HUMAN HEALTH ASPECTS RELATED TO THE INGESTION OF GEOPHAGIC CLAYEY SOILS FROM THE FREE STATE AND LIMPOPO PROVINCES, SOUTH AFRICA

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Abstract

Studies were undertaken in the Limpopo and Free State Provinces of South Africa to understand the beliefs, perceptions and health implications associated with geophagia. Questionnaires administered to 225 geophagic females covered their demographic details, their reasons for ingesting geophagic clayey soils and their perceptions regarding associated health conditions and implications. Respondents ingested clayey soils for body cleansing, craving, nutrient supplementation and weight loss. Some respondents considered the soils harmful, and < 50% of respondents had some knowledge of the contents of soils they ingested. Medical reasons in support of geophagia included lack of knowledge on the health implications of the practice. Medical consequences associated with geophagia may have occurred as a result of a lack of knowledge of the health implications of the practice. A clear need for educating geophagic individuals regarding the health implications of geophagia is called for.

Keywords: Body mass index, craving, geophagic females, medical history, perception

1. INTRODUCTION

Human health is central to the global agenda for reducing poverty and is consequently at the heart of the millennium development goals (UNDP MDG, 2010). Human health is influenced by several factors including among others levels of education, poverty, behaviour, and the environment. A behavioural factor that may affect human health includes the ingestion of non -food substances (pica) such as geologic materials like soils and clays. Soils may be accidentally ingested with food but deliberate ingestion of soil, referred to as geophagia, has been reported in many countries in Africa (South Africa, Cameroon, Democratic Republic of Congo, Nigeria, Swaziland, Tanzania and Uganda), Asia (China, India, Guatemala, New Guinea, the Philippines, and Thailand) and the Americas (Diamond, 1999; Dominy et al., 2004; Johns and Duquette, 1991; Woywodt and Kiss 2002; Young et al., 2008). Though the practice of geophagia is believed to be common among the poor in societies, studies in South Africa by Songca et al. (2010) indicated the practice to be common among all income and social groups.

The soils and clays ingested vary in their properties. Some have been described as having a clayey, clay loam, silty clay, or silty clay loam texture with varied pH and cation exchange capacities (CEC), electrical conductivity (EC) and mineralogical compositions (Minnich et al. 1968; Ngole et al. 2010).

Geophagia may play a positive role in the health of individuals indulging in this practice in that it may correct bodily homeostasis by adjusting an imbalance in or a deficiency of minerals. In addition, it could supplement elemental nutrients, adjust the pH in the digestive system, and serve as a treatment for some ailments (Aufreiter et al., 1997). According to Mpuchane et al. (2008), indigenous communities in Africa, the Americas, the Caribbean and Asia use clays as the active ingredient in the treatment of several ailments. Thompson (1913) and Black (1956) also reported the use of clay against poisons. Detoxification of food, the alleviation of gastrointestinal disorders such as diarrhea (Oliver 1997; Johns and Duquette 1991; Wilson 2003), and the supplementation of mineral nutrients including calcium, copper, iron, manganese and zinc (Johns and Duquette 1991; WHO, 1996) have also been reported as emerging factors in support of human geophagic practice.

Though geophagia may have several positive attributes, the Committee on Research Priorities for Earth Science and Public Health, National Research Council (2007) has cited it as a potential health threat to several communities. According to Oliver (1997), soil ingestion could lead to a specific disease or general ill health. Health issues that have been linked to geophagia include iron deficiency anemia, hypocalcaemia, parasitic infections, mechanical bowel disorder and perforation of the sigmoid colon (Key et al., 1982). Reid (1992) and Severance et al. (1988) showed an increased level of anemia following prolonged soil ingestion. Hooda (2003) reported that ingestion of clayey soil could also result in deficiencies of certain elements in the human system because soils with high CEC would absorb elements that are already in solution, thereby reducing their availability for absorption in the gastrointestinal tract (GI). Soils, especially those rich in clay and organic matter, are biological sinks for many micro organisms, some of which are pathogenic. In Nigeria and in the United States of America (USA), ascariasis in children and toxocariasis are commonly associated with geophagia (Callahan 2003). Perforation of the sigmoid colon has been reported in geophagic individuals (Woywodt and Kiss 1999).

Negative effects of geophagia on human health are influenced by factors that may include the properties of the clayey soils ingested, their genesis, mining environments, and other possible anthropogenic activities. Brouillard and Rateau (1989) have attributed deficiency of some cations in geophagic individuals to the CEC of the soil ingested. Prolonged ingestion of soils with high concentrations of heavy metals could result in metal toxicity. Whereas some individuals practising geophagia are aware of the health implications of the practice, others are not.

Ignorance with regards to the possible health implications of ingesting clayey soils may present a major health challenge in rural communities where nutrition is also compromised by poverty and where the practice is more prevalent. Songca et al. (2010) have indicated that ingesting clayey soils is more related to the culture of societies than the health of the geophagic individuals in their communities. Attempts to discourage the practice may therefore be met with stiff resistance (Ekosse and Jumbam 2010). In South Africa where there is a high prevalence of HIV/AIDS, immunity in many individuals is already low and so the risks of infections and other health complications that may arise as a result of soil ingestion are high.

