Health and social impacts of geophagy in panama

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ABSTRACT

Introduction: Geophagy is a human behaviour involving the ingestion of earthy substances such as soil and clay. Common among pregnant women in rural, tropical areas, it is culturally accepted within some societies and stigmatized within others. There is no scientific consensus on the effects of geophagy on human health. This study was developed as a comprehensive diagnostic to assess the causes, social aspects and potential health impacts of geophagy among pregnant women in rural Panama. **Methods**: Private, structured interviews (n=41) were carried out with women in ten subsistence community farms in the province of Veraguas and the Ngöbe-Bugle Comarca. Additional interviews with healthcare workers were conducted at nearby healthcare facilities. Five soil samples were collected in locations indicated by confirmed geophagists, subjected to simulated human digestion and analyzed for mineral composition and parasite eggs. **Results**: There is no cultural or religious element to the practice; rather it seems to be driven by physiological desires tied to the smell of the material. Prevalence is higher among women with lower education levels and poorer nutritional status suggesting that the practice is associated with low socioeconomic status. Soil analysis did not indicate presence of parasites, but there are potential nutritional benefits of the practice by providing essential minerals missing in the diet. **Discussion**: We find that geophagy in Panama may offer nutritional benefits. However, without a clearer understanding of specific effects of soil in the gastrointestinal tract, it is difficult to determine direct biophysical impacts of geophagy.

KEYWORDS

Geophagy, Health, Pregnancy

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INTRODUCTION

Pica is generally described as the act of habitually eating non-food substances. There is inconsistency in the literature about the precise definition of pica; it has been described as an eating disorder, as an obsessive-compulsive behaviour, or as a normal adaptive response to numerous physiological or environmental conditions *(1-3)*. Geophagy is a type of pica that involves the ingestion of earthy substances such as soil, clay, mud, ash or stones. Humans and animals on almost all continents practice geophagy in a variety of forms, making it one of the most common types of pica *(1, 4, 5)*. In animals, geophagy is considered to be a normal adaptive behavior, that is documented among numerous animal groups including primate species *(6)*. Despite its wide distribution and long documented history, human geophagy is not well understood. It is acknowledged that the behaviour is most prevalent among populations in tropical climates, and that it is possible to define high-risk groups *(4)*. Populations most likely to engage in geophagy live in rural areas, practice a traditional culture, and have little or no access to modern healthcare facilities *(7,8)*. Within these high-risk communities, geophagy is most common among young children and pregnant women who have a family history of pica, therefore it is perhaps a tradition that is passed on through generations *(8,9)*. Interestingly, geophagy has been shown to be associated with micronutrient deficiencies, especially iron and zinc *(10-14)*. Geophagy has been linked to physiological, cultural, and socioeconomic factors, adding to the complexity and mysterious nature of the behaviour.

BEHAVIOURAL DRIVERS

The many theories developed to explain the etiology of geophagy fall into two main categories: functional and cultural. Functional hypotheses focus on the physiological drivers, whereas the cultural hypotheses focus on the sociological drivers and cultural evolution of earth-eating traditions.

