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Environmental and Medicinal Impacts of Clay

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Abstract
The use of clay dates back to ancient times for nutritional, healing, and skincare purposes. Different clays are employed for other purposes. In the field of medicine, they are used as foams, binders, and scaffolds; in cosmetics, as absorbents, stabilizers, and emulsifiers; and pharmaceutically, as excipients, carriers, anti-toxins, and flavouring agents. Clays are also used as chemical agents for removing radioactive gases, heavy metals, and organic matter. However, the use of clay has its constraints. When ingested, clays can trap pollutants or toxins, depending on their source. In the case of peloids and ointments, podoconiosis, a disease associated with the long-term effect of bare feet on red clay soil in tropical regions, is a concern. Generally, clay is an important, natural, locally sourced material of great environmental benefit.

Keywords: Therapeutic, Clay, Environment, Health Risk, ancient times

Introduction

The use of clays for medicinal purposes has been on for centuries; it is as a result of its health benefits. It dates back to civilization with the Egyptians and Greeks. It helps with toxification, digestive issues, and skin conditions (Tian et al, 2024). It contains minerals such as calcium, magnesium, silicon, etc. Clay is pictured as a thin plate-like body; its molecular structure is such that negatively charged oxygen atoms are nearest to the upper and lower surfaces. Thus, attracting positively charged ions (cations) to the clay particles by electrostatic attraction, these cations replace one another in the process of cation exchange (Ovincy Real, 2023). Individuals with mouth sores, stomach disorders, diarrhoea, and other conditions, including those who want to detoxify, use clay. A large number of clays are being used in medicine for external purposes in both Spas and mud therapy. The Bhanahs physicians use it as anti-inflammatory agents and antiseptics, for preserving mummies and complexion (Carretaro et al., 2006). Among the clays commonly used are kaolin, smectite as bentonite, montmorillonite, and Fuller's earth. Famous physicians associated with clays are Aristotle (348- 322 BC), Galen, the famous Roman Obstetrician, gynaecologist, and paediatrician, Soranus of Ephesus of old and also Ibn al-Baytar, a famous Muslim scholar on pharmacology and the French naturalist Pierre Belon who visited the Limones Earth land for the various uses of clay. The breakthrough in cosmetics and pharmacy in the use of clays in the 19th century was a result of crystallographic development and mineralogical composition. Clay earth minerals are now being widely used in various purposes in medicine as anti-inflammatory detoxification, wound healing, skin care, and digestive health (Tian et al, 2024).

The properties that render materials useful are:

a. Plasticity, hygroscopicity, compatibility in biochemical systems (Chandler et al., 2021)

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b. The nano of clay materials < size 2µm and its nano nature, plant-like shape gives it a large surface area for its usage as drug delivery agents, skin adhesion, reducing heartburn, bloating, stomach lining, providing good surface as a catalyst in reactions. (Umudi & Awatafe 2018)

c. Its location on the Earth's surface and ease of excavation.

d. Some clay minerals of the smectite groups have expanding capacity 002-0.6 mV on the amount of water in the deposit and interrelated reactions and the amount of broken bonds at the edges of the particles. The expansions decrease when dry. Illite, on the other hand, has 0.5- 0.9mV per half degree, little expansion when water is added. Its abrasive and poor hardness gives a smooth sensation and good spread when in contact with the skin (Ovincy Real, 2023).

e. It forms a paste with liquid, especially water, making a stable suspension, and its adsorption ability promotes adsorption and elimination of viruses, bacteria, and toxins from skin in the treatment of psoriasis, eczema, and acne. Also, as kind carriers for controlled drug release and incorporating polar, inorganic and incorporating polar, and organic molecules.

f. Alkaline-based clays are used for gastrointestinal purposes to neutralize acid in the stomach-intestine.

g. French green clays are used to deactivating bacteria since they are toxic to human pathogens (microorganisms) because they reduce species as Fe^{2+} also clays have low thermal diffusion rate and heat retention capacity used for peloids coatings when applied cold or heat according to prescription depending on nature of minerals water and that of the disease. Medicinal clays have been used for centuries, but their environmental healing potential is equally impressive. They have shown vast application in contaminated soil and water (Gomer et al, 2024).