Making the practice of geophagia safer should therefore be the main focus of any intervention measure. Currently, there are several misconceptions and beliefs among geophagic individuals regarding what the soils they ingest can and cannot do in the human body. A study by Songca et al. (2010) reported that soils were ingested for a variety of reasons, including hunger, pregnancy, craving, taste of the soil, and as a supplement. In some instances there have been reports of different adverse medical conditions attributed to the indulgence by geophagic individuals in the practice of geophagia. However, there have also been various accounts of the benefits of ingesting soils by geophagic individuals. It is not clear if there is any relationship between these various conditions and the practice of geophagia. One way of finding out is to study the health characteristics of geophagic individuals with a view to understanding any patterns that may exist. Considering that the practice is entrenched in some communities, it may be a challenge to put a stop to it. Understanding the beliefs and perceptions of geophagic individuals with regards to health implications emanating from geophagic practice is imperative in the identification of possible suitable intervention strategies. Ethnographic surveys regarding awareness of the implications of the practice are necessary to understand how individuals involved in the practice perceive it health wise. This study therefore set out to investigate the knowledge, perceptions and beliefs of geophagic adult females in four communities in South Africa: QwaQwa and Mangaung (which are both in the Free State Province), and Polokwane and Sekhukhune (which are both in the Limpopo Province), with a view to understanding their levels of awareness of possible health implications of the practice. The study also set out to understand certain health aspects common among geophagic individuals in these communities.

2. MATERIALS AND METHODS

This study was conducted among females in communities in QwaQwa (28º 24´ 21.8 S; 28º 57´ 10.3E), Mangaung (29º 12´ 65S; 26º 15´46E), Polokwane (23º 54´ 44.1S; 29º 27´ 12.7E), and Sekhukhune (24º 45´ 11.3S; 30º 00´ 36.2E). Whereas Mangaung and QwaQwa are located in the Free State Province, Polokwane and Sekhukhune are located in the Limpopo Province in South Africa.

Both Mangaung and Polokwane have been established within urban settings, whereas QwaQwa and Sekhukhune are rural environments. Data on the knowledge, attitudes, beliefs and perceptions with regards to possible health implications related to geophagic practice were generated through the administration of a survey questionnaire to geophagic females in QwaQwa, Mangaung, Polokwane and Sekhukhune. The sample population was therefore females who were practising geophagia. Geophagic women who responded to the questionnaires in these areas were identified through a combination of purposive and snowballing techniques (Heckathorn 2002). Through purposive sampling, geophagic females in the different communities were identified. Each identified geophagic female then formed the initial subject through which other geophagic females were identified (i.e., snowballing). A maximum of five respondents were identified through any initial subject to reduce the bias that is usually associated with the snowballing technique of sampling. Through these methods, 225 respondents were identified in the different communities: Mangaung (urban) = 54, Polokwane (urban) = 55, Sekhukhune (rural) = 54, and QwaQwa (rural) = 62.

The questionnaire administered to the respondents comprised of sections which requested information on the demographic and human health characteristics of the geophagic females. Questions also solicited responses regarding their perceptions of geophagia in relation to their health. The demographic questions focused on age, ethnic origin, marital status, income source, occupation, monthly income and level of education of the geophagic females. With regards to the health of the respondents, information solicited through the questionnaire included: history of abdominal pains, whether they had undergone surgery at any time, how often they became sick because of infections like common colds and influenza, any chronic illness or disease that they were suffering from, whether they ingested clayey soils when they were sick, and whether they had been diagnosed with a medical condition that included iron deficiency, high blood pressure, constipation and headaches, among others. Respondents were required to indicate whether they perceived the soils they were ingesting to be harmful or not. They were also required to indicate what the soils contained according to their knowledge. Questions in this section also solicited information on whether the respondents believed the soils contained vitamins, calcium, iron, or any other substance. In addition, information on the health related reason for which the respondents were ingesting soil was also requested.

Considering that the respondents were from different ethnic groups, the questionnaire was translated into the different languages spoken by the respondents and administered by trained research assistants who were fluent in the respective indigenous languages. Throughout the study and during the interviews, respondents were guaranteed anonymity and freedom to withdraw their participation from the study at any time they felt uncomfortable to carry on with the interview.

The information collected was captured and subjected to Kruskal-Wallis and Fisher's exact Tests using SAS statistical software. Information on the marital status and level of education were cross tabulated with those of health aspects related to geophagia to determine how marital status and education level affected the perceptions and beliefs of geophagic females on health aspects related to geophagia. All analyses were done using the SAS statistical software.

3. RESULTS AND DISCUSSION

3.1 Demographic characteristics of the sample population

Details of the demographic characteristics of females practising geophagia who participated in the study were published by Songca et al. (2010). A concise discussion of the age, marital status, income, and educational level of the participants is very briefly presented.

The age of the females ranged between 17 and 60 with an overall mean age of 33.3 years. The mean age distributions of the females from Mangaung (31.0) and QwaQwa (27.7) were lower than those of females from Sekhukhune (36) and Polokwane (38.7). According to the South Africa Survey (2009) the life expectancy in the Free State and Limpopo provinces for women was 53 and 56 years respectively in 2008. The maximum age of the geophagic females (60 years, 58 years, 50 years, and 51 years respectively for Mangaung, Polokwane, QwaQwa, and Skhukhune) was therefore representative of the life expectancy of females in the respective provinces. The age distribution among these females was also similar to those reported for geophagic women in Kenya (Ngozi 2008) and Zambia (Shinondo and Mwikuma 2008).