FUNCTIONAL

The first and simplest functional explanation is that people may consume soil or clay because they have insufficient food; incidents of geophagy have certainly been documented in times of famine or food insecurity *(15,16)*. Another functional hypothesis proposes that humans eat earth in response to receiving insufficient nutrients. This crucial link between geophagy and micronutrient deficiencies is supported by the observation that individuals with heightened nutritional needs—children and pregnant women—are the primary geophagists. Some studies propose that it is a pre-existing nutrient deficiency from a lacking diet that creates the physiological desire to engage in geophagy *(12,17,18)*. Others, however, suggest that the ingestion of materials such as clay and soil that binds and blocks the absorption of minerals such as iron and zinc into the bloodstream, thus creating the observed deficiency *(3,8,19,20)*. Soils with high cation exchange capacity (largely negative surfaces) can bind and adsorb nutrient cations to their surface, decreasing their availability for absorption into the bloodstream *(21)*. In simulated human digestion, Hooda et. al. observed a decreased absorption of zinc, iron and copper in solution due to the presence of soil *(21)*. Similarly, Arcasoy et. al. reported a lower iron absorption in iron-deficient children who practiced geophagy when compared to controls *(22)*. A final functional hypothesis incorporates the two viewpoints and suggests that geophagy is both the cause and result of deficiencies. Geophagy may be initially driven by a deficit in the diet but then also leads to the binding of nutrients in the gut, which then exacerbates the deficiencies of the geophagists and reinforces the behavior *(23-26)*. Although many studies have shown a correlation between mineral deficiencies and geophagy, it is difficult to determine the net effect of the ingestion of different soil types on nutrient availability in the gut.

Clay consumption in response to nausea and vomiting is common during early pregnancy, and is evidence that geophagy alleviates gastrointestinal distress. It is postulated that clay and soil can also absorb pathogens and toxins, preventing their entry into the bloodstream or intestinal endothelium *(3,10)*. In fact, kaolin clay was the original active ingredient in Kaopectate, an over-the-counter drug used to treat nausea, vomiting and diarrhea *(10)*. From another theoretical perspective, geophagy is perceived as an adaptive behavior to enhance immune system function. The ingestion of soil may help prevent asthma and aid in the development of a healthy immune system *(9,27)*.

CULTURAL

Eating earth is often associated with rituals, traditions and religion. Hunter suggested that geophagy spread to the Americas during the slave trade, and the activity then disseminated all over North, Central and South America *(1)*. Early reasons for soil eating include supernatural beliefs that soil has the ability to ensure fertility and a healthy pregnancy *(28)*. In many parts of the tropics, earth-eating is a widespread and open practice and is deeply ingrained in traditional culture. It is still common practice to purchase specially prepared clay tablets and other geophagic materials at local marketplaces for consumption in rural areas of the developing world *(4)*. In African societies, geophagy is a social activity that forms part of the feminine identity. It is often carried out collectively in groups of women, but hidden from men of the community *(4, 29)*.

In many parts of Central America, geophagy is clearly deeply ingrained in religious practice. The ‘cult of the Black Christ’ has resulted in commercially traded white clay tablets available throughout Guatemala, Honduras, El Salvador, Nicaragua and Costa Rica *(1)*. Pilgrimages to holy sites associated with the ‘Black Christ’ to purchase tablets blessed by the Roman-Catholic Church are made at various times throughout the year *(30)*. Women eat as much as six small tablets of '*tierra santa*' per day hoping to ensure easy pregnancy and childbirth *(1, 30)*.

Note that this strong cultural link is not inherent in all cases of geophagy. In many parts of the world, the practice is highly stigmatized and geophagists carry out the behavior in solitude *(10, 25, 31)*.

CULTURE-NUTRITION HYPOTHESIS

Ultimately, cultural and functional reasons for geophagy are inextricably linked. The high incidence of co-existing geophagy and iron deficiency led to the development of a 'culture-nutrition hypothesis': physiological needs subconsciously determine behavior, with the behavior often being integrated into cultural practices *(16)*. This proposes that the practice of geophagy is an instinctual behavior, borne out of a biological need for essential minerals, and then incorporated into cultural practices.

Regardless of factors that motivate geophagy, it is still unclear whether the behavior has positive, neutral or negative impacts on human health. The scientific community often defines geophagy as a pathological behavior, an eating disorder, or a symptom of mental illness. This is likely associated with the general acceptance of 'germ theory' which views dirt as a vector for the spread of disease *(32)*.

