



Research article

Geophagic practice in Mashau Village, Limpopo Province, South Africa

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ABSTRACT

Large quantities of earth materials are consumed daily in Mashau Village; nonetheless, this practice had not been studied. Furthermore, the motivations for this geophagic behaviour in the study area were unclear. Thus, questionnaires were distributed to 200 participants in the study area with the aim of generating data on the motivations of and potential medical conditions associated to this practice. About 91% of the participants were geophagists, of which 98.5% were female. Craving was found to be the main reason (73.9%) why people of the Mashau communities consume soil. The majority of the geophagists in Mashau craved for the soil upon seeing it (31.2%), during pregnancy (22.5%) and when experiencing sleeplessness (21%). About 60% of the geophagists had chronic illnesses, and they were diagnosed with headaches (31.6%), low haemoglobin level (29.9%), constipation (18.8%), iron deficiency (12.0%) and high blood pressure (7.7%). There is a concern that the soil from the study area may be adversely affecting individuals ingesting these soils. Since females mostly reported practicing geophagia, counselling and education of women and girls would be a useful public health measure. Soil characterisation and beneficiation for healthy geophagic practices should also be carried out at Mashau Village.

1. Introduction

Geophagia, the habitual intended consumption of earthy materials (soils and clays) by humans and animals, has been practised for centuries by people from different socio-economic, ethnic, religious and racial groups (Abrahams, 2002; Hooda et al., 2004; Ngole and Ekosse, 2012; Momoh et al., 2015). Earth material consumption has been reported in all continents in the world, except Antarctica (Young et al., 2010; Ekosse et al., 2011). On the African continent, this practice has been reported to be predominant in Southern African countries; namely Malawi, Zambia, Zimbabwe, Swaziland and South Africa (Walker et al., 1997).

Human beings indulge in geophagic practices for a variety of reasons; some of which include craving, nutrient supplementation, easement of gastrointestinal disorders such as diarrhoea, relief from morning sickness, famine or as part of cultural belief systems. Young et al. (2010) indicated that expecting women with nutrient deficiencies develop cravings for earth, as a way of supplementing deficient nutrients like iron, zinc and calcium. Soil consumption has been shown to supply 17%–55% of recommended pregnancy supplementation of Ca, Mg, Zn, Fe, Cu, Mn, K and Se (Brand et al., 2009).

Geophagic materials are used to heal common illnesses of the gastrointestinal tract because they possess medicinal properties of binding

mucus in the intestines, causing intestinal linings to be impermeable to toxins and pathogens (Young, 2010). Diko and Diko (2014) found the geophagic soils from Cameroon and South Africa are ingested for the relief of nausea and vomiting during pregnancy (morning sickness). According to Msibi (2014), geophagia is often practised where poverty is prevalent and soil is used as an appetite suppressant and as a bulking agent to still hunger during times of insufficient food availability.

It is believed that soil consumption is the link between good health, fertility and cultural belief of ancestors' blessings (Msibi, 2014). To the Luo people of Kenya, women of reproductive age prefer particular soils from termite mounds because of their red colour (the colour of blood), intense taste and fertility (Geissler et al., 1999). Despite the beneficial aspects of geophagia, several studies have associated the practice with detrimental effects such as iron deficiency, anaemia, excessive dental damage, perforation of the intestines and metal toxicity (Magongoa et al., 2011).

Soil ingestion can potentially reduce bio-available nutrient absorption in the human diet and lead to micronutrient deficiencies. For example, anaemia (Hooda et al., 2004). Excessive tooth wear may also be an indication of geophagia, while radiological examination of these peoples abdomens may reveal abdominal obstruction as a result of soil accumulation in the colon (Abrahams, 2002; Young, 2007). Constipation,

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ulcerations and intestinal obstruction, perforation and death have been reported in cases where clay consumption was common (Abrahams, 2002).

