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Full Length Research Paper

Analyses of geophagic materials consumed by pregnant women in Embu, Meru and Chuka towns in eastern province, Kenya

Gichumbi, J. Mwangi* and Ombaka Ochieng

Department of Basic Sciences, Chuka University College, Kenya.

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Geophagy is the deliberate consumption of soil and clay deposits by animals, including man. During pregnancy all the nourishment needed by the developing fetus comes from the mother, either the food she eats or the supplement she may take. The geochemical and mineralogical composition of the materials which are consumed by pregnant women from Meru, Embu and Chuka open air markets were studied. The geophagic materials were subjected to standard digestion procedures and analyzed for full assay and elemental analysis for Co, Zn, Mg, Cu, Pb and Cd using Atomic absorption spectrometry and Energy-dispersive x-ray fluorescence spectrometry in 30 geophagic samples. The mineralogical composition was investigated using X-ray diffractometry (XRD). The geochemical analysis revealed that the geophagic materials contain high levels of silica from 48.59 to 60.27%. Geophagic materials from Embu showed the highest concentration of Pb at 0.96 ppm. The levels of Pb in all samples exceeded the levels recommended by WHO/FAO limits of 0.01 ppm. The levels obtained for Cd in all the samples did not exceed the WHO/FAO limits of 0.003 ppm. The XRD data showed that the geophagic materials of the area consisted mainly of silica.

Key words: Geophagy, mineralogical, mineral nutrients, geochemical.

INTRODUCTION

Geophagy, the purposeful consumption of earth has long been a source of fascination and puzzlement. Geophagy is a specific type of pica, which is defined by the craving and subsequent consumption of non-food substances (Young et al., 2009).There are three major groups of hypotheses concerning the physiological causes of pica: hunger, micronutrients deficiency and protection from toxins and pathogens (Young et al., 2009). First the hunger hypothesis posits that people with micronutrient deficiencies eat non-food substances in an attempt to increase micronutrient intake of Fe, Zn or Ca (Wiley and Katz, 1998). Third the protection hypothesis states that pica is motivated by an attempt to mitigate the harmful effects of plant chemicals or microbes (Profet, 1992). It is proposed that pica substances protect either by adsorbing pathogens and toxins within the gut or lumen or by coating the surface of the intestinal endothelium thereby rendering it less permeable to toxins and pathogens (Simjee, 2007). Additionally, this hypothesis implies that pica substances would be ingested during periods of rapid growth i.e. the times of greatest need for protection from toxins and microbes e.g. during childhood and pregnancy are the periods when pica is likely to occur (Flaxman and Sherman, 2000; Fessler, 2002).

Nutrients for the fetus come from the mother's diet, stored nutrients in the mother's bones and tissues and synthesis of certain nutrients in the placenta. Sometimes, a mother to be requires vitamin or mineral supplements especially iron, calcium and folate while some women require vitamin D (Willis, 1990).

Iron is important in the body, as it is the main components of hemoglobin which carries oxygen through the body. Pregnant women should eat iron-rich foods to prevent iron deficiency. Calcium is essential for maintaining the bone integrity of a pregnant women and providing skeletal development of the fetus. Magnesium

*Corresponding author. E-mail: jsmwangi2003@yahoo.co.uk.

is also an essential mineral and is needed for bone, protein and fatty acid formation, making new cells, activating B Vitamins and forming ATP (Njoki and Kiprono, 2009).

In Kenya, previous study on Geophagy among school going children and pregnant women in Western Kenya have been described by Gessler et al. (1997). They found out that over 70% of a sample of school going children in Nyanza province was found to consume soil at an average rate of approximately 30 mg daily. The eaten soils were mainly from termite nests, weathered stones and walls of huts but no mineralogical data was provided. This study aims at establishing both geochemical and mineralogical data of geophagic materials from Eastern province, where geophagy exists but no meaningful study have been done.

This study is aimed at establishing the mineral nutrients content and the amount of heavy metals lead and cadmium in the geophagic materials consumed by pregnant women in three towns in Eastern province; Embu, Chuka and Meru, Kenya. Thus, this study is important in reference to previous studies in that no study has been carried in this areas aimed at establishing the safety of these materials for human consumption.

