

Short Communication

RISKS ASSOCIATED WITH GEOPHAGIA IN GHANA

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ABSTRACT

An investigation was conducted to determine the risks associated with the ingestion of some geophagy clays mined in Ghana, Nigeria and Cote d'ivoire. These clays are widely distributed through major marketing centres in Ghana and within the West African sub-region. Samples of the geophagy clays were purchased from selected markets in the Greater Accra region and then subjected to X-ray fluorescence analysis to determine the levels of heavy metals present in them and their potential effects on consumers. The results indicate that the levels of arsenic, cadmium, mercury, lead and cobalt contained in 70g of the geophagy clay were far higher than the WHO/FAO and USDA approved maximum daily tolerable intake. This was interpreted to mean that consumers were at risk of heavy metal contamination which could lead to various diseases. The extent of bioavailability of these toxic elements to consumers of the clay was however not established. It was concluded that geophagy clay sold on Ghanaian markets could have potentially negative health impact on consumers if consumed at 70g per day or more and on regular basis.

Keywords: Harmful, heavy metals, geophagy, clay.

INTRODUCTION

The mining and selling of geophagy clay is an important livelihood in the West African sub-region. Clay from Ghana, particularly obtained from Anfoega in the Volta Region, is sold for direct consumption in all parts of Ghana and in some West Africa countries, for either medicinal or cultural purposes and for pleasure (Vermeer, 1971). Other sub-Saharan states including Nigeria also produce and distribute geophagy clay for sale in markets in the West Africa sub-region (Hunter, 1973).

The consumption of clay is a common practice especially among women and is often associated with pregnancy, poverty and famine (Woywodt and Kiss, 2002; Al-Rmali *et al.*, 2010). In Ghana 28% of women of reproductive age who practice geophagy consume a daily average of 70g of clay (Tayie *et al.*, 2013). Eating of clay and or soil as a habit was observed to be less frequent in boys than in girls. Geophagy in boys decreases with age (Bisi-Johnson *et al.*, 2010). Geophagia has been shown to be prevalent among females in the teenage bracket and that by educating these females geophagia and its consequences can be reduced (Woode, 2013).

Some research works have confirmed a strong correlation between some harmful heavy metals such as arsenic, lead, mercury and cadmium and human health (WHO, 2013; Al-Rmali *et al.*, 2010). High levels of arsenic, lead and cadmium were detected in geophagy clay eaten by Bangladeshi pregnant women. There have also been other reports of the presences of these harmful elements in geophagy clays from other places such as Ghana and

Kenya (Woywodt and Kiss, 2002; Gborbani, 2008; Tayie *et al.*, 2013).

Excessive exposure to the harmful heavy metals could lead to one disease or another. For instance Selinus *et al.* (2010) have found that acute exposure to lead can affect the human central nervous system and may cause anemia and dysfunction of the kidney, liver and heart. It has also been reported by WHO (December 2012, 2013) that exposure to arsenic over a long time from drinking-water and food can cause cancer. Arsenic is also associated with cardiovascular disease and diabetes. WHO (2013, April 2012) has also reported that mercury can affect the nervous, digestive and immune systems, as well as the lungs, kidneys, skin and eyes. Another study Kippler *et al.* (2009) have also found that cadmium can inhibit the secretion of calcium in breast milk and may have toxic effects on the kidney, the skeletal and the respiratory systems.

Geophagy clay may contain some relatively non toxic mineral elements such as copper, iron, magnesium and zinc which are important and therefore could have useful health benefits to the consumer. On the contrary Kawai *et al.* (2009) observed that geophagy in pregnant women in sub-Saharan Africa resulted in iron deficiency associated anemia. Njiru (2011) confirmed this finding and indicated that clay soils may obstruct the bioavailability of micronutrients resulting in micronutrient deficiency.

Geophagy clay may also be a source of microbial infection (Tano-Debrah and Bruce-Baiden, 2010). Microbiological health effects associated with geophagia

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in humans include the beneficial use of kaolin (a form of clay) to treat diarrhoea and enhancement of bioactivities (Bisi-Johnson *et al.*, 2010) as confirmed by Ngole *et al.* (2010) in their study of the physicochemical properties of geophagic clayey soils from South Africa and Swaziland. The presence of iron oxide in clay and the water retention capacity of clay was founded to alleviate anemia and diarrhea respectively.

