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Geophagia, a Soil - Environmental Related Disease

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ABSTRACT

Geophagia or geophagy is a habit for an uncontrollable urge to eat earth that commonly is occur in poverty-stricken populations and particularly there are in children under three years of age and pregnant women. The custom of involuntary or deliberate eating of soil, especially clayey soil, has a long history and is amazingly widespread. Some researchers have described an anomalous clay layer at a prehistoric site at the Kalambo Falls in Zambia indicating that clay might have been eaten by hominids. Von Humboidt reported from his travels in South America in early 18th century that clay was eaten to some extent at all times by the tribe in Peru. In the mid 19 century it was customary for certain people in the north of Sweden to mix earth with flour in making bread whether the clay effected an improvement in taste. In Iran, geophagia has seen in some of children and pregnant which that is solved with eating starch daily. For example, some reports are shown that there has been geophagia disease in some parts of Fars province, around Shiraz city which have been made different health as well as environmental complications. Clay with a large cation exchange capacity that is also fairly well saturated can release and supplement some macronutrients and micronutrients such as Cu, Fe, Mn and Zn. Deficiency of these elements led to dwarfism, hypogonadism, anemia, hepatosplenomegaly and skin problems. Almost all of these health complication evidences are seen in most of people who has been suffered from geophagy in Iran. However, geophagia has a history of 2000 years and the effects of soil and environmental chemistry on human health have been studied for hundreds years ago in China. In this review it has tried to introduce the geophagia as a nutritional and environmental complication in Iran as well as in the world which could be a serious health risk for human.

Keywords: Geophagia, Soil, Iron, Zinc, Anemia, Environment

INTRODUCTION

Soil can influence the human health and caused diseases by different ways (Oliver, 1997). Geophagy or geophagia is the way which soil is normally eaten by human and is digested in the stomach. This is a habit for an uncontrollable urge to eat earth that commonly is occur in poverty-stricken populations and particularly there are in children under 3 years of age and also in pregnant women.

The simplest form of mineral element intake from the environment is “geophagia” or direct eating of soil by human beings. Geophagia is widely reported in literature and can vary from undeliberate taking in of soil, e.g., by playing children to deliberate eating of soil either pure or mixed in other food substances. Geophagia is common among traditional societies, e.g., in sub-Saharan Africa. Soil may be directly eaten

from the ground, but in many situations there is a cultural preference for soil from “special sources” such as the walls of termite nests or in traditional herbal–soil mixtures. These are taken as a “special remedy” during pregnancy and by children when micronutrient requirements are increased (Smith et al., 2000).
Despite occurring in a wide variety of taxa, deliberate soil consumption is a poorly understood behavior. In humans, geophagy is sometimes considered as a sign of metabolic dysfunction. However, geophagy is normally assigned an adaptive function in nonhuman primates and various other organisms such as a wide diversity of mammals (Simon, 1998; Krishnamani and Mahaney, 2000). For humans, adaptive benefits must eclipse the costs of ingesting geohelminths (Saathoff et al., 2002) and soil-based toxins, such as lead, copper and potassium (to a hyperkalemic extent) (Simon, 1998). Despite such costs, an adaptive function is probable given its persistence in human history.
In Iran, geophagia has seen in some of children and pregnant which that is solved with eating starch daily (Ronaghy et al, 1968). Clay with a large cation exchange capacity that is also fairly well saturated can release and supplement some macrominerals, and trace elements such as Cu, Fe, Mn and Zn. Deficiency of this elements led to dwarfism, hypogonadism, enemia, hepatosplenomegaly and skin problems. In this review it has tried to introduce the geophagia as a nutritional and environmental complication in Iran as well as in the world which could be a serious health risk for human.