MATERIALS AND METHODS

Sampling site and Sample collection

Eastern Province Kenya was chosen as an appropriate research site due to the prevalence of geophagic behavior among pregnant women. The geophagic sample materials were collected from open air markets at Embu, Chuka and Meru towns. The town of Embu is 300 Km East of Nairobi, while Chuka and Meru are 338 and 360 km respectively. The geophagic materials from open air markets are commonly sold in accordance with the purchasing power of the consumers. The 30 samples picked from each sampling site were classified as A, B and C depending on Physical appearance. Samples classified as A were Dark grayish brown, B were light brownish grey, and while those classified C were pale brown with some pinkish patches.

Sample analyses

Determination of both the major and minor elements in geophagic samples was done by Energy dispersive X-ray fluorescence spectroscopy (XRF) using PANalytical Minipal QC model and Atomic absorption spectrometry (using 210 VGP AAS model). These are methods of choice for inorganic materials because the instrumentation is widely available and has become the standard method for the analysis of major and trace elements of rocks. XRF analysis was performed on pressed-powder disks and involves no pretreatment other than simple crushing and milling procedure. The mineralogy of the geophagic materials was determined by PANalytical X'celerator x-ray diffractometer (XRD) model.

Apparatus and reagents

Digestion block and digestion tubes, Filter papers, Analytical balance, small bottles for holding the digested samples were used. All reagents were analytical grade and these were standardized for respective metals. The reagents for digestion procedure were standardized.

Sample preparation and pretreatment

The samples were dried in an oven at 105°C and then placed in a dessicator to cool and then weighed. This process was repeated 4 times until the materials were of constant weight. The material was finally ground to uniform thickness.

Sample digestion

Sample solution for major oxides

A 0.100 g of dried and ground sample was weighed and transferred into 125 ml plastic container. A 1 ml aqua regia and 3 ml of HF were then added and left for at least 10 h for cold digestion to take place. Thereafter, 50 ml of a saturated Boric acid was added to the plastic container having cold digested sample solution and left for one hour. De-ionized double distilled water was used to top the solution to 100 ml (Okalebo et al., 2002).

Sample solution preparation for minor elements

0.100 g of finely ground soil sample was weighed into a platinum or Teflon crucible and moistened with a little water. 1 ml 60% $HClO_4$ and 40% HF was then added. The crucible was covered with a lid and digested slowly for 2 h and allowed to cool. The contents were then evaporated until dilute fumes of perchloric acid appeared. Thereafter, 1 ml of H_2SO_4 was added and the contents heated to drive off $HClO_4$ leaving H_2SO_4 and the mixture allowed to cool. The contents were then diluted and filtered into a 100 ml volumetric flask and diluted to 100 ml volume. The blank was also prepared in the same way.

Standard procedures for the preparation of stock solutions (1000 ppm) for Na, Ca, Fe, Zn, Mg, Pb and Cd were employed. The standard stock solutions were used to prepare serial solutions for the determination of these elements in the samples using AAS.

RESULTS AND DISCUSSION

Major elements

The results for the elemental oxides represent a mean value for samples having the same physical appearance. Table 1 shows that geophagic samples from Chuka town were the most siliceous where total silica content ranged from 56.61 to 60.00%. These samples also contained high levels of alumina and ferric oxide.

However the values of alumina and ferric oxide were highest in the samples from Embu with values ranging from 18.1 to 20.20% and 7.56 to 14.08% respectively. The values for alkaline and alkaline earths were variable among the three towns. Magnesium and manganese oxide had the lowest values in the samples from the three towns. The most iron-rich samples of the three were those obtained from Embu with values ranging from 7.56 to 14.08%.

Table 1. Bulk chemical (major element) analyses in geophagic samples from Chuka, Meru and Embu open air markets.