Among the 221 respondents, the majority were single (53.8%), followed by those who were married (33.1%) and those cohabiting or living together (9.9%). Men have been reported to frown upon the practice of geophagia (Eastwell 1979). Considering that geophagia is commonly reported among pregnant, mostly married women, the lower prevalence of geophagia among married compared to single females in this study may therefore be explained. Moreover, the fact that married women are not usually willing to expose their geophagic habits for fear of reproach from their husbands may also account for this lower reported prevalence. Whereas the majority of respondents from Mangaung and QwaQwa (Free State Province) were of Sotho origin, those from Polokwane and Sekhukhune (Limpopo Province) were of Pedi origin. This is a true reflection of the ethnicity of the two provinces as the Sotho people are the dominant ethnic group in the Free State Province and the Pedi people are the dominant group in the Limpopo Province.

The geophagic females sampled had a mean monthly income that ranged from SAR 464.75 (≈US$ 67.00) in Mangaung, to SAR 1 515.37 (≈US$217.00) in QwaQwa, to SAR 3 669.12 (≈ US$ 525.00) and SAR 4 572.97 (≈ US$655.00) in Polokwane and Sekhukhune respectively. Though geophagia was reported in all income brackets, it was more common in the lower income group. These results are concomitant with those reported in another geophagia study by Halsted (1968). Of the 225 geophagic females, 60% had attained secondary education whereas 31% had reached tertiary education. The majority of the respondents had spent between 9 and 16 years in formal education. The level of education of the geophagic females in the four regions studied indicated that these females were sufficiently literate to understand the consequences of geophagic practices.

3.2 Health status of geophagic females

3.2.1 Body Mass Index (BMI) of respondents

The weight and height of geophagic females from the different regions are presented in Table 1. The heights of the geophagic females ranged from 139 cm in Sekhukhune to 198 cm in Polokwane. Body weight also varied with communities, with the lowest and highest being 44 kg and 112 kg respectively. Both these respondents were from Mangaung. Whereas geophagic females from the Limpopo Province seemed comparatively taller than those from the Free State Province, there was no noticeable difference in their body weights (Table 1). The BMIs of the geophagic females from the Limpopo Province were slightly lower than those of the respondents from the Free State Province (Table 1). This study was focused on geophagic females in the respective communities. The BMI values of the geophagic females were compared with those of the World Health Organisation BMI classification. According to WHO (2004) BMI < 18.5 indicates underweight, whereas BMI values of between 18.5 and 24.9 indicate normal weight, and between 25 and 29.9 indicate over weight. Geophagic individuals from Polokwane and Sekhukhune could therefore be described as having normal body weight whereas those from QwaQwa and Mangaung could be described as being slightly overweight. No cases of underweight were reported among the geophagic females.

Table1: Mean height, weight and body mass index of respondents from the different communities

	Mangaung	QwaQwa	Polokwane	Sekhukhune
Mean Height in cm (SD)	156.6 (6.7)	156.1 (5.9)	177.1 (10.7)	172.1 (10.7)
Mean Weight in Kg (SD)	66.2 (16.0)	63.2 (14.0)	73.4 (11.6)	72.1 (10.9)
Mean BMI (SD)	26.9 (6.2)	25.9 (5.4)	23.4 (3.0)	24.3 (3.7)

(SD = standard deviation)

3.2.2 Medical history of geophagic females

Less than 15% of the geophagic females interviewed had undergone surgery. Among the 15%, the majority were from Polokwane (7%), followed by those from Sekhukhune (5%). Only one geophagic female in QwaQwa and none in Mangaung had undergone surgery. The main reasons given by geophagic females for undergoing surgery ranged from after birth pains (1%) to abdominal pains (5.8 %), and gastric ulcers (1.8%). Other reasons advanced for the surgery included appendicitis, blood in urine, constipation, and abdominal cysts. Only one geophagic female (from QwaQwa) alluded to have been operated upon as a result of soil ingestion. Although intestinal obstruction which usually results in surgical procedures has been reported among geophagic individuals (El Shallaly and Siddig 2011; Yé et al. 2004), the results obtained in this study showed no anomalies with regards to frequency of surgical procedures undergone by the females practising geophagia in these various communities. It was therefore concluded that soil ingestion had no surgical implication for these geophagic females.

Of the 225 geophagic females from each of the four regions, 91.5% admitted that they often suffered from common colds and influenza related infections. The frequency of occurrence of these infections among the geophagic females ranged from more than once a month (1.3%), once a month (5.8%), once every three months (17.5%), twice yearly (40.4%), to yearly (26.5%). In all four regions, many geophagic females suffered from these infections twice a year. Several females (65.6 %), especially those from Polokwane (21.2%) and Sekhukune (20%), admitted to having chronic illnesses, with Mangaung and QwaQwa contributing 13.5% and 10.9% respectively to those with chronic illnesses. No link could yet be established between geophagia and the common cold, but it could be argued that the ingestion of soils loaded with pathogens may render the immune system susceptible to attack by other pathogens, especially among those who have helminth infection, which is also a common occurrence among geophagic individuals. A variety of chronic illnesses was reported among the geophagic females in the four regions with the majority indicating headaches, dizziness, coughs, constipation, and high blood pressure as the main chronic diseases. The different diseases reported by the females from the four regions are indicated in Figure 1.