Geophagia may also constitute a health risk for human beings because geophagic materials are mostly contaminated with toxic metals (Fosso-Kankeu et al., 2015). Studies undertaken in KwaZulu-Natal (Saathoff et al., 2004; Msibi, 2014), Eastern Cape (Ngole and Ekosse, 2012), Free State (Magongoa et al., 2011) and Limpopo (Ekosse et al., 2010) Provinces in South Africa showed that geophagia is still more prevalent in rural communities. Geophagic behaviour has also been reported in the Vhembe District (Momoh et al., 2015), however, no known studies exist on geophagic practice in Mashau Village. Hence, the objectives of this study were to understand the motivations for the practice in the study area, evaluate the geophagists' perceptions about geophagia and determine potential medical conditions associated with the practice.

2. Materials and methods

2.1. Description of study area

Doli (23°09'30" S, 30°16'00" E) and Mukhoro (23°09'28" S, 30°14'00" E), both located in Mashau Village, within the Limpopo Province of South Africa, are the areas where the study was conducted (Figure 1). The two areas were chosen because of the dominance of the geophagic practice among these communities. The geology of the study area is dominated by rocks of the Sibasa Formation of the Soutpansberg Group, which is made up of basalts, with intercalated clastic sediments (Bumby, 2000). The soils were derived from sandstones and basalts with

the general soil types being sandy soils, shallow silty sands, loamy soils and clayey soils, which are found within the river valleys (Mostert et al., 2008). Mashau consists of undulating terrain, with a mountain on the far west, the Thavhayamipfa (Thorn Mountain). Topography of the study area varies, ranging from approximately 580 m and reaches an elevation of 1092 m above sea level at the mountain. The village is drained by a non-perennial river, Mutshenzheni, which originates from Thavhayamipfa. The river flows south-eastward and it incised through the hills that form spectacular landscape units. Settlement and subsistence agriculture are the main activities in Mashau; however, the land is also used for sand mining and brick making. The surrounding forest serves as grazing land for domesticated animals (cattle, goats and donkeys). Commercial farming in the form of cultivation is also practised; this includes the tea and macadamia plantations at Thondoni, the plant nursery at Tshirando and the forestry plantations on the mountains of Bodwe.

2.2. Ethical approval

The study complied with established ethical guidelines. Permission to conduct the study was granted by the University of Venda Research Ethics Committee (Project no. SES/17/MEG/10/0310). Permission to conduct the survey was also obtained from the local traditional leadership and participants signed informed consent forms prior to data collection. It was ensured that geophagists understood what their involvement meant and that they voluntarily admit to participate. Minors (participants younger than 18 years old) were given permission to participate by their parents. Participants were allowed to withdraw their consent and participation in the study at any stage, without prejudice.

