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The Future of Nigeria's Lithium Resources: Industrial Applications and Prospects – A Review

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ABSTRACT

Nigeria is home to significant lithium resources, particularly in regions such as Nasarawa, Kaduna, Oyo, Kwara, Kogi, Ekiti, and Plateau. These lithium-bearing pegmatites, mainly consisting of spodumene and lepidolite, contain high-grade lithium oxide (Li_2O) concentrations that are in demand globally due to the crucial role lithium plays in the development of clean energy technologies. As the world transitions away from fossil fuels, lithium is at the forefront of this shift, particularly in applications such as electric vehicle (EV) batteries, renewable energy storage systems, and consumer electronics. With the global market for lithium growing at an unprecedented rate, Nigeria stands poised to become a key player in the global lithium supply chain. However, while Nigeria's lithium resources have the potential to bring significant economic benefits, the country's lithium industry faces multiple challenges. Illegal mining practices, particularly in regions like Nasarawa's Wamba community, have resulted in environmental degradation and human rights violations, including child labor. Additionally, foreign involvement in illegal mining activities, especially from countries such as China, complicates efforts to regulate the sector. Despite these challenges, there are substantial opportunities for growth and development in Nigeria's lithium industry. To fully realize the economic potential of its lithium resources, Nigeria must focus on several key areas: the establishment of robust regulatory frameworks, the adoption of sustainable mining technologies, the development of critical infrastructure, and the promotion of public-private partnerships. With the right policies and investments, Nigeria can become a leading supplier of lithium for global clean energy technologies. This paper provides an overview of Nigeria's lithium resources, exploring the current state of the industry, challenges faced, and strategies for leveraging these resources to contribute to the global clean energy transition while ensuring the country's long-term economic growth and environmental sustainability.

Keywords: : Lithium Resources, Renewable Energy Storage, Lithium Extraction, Illegal Mining, Environmental Sustainability, Beneficiation Technologies.

Definition of terms:

DMS (Dense Medium Separation): A beneficiation process used to separate minerals based on their density, enhancing the concentration of valuable minerals like lithium from gangue.

EV (Electric Vehicle): A vehicle powered by electricity stored in batteries, such as lithium-ion batteries, rather than traditional internal combustion engines, contributing to cleaner transportation.

Beneficiation: The process of improving the quality of ore by removing unwanted minerals (gangue), thereby increasing the concentration of valuable minerals like lithium.

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Froth Flotation: A mineral processing technique that separates valuable minerals from gangue by using air bubbles to selectively attach to the desired minerals.

Leaching: A chemical process that extracts valuable metals, such as lithium, from ores by dissolving them in

a solvent, typically following roasting.

INTRODUCTION

Nigeria's lithium resources are increasingly becoming a focal point in discussions about the future of clean energy and technological advancements. The country is endowed with significant lithium-bearing pegmatites, particularly in regions such as Nasarawa, Oyo, Kwara, Kogi, Ekiti, and Plateau. These deposits, primarily composed of spodumene and lepidolite, are known to contain high-grade lithium oxide (Li_2O) concentrations, with some ores surpassing the global cutoff grade of 0.4% Li_2O (Isa et al., 2025). As the global demand for lithium continues to rise, particularly driven by its crucial role in electric vehicle (EV) batteries, renewable energy storage systems, and consumer electronics, Nigeria stands poised to play a critical role in the global lithium market.

Lithium as a Strategic Resource

The industrial applications of lithium are vast and growing. Lithium-ion batteries are essential for powering electric vehicles (EVs), which are central to the global push for reducing carbon emissions and transitioning away from fossil fuel-dependent transportation systems. Lithium is also used in energy storage systems for renewable energy sources like solar and wind, providing the necessary technology for storing intermittent energy. With the increasing adoption of these technologies worldwide, the demand for lithium has surged dramatically, making it one of the most sought-after commodities for clean energy (Isa et al., 2025).

Nigeria’s lithium deposits are ideally suited for meeting this demand, given their high purity levels. This positions Nigeria as a potential hub for lithium extraction and processing, with significant implications for its economy and the global clean energy transition. In particular, recent investments in the country’s lithium sector, such as a $1.3 billion deal for lithium processing plants in Nasarawa State, are signals of Nigeria’s increasing importance in the global supply chain (Isa et al., 2024). These developments are in line with the global trend of securing stable and sustainable sources of lithium, particularly as countries and industries seek to build out their electric vehicle fleets and energy storage capabilities.