HEALTH IMPACTS

The best-studied potential consequence of geophagy is the risk of ingesting soil-borne infectious parasites. Two organisms that are of concern during pregnancy are hookworm and *Toxoplasma gonii*, associated respectively with malnutrition and fetal nervous system damage *(2, 33)*. Another proposed consequence of geophagy is lead poisoning, with numerous reported case studies suggesting the co-occurrence of lead poisoning and geophagy *(34-36)*. Lead exposure can lead to maternal and fetal kidney damage, encephalopathy and impaired cognitive function *(35)*. Other documented health impacts include constipation, bowel obstruction, hypokalemia, poisoning due to other toxins present in the environment and a possible exacerbation of malnutrition *(35)*. Additionally, some studies have hypothesized possible associations of maternal geophagic behaviour with negative birth outcomes such as low birth weight, neural tube defects, small head circumference, premature birth, and elevated perinatal mortality, likely due to heavy metal toxicity and maternal malnutrition *(25,37)*. Finally, others have concluded there is no specific pregnancy outcome associated with geophagy *(38,39)*.

Many studies have treated geophagy as a behaviour that may provide nutrients otherwise absent in the diet *(10)*. The types of soil most commonly consumed tend to be high in calcium or iron *(11)*. Studies comparing the micro-nutritional value of geophagic material and pharmaceutical supplements for pregnancy show surprising comparability for several important nutrients including calcium, magnesium and iron *(25)*. Although the extent of soil absorption in the intestinal tract is unknown, it is possible that geophagists receive nutrients from the soil. Thus, there are potential benefits of geophagy that cannot be discounted, and must be explored to understand the implications of this behavior.

The practice of human geophagy, particularly during pregnancy, clearly has substantial and pertinent implications for maternal and child health as well as effects on social interaction and behaviour patterns in poor, rural communities. Studying the prevalence and impacts of this behaviour is becoming increasingly important, as the growing widespread use of agrochemicals in Panamanian agriculture *(40)* is causing high levels of toxic chemicals in soils that may be ingested. This study was developed to assess the causes as well as the social and biophysical impacts of human geophagy during pregnancy in Panama in order to understand its general context in a country where it has not previously been documented. Components of the study included informal interaction and observation within rural communities, structured individual interviews, and analysis of soil composition of confirmed geophagic materials.

Fig 1. Map of Panama showing provincial boundaries
Image used under creative commons license; accessed from http://mapsof.net/uploads/static-maps/countries_panama_provinces_2005_10_18_en.png

Fig 2. Map of Veraguas, Panama (green circles demark farms visited.)
Image used under creative commons license; accessed from http://mapsof.net/panama/static-maps/jpg/veraguas-panama-political-map

METHODOLOGY

Data were collected at 10 community-owned farms in western Panama, in the province of Veraguas and the *Ngöbe-Buglé comarca* land reserve (Fig. 1). Access to the farms was provided through the local NGO the '*Patronato de Nutrición*' that works with rural subsistence farmers to manage and run community farms. For the purposes of this project, farms were selected based on accessibility (Fig. 2). Data collection began with a concise, neutral introduction to geophagy including a description of the behaviour and summaries of both possible benefits and risks to maternal and child health, combined with an explanation of the research project and objectives. The introduction was given to all members of a farm and time was allowed for public sharing of stories or opinions on the topic by members of the community. This was followed by obtaining informed consent and conducting private, structured interviews with female volunteers (n=41) from the group using a questionnaire and interview methodology written in accordance with the McGill University Protocol for Research in Panama's Indigenous Communities *(41)*. Additional interviews were conducted with health care workers at the regional Hospital Ezequiel Abadía in Soná, Veraguas, and at the health center at Nuestra Señora del Camino in San Félix, Chiriquí. Five samples of approximately 100g of geophagic material, identified by confirmed geophagists were collected. Laboratory analysis for parasite eggs was carried out by the Parasitology Department of the University of Panama using a 3-step process of simple sedimentation, and treatment with formolether, and flotation. Mineral composition of the samples was determined by the "*Instituto de Investigaciones Científicas y Servicios de Alta Tecnología*" (INDICASAT) following the methodology in Geissler et. al. *(42)*: from each sample, 10.0g were shaken with 100ml of 0.1M HCl for 2 hours to simulate human digestion and the filtrate was examined for select minerals by inductively coupled plasma (ICP) mass spectrophotometry *(42)*.