Some medicinal clays have been shown to have the ability to sequester properties for carbon, which is used in the fight against climate change, they can also be used to restore a damaged ecosystem by promoting biodiversity and supporting the recovery of endangered species (Ghost et al., 2019). Clays is a rapidly growing field in research with exciting implications for sustainable development, environmental protection, and human well-being.

This paper aims to show the impact of clay in the environment and medical aspect. Although clay materials can be used as alternative potentials in environmental healing with limited resources.

Types of clay in medicinal use

Clays have been in use since prehistoric times. Native (indigenous people) use clay as a geophagy (Malebatja et al., 2024). For medicinal purposes, as external applications in health spas in clay-mud therapy, clays like kaolin and bentonite of the smectite clay are used.

I. Bentonite:

Bentonite is a swelling clay with absorbent capacity comprising mainly montmorillonite (Smectite) with calcium or sodium montmorillonite. It is formed from weathering of volcanic Ash in seawater or hydrothermal circulation of porosity of volcanic Ash beds (Barast et al., 2017), which converts volcanic (glass) present in the clay minerals. In the process, large silica is soluble and washed away living bentonite deposit. It is usually white, green, or light blue in its reduced form Fe^{2+} or cream, brown, or yellow in its oxidized form Fe^{3+}. Its ability to swell eight times by absorbing a large quantity of water renders it unfit for the construction of roads and buildings, nevertheless, its advantage is used in drilling mud and sealants in groundwater. It is platy in grains, giving rise to a large surface area and sticks to each other when wet - a value-added adsorbent. The common name for bentonite in Nigeria is Nzu or Ndom.

Bentonites help the gut absorb more nutrients by multiplying the Flora in your intestine, improving leaky guts and other digestive conditions (Young, et al., 2011). It is one of the healing agents from ancient times, it is used in detoxification because of its cationic nature, absorbing negative toxins. Studies have shown the safety of bentonite

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in foods and that it does not affect serum concentration of important vitamins and nutrients in humans, it reduce aflatoxins in feed ingested and reduce their bioavailability, also have the potential for absorbing organochlorine pesticides, which are organic pollutants in our environment because of their cation exchange nature (Mitchel et al., 2014, 2013; Cruz-Guzman et al., 2005)

Bentonites can be used in treating lead poisoning, which is toxic to major organs in the body, like the kidney, nervous system, heart, and intestine. In pigs, feeding supplements with bentonite for 100 days reduced the concentration in blood, liver, kidney, and hair (Yudy et al., 2008). Excessive copper and calcium in the body could be decreased by supplements of bentonite. It also decreases gene toxicity and cadmium-induced cytotoxicity in tilapia fish. (Kim et al., 2011; Mahrous et al., 2015)

Cosmetics mixed with salt lake water and applied over a paraffin layer are used in spas (geotherapy), as the combination is used in facial treatment to address blackheads and spots, when applied warm to the face. One of the problems in infancy, diaper dermatitis, can be controlled with bentonite (Adib-Hajbaghery et al., 2014). It can also be used in cream as a moisturizer to improve hand dermatitis in individuals prone to its exposure (Fowler, 2001; Moosavi, 2017). Its application is external. In sunscreen, it is used in commercial lotions for its adherence to skin, resistance to water and ultraviolet light absorbing capacity (Fowler, 2001; Movahedi, 2024), healing of ulcers and skin lesions (Sandi et al., 2014). Bentonite clay is shown in treating diarrhoea caused by food poisoning, virus infection, nucleus colitis, irritable bowel syndrome, and modulating bowel movement in constipation. Bentonite increases gut Flora, a complex microorganism in animals that helps in the fermentation of dietary fibre to short-chain fatty acids that synthesize bile acids, sterols, and xenobiotics (Yu et al., 2005; Clarke et al., 2014).