History

Geophagy was first reported by Aristotle and further described by Dioscorides and Avicenna in 40 BC and 1000 AD, respectively (Halstead, 1968). One of the first reports on geophagia is from Von Humbolt, who writes in his travel reports from South America between 1799 and 1804 that clay was eaten to some extent at all times by the Otomac tribe along the Orinocco River, and in Peru he saw mothers give their children lumps of clay to keep them quiet (Halsted, 1968).The habit can be traced back to ancient times, in the days of the philosophers Aristotle and Hippocrates, whose interest had been in the danger of the excessive consumption of ice-water and snow (Walker et al, 1997). The Roman physician Soranus is also noted for describing how geophagia was used to alleviate the unpredictable appetite and other symptoms associated with pregnancy. He noted that some unusual food items, were being consumed by pregnant women and that the craving for such unusual items began around the fortieth day of pregnancy and persisted for at least four months (Coltman, 1969). Soranus identified that these unusual foods could harm both the mother and child if not checked (Coltman, 1969).
Geophagia can also be traced back to the 18th century when it was learned that the Sultan of Turkey ate a special clay from the island of Lemnos; this resulted in Europeans adopting the product as a health food (Deutsch, 1977). In Africa, explorers and missionaries reported on clay eating dating from the 18th to the early 20th century as observed in Nigeria, Ghana and Sierra-Leone (Hunter, 1993). In the early part of the

20th Century, miners in Austria were reportedly eating earth and mountain tallow, which they spread onto bread as a substitute for butter and in Southern Germany, quarrymen developed " stone butter" derived from Clay and used as a food supplement (Hawass et al, 1987).

World Spread

Some people around the world eat clay, dirt and or other pieces of the lithosphere for a variety of reasons. Commonly, it is a traditional cultural activity, which takes place during pregnancy, religious ceremonies or as a remedy for disease (Jordan and Rowntree, 1990). Many studies on geophagia have been conducted over the years and around the world. As early as 1825, it was reported as a health hazard in the Southern States of North America (Makhobo, 1986).

In Asia, some comprehensive research on geophagia had also conducted which was very common in few villages around Shiraz city in Fars province of Iran (Ronaghy et al, 1968; Sayar et al, 1975). Geophagia is still exists in some parts of Iran especially among the pregnant women as well as children. In these areas it is a habit which is strongly favored by them and is going beyond a habit and mostly considered as a disease. In 1992 a study was conducted on the dietary habits of rural Jamaican women during pregnancy and 15 out the 38 pregnant women questioned reported cravings, common amongst which were cravings for cigarette ash and drinking soda (Melville and Francis, 1992). 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 medicinal purposes (Beteson and Lebroy, 1978)

Many reasons exist for geophagia around the world. In the Southern parts of the United States of America, 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 (Mcloughlin, 1987). In Malawi, it is reported to be surprising for a pregnant woman not to practice geophagia since it is their way of identifying if she is really pregnant. The taste of clay is claimed to diminish the nausea, discomfort and vomiting in "morning sickness" during pregnancy. Clay eating in this case is seen as normal during pregnancy and not between pregnancies (Hunter, 1993). The practice of geophagia is widespread in Africa and is associated with medicinal treatment and spiritual and ceremonial behavior (Walker et al, 1997). Clay eating is wide spread among women in five African countries namely Malawi, Zambia, Zimbabwe, Swaziland and South Africa, an estimated prevalence level in the rural areas of these countries is 90% (Walker et al, 1997). Poverty, starvation and famine have also been associated with geophagia practice (Hawass et al, 1987), in which case the substances function as a bulking agent to supplement insufficient food or a poor diet (Mclouglin, 1987).

Medical and Nutritional Effects

Intake of soil is usually associated with risk of human diseases. Examples are pathogens such as tetanus (Clostridium tetani), worm infections such as hookworm (Ancyclostoma duodenale, Necator americanua) or even non-filarial elephantiasis, which may enter through skin abrasions. In traditional societies where geophagia is common practice, parasite-causing soil-born pathogens are important to understand the etiology of certain human diseases. The nonfilarial elephantiasis or podoconidiosis is an interesting case: small worms in soil cause swelling of the legs by blocking lymph nodes! The disease is common in tropical highland areas on basaltic volcanic geology on “fine reddish brown soils”—most likely Nitisols (Nachtergaele et al., 2000). Price (1988) reports on the ecological niche of this disease. It seems to occur in well populated regions between 1250 and 2500 m altitude, with moderate mean annual temperature around 208C, and with more than 1000 mm of rain in the hot season. This covers areas such as the volcanic Highlands in Ethiopia, Kenya, Tanzania, Burundi and Cape Verde (Price and Plant, 1990). Very small particles of kaolin, amorphous silica and some quartz and iron were found in phagosomes of macrophages. The specific role of these soil minerals is still not yet clear and should be further investigated.