RESULTS

The prevalence of confirmed geophagy among women interviewed was 22.5%. The most commonly consumed materials were red non-porous clay, red dry soil and yellow dry soil, with more infrequent reports of termite mound soil, river rocks and wet ash. Although some women practiced geophagy throughout their lives, it was most common during childhood and pregnancy. The average amount consumed was shown as handfuls by geophagists and approximated as 50g per event, ingested about once a week. Discussions revealed a strong stigma associated with the behaviour: almost all geophagists practiced in complete solitude and expressed embarrassment in response to their actions. Those that admitted to a desire to partake in geophagy without having done so (12.2%) explained that they did not do so because the staff at the local *Centro de Salud* (health centre) told them it was dangerous. As well, geophagists reported an intense desire to ingest the material associated with its smell, and an increased likelihood of engaging in geophagy after heavy rainfall. Overall, confirmed geophagists had more children, lower estimated infant survival (calculated by dividing the number of children to survive past age 5 by the total number of births in the mother's lifetime), were older in age, ate animal protein less frequently and had fewer years of formal education than non-geophagists (*Table 1*).

Interviews with health care workers in the regional urban government hospital in Soná and rural non-government health center in San Félix revealed a perception that geophagy is an unhealthy vice that should be discouraged. The head nurse of obstetrics in the regional hospital believed geophagy used to be more common but is now almost unheard of due to the improvement of access to healthcare in Panama since the 1980s. Conversely, the worker at the small health center maintained it was very common in rural and indigenous areas and is recognized as one of the first symptoms of pregnancy. Both health care workers believed geophagy could lead to premature birth, maternal and fetal malnutrition and peri-natal complications.

Laboratory analysis of geophagic material samples revealed that no sample contained any human parasite eggs or any detectable amounts of lead or nickel; however they did contain considerable amounts of essential minerals such as copper, iron and magnesium.

	Geophagic women (n=9)	**Geophagic women** (n=9)	**p-value**
Average Age (years)	47.9	40.3	0.194 *(2-tailed t-test)*
Average # Children	6.1	4.8	0.271 *(2-tailed t-test)*
Estimated Infant Survival Rate	88.7%	93.9%	0.18 *(chi-square)*
Meat > 1/Week	0%	39.4%	0.054 *(chi-square)*
Literacy Rate	55.6%	96.9%	0.001 *(chi-square)*
Average # yrs of education	3.2	5.6	0.009 *(2-tailed t-test)*

Table 1. Comparison of pertinent socioeconomic indicators that were evaluated among interviewees

