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Elemental Analysis of Some Geophagic Soils of *Hagar Sari* Area Using Inductively Coupled Plasma Technique

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ABSTRACT:

Fifteen samples of soil lick were collected from *HagarSari* surroundings at Northern Darfur and analyzed for elemental composition. Inductively coupled plasma technique was used. The results show that the mean percentage mineral contents were as follow: Aluminum (1.968%), Iron (1.707%), Potassium (0.40%), Sodium (0.1679%), Calcium (0.1680%), Magnesium (8.6×10^{-2}%), Manganese (0.24×10^{-2}%),Bbarium (0.0117%), Vanadium (0.573×10^{-2}%), Chromium (0.51×10^{-2}%), Strontium (0.47×10^{-2}%), Zinc (0.253×10^{-2}%), Copper (0.132×10^{-2}%),Lead (0.235×10^{-2}%), andMolybdenum and Nickel showed significantly low concentrations (0.044×10^{-2}%, 0.0435×10^{-2}% respectively). Silver and Cobalt were not detected. Surprisingly, Aluminum and Iron were mostabundant instead of Sodium, Potassium, Calcium and Magnesium which are normally considered to be the essential animal attractants, because they normally showed higher concentration in the licked soil samples almost in all studies concerned with this field for so many years in different countries.

المستخلص

في هذه الدراسه جمعت خمسة عشر عينة من التربة الطبيعية التي تلعقها الغزلان من منطقة حجر ساري بشمال دارفور. وتم تحليلها لمعرفة تركيز العناصر المختلفة. تم التحليل بتقنية ال (Inductively Coupled Plasma). وقد اوضحت نتائج التحليل أن متوسط تراكيز العناصر بالنسبة المئوية كما يلي: الألمنيوم (1.968%)، الحديد (1.707%)، البوتاسيوم (0.40%)، الصوديوم (0.1679%)، الكالسيوم (0.1680%)، المغنيزيوم (8.6×10^{-2}%)، المنغنيز(0.24×10^{-2}%)، الباريوم (0.0117%)، الفانيديوم (0.573×10^{-2}%)، الكروم (0.51×10^{-2}%)، الاسترونشيوم (0.47×10^{-2}%)، الخارصين ($0.253\times10^{-}$ ^{2}%)، النحاس (0.132×10^{-2}%)، الرصاص (0.235×10^{-2}%)، عنصرا المولبدنوم والنيكل أظهرا تراكيز منخفضة (0.0435×10^{-2}) ، (0.044×10^{-2}%) لكلٍ على التوالي. لم يظهر وجود لعنصري الفضه والكوبالت في كل العينات. الألمنيوم والحديد أظهرا تراكيز عاليه في كل العينات خلافا لنتائج الدراسات السابقه التي اجريت في هذا المجال لعدة سنوات مضت والتي اوضحت وجود الصوديوم، الكالسيوم، البوتاسيوم والمغنيزيوم كعناصر أساسيه لجذب الحيوانات للتردد على هذه المناطق.

***KEYWORDS*:** ICP, Microwave digestion, Dorcas Gazelle, Western Sudan.

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INTRODUCTION

Mineral elements play an important role in the nutrition of wild games. Hence a real research dealing with brief discussion on wildlife nutrition is important.

There are many hypotheses about why do animals lick soils. The most expected reason behind soil eating behavior in mammals has been associated with deficiency of some elements.

There are five major hypotheses about the causes of geophagy:

1- Detoxification of plant secondary compounds, especially alkaloids (1, 2).
2- Mineral supplementation of diet, especially with sodium and calcium ions (3, 4).
3- Acquisition of soil to supplement mechanical grinding in the avian crop (5).
4- Zoopharmacognosy, with particular reference to internal parasites and alleviation of diarrhea (6, 7).
5- Buffering of gastric pH (1, 8).

Geophagia (eating soil behavior) in mammals has been associated with deficiencies of elements such as phosphorus, sodium, magnesium, sulphur, copper, cobalt and manganese (9). Geophagia may also be an instinctive behavioral response to gastro-intestinal disturbances (10, 11, and 12). This animal behavior is suggested to be strongly influenced by climatic, geographic, and taxonomic factors due to weather seasonality, variations in available food resources, soil pedology, and floristiccomponents of the region, among others (13). The list of animals that ingest soil is so large, not only includes a vast variety of mammals (14, 16, 17, and 18), but also do turtles, lizards, crocodiles, and birds (19, 20, and 21).

