Chemical Analysis of Calabash Chalk: Does It Affect Human Health?

A project submitted

by

Musharrat Zabin
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Dedicated to my parents and sister

Certification Statement

This is to certify that the project titled **"Chemical Analysis of Calabash Chalk: Does It Affect Human Health?"** submitted for the partial fulfillment of the requirements for the degree of Bachelor of Pharmacy from the Department of Pharmacy, BRAC University under the supervision of Dr. Sharmind Neelotpol, Assistant Professor, Department of Pharmacy, BRAC University and I have appositely used citation where other author's language, perception and writing style were used.

Signed,

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Counter signed by the supervisor

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Acknowledgement

Sagacity is the greatest accolade from Almighty bestowed upon mankind. I concede earnestly that, without His clemency and altruism it would be impossible for me to achieve knowledge and foresight through my whole academic studies. My indebtedness to Almighty is perpetual.

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Abstract

Consumption of geophagic soil by mankind is an enigmatic and convoluted fact. The fact has fecundity to produce huge conventional reasons for consuming the soil but still those are considered as elusive. Indigence naturally obstructs people to get proper level of nutrition and they try to replenish their lost nutrition by consuming geophagic soil. Studies relevant to this fact have illuminated that, most of the people are unwitting of the deleterious effects of consumption of soil. The compendium of several studies have erupted plethora of information about the dreadful effects of soil consumption. The paramount cause of providing lamentable effects is presence of trace elements and heavy metals. Superfluous ingestion of elements with the soil shows temerity to impair the balance of macromolecules in the body. The perennial and corrosive effects suggest iron deficiency, growth retardation, heavy metal exposure etc. All of these facts provoked a solicitous analysis of trace elements and heavy metals for Calabash chalk soil that was collected from Sylhet which is geographically located in Northeastern part of Bangladesh. Trace elements and heavy metals were analyzed by Atomic Absorption Spectroscopy which includes potassium (K), Manganese (Mn), Copper (Cu), Zinc (Zn), Iron (Fe), Chromium (Cr), Cadmium (Cd), Arsenic (As), Lead (Pb). The factual deduction of the analysis had shown the presence of Lead (pb) in significant amount 19.26 ppm that has plausible harmful and toxic effect in human body. In the context of presence of heavy metals, the soil contains another toxic element named Arsenic (As). This heavy metal's amount in the soil is represented as 4.57 ppm from the analysis that certainly can threat human health in the relevance of toxicity. Study result has given a platform to peruse and to discuss the salutary and terrible effects for excessive soil consumption.

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List of acronyms

AAS: Atomic Absorption Spectrophotometer

BCSIR: Bangladesh Council of Scientific & Industrial Reasearch.

BD: Below Detection Limit

CEC: Cation Exchange Capacity.

GIT: Gastro-Intestinal Tract.

HVG: Hydride Vapor Generator.

RDA: Recommended Dietary Allowance.

WHO: World Health Organization.

Chapter 1

Introduction

Introduction:

The primitive complicated practice of consuming earthy substance like specified clay or soil has the world wide common name, "Geophagia". This practice was sustaining from the ancient period among the child bearing women. The earthy substance which is being eaten by humankind is denoted as "Geophagic soil". As the name suggests, the practice includes having the soil directly from the source or the soil that is naturally occurring (Abrahams, 2003). People find the soil with fascinating characteristics like color, flavor and plasticity that develop the appetite of them to eat the soil(Abrahams,2003). As several analyzed soil reports lightened the difference between the naturally occurring and artificially formulated calabash chalk but both of them are equally famous in market. Consumption of the geophagic soil has become a custom among the humankind which is currently prevalent within the society. This custom has been documented in various areas of the world by several explorers. Earthy eating substance like Calabash Chalk consumption is deep-rooted for some superstitious thoughts among people. Halsted in 1968 notified an information that based on several superstitious thoughts, pregnant women deliberately intake geophagic soil for getting some health related advantages. (Ekosse, Jumbam.2010). Geophagia can be considered in other name which is "pica". This term is referred as consuming the non-food (Hooda, Henry.2007). Generally calabash chalk or geophagic soil are picked from several places includes brick walls, open field, mountains, road side, river beds (Ngole-Jeme and Ekosse, 2015).

From the historical aspect, geophagia was discovered between 16^{th} and 18^{th} century specially in the African region (Ekosse, Jumbam.2010). Observation of different explorers revealed that the practice of earthy substance gradually was spreading in Nigeria, Ghana, Sierra-Leone in the early 20^{th} century (Ghorbani, 2008). Apparently, in 40 BC Aristotle first introduced the term of geophagy. According to the chronological research on geophagya, a travel report by Von Humboldt disclosed that mothers of Otomac tribe insisted their child to eat clay to pacify them. Von Humboldt gave his report on the basis of some particular regions including Otomac tribe along with Orinocco River, Peru and so on. Roman physician Soranus observed many pregnant ladies and he mentioned why pregnant ladies are craving for the clay consumption which begins at fortieth day of pregnancy. He also notified that this craving for clay consumption lasts for minimum four months for the sake of nullifying unpredictable appetite (Ghorbani, 2008).

The complex behavior of geophagia in several communities is being continued to spread for some purposes. The most important reasons are socio-economic setting and poverty (Ekosse, Jumbam.2010). Besides, eating of geophagic soil is influenced by some other reasons which are thought to be medicinal purposes, cultural norms, religious belief and psychiatric disorders (Hooda, Henry.2007). Among the pregnant women and lactating mother, a strong belief about physiological advantage of calabash chalk soil. Accordingly, it is strongly believed that the soil can play the role for preventing Gastrointestinal disorders, nullifying the elemental imbalance like Iron (Fe), Potassium (K), Magnesium(Mg) imbalance within body. Moreover, Women are convinced for soil ingestion because they feel that soil can improve the digestive system and for healthy digestion process and can adjust the pH range within the gastrointestinal tract (Ngole-Jeme and Ekosse, 2015). Some child bearing women think that the soil's nutrition is helpful for the foundation of healthy and attractive skin of baby (Ekosse, Jumbam.2010).