Mineral nutrient supplementation is the historical and intuitive basis for geophagy (Jones and Hanson, 1985). Indeed, sodium acquisition reportedly explains the phenomenon in organisms ranging from butterflies to babirusas (Clayton and MacDonald, 1999). In humans, however, investigators have largely discounted the hypothesis that geophagy is a physiological response to a need for nutrients, such as iron. The tendency to infer that anemia elicits soil consumption (Abrahams, 1997) is confounded by the fact that geophagy often leads to, rather than corrects, iron, zinc, or potassium deficiencies (Reid, 1992). The phenomenon is exacerbated when clays with high cation-exchange capacities are ingested. Moreover, mineral nutrients are usually sufficient in an animal's routine diet (Gilardi et al., 1999); and, among primates, elements are similar between unconsumed soils and those consumed selectively and repeatedly (Mahaney et al., 1995). Furthermore, in soils consumed by chimpanzees, only Fe was present in high concentrations (range 6-17%; Mahaney et al., 1997). However, available Fe was only partially soluble in conditions modeling the chimpanzee stomach (oxalic acid at pH 2.0), indicating it was an improbable cue. Finally, it is notable that dissolved salts in some soils may render calcium oxalate soluble. To our knowledge, this hypothesis has never been tested despite the importance of Ca to vertebrate reproduction. In plants, Ca exists principally as oxalate crystals (Prychid and Rudall, 1999), which readily cross intestinal epithelia (Hatch and Freel, 1995). It is perhaps significant that primates incurring high reproductive costs consume soil despite considerable risk of predation (Heymann and Hartmann, 1991).

In 1958, a 21 year old male patient in the Iranian city of Shiraz presented with dwarfism, hypogonadism, hepatosplenomegaly, rough and dry skin, mental lethargy, geophagia, and iron deficiency anemia (Prasad,

2003). This patient had an unusual diet. His intake of animal protein was negligible, and he ate only unleavened bread. In addition, he consumed 0.5 kg of clay daily. His total intake of calories and protein (cereal) was adequate, and except for iron deficiency no other deficiency in micronutrients was documented consistently. In the following three months 10 more patients with a similar illness were seen in the same hospital. The growth retardation and testicular hypo function in all these patients could not be explained on the basis of iron deficiency—these manifestations are not observed even in iron deficient animals. In animals, among the transitional elements known to have adverse effects on health due to deficiency (Cr, Mn, Co, Cu, and Zn), only zinc deficiency was known to cause growth retardation and testicular hypo function.

In many studies, quoted in Smith et al. (2000), geophagia is considered as "good for health," especially for strengthening the blood and promoting growth and physical strength. It is not 100% clear what the precise reasons are for a beneficial effect of geophagia—are mineral elements exchanged from the CEC-complex under the acidic conditions in the stomach? Exchange reactions may also explain absorption on the clay surface of possible dietary toxins such as alkaloids, tannins and bacterial toxins. For instance, Johns and Duquette (1991), describe clay being eaten a.o. by Pomo Indians to detoxify bitter potatoes (Solanum spp.). The clay fraction of ingested soils could also protect the gastrointestinal epithelium by cross-linking with glycoproteins in the intestinal mucosa (Rateau et al., 1982). Because toxins and tannins cross or afflict the epithelium (Gee and Johnson, 1988), the adsorption of such dietary compounds is the leading hypothesis for geophagy in some animals (Gilardi et al., 1999). Clays with high cation-exchange properties also adsorb diarrhea-causing enter toxins (Brouillard and Rateau, 1989). Practitioners of geophagy are often socially disadvantaged cultural and ethnic groups living in the tropics (Simon, 1998). Under such conditions, geophagy may facilitate exploitation of marginal plant foods and concomitantly reduce the energetic costs of diarrhea. Given the selective benefits to pregnant women and children, it is unsurprising that they are the principal consumers of soil (Wiley and Katz, 1998). In fact, humans use clay explicitly to render tanniniferous acorns and alkaloid-rich potatoes edible (Johns and Duquette, 1991).