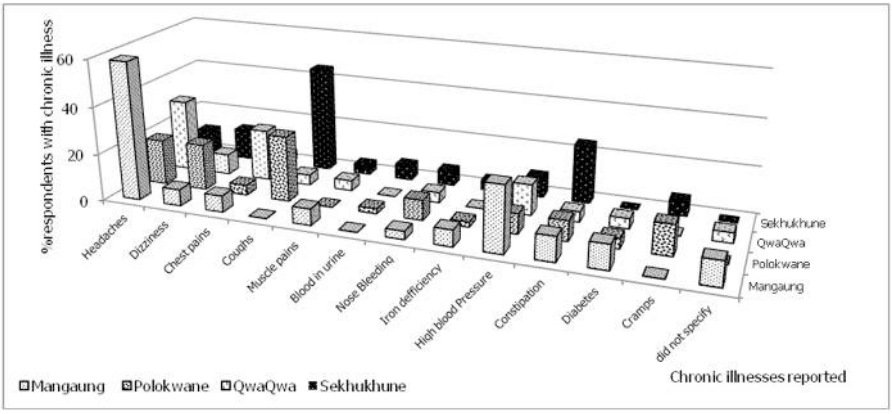

Figure 1: Types of illnesses indicated by geophagic females who admitted to having chronic diseases

Whereas 37.1 % of all the geophagic females interviewed indicated that they usually ate soil when they were sick, 19.2% indicated that they sometimes did and 43.7% indicated that they never ingested soil when they were sick. In Mangaung, QwaQwa and Sekhukhune, most of the geophagic females did not eat soil while they were sick, but in Polokwane soil ingestion was common when the females were sick. A number of stillbirths and miscarriages were reported by the geophagic females in the regions. The highest frequency of stillbirths was reported in Polokwane where up to 54.62 % of the respondents indicated they had had at least one stillbirth at some point. The frequency of stillbirths was much lower in Mangaung, QwaQwa and Sekhukhune, being 0.0%, 4.84% and 16.66% respectively. The occurrence of miscarriages among geophagic females in the regions was much higher than that of stillbirths, with percentages of 11.1%, 54.5%, 4.8%, and 37% reported for miscarriages by females in Mangaung, Polokwane, QwaQwa and Sekhukhune respectively. A few geophagic females also indicated congenital malformations among their babies. However, the occurrence of this phenomenon was very low (1.85% for Mangaung, 7.27% for Polokwane, 1.61 % for QwaQwa and 3.70 % for Sekhukhune). Congenital malformations in babies of geophagic females may occur if soil containing teratogenes is ingested. It is not clear if the congenital malformations occurring among the babies born to the geophagic females who participated in this study had been caused by soil ingestion, as no investigations related to the presence and amount of teratogenic compounds in the soils were carried out. Questions regarding health indicators of the geophagic females did not reveal any dominant symptoms or illnesses among the respondents. These geophagic females can therefore be described as experiencing average health conditions.

3.3 Beliefs and perceptions of geophagia among geophagic females

3.3.1 Awareness of the harmfulness of the ingested clayey soil

More than 75% of the respondents from the four communities believed that the clayey soils they were consuming were harmful (Figure 2). Whereas all the divorced women interviewed (100%) believed that the soil they ingested was harmful, 64%, 70%, 83% and 78% of the married women in Mangaung, Polokwane, QwaQwa and Sekhukhune respectively believed that the soil was harmful. QwaQwa had the highest percentage of single women (90%) who believed that the soil was harmful, whereas Sekhukhune had the lowest percentage (62%), with Mangaung (75%) and Polokwane (87%) in the middle. Of the geophagic females cohabiting, 92% believed that the clayey soil they were ingesting was harmful. These results indicated that more single than married women believed that the soil they were ingesting was harmful. The observed trend is not unexpected given that there were fewer women who were cohabiting or living together compared to those who were married or single. A higher prevalence of geophagic practice among single women emphasized the fact that it is no longer a practice that is predominant in pregnant women as very few of the women indicated that they consumed soil during pregnancy (Songca et al. 2010).

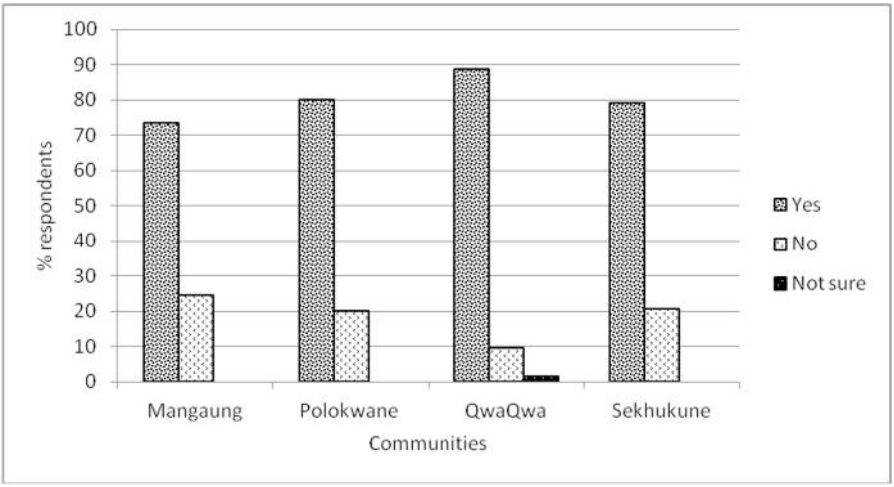

Figure 2: Respondents indicating awareness of the harmfulness of ingested clayey soil

The percentage of geophagic females with secondary and tertiary education who believed that the soil ingested was harmful was higher than those who had not been to school or had only attained primary education. At higher levels of education, more knowledge regarding the environment and hygiene is imparted to students.