Bentonite promotes the diffusion of urine from blood vessels to the intestine and facilitates its absorption in the intestine. It also decreases serum creatinine by absorbing and increasing its excretion from the intestine (Cao et al., 2009). Natural material of geological origin as clay, holds antibacterial properties. It could kill a broad spectrum of bacteria by mixing clay with water in a ratio of 2:4 and incubating for 24 hours at 37°C with live bacteria. Oral administration of bentonites slightly decreases absorption of calcium in bones of animals and helps in strong bone formation in broilers (Hayd et al, 2008). Recently, bentonite has been shown to inhibit the growth of human cancerous cell lines U251, controlling the growth level of the components. It also prolongs sleeping time, improves the hypoxia nanomaterials tolerance capacities of mice, decreases bleed time, and can be a haemostatic agent. Other uses are in used food packaging fillers, it can filter indoor volatile organic compounds emanating from building materials in improperly ventilated homes. (Mortazavic et al., 2009). Like other drugs, large doses of bentonite could have adverse effects, so a therapeutic dose is necessary. This review shows that bentonite clay can be used for various disorders and should be used in medicine.

2. Porcelain clay (Kaolin clay) with chemical composition $Al_2Si_2O_5(OH)_4$. It is a layered silicate mineral, with a tetrahedral sheet of silica (SiO_4) linked through oxygen atoms to an octahedral sheet of aluminium (ALO_6). White to cream in colour, sometimes red to brown from impurities, flexible but inelastic, produced from chemical weathering. It is a natural ingredient for short-term treatment of diarrhoea, skin dryness and minor bleeding of the skin (Flora, 2018). In spas, it is used as a mild cleanser, gentle exfoliator, natural acne blemish treatment and teeth whitener, swelling and mouth ulcers (oral mucositis). In veterinary medicine, it is used in minor stomach problems in animals, aids digestion by stabilising and coating the digestive tract of horses, cattle, sheep, goats, dogs and cats. It has been used as an emollient, drying agent, for weeping poison ivy, lesions, as a temporary relief of anorectal itching and diaper rash (Wan, 2006). It is used as a filtering agent to clarify liquids, decolorization of dye in wastewater using the electrocoagulation method (Zhuo, 2007), added to dusting powder and used as a tablet excipient as an antacid when used in the modified form. In detoxification of the toxic effects of graphene oxide nanoparticles used in biomedical materials (Rozhina, 2019). It improves stool consistency within 48 hours, but not the amount of fluid lost. As a haemostatic agent it is a recognized coagulation activator used for a long time to measure activated clothing time (ACT) to prevent thrombosis and reduces Inflammation (Dalbert, 2006), kaolin-soaked gauze in surgical procedures as haemostatic agent has been found (Delgado Chavez, 2014), also as safe and effects haemostatic for foot ulcer debridement for diabetic patients on anticoagulants (Hwang, 2019). It is on record that kaolin is been used as insecticides that affect crops (Barker, 2007), serodiagnosis of tuberculosis using the kaolin agglutination test, in testing serum in horses for seroconversion against equine influenza virus, and respiratory

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diseases in horses (Boliar, 2006). In wastewater purification, the addition of kaolin can result in the removal of pollutants as well as bactericidal effects, improve membrane filter index and corrosion inhibition (Umudi et al., 2024).

3. French clay (illite) The Egyptian, Roman and Greek civilizations usually used French clay, French clay usually naturally occurring rich mineral which derives its colour from iron oxides and decomposed matter, enhancing the clay's purifying and detoxifying properties. It has negatively charged ions that remove toxins from the skin (Sandra & Lynda, 2016). It can absorb excess oil and sebum, unclog pores and remove the appearance of blackheads and whiteheads. Its fine texture is an excellent mild exfoliating for sloughing dead skin cells, giving it a complexion that is radiant, good blood circulation and a refreshing feeling. It helps in making skin elastic, delaying wrinkles, anti-inflammatory, smoothing, calming inflammation of acne, eczema, and also improves faster rate of recovery. When incorporated into skin care products has a wonderful effect as a naturally occurring product. French clay can be green, pink, red, yellow or white. Their common properties include elasticity and softness, and they neutralize unpleasant body odours. In hair, they remove strands and scalp build-up of dandruff related to flakiness and remove dead cells. These stimulate the roots of hair.

Medically, they boost circulation by reducing inflammation, making them ideal for healing ulcers and sores (Lunda, 2019). Typically, they remove toxins of metallic origin as Mercury, by obstructing their reabsorption in the body, acting as an anti-poisoning. Their uses cut across cosmetics, odoriferous and medicinal, which include but are not limited to salts in baths, creams, lotions, powdered body Scrubs, facial masks, cleansers in the form of minerals, and poultice (Celso de Sousa, 2016).