Current State of Nigeria’s Lithium Industry

Despite the promising outlook, Nigeria’s lithium industry faces several challenges that must be addressed to unlock its full potential. The first major hurdle is the issue of illegal mining. Informal, unregulated mining activities, particularly in regions such as Nasarawa’s Pasali community, have raised concerns about environmental degradation and human rights violations. Children, as young as six years old, are reported to work in hazardous conditions in these illegal mines, with little to no regard for safety or sustainability (Isa et al., 2025). The environmental impacts of such operations are equally concerning, with the potential for significant destruction of local ecosystems due to unregulated mining practices and improper waste disposal.

The presence of foreign buyers, particularly from countries such as China, has complicated the situation. These buyers often engage in illicit transactions with local mining operators, contributing to the spread of illegal mining activities. As such, there is an urgent need for regulatory frameworks that can effectively manage and supervise mining activities in Nigeria, ensuring that the lithium extraction process is both environmentally sustainable and socially responsible.

The Role of Technological Innovation in Shaping the Future

To fully harness the economic potential of its lithium resources, Nigeria must adopt more efficient and sustainable mining and processing techniques. One promising area is the use of advanced beneficiation

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technologies, such as flotation and dense medium separation (DMS), which can improve the yield and quality of lithium extracted from pegmatite ores (Isa et al., 2025). For instance, flotation methods have been shown to enhance the recovery of lithium from spodumene-rich ores, improving both the grade and quantity of lithium produced. Furthermore, the adoption of innovative technologies like nanotechnology in mineral processing could improve operational efficiencies and reduce the environmental footprint of lithium extraction processes (Isa et al., 2024).

Economic and Environmental Sustainability

Aside from technological advancements, Nigeria's lithium sector must prioritize environmental sustainability. While the extraction of lithium can be economically beneficial, the environmental costs of mining and processing must be minimized. This includes adopting sustainable mining practices, such as reducing water and energy consumption, limiting land degradation, and ensuring that waste disposal practices are environmentally safe. The government of Nigeria, in collaboration with industry stakeholders, will need to develop and implement policies that balance economic growth with environmental protection. These efforts will not only ensure the long-term viability of the lithium industry but also promote the country's standing as a responsible player in the global supply chain for clean energy technologies.

The Path Forward: Policy, Investment, and Innovation

To unlock the full potential of Nigeria's lithium resources, several key actions are required. First, the government must establish robust policies and regulatory frameworks to ensure that lithium extraction is done sustainably, with proper oversight of both environmental and social aspects. This includes the enforcement of laws to curb illegal mining activities and the establishment of clear guidelines for mining companies to follow in their operations.

Second, there is a need for continued investment in infrastructure, particularly in the areas of transportation, processing, and storage. With the influx of foreign investments into Nigeria's lithium sector, the country must ensure that it has the necessary infrastructure to handle the processing of lithium on an industrial scale. This includes building world-class lithium processing plants, improving access to mining sites, and developing reliable storage systems for the raw material.

Lastly, fostering innovation in the lithium sector will be crucial for Nigeria to remain competitive on the global stage. Investing in research and development, particularly in the areas of beneficiation technologies and sustainable mining practices, will position Nigeria as a leader in the global lithium market.

METHOD

There is an ever-increasing output of scientific publications concerning lithium resources driven by recent demand for this, until now, relatively unfamiliar metal. This paper provides an up to-date

overview of the literature in this specific area and brings together relevant material from various sources. Articles included in this review were accessed from journal databases, bibliographic databases, and subject-specific professional websites. The inclusion criteria for articles comprised of only relevant peer-reviewed qualitative and quantitative articles related to both the uses and sources of lithium globally.

Lithium: Properties, Deposits, and Uses

Lithium is a soft, silvery-white alkali metal, the lightest metal in the periodic table, and the only metal that is liquid at room temperature. Its chemical symbol, Li, comes from the Greek word *lithos*, meaning stone, reflecting its occurrence in mineral forms. Lithium is highly reactive, particularly with water, and is primarily found in nature in mineral form, such as spodumene, petalite, lepidolite, and ambligonite, which are the main lithium-bearing minerals. Lithium is often extracted from lithium-rich pegmatite deposits or brines, which are the primary sources of lithium globally.