Knowledge on the composition of soils is also likely to be more common among students who have attained secondary and tertiary education levels compared to those with a primary education level. This may explain why geophagic females with higher levels of education were more aware of whether the soil they were ingesting was harmful.

Reasons advanced by the geophagic females to justify their belief that the soil they were ingesting was harmful varied from one community to the other. Constipation, abdominal pains, and body intoxication together accounted for about 78% of the reasons why geophagic females from the four regions believed that the soil they ingested was harmful (Figure 3). Other reasons advanced included tooth decay (4 %), fallopian tube blockage (3.6%), parasites (2.7%), and worms (2 %) (Figure 3).

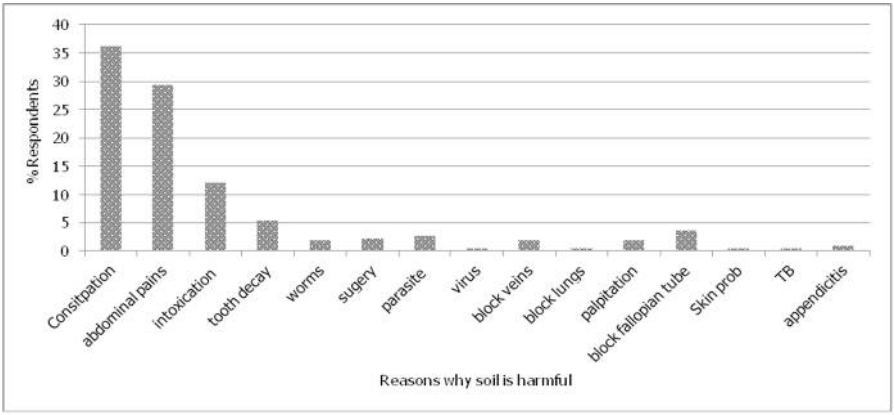

Figure 3: Reasons cited by geophagic females to justify their belief that the ingested clayey soil is harmful

There was no statistical difference in the belief of constipation as the main reason among married, divorced, and cohabiting geophagic women in the four regions. Body intoxication and constipation were also the most common reasons given for possible harmfulness of the soil ingested among geophagic females who had attained tertiary and secondary education. The reasons given by the geophagic females in the different regions to support their belief that the soil they were ingesting was harmful portrayed a misconception of the negative health effects of geophagia. For example, it may be difficult to explain the link between geophagia and health effects such as blocked veins, blocked lungs and blocked fallopian tubes, palpitations, and tuberculosis as cited by respondents with geophagia. There is a clear need for information and education regarding the practice of geophagia and its possible health effects.

3.3.2 Knowledge of substances contained in ingested clayey soil.

Only 36% of the respondents indicated that they knew what was contained in the soils they ingested. Knowledge of the content of the soil was most common in geophagic females from Mangaung (54%), followed by those from Sekhukhune (39.62%), Polokwane (30.91 %), and QwaQwa (22.58%). Except for Mangaung, the majority of the respondents had no clue as to the contents of the soils they were ingesting. The differences observed regarding the knowledge of the soil they ingested were significant (P = 0.0032) among the various communities. Level of education seemed to have had an influence on knowledge of the content of the soil ingested as all those who had no schooling indicated that they had no knowledge of the soil content. Except for those who had attained a tertiary level of education in Mangaung and QwaQwa, less than 50% of respondents who had attained some level of education knew what the soil contained. Secondary school leavers seemed to be more aware of the contents of the soil they were ingesting than primary and tertiary school leavers. Married and divorced geophagic women were also aware of the contents of the clayey soils they ingested whereas single women and those who were cohabiting or living together showed awareness to a lesser extent (Figure 4).

Of the 36% of the respondents who believed that they had knowledge of the soil contents, the majority believed that the soil contained iron and salt (Figure 5). Other contents cited by a few respondents included dead plant roots, starch, parasites, nutrients, Zn, and minerals (Figure 5). Whereas in QwaQwa only those who had a secondary school qualification had some knowledge of what was contained in the soil, in Mangaung all the geophagic females with a tertiary level of education and more than 50% of those with primary and secondary levels of education believed that the soil contained mainly Fe. Geophagic females in Polokwane with a secondary school education believed that the soils contained mainly calcium and salt while vitamins and Fe were cited as the main contents in the soils by geophagic females with tertiary education. According to married and single geophagic women in QwaQwa, Ca and Fe were the main contents of the ingested soil whereas, according to those from Mangaung, the soils contained Fe and salt.

