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Public and environmental health implications of artisanal petroleum refining and risk reduction strategies in the Niger Delta region of Nigeria

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Abstract

Artisanal petroleum refining (APR) is often the use of rudimentary equipment to process crude oil into different products. APR is rampant in the Niger Delta area of Nigeria and is often outside the boundaries of the state law. Some typical products of the process include gasoline, automated gas oil, and kerosene. Despite the socioeconomic advantages, which include creating jobs, it poses significant environmental and public health concerns. This review focuses on the environmental and human health effects of APR in the Niger Delta area of Nigeria. According to the research findings, these actions have resulted in the loss of arable farmland, plant cover, household and drinking water supplies, and human food sources. In addition, these activities lead to the emission of harmful particles and gases. These pollutants have adverse health effects, including loss of respiratory and cardiovascular functioning, irritation of the sensory organs, and congenital disabilities. In addition, food safety concerns may ensue from improper management of the APR's effects. It is, therefore, necessary to mitigate the dangers linked to APR in Nigeria's Niger Delta area, i.e., through institutional strengthening and licensing of the artisanal petroleum operatives in the region and applying the environmental and petroleum-related laws in Nigeria. Furthermore, the enlightenment of the populace on the dangers of the long-term impact of APR is crucial.

Keywords: Air pollution, Extractive resources, Crude oil refining, Health risks, Petroleum complexity

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INTRODUCTION

Energy is a vital resource for human survival and the economy's operation. It is hard to overstate the importance of energy in every aspect of a nation's economy (Ohimain and Izah, 2014a, b,c). In addition, energy resources provide foreign currency reserves, which the government employs for its many developmental initiatives, which are vital for economic growth and development (Jekayinfa and Bamgboye, 2007). These reserves also assist the government in funding diverse forms of development projects. However, in many developing countries, the overall price of goods and services is affected by insufficient and inefficient energy use in the various manufacturing processes. As a direct result, so many businesses have closed down in developing countries like Nigeria. To keep the economy from collapsing, individuals must prioritize using energy sources in the most efficient way feasible (Ohimain, 2012).

Nigeria has many energy resources, including geothermal, natural gas, crude oil, biomass, solar, wind, and hydropower. However, the world's other energy resources, except hydroelectricity, oil and gas production, and traditional cooking methods with biomass, have not yet been utilized to their full potential. As a result, most of Nigeria's industries and various medium and small-scale businesses rely on power plants that generate electricity and run on fossil fuels like gasoline and diesel (Ohimain, 2012; Gift *et al*., 2020).

Due to the underutilization of its major petroleum refineries, Nigeria is now experiencing a gasoline shortage (Ohimain,2012). Since Nigeria's domestic refining capacity is inadequate to fulfill the country's daily gasoline consumption, she must import refined gasoline from other nations. Consequently, Nigeria's gasoline usage has fluctuated. According to Eboh (2020a), daily gasoline consumption varied from 30 million to 60 million liters before the present administration. It is not easy to precisely estimate the nation's daily gasoline usage as a fuel. However, on February 25, 2020, the Department of Petroleum Resources reported that daily gasoline consumption was 38.2 million gallons (Eboh, 2020a). Between December 2021 and April 3, 2022, daily gasoline consumption climbed from 72.07 million liters per day to 74 million liters per day (Okafor, 2022). Nigeria is currently a large importer of several petroleum products. In 2019, Nigeria utilized petroleum products with a total volume of 19.18 billion liters, but the country was only able to refine 166.33 million gallons of gasoline (Eboh, 2020b). The government handles the distribution and sale of refined petroleum products at a reduced price. As of the 17th of November 2019, the Nigerian government was providing a gasoline subsidy of N18.68 per liter. N953 million (where $1 **USD** = about ₦361) in subsidies facilitated the delivery of 51 million liters daily (Eboh, 2019). In 2019, Nigeria imported petroleum products with a total volume of 19.18 billion liters, but the country was only able to refine 166.33 million gallons of gasoline (Eboh, 2020b). The government handles the distribution and sale of refined petroleum products at a reduced price. As of the 17th of November 2019, the Nigerian government was providing a gasoline subsidy of N18.68 per liter. N953 million in subsidies facilitated the delivery of 51 million liters daily (Eboh, 2019). The government has often sought to wean itself from contributing to the price of gasoline, but none of these efforts have been successful.

The Nigerian government has refineries in 3 different states, namely Delta, Rivers, and Kaduna, but due to the country's inability to refine the required amount of petroleum products needed, they rely heavily on the importation of transportation fuels. Again, due to poverty and a poor source of livelihood, some Nigerians have devised techniques for domestically refining petroleum products using indigenous technology to close the current supply-and-demand mismatch (Onakpohor et al., 2019). This approach employs a simple and localized distillery procedure to produce refined petroleum products by heating crude oil over an open fire (Onakpohor *et al.,* 2019).