Geophagic soil is famous as famine food. Many historical records give the evidence that geophagic soil was believed to be life savior in the period of famine among the Eskimos and Athabascans. They had a strong belief about the geophagic clay that it would be preventive for constipation when they were starving. Some of the South-American people had a thought that the clay might be helpful for suppressing the appetite. During food scarcity, the clay destroyed hunger and diminished the effect of gastric juice secretion. As previously mentioned about Von Humboldt's observation, Otomac tribe along the Orinoco River practiced eating the geophagicclay containing Iron Oxide in the rainy season without any physical complications when there was shortage of food supply. From the socioeconomic point of view, indeed the clay played an important role for those people who were struggling with poverty (Loveland, Furst, Lauritzen; 1989).

Another satisfying role of the geophagic clay is being detoxifying agent. People were financially unstable during draught or famine, used to eat many plants in order to annihilate hunger. The geophagic clay combined with the plants has a detoxifying effect. Johns in 1986 mentioned example of tubers of several species potatoes containing heat stable and water soluble characteristics. Certainly those glycoalkaloids are harmful for human body as they are proven to be toxic (Loveland, Furst, Lauritzen; 1989). This toxicity could be easily eradicated by the geophagic soil under the detoxifying process. On the other hand, geophagic clay helped to make

the plants palatable thus people could easily consume them. The clay specially masked the bitter or unacceptable taste of plant alkaloids, tannins etc (Loveland, Furst, Lauritzen; 1989).

Brouillard and Rateau (1989), revealed from their research that geophagic soils have the high cation exchange capacity (CEC) (Ghorbani, 2008).Geophagic soil functions by making CEC-complex with the toxic substances those are incorporated within plant alkaloids, tannins. Dietary toxins from alkaloids and tannins are adsorbed on the clay surface under the CEC-complex exchange reaction that is occurred within the gastrointestinal acidic condition. The debris of clay perfectly gets cross-linked with the glycoproteins in the intestinal mucosa that safeguards gastrointestinal epithelium (Ghorbani, 2008).

People from different regions of the world ingest geophagic soil as a regular food item. In those regions, clay is available as sold in different cake shape in the market. Promoting long life, well-being, good health, fertility all are strong influential factors behind having geophagic clay as staple diet (Loveland, Furst, Lauritzen; 1989).

Chemical and mineralogical analysis of calabash chalk chronologically exhibits information about medical cure or medical problems. According to the study, geophagic clay consumption has several beneficial aspects. From different analytical reports of the clay, the major compound Kaopectate has been found which includes mineral kaolin and bentonite. This compound has anti-diarrheal effect that helps gastrointestinal tract to relieve many other problems, like, dysentery, indigestion. Another problem of gastrointestinal tract is constipation. Apparently constipation is one of the severe problems that require a quick relief. Geophagic clay surprisingly has the solution for constipation. Medieval Muslim physicians and pharmacologists used geophagic clay for the controlling of nausea and vomiting (Loveland, Furst, Lauritzen; 1989).

Chinese people used the calabash chalk for treating dropsy, for curing of jaundice, for the healing of ophthalmic problem. People from different regions have believed the geophagic clay to be treating agent of beriberi and syphilis. Some people use this clay for controlling obesity (Loveland, Furst, Lauritzen; 1989).

Most importantly, the principal consumer of geophagic soil is a pregnant woman who deliberately consumes the clay for relieving from stress, morning sickness, gastrointestinal distress (Loveland, Furst, Lauritzen; 1989).Despite all the preventive and healing feature of the

calabash chalk, various testing of the soil has proven that it has many adverse effects on human body and can create many health disorders. The harmful effects were not only observed in pregnant women but also the unborn children were affected. Pathogenic microorganisms in the soil are responsible for creating variety of diseases including tetanus, worm infections, non-filarial elephantiasis (Ghorbani, 2008). However, various investigations show that the geophagic soil is enriched with earth metals. Chemical analysis of Calabash chalk assesses the soil composition which consists of heavy metals, such as, lead (Pb), Cadmium (Cd), Mercury (Hg), Arsenic (As) (Ekong*et*.al.2015). The variations of elements can lead to some of the major fatal issues on pregnant women and lactating mother by causing lung and skin cancer, kidney and liver dysfunction, neurological damage. It was reported by various studies that the heavy metals of soil indirectly damage the developed nervous system of the unborn children (Ekong*et*.al.2015). On the other hand, some beneficial trace elements have been detected from Calabash chalk which are generally possesses both macromolecules and micromolecules. The documented report shows that trace elements are not within the beneficial range in geophagic soil. In consequence, Iron status of the soil may affect the serum ferritin and cause Iron deficiency or anemia in pregnant women (Geissleretal.1998). On the other hand, study reveals about hypokalemia and zinc deficiency because during consumption of the soil, fluctuation of zinc and potassium concentration in the biological system is a common phenomenon. A very recent study about the negative impact of calabash chalk in human body includes, sinusoidal enlargement, fragmented liver parenchyma, depletion of red blood cells (Ekong*et*.al.2015).

Severe complications of stomach were observed in biological system after consuming geophagic soil enlisting haemorrhage in mucosa of stomach, acanthosis, hyperkeratosis, koilocytic changes in the mucosa of the oesophagus. Other problem includes alteration of growth rate and demineralization of the femur bone. Moreover, some neural problems also have been identified, such as, anxiogenic potentials and cerebral cortical alteration (Ekong*et*.al.2015).