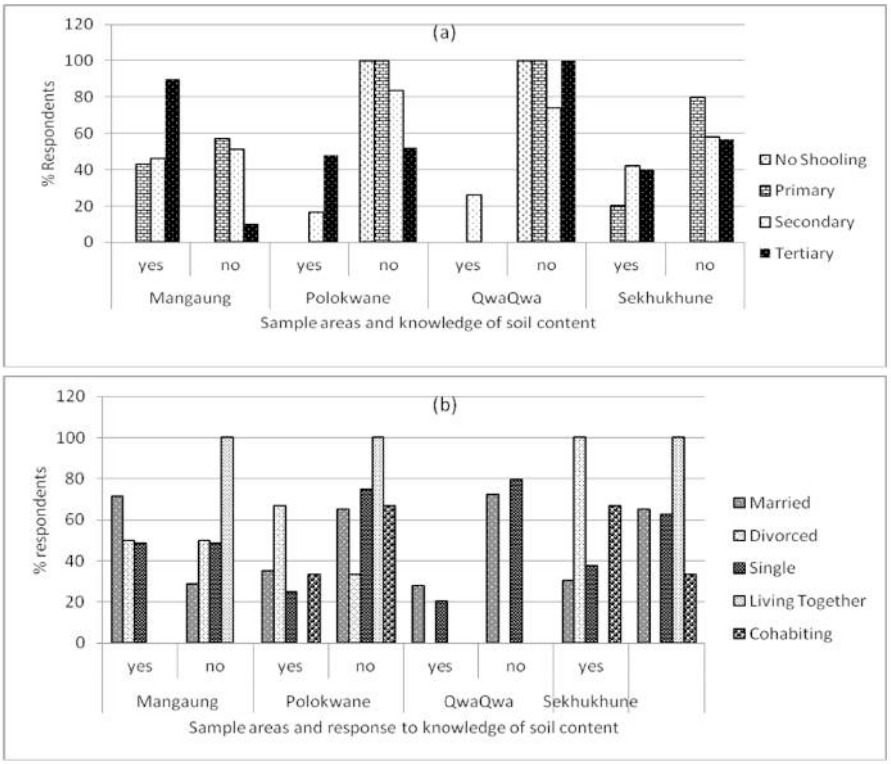

Figure 4: Relationship between Level of education (a), marital status (b), and knowledge of soil content

Whereas in Polokwane Fe was also cited as a common content of the soil by married and single geophagic females, salt was believed to be the main content in the soils ingested by single and married women. Respondents' perception of the contents of the geophagic soils corroborates the notion that soil ingestion is usually a means for supplementation of Fe, Ca, and other minerals in the body (Dominy et al. 2004; Hooda 2003; Jones and Hanson 1985). However, it is noteworthy that very few respondents believed that the soils contained parasites.

There is a need to characterize geophagic soils ingested in these different communities as the soils are likely to vary in their composition. Generally, geophagic individuals make use of the colour and the taste of the soil to determine its contents. These may sometimes be deceptive as studies have shown that soil colour may indicate the presence of an element in the soil but not its bio-accessibility when ingested.

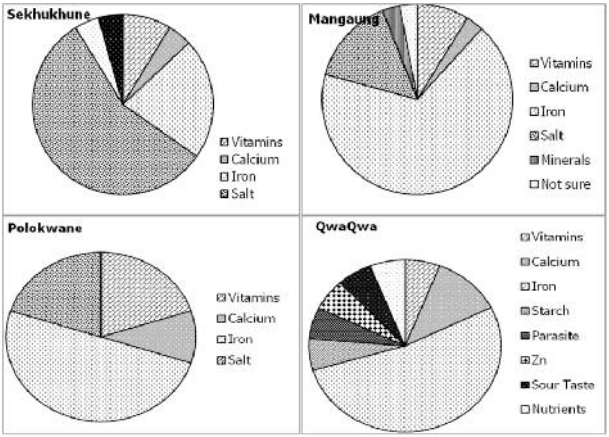

Figure 5: Contents of geophagic clayey soils according to respondents

3.3.3 Reasons for ingesting soil

The results obtained from the questionnaires indicated that geophagic females ingested soil for several reasons such as pregnancy, cleansing the body, weight loss and as a nutrient supplement. Craving appeared to be the main reason for soil ingestion in all communities (Figure 6). Craving, nutrient supplementation and pregnancy as main reasons for geophagia have also been reported by Forsyth and Benoit (1989), Frankel (1977), Hunter (1973), and Young et al. (2008). Using soil as a means of losing weight may be explained by the fact that it may be filling but is low in calories. Continuous ingestion of soil may therefore eventually result in weight loss. Medicinal reasons cited such as cleansing the body and protection against infection need to be further investigated.

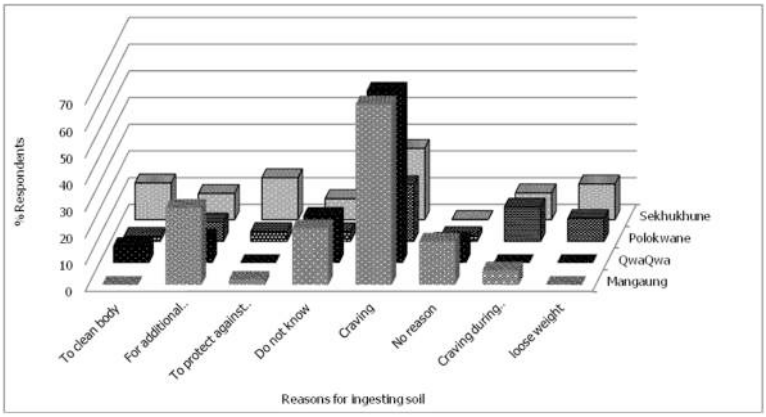

Figure 6: Health reasons advanced by geophagic females to justify ingestion of clayey soil

3.4 Health contributions and effects of geophagia

The effects of geophagia on human health may be exhibited in different ways by different body tissues and could be specific for each individual. On ingestion of soil, it goes through the GI where it may react with saliva in the mouth, gastric juices, and other enzymes in the stomach and intestines prior to being absorbed. On absorption, these substances are transported by the blood to the liver, the kidneys and other organs (Figure 7).