The refining of crude oil by artisanal petroleum refiners in the Niger Delta produces gasoline, kerosene, and diesel. All of the processing equipment and facilities are locally acquired. Depending on the investors' business expertise and the company's processing capacity, it may be feasible to manage the firm with a few staff. Because of the relatively cheap costs (use of unprofessional personnel and rudimentary equipment) involved, it is an easy-going company for individual investors in the local area (Asuru and Amadi, 2016). Regrettably, this is the case in

the Niger Delta, where private companies have established over 20,000 artisanal refineries to take advantage of the region's low-cost labor and raw materials (Onakpohor *et al.,* 2019). These businesses gain from the region's accessibility to these resources (Onakpohor *et al.,* 2019). In the Niger Delta region of Nigeria, "cooking," "bush burning," and "kpor fire" are all common names for artisanal refining (Goodnews and Wordu, 2019).

Illegal bunkering and artisanal refining play a key role because oil and gas corporations in the Niger Delta area of Nigeria are unable to conduct commercial activities to their total capacity (Goodnews and Anele, 2019). Consequently, APR activities impact human health and the environment (Richard et al., 2022, 2023). In addition, several studies have demonstrated the social and environmental consequences of APR in the Niger Delta area of Nigeria (Obenade and Amangabara, 2014a, b), including implications on plant cover and soil conditions (Asimiea and Omokhua, 2013; Yabrade and Tanee, 2016; Nwankwoala *et al.,* 2017). Therefore, this review focuses on the environmental and human health risks of APR in the Niger Delta region of Nigeria. The study concludes by suggesting viable management strategies and remedy options for hazards or pollutants that harm humans and the environment due to APR activities. The findings of this study will be useful in the management of APR to avoid the environmental and human health effects associated with it.

Niger Delta region of Nigeria and oil business among the locals

The Niger Delta wetland serves ecological, economic, social-cultural, and recreational functions (Izah *et al*., 2017a, 2018; Izah, 2018; Izah and Seiyaboh, 2018a, b; Raimi *et al.,* 2021a). The Niger Delta ecosystem has one of the highest concentrations of biodiversity in the world. It supports abundant flora and fauna, arable land capable of supporting a wide variety of crops, economic trees, and freshwater fish species (Donwa *et al.,* 2015; Ite *et al.,* 2013). In addition, Epidi et al. (2016a, b), Bassey and Izah (2017) reported that there are different types of plants in the area with medicinal value. The area has abundant surface water (estuarine, freshwater, and brackish water) and groundwater (Izah *et al.,* 2023, 2022a, b, 2021a, 2016; Izah and Srivastav, 2015; Aghoghovwia *et al.,* 2018a,b; Enaregha *et al.,* 2023). Aquatic environments sustain a diverse array of species, including planktons (Ogamba *et al*., 2019a, b) and various fish species (Izah and Anagye, 2016; Aghoghovwia *et al*., 2016), fishes, aquatic animals, and sea birds (Izah and Srivastav, 2015). The names of freshwater resources vary according to their size. Rivers, streams, ponds, lakes, creeks, and rivulets are specified.

There are two primary climatic conditions in the Niger Delta, i.e., the wet and the dry season. Monthly rainfall in the area is almost predictable, increasing towards July before decreasing in the dry season months of November-February (Ikezam *et al*., 2021a). As a result, the region experiences high rainfall in July and September. As a result, the area's temperature is 28±7 °C, and the relative humidity ranges from 50–95% all year round (Izah *et al*., 2017b).

The Niger Delta encompasses around 70,000 km^2 representing 7.5% of Nigeria's total geographical area, with approximately nine states in the southern region (Izah et al., 2017a; Bodo *et al*., 2020; Bodo and Gimah, 2020; Ikezam *et al.,* 2021a, b). The nine states that make up the region are in the southwest (Ondo), south-south (Akwa-Ibom, Cross River, Edo, Bayelsa, Delta, and Rivers), and southeast (Abia and Imo) geopolitical zones. Bodo and Gimah (2020) reported that there are around forty ethnic groupings in the area. According to Ite et al. (2013) and Boris (2015), the region contains over 900 oil-producing wells and over 800 oil-producing communities including cities, villages and towns.