Mineral licks, soil licks or salt licks (also known as salados, saladeros, or collpas) are specific sites in tropical and temperate ecosystems where a large diversity of mammals and birds come regularly to feed on soil. Although the reasons for vertebrate geophagy are not completely understood, animals are argued to obtain a variety of nutritional and health benefits from the ingestion of soil for mineral licks (52). Although few insectivorous animals eat soil at mineral licks, geophagy as well as visitations to licks is strongly biased toward frugivore– folivores(10). perhaps because levels of key minerals are low in plant food (fruits, leaves) relative to animal tissue or because herbivore exposes consumers to a more substantial intake of toxins and other plant secondary compounds that must be mediated through geophagy(52).Farmers also use mineral licks to meet their livestock's potential nutrient deficiencies (22). These artificial mineral licks may be models of those occurring naturally in the wild. The concentration of several mineral elements in soil is often higher than in the herbage. A marked increase of the concentration of several trace elements like Cu, Mn, Se, and Fe in the diet when adding a certain amount of soil (14%)into the diet of sheep (23). However, this increase in mineral elements reflects the total amounts ingested and not the available fractions of the elements. It should be noted that soil ingestion on pasture is higher when dry matter (DM) intakes are low due to feeding limitations. At such times, mineral elements available to the animal directly from soil can be a significant contribution to intake (23). I.e. Cobalt (Co) is included in vitamin B12, However, very little of Co is taken up by plants; therefore, it is mainly by soil ingestion that sheep and cattle can fulfill their needs of this mineral element (23, 24). The mineral supplementation hypothesis has been supported by some studies (10, 25, 26, and 27) and rejected by others (2 and 20). In the

Peruvian Amazon,Brightsmith and Muñoz-Najar(26) concluded that birds choose soils with higher sodium, whereas Gilardi*et al.*,(2) concluded that the detoxification of dietary toxins was more important, and that mineral supplementation was unlikely to be the primary cause of geophagy because they found that preferred soils did not have significantly higher levels of sodium than non-preferred soils.Sodium is vital for a wide variety of animal functions including maintenance of osmotic balance, nerve transmission etc. For this reason humans and other animals show such strong cravings for sodium and actively seek it out.Sodium is scarce in the diets of herbivorous animals because it is found in low concentrations in most plants. In Peru studies showed that parrots have diets with extremely low concentrations of sodium that is why these birds eat soils with the highest concentrations of sodium (26, 2). In the study conducted by Donald Brightsmith, (29) the scientificevidence suggests Peruvian parrots do not eat soil for grit but they do consume soil that provides an important source of dietary sodium and helps neutralize the plant toxins in their diet. Plants and young soils often contain concentrations of essential minerals below the mammalian requirements for maintenance, growth and reproduction (30, 37, 38, and 40). Most geophagic clayey soils from South Africa are whitish, grayish or khaki because of kaolin, smectite, and calcite; and others from Swaziland is reddish or yellowish due to hematite and goethite contained in them (42). The color and texture of the clay may have an influence on the type of soil consumed (42). The white clay is composed largely of kaolin; while the yellowish and the reddish clays contain iron, which could be a source of iron supplement (43, 44). The few published studies on this subject involve use of licks by native groups. In the Colombian Amazon, for example, indigenous communities of the Miriti-Parana River obtain about 25% of their consumed meat from wild animals' hunted natural licks (55).

Salt is unique, therefore animals have a much greater appetite for the sodium and chloride in the salt than for other minerals. This may be agreeing with the definition of geophagy as salt hunger (45). Because most plants provide insufficient sodium for animals feeding and may lack adequate chloride content, salt supplementation is a critical part of a nutritionally balanced diet for animals. Sodium plays major roles in nerves and impulse transmission and the rhythmic of heart action. Efficient absorption of amino acids and monosaccharide from the small intestine requires adequate sodium.