Sample No	Chuka			Meru			Embu		
	2973A	2973B	2973C	2975A	2975B	2975C	2977A	2977B	2977C
SiO_2	56.61	60	59.62	53.73	53.37	52.98	48.59	60.27	59.74
Al_2O_3	17.4	17.4	17.6	14.8	18.4	17.41	20	20.2	18.1
CaO	0.82	0.78	0.67	0.74	0.61	0.62	0.6	0.51	0.54
MgO	nil	0.08	0.17	0.42	0.31	0.28	0.55	0.2	0.18
Na_2O	3.02	2.02	1.55	2.44	0.71	3	1.02	0.85	1.55
K_2O	2.95	2	1.8	2.92	0.35	0.29	0.75	0.35	1.82
TiO_2	1.36	1.45	1.87	1.48	1.23	1.5	1.34	1.9	1.93
MnO	0.14	0.15	0.12	0.22	0.14	1.13	0.17	0.11	0.11
Fe_2O_3	9.38	8.4	7.7	9.92	11.82	10.75	14.08	10.36	7.56
LOI	7.44	6.52	8.46	8.84	10.71	9.85	10.94	6.94	9.1

Table 2. Average trace chemical (Minor element) analyses in geophagic samples from Chuka, Meru and Embu open air markets in ppm.

Elements	Zn		Co		Cu		Pb		Cd	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Chuka	0.95	±0.06	0.09	±0.03	0.18	± 0.09	0.14	±0.024	0.01	±0.005
Embu	0.75	±0.05	0.07	±0.02	0.02	±0.07	0.96	±0.034	0.01	±0.007
Meru	0.65	±0.051	0.12	±0.043	0.01	± 0.039	0.42	±0.021	0.01	±0.007

$\bar{x}$=mean SE=Standard error

Trace elements analyses

Trace elements analyzed were Zn, Co, Cu, Pb and Cd as shown in Table 2. The results were obtained from both XRF and AAS data. The XRF data was used as preliminary investigation and the qualitative analysis was done using AAS.

The level of zinc in the geophagic rocks was highest in Chuka with 0.95 ppm and lowest in Meru with 0.65 ppm. The levels were low as compared to those reported in literature (Young et al., 2010). The levels of cobalt, copper, lead and cadmium was lower than the values found for mineral soils as assessed by Mitchell (1964). The amount of Pb in all the samples did not exceed the recommended EPA (Environmental Protection Agency) standard levels of about 400 ppm by weight and 1200 ppm for non-play areas (ATSDR, 2007). But the levels of Pb exceeded the levels recommended by WHO/FAO limits of 0.01 ppm (WHO, 1995). The levels obtained for Cd in all the samples did not exceed the WHO/FAO limits of 0.003 ppm (WHO, 1992).

The materials were found not to be safe according to WHO/FAO limits of the levels of Pb and thus their consumption should be discouraged

Mineralogy data

The mineralogy data were obtained from a PAN analyical X-Pert X'celerator diffractometer. The mineral analyses were reasonably consistent with the results of bulk chemical analyses (Table 3). Geophagic samples from the three open air markets were silica rich; the most dominant silica was quartz (Table 1). The major clay fraction was kaolinite which was common in all the three samples.

The presence of kaolin mineral agree with the protection hypothesis (Young et al., 2009), given that kaolin minerals have long been used in pharmaceutical formulations to treat the causes and the symptoms of gastrointestinal distress (Gonzalez et al., 2004). Potassium tecto-alumosilicate and Sanidine were other major phases present in all the samples. A representative sample of the XRD spectra obtained is shown in Figure 1.

Conclusion

The present study has shown that the geophagic materials from the three open air markets consist mainly of silica and alumina. The presence of Fe and other related cations may be a source of Fe supplement. The levels of Pb exceeded the levels recommended by WHO/FAO limits of 0.01 ppm but the levels obtained for Cd in all the samples did not exceed the WHO/FAO limits of 0.003 ppm. Mineralogical studies show that the clay minerals present in the geophagic materials was dominated by kaolin type minerals.

Table 3. Full pattern fitting analyses (wt %) of geophagic soils.

Mineralogy	Chuka			Meru			Embu		
	A	B	C	A	B	C	A	B	C
Quartz(SiO_2)	72.0	68.0	76.0	67.0	70.0	71.0	60.0	73.0	74.0
Tecto-aluminosilicate	8.0	7.0	5.0	4.0	7.0	3.0	4.0	5.0	3.0
sanidine	2.0	1.0	2.0	4.0	1.0	0.9	0.8	0.4	3.0
calcite	0.1	0.2	0.5	0.3	0.1	0.2	0.1	0.5	0.4
goethite	0.0	0.0	0.0	0.1	0.3	0.4	0.1	0.2	0.10
hematite	0.1	0.6	1.0	0.0	0.0	0.0	0.0	0.0	0.1
kaolinite	15.6	20.1	14.0	21.0	23.0	23.9	30.9	20.1	18.9
halloysite	0.8	0.9	0.3	0.4	0.6	0.1	0.5	0.1	0.4

