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Assessment of Lithium Ore Deposits in Nigeria: A Study on the Potentials of Lithium for Renewable Energy

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Abstract: *This research looked into the prospects and potential for lithium minerals in Nigeria and how it can help to put the country on the world map. The energy crisis and insecurity faced today alongside the issues brought about by climate change necessitates the need for the presence of a renewable source of energy that would help in curbing energy issues and increasing technological innovations. This research attempted to understand the grade and composition of lithium in some places in Nigeria such as Kwara, Taraba, Bauchi, Ogun and Nasarawa states, with a view to establishing a baseline on the quality of lithium and locations where it can be found in the country. The prospects of manufacturing and energy industry can be further increased with the presence of the mineral because of the benefits of the lithium batteries. The research further stated the increase in demand of lithium all over the world and the benefits it would bring for the country through its extraction. It also highlighted the increase in projection of the demand that would occur in the future and the need for the country to be one of the world's main manufacturers of lithium batteries, which can further be used as a form of energy universally.*

Keywords: *Composition; Energy crisis; Grade; Lithium; Lithium batteries;*

Introduction

The third element in the periodic table is lithium, an alkali metal that is soft and silvery-white. It is the lightest metal there is and about 20 parts per million of lithium are found in the entire crust of the planet, whereas just 0.17 parts per million are found in the oceans and atmosphere. There are several industrial uses for lithium. It is employed in the production of glass, ceramics, medicines, and aluminum and magnesium alloys. The market for batteries, where lithium is used as an electrode and electrolyte in both lithium-ion rechargeable batteries and lithium-ion non-rechargeable batteries, has the most potential for growth (Ichu et al., 2019). The existence of such potential gives more hope to a swift shift to sustainable and renewable energy.

It would be recalled that the global energy crisis has become more pronounced because of its impact on global economies due to global supply disruptions, high energy prices, geopolitical turmoil, unrealized energy transition from carbon sources, and unexplored renewable energy options to name a few. A typical driving example includes the rapid drop in energy demand and cut in oil production during the COVID-19 pandemic, the coal trade dispute between Australia and China in 2020, and climate impact threats on renewable energy, the recently known contributing factor is the Russian-Ukraine military conflict that threatened the energy supply from Russia to Europe, causing countries to diversify their source of energy imports. These crises have had so many effects on different locations such as in countries like the United States of America and even in Nigeria where the fuel crisis has caused prices for importing fuel to go up by more than 100%, amongst other varying effects in other African countries.

Countries all across the world are establishing aggressive policy targets for the decarbonization of energy and transportation as combating climate change becomes a global concern. Due to this, there is a considerable increase in demand for energy storage and electric vehicles, particularly in Asia, Europe, and the USA. In this sense, lithium-ion batteries are the most common type of battery used in modern electric vehicles and energy storage systems. These batteries require a variety of raw materials, several of which have been classified as critical, including lithium, cobalt, graphite, nickel, and manganese. In particular, the first three of them are anticipated to experience a sharp increase in demand in the upcoming years, necessitating the creation of new sources and supply networks(Kathryn et al., 2021).

With each passing day and hour, the effects of climate change on Nigeria have gotten stronger and more pervasive. Climate change effects, such as a rise in climate change-related hazards, have been observed around the world as a result of an overreliance on fossil fuels due to rising demand. A contemporary issue is the country's growing flood frequency, which has resulted

in fatalities, property destruction, and widespread population displacement. Over 500 individuals have died as a result of the flooding and over 1.4 million people have been left homeless in the flooding occurrence in 2022. In addition, 1,546 people were hurt, 70,566 hectares of agriculture were submerged, 45,249 dwellings were "totally damaged," and 27 of the country's 36 states were affected (Washington Post, 2022).