In the other studies in Iran some researchers found significant clinical results on geophagia. A six years study on the patients in the area with geophagia habit showed that 9 of 13 patients with the syndrome of dwarfism, hypogonadism, iron-deficiency anemia, geophagia, and hepatosplenomegaly studied in Iran in 1959-1960 were traced in 1966. In this study, those who were able to consume a good diet the abnormalities had disappeared or had become much ameliorated. In those who were unable to maintain an adequate diet the syndrome continued unabated. These findings indicate that the syndrome is of nutritional origin and is reversible (Ronaghy et al, 1968). Other studies in Iran also showed that geophagia characterized by, severe, anemia, dwarfism, hypogonadism and hepatosplenomegaly is sometimes seen in young patients (and children) in Iran; Hematological aspects of the syndrome are those of, severe, iron

deficiency anemia; Gastric biopsies and histological findings revealed superficial or atrophic gastritis showing some resemblance to those seen in pernicious anemia; Hematological features, anemia and many of the clinical signs of the syndrome were improved after appropriate iron therapy; and histological changes of gastric mucosa improved, in 5 patients, 6 months after correction of the anemia (Sayar et al, 1975). Also, one of the first descriptions of zinc deficiency in man was made by Prasad, Halsted and Nadimi (1961) in adolescent boys in Iran who had been clay-eaters since childhood. It was a syndrome of dwarfism, sexual retardation and iron-deficiency anemia and the first two of these responded to zinc therapy.

Although the incidence of geophagy is decreasing, the practice remains common in many cultures. For example, a single Nigerian village produces 500 tons of soil yearly for consumption across West Africa (Vermeer and Ferrell, 1985). Moreover, children consume considerable quantities of soil regardless of geography and socio-economic status. Ingestion varies from the incidental to the incredible, ranging from 75 mg day-1 in Amherst, USA (Stanek and Calabrese, 1995) to 650 g reported in vivo in a single Gambian boy (Collinson et al., 2001). Accordingly, understanding and quantifying the adsorptive capacity of clay continues to be important. To date, modeling of dietary compound adsorption by clays has been investigated only in Amazonian parrots (Gilardi et al., 1999). Here we model the human gastrointestinal system and test the capacity of kaolin to adsorb a toxin (quinine) and tannins, both condensed (quebracho) and soluble (tannic acid). Furthermore, we evaluate the solubility of calcium oxalate in the presence of kaolin

The practice of geophagia and more specifically clay eating is strongly connected to folk medicine, social customs and obsessive-compulsive behavior (Crosby, 1976). The eating of some clays have been used as a remedy for diarrhea and stomach discomfort a practice that has been attributed to the presence of kaolin in these clays and it's absorptive ability (Morgan 1984). Clay has been identified as having the ability to absorb dietary toxins and bacterial toxins associated with gastro-intestinal disturbances that arise during pregnancy (Hunter, 1993). In some third world countries, clay is eaten to 'line the stomach' before eating yam or fish which may be poisonous, to reduce hunger and treat hook-warm infestation.

In a study conducted on 156 primary school children in Western Kenya by Geissler et al (1998), the proportion of anemic and iron depleted children was significantly higher among those with geophagia than in those without it. Geophagy among 204 primary school children aged between 10 and 18 years and relationship with helminthes (Ascaris lumbricoides, Trichuris trichiura, Schistosoma mansoni and hookworm) load was studied and results showed that 77% of the children ate soil daily and 48% of all soil samples were contaminated with eggs of the round worm - Ascaris lumbricoides (Geissler et al, 1998).