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The industrial uses of lithium are vast and growing. Its most prominent use is in the production of lithium-ion batteries, which power electric vehicles (EVs), consumer electronics, and renewable energy storage systems. The demand for lithium has surged due to the rapid growth of the electric vehicle market, the shift to renewable energy sources, and the increasing use of portable electronics. Aside from its applications in batteries, lithium is also used in the production of high-performance lubricants, heat-resistant glass, ceramics, and in the pharmaceutical industry for treating bipolar disorder (Isa et al., 2025).

Global Lithium Deposits

The global distribution of lithium is concentrated in a few key regions. Some of the largest lithium reserves are located in the Lithium Triangle, which includes parts of Chile, Argentina, and Bolivia. These countries together hold more than 50% of the world's lithium reserves, primarily in lithium-rich brines. Australia is also a significant player in the global lithium market, with its Greenbushes lithium mine, one of the largest and most productive lithium mines in the world, primarily extracting lithium from hard rock deposits (Isa et al., 2024).

Other countries such as China, Zimbabwe, and Canada also have substantial lithium resources. In China, both brine and hard rock deposits are utilized, while Zimbabwe is an emerging lithium supplier, with considerable spodumene deposits. Despite these global leaders, Africa is increasingly becoming an important source of lithium, particularly Zimbabwe, which has been recognized as Africa's top lithium producer (Energy Capital & Power, 2025).

Lithium in Africa

Africa’s lithium potential is attracting significant attention from global investors and miners. Zimbabwe is the largest lithium producer in Africa, with large reserves found in the Bikita and Kamativi mines. Zimbabwe's lithium reserves are significant, and the country is working to develop its lithium extraction capabilities to meet the rising global demand for this strategic resource (Isa et al., 2024).

In South Africa, the Blesberg lithium deposit in the Northern Cape has gained attention for its potential to boost Africa's contribution to global lithium production. The development of lithium projects in Mali and Namibia also suggests that Africa’s lithium reserves are diverse and growing, presenting further opportunities for development and investment (Energy Capital & Power, 2025).

Nigeria, as one of Africa’s emerging lithium producers, holds significant potential for lithium extraction. Several states, including Nasarawa, Kogi, Oyo, Kwara, and Plateau, are home to lithium deposits, primarily in the form of spodumene, petalite, and lepidolite (Olajuyi et al., 2025). In 2018, a Nigerian mining company, Kian Smith Trade & Co, discovered significant lithium deposits in Nasarawa State, with estimates indicating over 15,000 tonnes of commercial lithium content (Reuters, 2023). This discovery has sparked increased interest in Nigeria’s lithium industry, positioning the country as a potential key player in the lithium supply chain.

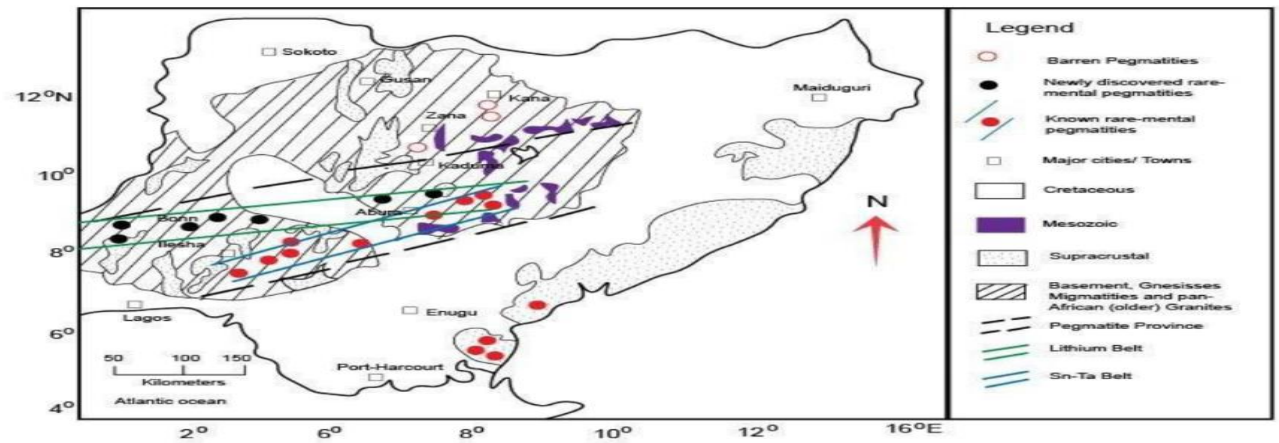

Figure 1: The Lithium and Tantalum Belts in Nigeria’s Pegmatite Province (Isa et al., 2024)