As lithium-ion will be a good source of energy investment, using it as an energy source can offer a possibility for energy stability and a way for renewable energy to grow. Nigeria has a potential to lessen its reliance on fossil fuels and the effects of the climate change brought on by Greenhouse Gas (GHG) emissions. Lithium-ion offers a greater capacity for energy storage as a means of resolving the energy issue, which can support sustainable development and enhance energy security. Lithium is used in a variety of industrial processes, including those that create glass, ceramics, pharmaceuticals, aluminum, and magnesium alloys. With lithium employed as an electrode and electrolyte in lithium-ion rechargeable batteries and lithium-ion non-rechargeable batteries, the battery business is expanding at the fastest rate. The most promise for expansion is lithium-ion non-rechargeable batteries and rechargeable batteries. The need for lithium is rising globally, and Nigeria's access to it provides the opportunity for companies to exploit it effectively as a source of energy production and use (Balaram, 2019; Boswell et al., 2016; Bradley et al., 2017; Graham et al., 2021; Ichu et al., 2019).

Related Works

Because of its distribution and presence in many places, the size of Nigeria's mineral resources cannot be overemphasized. In 1902, Nigeria began exploring and exploiting its natural resources, and at its height, the country's solid minerals industry was one of the world's top producers of tin, coal, and a significant 1.4 tons of gold each year. As previously said, the nation is rich in more than 40 different types of minerals, including marble, gypsum, lithium, galena, limestone, silver, granite, gold, gemstones, bentonite, and iron ore. Since lithium is present in minuscule amounts in practically all rocks, it has recently been detected in some states, including Kwara and Cross River (Agaku et al., 2020).

More significantly, lithium is used to make the majority of rechargeable batteries for electric cars, laptops, digital cameras, and cell phones. Its components are also used in the manufacture of heat-resistant glass and ceramics, lithium grease lubricants, and flux additives for the production of iron, steel, and aluminum, to name a few industrial applications. As battery technology develops, lithium is projected to be essential in attempts to reduce carbon dioxide emissions, which contribute to global warming. Due to the availability of lithium and other natural resources, Nigeria may now have new opportunities to boost its non-oil revenue and adopt the energy of the future (Boswell et al., 2016; Wang, 2021).

Aim and Objectives

The research is aimed at studying the occurrence, grade and distribution of lithium, as well as understanding its potential as a primary energy source in the country. The objectives of the study include to –

- To identify all possible lithium ore locations in Nigeria
- Measure the quality (grade of mineral) in various locations across Nigeria
- Identify various uses of lithium ore; its utilization in the production of energy

Scope of Research

In Nigeria, lithium minerals are known to be associated with metal-bearing rock types called pegmatite. These rock pegmatites stretch from the Wamba area, Nasarawa State (Kwon-Ndung et al., 2016); through Egbe-Isanlu, Kogi State; Ondo and Ekiti States in the southwest; to the Ife and Ilesa, Osun State. Another belt in the western half of Nigeria, stretching from Zamfara and Kaduna States; through Niger and Kwara States and Oyo State is known to host the rare metal-bearing pegmatites. Some have also been found in Obudu, Cross River State, in southern Nigeria. This research focused on analyzing lithium quality found in Kwara, Taraba, Nasarawa, Bauchi and Ogun States.

Lithium is seldom found in its elemental, metallic state because it is so reactive—it is extremely flammable and will even spontaneously react with water. Due to their extraordinary reactivity, certain lithium-ion batteries blow up when exposed to high temperatures. Instead, lithium is typically extracted from igneous rocks and brine pools where it is present as lithium minerals, principally spodumene and lithium chloride salts.

Methodology and Discussion

Five different samples of pegmatite rocks were collected from different locations in the study scope – Ogun, Kwara, Taraba, Bauchi and Nasarawa states. Each

sample was analyzed for their lithium composition through qualitative analysis. The samples were analyzed through crushing and optical sorting treatment. Chloride salts – sodium chloride and calcium chloride were used in roasting for increasing the Li extraction. The leaching agent was water and whatman filter paper was used for filtration experiments. The bulk chemical composition was analyzed by using atomic emission spectrometer which was used to determine the content of Li, using standard procedures.

Table 1 depicts the grade and composition of lithium found in each sample that was analyzed.

