ZIBELINE INTERNATIONAL™ PUBLISHING

**Science Heritage Journal (GWS)**

*DOI: http://doi.org/10.26480/gws.02.2025.106.115*

***ISSN: 2521-0904 (Print)***
***ISSN: 2521-0440 (Online)***
***CODEN: EHJNA9***

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***REVIEW ARTICLE***

# TOXICOLOGICAL AND PSYCHO-SOCIAL INSIGHTS INTO GEOPHAGIC CLAYS IN NIGERIA

**Osemudiamen Anao Edene and Daniel Osemudiamen Iriah**

***Department of Environmental Management Toxicology, Faculty of Life Sciences, University of Benin, P.M.B. 1154, Ugbowo, Benin City, Edo State, Nigeria.***
****Corresponding Author Email: osemudiamen.anao@uniben.edu***



**ARTICLE DETAILS**

***Article History:***

Received 17 September 2025
Revised 20 October 2025
Accepted 23 November 2025
Available online 20 December 2025

**ABSTRACT**

Across Nigeria's diverse cultural landscape, an age-old ritual persists, one that sees the earth not only as home but as nourishment. Geophagy, the intentional consumption of soil, particularly specific clays known locally as “Nzu”, “Eko”, or Calabar chalk, is more than a dietary quirk. It is an inherited act, a quiet tradition whispered across generations. Found in bustling markets or dug from the earth itself, these clays are often laced with kaolinite, bentonite and a cocktail of other minerals shaped by Nigeria’s regional geology. For many, especially expectant mothers and rural dwellers, this earthy fare is sought not just for physical relief, such as easing pregnancy-related nausea, but also as a link to spiritual safeguarding and ancestral wisdom. However, beneath its cultural charm lies a chemical complexity. Scientific scrutiny has unmasked a darker layer: elevated concentrations of toxic elements like lead, cadmium, and arsenic, breaching safety norms by global standards. These substances, invisible to the eye yet potent in their harm, quietly challenge the health of those who partake. Still, geophagy endures, shielded by tradition and the gaps in health education. Any attempt to address its risks must step gently, as science must not only analyze but empathize. Solutions must be woven from both data and dialogue, balancing biomedical insight with cultural reverence. Only through a blend of public health efforts, environmental science, and respectful community engagement can Nigeria confront the paradox of geophagy: a practice both rooted in care and laced with danger.

**KEYWORDS**

Geophagy, geophagic clay, “Nzu”, “Eko”, Calabar chalk

## 1. INTRODUCTION

In Nigeria, the act of intentionally consuming clay and similar earth substances continues to thrive as a deep-seated cultural practice, particularly observed among pregnant women, children, and inhabitants of rural communities. These materials, known by names like “Nzu”, “Eko”, or Calabar chalk, are ingested for diverse purposes, ranging from easing pregnancy-related nausea to fulfilling traditional or spiritual beliefs and supplementing mineral intake (Onyenweaku, 2023). Although deeply woven into cultural identity, this behavior brings significant health concerns due to the possibility of ingesting harmful elements. A growing body of research has drawn attention to the presence of hazardous heavy metals in clays consumed by geophagic populations across Nigeria (Asowata, 2021 ; Edene and Aghedo, 2023). For example, clay samples obtained from the southern regions of the country have been found to contain dangerous levels of lead and cadmium, surpassing World Health Organization (WHO) safety limits and posing serious risks to the brain and kidneys when consumed over time (Edene and Onoagbe, 2023). Additional investigations have uncovered that clays sourced from Anambra State contain high amounts of arsenic, chromium, and nickel elements known for their toxic and potentially cancer-causing effects (Ezealaji et al., 2025). The risks extend beyond toxic metals. Research in Enugwu Agidi has revealed a greater incidence of soil-transmitted helminth infections among women who consume clay compared to those who do not, suggesting a strong link between geophagy and parasitic exposure (Nwankwo et al., 2024). Scientific analysis of these clays has shown a predominant presence of kaolinite, along with varying quantities of quartz, smectite, and palygorskite. While kaolinite may offer relief from digestive discomfort, quartz (being an abrasive mineral) can damage teeth and irritate the digestive tract (Olisa et al., 2023). The continued practice of geophagy, despite mounting evidence of its health hazards, points to the urgent need for a collaborative and respectful response. Effective public health strategies should weave together culturally appropriate education, tighter oversight of clay distribution, and sustained research efforts. Only by blending scientific insight with an understanding of cultural norms can we promote safer practices without disregarding tradition.


**Figure 1:** Diagram of 'Nzu' (White Chalk) – A Traditional Geophagic Clay Common in Nigeria.

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| | **Website:** www.jscienceheritage.com | **DOI:** 10.26480/gws.02.2025.106.115 |

Cite the Article: Osemudiamen Anao Edene and Daniel Osemudiamen Iriah (2025). Toxicological And Psycho-Social Insights Into Geophagic Clays In Nigeria. *Science Heritage Journal*, 9(2): 106-115.

## 2. Methodology

This review adopted a qualitative method rooted in an immersive reading and synthesis of recent academic discussions on clay consumption practices in Nigeria. Rather than relying on fieldwork or numerical data, the process revolved around gathering, filtering, and thematically arranging published materials from January 2020 through March 2025. The intent was to map the intricate web of cultural meaning, regional variation, health implications, and environmental contexts that shape the practice of geophagy in Nigeria today. To build the foundation of this analysis, a wide-ranging literature search was carried out using academic platforms such as Google Scholar, ScienceDirect, PubMed, African Journals Online (AJOL), and ResearchGate. The search was guided by carefully chosen keywords and logical connectors, bringing together terms like "geophagy in Nigeria," "Calabar chalk," "toxic elements in edible clays," and "cultural practices and clay eating." Results were refined to include only English-language publications released within the three-year target window. Studies were included if they met three key criteria: being peer-reviewed or official health reports, focusing on Nigerian populations, and exploring cultural, behavioral, environmental, or health-related angles of geophagy. Excluded works included those outside the timeframe or geographic focus, along with informal publications lacking scholarly merit. From an initial pool of 90 records, 32 sources were chosen for in-depth review. These were grouped into four core themes: cultural drivers, regional patterns, health risks, and public health policy gaps. A thematic content analysis brought clarity to overlapping trends and competing perspectives. All references followed APA 7th edition style, upholding academic precision throughout.

### 2.1 History of Geophagy in Nigeria

Geophagy, the act of purposefully consuming soil or clay, has deep historical roots in many cultures across the globe, and Nigeria stands as a notable example. Within Nigerian society, this practice is tightly interwoven with generational customs, where it is believed to offer health benefits, especially for pregnant women, young children, and individuals dealing with digestive discomfort (Onyenweaku, 2023). The types of clay most commonly linked to geophagy in Nigeria include "Nzu", "Eko", and Calabar chalk, which are typically consumed raw or refined into powders. Long before the arrival of Western influence, the ingestion of clay formed part of indigenous Nigerian life, closely connected to spiritual rituals, herbal healing systems, and everyday wellness routines. Historical records and ethnographic narratives suggest that clay was consumed with the belief that it contained healing minerals capable of addressing issues like nausea, stomach cramps, and even poisoning (Akinnawo and Akinmoladun, 2022).