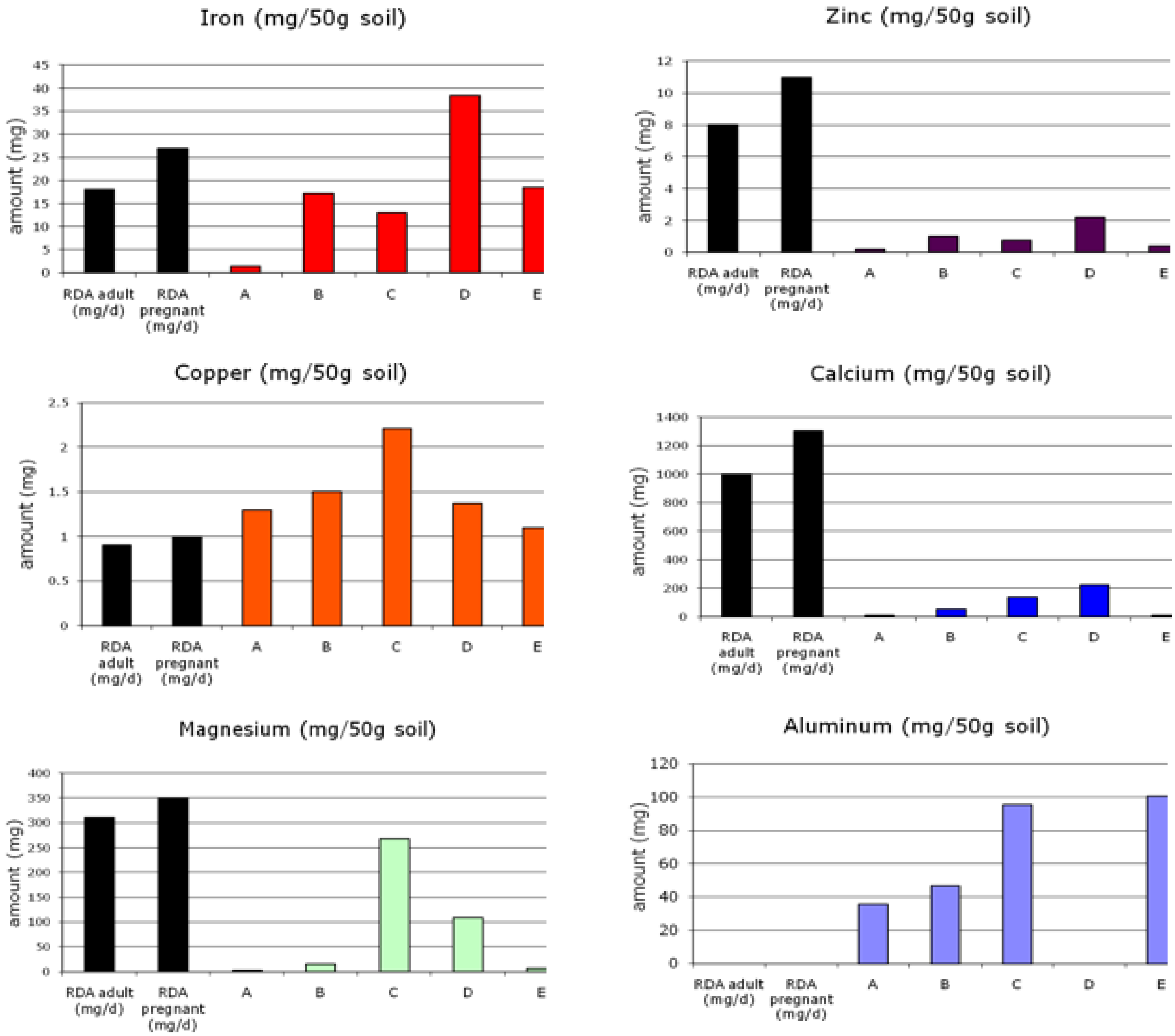

Fig. 3 Nutrients in soil available for absorption in an average single geophagic event of 50g soil. Amounts of the five soil samples are compared to Health Canada's recommended daily allowances (RDAs) (43, 44) for adults (first column) and for pregnant women (second column) for six nutrients. No sample had any detectable amounts of lead or nickel

DISCUSSION

This is the first documented study of geophagy in Panama. In the examined area, there is no apparent cultural or religious component to the behaviour. All confirmed geophagists indicated that they carried out the activity in solitude in response to a strong desire for the material associated with its smell. For many of the respondents, the formal interview was the first time they had spoken about geophagy. Because of the strong stigma associated with the behaviour, it is extremely likely that the prevalence of geophagy is higher than observed, thus making analysis of associated socioeconomic and health effects extremely difficult.

The observed social stigma associated with geophagy is clearly perpetuated by local health care workers that regard it as an undesirable act. Some of the interviewees expressed a desire to engage in geophagy but had never done it because they were given the impression by healthcare workers that it was a dangerous and unhealthy practice. However, if geophagy is an adaptive response to a physiological need, it is entirely possible there are nutritional benefits gleaned by those who desire to engage in this activity. Until we have a more full understanding of its impacts on health and social interaction within a community, the subject should be approached with neutrality and sensitivity by both researchers and health care workers.