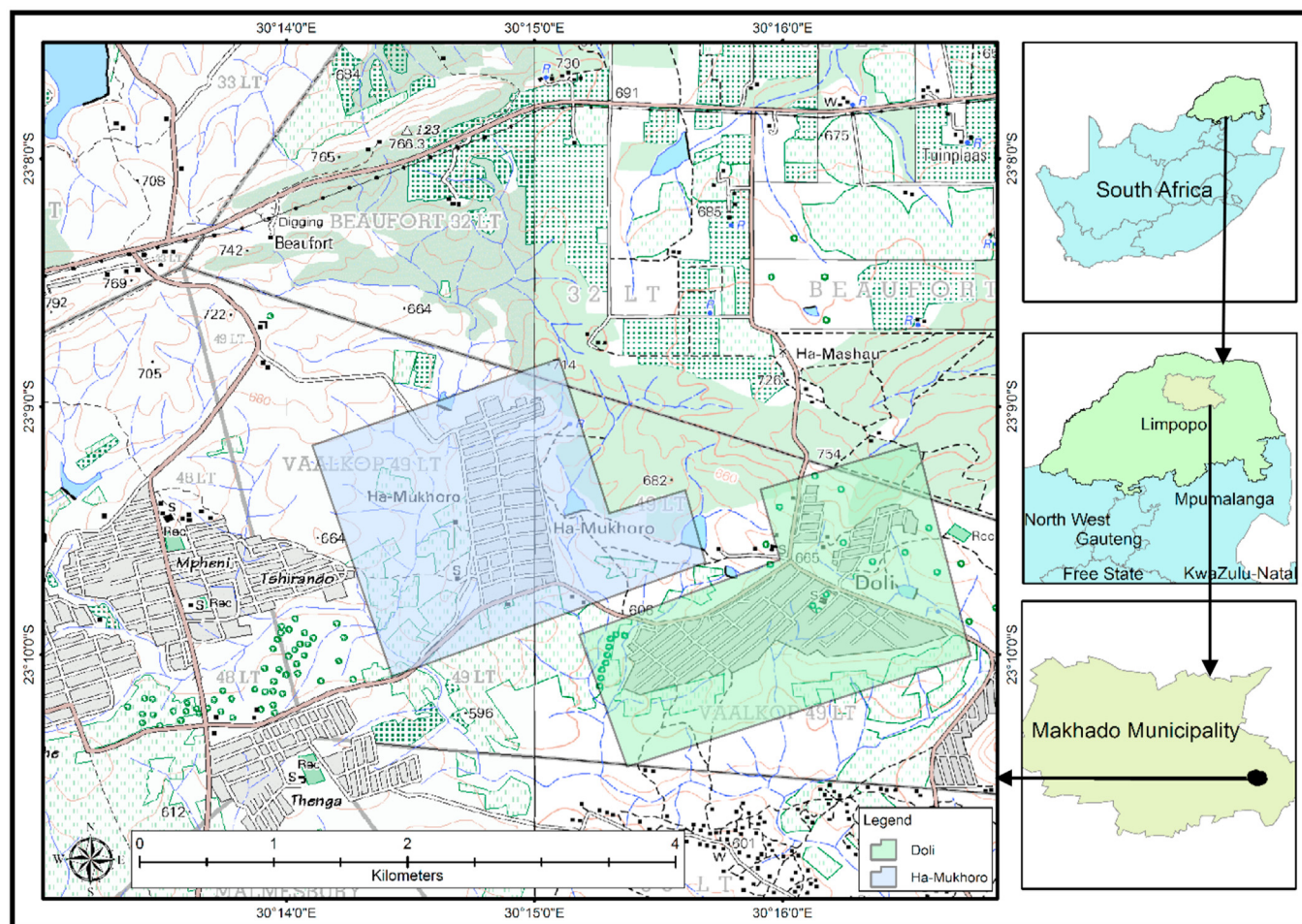


Figure 1. Location of Mashau Village.

Results of the study, including personal details were processed into a study report and participants were assured of the confidentiality of their responses.

2.3. Questionnaire administration

Doli and Mukhoro have 1887 and 2284 inhabitants, respectively (Statistics South Africa, 2012). To calculate a sample size that would be representative of each sub-village, Yamane's formula (1967) was used (Equation 1):

$$n = N / 1 + N (e)^2 \quad [1]$$

where N is the population size and e is the level of precision (Sarmah et al., 2013). For this study, a 90% confidence level was assumed with $\pm 10\%$ precision. According to the formula, a sample size of 191 would be representative of the population but two hundred (200) questionnaires were administered to participants instead. The figure was rounded up to reduce sampling errors that could occur if some participants withdrew from the survey.

The study relied on a standardised questionnaire previously used by the Geophagia Working Group in other parts of South Africa, Botswana and Swaziland to characterise human geophagic habits (Ekosse, 2008). The introductory part of the questionnaire sought demographic information including gender, age, marital status, income source, occupation and educational level. Other parts of the questionnaire aimed to generate data on the geophagic habit (motives, types of soils consumed, frequency of soil consumption, perceptions about the practice, location and properties of the consumed materials) as well as the self-reported health implications participants believed to have experienced as a result their geophagic practice.

