Journal of Sciences and Multidisciplinary Research
Volume 8, No. 1, 2016
ISSN: 2277-0135

GEOPHAGIC PRACTICE AND ITS POSSIBLE HEALTH IMPLICATIONS – A REVIEW

Ogidi Odangowei I. & Omu Okiemute

Department of Science Laboratory Technology,
Federal Polytechnic Ekowe, Bayelsa State, Nigeria
Email: oodangowei@yahoo.com

Abstract: Geophagia is the habitual and intentional ingestion of soil and clay deposits by humans and animals. It is a controversial centuries-old practice, common to all societies yet deeply frowned upon by many. The practice is due to reasons of culture, medicinal, religious and mineral deficiency. Geophagia has been reported to be common among pregnant women, lactating women, school children and people with psychiatric disorders and this is evidenced by the sale of geophagic materials in markets across Africa. Geophagia may be beneficial or detrimental to human health. Beneficial aspects include the use of kaolin as antidiarrhoeals, and for the allevation of gastrointestinal upsets, supplementation of mineral nutrients and relief of excess acidity in the digestive tract. Certain clays or soils have been identified as having special constituents, valuable as oral and topical antimicrobials as well adsorbents to toxins. Geophagia has been associated with iron deficiency anaemia. Other health implications of geophagia include constipation, intestinal obstruction, dental damage, peritonitis and eclampsia. Whatever the possible benefits that may accrue from such a habit, the risk of ingesting the eggs of parasitic worms as well as exposure to highly toxic bacteria and heavy metal poisoning cannot be excluded. The interplay of factors involved in geophagia, though varied, complicated and researched may not have been fully known.

Keywords: Geophagia, Human Health, Pregnancy, Anaemia.

INTRODUCTION

Geophagia is the deliberate intake of high doses of soils and clays (tens of grammes) by humans that has been described as difficult to comprehend by some people in developed societies and even by some in the academic fraternity who regard it as bizarre, filthy, degrading, morbid, odd and curious, hence the pejorative name 'dirt eaters' [19].The practice of geophagia appears to be as old as human-kind and is more prevalent in some societies than others. Various theories have been advanced for its existence but satisfactory explanation is yet to be provided. Geophagia was regarded as magical and superstitious in the 16th to 18th centuries, hence the desire to prevent it and provide therapy for those who indulged in the practice [23]. Women practicing geophagia believe geophagia enhances beauty, could be beneficial to pregnant women or even enhance fertility [60]. There are three major hypotheses about the physiological causes of pica: hunger, micronutrient deficiency and protection from toxins and pathogens. In Africa pregnant women consume soil because they believe it facilitates smooth delivery and enhance dark skin pigment for the baby. Other reasons advanced by pregnant women include simple craving due to their smell and texture, the soils ability to reduce the symptoms of morning sickness, hunger pangs and believe that soils can provide some micronutrients important for the fetus [28]. Although there is evidence to suggest that the practice is not limited to poor people but cuts across socioeconomic, ethnic, religious, gender and racial divides [3]. The African explorer, David Livingstone, in his detailed report on his observations of geophagia, refuted poverty as a possible explanation [81] and noted that the practice was common amongst slaves, contented workers, as well as the poor, and that the abundance of food did not prevent it [53]. No single reason for the practice of geophagia by all

societies has been advanced. In Peru, lumps of clay were used as pacifiers for little children [75] and in the 19th century Sweden it was not unusual for certain people to mix earth and flour to bake bread [35] although it is not clear whether such action was necessitated by the shortage of flour or an act to improve quality and/ or taste of bread [62]. In the south of USA, geophagia was reported to be so prevalent that clay could be purchased in small bags at bus stations for the convenience of travellers; and migration of African American families to the North in search of jobs, saw large sacks of clay purchased and mailed to them by relatives who stayed behind [22, 55]. Geophagia clays have been commonly designated according to the name of community from which they come [74]. In parts of Nigeria, clays is mined in large quantities and distributed for sale in markets all over West Africa [40]. Geophagic practice is so prevalence that some clay for sale in open markets throughout Cameroon are generally referred to as 'Calabar chalk'; named after Calabar, a city in the South Eastern part of Nigeria renowned for mining and sale of geophagic clays. Pregnant women in Nigeria and Cameroon believe that the eating of clay is good for their unborn children because it makes the skin of their babies smooth and beautiful.