Microwave technology has now advanced to the point where it is revolutionizing chemical sample preparation and chemical synthesis. Since the first application of a microwave oven for sample preparation in 1975, many microwave-assisted dissolution methods have been developed. These are applicable to virtually any kind of sample type (54). One of the milestones in the development of sample preparation strategies has been the evolution of microwave technologies, mainly after the 1980's (46). Nowadays thistechnology is being applied not only in analytical chemistry but also in organic synthesis, inorganic reactions, preparation of catalysts, and other fields (47). Different acid mixtures have been used for the microwave digestion of geological and environmental matrices, few of them leading to complete digestion of the samples (48).This technique is susceptible to loss of volatile analytes and cross-contamination (54).

The aim of this study was to investigate the presence of some minerals other than the normally determined ones in soil licks (Na, K, Mg and Ca). It also aims to use the most recent, sensitive, accurate, and time saving technique such as, inductively coupled plasma technique (ICP). Inductively coupled plasma technique is not used in this type of soil analysis for so prolonged years of soil lick research.

MATERIALS AND METHODS

Study area: Sudan is located in Northern Africa, bordering the Red Sea, between Egypt and Eritrea, Situated in the northeastern part of Africa; Sudan has a climate ranging from very arid in the northern parts to equatorial in its most southern parts. The central part is occupied by savannah (39).

The study area was selected within Northern Darfur (Al-kuma and Hagar Sari area). The lick sites under study are scattered with approximate distance ranging from 20 to 50Km from each other and between longitudes 26.0'0-29.0'0 and latitude 13.30'0- 14.30'0. Fifteen Samples were collected from separate soil lick sites, within, a certain fields. Lick sites were determined by observation of animals visiting from time to time, and they are known by local hunters in the area. Most Geophagic clayey soils are strong brown, red,and darkbrown. The study area has a rocky nature.

SAMPLES COLLECTION

Fifteen natural soil licks samples were collected from the top with 10cm depth in each site, kept in clean and dried plastic containers. Then 0.5g of each sample was analyzed. ICP technique was applied using a closed microwave digestion procedure. Preparation methods used are typically based on microwave close digestion system with nitric acid, hydrofluoric acid and hydrochloric acid. The problems caused by excess hydrofluoric acid are avoided by the addition of boric acid.

Chemicals: All chemicals used were of analytical grade (High purity).

- Nitric acid, (scharlau), Spain.
- Hydrochloric acid (scharlau), Spain.
- Hydrofluoric acid, (scharlau), Spain.
- Boric acid, (scharlau), Spain.

Instruments:

- Inductively Coupled Plasma - Optical Emiss ion Spectrometer (ICP-OES), Varian, 725-ES.
- Microwave digestion system- Ethos one- Milestone.

RESULTS and DISCUSSION

Table: (1) shows the percentage concentration of the major and trace elements. The studied soils showed high concentrations of alkali metal, alkali earth metals, some transition metals (e.g: Fe, Mn), and rare earth elements. Aluminum showed the highest concentration of minerals in all samples (Figure 1). Although this ion is a non-nutrient it was shown to form aluminum-tannate complexes (49). High value of aluminum suggests the presence found of Clay minerals likeSmectite (Na montmorillonite), mica (muscovite), kaolinite and feldspar (microcline), these compounds acts as cation adsorbent or anti acidic.