Participants were randomly identified through a combination of purposive and snowball sampling. Purposive sampling was used to select few known geophagists based on one of the authors' (U.M.) knowledge about their geophagic habit (they live in the same neighbourhood at Mashau Village). Then, using snowball sampling, the initially identified geophagists during purposive sampling referred U.M. to other potential geophagists.

2.4. Statistical analyses

Data collected from the survey were analysed with the IBM Statistical Package for the Social Sciences (SPSS) Statistics (version 25) software. Furthermore, the Pearson's Chi-square (X^2) test was used to evaluate association of geophagia with factors such as age, gender, income source and educational level.

3. Results

Out of the 200 study participants, 181 (90.5 %) admitted they were consuming soil, 0.5% used to do it and 9.0% had never consumed earth materials. Of these 181 respondents, 34.8% stated that they consumed soil more than once a day, 36.7% indicated that they consumed at least once per day, 21.0% once a week and 17.7% once a month.

3.1. Factors associated with geophagia

Outcomes of the questionnaire survey showed that 98.5% of the study participants were females and only 1.5% were males. Of the total sample size ($N = 200$), only 146 respondents indicated their age; the youngest participant was 7 years old and the oldest was 65 years old. Study participants were largely from the 26–35 years age group (27.4%), with those in the 56–65 years age group participating in minority (4.8%). A greater proportion of the respondents (41.5%) were married, followed by those whom were single (40.0%), with the rest of the respondents living with their partners (15.0%), divorced (41.5%) or widowed (1.5%).

Majority of the respondents (43.6%) indicated wage employment as their income source and only 17.5% of the respondents depended on non-wage employment. The remaining 39.1% depended on their spouses, parents, children and grants (child and old age grant) for their income. With regard to occupation, most study participants were not working with 20.44% of them being unemployed, 19.34% being students and the remaining 60.22% having jobs.

Most of those who were formally employed were having non-professional jobs such as farm workers (10.5%), freelancers (9.39%), domestic workers (5.52%), vendors (4.42%), general workers (3.41%) and other non-professional jobs in minority. In terms of the study participants' highest qualification, more than half (78.0%) had progressed up to secondary level, 2.5% had reached the professional level and only three participants (1.5%) were illiterate. The Chi-square (X^2) analysis showed a significant association of educational level with geophagia ($p < 0.05$). There was no association of age ($p > 0.05$), gender ($p > 0.05$) and income source ($p > 0.05$) with the practice of consuming soils (Table 1).

3.2. Motives for the geophagic habit

Although results of the survey showed craving to be the main reason people ingested soil (73.9%), other participants (2.8%) did not know why they indulged in earth materials eating. From the survey, it was observed that none of the geophagists consumed earth materials because of cultural, spiritual or traditional beliefs. Geophagists in the study also disclosed that when pregnant, they consumed earth materials daily (81.8%). From the responses about when geophagists craved for the soil, it is clear that majority (31.2%) craved for the soil upon seeing it, 22.5% during pregnancy and 19.0% craved for the soil when experiencing sleeplessness. As displayed in Figure 2, boredom, feeling weak and constipation contributed the least to the craving.

3.3. Preferred geophagic materials

The most favoured geophagic substance was soil from termite mounds, with 30.6% of geophagists consuming it only, followed by soil (16.0%) and only 1.7% preferred to consume clay only (Figure 3). Some earth consumers preferred to consume different geophagic materials with 27.4% preferring to consume both soil and soil from termite mounds while others (24.3%) consumed all the geophagic materials (soil, clay and soil from termite mounds). Only 6.1% of the study participants admitted they consumed other non-food substances, which included ice, glycerine and candle wax.

