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Determination of Essential Minerals and Toxic Elements Composition of Natural Soil Lick (*Ng'engta*) in Yatya Village, Baringo County, Kenya

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ABSTRACT

Soil licks, locally known as 'ng'engta' are deposits where animals access essential minerals naturally present in the soil. Assessing their mineral content is important whether they meet the nutritional needs of livestock and the need to protect from destruction and commercialization for the benefit of the local community. In order to meet the demands of development and production as well as to replenish cells lost during regular metabolism, minerals are necessary for life. Therefore, they require constant resupply in the form of food, drink, or supplements. The use of soil additives for ruminants by rural residents in yatya village, despite the lack of research, is thought to increase livestock productivity. This study was carried out to investigate the mineral composition of the soil that ruminants in yatya village use as supplemental food, compare the results with those of commercial salt licks, and provide pertinent recommendations. To determine the components' concentration and composition, a representative sample of soil lick was collected from the kimotor soil lick site. After gathering and air drying the soil lick sample, any visible outside particles were crushed, homogenized, sieved through a 2 mm mesh screen, precisely weighed, labeled in plastic bags, and delivered to the chemical lab for testing using Flame, AAS, and UV-vis spectroscopy at the University of Eldoret. The variations in the amounts of mineral components in the commercial salt lick and natural soil lick were assessed using normal averaging and ratio scales. According to the results, there are more than eleven (11) elements in the soil sample. Among them N (0.06%), P (0.05%), K (42.5 ± 0.71 mg/kg), Na (3622 ± 2.83 mg/kg), Ca (2995 ± 0.01 mg/kg), Mg (187.50 ± 0.01 mg/kg) are essential macronutrients and Fe (4829.17±0.02 mg/kg), Cu (604.17 ± 0.01 mg/kg), Zn (12.5 ± 0.01 mg/kg), Co (184.17 ± 0.01 mg/kg) and Mn (375 ± 0.01 mg/kg), are essential micronutrients. The study also showed the natural soil lick did not contain heavy metals such as Cr and Cd, which are toxic even at very low concentrations. However, it contained Pb (20.833 ±0.01 mg/kg) which was within global mean concentrations. Higher amounts of critical components were found in natural soil licks, according to the study. Livestock at the kimotor natural soil lick site in yatya village, Baringo County, may eat natural soil licks mostly because of mineral supplementation. Therefore, there is a need to be managed sustainably for livestock essential mineral supplementation.

Keywords: *Essential minerals, Toxic elements, Livestock, Natural soil lick, Commercial salt lick.*

Introduction

The current research effort is to focus on increasing the use of less expensive animal feed sources [1]. Large or tiny amounts of mineral elements can be found in soil or living tissues. The macro elements that are found in enormous numbers are needed in large quantities, whereas the micro elements are needed in little amounts. Mineral replenishment, detoxification of plant secondary metabolites, and relief of digestive diseases are only a few advantages of geophagy, or the consumption of dirt by animals [2]. Both domestic and wild animals frequently engage in geophagy, and it has been documented that they may travel great distances to eat the naturally occurring minerals in their natural lick locations [3] [4].

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Natural soil licks serve as a vital source of sodium, particularly because terrestrial plants generally lack sufficient levels of this mineral to meet the needs of animals, especially in inland areas far from marine influences [5][6]. Animals are naturally equipped to detect sodium chloride through taste, allowing them to locate mineral-rich sites by using their tongues to sample environmental chemicals [7]. Besides sodium, natural soil licks provide other essential minerals that are critical for animal health. For instance, calcium and phosphorus are fundamental for the development of bones and teeth, nerve signal transmission, and muscle function. A deficiency of these minerals in an animal's diet can lead to reduced blood serum levels, potentially causing conditions such as milk fever in lactating animals [8]. Sodium and Potassium are essential for fluid balance, nerve function, and muscle contraction, and their deficiencies in the diet lead to low osmotic pressure and consequently dehydration of the animal [9]. Magnesium is involved in numerous enzymatic reactions and is essential for nerve impulse transmission and muscle control [10]. Iron is crucial for carrying oxygen in the blood and is particularly important for young animals and pregnant animals [11]. Copper is essential for various metabolic processes, including energy production and growth. Zinc is a component of many enzymes and is essential for growth, immunity, and reproduction [12]. Manganese is involved in carbohydrate, protein, and lipid metabolism and is essential for overall health [13]. Cobalt is essential for the synthesis of vitamin B12 in the rumen, which is needed for starch metabolism and energy production [14].