Reports in South Africa reveal that young urban women believe that earth-eating makes them more beautiful [81]. Geophagic materials are generally unprocessed but there are a few cases in which the materials are processed before consumption. For example, they are sometimes burnt or mixed in water and then allowed to settle before the suspension is drunk. Such an aqueous suspension, called argillic water, not only modifies the mineralogical composition of the material, since the minerals in water settle according to their difference specific gravity and size, but also changes the water chemistry, due largely to the hydrolysis of minerals, oxides, hydroxides and other matters present in the geophagic material [72]. Some of the reasons advanced bygeophagic individuals include; nutrient supplementation, detoxification, alleviation of gastrointestinal disorders such as diarrhoea, craving and relief from morning sickness [34] or as part of cultural belief system [61]. Despite these beneficial aspects of geophagia, several studies have associated the practice with detrimental effects such as; iron deficiency anaemia [60], hypokalaemia [9], excessive tooth wear, enamel damage and erosion of the mucosal surface of the stomach, perforation of the colon [7, 24], parasitic infections resulting from transmission of Ascarislumbricoides, and other highly toxigenic bacteria causative agents of gas gangreus, tetanus and boitulism [66, 9]. The main purpose of this review is to evaluate the implications of geophagic practice on human health as a precursor to undertake a multidisciplinary research in an effort to unlock the secret of geophagia.

EPIDEMOLOGICAL ASPECT OF HUMAN GEOPHAGIA

The practice of ingestion of soils and clays may be deliberate or non-deliberate. Their components get into humans and animals through various pathways which could be direct or indirect. Some of the direct pathways include geophagia, soil in association with edibles, inhalation of dust, inhalation of soil gases, and assimilation of soil components by skin lesions. Also, components of soil may be acquired through water sources; particularly of importance is the 'biomagnifications' of chemical such as pesticides and their detrimental effects. Any of these pathways can also be route of pathogens and exposure to hazard [25, 43, and 76]. Studies have shown the antiquity and worldwide distribution of geophagia. There are indications that the phenomenon is not restricted to any particular age group, race, sex, geographic region, or time period [6,17,50], although young children are particularly vulnerable to the habit of soil-eating. Children under the age of 18 – 20 months normally explore and acquaint themselves with the environment by mouthing everything they come across [27]. Beyond this age however, deliberate soil – eating is often considered abnormal [3]. Generally, geophagia is a traditional

cultural or religious activity [74], which has been observed during pregnancy [81], or as a remedy for disease [73, 20]. Culturally speaking, the practice amongst many of the kaolin eaters emanates from having doubtless watched their mothers or close relations eat the clay. Many of the studies on geophagia have advanced many more other reasons for this practice around the world. In the Southern parts of USA, pregnant women who traditionally ate substances like clay, corn starch and baking soda believed that such substances helped to prevent vomiting, helped babies to thrive, cured swollen legs and ensured beautiful children. Many pregnant women in rural southern Georgia eat kaolin or grayish native clay to Georgia. They crave the 'dirt' and claim that it helps quite their pregnancy sickness and make them feel better [18]. Clay eating is widespread among women in Africa but in particular five African countries namely Malawi, Zambia, Zimbabwe, Swaziland and South Africa, where an estimated prevalence level in the rural areas of these countries is part at 90% [77]. In South Africa, the eating of clay is mostly observed among pregnant women. The prevalence of pica among urban and rural black South African women was reported to be 38.3 and 44.0% respectively as compared to the prevalence among the Indian, coloured and White women put at 2.2, 4.4 and 1.6%, respectively [77]. Studies have also established that geophagia is rife among the Tanzanians and Kenyans in the Eastern part of Africa [82]. A particular study by [54] among 827 pregnant women in Western Kenya during and after pregnancy showed that a significant number of these women (65%) reported earth – eating before pregnancy. The prevalence remained high during pregnancy, and then declined to 34.5 and 29.6% at 3 and 6 months post – partum, respectively. Analysis of random stool samples from the study group revealed that faecal silica and geophagia were strongly correlated. Geisler *et al* [29] also reported geophagia as a risk factor for heliminthiasis in Kenyan school children. Geophagia has also been reported in Senegal, Mali [58], Guinea [33] as well as Nigeria [4] in West Africa. Gilardi and Co-investigators quoted by Diamond (1999) noted that there are preferred soils as far as soil-eating is concerned. Several soil types are consumed by geophagic individuals. These include red, white, yellow, brown clay types, termite mounds and various other types of soil. In Australia, some aborigines eat white clay found mostly in the billabounds of the coastal areas of the North territory, fresh water, springs and riverbeds mainly for Medical purposes [8]. The preferred type of earth eaten by Kenyan women according to Louba *et al* [54] was soft stone, known locally as Odowa and earth from termite mounds.