Geophagists had different preferences for the source, colour and texture of the consumed soils (Table 2). Study geophagists desired earth materials more when dry (98.0%) than when wet (2.0%). Preferred colours were chosen essentially because of their appearance and taste, with accessibility contributing the least. It was also indicated that geophagic materials are typically stored in plastic bags (36.6% of geophagists); however, 25% of the geophagists did not store them at all. The given traditional names included *mavu*, *munyaka*, *mutwa*, *tshilogo* and *vumba*. The most common ways of collecting the material were digging and scrapping as they were used by 80% of the geophagists against 20% who used selective hand picking. The environment from which geophagic materials were collected varied; but most people obtained the substance from termitaria (38.1%), their yards (27.9%), hilly areas (24.9%), along the road (7.5%) and from riverbed (1.7%). Geophagists had different preferences for the feel (texture) of the substances; most (41.9%) favoured the powdery, some (21.7%) favoured the silky, while others (5.5%) favoured the gritty. The texture of the material did not matter to 30.9% of the respondents as presented in Table 2.

Findings from the survey also showed that those who processed consumed items did so by either grinding (87.5%) or sieving (12.5%). A large portion (87%) of geophagists did not apply any heat treatment before consumption but few (11.3%) did and 1.7% applied only at times.

Table 1. Factors associated with geophagia

	Chi-square	df*	p-value
Gender	0.322 ^a	1	0.571
Income source	2.906 ^a	2	0.234
Educational level	15.780 ^a	5	0.008 [†]
Age	2.939 ^a	5	0.709

a = 0 cells (0%) have expected frequencies less than 5; *df = degree of freedom; †statistically significant.

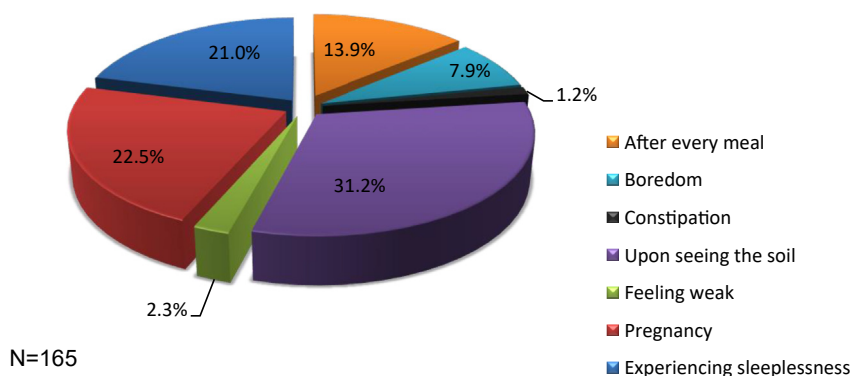


Figure 2. Reasons for craving for the soil.

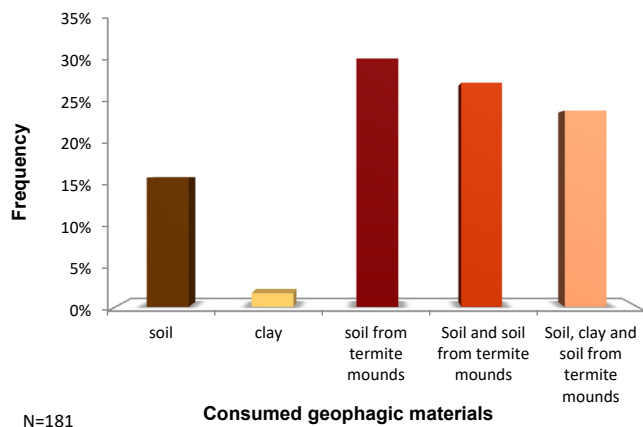


Figure 3. Commonly consumed substances.

Of those who treated the material, 63.4% baked, 26.6% burned and 10% burned and salted the earth materials.

Between the tree and mound termiteria, tree termiteria was mostly (65.9% of respondents) picked over the mound (34.1%). Those who consumed the earth material from trees, only 14.6%, collected the material from specific trees. About 85.4% of the respondents neither collected the material from certain trees (30.6%) nor bother about the type of tree it was collected from (54.8%). Respondents who were

cautious of the tree type preferred soil from *munngo* (66.6%) and *muberegisi* (33.3%) trees.