Consumption of geophagic soil causes severe Iron deficiency within body. Anemia is one of the consequences along with hypogonadism, and hepatosplenomegaly. Research enlightened that the ion exchange capacity of the geophagic soil prevents the absorption of Iron thus it causes Iron deficiency. Not only Iron but also Zinc and Potassium are prevented from absorption by ion exchange capacity of the clay (Loveland, Furst, Lauritzen. 1989).

In case of geophagic soil, an important point must be noted the coarse particle size of the soil and pH fluctuation of the gastrointestinal tract have the deleterious effect in the body (Ngole-Jeme and Ekosse, 2015).

This study is focused on the detection of the trace elements and heavy metals of the geophagic soil with their existing concentration which in usual case, get directly consumed by the pregnant or postpartum women. Moreover, mineralogical study of the Calabash chalk is coupled with the discussion of the possible health implications. On the basis of the fact of gastrointestinal environment, the study shows about the determination of pH status of the gastrointestinal tract.

1.1. Gyophagic soils' Contribution at Extreme Dearth of Food:

During wandering, (Laufer, 1930) observed and delineated Chinese and Eskimo's statements that gyophagic soil was considered as paramount food item during famine by the famine experienced people in the early history. The fact pointed an important corner that was predicted by the people. The interesting point was about the geophagic soil that might put its' role to diminish gastric juice secretion thus reducing urge of eating. During the period of famine, penury overshadowed the whole particular territory that kindled malnutrition of people. Thus substandard diet comprised practice of consuming soil (Loveland, Furst, Lauritzen. 1989).

1.2. Savior in Destitution:

Impoverishment of the specific population is a vital question because their nutrition level is not being up to the mark. Due to not taking proper nutritional diet, they become malnourished over the time. The poverty stricken people cannot spend money extravagantly to upgrade their food habits. This phenomenon engenders an intense craving among people to consume geophagic soil because their orthodox belief of having higher nutritional value of the soil convinces them to do.

1.3. Religious and Cultural Behavior to Geophagic Soil Consumption:

Soil consumption is vehemently embraced with people's religious belief.

Hunter and DeKline (1984) depicted about a famous priest of a church in Esquipulas in the period of Spanish colony. He was praised for his work as he used to make small tablets from pica or geophagic soil. These tablets were dry in its formation and were possessing enormous healing features (Loveland, Furst, Lauritzen; 1989).

According to the healer, the soil's healing features suggested mitigation of several diseases including stomach ache, cardiac problems, ophthalmic disease. The foremost healing attributes were to assuage menstruation problems and pregnancy complications.

Consumption practice promulgated worldwide by giving evidence of an ardent acceptance by people. Eventually, several doctrinal and ecclesiastical activities started to involve the usage of geophagic soil. Countries like India, China were sanguine to use geophagic soil in religious activities (Loveland, Furst, Lauritzen; 1989).

In the context of social aspects of clay eating, researchers were astounded by observing some less important facts. Tuskegee, Alabama, Edwards et al. (1959:811) reported their findings those were extricated from women and children food intake behavior. The finding depicted that some women had tendency to consume soil before or after taking daily meals. Quantity of intake soil ranged from 6 to 130 grams. According to the urge of having the soil for consumption, geophagic soil was mentioned as "A Women's Dish"(Loveland, Furst, Lauritzen; 1989).

Many researchers described that some women were consciously and enthusiastically consuming the geophagic soil embraced with a firm belief of producing fair skin tone of their offspring. Woywodt and Kiss (2000) delineated South African women's belief that they thought their beauty would be augmented if they consumed geophagicsoil (Zakari, 2015).

1.4. Irreproachable Health Related Features of Geophagic Soil:

The chemical and mineral study of geophagic soil revealed that it comprises keopectate which remarkably shows anti-diarrheal property. Main formulation of keopectate includes Kaoline and bentonite, pectin, citric acid, methylparabene, sorbic acid, sucrose, flavoring agents and purified water. It fights against diarrhea, dysentery. Paradoxically, in Philippine and Java, geophagic soil was used to treat constipation.

Earth eating was intensely exalted by medieval Muslim physicians and pharmacologists for geophagic soil's function to restrict vomiting and nausea.

Wilson (2003) illustrated that geophagic clay is alkaline in nature that produces the inhibiting power of acidity. This property of the soil naturally plays important role in pregnancy as it diminishes heartburn and nausea (Zakari, 2015).

The soil's nutrients accumulate multiple micronutrients that endanger the circulating pathogens and toxic chemicals in the blood stream (Zakari, 2015). China clay was believed to be treating agent against dropsy and jaundice (Loveland, Furst, Lauritzen. 1989). Many parasites struggled in the stomach to survive due to presence of the clay (Zakari, 2015).

1.5. Deplorable Health Related Features of Geophagic Soil:

Earth eating can produce hookworm infestation that might cause anemia (Loveland, Furst, Lauritzen. 1989). Many researchers enlisted its' atrocious impacts on health, such as, dilation of stomach and intestine, helminthiasis, emaciation, cachexy (malnutrition).

Clay eating normally causes facial edema, distended abdomen, painful joints.

Furthermore, geophagic soil tends not to be absorbed properly in the intestine. Due to malabsorption, body experiences malnutrition, emaciation, anemia, distention of stomach etc (Loveland, Furst, Lauritzen. 1989).There are no doubts that the negative impacts of calabash chalk may cause fatal consequences.