S/No	Sample I. D	State (Region)	% Li_2O	% Fe_2O_3	% L.O.I
1.	Sample A	Ogun	**3.11**	**0.34**	**1.60**
2.	Sample B	Bauchi	**2.51**	**0.19**	**2.10**
3.	Sample C	Kwara	**4.15**	**0.30**	**1.00**
4.	Sample D	Taraba	**3.46**	**0.29**	**2.52**
5.	Sample E	Nasarawa	**5.61**	**0.11**	**1.11**

As shown in the results above, it is seen that the sample collected from Nasarawa state has the highest composition and grade – approximately 6%. Also, the sample from Kwara state has a high composition of 4% as well as sample from Taraba which showed a composition of 3.5% and Ogun state with a composition of 3%. As discussed by Kathryn et al., (2021), lithium is a moderately abundant element in the Earth's crust, and is predominantly concentrated into three types of mineral deposit: pegmatites and granites; sedimentary deposits; and brines. Nigeria has more than 44 different types of minerals discovered in 500 locations according to a report of the Ministry of Solid Mineral Development. According to Ichu et al., (2019), there are lithium deposits in Kogi, Nasarawa, Ekiti, Kwara, Cross River, Oyo, Plateau, and a few other states in Nigeria. This result further proves that these state exhibit high potential for locations with lithium ore but at present, there are no mining or processing facilities for lithium in the country. The country has a sizable market for lithium-ion batteries due to the significant consumption of large amounts of lithium-based end products like lithium-ion solar batteries and mobile phone batteries. Favorable regulations, such as subsidies and tax breaks, are anticipated to encourage investment in the local mining, beneficiation, and utilization of Nigerian lithium ores, which will in turn stimulate the development of lithium-ion batteries made in Nigeria for domestic use and possibly export.

The Potentials of Lithium for Renewable Energy

Since lithium-ion (Li-ion) batteries have a very high energy density, they serve as one of the key pillars of the emerging battery technologies (Wang, 2021). Additionally, lithium is needed as a raw critical ingredient in the creation of lithium-ion batteries (LIBs), a technology for energy storage that is crucial for electrified transportation systems and utility-scale energy storage systems for renewable electricity(Graham et al., 2021). By reducing reliance on fossil fuels for transportation and energy production, lithium-ion batteries can promote sustainable development and energy security. A great example of this is the well-known invention Tesla(Agaku et al., 2020). Lithium is also one of the most important chips for cars, especially for thermal glass – at this point, the prospects of use for lithium in the manufacturing industries cannot be understated (Kathryn et al., 2021).

Since the majority of studies have shown that there are enough lithium resources to meet future demands, the rising demand for lithium has given rise to an ongoing discussion concerning its availability (Figure 1). It is expected that batteries are expected to account for 95% of lithium demand by 2030 (Figure 2). However, the study's emphasis on supply and demand equilibrium has drawn attention to the issue of extraction limits brought on by resource concentration and geopolitical risk(Bradley et al., 2017). On the other hand, as low-carbon technologies are material-intensive, any interruption in the supply of minerals may have an effect on the rate and scope of their global adoption.