One major challenge faced by many smallholder and rural livestock producers is their inability to meet the mineral needs of their animals, which results in lowered productivity [15]. Although it is widely recognized that animals need essential minerals for maintenance and production, most livestock in tropical regions rarely receive mineral supplementation [16]. As a result, animals are generally expected to derive these minerals from the feeds and forages they consume, whose mineral content is largely influenced by soil properties and other environmental factors.

Numerous mineral deficiencies, imbalances, and toxicities have been reported as economically important in livestock production throughout the world [17]. Toxic mineral elements if present in natural soil licks can severely impact livestock health, causing a range of issues from organ damage to reproductive problems and even death [18]. While mineral toxicities are generally less common than deficiencies, they can still pose significant health risks due to the bioaccumulation of toxic elements in body organs such as the liver and bones. This accumulation may occur through the ingestion of contaminated soils by animals or the subsequent consumption of animal products like meat and milk by humans [19][20][21]. Given that geophagic soils across the globe originate from diverse geological formations, it is essential to conduct region-specific chemical analyses to assess the concentrations of both essential and toxic mineral elements. Such analyses are necessary to evaluate their potential health benefits and risks for both humans and animals [22][23].

These insights may offer a cost-effective alternative to the increasingly unaffordable commercial mineral licks, especially for resource-constrained rural farmers facing economic challenges in Kenya [24]. Although commercial salt licks, widely used in developing countries, are reliable sources of essential minerals, their high costs render them inaccessible to many smallholder farmers. In contrast, naturally occurring soil licks locally referred to as *Ng'engta* by the Tugen community, are more readily available to local livestock keepers. The kimotor natural soil lick site located in yatya village, Baringo County, is one such example. However, there is limited documented information on the mineral composition of this natural resource.

This study aims to analyze the mineral and toxic element content of the kimotor natural soil lick site. The findings will contribute to the development of affordable and locally accessible mineral supplements for livestock. Additionally, the results may stimulate further research into the integration of natural soil licks into livestock feeding strategies.

Materials and Methods

Description of study Site

The study was conducted at the kimotor natural soil lick site located in yatya yillage, Baringo County, Kenya. This location was selected because of its natural soil licks, which have traditionally been utilized by livestock farmers. Geographically, Kimotor natural soil lick site in yatya village is situated between 0°47'00.6"N 35°55'27.6" E in Baringo County. See Figure 1 below.

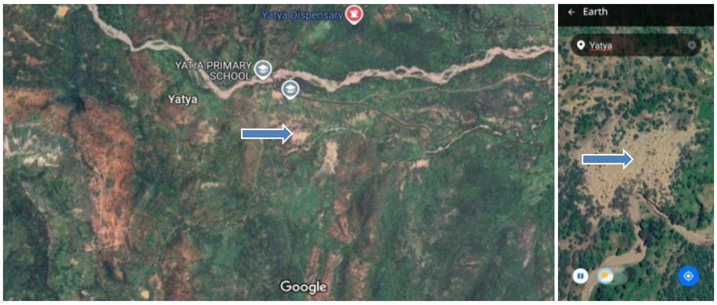


Fig. 1: Screenshot of google earth maps of kimotor natural soil lick site in yatya village, Baringo County. The right photo shows the magnified spot (https://maps.app.goo.gl/qFGQq2P9Wjw9AxT96).

Sample Collection

The geophagy spot which is highly frequented by livestock was chosen. Pastoral livestock farmers move animals to the soil lick. Soil licks in kimotor soil lick site, yatya village are also collected and transported for supplementing livestock in high-altitude areas. The following procedure as described by Nderi et al. [25] was followed. At the natural soil lick site, a composite soil sample was obtained using a soil auger and trowel from a location where geophagic activity was clearly observed. Soil was sampled at depths of 0–15 cm, 15–30 cm, and 30–60 cm to account for water-soluble elements like sodium that are prone to leaching. The three sub-samples from the site were combined to form a single composite sample, which was placed in a plastic bag and taken to the laboratory for analysis. Commercial salt lick was also purchased from a local livestock feed store for analyses. See figures 2a and 2b below.