Geophagia, especially clay eating has often been associated with lead poisoning abdominal problems, hypokalemia, hyperkalemia, phosphorous intoxication and dental injury. The high aluminium content of

the clays eaten may increase the risk for Alzheimer's disease (Alzheimer's Society, 2002). A study in Washington DC among Afro-American women reported that large quantities of ice and freezer frost, about half to two cups a day, were consumed by women at a frequency of between one and seven times a week, resulting in low serum ferritin levels among those who are pregnant especially in the second and third trimesters (Edwards et al, 1994).

In a study conducted on 553 African American women admitted to prenatal clinics in Washington, geophagia was not observed. However, pagophagia (the ingestion of large quantities of ice and freezer frost) was reported. Some of the women were found to consume as much as 2 cups of frost a day (Edwards et al, 1994). In this study, the findings were well correlated with that of more recent ones by the likes of Geissler et al (1998) and Tayie and Lartey (1999). The serum ferritin concentrations for women with geophagia habit were significantly lower during the second and third trimesters of pregnancy; the average values for three trimesters of pregnancy for both ferritin and mean corpuscular hemoglobin were lower in geophagia women than their non-geophagia counterparts (Edwards et al, 1994).

The types of clay eaten in most countries could contribute some mineral nutrients. About 100g of white copper belt clay could contribute 15mg of calcium, 48 mg of iron, 42mg of zinc and small amounts of copper, chromium nickel and molybdenum, which may be significant amounts where deficiency exists (Hunter, 1993).

In South Africa as in other parts of Africa, the eating of clay is mostly observed among pregnant women. The prevalence of geophagia among urban and rural South African women was reported to be 38.3% and 44.0% respectively as compared to the prevalence among the Indian, colored and white women at 2.2%, 4.4% and 1.6% respectively (Walker et al, 1997). In some studies such as that reported by Vermeer and Frate (1979), the average daily intake of clay consumed by women in rural Holmes County, Mississippi, was 50g.

In Malawi, geophagia habit is used as a marker for pregnancy (Walker et al 1997). In a recent cross sectional study at in an antenatal clinic at Kilifi District Hospital, Coast Province, Kenya, low iron status and high anemia prevalence was present among 154 out of 275 pregnant women (56%) and were reported to eat soil regularly (Geisslier et al, 1998). In an accompanying interview on the said study at Kilifi District hospital, soil eating was found to be more than just a physiologically induced practice and involved a rich cultural practice favored by most females with strong relations to fertility and reproduction (Geissler et al, 1999). Geophagia is a natural habit among infants who crawl and eat whatever they can pick up and though usually the total amount of earth eaten is small and insignificant, carelessness or indifference on the part of parents may contribute to the continuation of this habit as the child matures (Hawass et al 1987). The phenomenon of geophagia is reported to be more prevalent than commonly

believed. Women at high risk of geophagia are more likely to be of African origin, to live in rural areas, and to have a family history of geophagia.

CONCLUSION

Geophagia is defined as deliberate consumption of earth, soil, or clay1. From different viewpoints it has been regarded as a psychiatric disease, a culturally sanctioned practice or a sequel to poverty and famine. In view of the high prevalence of geophagia in many regions of the world, it is hypothesized that ancient medical texts would also contain reports of the disorder. To our surprise, geophagia was indeed reported by many authors ranging from Roman physicians to 18th century explorers. All the concepts of geophagia—as psychiatric disorder, culturally sanctioned practice or sequel to famine—fall short of a satisfying explanation. The causation is certainly multifactorial; and clearly the practice of earth-eating has existed since the first medical texts were written. The descriptions do not allow simple categorization as a psychiatric disease. Finally, geophagia is not confined to a particular cultural environment and is observed in the absence of hunger. Might it be an atavistic mode of behavior, formerly invaluable when minerals and trace elements were scarce? Its re-emergence might then be triggered by events such as famine, cultural change or psychiatric disease. However, geophagia now is a world wide disorder which needs to be addressed more than in the past.

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