Eventually, the substances are either excreted in the urine or faeces. Substances contained in the ingested soil could therefore be identified in the blood, faeces or urine of the geophagic individual. Further studies on these endpoints are necessary to generate a better understanding of the health contributions and possible adverse effects of geophagia.
The findings of this study have exposed the need to sensitize communities about the health implications of geophagia. Moreover, it has highlighted the need for further studies that would investigate some of the beliefs and perceptions postulated by geophagic females from these four regions. A multidisciplinary approach that would look at soil physic-chemistry, mineralogy and microbiology in conjunction with health endpoints such as blood counts, iron studies, electrolyte levels, stool tests for parasite infections and abdominal complications, is therefore proposed.

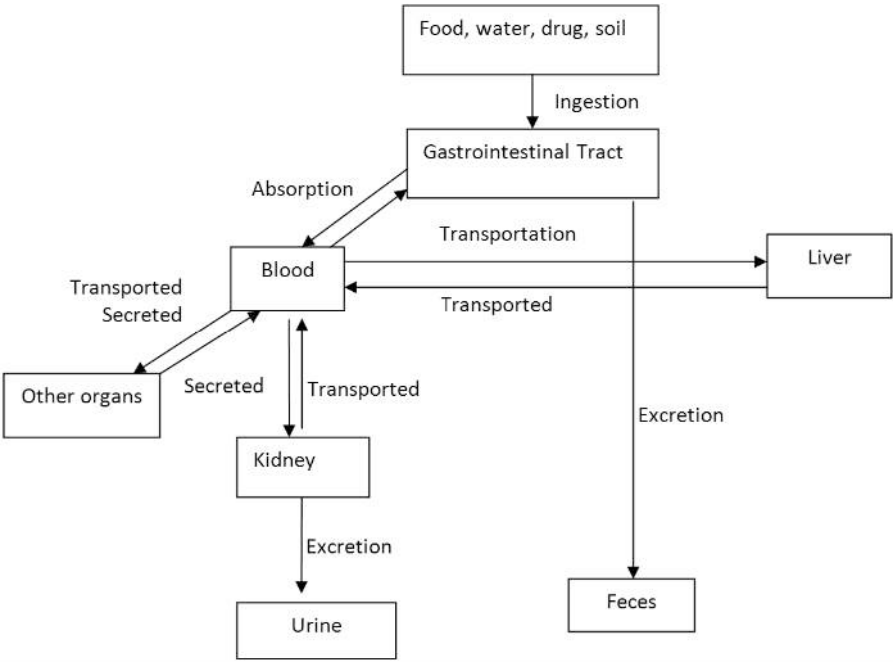

Figure 7: Routes of absorption, transportation and excretion of substances

4. CONCLUSION

Though geophagia is a prevalent practice among African people, not much is understood about the factors that trigger humans' craving to ingest clayey soil. Many of the geophagic females in this study displayed ignorance with regards to the contents of the soils they ingested and cited several medical reasons why they indulged in the practice. The scientific basis for the linkage between geophagia and the medical conditions cited by the geophagic females from these communities need to be investigated. This study has revealed a lack of knowledge regarding the health implications of the practice of geophagia on humans by geophagic females. Considering the fact that the geophagic habit is endemic among the communities studied, there is a clear need for the design and implementation of education programs to sensitize geophagic individuals on the health implications of the practice. Studies that investigate the relationship between the medical conditions cited and the reasons advanced to justify the practice among humans are overdue.

5. ACKNOWLEDGEMENT

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6. REFERENCES

Aufreiter S, Hancock RGV, Mahaney WC, Stambolic RA, Sanmugadas K 1997. Geochemistry and Mineralogy of soils eaten by humans. International Journal of Food Science and Nutrition, 48(5): 293-305.

Black, DAK 1956. Re-evaluation of Terra Sigillata. Lancet, 2: 883-4.

Brouillard MY, and Rateau JG 1989. Pourvoir d'adsorption de deux argilles, la smectitie a la kaolin sur des entérotoxines bactériennes. Gastroenterology Clinical Biology, 13: 18-24.

Callahan GN 2003. Eating Dirt. Emerging Infectious Diseases, 9(8): 1016-1021.

Committee on Research Priorities for Earth Science and Public Health, National Research Council 2007. What we eat. In Earth materials and health: Research priorities for earth science and public health. The National Academies Press, Washington, D.C.: 83-89.

Diamond J 1999. Dirty eating for healthy living. Nature, 400: 120-121.

Dominy JN, Davoust E, and Minekus M 2004. Adaptive function of soil consumption: an in-vitro study modeling the human stomach and small intestine. Journal of Experimental Biology, 207: 319-324.