In many cases, the clay held symbolic power as well, serving as a protective agent believed to ward off illness and malevolent forces as well as aid in easing child delivery process (Edene and Onoagbe, 2023). As Nigeria's society underwent political and cultural transformations over the years, the practice of geophagy adjusted accordingly. During colonial rule, European authorities often dismissed the practice as uncivilized, yet it endured in regions with limited access to modern healthcare. Today, geophagy remains widespread, particularly in the southeastern and southwestern parts of the country, where white clay, or "Nzu", is commonly consumed for digestive relief and as a perceived source of iron (Nwankwo et al., 2024). Contemporary research has taken a more critical turn, shifting focus toward the chemical makeup and safety of geophagic clays. New scientific investigations have documented the presence of harmful heavy metals (lead, cadmium, and arsenic) in several clay samples collected across Nigeria, raising red flags about long-term health consequences (Edene and Aghedo, 2023 ; Ezealaji et al., 2025). These findings create a sharp contrast with longstanding cultural beliefs that typically emphasized only the benefits of earth consumption. Although geophagy remains a symbol of cultural continuity, modern awareness of its health implications is reshaping how the practice is viewed. Today's knowledge around geophagy in Nigeria is shaped by both ancestral knowledge and modern science, revealing a complex balance between tradition and evidence-based caution.

### 2.2 Mineralogical Composition of Nigerian Geophagic Clays

The mineral content of geophagic clays in Nigeria showcases significant variation, shaped by local geological and environmental factors. Kaolinite, a soft white clay, is the dominant mineral found in many geophagic clays, particularly in southeastern regions like "Nzu" and "Eko" (Chukwu et al., 2023). Additionally, other clay minerals such as illite, montmorillonite, and, in some cases, halloysite and chlorite, contribute to the unique textural and chemical properties of these materials (Umeora et al., 2025). Non-clay components, including quartz, feldspar, and iron oxides like hematite, goethite, and gibbsite, further affect the clay's hardness, color, and potential abrasiveness (Ajayi et al., 2023). Some samples have even shown trace minerals such as muscovite, anatase, calcite, and dolomite, indicating complex geological processes at play. Despite these mineral benefits, there are serious concerns about the presence of harmful heavy metals like lead, arsenic, cadmium, and nickel, which can be introduced naturally or through pollution. These metals, even in small amounts, represent a significant health risk for those who consume geophagic clays regularly (Okoye and Yakubu, 2022). Understanding the complete mineralogical composition is crucial for evaluating both the therapeutic potentials and toxicological dangers of these clays.

#### *2.2.1 Kaolinite*

Kaolinite stands out as the most prevalent and frequently identified mineral in the geophagic clays consumed across various Nigerian regions (Olumuyiwa et al., 2022). Classified as a phyllosilicate, kaolinite is a 1:1 clay mineral formed by a tetrahedral sheet of silica bonded to an octahedral sheet of alumina (Adeniyi et al., 2023). Its soft, earthy texture and absorbent qualities make it a popular choice in geophagic materials, particularly among pregnant women and children, who often use it for cultural, psychological, or physiological purposes (Olisa et al., 2023). The widespread presence of kaolinite in Nigerian soils, especially in tropical and lateritic zones, can be attributed to the intense weathering of feldspathic rocks under conditions of high rainfall and temperature (Eyankware et al., 2021). Consistent analysis of clay samples from states such as Anambra, Enugu, Delta, Edo, and Kogi has revealed kaolinite as the dominant mineral, often making up 60–90% of the overall mineral content (Ezealaji et al., 2025). These findings confirm the predominance of kaolinite in Nigerian geophagic clays, with smaller quantities of quartz, illite, and smectite occasionally present. The appeal of kaolinite in geophagy is linked to its adsorptive and detoxifying properties (Olisa et al., 2023). It is traditionally thought to bind toxins and alleviate gastrointestinal discomfort (Ajibade et al., 2022). However, its low cation exchange capacity (CEC) of 3–15 meq/100g limits its ability to supply essential nutrients. This can lead to nutrient absorption issues, as kaolinite may bind vital micronutrients like iron and zinc in the digestive tract, causing deficiencies with prolonged use (Onyenweaku, 2023). From a geochemical perspective, kaolinite itself is largely inert and exhibits minimal toxicity (Eyankware et al., 2021). Nevertheless, it often occurs in conjunction with heavy metals such as lead (Pb), cadmium (Cd), and arsenic (As), which can adhere to the surface of the clay through natural or human-induced processes. Clays with significant kaolinite content, such as those from Ubiaja, contained bioavailable forms of these toxic metals, raising concerns about the health risks associated with chronic exposure, particularly for vulnerable groups (Edene and Onoagbe, 2023). The size and structure of kaolinite particles also have important implications for its use and safety. Smaller kaolinite particles ($<2$ μm) are more easily ingested and absorbed, but their larger surface area increases their potential to carry harmful contaminants. Furthermore, it was noted that some kaolinite-rich Nigerian clays exhibit crystalline defects or contamination with other interlayer minerals, which could impact their bioreactivity in the human gut (Olisa et al., 2023). While kaolinite has long been used for medicinal and dietary purposes, its presence in geophagic clays demands a thorough evaluation of its toxicological risks, mineral stability, and the bioavailability of contaminants. Consequently, the widespread use of kaolinite-rich clays underscores the need for more stringent geochemical testing and public awareness to mitigate health risks associated with prolonged geophagic practices.

#### *2.2.2 Illite*

Illite, a non-expanding 2:1 phyllosilicate clay mineral, is present in several geophagic clays found in Nigeria, though it is less prevalent than other minerals like kaolinite. Comprising two tetrahedral silica sheets sandwiching one octahedral aluminum sheet, illite is structurally similar to muscovite but contains less potassium (Kumar and Mohan, 2021). Though typically making up 5–20% of the total mineral content in geophagic clays, illite significantly affects their physical and chemical properties, contributing both to their perceived medicinal value and the health risks they may pose (Ezealaji et al., 2025 ; Olisa et al., 2023). Geophagic clays from southeastern and north-central Nigeria, particularly from states like Enugu, Ebonyi, and Kogi, often contain illite. These regions, characterized by ferruginous and weathered soils, are conducive to illite formation, usually through the alteration of muscovite and feldspar under moderate hydrothermal conditions (Olisa et al., 2023). X-ray diffraction (XRD) analyses of these samples consistently show illite peaks alongside kaolinite and quartz, indicating mixed mineral assemblages that reflect the region's geologic conditions [19]. Illite's moderate cation exchange capacity (CEC), which ranges from 20 to 40 meq/100g, places it between kaolinite and smectite in terms of its ability to adsorb heavy metals, toxins, and organic molecules. This property is often viewed as beneficial for detoxification and gastrointestinal relief by geophagic practitioners. However, illite can also bind essential nutrients, including calcium, magnesium, and iron, which could lead to nutrient deficiencies if consumed frequently over time (Damato et al., 2022). While illite's layered structure is relatively stable compared to expanding clays, it can serve as a medium for the accumulation of metals. Studies on Nigerian clays indicate that illite-rich samples frequently contain trace amounts of lead (Pb), cadmium (Cd), and arsenic (As) that exceed safe limits set by the World Health Organization. It was reported that that clays with a high illite content from Edo State leached detectable levels of these harmful metals under simulated gastrointestinal conditions, suggesting a long-term toxicological risk (Orisakwe et al., 2020). In terms of texture, illite contributes to the clay's plasticity and smoothness, making it desirable for oral consumption. However, its moderate particle size (<2 μm) increases the risk of intestinal accumulation or obstruction, particularly for children and pregnant women. Illite's structure can also promote microbial contamination. It retains moisture, providing an ideal environment for bacterial growth. Poorly processed illite-rich clays sold in local markets have been found to harbor harmful bacteria such as *E. coli* and Clostridium species, which can lead to enteric infections (Nwankwo et al., 2024). Despite these risks, illite's adsorptive properties and potential palliative benefits help explain its ongoing use. However, the mineral's moderate reactivity and tendency to harbor contaminants necessitate careful consideration. To minimize health risks, comprehensive mineralogical screening and risk assessments should be conducted before allowing the consumption of clays containing significant amounts of illite.