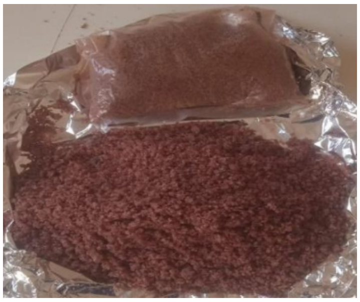


Fig.2a: Kimotor natural soil lick sample
Fig.2b: Commercial salt lick sample

Sample preparation

The soil samples collected from the field were placed in a plastic bag and left to air dry. To facilitate faster drying, large clods were crushed. Any roots, stems, leaves, and animal droppings were carefully removed. Once dried, the samples were thoroughly mixed using a mortar and pestle, and then passed through a 2 *mm* sieve for uniformity.

Samples Analyses

The soil lick sample and positive control were analysed for presence and concentration of essential and toxic mineral elements.

The pH was also determined. Air dried soil samples were analyzed at the laboratories of the Department of Soil Science and Chemistry & Biochemistry, University of Eldoret, Kenya. The samples were air-dried, processed, and analyzed following standard procedures outlined by Okalebo et al. [26]. Specifically, soil pH was measured using a glass electrode pH meter in a 1:2.5 soil-to-water suspension. Sodium (Na) and potassium (K) ions were extracted using ammonium acetate at pH 7, and their exchangeable forms were quantified through flame photometry. Other essential soil elements were analyzed using an atomic absorption spectrophotometer. Total nitrogen (N) and phosphorus (P) were determined by digesting 0.3 g of soil with a mixture of selenium (Se), lithium sulfate ($LiSO_4$), hydrogen peroxide (H_2O_2), and concentrated sulfuric acid (H_2SO_4). The concentrations of N and P in the resulting digest were then measured using a UV-Visible spectrophotometer. Soil samples from each salt lick were compared with commercial salt lick samples from the local animal feed store (positive-control), therefore mean and standard deviation differences in pH, mineral and toxic elements concentrations between natural soil lick and commercial salt lick samples were determined.

Data Analysis

Data analysis involved using simple averaging method to assess the differences in the quantities of mineral elements between the natural soil lick and the commercial salt lick samples.

Results and Discussion

The present study aimed to determine whether the natural soil licks consumed by livestock in yatya village contain essential minerals and potentially harmful elements. Table 1 presents the results of the analysis for essential minerals, toxic elements, and the pH levels of soil samples collected from the natural soil lick at yatya village.

The pH analysis revealed that the soil from the natural lick was highly alkaline, with a pH of 9.22 ± 0.03, in contrast to the neutral pH of the commercial salt lick (7.01 ± 0.02). The elevated pH in most of the natural licks may account for the higher concentrations of certain basic elements, such as calcium, which tends to accumulate in alkaline soils due to its low mobility [27][28]. Additionally, the high alkalinity of the soil lick could explain the absence of farming activities in the area, as well as the visibly poor plant growth typically observed at the site. [29].

Macro mineral element composition revealed Chemical analysis showed that natural soil lick had higher levels of both nitrogen (0.0595 ± 0.00 %), phosphorus (0.045 ± 0.01 %) potassium (42.5 ± 0.71 mg/kg), and sodium (3624 ± 2.83 mg/kg) compared to the commercial salt lick. The salt lick had lower levels of calcium (2995 ± 0.01 mg/kg) and magnesium (187.50 ± 0.01 mg/kg) compared to the commercial salt lick. The high levels of essential minerals as compared with commercial salt lick have been reported in another study by Razali et al. [30]. Studies have shown that salt-lick soils with high concentrations of sodium are frequently visited by animals for mineral supplementations [31].