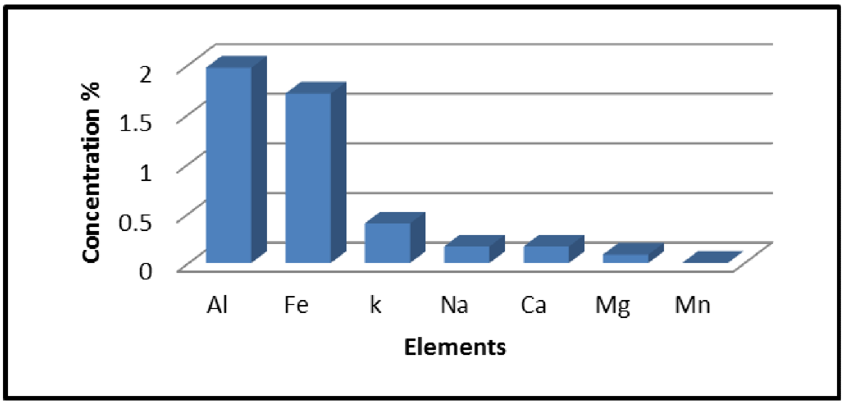

Figure (1): Percentage means concentration of Major Elements

Iron (Fe), potassium (K), calcium (Ca), magnesium (Mg) and sodium (Na) concentrations were significantly higher in all samples. The concentration of these minerals suggests that animals use soil licks for nutrition supplementation of all minerals not for sodium as a main nutrient. All previous studies showed high concentration of macro elements. Iron in some studies has a highest concentration (50, 52). High concentration of iron may be due to dead leaves, urination and soil parent materials.

Trace elements showed considerable values (Figure 2), were lower in comparison to those reported by Ekosse and Jumbam, (2010) and highest than that reported by Esraa Omer (52) However, Gichumbi*et al*., (53) reported concentration of Zn, Co and Mo higher than that reported by this study, and showed low concentrations of Cu, Cr, Sr than the results in this study, V and Cd showed low concentration in this study but has not detected byGichumbi*et al*., (53). All samples showed absence of silver and cobalt elements. Sample (No. 9) showed the lowest value of macro minerals, and gave a low concentration of other elements, because this sample has a large ratio of silica, that acts as evidence for using lick soils as grinding aid for animals. Results of analysis obtained from Mohamed A. Abbo et al (31) showed high concentration of sodium and low concentration of trace and toxic minerals in comparison with this study.

This variation in samples composition and the consequent characteristics of the salt licks may be related to the location of the salt lick, topography, surrounding forest structure and other factors related to the natural history of each site in addition to the diet supplementation (50). Salt is known to be a carrier of trace minerals, since all herbivores have natural appetite for salt. This could serve as a source of trace minerals for them. Variation in thesizes and colors of the geophagical soils may result from the visits of different species to each salt lick. The clear importance of salt licks to the wildlife communities is evident here and in other localities by their frequent use (32, 29, 33, 34, 35, and 36) and emphasizes the need to priorities conservation areas by maximizing the complementarities of lick sites.

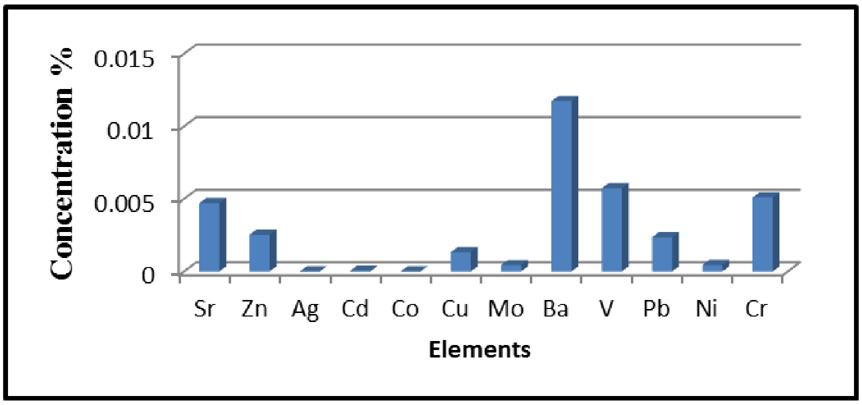

Figure (2): Percentage means concentration of Trace Elements

CONCLUSION and RECOMMEND -ATIONS

-This study was conducted on the mineralogy of geophagicclayey soils from different lick sites from Hagar Sari area to establish the quantitative minerals compositions of the geophagic clayey soils .

-Analyses of the collected samples showed that mineral licks are used for nutritional and as digestive aids .

-Dorcas gazelles use lick soils as grinding aid.

-Further analyses should be carried out on different soil lick sites to explore some questions concerning palatability improvement, digestibility, detoxification and dietary supplementation, as well as, the exact chemical composition of soil licks and clay minerals consumed by herbivores .

-More close observations may be needed to record at what time or season animals are attracted to geophagic sites; including their age, sex, reproductive state (pregnancy and lactation.

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