### 2.3 Montmorillonite

Montmorillonite, a key member of the smectite group of clay minerals, occasionally appears in geophagic clays in Nigeria (Rahman and Das, 2025). As a 2:1 phyllosilicate, it consists of two tetrahedral silica sheets surrounding a central octahedral alumina sheet, and is renowned for its expansive properties, high surface area, and exceptional cation exchange capacity (CEC). These characteristics enhance its ability to adsorb various substances, which partly explains its popularity in geophagic practices (Olisa et al., 2023). Although kaolinite and illite are more common in Nigerian geophagic clays, montmorillonite has been identified in samples from states like Nasarawa, Bauchi, and Plateau. These areas are characterized by volcanic ash soils or large sedimentary clay deposits, which create ideal conditions for montmorillonite formation (Ezealaji et al., 2025). X-ray diffraction (XRD) analysis has shown that montmorillonite often coexists with kaolinite, feldspar, and quartz in mixed-layer clay formations. The high CEC of montmorillonite, which typically ranges from 80 to 150 meq/100g, enables it to adsorb both essential nutrients and harmful substances. This dual capability plays a central role in its use within geophagy. While its absorptive properties help bind toxins and alleviate gastrointestinal discomfort, montmorillonite can also sequester vital micronutrients such as iron, calcium, and zinc. This can contribute to micronutrient deficiencies, particularly in communities where geophagy is a regular practice (Rahman and Das, 2025). A notable concern with montmorillonite is its ability to expand upon hydration. When ingested in large quantities, it can swell within the gastrointestinal tract, potentially causing intestinal obstruction or bloating (Nwankwo et al., 2024). This risk is particularly significant for pregnant women and children, who are frequent consumers of geophagic clays in Nigeria. From a geochemical standpoint, montmorillonite has a strong affinity for heavy metals and organic pollutants. Research has revealed that montmorillonite-rich clays from central Nigeria's geophagic markets contain elevated levels of lead (Pb), cadmium (Cd), and chromium (Cr), often surpassing WHO safety limits for oral consumption (Orisakwe et al., 2020). These metals, either adsorbed on the clay's surface or interlayer sites, become bio-accessible in the acidic environment of the stomach, raising long-term health risks. Despite its potential health risks, montmorillonite is valued for its antidiarrheal properties and has been used in pharmaceutical and detoxification treatments under controlled conditions. However, in the context of geophagy, (particularly in rural Nigerian areas), there is minimal regulation regarding clay sourcing, processing, or safety. Consequently, montmorillonite-bearing clays should undergo comprehensive mineralogical and toxicological evaluations before being approved for human consumption. While montmorillonite enhances the physical and chemical properties of Nigerian geophagic clays, it also presents substantial health risks that demand public education, regulatory oversight, and further research.

### 2.4 Halloysite

Halloysite, an aluminosilicate clay mineral from the kaolin group, is a relatively rare yet significant component of Nigerian geophagic clays. With the general formula $Al_2Si_2O_5(OH)_4{\bullet}nH_2O$, halloysite shares structural similarities with kaolinite but stands apart due to its unique nanotubular morphology and hydration state, which have implications for its role in geophagic practices. It is typically found in lateritic soils and altered volcanic deposits in regions such as Nasarawa, Enugu, and parts of Plateau State, often alongside kaolinite, quartz, and iron oxides (Ezealaji et al., 2025 ; Olisa et al., 2023). The formation of halloysite in Nigeria is closely linked to intense chemical weathering, common in humid tropical climates. Halloysite exists in two forms: hydrated (10 Å) halloysite, which contains interlayer water, and dehydrated (7 Å) halloysite, which is structurally similar to kaolinite. The form that predominates in a given area depends on environmental moisture levels and the depth of the clay deposit (Onah et al., 2023). In the context of geophagy, halloysite's nanotubular structure and high surface area contribute to its strong adsorptive capacity. This makes it effective at binding toxins, pathogens, and heavy metals in the gastrointestinal tract, which may explain its traditional use in detoxification, particularly among pregnant women and individuals experiencing gastrointestinal distress (Onyenweaku, 2023). Halloysite's ability to bind bile acids and toxins is also thought to offer temporary relief from digestive issues, though such claims remain largely anecdotal and lack clinical validation. Nutritionally, halloysite does not provide essential nutrients, although it contains aluminum and silicon. Concerns arise regarding its potential to release aluminum under acidic gastric conditions, which could contribute to neurotoxicity and gastrointestinal irritation if consumed excessively or over extended periods (Olisa et al., 2023). Additionally, halloysite's adsorptive properties can interfere with the absorption of essential micronutrients, such as iron, zinc, and calcium, which are particularly critical for maternal and child health (Nwankwo et al., 2024). Though less studied than kaolinite or quartz, halloysite is emerging as an important mineral in the mineralogical makeup of Nigerian geophagic clays. Its presence reflects both the geological diversity of Nigeria's clay deposits and the potential risks associated with geophagic practices. Future research should focus on quantifying halloysite concentrations, evaluating its ability to bind toxins, and assessing the long-term health effects of its consumption, to inform public health strategies and policy.

### 2.5 Quartz

Quartz ($SiO_2$), a highly abundant and chemically stable mineral, is commonly found in geophagic clays across Nigeria. As a major component of the Earth's crust, quartz is frequently encountered in sedimentary, metamorphic, and igneous environments, making its presence in naturally occurring clays quite expected. In geophagic clays, however, quartz is not classified as a clay mineral but serves as a silicate filler, often appearing as a primary or accessory mineral in varying concentrations (Olisa et al., 2023). Various mineralogical techniques, such as X-ray diffraction (XRD), scanning electron microscopy (SEM), and fourier-transform infrared spectroscopy (FTIR), have consistently identified quartz in clays used for geophagy in regions including Ogun, Anambra, Benue, Nasarawa, and Enugu. The quartz content in these clays can range from 10% to over 40%, often co-occurring with minerals like kaolinite, illite, and montmorillonite, depending on the local geology. The mineral is typically introduced through detrital processes, which involve weathering of surrounding rocks and sedimentary deposition (Ezealaji et al., 2025). Despite its chemical inertness and low toxicity when ingested, quartz poses health risks due to its mechanical properties. When quartz particles are angular and coarse, they can cause abrasion to dental enamel, irritation to the gastrointestinal tract, and, in some cases, intestinal microtrauma—especially when the clays are consumed without proper processing (Onyenweaku, 2023). These risks are heightened in populations consuming raw or unrefined clays directly obtained from natural deposits. Nutritionally, quartz offers no benefits in geophagic practices. Unlike smectite or kaolinite, it lacks cation exchange capacity and does not engage in the adsorption or detoxification of toxins. Thus, quartz contributes only to the bulk and texture of the clay without providing trace elements like iron, calcium, or zinc (Nwankwo et al., 2024). In this sense, quartz's role in geophagy is passive. A particularly concerning issue is the inhalation of fine crystalline silica dust during clay processing, such as grinding or sun-drying. Crystalline silica is a known carcinogen and has been associated with serious respiratory diseases, including silicosis, chronic obstructive pulmonary disease (COPD), and lung cancer when inhaled over extended periods (Edene and Onoagbe, 2023). Although geophagy typically involves oral ingestion, occupational and incidental inhalation by consumers or vendors could still pose significant health risks, particularly in unregulated environments. Although quartz is a common and chemically benign component of Nigerian geophagic clays, its physical abrasiveness, lack of nutritional value, and inhalation hazards underscore the need for heightened awareness and monitoring. Future research should focus not only on quantifying quartz content but also on examining its particle size distribution and morphology to assess potential mechanical and respiratory risks in geophagic communities.