3.4. Health aspects

Outcomes of the survey showed that the majority of the respondents (58.6%) presumed that the consumed substances could be harmful to their health; however, they were not aware (65.7%) of the harmful parasites that could be present. Out of the total experimental group (181 respondents), only one respondent (0.6%) was ever operated upon because of stomach problems. Respondents did not know (84%) the content of the substance, nevertheless, those who said they knew (16.0%) believed the material contained iron (88.9%) and vitamins (11.1%). More than half of the geophagists (56.9%) had chronic illnesses. The most frequent chronic illness was dizziness with 41.7% of geophagists complaining about it followed by headaches (38.8%); blood in stool (13.6%) and nose bleeding (5.8%) were the infrequent ones.

Only two people had children with abnormalities of which one was cross-eyed and the other could not defecate when still a baby. It was also mentioned that the cross-eyed child was a premature but the child who could not defecate reached the expected developmental and growth stages. Medical conditions diagnosed with or experienced included constant headaches, constipation, high blood pressure (BP), iron deficiency and having low haemoglobin (Hb) level. The majority of the geophagists experienced constant headaches (31.6%) and had low Hb level (29.9%). Other geophagists experienced constipation (18.8%); others were diagnosed with iron deficiency (12.0%) and some with high BP (7.7%). The responses from study participants regarding the people's

Table 2. Source, colour and texture of the consumed soil.

Source of consumed soil	Hill/mountain	Riverbed	Road	Termiteria	Yard	
N = 161	24.9%	1.7%	7.5%	38.1%	27.9	
Soil colour	Blackish	Brownish	Khaki	Pinkish	Reddish	Yellowish
N = 143	11.0%	26.3%	20.1%	5.5%	34.3%	2.8%
Soil texture	Gritty	Powdery	Silky	Doesn't matter		
N = 113	5.5%	41.9%	21.7%	30.9%		

perceptions about the habit of eating non-food substances revealed that people have different insights about this practice. From the responses, 86.0% indicated that the habit is perceived negatively, 9.7% said it is perceived positively and 4.3% did not know how people viewed this habit.

A *p*-value greater than 0.05 was obtained when cross-tabulating the frequency of soil eating and diagnosed health conditions reported by geophagists. No clear pattern was observed between these two variables. However, there was a significant relationship (*p*-value < 0.05) between reportedly diagnosed health conditions and the duration of the practice, as well as between diagnosed health conditions and the age of geophagists. Headaches, iron deficiency and low Hb level were mostly reported by individuals who had been practicing geophagia from one to 15 years. Geophagists between 18 to 53 years mainly experienced diagnosed health conditions (constipation, headaches, iron deficiency and low Hb level), with low Hb level being more recurrent in geophagists aged between 18 and 35 years.

4. Discussion

In this study carried out in Mashau Village, geophagia was found to be practiced by more than 75% of participants, especially among women of reproductive age (26–36 years). This finding confirms the results from a study by [George and Ndip \(2011\)](#) in which 75% of the study participants had practiced geophagia. The youngest participant to report geophagia was 7 years old. [Okereke et al. \(2015\)](#) revealed that children between the ages of 5 and 7 years were significantly more geophagic. This can be attributed to the frequent hand-to-mouth activity associated with children of that age range and poor personal hygiene.

Few males reported practicing geophagia. It is likely that under-reporting of geophagia by men occurs for various reasons, including embarrassment regarding the behaviour. In Kenya, women reported that men secretly eat soil ([Geissler et al., 1999](#)). In Uganda, the geophagic practice among men is not considered as shameful, and this broad acceptance within the community led to an uninhibited conversation ([Huebl et al., 2016](#)). However, [Geissler et al. \(1997\)](#) indicated that the geophagic behaviour in males usually declines from childhood to adolescence. [Msibi \(2014\)](#) reported that geophagia was highly practiced by women probably be due to mother/daughter-sharing traditions (activities a mother and daughter practice together).