BENEFITS OF HUMAN GEOPHAGIC PRACTICE

Clay-rich soils have been reported to adsorb intestinal unwanted substances (Dominy *et al.,* 2004). Microbial agents such as *Yersiniaenterocolitica, Escherichia coli, Streptococcus Faecalis, Helicibacter Pylori,* and Mycobacteria have been postulated to play a role in the aetiology of Crohn's disease which is characterized by a severe, non-specific, chronic inflammation of the intestinal wall [51, 65, 48]. According to Shanahan [68], alterations of the flora with probiotics and antibiotic strategies have putative beneficial effects in human beings and other animals. Several studies have emphasized the role of probiotic bacteria to favourably alter the intestinal microflora balance, inhibit the growth of harmful bacteria, promote good digestion, boost immune function, and increase resistance to infection [77]. There is therefore, evidence that supports the usefulness of the commensal flora found in soil as vital in the establishment of healthy bacteria within the digestive tract, addressing the problems presented by Crohn's disease and Leaky gut syndrome. Just as charcoal is prescribed in cases of child poisoning for its adsorptive role, ingested clay in pregnant women may improve digestive efficiency and also reduce fetal exposure to toxins tolerated by mother. Aflatoxin is a known toxin produced by fungi. There have been reports of the amelioration of the toxic effect of aflatoxin [64], aflatoxin and fumonisin [59] in animal feeds by the addition of Sodium bentonite to the broiler chick

diets. Some specific beneficial pharmaceutical usage of edible soil includes that of white clay (Kaolin) mined in Georgia and South Carolina used in the production of Mist kaolin, a diarrhoea remedy [56].Studies have showed that minerals from clay could provide inexpensive, highly – effective antimicrobials to fight numerous human bacteria infections including the Superbug Methicillin – resistance Staphylococcus aureus (MRSA) [36, 80] and buruli ulcer an infection caused by mycobacterium ulcerans which has been declared to be ' an emerging public health threat' by the WHO [79]. The bacterium produces a potent Immunosuppressant toxin that causes necrotic lesions and destroys the fatty tissues under the skin. In West Africa, specifically Cameroon and Nigeria, where human consumption of geophagic clays is very prevalent, Ekosse and Jumbam [23] looked at the mineralogy and chemistry of some commercially available geophagic samples from the two countries. They concluded that geophagic individuals who consume the clays may benefit from their possible medicinal and nutritional values. For example, Calcium is very important for the development of bones, especially for unborn children and some clay have been claimed to supplement Calcium, augmenting the Calcium contribution from milk and other dairy products [38]. This claim may justify the observation that pregnant women, who need extra Calcium, are predisposed to geophagia [31, 32, 54]. Soil colloids and minerals have been reported to provide protection to DNA against degradation and this is dependent on the mineralogy of the soil [10]. According to the study, higher level of protection was found with Montmorillonite and organic clays compared to kaolinite and inorganic clays.

Harmful Effects of Human Geophagic Pratice

The intake of essential elements and minerals by the human body is achieved unconsciously by way of balanced nutrition or through conscious supplementation whenever the need arises. Although essential to human health, some chemical elements can be toxic or even lethal, depending on the individual dosage [34]. This principle of dosage and toxicity was first described by Paracelcus (1493 – 1541BC), who claimed that 'all substances are poisonous; there is none which is not a poison; the right dose differentiates a poison from a remedy'. Geophagia has been linked to anaemia (iron deficiency) for several centuries [21, 81]. More recently, researchers and physicians have confirmed this long-held observation [13, 49]. In terms of toxicity of chemical elements in geophagic materials, emphasis to date has been placed on Lead in children and adult [78]. Lead is a well-known neurotoxin and particularly harmful to the developing brains and nervous systems of young people. While there has been a sheep decline in blood Lead concentration in the last decade due to the removal of Lead from petrol and food canning processes. There are still substantial amounts of Lead, Calcium and Zinc, particularly in urban soils. Children in such areas are susceptible to poisoning from deliberate (or otherwise) ingestion of soil from their local yard and school playgrounds [37]. It is therefore necessary that any risk assessment should involve Lead as well as encompass other potentially harmful elements such as arsenic and organic contaminants. The toxic effects of chemical elements and organic pollutants may not be immediate, accumulating over time and manifesting too late for any meaningful medical intervention, although dental inspection may reveal soil ingestion or geophagic habits due to excessive tooth wear [1]. However, internal accumulation of soils may cause not only constipation and abdominal pain but also obstruction and perforation of the colon [5, 8]. In pregnant women cases of dysfunctional labour and maternal deaths due to internal accumulation of soils have been reported [39, 46]. Soil harbour so many pathogenic microorganism is no mere speculation but a fact. Isolation of human pathogens from soil dated back to several decades. A recent molecular characterization of a novel clinical isolate of *Franisellaspp* (the causative pathogen of tularaemia) showed genetic relatedness to species of the pathogen cloned from soil sample. Therefore, a lot of pathogenic