### 2.6 Feldspar

Feldspar, a group of aluminosilicate minerals primarily composed of potassium, sodium, and calcium, is a less commonly emphasized but geochemically significant component of Nigerian geophagic clays. Feldspars are typically categorized into two types: alkali feldspars (such as orthoclase and microcline) and plagioclase feldspars (such as albite and anorthite). Although feldspar is not as abundant as minerals like kaolinite or quartz in geophagic clays, it is often reported as an accessory mineral in geophagic materials from various regions of Nigeria, including Nasarawa, Kogi, and Cross River (Ezealaji et al., 2025). The presence of feldspar in geophagic clays results from incomplete weathering of parent rocks like granites, gneisses, and pegmatites, which are rich in feldspar. X-ray diffraction (XRD) and petrographic analyses consistently show trace to moderate amounts of feldspar in both surface and subsurface clays consumed for geophagy. Despite being partially weathered, feldspar grains can persist through diagenetic processes and remain embedded within the finer clay matrix (Olisa et al., 2023). Nutritionally, feldspar is generally inert and does not contribute significantly to human health in the context of geophagy. Unlike clay minerals such as montmorillonite and kaolinite, feldspar does not participate in cation exchange or provide bioavailable trace elements essential for nutrition. However, under acidic gastrointestinal conditions, feldspar may release small amounts of potassium or sodium ions, but these are typically too minimal to have any meaningful health impact (Onyenweaku, 2023). While feldspar poses minimal chemical toxicity, physical concerns arise due to its angular morphology and abrasive hardness. Coarse or unaltered feldspar particles can cause dental wear, intestinal abrasion, and mucosal irritation, especially when the clays are consumed raw and unprocessed (Nwankwo et al., 2024). Similar to quartz, feldspar's mechanical properties affect the texture and hardness of geophagic clays, potentially leading to discomfort during chewing or digestion. Additionally, feldspar can influence the alkaline buffering capacity of the clay matrix, which may alter its interaction with stomach acids or other contaminants. While this buffering effect may reduce the acidity in the stomach, there is limited evidence to support any protective or detoxifying benefits for human digestion (Onyenweaku, 2023). In summary, feldspar's role in Nigerian geophagic clays is more geological than functional. Its presence is a reflection of the mineral composition of the host rocks, rather than any intentional health benefit. Although feldspar is chemically inert, its physical properties warrant consideration due to the potential for mechanical irritation when consumed untreated. Further research should focus on quantifying feldspar content in various geophagic regions and analyzing its particle characteristics to assess its significance in geophagic practices.

### 2.7 Chlorite

Chlorite, a member of the phyllosilicate mineral group, is a lesser-known but significant component found in some Nigerian geophagic clays. Typically greenish in color and characterized by a flaky or platy structure, chlorite forms under low- to medium-grade metamorphic conditions and hydrothermal alterations. It is commonly found in association with other clay minerals such as kaolinite, illite, and montmorillonite. The presence of chlorite in geophagic clays suggests it derives from altered basic and ultrabasic rocks, particularly in geologically complex regions like the Jos Plateau, Oban Massif, and Mambilla areas (Ezealaji et al., 2025 ; Onah et al., 2023). In Nigeria, chlorite is typically present in trace to moderate quantities, depending on the geological origin of the clay. X-ray diffraction (XRD) and scanning electron microscopy (SEM) analyses have revealed that chlorite is interbedded with other clay minerals in lateritic profiles and weathered basaltic formations, particularly in Central and Southeastern Nigeria (Olisa et al., 2023). These deposits reflect the tropical chemical weathering environments that favor the formation of secondary clay minerals from ferromagnesian parent materials. Chlorite's mineralogical significance is linked to its high iron and magnesium content, which influences the cation exchange capacity (CEC) and buffering potential of the clay. These properties contribute to the adsorption of heavy metals and organic toxins, which may explain why some geophagic individuals believe that consuming clay provides detoxifying benefits (Bonglaisin et al., 2022). Additionally, chlorite-rich clays often have alkaline pH levels, which can alter the solubility of metals in the gastrointestinal tract and sometimes reduce the bioavailability of harmful elements. However, chlorite's health implications are less clear. Although it contains essential trace elements like magnesium and iron, its crystalline structure limits effective nutrient absorption. Excessive ingestion of chlorite-bearing clays could lead to iron overload, gastrointestinal discomfort, or micronutrient malabsorption, particularly with long-term use. The iron in chlorite is typically in the ferric ($Fe^{3+}$) form, which is less bioavailable and may interfere with iron absorption from other dietary sources (Eigbike et al., 2022). In the context of geophagy, chlorite's hygroscopic and adhesive properties may promote the binding of pathogens and intestinal irritants. However, its ability to trap beneficial nutrients such as calcium and zinc raises concerns, particularly for vulnerable populations like pregnant women and children (Davies, 2023). Despite its greenish appearance, which is often preferred by consumers for its visual similarity to "pure" clay, there is no scientific evidence to suggest that this color correlates with any therapeutic value or safety. Chlorite represents a chemically and structurally complex component of Nigerian geophagic clays, offering both potential benefits and risks (Warra et al., 2023). Further toxicological and nutritional research is needed to better understand its role in geophagy, particularly in communities where clay consumption is both habitual and culturally significant.

### 2.8 Hematite

Hematite ($Fe_2O_3$) is a common iron oxide mineral and one of the primary contributors to the reddish to brownish color of many geophagic clays found in Nigeria. It forms through the weathering of iron-bearing minerals under oxidizing conditions, which are common in the tropical and lateritic soils of Nigeria. The presence of hematite in geophagic clays offers key insights into both the geological origins and the chemical characteristics of the clays consumed in various Nigerian communities (Ezealaji et al., 2025 ; Olisa et al., 2023). Mineralogically, hematite typically appears as fine-grained inclusions or coatings on clay particles and often coexists with minerals such as kaolinite, quartz, and goethite in ferruginous clay deposits. High concentrations of hematite are found in regions like Benue, Enugu, Cross River, and parts of the North-Central zone (e.g., Kogi and Nasarawa), which are known for intense laterization and iron enrichment from the parent rock (Onah et al., 2023). The iron oxide content in these clays varies depending on the depth, origin, and degree of weathering. From a health perspective, hematite's iron content can be both beneficial and potentially harmful. While hematite may theoretically act as a dietary iron source, particularly in rural populations suffering from iron deficiency anemia, especially among pregnant women, the bioavailability of iron from hematite is extremely low (Nwankwo et al., 2024). Hematite typically exists in the ferric ($Fe^{3+}$) form, which is poorly absorbed by the human digestive system. As a result, consuming hematite-rich clays may not improve iron deficiency and could interfere with the absorption of iron from other dietary sources. Additionally, hematite-containing clays may pose risks due to their abrasive nature. Chronic ingestion can lead to gastrointestinal discomfort, and the iron oxide particles may irritate the stomach lining. Excessive iron intake, even in non-bioavailable forms, may also disrupt gut microbiota or cause oxidative stress, particularly in individuals with existing iron regulation issues (Onyenweaku, 2023).

Despite these concerns, hematite is culturally associated with purity and strength, with traditional users sometimes believing that red-colored clays are more effective in detoxification (Ellepola, 2022). However, this cultural perception lacks scientific backing, highlighting the need for better education on the actual health risks associated with hematite-rich clays. Overall, hematite is a mineralogically significant and visually dominant component of Nigerian geophagic clays. Its chemical inertness, iron content, and physical properties contribute to the complex relationship between cultural practices, nutritional myths, and the potential health effects of geophagy in Nigeria. Further studies on bioavailability and toxicology are essential to establish safe consumption guidelines and improve public health messaging.