However, the Niger Delta wetland is under severe stress due to human activity, such as illicit crude oil bunkers, artisanal petroleum refiners, oil theft, and vandalism. Many Nigerians erroneously characterized "oil bunkering" as a significant crime against the Nigerian country, even though it is a legal industry that any government-authorized individual may engage in (Bodo et al., 2020). Oil bunkering activities are an international transaction between oil-producing nations and other coastal nations on the high seas and oceans (Boniface and Samuel, 2016; Bodo *et al*., 2020). In 1979, the business began in Nigeria. However, the government halted it in 2020 owing to petroleum product subsidies and then prohibited it over time due to unlicensed

operators' abuses (Boniface and Samuel, 2016; Bodo *et al.,* 2020).

The phrase "illegal oil bunkering" (IOB) refers to any illegal involvement in the oil sector; hence, it encompasses any oil theft (including smuggling and diversion of oil). IOB is the term Bodo et al. (2020), and Boris (2015) refer to the diversion and smuggling of crude oil to prohibited locations. The operations of IOB are responsible for the daily loss of 200,000 to 300,000 barrels of oil from the Niger Delta (Obenade and Amangabara, 2014a, b). According to Obenade and Amangabara (2014a, b), IOB and APR are expanding in the Niger Delta, exacerbating the environmental devastation and social conflict caused by the oil industry in the region. According to prior reports, IOB is growing as a genuine firm, with active participation from many entrepreneurs. Militant organizations in the region, commodities dealers, military personnel, multinational businesspeople, indigenous oil service businesses, and government officers are some of the individuals involved (Olateju, 2013; Ogunmade and Uwaezuoke, 2013; Bodo, 2019). According to the research, the personnel associated with the company also play crucial responsibilities. For instance, the IOB-interested persons have worldwide correspondents who purchase the merchandise (Bodo *et al.,* 2020). Nigeria is on the list of nations with the most oil thieves due to the influence of IOB officials (Boris, 2015).

IOB will likely continue owing to its large profit margin, causing environmental damage in the region and endangering human lives (Bodo et al., 2020). In addition, the Nigerian oil business suffers significant income losses owing to the operations of oil thieves, who steal marked barrels of unrefined petroleum daily (Boris, 2015; Bodo et al., 2022).

Artisanal crude oil refining

APR refers to refining crude oil using local resources, knowledge, and technology. The APR process begins with storing crude oil in metallic drums, heating those drums until they reach the boiling point, and finally allowing those drums to cool and condense (Ikezam *et al.,* 2021b; Goodnews and Wordu, 2019). According to Ikezam *et al.* (2021b) and Luke *et al.* (2021), the APR in the Niger Delta frequently uses the same talents and technology utilized in the production of local gin in Nigeria.

The indigenous refining of crude oil camps in Nigeria's Niger Delta is established and used for local crude oil processing in the Niger Delta's deep forest (Bebeteidoh *et al*., 2020). In the Niger Delta, APR procedures involve drilling holes and installing taps to siphon crude oil into a boat to receive oil (Onakpohor *et al*., 2019). Then, vessels, commonly called "Cotonou boats," transport refined crude oil. The crude oil is stored at the camp for some time to reduce the amount of gas contained within through evaporation. After that, it goes into the refining oven. It is heated to different degrees during the distillation process, based on the boiling points.

The employees at the site use a rubber hose and pump to move the cold crude oil from the tapping point to a storage tank after it has been carried to the site by boat. The stolen crude may also be stored in open pits at APR locations. These pits are nothing more than large holes excavated in the ground and covered with synthetic material or plastic of sufficient thickness to prevent oil leakage. The typical number of camp staff is 12 to 20, while bigger camps may have much more (Onakpohor *et al*., 2019).

The typical requirements for a refining camp include: land with access to a river, a primary cooking "oven," storage space (GEEPEE tanks is commonly used for storage), a cooling system, a series of drums (typically made of rubber or metal), galvanized pipes, pumping equipment, hoses, bundles of zinc, 12 by one board, and some quantity of detergent (laundry powder for washing drums) (Onuh *et al.,* 2021).

Due to the proliferation of hundreds of artisanal refineries across the central Niger Delta over the years, this sort of illicit commerce has grown enormously (Onuh *et al.,* 2021). There are several crude oil deposits in the Niger Delta, especially in the South-South area (Ikezam et al., 2021a). Ikezam *et al.* (2021a, b) reported 521, 721, and 82 APR sites in the Rivers, Bayelsa, and Delta. Figure 1 depicts the locations of each of these places.