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Lithium in Nigeria: Current and Future Prospects

Nigeria's lithium resources remain largely untapped, but recent discoveries suggest a significant potential

for both extraction and processing. The lithium-bearing deposits in Nasarawa and Oyo are among the most notable in Nigeria. These areas contain high-grade minerals that are well-suited for commercial lithium production. The Nigerian government, in collaboration with private stakeholders, has started to focus on developing this resource. In particular, there are increasing investments aimed at establishing lithium processing plants, including a $1.3 billion deal for processing facilities in Nasarawa State (Isa et al., 2024).

Despite this potential, Nigeria faces several challenges in fully exploiting its lithium resources. One major issue is the prevalence of illegal mining activities in certain regions, especially in Nasarawa's Pasali community, where unregulated mining has led to significant environmental and social issues. Reports indicate that child labor is prevalent in these illegal mining operations, with children working in dangerous conditions under informal arrangements with foreign buyers, including Chinese firms (Isa et al., 2025). To address these issues, the Nigerian government must implement stricter regulations and oversight to ensure sustainable mining practices and protect local communities.

Deposit	**State**	**Associated Minerals**
Panda	Nasarawa	Pegmatite
Wamba	Nasarawa	Quartzite
Kabba	Kogi	Quartzite
Kushaka, Birnin Gwari	Niger	Pegmatite/Petalite
Isanlu Egbe	Kogi	Pegmatite
Ilesha	Osun	Pegmatite
Ijero Aramoko	Ekiti	Pegmatite
Arikya Tsauni	Nasarawa	Pegmatite and Quartzite
Kafin Maiyarki	Nasarawa	Granite
Itakpe Area	Kogi	Quartzite and Pegmatite
Oke Ogun	Oyo	Quartzite
Ago Iwoye	Ogun	Pegmatite
Hong	Adamawa	Lepidolite/Kunzite
Zuru	Zamfara	Petalite
Kafanchan	Kaduna	Spodumene/Kunzite
Lere	Kaduna	Petalite
Jos-South	Plateau	Quartzite/Lepidolite
Ganjuwa	Bauchi	Lithium Oxide/Lithia

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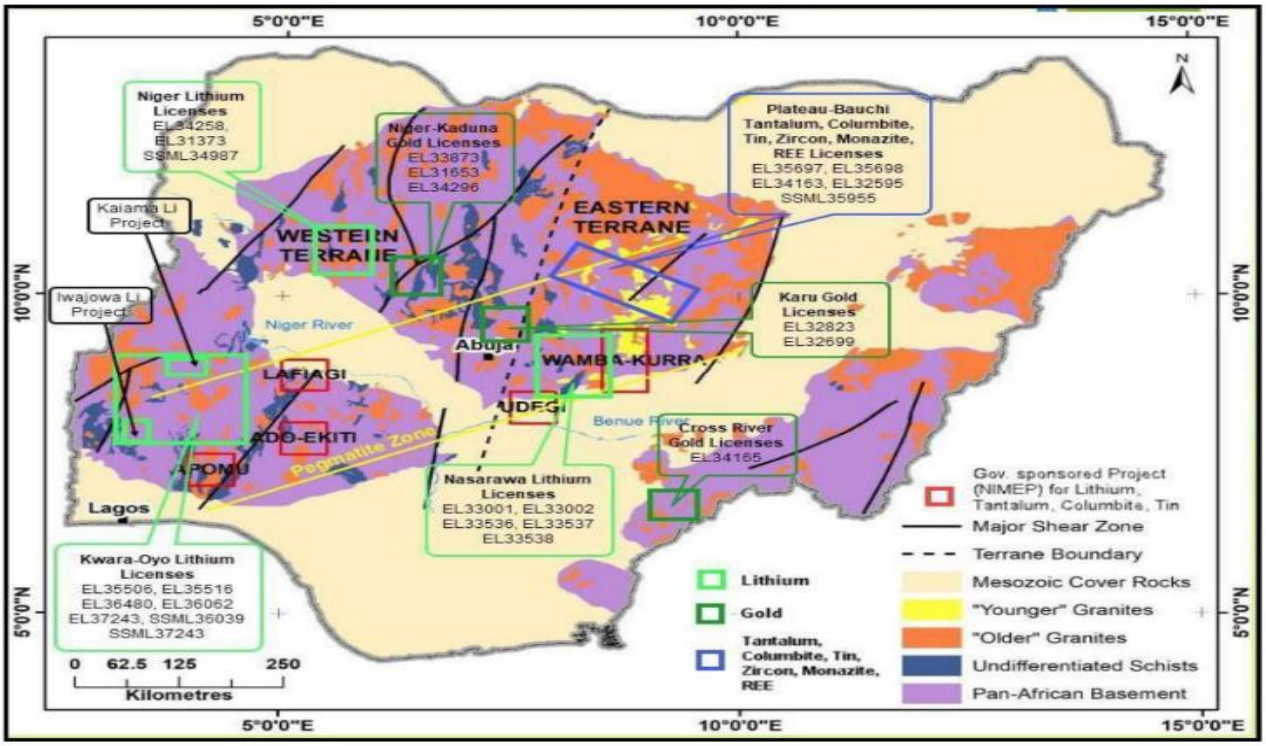
Gidan Boda, Baruten	Kwara	Spodumene
Keffi	Nasarawa	Lepidolite