Geophagia has no educational divides, both the educated and the illiterate indulged in the practice. The study confirms the results of [Momoh et al. \(2015\)](#), which also discovered that geophagia was practiced by both the educated and illiterate. There was, however, a significant association of geophagic behaviour with educational level. This finding suggests that educational level might be a predictor of the practice of geophagia and that it is more likely for someone at the lower educational stages to practice geophagia. [Fawcett et al. \(2016\)](#) also showed that in Africa, America and Eurasia, the practice of geophagia generally decreased with increased educational level.

The practice of geophagia has been attributed to several reasons in this study, but the principal motive for soil consumption in Mashau was craving. [Diko and Ekosse \(2014\)](#) also reported craving as the main cause of geophagia. [Norman et al. \(2015\)](#) reported that in Ghana, the practice of geophagia is mainly a cultural-nutritional fact and health-seeking behaviour. It is a belief that some pregnant Mexican women consume soil because it prevents birthmarks or fetal loss ([Lin et al., 2015](#)). Some geophagic individuals indulged in the practice of geophagia for additional nutritional value (those who believed the material had iron and vitamins). [Young et al. \(2010\)](#) also stated that people who consume soils do so in an attempt to supply the deficient micro-nutrients. [Nyanza et al. \(2014\)](#) reported that in Tanzania, geophagia occurs because of pregnant women need to manage nausea. Geophagia is mostly practiced by pregnant women during the first term of the pregnancy, and the habit gradually decreases during subsequent terms until it disappears during postpartum ([Fawcett et al., 2016](#); [Gundacker et al., 2017](#)). In Georgia

(USA), African America women generally practice geophagia ([Jackson et al., 2020](#)). About 95% of these women consume clay because of its taste ([Grigsby et al., 1999](#)). The interesting finding that geophagists also consumed substances like candle wax, glycerine and ice suggests that there could be more reasons why people consume non-food materials.

The practice of geophagia is negatively perceived in the communities of Mashau. As a result, soil consumers hid their geophagic behaviour from their family members and only friends knew about this habit. Though the practice is believed to be common among the poor in societies, studies by [Ngole et al. \(2010\)](#) indicated the practice to be common among all income and social groups. Outcomes of this study also supported this finding. The income sources of the soil consumers varied, ranging from wage employment, non-wage employment to depending on others. The Chi-square analysis showed no association of income source (*p* > 0.05) with the practice of consuming soils.

Geophagists reported to be very cautious of the materials they consumed; the suitability of the soils for consumption was determined by their appearance, their taste or both their appearance and taste. The texture of the material seemed to make it attractive since powdery and silky materials were favoured. Reddish soils were probably preferred because of their inferred high iron content. According to [Diko and Diko \(2014\)](#), texture and appearance plays an important role in the selection of the consumed materials. Geophagic materials were collected when dry, although few soil consumers preferred wet and sticky ones. Consumed materials were sometimes processed (grinding and sieving) or heat-treated (baking, burning, burning and salted) as the materials reported by [Smit \(2011\)](#).

The health impacts of geophagia remain controversial and uncertain, as literature show both health benefits and harmful effects. Studies comparing the micronutritional value of geophagic materials and pharmaceutical supplements for pregnancy showed surprising comparability for several important nutrients, including calcium, magnesium and iron ([Lopez et al., 2004](#)). [Young and Miller \(2019\)](#) elaborated on the benefits of geophagia, which included protection against pathogens and toxins, relief from gastrointestinal upset, nutrient supplementation, nutritional immunity.

