Kimenyi	Kieroo	Thuci	Corr.(r)	F-Cal.	F-tab.
Ca	27074.16	31224.16	71398.39	28477.74	9393.13	8011.80	24545.13	44445.13	19811.80	6816.80	0.93	84.69	2.949
Mg	6472.21	9796.05	40857.80	31357.57	4625.00	6941.33	14063.33	26640.00	24426.67	4372.33	0.94	161.06	2.949
Mn	590.10	448.14	631.68	110.97	1106.94	546.87	409.07	185.92	838.87	1341.87	0.44	3.13	2.949
K	7604.14	4265.81	8390.89	1507.06	13905.12	1800.00	578.67	392.00	679.33	1583.33	0.55	5.65	2.949
Fe	32986.60	24038.35	16756.57	14744.03	36468.00	39650.00	40818.33	20541.67	15251.67	56733.33	0.93	89.13	2.949
Cu	22.24	17.96	11.00	9.50	5.67	39.77	49.91	22.91	27.21	1.82	0.86	37.99	2.949
Zn	42.10	30.68	35.39	12.65	87.72	10.14	9.68	3.91	11.76	25.17	0.78	20.17	2.949
Pb	27.63	8.29	8.72	0.34	9.04	3.51	3.37	0.91	3.09	7.91	0.02	142.05	2.949

Key: TXRF= Transform X-Ray Fluorescence; AAS= Atomic absorption spectrophotometer; Corr. =correlation, F-cal= F-test calculated value; F-test critical value

4.2 The mean concentrations of macro and micro minerals, toxic elements and pH in the natural licks

Results of essential minerals, toxic elements analysis, and pH of soil samples from the natural licks in Igambang'ombe are shown in Table 2. Chemical analysis showed that there were considerable variations in the levels of minerals and toxic elements in the licks, and minimal variations in the pH (6.86-9.87). Kimenyi natural lick had the highest quantities of both calcium (44,445±425 mg/kg) and magnesium (26,640±85 mg/kg), whereas Kigwanga, Kibuuri and Kieroo licks showed higher levels of sodium (11,279±35 mg/kg), potassium (1,800±12 mg/kg) and phosphorus (67 mg/kg) than the control respectively.

Presence of high levels of essential minerals may thus be the reason why natural licks are sought for by livestock for mineral supplementation. This agrees with the studies by Lameed and Adetola, (2012) [33], that natural lick in Kanji Lake National Park played important role in mineral supplementation of deficient animal diets. However, phosphorus was not detected in half of the sampled licks. Levels of iron were high in most of the licks, and ranging from 15,252±166 to 67,717±351 mg/kg. Kang'au, Maara, Riankui, Kanduga licks and control were leading in the quantities of copper (50±0.13), zinc (30±0.15), cobalt (37±1.02), manganese (1,693±10.35) and chromium (41±3.93) in mg/kg respectively.

These results shows that there was no lick which contained higher quantities of all the minerals than other licks, and this could be attributed to differences in the soil types in Igambang'ombe which are mainly loam, clay textures (cambisols, luvisols and regosols) and rocky soils (leptosols) [21]. Among the toxic elements, lead and vanadium were highest in Kabuai (15±0.10) and Riankui licks (700±51) in mg/kg, respectively. The levels of lead in these sites were below the global median concentrations of 29.2 mg/kg, and this implies that there may be no risk to the animals consuming licks from these sites or human beings who consume their products [30]. Vanadium level in Maara lick was above the global median range of 150 mg/kg, but due to poor absorption of this element in the animal's intestines (0.1 to 1.0%), animals would be safe after consuming licks from this site.

The pH values for the licks were as follow; Sites Kibuuri (9.45), Kang'au (8.79), Kandondo (9.28), Gikurwe (8.67), Mikame (8.81), Maara (8.66), Nagundu (9.78), Kabariange (9.21), Kabuai (6.98), Kigwanga (8.94), Riankui (9.11), Kanduga (8.94), Kimenyi (9.87), Kieroo (9.65), Ikindu (9.54), Thuci (6.86) and Control (7.01). The pH was generally higher and it is consistent with the work by Njoka *et al.* (2015) [34]. The higher pH value in almost all the licks explains why some of the basic elements like calcium which is also not mobile in alkaline soils to be generally high [35]. Further, the high pH could be the reason why farming activities does not take place around the licks, and also this is consistent with the beliefs of local community in Igambang'ombe that a natural lick site can be identified by poor or absence of plant growth on particular sites.

