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Developing a Chemical Database for Resolving Environmental Issues in the Petrochemical Industry in Nigeria

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Abstract

Petrochemical exploration in Nigeria poses a significant threat to the environment, health and livelihoods of local people. The inability to find a holistic solution to address amicably the issues associated with oil and gas exploration and production has resulted in an unending wave of tension, crises and countless legal battles between communities and oil operators. This development is further complicated by the lack of adequate capacity on the part of regulators in the sector. The situation has forced some oil operators to move their operations from land and shallow waters into the deep sea with the hope to reduce hostilities within operational facilities and conflict with local people. Despite efforts to have a better understanding among the stakeholders, particularly oil operators and local communities, environmental issues persist creating mistrust between parties. Developing a chemical database with a comprehensive contaminants profile in the petrochemical industry would improve the management of chemical spills and associated issues and bring some level of fairness to conflict resolution in the sector.

Keywords: pollution, environmental justice, Niger Delta, chemical screening, contaminants fingerprinting

Introduction

Petrochemical exploration in Nigeria poses a significant threat to the environment, health and livelihoods of community members due to the lack of global best practices in petrochemical spill management in the region. The inability to find a holistic solution to address amicably the environmental issues associated with oil and gas exploration and production has resulted in an unending wave of tension, crises and countless legal battles between communities and oil operators (Ekperusi et al. 2020; Ekperusi and Ekperusi 2021).

In a bid to avoid direct conflict with local communities and reduce hostilities within operational facilities, several multinational companies divest their interest in their onshore and shallow assets to indigenous players and move their operations to offshore or deep waters. Many stakeholders view this geographical

shift as evasive tactics by multinationals to abdicate their responsibility to environmental stewardship which is well codified in corporate communications but lacking in practice in the Nigerian oil and gas industry (Ekperusi et al. 2020; Ekperusi and Ekperusi 2021). Shifting operational base from onshore to offshore by oil giants has not ameliorated the lingering issues in the region. Although oil assets may become inaccessible to local communities for picketing actions, oil spill accidents that occurred several kilometres on the high seas get to the shore through tidal and wave action and negatively impact the life support system of local communities like fishing grounds, aquaculture ponds and farmlands (Ekperusi et al. 2020).

Despite efforts to have a better understanding among the stakeholders especially operators and local communities, environmental issues persist creating mistrust between parties. The lack of transparency, frustration and suppression of voices related to spill management has led to the long quest for justice, even outside the shores of Nigeria by local communities (Ekperusi et al. 2020; Ekperusi and Ekperusi 2021). The situation is further complicated by the lack of adequate capacity on the part of federal and state regulators and the inability to apply current and sound technological tools in the industry, particularly with oil spill reporting, assessment, containment, clean-up and restoration (Rim-Rukeh, 2015; Ekperusi et al. 2020; Ekperusi and Ekperusi 2021). This persistent scenario is not good for an industry that plays a critical role in providing energy solutions to society.

Conventional analytical methods for the determination of organic compounds in environmental matrices are becoming inadequate in meeting the needs of monitoring programmes designed to evaluate chemical safety for public health (Sobus et al. 2018). Also, as more chemicals are developed and used in the petrochemical industry, conventional analytical techniques will be insufficient to provide the relevant knowledge and insight to protect human health and the environment. Crude oil contains certain chemical biomarkers or fingerprints, depending on its origin, location and geologic conditions. Crude oil from different wells contains different molecular makeup that could be exploited to differentiate one from another. The application of chemical forensics with chromatographic methods could unravel the chemical profile unique to oil extracted from a particular oilfield (Duncombe, 2019).

Developing a chemical database with a comprehensive contaminants profile in the petrochemical industry with the combination of conventional and new analytical tools is essential for the management of chemical spills and associated issues in an open and transparent manner to resolve key issues in the industry and also bring some level of fairness to conflict resolution.

Environmental Issues in the Petrochemical Industry

In Nigeria, within the last three decades, several environmental issues have perpetually put the petrochemical industry in a bad light. Some of the major issues are highlighted below;

Oil Spills

Oil spill management, either from accidents, old and broken facilities or sabotage in the Niger Delta region has left decades of scars in the memory of local communities, oil operators and regulatory agencies. The lack of adequate spill management programme over the years has resulted in a drastic decline of mangrove swamp forests, rendered many lands unproductive for agricultural purposes, and destroyed fishing grounds and aquaculture farms in local communities. In extreme cases, it has led to military invasion, threats, arrest, detention and death of several community members and leaders. For oil operators, it has resulted in the assault of oil workers, kidnapping, and death, while regulators have also experienced the wrath of community members due to a perceived lack of transparency and inconclusive investigations of oil spill management in the region (Rim-Rukeh 2015; Ekperusi et al. 2020; Ekperusi and Ekperusi 2021).