1.5.1. Being Insidious for Occurring Iron Deficiency and Anemia:

Worldwide research of earth eating revealed that consumption of the clay causes iron deficiency thus making women anemic. Halsted observed a study that was done with seven Iranian children. They were practicing clay consumption. Afterward, the observation study revealed that all the children were suffering from anemia, hypogonadism, hepatosplenomegaly.

This phenomenon is occurred due to Ion Exchange Capacity that was responsible to alter absorption of Iron and other minerals. The author mentioned this fact as alarming that it might allow parasitic accumulation that also could engender anemia. Paramount parasitic accumulations are named as *Ascarislumbricoides* (roundworms) *Trichuristrichuria* (whipworm) *Toxocaraspp,* (hookworm) (Zakari, 2015).

The study also associated that children under observation were experiencing growth retardation because they possessed lower level of Iron (Fe) and Zinc (Zn) in the body (Loveland, Furst,

Lauritzen. 1989).Soil consumption is also responsible for delayed maturity, liver and spleen enlargement (Zakari,2015).

1.5.2. Zinc Malabsorption and Growth Retardation:

Zinc is the vital element existing within the body and this element holds foremost responsibilities in physiological activities. Zinc is the part of twenty four enzymes which function for carbohydrate, protein and fat metabolism. In human body, growth is intensely depended on zinc (Zn).

Halsted et al. (1972) observed and verified from a study of Iranian children who deliberately consumed geophagic soil and extracted information related to Zinc (Zn) deficiency. The group of children who practiced eating clay possessed lower Zinc (Zn) level in their body. This made a deplorable consequence which is growth retardation. On the contrary, geophagia implies to high calcium intake. The fact is consisting of important notion because the Calcium in higher amount is obstreperous for Zinc absorption. Excessive amount of copper (Cu) in the body also plays similar role for Zinc (Zn) absorption (Loveland, Furst, Lauritzen. 1989).

1.5.3. Source of Appalling Heavy Metals and Minerals:

Various heavy metals were mentioned in the study and analysis of geophagic soil. These heavy metals include Arsenic (As), Lead (Pb), Cadmium (Cd) and they are prone to make toxicity if they get accumulated in the body beyond recommended value. Potassium (K) absorption gets increased due to altered Cation exchange capacity thus occurs egregious effect called hypokalemia or hyperkalemia (Ghorbani, 2008).

1.5.4. The Nature of Geophagic Soil in Intestinal Tract:

In the intestine, geophagic soil ingestion causes alteration of peristalsis. Natural process of intestinal peristalsis often is obstructed. This immutable nature in intestinal peristalsis allows cadmium (Cd) to irritate the lining of intestine due to malabsorption. Paradox version of statement implies that impaired peristalsis causes increased Iron (Fe) absorption.

Hunter (1973:189) depicted that limited consumption of the geophagic soil gives good results to treat gastrointestinal problems but excessive ingestion causes constipation.

1.6. Ion Exchange Capacity of Geophagic Soil in Gastrointestinal Milieu:

The ingestion of geophagic soil produces an obscure fact called Ion Exchange characteristics within the gastrointestinal tract and certainly this inference can make a clear view of soil ingestion consequence (Loveland, Furst, Lauritzen. 1989). The composition of geophagic soil suggests that the soil is organomineralic. Several organic compounds are existing in the soil composition abundantly.

Table 1.1. Function of geophagia in selected cultures

Location	Comment
Famine	
China	Day and earth eating mentioned in legends and myths about famine
Germany	During Thirty Years War
United State	Indians along central coast of Texas
South America	Otomac tribe along Orinoco River subsisted almost entirely on clay during rainy season
South America	Indians along Rio de la Hacha ate clay to suppress the appetite while stimulating the gastric juices
United States	Blacks—hunger and malnutrition (diet limited to com)
North America	Eskimo and Athabascans—famine food
Detoxification	
United States	Southwestern Indians used clay to detoxify plants that may haveserved primarily as famine foods
United States	Hopi ate clay with wild potatoes and berries
United States	Navaho Indians mixed rhyolitc tuff with potatoes to prevent poisoning
United States	Zuni, Oraibi, Apache & Moqui
South America	Ancient and recent Peruvian and Bolivian populations cooked clay with potatoes
United States	Porno Indians of California added clay to acorn meal to neutralize tannic acid in acorns
Japan	Ainu boiled bulbs of Corydalis ambigua with clay to remove bitter flavor
North America	Eskimo legends tied geophagia to times of famine
Food Items	
Ghana	Ewe tribe molded clay into egg shape for use as a food item
Africa	Earth mixed with bean or green leaf relish was frequently eaten by all family members, often as a famine food
United States	Indians along the lower Rio Grande mixed earth with ground mesquitc beans to sweeten them
Peru	Mixed with crushed coca leaves, used by Indian messengers

United States	Navaho mixed with berries *of Lyciumtorreyi*to sweeten them
United States	Porno mixed red clay with a corn meal to make a dark bread they considered superior to acorn bread
South America	Earth fried in fish grease was favorite food of Timbu
Pleasure	
Northeastern Siberia	Siberian tribesman considered earth a delicacy
South America	Otomac children given lumps of clay to suck as a pacifier
United States	Catawba and Pamunkcy potters ingested small amounts of clay while working because h tasted good
India	Men of the mountain tribes of Travancore ate white-ants nests mixed with honey as a delicacy
Siberia	Broth served by Gilyak tribesmen to their guests consisted of white clay, fishskins, seals fat, berries, rice, and minced fish
Medical Association	
China	Cures dropsy, cleans the eyes, and heals jaundice
Northeastern Siberia	Cure for indigestion, diarrhea, and dysentery
Australia	Aborigines consumed clay to relieve diarrhea and dysentery
Philippines, New Guinea	Cure constipation
Southeast Asia	Used by men as a tonic
Greece (Lemnos)	Variety of illnesses
Europe	Variety of illnesses until 19th century
Mideast	Muslim physicians and pharmacologists attributed medicinal benefits to more than 45 varieties of clay Clays of Nishabur used to control nausea and vomiting
Germany	Treat poisoning
United States	Virginia Indians ate clay to cure stomach aches
Guatemala (later diffusion into Mexico and New Mexico)	Chora Indians manufactured small clay cakes believed beneficial for stomach, heart, and eye diseases, menstrual difficulties, problems of pregnancy and childbirth (tablets blessed by Roman Catholic priests)
United States	Syndrome Cachexia Africana. generally associated with blacks,