Natural licks in the study area can be broadly described as earth exposures and wall natural licks based on their structural characteristics [36]. The earth exposure licks (Kibuuri, Mikame, Nagundu, Kabariange and Ikindu) were located on the low lands with characteristic large areas of excavated soils, high vertical edges and numerous micro sites of soil ingestion at the bottom as shown in Fig. 2 below.

Figure 2: Goats consuming licks from an earth exposure lick in Igambang'ombe Division, Tharaka-Nithi County

Higher levels of potassium at Kibuuri lick may be associated with the natural weathering processes of the basement rocks and atmospheric deposition that is accompanied by low leaching effect due to high evaporation and low rainfall in the study area [37]. The absence of phosphorus in Kibuuri, Mikame and Ikindu licks might contribute to low energy metabolism in animals consuming the licks and hence causing depraved appetite in animals which makes them to abnormally consume inanimate objects like plastics [7]. The levels of cobalt were below detection limits in Nagundu and Kabariange licks, and this can interfere with the synthesis of vitamin B12 in ruminants that mainly depends on the soil lick from these sites as a source of essential minerals which might lead to emaciation and anemia in them. Animals can obtain all the essential minerals by mixing soil licks from Nagundu and Kabariange.

The wall licks (Kang'au, Kandondo, Gikurwe, Maara, Kabuai, Kigwanga, Riankui, M2, Kimenyi, Kieroo and Thuci) were found mainly along the banks of various seasonal streams in the study area as indicated in Fig. 3 below.

Figure 3: Goats consuming soils from a wall lick along a seasonal stream in Igambang'ombe Division, Tharaka-Nithi County

Higher levels of (calcium and magnesium), sodium, (iron and manganese), copper, cobalt in Kimenyi; Kigwanga, Kanduga; Kang'au and Riankui licks respectively may have been caused by stream bed grinding and the anthropogenic activities such as the use of fertilizers from agricultural practices on the upper zones of Chuka, Muthambi and Mwimbi Divisions that lie on the slopes of Mount Kenya. During the rainy season, mineral elements in the fertilizers are likely to be swept downstream through runoff water and then deposit on the semi-arid area of Igambang'ombe when evaporation takes place [38].

The levels of vanadium in Riankui and Kanduga licks were above the global median concentration, and this poses a risk to the animals consuming these licks especially when this element accumulates in body organs such as the liver hence there is need for beneficiation before feeding the animals. The levels of lead were below the global mean concentrations in all the licks and this shows that there is no danger associated with this element to those animals that feed on the licks from this region.

The use of licks at Kang'au, Kanduga, Kieroo and Kimenyi sites by animals could result into cobalt related deficiencies given that cobalt was not detected in these sites. The problem can be overcome by mixing the licks from the sites which contain this element. The absence of phosphorus in Kigwanga and Kanduga licks might result into a deficiency related to this element such as infertility hence a mixture with other soil licks may provide the required essential elements. Animals consuming licks from Riankui site may obtain most of the essential elements, however, low levels of sodium, calcium and magnesium which have high level of influence in milk production, and a high level of vanadium which was above the global mean concentrations makes this natural lick unsuitable for feeding. The higher levels of sodium, calcium and magnesium in soil licks from Kimenyi, Kabariange, Kang'au and Nagundu licks makes them to be the most appropriate sites to use when targeting milk production in animals. The levels of toxic elements in these sites were found to be within the globally acceptable levels.

The magnesium levels were higher in all the sites in comparison with sodium and it might have been one of the physiological needs which might be driving animals to the licks [39]. The higher levels of magnesium in Igambang'ombe when soil licks, could act an enzyme activator for the enzymes such as phosphate transferases, decarboxylases and acyl transferases which are crucial in the energy metabolism in the body when ingested by the animals [7]. This might contribute in maintaining the physiological processes such as nerve coordination and muscle contraction an in animal's body.