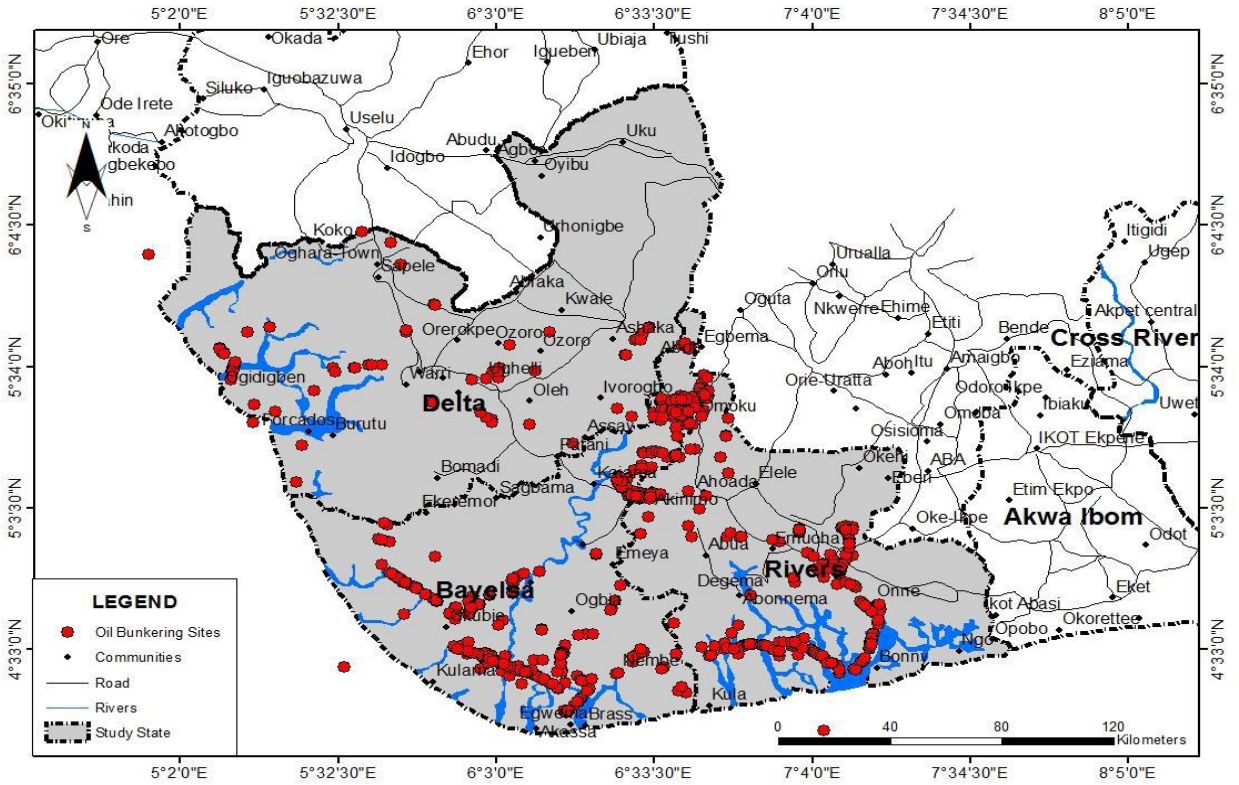

Figure 1: Oil bunkering sites in some of the states (Delta, Bayelsa and Rivers) in the Niger Delta, Nigeria (Ikezam et al., 2021a,b).

Typically, these refineries are oil-soaked in concealed environment. The Nigerian Government has destroyed several APR camps and quantity of refined or partly refined petroleum products in the areas. In 2016, the military destroyed up to 181 illicit artisanal refineries, and arrested 748 operators and 420-billion-naira worth of crude oil and petrol were confiscated (Sahara Reporter, 2017). In addition, between January 2014 and April 2022, the actions of the APR and the violence associated with illicit bunkering were responsible for the deaths of nearly 500 people (PIND foundation, 2022).

Environmental impacts of artisanal crude oil refining

Human activities are the leading cause of biodiversity loss in the World (Raimi et al., 2022a,b; Ogwu et al., 2022, Inatimi et al., 2022). Specifically, petroleum industry emissions harm the ecosystem and all kinds of biodiversity, including humans. The petroleum industry's emissions consist of four categories: solid, liquid, heat, and gaseous (Figure 2). For example, pollutants such as gases are released into the environment during the transformation of crude oil into various end products. Refining crude oil and burning processed solid waste leads to the release of environmentally hazardous gases. These gases may result from pollution. Gaseous pollutants include the oxides of carbon and sulfur, ammonia, nitrogen dioxide, volatile organic compounds, and hydrocarbon compounds, including polycyclic aromatic hydrocarbons. Combining sulfuric and carbonic oxides with water has the potential to produce a mild acid. The weak acids ultimately condense as acid rain, which corrodes the earth, surrounding plants, infrastructures, and water bodies (Seiyaboh & Izah, 2017a). When water becomes acidic, it threatens the continued existence of aquatic animals especially those living in surface water. In addition, toxicants may collect in the adipose tissues of living organisms and travel up the food chain to reach humans.