	characterized by severe anemia and hypokalemia
United States	Blacks—desire to make oneself ill (especially during the slave period)
United States Alabama	Clay consumed to relieve stress
Java	Used by men and women to check obesity
Java	Used as a remedy for syphilis and beriberi
Siberia	Clay cakes eaten to alleviate stomach troubles, including diarrhea
United States	Hookworm infestation among blacks
Indochina	Dilation of stomach and intestines, parasite infestation, emaciation, and cachexy
India	Facial edema, distended abdomens, and enlarged painful joints
Africa	Sundi who consume too much clay will have swollen joints
Africa	Pale bair and complexion, paralysis, leprosy, and bladder stones
Pregnancy	
Southeast Asia	Ensure health of mother and child
India	All social classes
Torres Straits	Insure babies would have light skins
Mexico	Mexican women forbidden to cat clay during pregnancy
United States	White Mountain Apache ate red burned earth from beneath a firepit to prevent pregnancy
United States	Blacks ingested clay to relieve nausea and to insure child wouldn't be marked
United States Alabama	Relieved nausea and vomiting during pregnancy; helped babies; relieved dizziness; helped a weak stomach; cured swollen legs; relieved headaches
United States Alamaba	Anti-clay eating superstitions: (a) cause hard delivery (b) kill the woman (c) cause constipation (d) dry up the blood (e) cause child to lump up (0 cause jaundice, dropsy, rumors, or gas
Java	Eaten because women believed the fetus was fond of it; Geophagia insured trouble-free delivery
Siberia	Sungar tribesmen believed consumption of earth

	gathered during earthquakes would expedite birth and expulsion of afterbirth
Religion	
China	Taoist religious activities
India	linked to some religious sects
Mexico	Used in ceremony in honor of Tezcalipoca
Guatemala	Tablets blessed by Roman Catholic priests used for medicinal purposes
Malaya	Consumption of earth during religious ordeals
Java, Floras, and Timor	Earth eaten while swearing an oath of innocence
India	Clay used at me end of the day's religious activities by members of the Vaishnava Sect
Miscellaneous	
United States	Associated with blacks of low economic status
United States	Found among blacks with family history of geophagia
United States	Pan of the African heritage of blacks
Spain and Portugal	Consumption of clay believed to improve the complexion
United States	Used by ghetto residents to satisfy oral needs and to relieve behavioral disorders

Source: Loveland, Furst, Lauritzen. 1989

1.7 Analytical perspective of calabash chalk:

First and foremost, one very important point is to be noted about the elemental analysis of soil includes which analytical method should be followed for accurate analysis. Most of the researchers had developed the analytical methodology by using atomic absorption, atomic emission and mass spectroscopy with the intention of analyze elements. Among the variety of accepted methodology, four most important instruments met the acclaim in the area of elemental analysis. Instruments those are enlisted are Flame Atomic Absorption Spectroscopy (FAAS), Graphite Furnace Atomic Absorption Spectroscopy (GFAAS), Inductively Coupled Plasma Optical emission Spectroscopy (ICP-OES), Inductively Coupled Plasma Mass Spectroscopy. All the researchers always try to find the best instrument to which their developed methodology for detecting element in any source can maintain congruency. Selecting the best instrument is highly depended on other factors (World leader In AA, ICP-OES and ICP-MS, n.d.)

Analytical instruments must possess sufficient detection limit. Without the specific characteristic the instrument might not be eligible and efficient to detect elements properly. Furthermore this inadequacy often suggests a long term sample solution preparation or digestion prior to the actual analysis. All the world-wide accepted analytical instruments have their eccentric detection-limit range that might help researchers to choose their priorities.

Analytical working range is regarded as another important factor advocates the fact of concentration range that along with the quantitative is easily handed over the researchers without having a recalibration procedure (World leader In AA, ICP-OES and ICP-MS, n.d.)

Sample throughput is one of the exacting features for measuring instruments' efficiency. The main idea about sample throughput can be extrapolated from the definition. The number of elements that can be analyzed per unit of time is the dedicated definition of the sample throughput. Higher level of sample throughput is responsible for making the analysis less time consuming with greater level of precision. FAAS is holding greater level of sample throughput with large number of samples and specific as well as limited number of elements. This instrument efficiently determines the element within 3-10 seconds. Element detection requires individual element specific light sources and flame gases. GFAAS considerably holds low sample throughput that may work for elemental detection with a time of 2-3 minutes. ICP-OES is greatly expedient with the higher and exceptional level of sample throughput. It has efficiency of detecting abundant amount elements includes at least 73 elements and those are being analyzed

individually within 15-30 seconds. The working facilities and the limitations of ICP-MS are almost maintaining congruency to the ICP-OES.

All the instruments, according to their complex handling procedure are being handled by proportional cost. When the instrument is relatively less convoluted at time of handling it (single element determination), generally are performed at lower cost. Conversely, relatively more convoluted process providing instruments are highly dedicated to high cost. An efficient instrument comprising the features including high precision, higher sample throughput, automation are prone to be costly.