Eastwell H. D 1979. Pica Epidemic: a Price for Sedentarism Among Australian Ex-Hunter-Gatherers by. Psychiatry, 42 1979: 264-73.

Ekosse GE, and Jumbam DN 2010 Geophagic clays: their mineralogy, chemistry and possible human health effects. African Journal of Biotechnology, 9 (40): 6755-6767.

El Shallaly G, and Siddig NO 2011. Geophagia: A rare cause of intestinal obstruction. Sudan Journal of Medical Sciences, 5(4). 313 – 320.

Forsyth C, and Benoit GM 1989 "Rare, old, dirty snacks": Some research notes on dirt eating. Deviant Behaviour, 10: 61–68.

Frankel B 1977. Childbirth in the ghetto: Folk beliefs of Negro women in a North Philadelphia hospital ward. San Francisco: R & E Research Associates.

Halsted J. A. 1968. Geophagia in man: Its nature and nutritional effects. The American Journal of Clinical Nutrition, 21: 1384-1392.

Heckathorn DD 2002. Respondent-driven sampling II: Deriving valid estimates from chain-referral samples of hidden populations. Social Problems, 49: 11-34.

Hooda PS 2003. Soil ingestion affects the potential bioavailability of Cu, Mn, and Zn. Proceedings of the 7th International Conference on the Biogeochemistry of Trace Elements, Uppsala, Sweden, June 15-19, 2003. SP9o-Trace elements issues in developing countries: 8-11.

Hunter JM 1973. Geophagy in Africa and in the United States: A culture nutrition hypothesis. Geographical Reviews, 63: 170–195.

Johns T, and Duquette M 1991. Detoxification and mineral supplementation as functions of geophagy. American Journal of Clinical Nutrition, 53: 448-456.

Jones RL, and Hanson HC 1985. Mineral licks. Geophagy and biogeochemistry of North American ungulates. Ames, Iowa: Iowa State University Press.

Key TC Jr, Horger EO 3rd, and Miller JM Jr. 1982 Geophagia as a cause of maternal death. Obstetrics and Gynecology, 60: 525–526.

Minnich V, Okacuoglu A, Taron Y, Arcasoy A, Cin S, and Yurukoglu O. 1968. Pica in Turkey. II Effect of clay upon ion adsorption. American Journal of Clinical Nutrition, 21: 78-86.

Mpuchane SF, Ekosse EG-I, Gashe BA, Morobe I, and Coetzee SH 2008. Mineralogy of Southern African medicinal and cosmetic clays and their effects on the growth of selected test microorganisms. Fresenius Environmental Bulletin, 17(5): 547-557.

Ngole VM, Ekosse GE, de Jager L, and Songca SP 2010. Physicochemical characteristics of geophagic clayey soils from South Africa and Swaziland. African Journal of Biotechnology, 9(36): 5929–5937.

Ngozi PO (2008). Pica practices of pregnant women in Kenya. East African Medical Journal, 85(2): 72-79.

Oliver MA 1997. Soil and human health: A review. European Journal of Soil Science, 48(4): 573–592.

Reid RM (1992). Cultural and medical perspectives on geophagia. Medical Anthropology, 13: 337-351.

Severance HW, Holt T, Patrone NA, and Chapman L 1988. Profound muscle weakness and hypokalemia due to clay ingestion. Southern Medical Journal, 18: 272-274.

Shinondo C.J, and Mwikuma G2008. Geophagy as a risk factor for helminth infections in pregnant women in Lusaka, Zambia. Medical Journal of Zambia, 35(2): 48-52.

Songca SP, Ngole VM, Ekosse GE, and De Jager L2010. Demographic characteristics associated with consumption of geophagic clays among ethnic groups in the Free State and Limpopo provinces. Indilinga, African Journal of Indigenous Knowledge Systems, 9: 110-123.

South African Survey, the 2009. Demography. South African Institute for Race relations. http://www.sairr.org.za/services/publications/south-africa-survey/south-africa-survey-online-2009-2010.

Thompson CJS 1913. Terra Sigillata: A famous medicament of ancient times. Trans 17th International Medical Congress, London. History of Medicine, 23: 433-433.

United Nations Development Program Millennium Development Goals. Basic facts, Goal 1: Eradication of Poverty. http://www.undp.org/mdg/goal1.shtml. Accessed 10th February 2011.

World Health Organization 2004. Expert consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. The Lancet, 2004: 157-163.

Wilson MJ 2003. Clay mineralogical and related characteristics of geophagic materials. Journal of Chemical Ecology, 29(7): 1525-1545.

Woywodt A, and Kiss A 1999. Perforation of the sigmoid colon due to geophagia. Archives of Surgery, 134: 88-89.

Woywodt A, and Kiss A 2002. Geophagia: the history of earth-eating. Journal of the Royal Society of Medicine, 95(3): 143-146.

Yé D, Kam K, Sanou F, Traoré SS, Kambou S, Yonaba C, Dao F, and Sawadogo A 2004. Intestinal obstruction and geophagia in a 14-year-old child. Archives de Pédiatrie, 11(5): 461-462.

Young SL, Wilson MJ, Miller D, and Hillier S 2008. Toward a comprehensive approach to the collection and analysis of pica substances, with emphasis on geophagic materials. Plos One, 3(9): 3147. doi:10.1371/journal.pone.0003147.