MMSD, 2022

Figure 2: Geological Map of Nigeria Showing Major Rock Groups (MMSD, 2022)



Geology of Lithium Deposits in Nigeria

The geology of lithium deposits in Nigeria is associated with a complex interconnection of diverse geological frameworks prevalent in the region. This framework includes a wide array of rock formations, such as igneous, metamorphic, and sedimentary rocks, all of which play a significant role in the formation and distribution of lithium deposits.

Nigeria's Precambrian Basement Complex comprises crystalline igneous and metamorphic rocks, forming the oldest geological foundation of the country. This complex is interspersed with sedimentary basins of Cretaceous and Cenozoic age (Olajuyi et al., 2025). Lithium-bearing minerals such as lepidolite, spodumene, and petalite are primarily found in pegmatite fields, which are steeply inclined intrusive bodies within the basement rocks of gneisses and schistose assemblages, occasionally pulsed with isolated granitic bodies (Olajuyi et al., 2025). These pegmatites are rich in lithium and other valuable minerals like tantalum, niobium, tin, and beryllium, with significant deposits in Kogi, Nasarawa, Ekiti, Kwara, Cross River, Oyo, and Plateau States (Olajuyi et al., 2025).

The lepidolite from the Ijero-Aramoko pegmatite field exhibits a layered structure with high silica content (49.43%–57.81%) and notable concentrations of lithium (1,656 ppm–1,859 ppm), along with aluminium and potassium, making it suitable for industrial applications such as lithium-ion batteries and pharmaceuticals (Olajuyi et al., 2025). Additionally, the polylithionite ore from Keffi in Nigeria has been successfully extracted in chloride media, demonstrating a high lithium leaching efficiency of 83.82% under optimal conditions (Olajuyi et al., 2025).

The geological settings of these lithium deposits are further characterized by the presence of various rock types, including charnockite and granite, which are part of the older granite suite occupying significant portions of the area (Olajuyi et al., 2025). The diverse mineralogy and geochemical characteristics of lithium-containing rocks

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are evident, primarily associated with high silica and barium content, indicating a sedimentary protolith origin derived from a continental environment (Olajuyi et al., 2025).

Nigeria's rich endowment of lithium and other solid mineral resources underscores the potential for economic diversification from petroleum exploration. Research and technological advancement are also targeted at achieving local beneficiation and refining of these ores or minerals-containing rocks to drive economic growth and create wealth for the citizenry (Olajuyi et al., 2025). Nigeria's geological, structural, and tectonic settings have not only facilitated the exploitation of these mineral deposits but have also contributed to the geomorphological evolution of the landscapes, offering considerable aesthetic and touristic potential (Olajuyi et al., 2025).