Even though geophagy clay consumption in Ghana has gone on for a very long time there are relatively few known publications on the risks that it poses to consumers and therefore its health implication. The aim of this study therefore is to determine the levels of the harmful heavy metals found in geophagy clays sold in some major markets in Ghana and to communicate the potential health risk associated with the consumption of the clay.

MATERIALS AND METHODS

Materials

Samples of dry unprocessed geophagy clay were obtained from three major markets in the Greater Accra region of Ghana for analysis. The markets-Makola, Madina and Ashiaman markets were chosen because of the high level

of trading in geophagy clay sourced from Nigeria, Abidjan in Cote d'ivoire and Ghana. A major source of supply of geophagy clay to most market places in Ghana is Anfoega in the Volta region and along the coastline of the Greater Accra region of Ghana. The geophagy clays samples obtained from the markets and sourced from same locations – Accra, Anfoega, Abidjan and Nigeria were bulked together for laboratory analysis.

Method

The clays obtained from the markets were crushed in turns in a crucible. The crushed samples were then sieved through the 180µm sieve. The crucible and sieve were cleaned after each sample prepared to avoid contamination. Four gram (4g) of each sieved sample and 0.9g wax added as a binder were then put into mix for 3minutes at 15Hz in a homogenizer (Model Retsch mm301). The mix was pressed into pellet discs for the test.

Three replicates of the pellet discs of each sample were placed in an X-ray Fluorescence Spectrometry (XRF) machine (Model Spectro X-Lab 2000) for the determination of the heavy metals. The results obtained are presented in table 1.

Table 1. Levels of heavy metals in twelve geophagy clay samples from Ghana (Anf, Acc), Cote d'ivoire (Abj) and Nigeria (Nig) in ppm.

Heavy metals	Anf 1	Anf 2	Anf 3	Acc 1	Acc 2	Acc 3	Abj 1	Abj 2	Abj 3	Nig 1	Nig 2	Nig 3
V	185.2	156.3	156.7	91	99	77	83	105	95	123	147	14
Cr	83.8	109	84	695	90	833	1213	1349	13	112	99	1031
Co	32.4	18.7	20.8	17	17	17	15	15	15	20	20	20
Ni	11.4	8.7	7.2	15.5	13.6	14.7	18.2	16.1	18.8	25.4	26.2	26.2
Cu	23.1	23.6	22.6	11.9	12.1	12.3	2.2	3.7	0.9	15.1	13.2	15.6
Sn	6.4	5.1	5.2	1.2	1.2	2.6	2	2.4	1.7	1.6	1.6	3.1
Zn	32.1	26.4	31.7	14.6	14.9	15.8	18	17.1	18.7	68	72.7	79.5
Ga	16.9	15.6	17.4	18	18.4	18.6	27.8	27.7	27.8	24	25.1	26.2
As	1.8	0.6	0.6	5.8	4.7	5.3	9.0	9.9	10.6	2.9	3.5	3.9
Cd	0.9	0.7	0.7	1.5	1.6	1.4	1.5	1.4	1.4	1.3	1.4	1.4
Hg	4.2	1.6	0.3	2.4	1.6	1.6	1.4	1.3	3.1	1.5	1.5	0.8
Pb	18.3	14.9	10.7	14.5	15.6	15.8	12.6	11.4	10.8	15.7	16	14.7

Anf = Anfoega; Acc = Accra; Abj = Abidjan; Nig = Nigeria

Table 2. PMTDI values for some heavy metals (after WHO/FAO, 2010) and the amount of the heavy metals in 70g of clay from Anf, Acc, Abj, and Nig. consumed.

Heavy Metals	WHO/FAO PMTDI (µg/kg BW/day)	PMTDI for 60kg BW(µg/day)	Average amount of heavy metals in 70g of geophagy clays consumed(µg /day)			
			Anf	Acc	Abj	Nig
As	3.0	180	126	371	688	240
Pb	3.0	180	1281	1071	812	1085
Hg	0.6	36	301	131	135	91
Cd	0.8	48	63	105	98	98

PMTDI- Permitted Maximum Tolerable Daily Intake

RESULTS DISCUSSION

The amount of heavy metals in 70g of the clay consumed have been computed and presented in table 2. The 70g was adopted from Tayie *et al.* (2013) who indicated that to be the amount of clay ingested daily by the women who practice geophagia in Ghana. The amounts of heavy metals consumed were calculated using the average of three of the samples from the same source in table 1. The values obtained are then compared to the Permitted Maximum Tolerable Daily Intake (PMTDI) recommended by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) and are presented in table 2 and figures 1-4.