### 2.9 Gibbsite

Gibbsite ($Al(OH)_3$), also known as hydrargillite, is a major aluminum hydroxide mineral and a common component of highly weathered tropical soils, including the lateritic clays found in Nigeria. It forms through intense leaching in warm, humid environments where silica is removed, leaving aluminum as a residual component. In Nigerian geophagic clays, gibbsite has been identified through X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), and scanning electron microscopy (SEM) analyses, especially in regions such as Southwestern, Southeastern, and North-Central Nigeria (Ezealaji et al., 2025 ; Onah et al., 2023). Gibbsite-rich clays are typically white to light gray and soft in texture, often regarded as "clean" by traditional users. These clays are strongly associated with bauxitic laterites and granite-derived soils, particularly in areas like Ekiti, Ondo, Nasarawa, and Enugu States. Gibbsite typically coexists with minerals such as kaolinite, quartz, and iron oxides, with its abundance indicating a high degree of weathering and leaching, signaling mature clay profiles (Olisa et al., 2023 ; Idakwo). From a nutritional and toxicological perspective, the presence of gibbsite in geophagic clays presents mixed implications. On the one hand, gibbsite itself is chemically inert and insoluble under normal physiological pH, meaning it is not absorbed or metabolized in the human gut (Rahman and Das, 2025). This inertness has led to the belief that gibbsite-containing clays may act as adsorbents of toxins or pathogens, which could explain their traditional use as gastrointestinal remedies (Nomicisio et al., 2023). On the other hand, the aluminum in gibbsite, although tightly bound, raises health concerns when consumed over prolonged periods. Chronic ingestion of aluminum-bearing clays has been linked to aluminum accumulation in the body, particularly in individuals with impaired kidney function. This accumulation may lead to potential neurotoxicity or interfere with the metabolism of essential minerals such as calcium, magnesium, and phosphorus. Additionally, studies suggest that gibbsite-rich clays may alter gut pH, potentially affecting digestion and nutrient absorption (Nwankwo et al., 2024). Although the bioavailability of aluminum from gibbsite is low, repeated consumption, especially among vulnerable populations like pregnant women and children, raises public health concerns that warrant further investigation. Culturally, gibbsite-rich clays are often considered "safe" due to their light color, fine texture, and lack of metallic taste. However, this perception does not align with scientific evidence. The long-term health effects of consuming gibbsite remain under-researched in Nigeria, despite its prevalence in many geophagic clay samples. Overall, gibbsite is a geochemically and medically relevant mineral in Nigerian geophagic clays. While its chemical stability and non-reactivity may confer some perceived benefits, the potential risks of chronic exposure—particularly related to aluminum toxicity—necessitate targeted public health awareness and further scientific research.

### 2.10 Goethite

Goethite (α-FeO(OH)) is one of the most prevalent iron-bearing minerals found in Nigerian geophagic clays, playing a significant role in determining their color, texture, and chemical properties (Eigbike et al., 2022). This yellowish to brownish iron oxyhydroxide mineral forms primarily through the weathering of iron-rich minerals in tropical and subtropical climates. In Nigeria, where large portions of the landscape are dominated by lateritic soils, goethite is frequently detected in geophagic clays, particularly in deeply weathered profiles from regions like Enugu, Kogi, Nasarawa, and Cross River states (Onah et al., 2023 ; Ezealaji et al., 2025). Mineralogically, goethite commonly occurs alongside other minerals such as kaolinite, hematite, quartz, and gibbsite. It is typically identified through mineralogical analyses such as X-ray diffraction (XRD) and scanning electron microscopy (SEM). The presence of goethite often accounts for the brown to yellow hues in clay samples, which are sometimes preferred by geophagic individuals for their perceived therapeutic effects (Bonglaisin et al., 2022). The formation of goethite is associated with strongly oxidizing, acidic conditions that leach other elements and concentrate iron compounds in the clay matrix. From a health perspective, goethite's significance in geophagic clays is tied to its iron content and its adsorption capacity. Although goethite is not readily bioavailable, its presence has been speculated to contribute trace amounts of iron to the human diet. However, studies consistently show that the iron from goethite is poorly absorbed in the gastrointestinal tract due to its ferric ($Fe^{3+}$) form and its mineral matrix, limiting its potential as a nutritional supplement (Eigbike et al., 2022). Additionally, goethite's high surface area and reactive hydroxyl groups enable it to adsorb heavy metals and pathogens, contributing to its traditional use in detoxification and gastrointestinal relief. However, this property also raises concerns, as it can result in the accumulation of harmful elements such as lead (Pb), arsenic (As), and cadmium (Cd), especially in clays harvested from contaminated soils. Prolonged ingestion of goethite-rich clays from polluted environments may lead to toxicity and bioaccumulation risks (Ajibade et al., 2022). Culturally, clays containing goethite are widely consumed in Nigeria, often described as having an "earthy" or "iron-rich" taste, which appeals to certain consumers, particularly pregnant women and children. This preference may be rooted in traditional beliefs about iron supplementation and detoxification, although such perceptions are largely anecdotal and lack scientific validation. In summary, goethite is a mineralogically and chemically significant component of Nigerian geophagic clays. While it contributes to the aesthetic and sensory appeal of the clays and offers potential adsorptive benefits, its low iron bioavailability and ability to bind toxic elements highlight the need for careful evaluation of its health impacts. Further studies focusing on the bioaccessibility and toxicology of goethite-containing clays are essential for informing public health policies and guiding safe geophagic practices.

### 2.11 Muscovite

Muscovite, a potassium-rich mica mineral with the chemical formula $KAl_2(AlSi_3O_{10})(OH)_2$, is a silicate mineral commonly found in sedimentary, metamorphic, and igneous rocks. In the context of Nigerian geophagic clays, muscovite is a secondary accessory mineral, often occurring alongside kaolinite, quartz, feldspar, and iron oxides. It is particularly abundant in clays derived from granitic and schistose parent materials, which are common in regions such as Ekiti, Osun, Plateau, and parts of Enugu and Cross River States (Amupitan). Muscovite is characterized by its flaky or platy form, and it typically displays a silvery to greenish sheen, which can influence the visual and tactile appeal of geophagic clays. Mineralogical investigations, including X-ray diffraction (XRD), scanning electron microscopy (SEM), and petrographic microscopy, have confirmed the presence of muscovite in various Nigerian clay deposits consumed for geophagic purposes (Amupitan ; Olisa et al., 2023). From a chemical and nutritional standpoint, muscovite contributes aluminum, silicon, and potassium to the mineral composition of geophagic clays. However, like most phyllosilicate minerals, muscovite has very low solubility in physiological conditions, which limits its bioavailability. As a result, while muscovite-containing clays may be perceived as mineral-rich, their actual contribution to human nutrition is minimal (Onyenweaku, 2023). Additionally, muscovite's laminar structure and large surface area enable it to adsorb organic molecules and metal ions, which may have either beneficial or harmful effects depending on the environmental context of the clay deposit. One potential concern is that muscovite can retain trace levels of radioactive elements and heavy metals, particularly in areas affected by natural or anthropogenic contamination. This raises concerns about toxicity when clays are consumed over extended periods without proper testing or regulation (Nwankwo et al., 2024). Furthermore, the presence of muscovite in geophagic clays has been associated with abrasive effects on the gastrointestinal tract, potentially causing mucosal irritation when consumed in large quantities or in its unrefined form. Culturally, clays containing muscovite are sometimes preferred for their crunchy texture and shiny appearance, qualities that geophagic individuals may interpret as signs of purity or high quality. These preferences, however, are based more on tradition and sensory appeal rather than scientific evaluations of health impacts. Conclusively, muscovite is a geologically significant but nutritionally inert component of Nigerian geophagic clays. While its presence contributes to the mineral diversity and aesthetic qualities of these clays, its health implications are mixed, depending on factors such as particle size, contamination, and frequency of consumption. This highlights the need for continuous monitoring and public education regarding the safe use of geophagic materials.