Nigeria's Lithium Belt

Nigeria's lithium deposits are dispersed within the WSE-ENE trending zone called the Lithium Belt or pegmatite metallogenic province. This zone spans over 700 km, covering an area from Oyo State in Southwestern Nigeria to Plateau State in the north-central region. As mentioned, the belt is characterized by Lithium-Caesium-Tantalum (LCT) pegmatites that are rich in lithium-bearing minerals, including lepidolite and spodumene. Similarly, the zone lies within the Precambrian basement complex, as indicated on the geological map. In addition to the LCT pegmatites, the rare-metal pegmatites form a new lithium belt, slightly north and west of the Tin-Tantalum Belt.

Overall, the Nigerian Lithium Belt reveals a vast lithium mineralization that is rich in high-grade lithium ores, with some low- to medium-grade metasediments embedded in metavolcanic rocks of the Proterozoic Schist Belts.

Major Lithium Ore Deposits in Nigeria

Nigeria possesses a substantial reserve of lithium ore deposits, which have garnered increasing significance in response to the escalating worldwide need for lithium, particularly for lithium-ion batteries and other sustainable energy applications. The primary lithium ore reserves are located in Kogi, Nasarawa, Ekiti, Kwara, Cross River, Oyo, and Plateau States. These deposits contain various lithium-bearing minerals such as amblygonite, lepidolite, spodumene, and petalite, essential for the production of lithium-ion batteries used in numerous high-tech devices and electric vehicles (Olajuyi et al., 2025).

Specifically, the polylithionite ore from Keffi, Nasarawa State, has been studied for its lithium content, showing promising results with a lithium assay of 3.25 wt% and an extraction efficiency of 83.82% under optimal conditions (Olajuyi et al., 2025). Additionally, the Egbe District in Kabba Province of Kogi State is notable for its nigerite-group minerals, containing essential lithium, as demonstrated by Secondary Ion Mass Spectrometry (SIMS) analysis (Olajuyi et al., 2025). The financial market theory of development has been applied to optimize lithium ore exploration in Nasarawa State, revealing high lithium presence, with concentrations exceeding 1,859 parts per million (ppm) (Olajuyi et al., 2025).

Uses of Lithium

Lithium's primary industrial applications are in the production of lithium-ion batteries, which are essential for modern energy systems. These batteries are used in electric vehicles (EVs), which are pivotal to reducing carbon emissions and transitioning to renewable energy sources. Lithium-ion batteries also serve as energy storage systems for solar and wind power, making them crucial for the expansion of renewable energy infrastructure (Isa et al., 2025).

In addition to energy storage, lithium is used in the production of high-performance lubricants, especially lithium-based greases, which are vital in automotive and industrial machinery. Lithium ceramics are another important use, as lithium compounds help lower the melting point of glass, making it more durable and resistant to thermal shock. This property is particularly useful in the production of heat-resistant glass, such as that used in cookware, windows, and televisions (HealthDirect, 2025).

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Environmental and Social Challenges

While lithium mining offers significant economic opportunities, it also poses environmental and social risks. The mining and processing of lithium can lead to habitat destruction, pollution, and the depletion of water resources, especially in areas where brines are extracted for lithium. Moreover, the issue of child labor in some African and South American mining operations is a major concern. The presence of informal mining activities in regions like Nasarawa has led to violations of human rights, making it critical for governments and companies to establish fair and ethical labor practices and environmentally responsible mining techniques (Isa et al., 2025).

Lithium Ores Processing in Nigeria

The lithium extraction process begins with mining, where ore deposits are identified and extracted using conventional methods. The choice of mining technique depends on various factors, including the depth, size, and economic viability of the deposits. After extraction, the ore undergoes crushing and grinding, a mechanical process that breaks the ore into smaller particles. This process, known as comminution, reduces the ore's size and helps efficiently release and separate lithium from other minerals. The aim is to achieve a fine enough particle size to optimize the recovery process (Isa et al., 2025).

Once the ore is crushed and ground, froth flotation is used to separate and concentrate lithium minerals, such as spodumene and lepidolite, from other minerals in the pegmatitic deposits. Froth flotation is a mineral processing method that exploits differences in the surface properties of minerals, enabling the selective separation of lithium minerals based on their ability to adhere to air bubbles, which are then floated to the surface. Studies of lithium ore deposits in Europe have shown that froth flotation can produce Li2O concentrates, although challenges such as fine quartz and albite inclusions can reduce the process's effectiveness (Isa et al., 2025). Depending on the ore's specific characteristics, flotation can be performed through either direct or reverse flotation.