microorganism which are resident in soil can be detrimental to human health if such soil is consumed. Aneamia resulting from geophagia, to which the craving for soil is attributed, is believed in some cases to have actually resulted from the worm or microbial infection encountered by ingestion of soil. The global burden of geohelminth infections is of great enormity. Worldwide, there are approximately 3.5 billion infections with parasitic geohelminths:Ascaris, Trichuris, and hookworm [15]. The eggs of parasitic worms (geohelminths) can be consumed with ingestion of soil. Ascariasis (characterized by abdominal pain and nausea with disturbed functioning of the alimentary tract) and trichiuriasis are caused by the ingestion of Ascarislumbricoides and Trichuristrichiura eggs, respectively [3]. Several studies have linked geohelminths infection with soil consumption. Geohelminths infection was linked to iron-deficiency among HIV-infected women who indulge in geophagia [44]. Separate studies on geophagous children in Jamaica and Kenya [30] reportedly gave a quantitative estimate of the level of exposure to intestinal A. lumbricoides and T. trichiura infection experienced by the children. Geophagia according to Glickman *et al.,* [33] is an important risk factor for orally acquired nematode infections in African children. The spore-bearing Clostridium perfringens and C. tetani are often encountered in the surface layers of soil (and in human and animal excreta). They are particularly abundant in cultivated and manured fields, especially in the trophies [3]. These bacilli belonging to the family of bacteria which produce one of the deadliest toxins often cause infections by contamination of wounds exposed to the spore-bearing soil. C. tetani is the causative organism of tetanus while C. perfringens is the etiology of gas gangrene. Also of important consideration is the association and survival of prions in soil. Prions are incriminated in transmissible spongiform encephalopathies (TSEs) in humans and animals, primarily affecting the central nervous system [63]. Kuru provides the principal experience of epidemic, human prion disease giving rise to the onset of variant Creutzfeildt-Jakob disease (VCJD) [14, 16].

Its incidence has steadily fallen after the abrupt cessation of its route of transmission (endocannibalism) in Papua New Guinea in the 1950s. Johnson *et al.* [42] examined the potentials for soil to serve as a TSE reservoir by studying the interaction of the disease associated prion protein with common soil minerals. The study demonstrated substantial prion protein adsorption to two clay minerals, quartz, and four whole soil samples. Despite cleavage and avid binding, prion protein bound to Montmorillonite remained infectious. From the study it was suggested that prion protein released into soil environments may be preserved in a bio-available form, perpetuating prion disease epizootics and exposing other species including humans to the infections agent. The role of plasmid DNA in genetic material transfer particularly the transfer of antibiotic resistance genes among species of microorganism humans and animals cannot be overemphasized. Studies have shown that plasmid DNA could be amplified from soil or clay particles [10, 11, 12, 83]. According to Cai*et al.* [11], polymerase chain reaction (PCR) was used to amplify plasmid DNA bound to soil colloidal particles from brown and Red soil, and three different minerals (goethite, Kaolinite, Montmorillonite). The ease of isolation was dependent on the particle type. The consumption of soils or clays which contain antibiotic resistance plasmid may be of grave adverse effects to humans. This may significantly contribute to the problem of emerging antibiotic resistance.

Human Geophagic Practice: General Health and Economic Considerations

Issues around geophagia are conflicting while some beneficial roles have been described for this form of pica, others have found it detrimental and an aberrant behaviour. Klein *et al.* [47] alluded to the hypothesis that soil enhances the pharmacological properties of the bio-available gastric fraction. In other words, it enhances bioactivities. Highly adsorbent smectitil clays have

been demonstrated to cause the lining of the vertebrate gut to change both on a cellular and acellular level, potentially protecting the gut from unwanted chemicals as well as alleviating ailments such as esophagitis, gastritis and colitis. According to Johns and Duquette [41], humans use clay explicit to render tanniniferous acorns and alkaloid-rich potatoes edible. The benefits accruing from soil is unquantifiable. Abrahams [2] highlights the fact that geophagia provides for a direct soil-human geochemical pathway given that ingested soils have the potential to supply important elements such as iron (Fe) to an individual [71]. There could be some economic advantage accruing from the practice of geophagia. Vermeer and Ferrel [73] revealed that a single Nigerian Village produces 500 tons of soil yearly for consumption across West Africa; hence geophagia is a source of income generation. To date, scavenging for geophagic material still persist and forms a source of income to most rural dwellers involved. Trade in geophagic material as therapeutics serves a means of income [69].