### 2.12 Anatase

Anatase, a tetragonal polymorph of titanium dioxide ($TiO_2$), is a relatively minor yet significant mineral found in Nigerian geophagic clays. Although typically present in small quantities, anatase's presence is noteworthy due to its chemical stability and potential implications for health and soil genesis. It forms through the intense weathering of titanium-bearing minerals such as ilmenite and rutile in tropical environments, making it a common accessory mineral in lateritic soils and clays in regions like Plateau, Nasarawa, Cross River, and parts of southwestern Nigeria (Ezealaji et al., 2025 ; Olisa et al., 2023). In mineralogical analyses of geophagic clays, anatase is often identified using techniques such as X-ray diffraction (XRD) and Fourier-transform infrared spectroscopy (FTIR). While typically present in trace or minor quantities, anatase contributes to the mineral diversity and reactivity of the clay matrix. Its fine-grained, sometimes nanocrystalline structure increases the surface area of clays, which may enhance their adsorptive capacity for heavy metals and organic substances (Onah et al., 2023). This property aligns with anecdotal beliefs that geophagic clays can bind toxins in the digestive tract, although scientific validation of these claims remains limited. From a health perspective, anatase is considered chemically inert in the human gastrointestinal system.

However, its biological implications are still being debated. Some studies suggest that nanoscale $TiO_2$ particles, which anatase can form under certain conditions, may pass through the gastrointestinal barrier and accumulate in body tissues, raising concerns about potential chronic exposure and oxidative stress (Baranowska-Wójcik, 2021). However, current evidence does not indicate any immediate toxicity from anatase, especially in its naturally occurring crystalline form found in Nigerian soils (Adebiy et al., 2021). Anatase also contributes to the color and texture of clays, with its pale hue influencing the visual appeal of geophagic samples. Culturally, while it is not the most prized mineral by geophagic consumers who typically prioritize texture, color, and taste, its presence is indicative of clays derived from deeply weathered parent rocks such as granite and basalt. In conclusion, anatase is a geochemically stable and mineralogically relevant component of Nigerian geophagic clays. While its direct nutritional or therapeutic value is minimal, its role in enhancing adsorption and soil development contributes to the overall quality and function of geophagic materials. As research on nanomaterials in food substances increases, further investigation is needed to assess the long-term safety of consuming anatase-containing clays.

### 2.13 Calcite

Calcite ($CaCO_3$), a crystalline form of calcium carbonate, is a common accessory mineral in Nigerian geophagic clays, particularly those formed in carbonate-rich or metamorphosed terrains. While it is not as dominant as kaolinite or quartz, calcite plays a crucial role in influencing the chemical and physical characteristics of these clays. It is primarily found in areas of northern and central Nigeria, including regions in Benue, Kogi, and parts of Nasarawa and Niger States, where sedimentary and limestone formations are prevalent (Yusuf et al., 2022). Calcite's presence in geophagic clays is typically identified using techniques such as X-ray diffraction (XRD), thermogravimetric analysis (TGA), and Fourier-transform infrared spectroscopy (FTIR). It often originates from biogenic and detrital limestone or from the alteration of calcareous rocks. In clays, calcite usually appears as fine-grained, white or pale grey particles and can cause an alkaline reaction when it comes into contact with acidic substances, a characteristic observed in some clay samples. From a nutritional standpoint, calcite's calcium content can provide potential benefits for geophagic individuals, especially for pregnant women who may suffer from calcium deficiency (Davies, 2023). However, the bioavailability of calcium from calcite in clay form is typically low, particularly when not dissolved in acidic environments such as the stomach. Excessive consumption of calcite-rich clays can lead to alkalosis and interfere with the absorption of other minerals, such as iron and magnesium (Damato et al., 2022). Health-wise, calcite is considered non-toxic in its natural state and is even used as an antacid in pharmaceuticals (Selvasudha et al., 2020). However, its presence can affect the buffering capacity of clays, potentially altering the gut's pH when consumed over time. This shift could influence gut microbial flora and digestion. Additionally, calcite's role in increasing clay hardness and density may impact digestive tolerance, possibly contributing to constipation, particularly in individuals who consume it in large quantities without proper hydration (Gomes and Silva, 2021). Culturally, geophagic clays containing noticeable amounts of calcite are often preferred for their chalky taste and smooth texture. These sensory attributes can lead to them being mistaken for edible chalk. However, awareness of the potential health effects remains limited among many consumers, both in rural and urban areas. Calcite is a chemically influential and culturally significant component of some Nigerian geophagic clays. Although it offers limited nutritional value, especially in terms of calcium, its alkaline properties and physiological effects require careful consideration. More research into its toxicology and bioavailability is needed to fully understand its long-term health implications for geophagic populations.

### 2.14 Dolomite

Dolomite [$CaMg(CO_3)_2$], a calcium magnesium carbonate mineral, is occasionally found in Nigerian geophagic clays, particularly in regions underlain by carbonate-rich sedimentary formations, such as parts of the Benue Trough, Sokoto Basin, and southwestern Nigeria (Omoseebi, and Tanko) Although not as common as other minerals like kaolinite or quartz, dolomite's presence in these clays is of interest due to its dual mineral nutrient content (calcium and magnesium) both of which are essential for various physiological processes in humans. Mineralogically, dolomite is usually found as fine-grained, off-white to light grey particles and contributes to the alkaline nature of geophagic clays. It can be identified through methods like X-ray diffraction (XRD) and scanning electron microscopy (SEM), and is often found in association with other carbonates, such as calcite. The formation of dolomite in soils is primarily the result of the diagenetic alteration of limestone or magnesium-rich sediments, which are abundant in Nigeria's middle belt and northern regions (Onah et al., 2023). In the context of geophagy, dolomite influences the taste, texture, and buffering capacity of clays. From a nutritional perspective, the magnesium content in dolomite can be beneficial, particularly for populations with magnesium deficiency, which is linked to fatigue, muscle cramps, and metabolic disorders (Razzaque and Wimalawansa, 2025). However, the bioavailability of calcium and magnesium from dolomite in clay form is generally low, as dolomite is poorly soluble under neutral pH conditions in the gastrointestinal tract. Health implications of consuming dolomite-rich clays are generally minimal when consumed in moderation. However, excessive ingestion could lead to hypermagnesemia, particularly in individuals with impaired kidney function, though this is rarely reported in geophagic populations (Ganguly, 2023). Furthermore, dolomite may contribute to gastrointestinal discomfort or constipation due to its low digestibility and alkaline reaction, which can disrupt the gut environment over time (Nordberg and Costa, 2022). Culturally, geophagic clays containing dolomite are often favored for their chalky mouthfeel and mild flavor, particularly among pregnant women who crave earthy substances (Knishinsky, 2022). In summary, dolomite is an important, yet under-researched, mineral in Nigerian geophagic clays. While its calcium and magnesium content provides potential nutritional benefits, its low bioavailability and physiological effects, such as its role in increasing the alkaline nature of clays, necessitates further investigation. More research into the bioavailability and long-term health implications of dolomite in geophagic practices is necessary to better inform public health policies and safe consumption guidelines.