One notable observation was the correlation between socioeconomic factors and geophagy. There was a strong, statistically significant association between levels of education and geophagy, with geophagic women reporting fewer years of education ($p=0.009$) and lower literacy rates ($p=0.001$). This is interesting because it points to geophagy being more strongly linked with education as opposed to nutrition. Statistically insignificant associations include less meat intake ($p=0.054$), lower infant survival rate ($p=0.18$), older age ($p=0.194$) and greater number of children ($p=0.271$). An increase in sample size is required in order to guarantee statistical significance of results and run regression modeling in order to determine relative strength of correlation. In agreement with previous studies linking the behaviour with iron deficiency and anemia, we found geophagy to be more common in individuals with lower frequency of meat consumption and poorer overall nutrition in general. Many of the geophagic women indicated they did not have enough food for three meals a day, and were subsisting on rice and beans, with meat consumption occurring less than once per week. The iron, copper and magnesium from a 50-g sample of the soil could potentially contribute substantially to meeting Health Canada's recommended daily allowances for essential micronutrients (*Fig. 3*).

If the behaviour is in fact driven by iron-deficiency anemia or other micronutrient deficiencies, geophagy may be a physiologically corrective behaviour. However, in vitro attempts by Hooda et. al (2004) to determine actual benefit from samples of geophagic materials suggest a net decrease in nutrient absorption for iron, copper and zinc, despite the minerals being present in the soil itself *(21)*. Conversely, the study also suggests the same soils may increase the absorption of other nutrients such as calcium, magnesium and manganese, yet this varies for different samples studied. Clearly, the mechanisms of nutrient absorption are complex across different soils and for different minerals. In our study, we observed a large contribution of the daily requirement of iron and other minerals by the soil after a simple simulated human digestion. Yet it is clear that without a complete and in-depth absorption analysis like that done by Hooda et. al. for these specific samples, it is difficult to draw final conclusions on the overall physiological benefits or harm of the observed geophagy.

In three communities, there were reports of people having severe medical complications due to geophagy. There were reported incidences of abdominal swelling, yellowing of the skin, and death due to soil consumption. However, there were no available hospital records to confirm this. Yellow skin and abdominal swelling are both symptoms of liver failure, which may indicate parasite infection or heavy metal poisoning *(45)*. Although we found no evidence of human parasite eggs, our limited sample size made it unlikely that we would detect such parasites. None of the soil samples had any detectable levels of lead or nickel. Copper intake from 50g soil is below the acute copper toxicity limit of 15mg/d *(43)*. Aluminum intake from 50g of any of the soil samples was well below the acutely dangerous level of 302mg of aluminum/day *(46)*, but the accumulation of aluminum in the body over time even at lower levels of intake per day may negatively affect blood iron levels and nerve function *(46)*. Adverse effects of geophagy indicative of liver failure, such as those reported in the farms, could occur if the amount of soil ingested exceeds approximately 150-200g per day, an amount substantially higher than the average 50g per week.

CONCLUSION

In this study, we show that geophagy exists in modern day Panama among the rural poor. Women carry out this highly stigmatized behavior in private, primarily during pregnancy and childhood. Soil samples of confirmed geophagic materials indicate no presence of parasites or acutely dangerous levels of heavy metals, and the potential for nutritional benefits. Within rural communities, geophagy was most notably linked to lower levels of education, and may be linked to poorer nutritional status, more children, and older age. The multifaceted nature of this topic of research calls for an interdisciplinary team of researchers in order to effectively evaluate its prevalence and potential health impacts. Further studies are needed to investigate the physiological impact of soil ingestion on mineral status, to increase the sample size, and delve into causative pathways and health outcomes of this under-studied behaviour in rural Panama.

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