Micro essential elements composition showed that the natural soil lick had higher concentrations of iron (4829.17±0.02 mg/kg), manganese (375 ± 0.01 mg/kg), and cobalt (184.17 ± 0.01 mg/kg) compared to the commercial salt lick. The commercial salt lick had slightly higher levels of copper and zinc compared to the natural soil lick. The high concentration of essential minerals may explain why livestock are naturally drawn to soil licks for mineral supplementation. This observation aligns with findings by Chaiyarat et al. [32], who noted that natural soil licks play a significant role in supplementing mineral-deficient animal diets. In the study area, natural soil licks can generally be classified into earth exposures and wall-type soil licks based on their physical structure [33]. The abundance of vital minerals likely contributes to the popularity of the Yatya natural soil lick among livestock farmers. This finding supports Chaiyarat et al. [32], who emphasized the importance of natural soil licks in meeting animals' mineral requirements.

Heavy metals such as arsenic (As), lead (Pb), mercury (Hg), cadmium (Cd), and chromium (Cr), among others, are known to be harmful to both humans and animals when ingested in large quantities [34]. According to the WHO [35], As, Pb, Hg, and Cd are among the top ten hazardous substances posing major public health concerns. These heavy metals are particularly dangerous because they are not easily metabolized or excreted from the body, potentially causing serious illnesses or even death in both humans and animals [36]. In this study, lead was the only toxic element detected, with a concentration of 20.833 ±0.01 mg/kg, which was lower than that found in commercial salt licks. Chromium and cadmium were not present in the samples. The lead concentration at the natural soil lick site was within the safety limits set by FAO/WHO [37], indicating that the site poses minimal risk to livestock and, by extension, to humans consuming products such as meat and milk from these animals.

Table 1: pH and mean concentrations (mg/kg) of essential minerals and toxic elements of the natural soil lick in kimotor site and the commercial salt lick.

Elements	Sample source	
	Natural mineral lick (test sample) (MEAN ± SD)	Commercial salt lick (positive control) (MEAN ± SD)
pH	9.22 ± 0.03	7.01± 002
N (%)	0.0595 ± 0.00	0.0295 ± 0.001
P (%)	0.045 ± 0.01	0.03 ± 0.001
K	42.5 ± 0.71	1.14 ± 0.000
Na	3624 ± 2.83	63.115 ± 0.014
Ca	2995 ± 0.01	11053.333 ± 0.000
Mg	187.50 ± 0.01	428.333 ± 0.014
Fe	4829.17±0.02	625 ± 0.014
Cu	604.17 ± 0.01	845 ± 0.014
Zn	12.5 ± 0.01	35 ± 0.000
Co	184.17 ± 0.01	83.33 ±0.007
Mn	375 ± 0.01	41.67 ± 0.000
Cr	ND	ND
Pb	20.833 ±0.01	22.50 ± 0.007
Cd	ND	ND

Key: pH= per hydrogen ion; N= Nitrogen; P= Phosphorus; K= Potassium; Na= Sodium; Ca= Calcium; Mg= Magnesium; Fe= Iron; Cu= Copper; Zn= Zinc; Co= Cobalt; Mn= Manganese; Cr= Chromium; Pb= Lead; Cd= Cadmium; ND= Not Detected.

Kimotor natural soil lick site study area can be described as an earth-exposed natural lick based on its structural features [25]. It is situated in the lowlands and is characterized by extensive excavated soil areas and multiple small sites where animals ingest soil, resembling the one illustrated in Figure 3 below.

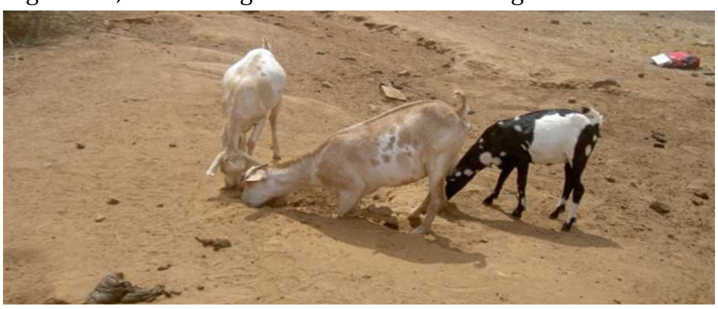
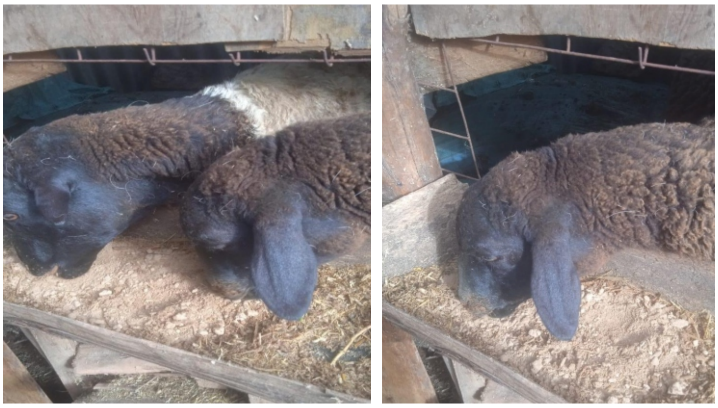