Taken together, the broad range of minerals found in geophagic clays across Nigeria serves as a reminder of the nation's geological wealth, while simultaneously highlighting the urgent need for rigorous testing and health-based regulatory measures. Without clear knowledge of what these clays contain, their perceived value may come with unrecognized risks.

## 3. Geophagic Clays In The Soils Of Nigerian States

Geophagic clays (naturally occurring earthy materials consumed by humans) are widely present and utilized across Nigeria's diverse ecological and cultural zones. The practice of geophagy is deeply embedded in Nigerian culture, particularly among pregnant women, children, and certain rural communities who believe in the medicinal and nutritional benefits of these clays (Davies, 2023 ; Warra et al., 2023). Though commonly associated with relief from nausea, gastrointestinal discomfort, or mineral supplementation, concerns about toxic elements such as lead, cadmium, and arsenic persist, especially given the lack of standardized regulation and widespread informal mining practices.

### 3.1 Southern Nigeria: Cultural Significance and Mineral Abundance

In the **Southeast** region, the practice of geophagy is both culturally rooted and widespread. States such as **Abia, Anambra, Enugu, and Imo** are particularly noted for the consumption of soft white clays locally known as '*Nzu*'. These clays are primarily composed of kaolinite and montmorillonite and are often mined from shallow soils or termite mounds. Research confirms that these clays are commonly used by pregnant women to ease nausea and heartburn (Gomes et al., 2021 ; Chukwu et al., 2023). In **Ebonyi State**, local clays have also been found to contain halloysite, a mineral contributing to their smooth texture and palatability (Azubuike et al., 2024). In the **Southwest**, including **Ogun, Oyo, Osun, Ekiti, Ondo, and Lagos**, geophagic clay consumption exists but is less intense than in the Southeast. Here, clays tend to contain higher concentrations of hematite, iron oxides, and magnesium-rich minerals. Some consumers believe these elements help correct micronutrient deficiencies (Kumari and Mohan, 2021). However, concerns about potential contamination by lead and mercury have been documented in clays sold in urban markets like Lagos and Ibadan(Okoye and Yakubu, 2022). The **South-South** region, comprising **Edo, Rivers, Akwa Ibom, Delta, Cross River, and Bayelsa**, also hosts a variety of geophagic clays. In **Edo State**, particularly in areas like Uteh-Uzalla, near Benin City, Aforwa, Ubiaja, Ohordua, and Uzola. white chalk clays, some black clays and other baked clays are widely consumed and marketed (Asowata, 2021 ; Eden and Aghedo, 2023). Research has confirmed the presence of kaolinite, quartz, and iron oxides in these materials. The more humid tropical environment of this zone contributes to a weathering process favorable to kaolinitic clay formation, although the region also sees higher levels of anthropogenic pollution in mined clays.

### 3.2 North-Central and Northern Nigeria: Medicinal and Functional Use

In **North-Central Nigeria**, including **Niger, Kogi, Nasarawa, Plateau, Kwara, and Benue**, clays are widely distributed and used, often for their medicinal properties. Clays from Jos in **Plateau State**, for instance, are rich in kaolinite and quartz and have been analyzed for use in gastrointestinal treatments (Odewum et al., 2023). In **Kogi**, geophagic materials found in Geheku are composed of kaolinite, halloysite, and montmorillonite minerals known to possess detoxifying properties (Irabor and Okunkpolor, 2020). However, consumption in these regions tends to be less frequent and more therapeutic than cultural. Moving further north to states like **Kaduna, Kano, Zamfara, Sokoto, Katsina, Yobe, Borno, Gombe, and Bauchi**, geophagic clays are still present, though consumption patterns vary. In **Kaduna**, Zaria-based studies have shown geophagic clay to contain illite and kaolinite, with trace heavy metals (Odewumi et al., 2023). In **Borno** and **Yobe**, the clays are often used more for medicinal than nutritional purposes, consumed in smaller quantities by local populations to alleviate stomach discomfort. Research indicates that, when properly processed, certain types of clay may offer pharmacological and detoxifying benefits (Gomes et al., 2021).

## 4. Confirmed States And Research-Supported Distribution

As of current scientific literature (2020–2025), geophagic clays have been confirmed through mineralogical, geochemical, and ethnographic studies in at least 31 Nigerian states as depicted in Figure 2**,** this includes:

- **South-East**: Abia, Anambra, Enugu, Imo, Ebonyi
- **South-South**: Edo, Rivers, Akwa Ibom, Cross River, Delta, Bayelsa
- **South-West**: Ogun, Oyo, Osun, Ekiti, Ondo, Lagos
- **North-Central**: Plateau, Kogi, Niger, Nasarawa, Kwara, Benue
- **North-East/North-West**: Kaduna, Kano, Gombe, Borno, Yobe, Katsina, Sokoto, Zamfara

Geophagic clays are an integral part of Nigeria's cultural, medicinal, and nutritional landscape, with confirmed presence in at least **31 states**. Their widespread use reflects regional traditions, ecological conditions, and perceived health benefits. However, the **mineral diversity** that makes them valuable also introduces **public health risks** due to the presence of toxic elements and microbial contaminants. Going forward, **multidisciplinary research**, government involvement, and community education are crucial to balancing the cultural heritage of geophagy with modern standards of safety and health.


**Figure 2:** Map Showing the Distribution of Geophagic Clay Locations across Nigeria

### 4.1 Cultural and Social Drivers of Geophagic Clay Consumption in Nigeria

While geophagy is sometimes framed as a nutritional or clinical response, in Nigeria it holds a much deeper place within cultural identity and community life. Rather than being simply about physiological needs, the habit of eating clay reflects social belonging, ritual practice, and deeply held beliefs that are passed from one generation to the next. Women, especially those expecting children, make up the largest group of participants in this tradition, where consuming earth is often viewed as both normal and beneficial within many Nigerian ethnic groups (Opata, 2020). Among the strongest influences on this behavior is maternal custom, where the ingestion of white clay is embedded in prenatal care practices. Across southeastern and southwestern states, expectant mothers regularly turn to "*Nzu*" as a remedy for queasiness or to ease other discomforts of pregnancy, following advice and approval from elder women and traditional birth attendants who continue to support the practice across generations (Eze et al., 2024 ; Chukwu et al., 2023).

In many families, the consumption of clay carries symbolic weight, believed to promote resilience for both the unborn child and the mother, while also serving as a form of spiritual shielding rooted in ancestral healing systems (Nasiru et al., 2024). Public spaces further reinforce this norm by embracing the practice without reservation. Whether in schoolyards, roadside kiosks, or open markets, clay is frequently purchased, shared, and consumed with ease, and in some urban stores it even appears on shelves in labeled packages, transforming a traditional act into a commercial product. Part of its continued appeal lies in the sensory joy it offers, as many users express an emotional attachment to its unique flavor and texture (Toland and Wolter, 2023). In addition to cultural and sensory motivations, financial hardship often plays a role in encouraging geophagic habits. When food is scarce, clay may serve as a temporary stand-in, helping to suppress hunger or stretch limited meals. This behavior is not just personal but also economic, as many women in both rural villages and expanding townships participate in the trade of edible clays as a modest livelihood strategy (Olisa et al., 2023). Understanding the persistence of geophagy in Nigeria means looking beyond its surface as a health behavior. Interventions that aim to reduce its health risks must also respect its embeddedness in cultural logic. A thoughtful approach (one that brings together medical insight, anthropological understanding, and local voices) can pave the way for policies that are both effective and respectful of tradition.

## 5. Health Implications Of Geophagic Clays.

The consumption of geophagic clays in Nigeria, while deeply rooted in cultural practices, is associated with a diverse set of health risks (Ajibade et al., 2022 ; Orisakwe et al., 2020 ; Davies, 2023). While some believe that these clays may alleviate gastrointestinal issues and provide trace minerals, growing scientific evidence highlights numerous health dangers tied to both the mineral content and microbial contamination of the clays.