The Joint FAO/WHO Expert Committee on Food Additives (JECFA, 2010) estimated the total dietary exposure to arsenic to range between 2.0 and 7.0 μg /kg BW/day. The committee fixed the mean exposure level at 3.0 μg /kg BW/day. The Arsenic in the Anfoega clay sample ranges between 0.6 to 1.8ppm (Table 1). This works out to a maximum of 126 μg of As in 70g of the Anfoega clay consumed in a day (Table 2). The 126 μg is lower than the 180 μg permitted maximum tolerable daily intake for a 60kg adult and so adult consumers may not be at risk of arsenic (As) contamination unless they consume higher quantity. Children with body mass of less than 60kg who consume 70g of the clay may experience the effects of arsenic toxicity which includes skin and lung

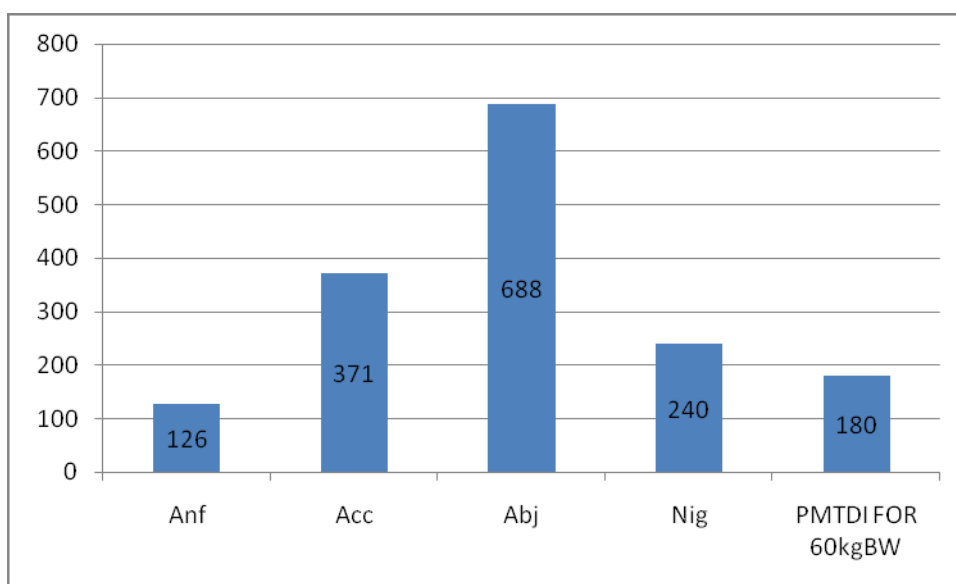


Fig. 1. The levels of Arsenic in clays compared to PMTDI.

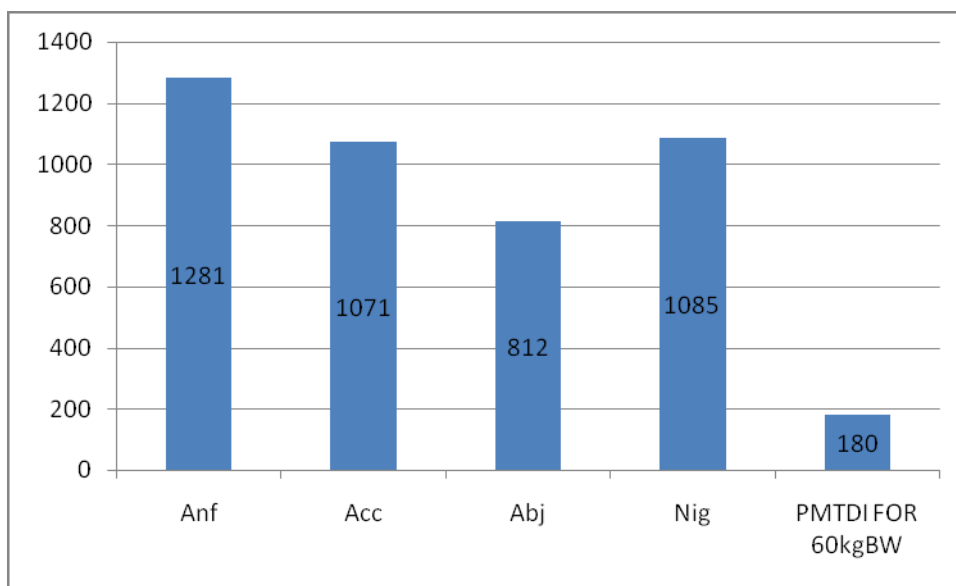


Fig. 2. The levels of lead in clays compared to PMTDI.