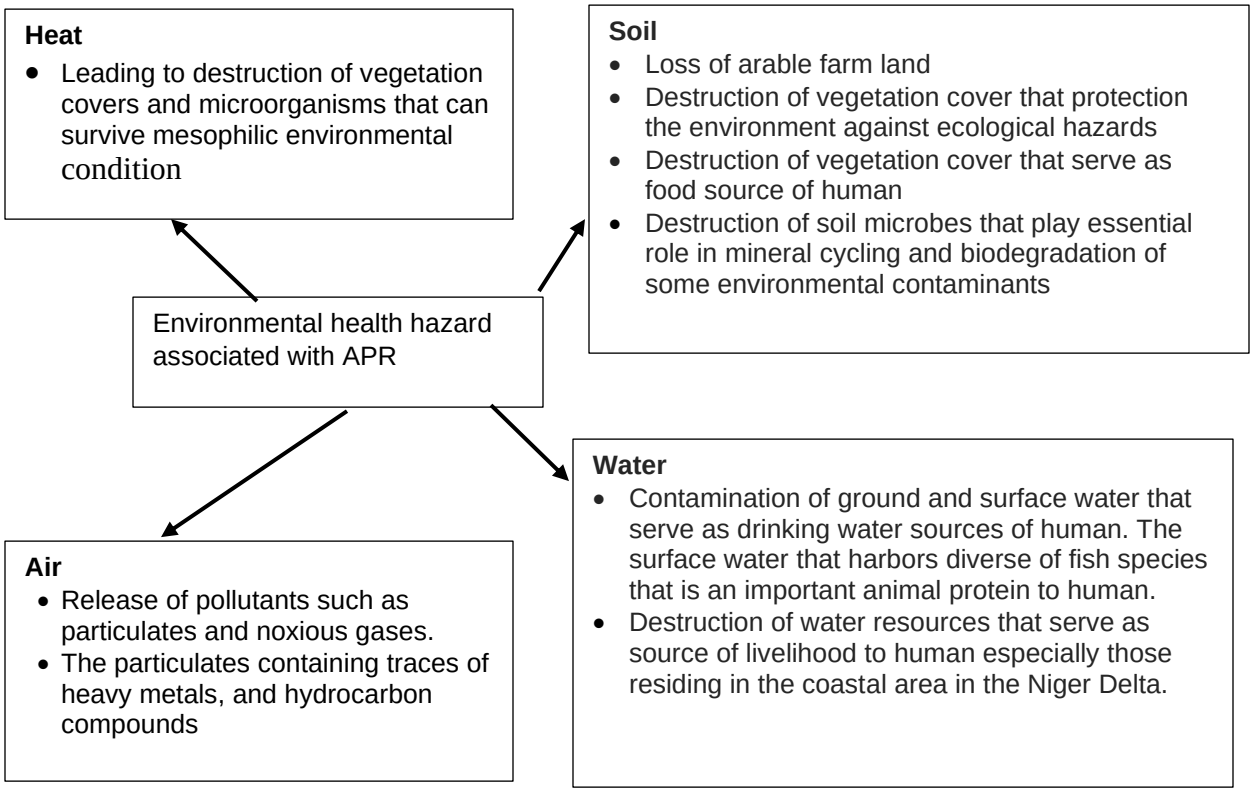

Figure 2: Environmental hazards associated with artisanal petroleum refining in the Niger Delta region of Nigeria