CONCLUSION

Geophagia is a result of an interwoven multivariate factors ranging from cultural to religious and even disorders. First of all, considerable research and education need to be invested in it. This is not likely to happen soon since the practice is looked upon as a minority problem with, as yet, no evidence of alarming health risks that would trigger the interest of governments or industry. From the scientific point of view, geophagia remains a challenge as there is as yet no acceptable explanation for this practice which allows geochemical elements to enter the human system in much higher concentrations than normal. Nevertheless, there is increase evidence that the interactions of chemical elements within the human body are more complex than originally thought. Geophagic studies have focused more on the mobility of hazardous or dangerous elements whereas the bioavailability of such elements is neglected. Geophagists can be affected either positively or negatively by the chemical elements in the soil they eat. The healing use of soil and clay materials is widespread in every culture. Clayey materials in particular are regarded as chemically inert with low or no toxicity. Due to their high specific surface areas and their absorption and adsorption capacities, they find applications as gastrointestinal protectors, laxatives and as antidiarrhoeals. While the beneficial effects of healing soils and clays have been identified by trial and error, the side-effects of some of these materials can go unnoticed for a long time. Many reports on geophagia have concentrated on the beneficial effects of the practice while neglecting the possible risks that may come from toxic chemical elements and pathogenic microorganisms. However, education of geophagic individuals on the risks and benefits as well as safe preparation, storage and use of geophagic clays should be intensified. Let us not forget that there could be some economic advantage accruing from the practice of geophagia. A lot needs to be unravelled in terms of the soil, constituents, human consumption and health. The interplay of factors involved in geophagia, though varied, intricate and researched, may not have been fully elucidated. This review is expected to stimulate interest in this area of significance. Further concerted efforts aimed at multidisciplinary research are warranted so as to address gaps in the corpus of knowledge on the important subjects.

REFERENCES

1. Abbey, L.M. and Lombard, J.A. 1973. The Etiological Factors and Clinical Implications of Pica: Report of a Case. *Journal of American Dental Association* 87: 885–887.

2. Abrahams, P. 1999. The Chemistry and Mineralogy of Three Savanna Lick Soils. *Journal of Chemical Ecology, 25,*2215-2228.

3. Abrahams, P.W. 2002. Soils: Their Implications to Human Health. The Science of the Total Environment 291: 1–32.

4. Ademuwagun, Z.A., Ayoade, J.A., Harrison, I.E. and Warren, D.M. 1979. The African Therapeutic Systems. Waltham, Mass., USA: Crossroads Press. (African Studies Association); Brandeis University, p. 273.

5. Amerson, J.R. and Jones, H.Q. 1967. Prolonged Kaolin (clay) Ingestion: A Cause of Colon Perforation and Peritonitis. Bulletin of Emory University Clinic 5: 11–15.

6. Anell, B. and Lagercrantz, S. 1958. Geophagical Customs. Uppsala. Uppsala University Studia Ethnographica Upsaliensa. 17: 1 -84.

7. Barker, O.B. 2005. Tooth Wear as a Result of Pica. *British Dental Journal*, 199: 271-273.

9. Bateson, E.M and Lebroy, T. 1978. Clay Eating by Aboriginals of the Northern Territory. *Medical Journal of Australia Special Supplement: Aboriginal Health* 10: 1–3.

10. Bisi-Johnson, M.A., Obi, C.L. and Ekosse, G.E. 2010. Microbiological and Health Related Perspectives of Geophagia: An Overview. *African Journal of Biotechnology* 9(19): 5784–5791.

11. Cai, P., Huang, Q.Y. and Zhang, X.W. 2006. Interactions of DNA with Clay Minerals and Soil Colloidal Particles and Protection against Degradation by DNASE. Environ. Sci. Technol. 40(9): 2971-2976.

12. Cai, P., Huang, Q.Y., Lu, Y.D., Chen, W.L., Jiang, D.H. and Liang, W. 2007. Amplification of Plasmid DNA Bound on Soil Colloidal Particles and Clay Minerals by the Polymerase Chain Reaction. J. Environ. Sci. (China). 19(11): 1326-1329.

13. Cai, P., Zhu, J., Huang, Q., Fang, L., Liang, W. and Chen, W. 2009. Role of Bacteria in the Adsorption and Binding of DNA on Soil Colloids and Minerals. Colloids Surf B Biointerfaces. 15, 69(1): 26-30.

14. Carlander, O. 1959. Aetiology of Pica. Lancet, 2: 569.

15. Caughey, B. 2003. Prion Protein Conversions: Insight into Mechanisms, TSE Transmission Barriers and Strains. Br. Med. Bull. 66: 109-120.

16. Chan, M.S. 1997. The Global Burden of Intestinal Nematode Infections- Fifty years on. Parasitol. Today, 13: 438-443.

17. Collinge, J., Whitfield, J., Mckintosh, E., Beck, J., Mead, S., Thomas, D.J. and Alpers, M.P. 2006. Kuru in the 21st Century-An Acquired Human Prion Disease with Very Long Incubation Periods. Lancet, 367(9528): 2068- 2074.

18. Cooper, M. 1957. Pica. Illinois: Charles C. Thomas, p. 105.

19. Corwin, T. 1999. The clay eaters. http://chronicle.augusta.com/stories/ 031899/fea clay. Shtml

20. Dickens, D. and Ford, R.N. 1942. Geophagy (dirt eating) among Mississippi Negro School Children. American Sociological Review 7: 59–65.

21. Dominy, N.J., Davoust, E. and Minekus, M. 2004. Adaptive Function of Soil Consumption: An in Vitro Study Modeling the Human Stomach and Small Intestine. The Journal of Experimental Biology 207: 319–324.