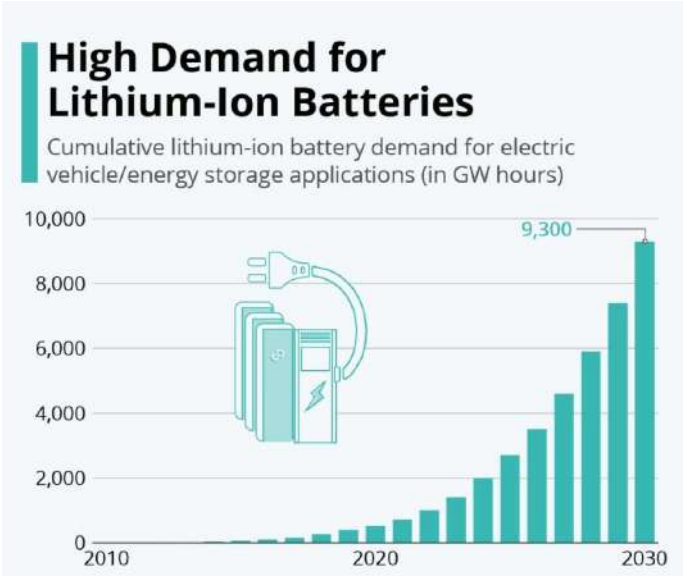

Figure 1: progressive increase in demand for Lithium battery

Source: World Economic Forum, 2021

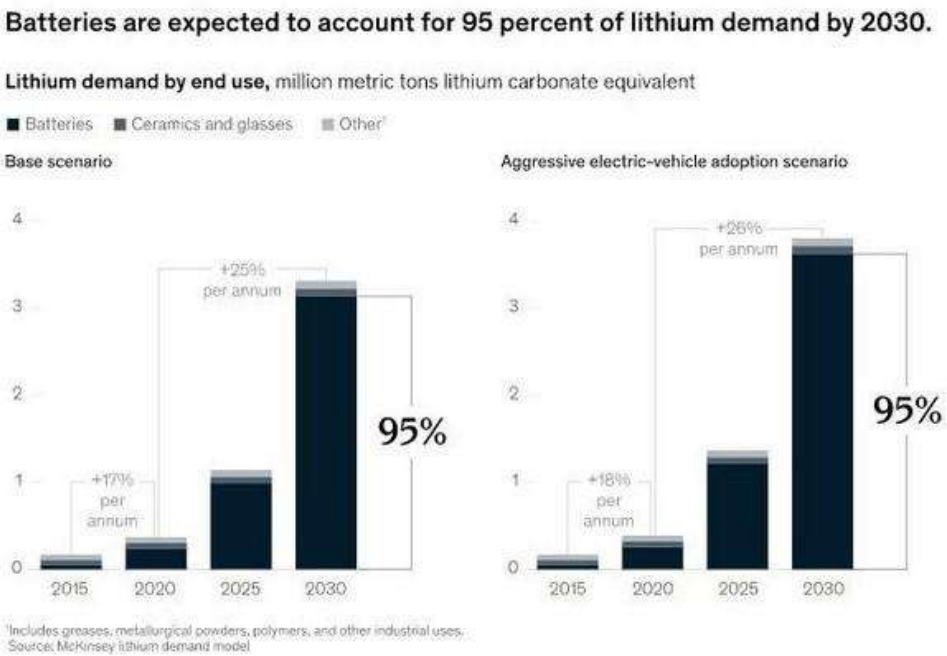

Figure 2: Lithium Demand by 2030. (Source: Mckinsey & Company, 2022)

Nigeria is home to a wide variety of solid minerals, including, but not limited to, talc, gypsum, iron ore, lead, zinc, gold, bitumen, coal, and lithium. Along with other metals like tantalum, lithium metal is currently experiencing a global boom as a result of its many applications. It is the lightest metal known to exist, and of all the solid elements, it has the highest specific heat and excellent electrochemical properties. Lithium compounds also exhibit viscosity/temperature ratios, and because of their exceptional qualities, these compounds have attracted a lot of interest for use in a range of applications.

When lithium gained enormous popularity in portable electronic gadgets in the late 1990s, its journey toward being the "metal of the future" really began. This is shown in the reports where it is stated that the consumption of lithium and items related to it significantly expanded around the world by more than 20% per year in the past several years (Ichu et al., 2019; Warren, 2021). The world reserve for lithium is about 16 million tonnes and about 56% of the global

lithium extraction is used for battery production. Australia produces the most lithium but Chile has the world's largest reserve (Boswell et al., 2016; Kathryn et al., 2021; Wang, 2021; Warren, 2021). It can be inferred that Nigeria is not on the list of major production fronts or reserves. The discovery, production, and occurrence of lithium ore deposits would put the country on the spot globally.

Conclusion

For a country blessed with mineral resources such as lithium, its universal use, particularly in the area of energy would help to put Nigeria along with other African countries such as South Africa and Zimbabwe on the world map as 'countries with high energy potential'. For consumer electronics, Li-ion batteries are commonly used particularly in laptops, i-pads and smartphones. Following electric vehicles, the mass energy storage sector can grow as major utilities would install Li-ion battery storage systems to harness excess power generated by the grid. This research and development project has beneficial impact to the Nigerian nation which includes:

- Contributing to the current technology on energy storage devices by the design and development of lithium-ion battery of different capacities. This will further the promotion of science, technology and innovative designs in the country.
- Reduce the over dependence on the importation of batteries for local use by the establishment of a pilot plant production of lithium batteries that would trigger for small and medium scale enterprise that will drive the economy.
- Reduce the cost of production of batteries by utilizing thin and flexible battery technology. This would kick start the beneficiation of some of the raw materials content which are available in the country and thus spring up many S.M.Es for creating wealth for the citizens.

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