In the Niger Delta, pollution is caused by the improper disposal of waste especially industrial and municipal into the surrounding environment, including the land and the water. Disposing of hazardous waste may affect the soil's physical and chemical properties (Raimi *et al.,* 2022a). It also harms organisms essential to the biogeochemical cycles, decreasing the most vital functions of flora and fauna within the ecosystem (Raimi *et al*., 2021b). In addition, its presence in the water makes it unfit for ingestion, generating substantial worries about the safety of potable water sources in the region (Izah *et al.,* 2022a,b; 2016; Ogamba *et al.,* 2015a-c; Seiyaboh *et al*., 2017a,b; Agedah *et al.,* 2015; Izah and Srivastav, 2015; Seiyaboh and Izah, 2017b,c; Raimi *et al.,* 2022c-e, 2021b, 2020; 2018; Gift and Raimi, 2020). In addition, there is the possibility that the waste may flow into the groundwater, contaminating it. Even trace amounts of petroleum compounds such as gasoline, kerosene, or diesel may contaminate millions of liters of ground and surface water. According to Igben (2021), the operations of APR in the region are reducing the quantity of usable rangeland for farming, animal husbandry, fishing, rubber and Raphia palm tapping, and other similar activities. Due to the importance of water and soil resources to the economic development of coastal cities and communities in the Niger Delta, a coordinated effort is necessary to mitigate the threats presented by APR in this region. Additionally, water contamination impacts aquatic organisms. Trace metals occur in a variety of environmental situations, such as air (Uzoekwe *et al*., 2021; Izah *et al.,* 2021b), soil (Izah *et al.,* 2017b; Raimi *et al.,* 2022a), and aquatic habitats (Uzoekwe et al., 2021; Izah et al., 2021a; Ogamba *et a*l., 2021). There have been findings of trace metals in fish, as well as in the water and the sediment (Ogamba *et al.,* 2017, 2016a,b,c, 2015d; Aigberua *et al.,* 2021). Because of pollution caused by heavy metals, fish in rivers have become a source of heavy metal toxicity. There is potential damage to aquatic vegetation and other natural food resources found in aquatic ecosystems. According to the findings of a study carried out by Ikezam *et al*. (2021a, b), residents of an APR have stated that the activities cause soil erosion, which is an indication that there is a limited amount of arable land available for agricultural operations. As a consequence of this,

fewer people are choosing to work in the agricultural industry. The food crops grown in the area are affected by human activities because the soil is contaminated. Asimiea and Omokhua (2013) research on the floristic composition of a freshwater wetland, including an APR site in the Niger Delta, showed that 73.91% and 82.61% of the vegetation in Delta and Bayelsa States, respectively, have been destroyed due to APR. According to the authors, APR's actions in the region significantly impact various factors, including biodiversity, the appearance of forests, plant growth, destruction of habitat, the water cycle, and medicinal plant species. Low productivity is an expected outcome. Research findings by Nwankwoala *et al.* (2017) in Okrika and Ogu-Bolo Rivers show the effects of artisanal refining on soil and water quality. The water quality in the area is inadequate, and the concentration of iron and zinc in the water makes it unfit for consumption. The authors further reported that the level of contamination in the soil reduces with increasing depth, and in terms of contamination, approximately 23.59 kilometers (5.71 percent), 85.65 kilometers (20.71 percent), 140.37 kilometers (33.9 percent), 112.56 kilometers (27.2 percent), and 51.29 kilometers (12.40 percent) of the land mass were rated as very good, good, moderate, and very bad, respectively. The actions of APR have led to the destruction of mangrove fish habitats in the Niger Delta (Bebeteidoh *et al*., 2020), as well as a significant increase in the amount of pollution in the marshes and rivers. Polycyclic aromatic hydrocarbons, one of the components of crude oil and other components of crude oil, have been found in the surface water and sediment of the Niger Delta. Petroleum hydrocarbons also float on the surface of river systems, causing oxygen depletion in the aquatic ecosystem and ultimately contributing to the death of aquatic creatures. These hydrocarbons come from the combustion of fossil fuels. As a result, there is a connection between the presence of contaminants that contain hydrocarbon compounds and the productivity, survival, reproduction, and diversity of fish. Because of declining soil quality, leaching, and erosion, agricultural production is affected by polycyclic aromatic hydrocarbons and other toxins in crude oil. This primary pollutant also occurs in the APR vicinity. According to Wokoma et al. (2020), there was a higher concentration of total hydrocarbon content in the water and sediment around APR in the Sombrero River. The authors also reported that the activities of APR affect water quality, sediments, and the structure of the zooplankton in the area. According to Howard *et al*. (2021), river systems' hydrodynamics cause pollutants accumulated in the river bed sediments to be re-suspended in the water column. Therefore, APR activities pose a potential ecological risk to aquatic resources and the inhabitants who depend on such resources. Ineyougha et al. (2015) reported that people in the Niger Delta get most of their animal protein from aquatic resources like fish (both their shells and fins).

The soil's physical, chemical, and physical qualities are also crucial aspects influenced by climate, landforms, and, most crucially, humans. Physical, chemical, and biological qualities are fundamental aspects of soil quality. The biological and physicochemical aspects of soil characteristics are critical for the soil's functions. Hydrocarbons from petroleum can negatively impact the soil's properties, rendering it unfit for the growth of some plant species and making it harder for farmers to make money in parts of the Niger Delta, where APR is typical. Microbes are ubiquitous and have evolved in various ways to survive in their environments. Unfortunately, some carcinogenic hydrocarbons produce microbial mutations that may disrupt the synergy between different microorganisms and the environment with predictable and unpredictable consequences.