22. Dunn, P.M. 1997. Avicenna (AD 980–1037) and Arabic Perinatal Medicine. Archives of Diseases in Childhood 77: F75–F76.

23. Edwards, C.H., Johnson, A.A., Knight, E.M., Oyemade, U.J., Cole, O.J., Westney, O.E., Johns, S., Laryea, H. and Westney, L.S. 1994. African American Women and their Pregnancies. *Journal of Nutrition* 124(6): 9545–9625.

24. Ekosse, G.E. and Jumbam, N.D. 2010. Geophagic Clays: Their Mineralogy, Chemistry and Possible Human Health Effects. *African Journal of Biotechnology* 9: 6755–6767.

25. Ekosse, G.E. and Anyangwe, S. 2012. Mineralogical and Particulate Morphological Characterization of Geophagic Clayey Soils from Botswana. *Bulletin of the Chemical Society of Ethiopia,* 26(3): 373-382.

26. Fergusson, J.E., Forbes, E.A. and Schroeder, R.J. 1986. The Elemental Composition and Sources of House Dust and Street Dust. Sci. Total Environ. 50: 217-221.

27. Ferrell, R.E. 2008. Medicinal Clay and Spiritual Healing. J. Clay, Clay Min. 56(6): 751-760.

28. Fessler, D.T. and Abrams, E.T. 2004. Infant Mouthing Behavior: the Immunocalibration Hypothesis. Med. Hypotheses. 63: 925-932.

30. George, G. and Ndip, E. 2011. Prevalence of Geophagia and its Possible Implications to Health – A Study in Rural South Africa: 2nd International Conference on Environmental Science and Development IPCBEE vol.4 Retrieved from http://www.ipcbee.com/vol4/37-ICESD2011D10046.pdf

31. Geissler, P.W., Mwaniki, D., Thiong'o, F. andFriis, H. 1998a. Geophagy Asa Risk Factor for Geohelminth Infection: a Longitudinal Study of Kenyan Primary School Children. Transactions of the Royal Society of Tropical Medicine & Hygiene 92(1): 7–11.

32. Geissler, P.W., Mwaniki, D., Thiong'o, F., Michaelsen, K.F. and Friis, H. 1998b. Geophagy, Iron Status and Anemia among Primary School Children in Western Kenya. Tropical Medicine & International Health 3(7): 529–534.

33. Geissler, P.W., Shulman, C.E., Prince, R.J., Mutemi, W., Mnazi, C., Friis, H. andLowe, B. 1998c. Geophagy, Iron Status and Aneamia among Pregnant Women on the Coast of Kenya. Transactions of the Royal Society of Tropical Medicine & Hygiene 92(5): 549–553.

34. Geissler, P.W., Shulman, C.E., Prince, R.J., Levene, M., Poda, C., Beckerleg, S.E., Mutemi, W. and Shulman, C.E. 1999. Perception of Soil Eating and Anaemia among Pregnant Women on the Kenyan Coast. Soil Science & Medicine 48: 1069–1079.

35. Glickman, L.T., Camara, A.O., Glickman, N.W. and McCabe, G.P. 1999. Nematode Intestinal Parasites of Children in Rural Guinea, Africa: Prevalence and Relationship to geophagia. Int. J. Epidemiol. 28: 169- 174.

36. Gomes, Celso, D.E., Sousa, F. and Silva, J.B. 2007. Minerals and Clay Minerals in geology. Applied Clay Science 36: 4–21.

37. Halsted, J.A. 1968. Geophagia in Man: Its Nature and Nutritional Effects. *American Journal of Clinical Nutrition* 21: 1384–1392.

38. Haydel, S.E., Remenih, C.M. and William, L.B. 2008. Broad-spectrum in Vitro Antibacterial Activities of Clay Minerals against Antibiotic-Susceptible and Antibiotic-Resistant Bacterial Pathogens. J. Antimicrob. Chem. 61: 353-361.

39. Higgs, F.J., Mielke, H.W. and Brisco, M. 1999. Soil Lead at Elementary Public Schools: Comparison between School Properties and Residential Neighborhoods of New Orleans. Environmental Geochemistry & Health 216: 27–36.

40. Hooda, P.S., Henry, C.J., Seyoum, T.A., Armstrong, L.D. and Fowler, M.B. 2002. The Potential Impact of Geophagia on the Bioavailability of Iron, Zinc and Calcium in Human Nutrition. J. Environ. Geochem. Health, 24: 305-319.

41. Horner, R.D, Lackey, C.J, Kolasa, K. and Warren, K. 1991. Pica Practices of Pregnant Women. *Journal of American Dietetic Association* 91: 34–38.

42. Hunter, J.M. 1973. Geophagy in Africa and the United States: A Culture Nutrition Hypothesis. J. Geog. Rev. 63: 170-195.

43. Johns, T. and Duquette, M. 1991. Detoxification and Mineral Supplementation as Functions of Geophagy. Am. J. Clin. Nutr. 53: 448- 456.