This is an obvious matter of having several aptitudes and shortcomings of the instruments those are being used worldwide. From all the corners, the feedbacks about several aptitudes and shortcomings are now completely becoming lucid (World leader In AA, ICP-OES and ICP-MS, n.d.)

Aptitudes and shortcomings of FAAS:

Strength:

- FAAS had met extraordinary acclaim from researchers because this instrument is very easy to handle. Generally this handling process doesn't include any convoluted step that might ruin the detection in the further stage of procedure.
- The procedure guideline is much more user friendly and enthusiastically provides sweeping and exhaustive informations.
- The using of the instrument is mostly cost-effective.
- This instrument has extraordinary capability to detect limited elements with large number of samples.

Limitations:

- The instrument possesses lower sensitivity.
- Process is not demonstrated as automated. In such condition, for avoiding unacceptable occurrence this is highly recommended for the instrument to be handled continuously by one attendant.
- The capacity of the instrument is single-element detection.

Aptitudes and Shortcomings of GFAAS:

Strength:

- This instrument possesses detection limit that is considered as an exceptional.
- The procedure guideline is lucid.
- Instrument is more or less automated.

Limitations:

- Analytical working range is not being considered as feasible because the range is less in comparison to other instruments.
- In the technique of this instrument, sample throughput is not in satisfactory level.

Aptitudes and Shortcomings of ICP-OES:

Strength:

- This instrument is considered as multi-element technique through which over 73 elements are being detected with moderate large number of samples.
- It provides preeminent analytical working range and sample throughput.
- Handing process is not convoluted at all.

Limitations:

- This instrument handling involves higher investment of money.

Aptitudes and Shortcomings of ICP-MS:

Strength:

- This instrument is dedicated not only to the detection of elements but also highly efficient to conduct isotopic analysis of the elements.
- The procedure guideline documented all the fact about interferences and tried to show compensating pathway to avoid the problems associated with it.
- Detection limit is almost congruent to GFAAS.

Limitations:

- This methodology is superlative costly.

Methodology developed for element detection is very complex to be performed (World leader In AA, ICP-OES and ICP-MS, n.d.).

Among all the putative instruments those are supposed to be used for conduction the elemental detection study, FAAS was the most convenient one to detect limited numbers of elements. The methodology that is being developed might be seemed as protracted but this one gives proximity of the accuracy. Furthermore it proscribes the high investment for study conduction.

Aim: The aim of the study is to evaluate the clay by chemical analysis.

Objectives: The main objectives are:

a) To evaluate heavy metals in the calabash chalk.

b) To evaluate trace elements in the soil.

Chapter 2

Methodology for Sample Analysis

Methods of soil analysis:

2.1. Sample collection:

Calabash chalk soil sample in dried form and cube shape were purchased from local market in Sylhet, the region of Bangladesh. The dried soil is sold in particular territory that has to experience the commercial treatment from ultimate raw form of calabash chalk.

2.2. Instrumentation:

Microwave digestion system and flame atomic absorption spectroscopy were consolidated to analyze the geophagic soil. The process of analysis provided pivotal requirements to use those delicate instruments.

2.2.1. Microwave digestion system:

Microwave digestion system corroborates the essential and efficient sample preparation. This process requires for using various reagents that makes an ideal sample preparation for analysis in the spectroscopy (Kingston, 1997).

2.2.2. Flame Atomic Absorption Spectroscopy:

Soil elemental analysis is beholden to Flame Atomic Absorption Spectroscopy that is exquisite to perform analysis of samples by distinctly absorbed radiation. This process is dedicated to provoke excited radiation in the presence of produced spectra (García, 2012).

2.3. Reagents:

a) 0.9973 gm calabash chalk soil

b) 10 mL nitric acid which is in concentratedform.

c) 5 mL per chloric acid.

d) Distilled water.

2.4.1 Sample digestion:

Procedure:

Soil sample is required to be weighed for experiencing successful digestion process. The entailed soil sample must be commensurate to the method of digestion. In consequence, 0.9973 gm of soil sample was accurately measured by the electronic weight balance. The further step was dedicated to adjoin 10 mL Nitric Acid to the weighed sample soil as well as to amalgamate them prior to heating. The vessel containing mixture was placed in an exacting manner within the digestion chamber to comprehend vehement purpose of soil microwave digestion. Forward step circumscribed heating of mixture at 70° C for 2~3 hours. Once the desired time and temperature have reached to the exact point, the mixture was left in room temperature at 23°C for half an hour. Next step demanded for supplementation of 5 ml per chloric acid and further heating for acid digestion. This emerged a paste formation of the mixture where addition of 10 ml of distilled water let diminishing temperature of the paste. Filtration of the paste allowed making volume up to 25 ml with distilled water.

2.4.2. Calibration Curve Method of Standard Preparation:

a) Standard Solution Preparation:

Standard solutions of the elements those were supposed to be determined were carefully made up with different concentrations (2, 4, 6, 10, 12 ppm). In the context of making standard solution, at least five concentrations containing solutions were guided to be prepared. In the next step, absorbance measurement is the demanding stage to be accomplished. After the measurement of absorbance, all the accumulated data were used to make the calibration curve. The required equation for measuring the desired elemental concentration is given below:

$$\mathbf{Y = mx + c}$$

Sample analysis through Flame AAS:

Sample analysis:

Manganese, Copper, Zinc, Iron, Chromium, Lead, Cadmium:

Flame Atomic Absorption Spectrophotometer is one of the best instruments under Atomic Absorption Spectroscopy that hinders to give any unwanted inter-element spectral interferences. The condition of analytical milieu has to be under the proper supervision for this instrument otherwise the negligence may engender ionization interference.