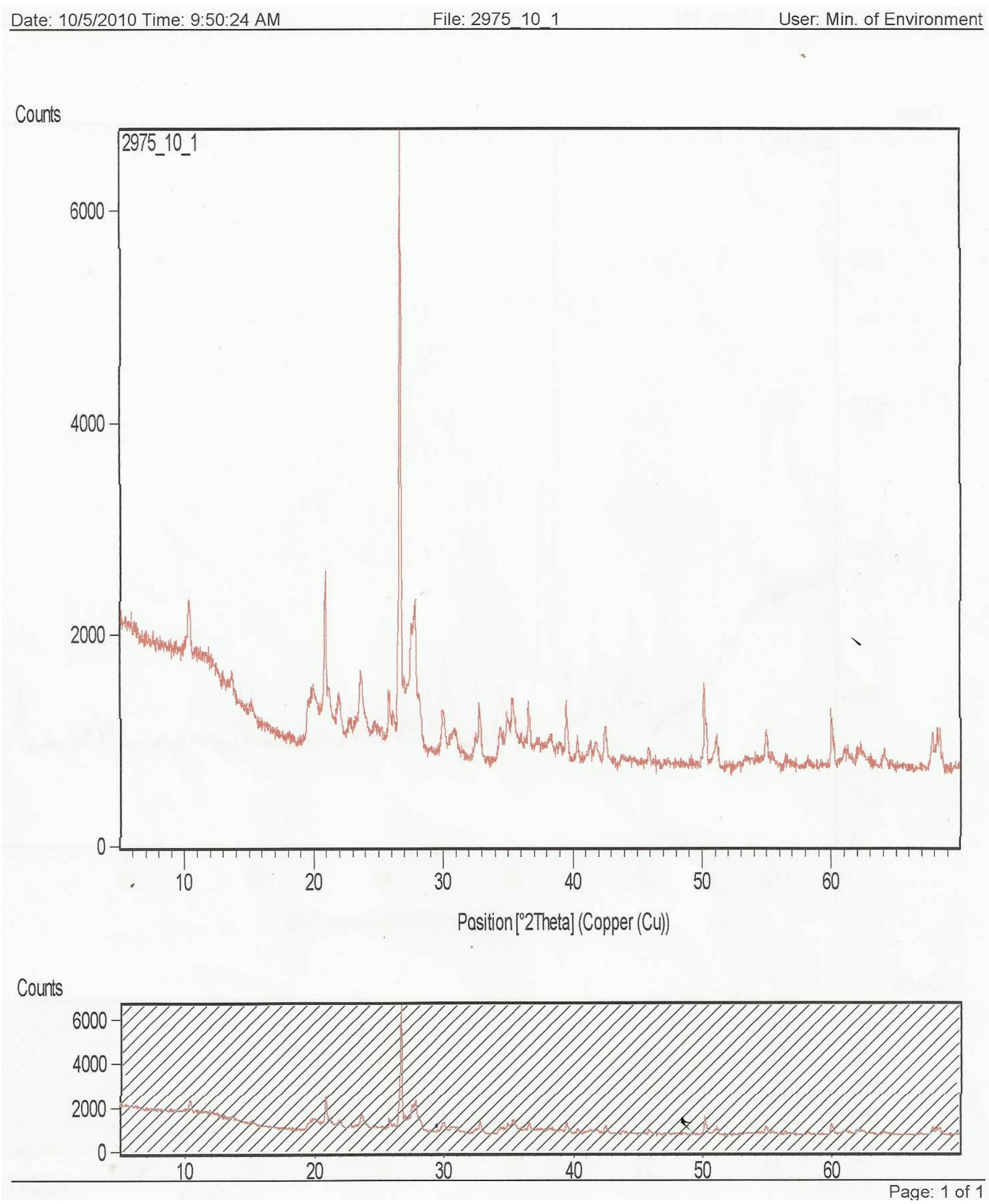

Figure 1. XRD spectra for a sample obtained from Meru town

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