44. Johnson, C.J., Phillips, K.E., Schramm, P.T., McKenzie, D., Aiken, J.M. and Pedersen, J.A. 2006. Prions Adhere to Soil Minerals and Remain Infectious. PLoSPathol. 2(4): e32.

45. Juozulynas, A., Jurgel_nas, A., Butkien, B., Greiit, K. and Saviit, R. 2008. Implications of Soil Pollution with Heavy Metals for Public Health. Geologija, 50. 2(62): 75-79.

46. Kawai, K., Saathoff, E., Antelman, G., Msamanga, G. and Fawzi, W.W. 2009. Geophagy (Soil-eating) in Relation to Anemia and Helminth Infection among HIV–Infected Pregnant Women in Tanzania. Am. J. Trop. Med. Hyg. 80(1): 36-43.

47. Kawase, K. 1982. Effects of Nutrients on the Intestinal Microflora of Infants. JPN. J. Dairy Food Sci. 31: A241-243.

48. Key, T.C, Horger, E.O. and Miller, J.M. 1982. Geophagia as a Cause of Maternal Death. Obstetrics and Gynecology 60: 525–526.

49. Klein, N., Fröhlich, F. and Krief, S. 2008. Geophagy: Soil Consumption Enhances the Bioactivities of Plants Eaten by Chimpanzees. Naturwissenschaften, 95(4): 325-331.

50. Lamps, L.W., Madhusudhan, K.T., Havens, J.M., Greenson, J.K., Bronner, M.P., Chiles, M.C., Dean, P.J. and Scott, M.A. 2003. Pathogenic Yersinia DNA is detected in Bowel and Mesenteric Lymph Nodes from Patients with Crohn's Disease. Am. J. Surg. Pathol. 27: 220-227.

51. Lanzkowsky, P. 1959. Investigation into the Aetiology and Treatment of Pica. Arch. Dis. Childhood, 34: 140-148.

52. Laufer, B. 1930. Geophagy. Field Museum of Natural History and Anthropology Series, 18: 99-198.

53. Liu, Y., Van-Kruiningen, H.J., West, A.B., Cartun, R.W., Cortot, A. and Colombel, J.F. 1995. Immunocyto Chemical Evidence of Listeria, *Escherichia coli*, and Streptococcus Antigens in Crohn's Disease. Yeast, 108: 1396- 1404.

54. Liu, J., Lee, L.S., Nies, L.F., Nakatsu, C.H. and Turcot, R.F. 2007. Biotransformation of 8:2 Fluorotelomer Alcohol in Soil and by Soil Bacteria Isolates. Environ. Sci. Technol. 41(23): 8024-8030.

55. Livingstone, D. 1870. *The Last Journals of David Livingston in Central Africa* from 1865 to His Death, 2(2): 1869-1873 Continued by a Narrative of His Last Moments and Sufferings. p. 346.

56. Louba, A., Geissler, P.W., Estambale, B., Ouma, J.H. and Magnussen, P. 2004. Geophagy among Pregnant and Lactating Women in Bondo District, Western Kenya. Trans. R. Soc. Trop. Med. Hyg. 98: 734-741.

57. Lourie, R.S., Layman, E.M. and Millican, F.K. 1963. Why Children Eat the Things that are not Food. Children, 10: p. 143.

58. Martindale, W. 1993. In: Reynolds JEF, Editor. Extra Pharmacopoeia, 30th rev Edition. London: Pharmaceutical Press, p. 2363.

59. Mcloughlin, I.J. 1987. The Pica Habit. Hosp. Med. 37: 286-290.

60. Medilink, 2004. Senegal: Clay as Delicacy and Danger. http://ipsnews.net/africa/ Accessed 30 August 2008.

61. Miazzo, R., Peralta, M.F., Magnoli, C., Salvano, M., Ferrero, S., Chiacchiera, S.M., Carvalho, E.C., Rosa, C.A. and Dalcero, A. 2005. Efficacy of sodium bentonite as a detoxifier of broiler feed contaminated with aflatoxin and fumonisin. Poult. Sci. 84(1): 1-8.

62. Mogongoa, L.F., Brand, C.E., de Jager, L. and Ekosse, G.E. 2011. Haematological Status of Qwaqwa Women who Ingest Clays. *SA Medical Technology*, 25 (1): 33-37.

63. Ngole, V. and Ekosse, G.E. 2012. Physico-Chemistry, Mineralogy, Geochemistry and Nutrient Bioaccessibility of Geophagic Soils from Eastern Cape, South Africa. *Scientific Research and Essays*, 7(12): 1319-1331.