Some crucial aspects should be noted in case of choosing Flame AAS including:

a)Atomization process for using gas or liquid solution. Even in some cases solid is applicable.

b)Laminar Air Flow burner should be under supervision that includes flame generally.

c)Instrument reproducibility should be less than 1% and this the fortune that Flame AAS contains the desired reproducibility.

d)It provides relatively insensitiveness (García, 2012).

Working Procedure:

All the elements of the samples those were supposed to be analyzed had to absorb characteristic wavelengths of lights. The main purpose was for conducting the analysis was to verify the presence of particular element in the soil. The main process criteria include the using of specific metal containing cathode lamp that is individually element specific. When the cathode lamp with specific metal emits light from excited metal atoms, Sample solution is inevitably being atomized and the vaporized sample is the only media through which the ground state free atom gets to be passed. In such process, some atoms of a specific elements existing in the atomized solution, are supposed to absorb electromagnetic radiation. It’s an obvious phenomenon that the amount of atoms present in the vaporized solution is directly proportional to the level of radiation was being absorbed (Atomic Absorption Spectroscopy, n.d.).

Light source:

Hollow Cathode Lamp:

The light source is made up of tungsten anode and cylindrical hollow cathode (made of to be detected element). These are embraced with an inert gas and successfully concealed within a glass tube.

Average Pressure:

Pressure was supposed to be maintained between 1 Nm–2 and 5 Nm–2.

Potential Difference:

Potential difference was maintained between 300-400 V and that was certainly performed between anode and cathode.

The four steps of this hollow cathode lamp includes Ionisation, Sputtering, Excitation and Emission were successfully performed (Atomic Absorption Spectroscopy, n.d.).

The Optical System and Detector:

In this section, every single light with specific wavelength was selected by monochromator. Furthermore, another job for monochromator was to exclude other wavelength during detecting of specific element (Atomic Absorption Spectroscopy, n.d.).

Flame Aspiration:

Flame aspiration was chosen for the atomization of the sample solution.

Arsenic: Flame Atomic Absorption Spectrophotometer with Hydride Vapor Generator (HVG)

Potassium : Flame Photometer.

Chapter 3

Result and Discussion

Result and discussion:

In the context of Calabash chalk element analysis, several trace elements and heavy metals were analyzed. Elemental analysis were done with only one prepared sample.

The list of trace elements those were analyzed included Potassium (K), Manganese (Mn), Copper (Cu), Zinc (Zn), Iron (Fe), Chromium (Cr). These six elements are considered as the major trace elements contributing disparate roles within the Human body.

Three heavy metals were considered to be anatomized encompassing Lead (Pb), Cadmium (Cd), Arsenic (As). These elements incline to make toxic level in the body if they get increased in amount.

Table 3.1: Analysis report on amount of certain trace elements and heavy metals in calabash chalk.:

Sample ID with details (as mentioned)	**Sl. No**	**Parameter**	**Result**
Soil Sample	01.	Potassium (K)	0.20%
	02.	Manganese (Mn)	37.17 ppm
	03.	Copper (Cu)	19.30 ppm
	04.	Zinc (Zn)	55.82 ppm
	05.	Iron (Fe)	2.53%
	06.	Chromium (Cr)	34.73 ppm
	07.	Lead (Pb)	19.26 ppm
	08.	Cadmium (Cd)	BDL*
	09.	Arsenic (As)	4.57 ppm

***BDL**= Below Detection Limit (Method Detection Limit: Cd= 0.10 ppm)

(Analytical report is being attached to Appendix)

At the stage of sample solution digestion, Nitric acid was introduced in the pretreatment of sample. The reason behind using this particular acid is to avoid the dangerous effect of using hot perchloric acid. Nitric acid was found to be less corrosive. From research, it was found that Nitric acid at a certain amount engenders a greater level of dissolution of the soil sample.

At the moment of lengthy soil digestion, the chances ware so great for the dissolved soil in nitric acid to be burned. So during the digestion period it was somewhat challenging to give stricture the woe for successful conduction of the study.

The most important factor was to consider the way of atomization of the sample. According to the correct developed methodology, if samples are introduced into the light path with idiosyncratic spectral line then it would be the best performance for analysis. In the conduction of the elemental study, flame aspiration was the way through which the sample solution was nebulized through a flexible capillary tube at the temperature of 2200–2400 °C. Though conducted atomization process is considered as less sensitive than electrothermal aspiration. Because electrothermal aspiration is the way in which greater level of sample atomization can be obtained. But in this case, the maintenance procedure in the graphite tube is somewhat considered as involved.

The beam splitter present in the FAAS instrument was extraordinarily sublime because it was dedicated to solve the problem of inconsistent light source intensity. When the inconsistency is being created during analysis, the result may not show the fidelity to be correct or accurate. So in this way one part of the beam was passing through sample and another part was through the reference. By following the particular way, the affliction related to the light source intensity got easily negated (Atomic Absorption Spectroscopy, n.d.).

Potassium (K) is one of the most important electrolytes in the body possessing several affluent responsibilities. In biological system, potassium is required in the amount of 4700 mg/day. A huge level of potassium can be obtained from geophagic soil also. The soil sample is possessing 0.20 % of potassium. For a salubrious physical condition, potassium is required to be supplied continuously within the biological system. If potassium level gets lowered, the condition is referred as hypokalemia. On the contrary, increased level of potassium is called hyperkalemia. Hypokalemia can cause the heart to beat irregularly, constipation, fatigue, muscle damage, muscle weakness and muscle paralysis. On the other hand, hyperkalemia causes slow heart beat, muscle weakness (Zakari, 2015)

Manganese (Mn) present in the soil sample was determined as 37.17 ppm. This value suggests safety limit in the context of consuming soil because Recommended Dietary Allowance (RDA) value ranges from 1.8-2.6 mg/day. University of Maryland Medical College implied an observation about the mechanism of manganese. The mechanism obtained creation of connective tissue, bone creation, blood-clotting factor creation, sex hormone creation, fat metabolism, calcium absorption and blood sugar regulation.