However, [Carmichael et al. \(2003\)](#) indicated inferred possible associations of maternal geophagic behaviour with negative birth outcomes include low birth weight, neural tube defects, premature birth and elevated prenatal mortality, due to heavy metal toxicity and maternal nutrition. Only two abnormalities in geophagists' babies at Mashau were reported. The first was a baby, who could not defecate, and the second was a premature baby with strabismus. Ingestion of soils rich in high amounts of Fe could be harmful to pregnant women and their unborn child ([Abrahams et al., 2006](#)). [Carmichael et al. \(2003\)](#) and [Akah et al. \(2020\)](#) also stated that the practice of geophagia during pregnancy could be a risk factor for lead toxicity in infants. [Gundacker et al. \(2017\)](#) reported that soils ingested by pregnant women in some parts Democratic Republic of Congo contained substantial amount of lead, which could lead to prenatal lead exposure. Moreover, lead is not the only metal of concern for pregnant women. [Msoffe et al. \(2019\)](#) indicated that pregnant women in Tanzania and their babies are potentially exposed to toxic levels of As, Al, Ba, Cd, Ni, and Pb. The practice of geophagia during pregnancy is also associated high serum level of the heavy metals, as shown in a study conducted in Nigeria among geophagic pregnant women ([Akah et al., 2020](#)). [Zeigbo et al. \(2020\)](#) also showed that geophagia may predispose pregnant women to gestational diabetes, electrolytes imbalance and reduced intestinal enzymes activities. The self-reported medical conditions (constant headaches and dizziness) and those that participants were diagnosed with (iron deficiency and low Hb levels participants) could be an indication of more complicated health issues such as anaemia.

There is also a concern that geophagists are at risk of ingesting soil-borne infectious parasites such as hookworm, roundworm and whipworm. These parasites are associated with malnutrition and fetal nervous damage in children ([Okereke et al., 2015](#)). The most prevalent parasitic

infection in humans is toxoplasmosis caused by ingestion of *Toxoplasma gondii*, which is usually found in soils (Du et al., 2012; Saki et al., 2017). However, Raissi et al. (2020) found no significant relationship between geophagia and *Toxoplasma gondii* infection Southeast Iran. Kutalek et al. (2010) also concluded that geophagia is not a cause of adult helminth infection. In Jos (Nigeria), geophagia is believed to be one of the main sources of toxocarosis, through the ingestion of soils containing eggs of *Toxocara canis*, a saprozoontic parasite (Ajayi et al., 2000). A severe case of aggressive periodontitis was also reported in a patient who practiced geophagia from seven to 25 years in Turkey (Toker et al., 2009).

In this study, geophagists (including men and non-pregnant women who are rarely considered in geophagy studies) from different backgrounds were engaged. It is also the first study that addressed the geophagic practice in Mashau. More people were involved in the study than the required sample size of 188, which reduced the inaccuracy of findings caused by participants withdrawing from the study. The primary limitation of this study was the restricted time in the field as only the questionnaires were administered and no other qualitative method was performed. Moreover, the response rate from participants was not always 100% for some study variables.

5. Conclusion

This study has established that geophagia is prevalent in the studied population in Mashau Village. Geophagia is a broad and accepted practice among communities that is not limited to age, gender or socio-economic status. It is, however, common in people at the lower educational levels than in those at the upper levels. The geophagic behaviour in Mashau Village was mainly as a result of craving. Hunger or beliefs (cultural, spiritual and traditional) did not influence the practice as reported in other studies. The consumed materials were selected based on their source and properties. Significant relationships were observed between diagnosed medical conditions in geophagists and the age and frequency of soil eating. It is therefore recommended that more studies be conducted on the microbial, physico-chemical, mineralogical and chemical characteristics of the consumed materials to evaluate health implications that could result from their consumption. Moreover, since females mostly reported practicing geophagia, counselling and education of women and girls would be a useful public health measure.

Declarations

Author contribution statement

Unarine Mashao: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Georges-Ivo Ekosse: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.

John Odiyo: Conceived and designed the analysis; Contributed analysis tools or data.

Nenita Bukalo: Conceived and designed the experiments; Analyzed and interpreted the data.

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Data availability statement

Data associated with this study has been deposited in the University of Venda Institutional Repository (UnivenIR) at <http://univendspace.uv.ac.za/handle/11602/1115>.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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