64. Oliver, M.A. 1997. Soil and Human Health: a Review. European Journal of Soil Science 48: 573–592.

65. Prusiner, S.B. 1998. The Prion Diseases. Brain Pathol. 8: 499-513.

66. Rosa, C.A., Miazzo, R., Magnoli, C., Salvano, M., Chiacchiera, S.M., Ferrero, S., Saenz, M., Carvalho, E.C. and Dalcero, A. 2001. Evaluation of the Efficacy of Bentonite from

the South of Argentina to Ameliorate the Toxic Effects of Aflatoxin in Broilers. Poult. Sci. 80(2): 139-144.

67. Rubery, E. 2002. A Review of the Evidence for a Link between Exposure to *Mycobacterium Paratuberculosis* (MAP) and Crohn's Disease (CD) in Humans. FSA/MAP/Report. Food Standards Agency. Ref Type: Report.

68. Saathoff, E., Olsen, A., Kvalsvig, J.D. and Geissler, P.W. 2002. Geophagy and Its Association with Geohelminth Infection in Rural Schoolchildren from Northern KwaZulu-Natal, South Africa. Trans. R. Soc. Trop. Med. Hyg. 96(5): 485-90.

69. Sanders, R.K. 1996. The Management of Tetanus. Trop. Doct. (26): 107-115.

70. Shanahan, F. 2000. Probiotics and Inflammatory Bowel Disease: Is there a Scientific Rationale? Inflamm. Bowel. Dis. 6: 107-115.

71. Shirleys Wellness Café, 1996. Holistic Health Care for People and Animals. http://www.shirleys-wellness-cafe.com/ index.html. Accessed October 2008.

72. Sirnov, V.V., Reznik, S.R. and V'iunitskaia, V.A. 1993. The Current Concepts of the Mechanisms of the Therapeutic-Prophylactic Action of Probiotics from Bacteria and the Genus Bacillus Mikrobiolohichnyi Zhurnal 55(4): 92-112.

73. Smith, B., Rawlins, B.G., Cordeiro, M.J., Hutchins, M.G., Tiberindwa, J.V., Sserunjogi, L. and Tomkins, A.M. 2000. The Bioaccessibility of Essential and Potentially Toxic Elements in Tropical Soils from Mukono District, Uganda. J. Geol. Soc. 157: 885-891.

74. Tateo, F., Summa, V., Giannossi, M.L. and Ferraro, G. 2006. Healing Clays: Mineralogical and Geochemical Constraints on the Preparation of Claywater Suspension (argillic water). Appl. Clay Sci. 33(3-4) 181-194.

75. Vermeer, D.E. and Ferrell, (Jr). 1985. Nigerian Geophagical Clay: A Traditional Anti-Diarrhoeal Pharmaceutical. Science, 227: 634-636.

76. Vermeer, D.E. and Frate, D.A. 1979. Geophagia in Rural Mississippi: Environmental and Cultural Contexts and Nutritional Implications. Am. J. Clin. Nutr. 32: 2129-2135. [PubMed].

77. Von Homboldt, A. 1985. Vom Orinokkozum Amazonas. Wiesbaden: FA Brockhaus, p. 341.

78. Wagner, J.C. 1980. The Pneumoconioses Due to Mineral Dusts. J. Geol. Soc. Lond. 137: 537-545.

79. Walker, A.R., Walker, B.F., Sookaria, F.I. and Canaan, R.J. 1997. Pica. J. Roy. Health, 117: 280-284.

80. Wedeen, R.P., Mallik, D.K., Batuman, V. and Bogden, J.D. 1978. Geophagic Lead Nephropathy: Case Report. Environmental Research17: 409–415.

81. World Health Organisation, WHO 1998. Presidents Join Battle to Combat Buruli Ulcer. Press Release WHO/50. https://apps.who.int/infpr- 1998/en/pr 98-50.html. Accessed September 2009.

82. Williams, L.B., Haydel, S.E., Giese, R.F. and Eberl, D.D. 2008. Chemical and Mineralogical Characteristics of French Green Clays used for Healing. Clays and Clay Minerals, 56(4): 437-452.

83. Woywodt, A. and Kiss, A. 1999. Perforation of the Sigmoid Colon Due to Geophagia. Arch Surg-Chicago, 134: 88-89.

84. Young, S.L., Goodman, D., Farag, T.H., Ali, S.M., Khatib, M.R., Khalfan, S.S., Tielsch, J.M. and Stoltzfus, R.J. 2007. Geophagia is not associated with Trichuris or Hookworm Transmission in Zanzibar, Tanzania. T. R. Soc. Trop. Med. Hyg. 101(8): 766-772.

85. Zhou, J., Bruns, M.A. and Tiedje, J.M. 1996. DNA Recovery from Soils of Diverse Composition. Appl. Environ. Microbiol. 62: 316-322.

Reference to this paper should be made as follows: Ogidi Odangowei I. & Omu Okiemute (2016), Geophagic Practice and Its Possible Health Implications – A Review. *J. of Sciences and Multidisciplinary Research,* Vol. 8, No. 1, Pp. 1 – 12.