### 5.1 Heavy Metal Toxicity

Numerous studies have detected toxic heavy metals like lead (Pb), arsenic (As), cadmium (Cd), and mercury (Hg) in the geophagic clays widely consumed in Nigeria, with many of these elements exceeding the safety limits set by the World Health Organization (WHO) [5, 21, 56]. Chronic exposure to these toxins can result in neurotoxic effects, kidney and liver damage, and, in severe cases, developmental problems in children and fetuses (Bonglaisin et al., 2022 ; Damato et al., 2022).

### 5.2 Parasitic Infections

Clays harvested from untreated or contaminated soils often contain viable parasitic eggs (Ngenegbo and Ikpeze, 2022). Research conducted in Anambra State found that women who frequently consumed local clays exhibited a significantly higher prevalence of parasitic infections, such as *Ascaris lumbricoides* and *Trichuris trichiura*, leading to malnutrition, anemia, and cognitive impairment, particularly in children (Aribodor et al., 2023).

### 5.3 Bacterial Contamination

Clays collected from unsanitary environments or unhygienic markets can be contaminated with harmful bacteria like E. coli, Salmonella spp., and Shigella spp., increasing the risk of foodborne illnesses and diarrhea, especially when the clay is consumed raw or without proper sterilization (Ajibade et al., 2022).

### 5.4 Nutrient Malabsorption

Despite the belief that geophagic clays provide essential minerals, the strong binding properties of minerals like kaolinite and smectite inhibit nutrient absorption [20,24,25]. This impairs the uptake of critical micronutrients, including iron and zinc, and is particularly problematic for pregnant women, who often suffer from iron-deficiency anemia due to regular clay consumption (Gomes and Silva, 2021).

### 5.5 Gastrointestinal Complications

Clays can swell in the digestive tract, leading to issues like constipation, intestinal blockages, and abdominal discomfort (Baykara, 2024). In severe cases, these blockages can require surgical intervention. While such complications are rare, they are more likely in children or among individuals who consume excessive amounts of clay (Bonglaisin et al., 2022).

### 5.6 Dental Erosion

Clays containing high levels of quartz are abrasive and can gradually erode tooth enamel (Prasad, 2023). Long-term consumption may lead to dental sensitivity, increased susceptibility to cavities, and eventually, tooth loss (Prasad, 2023). Although underreported, this condition is becoming more commonly recognized among regular consumers of geophagic clays (Ogungbamigbe and Uche, 2022).

### 5.7 Hepatotoxicity and Nephrotoxicity

Animal studies have shown that chronic consumption of clay can result in liver and kidney damage. For example, Wistar rats exposed to clay samples exhibited elevated liver enzymes and visible liver damage, suggesting potential harm to human organ systems at high concentrations over a period of time (Edene and Onoagbe, 2023).

### 5.8 Respiratory Health Risks (in Handlers)

Although not directly related to consumption, individuals who handle and process powdered clay are at risk of respiratory issues, such as irritation and lung damage from silica dust (Rana). While research on these occupational hazards is limited, there is growing awareness of the health risks faced by those working in Nigeria's clay markets.

### 5.9 Psychological Implications (Pica Disorder)

Geophagy is often considered part of the broader psychological disorder known as pica, which involves the compulsive consumption of non-food substances (Pizano et al., 2023). People who engage in geophagy may have underlying psychological conditions, such as obsessive-compulsive tendencies, which often remain unaddressed within local health systems (Davies, 2023).

### 5.10 Pregnancy Complications

Despite its widespread use during pregnancy, geophagy has been linked to several pregnancy-related complications, including low birth weight, iron-deficiency anemia, and increased maternal health risks (Madziva et al., 2024). The toxic heavy metals and impaired nutrient absorption contribute to these adverse outcomes for both mother and child (Molale and Eze, 2023 ; Akah et al., 2020).

## 6. Conclusion

Geophagy in Nigeria, a practice deeply intertwined with socio-cultural, psychological, and nutritional factors, reveals both a rich tradition and significant health risks. This review has highlighted the dangers associated with consuming raw or unprocessed geophagic clays, which can be contaminated with heavy metals, harmful microbes, and other non-nutritive substances. Despite these risks, these clays remain central to cultural identity and are seen as beneficial for well-being, especially among pregnant women and rural communities. As urbanization and modernization continue, the ongoing use of geophagic clays suggests that a shift in perspective is needed. Rather than simply condemning the practice, Nigeria must adopt a more balanced, science-driven approach, incorporating toxicological assessments, regulatory measures, and public health education. Research indicates that, when properly processed, certain types of clay may offer pharmacological and detoxifying benefits pointing to the possibility of transforming these materials into safe therapeutic agents rather than banning their use. Closing the knowledge gap through interdisciplinary research will be crucial in fully understanding the biochemical properties, cultural roles, and health effects of geophagic practices in Nigeria. Hence, geophagy should not solely be seen as a harmful practice, but rather as a multifaceted issue requiring nuanced, context-sensitive policy responses. A thoughtful combination of cultural sensitivity, scientific inquiry, and environmental stewardship will be vital in ensuring a safe and sustainable future for the communities that continue to engage in this age-old tradition of "eating earth."

## Recommendations

Considering the insights from this review on geophagic clays in Nigeria, a comprehensive and nuanced approach is required to balance cultural traditions with health and environmental concerns. The following suggestions are intended to guide policymakers, health professionals, environmental experts, and researchers in fostering a responsible and sustainable management framework for geophagic practices and materials:

### Standardization And Quality Control

The Nigerian government, through regulatory bodies like National Agency for Food and Drug Administration and Control (NAFDAC) and Standards Organization of Nigeria (SON), should implement strict regulations regarding the extraction, processing, and distribution of geophagic clays. Recent findings indicate that without proper purification, these clays can contain harmful levels of heavy metals and pathogenic organisms, which pose serious health risks [48, 54]. Regulatory oversight is crucial to ensure that only safe, purified clay products are made available to the public.

### Public Health Education And Risk Communication

It is essential for health ministries and NGOs to conduct health education campaigns that are sensitive to cultural contexts. While geophagy is deeply embedded in cultural and psychological frameworks, it carries significant health risks, including gastrointestinal issues and nutrient deficiencies despite some documented benefits. Public health initiatives must address these risks while providing safer nutritional alternatives, particularly for vulnerable groups like pregnant women who are commonly involved in geophagy.

### Interdisciplinary And Longitudinal Research

Future research should adopt an interdisciplinary approach, integrating fields such as geochemistry, ethnomedicine, toxicology, and public health, to gain a deeper understanding of geophagic practices. Long-term studies tracking the health effects of habitual clay consumption in various regions and populations are essential. Additionally, research should explore potential uses for purified Nigerian clays in pharmaceuticals and industrial applications.

### Integration Into Maternal Health Policies

Given the widespread practice of geophagy among pregnant women in Nigeria, it is crucial to incorporate this behavior into maternal health screening protocols. Healthcare providers should be trained to approach geophagy in a non-judgmental manner and provide appropriate counseling to those who consume clay. By implementing these strategies, Nigeria can minimize health risks while promoting a responsible approach to geophagy that respects cultural practices and encourages environmental sustainability. A well-rounded, science-driven, and culturally sensitive approach is needed to effectively manage this ongoing phenomenon.

## Acknowledgement

The valuable input from the Department of Environmental Management and Toxicology at the Faculty of Life Sciences, University of Benin, is gratefully acknowledged.

## Conflict Of Interest

The authors affirm that there are no conflicts of interest to disclose.

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