Table 2: The mean concentrations (mg/kg) of macro-minerals, trace and toxic elements in natural licks and the pH in Igambang'ombe

Lick sites	Ca	Na	K	Mg	P	Fe	Cu	Zn	Co	Mn	Cr	V	Pb	pH
Kibuuri	8012±100	2119±36	1800±12	6941±42	ND	39650±103	40±0.22	10	2±0.05	547±4.16	ND	90±1.81	4±0.10	9.42
Kang'au	24545±208	3227±27	579±6	14063±51	14±0.12	40818±89	50±0.13	10±0.006	ND	409±4.83	10±0.62	119±1.09	3±0.15	8.79
Kandondo	6495±189	2242±10	609±13	7298±3	27±0.01	45777	29±0.38	14±0.04	3±0.06	626±2.14	21±1.06	118±0.80	3±0.18	9.28
Gikurwe	3333±45	1331±35	945±6	6491±4	ND	34310±91	16±0.02	9±0.02	4±0.02	324±4.88	23±1.21	90±0.26	4±0.13	8.67
Mikame	2825±81	4634±7	399±10	3627±6	ND	61467±840	20±0.09	9±0.04	10±0.02	755±4.52	25±0.95	174±0.61	5±0.07	8.81
Maara	2725±235	1043±3	489±11	2117±4	1±0.11	64467±252	13±0.12	30±0.15	ND	1516±3.59	12±0.21	26±0.20	10±0.36	8.66
Nagundu	13762±180	4150±8	444±7	9584±3	13±0.06	30233±26	10±0.03	8±0.02	ND	447±4.80	18±0.20	31±0.79	2±0.17	9.78
Kabariange	14512±180	4290±9	439±7	5891±4	22±0.05	37498±48	21±0.17	13±0.03	ND	420±2.86	ND	45±0.23	3±0.27	9.21
Kabuai	2873±53	8206±57	608±10	3958±13	ND	52500±477	8±0.15	26±0.31	ND	888±5.00	8±10.21	ND	15±0.10	6.98
Kigwanga	1614±6	11279±35	795±9	3392±5	ND	55717±525	4±0.04	12±0.11	0.5±0.02	792±3.30	ND	ND	14±0.11	8.92
Riankui	12345±225	2777±5	854±6	8968±8	12±0.03	46555±41	26±0.22	8±0.05	37±1.02	399±2.03	24±0.81	700±51.97	3±0.03	9.11
Kanduga	2672±51	6202±58	267±7	7071±9	ND	67717±351	37±0.61	11±0.09	ND	1693±10.35	27±1.01	185±0.57	4±0.26	8.94
Kimenyi	44445±425	7961±33	392±6	26640±85	13±0.05	20542±18	23±0.49	4±0.02	ND	186±6.37	30±0.92	66±0.41	1±0.13	9.87
Kieroo	19812±350	4756±8	679±8	24427±25	67±0.04	15252±166	27±0.32	12±0.04	ND	839±3.13	ND	56±0.33	3±0.31	9.65
Ikindu	14045±201	5516±22	343±8	11470±80	ND	47053±220	22±0.59	10±0.02	3±0.13	185±2.13	24±2.27	64±1.69	2±0.08	9.54
Thuci	6817±502	ND	1583±8	4372±6	14±0.06	56733±301	2±0.02	25±1.11	ND	1342±2.77	2±0.17	ND	8±0.116	6.86
Control	1125±13	104±0.41	1074±6	3462±9	ND	33748±18	34±1.63	9±0.05	ND	505±2.91	41±3.93	48±0.15	5±0.36	7.01

Key: Ca= calcium; Na= sodium; K= potassium; Mg= magnesium; P= phosphorus; Fe= iron; Cu= copper; Zn= zinc; Co= cobalt; Mn= manganese; Cr= chromium; V= vanadium; Pb= lead; pH= per hydrogen ion; ND=Not detected