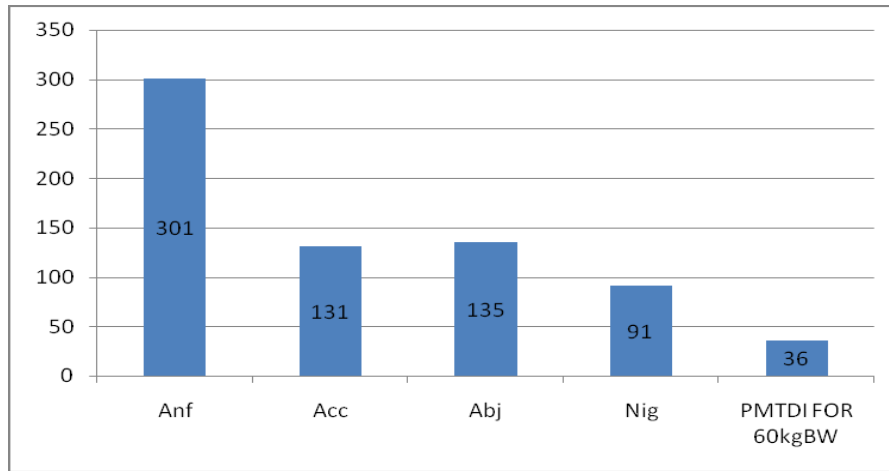


Fig. 3. The levels of mercury in clays compared to PMTDI.

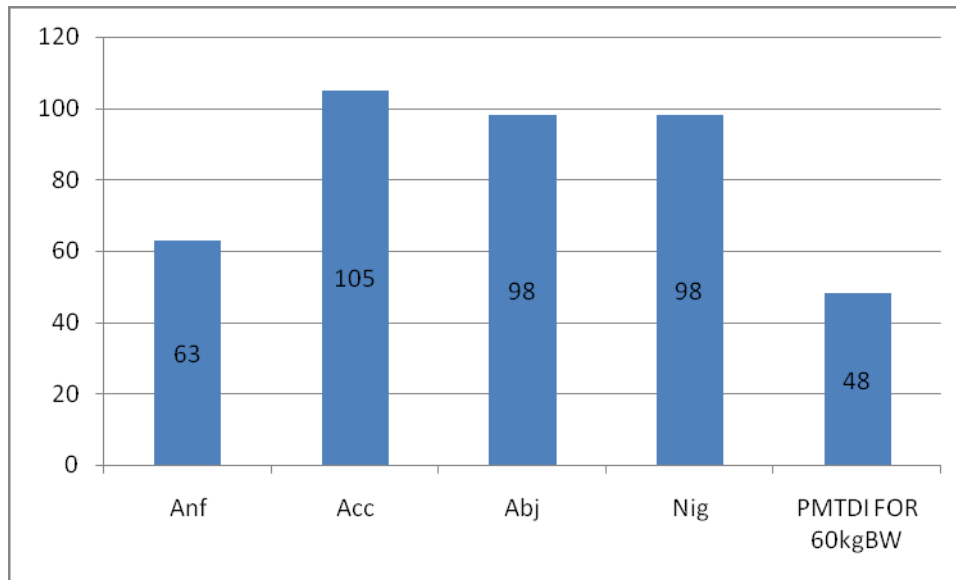


Fig. 4. The levels of cadmium in clays compared to PMTDI.

cancer. The level of arsenic in 70g of each of the other clays is higher than the PMTDI. The arsenic in the clay from Abidjan (Abj) is nearly four times that of PMTDI, and clay from Accra (Acc) contains about twice the PMTDI (Fig. 1).

Other harmful heavy metals in the Anfoega clay range between 10.7 and 18.3ppm for lead (Pb), 0.7 and 0.9ppm for cadmium (Cd) and 0.3 and 4.2ppm for mercury (Hg). The quantity of lead in 70g of Anfoega clay (1281 μ g) computed in table 2 is over seven times the required daily intake for an adult of 60kg weight. When consumed over a long time therefore, Anfoega clay could have very serious health effects such as the dysfunctioning of the kidney, liver and heart of the consumers (Selinus *et al.*, 2010). Children who consume about 70g of the clay/day will in addition suffer damages including learning and

behavior disorder. The lead values obtained for all the other clays are far higher than the PMTDI (Fig. 2).