Following flotation, the concentrate undergoes roasting, a thermal process that converts lithium minerals into water-soluble compounds, making them ready for the next stage—leaching. Roasting is a vital step in lithium extraction, as it enhances the accessibility of lithium for further extraction. For instance, Philippe Yolka's study on lithium recovery from spent lithium-ion batteries (LIBs) demonstrated that sulfuric acid roasting at 750 °C efficiently converts lithium oxide into lithium sulfate, which can then be dissolved in water for further processing (Isa et al., 2025). Another method, explored by Dong et al. (2024), involves calcium sulfate roasting of overhaul slag, which also transforms lithium into a soluble form, aiding subsequent extraction and refining.

These essential processing steps—from mining to roasting—are critical to lithium recovery and refining in Nigeria. With extensive lithium reserves, primarily in Kogi, Nasarawa, Ekiti, Kwara, Cross River, Oyo, and Plateau States, Nigeria has the potential to play a significant role in the global lithium supply, especially as the demand for lithium-ion batteries and other sustainable energy technologies continues to rise (Isa et al., 2025).

Nigeria Government Contributions towards Safe and Sustainable Lithium Mining and processing

The global demand for lithium has surged with the transition to clean energy, which is vital for driving renewable energy sources and advancing battery technology. Ensuring a steady supply of lithium is key to making this energy transition sustainable, and this requires efficient lithium ore mining and the use of environmentally friendly extraction methods. The government plays a crucial role in addressing illegal mining, enforcing mining regulations, and protecting resources, miners, the mining community, and the environment. However, illegal mining activities in Nigeria remain a complex issue due to poor documentation, limited data on these activities, and a lack of detailed location information. While licensed miners are organized into formal groups, formalizing the activities of illegal miners has been challenging due to economic hardship, corruption, and terrorism. Tackling these developmental issues in lithium extraction will enhance the confidence of licensed mining companies, attract potential investors, and ensure a sustainable supply of lithium and other rare earth minerals crucial for the energy transition.

Nigeria has intensified its efforts to combat illegal lithium mining. Recent operations have led to the arrest of foreign nationals and local illegal miners, highlighting the involvement of foreign entities in these activities.

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Illegal mining is linked to several issues, including banditry and corruption. The government's efforts to formalize artisanal and small-scale miners, along with the enactment of mining regulations, have helped reduce illegal mining and the extraction of lithium and other minerals in Nigeria. Additionally, the reactivation of the Solid Minerals Development Fund (SMDF) through a partnership with the Africa Finance Corporation (AFC) will stimulate private sector investment in mining, support promising mining projects, and provide funding for sustainable lithium extraction. This partnership will also facilitate the construction of midstream processing plants for lithium, nickel, and other critical energy transition metals in Nigeria, essential for the global clean energy transition, increased investment, and environmental protection.

The Nigerian government has also introduced the Electronic Mining Cadastre System (eMC+)**,** a digital platform that streamlines the online management of mineral titles. Since its launch, the platform has increased revenue generation for the government, ensuring transparency and efficiency in the licensing process. However, there are no records of sanctions against illegal miners or the closure of illegal mining operations. While the platform aims to improve communication between the government and industry stakeholders, its main impact has been in boosting revenue generation rather than addressing mining practices, processes, and the people involved. A comprehensive data collection and analysis of lithium mining activities are crucial for formalizing the industry and its participants, ensuring that digital systems and processes can truly transform the mining sector.

CONCLUSION AND RECOMMENDATION

Nigeria's lithium deposits offer significant economic growth potential, driven by the global demand for clean energy technologies like electric vehicles and renewable energy storage. However, the industry faces challenges such as illegal mining, environmental degradation, and social issues like child labor. To unlock its full potential, Nigeria must strengthen mining regulations, promote sustainable practices, and invest in infrastructure and technological advancements. Public-private partnerships and initiatives like the Electronic Mining Cadastre System will be key in fostering a responsible, transparent mining sector. By addressing these challenges, Nigeria can become a leading, responsible supplier of lithium in the global market, contributing to the clean energy transition.

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