Associated health risks to artisanal crude oil refining

Living near oil spills and facilities that produce petroleum can be an environmental stressor that has a detrimental effect on one's health, well-being, and quality of life (Nriagu et al., 2016). The effects of polluted air impact human lives. It can impact the respiratory system, and it may also exacerbate the symptoms of diseases that are already present (Ikezam *et al.,* 2021a). According to Onakpohor *et al*. (2019), most air pollutants may induce breathing and reproductive issues, reduce respiratory function, and harm human DNA. In addition, certain components of petroleum products have specific impacts on people's health. For example, exposure to naturally harmful compounds like polycyclic aromatic hydrocarbons in crude oil may affect one's health due to system toxicity. However, indirect routes that act via perceptions of danger,

anxiety, irritation, and chronic stress may lessen the consequences of poor health outcomes.

The significant physiological health effects of exposure to oil pollution include abnormalities in hematologic, hepatic, respiratory, renal, and neurologic functions characterized by asthmatic attacks, headaches, dizziness, abdominal pain, back pain, nausea, diarrhea, sore eyes, sore throat, cough, itchy skin, rashes, respiratory issues, and an overall feeling of malaise (Nriagu et al., 2016; Onakpohor *et al*., 2019). In addition, the hydrocarbon chemicals extracted from crude oil can potentially induce mutations and cancer in humans when exposed to high concentrations (Onakpohor *et al.,* 2019). High molecular weight polycyclic aromatic hydrocarbons are particularly hazardous because of their mutagenicity and carcinogenicity (Ite *et al.,* 2013). Additionally, due to the lipophilic features of these hydrocarbons, they bioaccumulate in tissues. Long-term exposure to hydrocarbons can result in respiratory effects and damage to chromosomes, skin tumors, skin damage, suppressed growth, and induced or inhibited enzymes. Other effects include adverse physiological reactions, blood disorders, impact on reproduction, decreased immunity to disease and parasites, and bronchial symptoms (Ite *et al*., 2013; Nriagu *et al*., 2016).
In addition to the harmful chemicals, the operations of APR also result in the production of noxious gases and odors that are highly disagreeable. Hypersensitivity and sensory discomfort may result from prolonged exposure to ambient odorants caused by APR (Nriagu *et al.,* 2016). These unpleasant smells stem from volatile organic chemical compounds and some toxicological agents that also effects the eye, nose, or throat to harm health (Nriagu *et al.,* 2016).

The concept of risk is multifaceted and is often associated with feelings of psychological unease, in addition to a wide range of other factors that are detrimental to one's health and well-being (Nriagu et al., 2016). Risk perception is how individuals approach, think, and comprehend the risks in their environment. For example, Nriagu *et al.* (2016) reported that the fears about disasters like pipeline explosions and fires caused by oil spills, visual cues (especially gas flares and smokestacks), and chemosensory signals in the Niger Delta have a significant effect on how other people see the risks of oil pollution. Emissions from petrochemical industries and oil-polluted regions may taint the air surrounding them with unpleasant odors. In addition, people may be subjected to heat, constant light, and air and noise pollution when gas flares and activities are present. Due to this, residents near the APR plant may experience hazardous health conditions from irritation, a feeling associated with any agent or circumstance that has a harmful effect. The irritation provided by danger is a crucial component that arrives before and is a powerful signal of harmful, damaging, or undesirable effects over a prolonged period. When irritation is prevalent, concerns about the environment could rise to feelings of anger, fear, and hostility (Nriagu *et al.,* 2016).
A person's level of chronic stress is proportional to how successfully they can deal with the challenges posed by their surroundings. For example, people sensitive to environmental risks are more likely to interpret all ambiguous risk information as threatening, resulting in strong emotional reactions. It could be problematic for people trying to make informed decisions about responding to environmental risks. On the other hand, risk tolerance is a developed trait that, in contrast to such risk aversion, enables an individual to sleep at night without being concerned about oil pollution and other environmental issues. The capacity to tolerate environmental risk is an essential coping mechanism in the communities of the Niger Delta. People are still going about their typical activities for this reason, despite the threat posed by pollution in residential areas. However, as time passes, high anxiety, aggravation, and intolerance related to oil production and processing are noticed. According to Nriagu *et al.* (2016), emotional stress can lead to abnormalities in various interconnected physiological systems. These physiological systems include the cardiovascular, endocrinological, and immunological systems (Nriagu *et al.,* 2016). It indicates that psychological strain is a factor in developing various clinical conditions.