4.3 Ratio of mean for the elemental composition of natural licks to the control

Results of the mean ratio between elemental composition of natural licks and control in the soil samples obtained from Igambang'ombe are shown in Table 3. In the present in investigation, a comparison was done in order to determine whether the elemental composition of the natural lick samples differed significantly from the surroundings. These results indicate that there were great variations in the quantities of sodium, calcium and magnesium respectively. The quantities of sodium ranged from 10.03 to 108.45 times greater than the mean of the control. The greatest variation was observed in site Kigwanga and the lowest was in site Maara lick. The observed differences in calcium and magnesium ranged between 1.43 to 39.5 and 0.6 to 7.69 respectively. These results indicate that the range of sodium was greatest in the natural lick soils compared to respective soil. These results suggest that sodium could be the major element in natural licks that attracts goats because of their inherent liking for this mineral [40]. However, there is need to conduct animal feeding trials in order to determine whether there are other minerals that animals seek for in the natural licks in order to satisfy the demands.

Among the toxic elements, the major variation between licks and control was observed with vanadium in site Riankui lick (14).

Table 3: ratio of mean for the elemental composition of natural licks to the control in Igambang'ombe Division

Lick sites	Ca	Na	K	Mg	P	Fe	Cu	Zn	Co	Mn	Cr	V	Pb
Kibuuri	7.12	20.36	1.68	2.00	ND	1.17	1.18	1.11	ND	1.08	ND	1.88	0.86
Kang'au	21.82	31.03	0.54	4.06	ND	1.21	1.47	1.11	ND	0.81	0.24	2.48	0.6
Kandondo	5.77	21.56	0.57	2.11	ND	1.35	0.85	1.56	ND	1.23	0.51	2.46	0.6
Gikurwe	2.96	12.80	0.88	1.87	ND	1.01	0.47	1	ND	0.64	0.56	1.88	0.8
Mikame	2.51	44.56	0.37	1.04	ND	1.82	0.59	1	ND	1.50	0.61	3.62	1
Maara	2.42	10.03	0.46	0.6	ND	1.91	0.38	3.33	ND	3.00	0.29	0.54	2
Nagundu	12.23	39.90	0.41	2.77	ND	0.90	0.29	0.89	ND	0.89	0.43	0.64	0.4
Kabariange	12.90	41.25	0.41	1.70	ND	1.11	0.62	1.44	ND	0.83	ND	0.94	0.6
Kabuai	2.55	78.90	0.57	1.14	ND	1.55	0.24	2.89	ND	1.76	0.19	ND	3
Kigwanga	1.43	108.45	0.74	0.97	ND	1.65	0.12	1.33	ND	1.57	ND	ND	2.8
Riankui	10.97	26.70	0.80	2.59	ND	1.38	0.76	0.88	ND	0.79	0.59	14	0.6
Kanduga	2.38	59.63	0.25	2.04	ND	2.01	1.09	1.22	ND	3.35	0.66	3.85	0.8
Kimenyi	39.51	76.55	0.36	7.69	ND	0.61	0.68	0.44	ND	0.37	0.73	1.36	0.2
Kieroo	17.61	45.73	0.63	7.06	ND	0.61	0.79	1.33	ND	1.66	ND	1.17	0.6
Ikindu	12.48	53.04	0.32	3.31	ND	1.39	0.65	1.11	ND	0.37	0.59	1.3	0.4
Thuci	6.06	ND	1.47	1.26	ND	1.68	0.06	2.78	ND	2.66	0.05	ND	1.6

Ca= calcium; Na= sodium; K= potassium; Mg= magnesium; P= phosphorus; Fe= iron; Cu= copper; Zn= zinc; Co= cobalt; Mn= manganese; Cr= chromium; V= vanadium; Pb= lead; pH= per hydrogen ion
ND= Not detected

V. Conclusion

Since the levels of calcium, sodium and magnesium were many times more than the control site, mineral supplementation is considered to be the major reason why livestock consume natural licks in Igambang'ombe Division, Tharaka-Nithi County. The levels of lead and Vanadium in most of the licks sites were also below the global median concentrations, which implies that there may be no risk associated with these elements to the animals consuming licks from the study area or human beings who consume their products.

Acknowledgements

The authors sincerely acknowledge financial grants from the National Commission for Science, Technology and Innovation (NACOSTI) and Chuka University. More appreciation is made of the technical support from Chuka University, Ministry of Mining, World Agro forestry Centre (WAC) and National Agriculture Laboratory (NAL) laboratories in Kenya.

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