Fig. 3: Goats consuming natural soil licks from an earth exposure lick [25]



Photos of Sheep consuming the natural soil lick sample during the study in a farm in Eldoret City

Elevated potassium levels in the soil lick may be attributed to natural weathering of the underlying basement rocks and atmospheric deposition. These processes are likely enhanced by limited leaching due to the area's high evaporation rates and low rainfall [38]. The minimal phosphorus content in the natural soil lick could contribute to reduced energy metabolism in animals that consume it. This deficiency may lead to abnormal feeding behaviors, such as pica-a condition where animals chew on non-nutritive substances like rocks, bones, wood, plastic, soil, clay and rags, which is often associated with a lack of phosphorus [39].

Some sections of the Yatya natural soil lick are located near the edges of seasonal streams. The elevated concentrations of potassium, sodium, calcium, and iron in the lick may be a result of mechanical grinding of stream bed materials [40].

Conclusion

This study established that the kimotor natural soil lick site in yatya village, Baringo County contains essential macro-elements; Nitrogen, Phosphorus, Potassium, Sodium, Calcium, and Magnesium as well as trace minerals such as Iron, Copper, Zinc, Cobalt, and Manganese. These nutrients likely explain why livestock from surrounding areas are drawn to this particular site. This was confirmed by our pilot test where we exposed some farm animals to the natural soil lick sample (see appendix). We observed the animals were craving to lick the soil sample. Toxic element levels were either undetectable or fell within global median concentrations, indicating minimal to no health risks for animals consuming the soil lick or for humans who consume animal products from those livestock. As such, kimotor natural soil lick site at yatya village in Baringo County could potentially serve as an alternative source of essential minerals to the expensive commercial mineral supplements in animal feed, given that minerals play a crucial role in processes such as cellular respiration, nervous system function, protein synthesis, metabolism, and reproduction in livestock.

Recommendations

The authors would make the following recommendations from the study done;

1. For the purpose of improving overall usage, efficiency and optimization of the natural soil lick (Ng'engta), other essential minerals and toxic elements should be studied in future since our scope of study was limited to the available element standards and AAS lamps in our research laboratory.

2. Likewise, feeding or biological trials should be carried out to determine the appropriate inclusion levels, as well as the preference and acceptability of the natural soil lick on a broader scale.

3. Buying commercial mineral blocks is expensive, yet farmers can make their own mineral blocks at home using cheap and available natural mineral soil licks and provide almost the same amount of essential minerals found in commercial salt licks.

4. Local farmers and community groups can start producing natural soil lick blocks for sale as an income-generating activity to improve their livelihoods.

Disclaimer

The commercial mineral salt used in this study is a widely used product in the study area and across the country. It was included solely as a positive control for comparative purposes and to contribute to the advancement of scientific knowledge. Importantly, the research was not sponsored by the manufacturer of the product; it was entirely funded through the personal contributions of the authors. Therefore, we found it necessary to conceal the product name and producing company.

Author Contributions

Richard Kiptisia: Conceptualization, sample collection, methodology, formal analysis, resources, data curation, writing the original draft manuscript, review and editing and funding acquisition for publication.

Margaret Maina: Methodology, formal analysis, resources, data curation, review & editing and funding acquisition for publication.

Edwin Kirwa: Methodology, formal analysis, resources, data curation, review & editing and funding acquisition for publication. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The Authors declare that they have no competing interests.

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