Generally, during the 20th century, clay and mineral mixtures in water were used in poultices and mud baths as they can break barriers in the human system through skin and absorption, inhalation and indigestion pathways. As a protector of the gastrointestinal tract, antidiarrheals, excipients, emulsifiers, diluents and carriers for molecules that are biologically active in the improvement of the availability of the drug. (Gomes, 2013, Gomes, 2020). In SPAs, as healing materials called peloids/peloids stricto sensu (Carretaro, 2920). Geophagy, the eating of clay by human and animals, serves as a dietary supplement, by providing nutrients like Fe, Zn and Mg and other gastroenterological benefits as a result of their alkalinity and absorbent properties. Also incorporated into animal feeds to bind micro toxins and toxic metabolites. The production of aflatoxins is decreased by the addition of clay as an additive for human food safety (Nadziakiewicz et al., 2019). Combat Gauze, a auze kaolin, is endorsed for homeostatic dressing of life-threatening injuries in first-time treatment. Organoclay made by substituting organic cations with the 2:1 clay interlayer structure in montmorillonite clays is used as a disinfection agent, also used in producing polymer-clay nano-composites for removing organic contaminants in herbicides, pesticides, pharmaceuticals, and cosmetics found in water resources, even after treatment. (Gueugen, 2019), (Sandril, 2020).

Clays are incorporated as lubricating agents in powder (talc), correcting flavours (smectites), thickeners (kaolin and smectites), binders and diluents (talc, smectite and kaolin), carriers for drugs released in antimycotic, anticancer, antioxidants in drug clay hybridization (Gomes, et al., 2024). In cosmetics, they are used as pH stabilizers, emollients, emulsifiers and absorbents. (Moses, et al., 2017). The basic property of material to be used for cosmetic and drug delivery must conform to the following: non-toxic even at low concentration, stable, chemically inert, the right particle size and texture. (Roselli et al., 2015).

Peloid and its Pelotherapy

Clay plays an important role in peloid - a natural product of a mixture of mineral water, seawater and lake water in combination with inorganic and organic materials of biological or geological matter in baths, for therapeutic purposes, which is now in application by hydrological medical experts (Gomes, 2021). The unnatural clay water mixture with maturation at a health spa or natural mineral water used in a health spa, i.e. specific clay-specific water functional with added additives. The therapy is thermotherapeutic, biochemical, chemotherapeutic and biological. The Dead Sea's salt pan environment, with its Dead Sea clay, is a natural climatotherapy tourist centre for the treatment of psoriasis. (Gomers, 2019). It becomes a source of hazard at low pH, being corrosive to skin and a famous source of corrosion of metals.

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Although French clays have many benefits, they are used for external purposes. Pregnant and nursing women are advised to use French clay with the medical advice of a physician. It should be kept away from children under the age of 7 (seven) to avoid inhalation, and kept dry to retain its effectiveness. Clay should not be kept in metallic tins, so that their properties are retained. Dry clay can be stored in ceramics, glass or wooden containers. Anaemic patients should not use clay (French) since absorption of iron may be affected, if absorbed through the skin (podoconiosis), depending on duration and level of exposure. (Chandler, et al., 2021; Gomes et al., 2021; Carretaro, 2020b). Some clays can cause podoconiosis, a disease of the foot, limited to inhabitants who work with bare feet in the tropics (Chandler, et al., 2021), but this risk to humans is of low toxicity according to WHO 2005.

Conclusion

Clay, as a natural product, has numerous applications of various importance to humans. This is attributed to its abundance, platy shape, cation exchange capacity, low cost, absorptivity and nanosize compatibility with biological matters and its ease of manipulation. Its usage includes but is not limited to carriers in drugs and medicine, therapeutic applications, packages for food, binders and healing properties in cosmetics, and its bactericidal properties. From the literature, the applications of clay have both negative and positive sides on humans and the environment. However, it is more valuable to humans than its harm.

Suggestion

Further research would look into the global application of clays.

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