Risk reduction strategies due to artisanal crude oil refining

The oil and gas sector continues to form the backbone of Nigeria's economy. Despite attempts to diversify and the crucial significance of natural resources to millions of people's lives, most inhabitants of resource-rich nations have not succeeded in adequately exploiting their oil and gas industries as a stepping stone for more comprehensive economic reform. Consequently,

while the sector is a significant income producer, its links with the rest of the economy remain poor. At the same time, the legislation that the government of Nigeria has established serves as a reference for controlling hydrocarbon spills and the waste linked with them. Several government agencies, such as the National Oil Spill Detection and Response Agency, the Department of Petroleum Resources, the National Emergency Management Agency, and the National Environmental Standards and Regulation Enforcement Agency, are responsible for the management of oil spill response operations (Bebeteidoh *et al.,* 2020; Ite *et al.,* 2013). The pollution control policy comprises critical components that enhance all stakeholders' commitment to environmental sustainability.

It includes making it illegal to transport hazardous material, dump it, or otherwise dispose of it in biophysical settings. However, despite these agencies and legislation, the government can still not implement effective implementation and enforcement (Bebeteidoh *et al.,* 2020). Furthermore, the failure of environmental protection organizations to commit to making long-lasting changes to environmental protection makes this problem even more severe. In Nigeria, there is a significant amount of corruption, the level of professionalism is not very high, and the host communities are not participating in adopting environmental protection and management systems. In addition, there is not a sufficient number of operating facilities, as seen in a few different industries.

A quarter of a century has passed since APR's operations began in Nigeria. It began with oil theft and illicit bunkering, among other unlawful activities. On the other hand, there has been a discernible rise in the number of activities during the past decade. Their actions are responsible for a considerable economic loss sustained by the nation. Furthermore, the current APR approaches in the region involves outright devastation of the land by setting it on fire, which further exacerbates the adverse effects on the environment related to the activities of APR. Thus, soot is frequent in States like Rivers and Bayelsa, typical of artisan petroleum refining.

The following are prerequisites for effectively and sustainably managing APR activities in the Niger Delta: (i) Governments should completely enforce environmental protection laws and regulations. In addition, the government should identify deficiency in the existing law and legislation gaps and enact some that could make them manage APR activities. (II). The government should permit processing petroleum products seized from artisanal refiners by sending it to any of the government owned refineries, and stop the practice of setting ablaze the APR facilities. (iii).The government should commit to preserving the highest human, social, and environmental rights standards and allocating tax dollars to generate the most significant and fair results for future generations. In addition, it should promote an upward harmonization of standards to assist sustainable growth and offer a framework for doing so. (iv). The development of industry and manufacturing competence in the Niger Delta may improve with the government's promotion and strengthening of local content requirements. However, this new capacity cannot stay competitive in the face of competition from other countries' providers of products and services. In that case, it will reach the same conclusion when the sources run out. Therefore, local content regulations should increase competitiveness to guarantee forward, backward, and horizontal linkages with other regional enterprises. (v). The government should continue to educate the people on how APR activities influence them using social media, network (electronic), and print media, as well as face-to-face orientation.

CONCLUSION

In Nigeria's Niger Delta area, artisanal processing of crude oil is threat to the environmental and human health. Using crude technology like, the natives transform crude oil into various products, including gasoline, automated gas oil, kerosene, etc. Despite the financial advantages of the process, such as the creation of job opportunities, payment of education fees, health security, and equality, APR activity poses considerable dangers to human and environmental health. The environmental risks include the loss of arable farmland, the degradation of plant cover that protects the soil from erosion, and the contamination of human food supplies. Further problems arise from soil microorganisms essential to nitrogen cycling and polluting human drinking water sources and surface water. In addition, the surface water supports a variety of fish species that provide coastal homes with a supply of animal protein and a means of subsistence. In addition, these environmental risks include the destruction of cropland. These

pollutants negatively impact human health, including loss of respiratory and cardiovascular system functioning, irritation of the sensory organs, and congenital disabilities. Inadequate regulation of the APR's effects might lead to food safety and availability concerns. Consequently, there is an urgent need in the Niger Delta region of Nigeria to mitigate the risks associated with APR by granting exploration and production licenses and contracts, environmental permits, or other permits that meet the requirements of the law and regulations. Through academic publications, community discussions, and conference presentations, the findings of this study will help bring more attention to diagnostic and analytical tools, inspire action, and raise awareness in host communities. These initiatives will aid the oil-and gas-producing nations in making sensible choices about their energy futures, protecting the environment, strengthening their economies, and making their societies more equitable.

Author contribution

GR conceived the study. GR and A-AI performed the literature search while GR, SCI, and MOR wrote the draft. A-AI made technical corrections. All authors read and approved the final draft of the manuscript.

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