Copper is estimated as 19.30 ppm in the prepared soil sample. The recommended dietary allowance (RDA) value of copper ingestion ranges 1.5-03 mg/day. The toxicity of copper is not common but there are minimal possibilities to form toxicity due to excessive consumption of copper. It can be inferred, excessive soil consumption may cause a situation where Copper value in the body exceed the RDA value. Many detrimental effects can be occurred due to overabundance of Copper element including liver and kidney damage. Furthermore, Toxicity may engender neural dysfunction (WHO, 1993).

Zinc comprises a bunch of important roles to accomplish within human body. This essential trace element takes part in cell processing, growth mechanism, neuronal development, bone formations and so on. As Zinc is one of the most vital trace elements, this element is vehemently considered to be non-toxic. Zinc is recommended to intake daily basis according to Recommended Dietary Allowance range (Zakari, 2015). To avoid appalling physical conditions, Zinc consumption should not exceed 15 mg/Kg (WHO, 1993). Analyzed soil presented a significant amount of Zinc incorporated in sample and that is valued as 55.82 ppm. Soil consumption should be limited to avoid unwanted deterioration of physical condition. Ample

amount of Zinc in human body dedicatedly produces detrimental effects suggesting electrolyte imbalance, abdominal pain, dehydration, vomiting, nausea (Zakari, 2015). It was previously mentioned that Zinc absorption can be diminished with interference of other elements. Therefore purpose of getting nutrition by consumption becomes hampered (Loveland, Furst, Lauritzen; 1989).

The geophagic soil sample analysis enumerated the value of Iron as 2.53%. This value suggests the overabundance of Iron (Fe) in the soil. The foremost fact about Iron consumption is about RDA value that recommends 8 mg/day. Furthermore, the safety limit of iron intake suggests maximum 45 mg/day. Several study about clay consumption depicted Iron deficiency leading to anemia. This can be easily inferred that Iron malabsorption is very common due to Ion Exchange Capacity of the soil. This altered Iron absorption can cause anemia despite consuming ample amount of Iron from clay (Loveland, Furst, Lauritzen; 1989). Naturally, lower amount of Iron can cause atrocious effects enlisting anemia, myocardial infarction, gastrointestinal linfection(Hunt, 1994).

Chromium (Cr) is extolled as a paramount element for biological system. According to the soil sample analysis profile, the extricated value is 34.73 ppm. This value is not representing alarming condition in the context of consumption. However the RDA value is carrying significance to intake chromium cautiously. United States National Academy Science recommended the range of chromium consumption as 1-300 mg/Kg or 50-200 mcg (Watson, 1993). Excessive amount of soil ingestion is the vital reason for causing toxicity including egregious consequences. This may include some conditions as skin problem, gastrointestinal problem, hepatic and renal damage (Zakari 2015).

Lead is considered as prime egregious heavy metal whose minimal exposure to the biological system can make an issue of toxicity. The soil analysis report has revealed a shocking result of lead existence as the value is 19.26 ppm. This value is far beyond the accepted value of lead that can is allowed to be consumed. Suggested maximum value of lead consumption is 0.01 ppm or 3mg/week (WHO,1998).

Atrocious effects of lead exposure include colic, anemia, headache, chronic nephritis. Moreover, infants are prone to get neuronal damage and neuronal growth retardation (Zakari, 2015).

Arsenic (As) is another harmful heavy metal that possesses carcinogenic properties. The RDA value of eating Arsenic is 0.01 ppm. Safety limit of arsenic in soil ranges 5-20 ppm that will not make harmful effects for long period of time (Environmental Health Information, 2007).In case of soil analysis, arsenic level was within the acceptable range as value was 4.57 ppm. On the contrary, huge soil consumption can cause major toxicity and produce several complications such as risk of cancer of the skin, lungs, urinary bladder and possibly kidney, liver and prostrate **(**Zakari,2015).

Cadmium is considered as another significant heavy metal that was analyzed in soil sample. Unexpectedly, the cadmium level was determined as below detection level or 0.10 ppm Cadmium exposure in biological system can cause Iron and Zinc malabsorption. Thus it has responsibility in growth retardation (Loveland, Furst, Lauritzen. 1989).

Chapter 4

Conclusion

Conclusion:

Calabash Chalk soil has been analyzed and the congruent discussions were documented. The discussion chapter showed both conspicuously benevolent and malicious effects. According to the discussion, some discrepancies are not ambiguous anymore in the context of good or bad consequences. No research has proved the geophagic soil to be lethal. The study of amount of trace element and heavy metal in soil provided significantly important information. The fact of presence of lead (pb) in the increased amount helped to extract the deduction and prediction about the toxic result in the human body. On the other hand, amount of Cadmium and Arsenic didn't reflect any dangerous prediction that could give cursed effect in human body. Most importantly, this phenomenon never could pacify researchers. They always discouraged the fact of consumption of geophagic soil.

Future Research Plan:

In future, we have a plan to evaluate the effect of the soil *in vivo*. The eccentric study plan would be designed in such form that can fecund an accurate result about elemental fluctuation within human body. Furthermore this study would be enough helpful to both engender and consolidate the plausible discussion of benevolent and malevolent effects of the fluctuated elements that would be truly justified by the research.

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Appendix