From table 1 the maximum quantity of cadmium in the sample obtained from the XRF test is 0.9 μ g/g. Therefore, the cadmium in 70g of Anfoega clay consumed daily is 63.0 μ g. This value is about twice the level fixed by JECFA in 2010 for a 60kg adult (Table 2). This means that consuming clay from Anfoega over a period of time could result in kidney damage (Jarup *et al.*, 1998). The Accra clay has the highest level of 105 μ g of cadmium in 70g compared to all the other clays. All the clays however, have higher cadmium than the PMTDI (Fig. 4). JECFA (Feb, 2010) fixed the weekly intake of mercury to be 4.0 μ g /kg BW/week. The daily intake therefore should be at most 0.6 μ g/kg BW/day. The mercury in 70g of Anfoega clay is estimated to be 301 μ g (Table 2). This

Table 3. Recommended Dietary Allowance (RDA) values of some heavy metals and the amount in sampled geophagy clays.

Heavy Metals	Highest RDA for an adult ($\mu\text{g}/\text{day}$)	Tolerable Upper Intake Level by USDA (μg)	Average amount of heavy metals in 70g of geophagy clays consumed ($\mu\text{g}/\text{day}$)			
			Anf	Acc	Abj	Nig
Cr	35	N/A	6,419	37,590	60,060	28,980
Ni	700	>1,000	623	1022	1239	1799
Mo	45	> 2,000	63	273	252	301
Cu	900	> 10,000	1575	847	161	1022
Co	20	> 250	1678	1190	1050	1400

Recommended Dietary Allowance values (after United States Department of Agriculture (USDA) Dietary Reference Intake, 2013).

means that the mercury in 70g of Anfoega clay is over eight times the required daily intake and therefore consumers are likely to suffer diseases associated with mercury toxicity. All the other clays have higher mercury than the PMTDI (Fig. 3).

Recommended Dietary Allowance values (after the United States Department of Agriculture (USDA) Dietary Reference Intake, 2013).

The amount of copper in 70g of geophagy clay ingested in a day is far less than the tolerable upper intake level by USDA (Table 3). None of the clays from the markets therefore contribute significant amounts of copper to the consumer. Cr values on the other hand are in some cases more than a thousand times over the recommended dietary allowance values in table 3. The clays therefore are a good source of chromium for the consumer. However, nickel is marginally more than the recommended dietary allowance. Clays from Accra, Nigeria and Abidjan have Ni values higher than the tolerable upper intake level in table 3. The levels of molybdenum in the clays are less than the tolerable upper intake levels by USDA. Cobalt values in 70g of the clays are all far higher than the tolerable upper intake levels. Consumers of the clays therefore are at risk of cobalt contamination and its consequence.

Even though very high amounts of As, Pb, Hg, Cd and Co have been recorded for the clays, indicating a possible risk to the consumer, the harmful metals may not be bioavailable to the consumer.

In order to determine whether the harmful elements will be bioavailable Tayie *et al.* (2013) simulated the acidic conditions in the human stomach by performing an extraction process on white clay from Anfoega and other areas using HCl and observed that arsenic and lead were not detected in the acid extract. They therefore concluded that the toxic minerals were not bioavailable and therefore the clay was safe for human consumption.

Some previous studies, on the contrary, have indicated that bioavailability of heavy metals in soil such as geophagy clay is dependent on many other factors other than the presence of acid in the stomach. The factors include the concentration of the metals, physical and chemical forms of the metals, pH, Eh, temperature, particulate and dissolved organic content (Luoma, 1989; Ernst, 1996; Violante, 2010).

An acid extraction therefore, may not adequately explain whether some heavy metals may be bioavailable or not. Further research may be necessary to establish the role of other factors in ensuring the availability of these harmful metals to consumers.

CONCLUSION

The levels of arsenic, lead, mercury, cadmium and cobalt in all the geophagy clays sold in three major markets in Ghana are higher than WHO/FAO requirement and the levels established by the United States Department of Agriculture. The consumption of these clays by both adults and children therefore could lead to various life-threatening diseases. The clays are therefore risky for human consumption.

ACKNOWLEDGEMENT

The XRF test was carried out in the laboratory of the Geological Survey Department of Ghana.

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Received: Aug 6, 2013; Accepted: Sept 25, 2013