In many instances, community members are the first to raise the alarm of an impending oil spill in the coastal region, which is further amplified in the news circle by civil society groups operating in the region. This in turn triggers state and federal regulators into action (Ekperusi and Ekperusi 2021). Oil operators

are very quick to deny the existence of oil spills. This approach has been attributed to many reasons. The denial could provide oil operators with the opportunity to swiftly try to contain the spill and clean up the impacted area in the cases of minor spill incidents and claim there was no spill in the first place. It also helps the spiller to avoid conflicts and payment of compensation to impacted community resources and fines from regulators where the cause of the spill is established to be a result of negligence on the part of the spiller. Regulators lack the capacity to swiftly mobilize resources to investigate oil spill incidents and rely on the spiller to do so. A spiller can deny an oil spill or slow the investigation delay in mobilization for joint investigation visits. When the evidence of an oil spill becomes incontrovertible due to the volume or extent of the spill, the spiller could attribute the spill incident to sabotage from third-party activities. The argument for sabotage is gaining more credence due to the increased level of third-party activities in the sector. When an operator attributes an oil spill to sabotage, the onus now lies on the affected community and the regulators to prove otherwise. Although there is no justification for oil operators to abdicate their corporate and social responsibility, there has been an unprecedented rise in oil facilities tempering and oil theft in the Niger Delta region (NOSDRA 2022). Community members and their associates are known to puncture pipelines and steal oil for artisanal refining. Others tamper with pipelines and create channels to direct spilt products into farmlands, shrines and other vital resources to increase compensation claims from oil operators. This practice has complicated oil spill management and conflict resolution process in the Niger Delta region. Over the years, the activities of illegal oil bunkers and local refiners have contributed significantly to environmental degradation, oil revenue loss and extra burden on oil operation activities. There is a need for new thinking in dealing with this menace in the region if the environment must be spared from the activities of third parties in the oil and gas industry.

In January 2021, fishermen and community leaders of Koluama in Bayelsa State reported oil leakage around well 5 of the Funiwa oilfields, but officials of Chevron Nigeria Limited (CNL) denied the claims. It was further reported that CNL hurriedly deploy helicopters to spray chemical dispersant on the affected area while using security agents to stop community members from accessing the area and taking photographs (Oyadongha 2021). This is done to stop community members or advocacy groups from procuring evidence. Without evidence, oil operators could avoid regulatory oversight, sanction and liability, while they quietly mobilize a response team to mitigate the spill (Oyadongha 2021). In November 2021, women in various communities in Warri Southwest accused CNL of negligence in an oil spill that was affecting fishing communities, but CNL denies the claim. CNL insisted that aerial surveillance did not show any evidence of a spill from any of their facilities (Maclean et al. 2021). Dissatisfied with the inaction of CNL, women from several communities staged a protest at CNL office in Warri to force the company to act towards mitigating the spill (Maclean et al. 2021). Fishing in creeks and mangroves is dominated by women, while men fish in the coastal and open seas, so it is important that these women would speak up when the source of their livelihood is threatened.

More than 80 per cent of oil spills in the Niger Delta region generates controversy in trying to determine the remote and immediate cause. Oil operators are quick to blame spills on sabotage while community members accuse oil companies of negligence. Negligence results in fines and compensation while sabotage absolves oil companies from any fines or compensation. Notwithstanding the increasing third-party activities in the sector, the majority of the oil installations across the region have overwhelmingly exhausted their lifespan and could easily malfunction on their own accord. Efforts to replace old facilities have been very slow on the part of oil operators and sometimes made complicated by community members. Some communities can block access to oil contractors and collect bribes while others want the contracts to be awarded solely to members of their community even when they lack the competence to handle such technical projects. The outcome of the intervention of regulatory agencies at the federal and state level, with the joint participation of all interested stakeholders, may not be suitable for the concerned parties. Federal regulators could be seen to be shielding oil operators due to the large stake of the federal government in

joint venture operations or as a result of bribery and corruption, while state regulators could be perceived to be supporting communities against multinationals due to ties or closeness to impacted communities.

For over 12 months, Shell Petroleum Development Company (SPDC) and Ikarama Community in Bayelsa State were in a confrontational face-off due to a pipeline spill in November 2019. The National Oil Spill Detection and Response Agency (NOSDRA) conducted a joint investigation and the report concluded that the spill at Ikarama Community was due to corrosion, but the report was rejected by SPDC which renders the investigation inconclusive. It is interesting to note that although NOSDRA employed technology owned by SPDC in the investigation, the outcome of the investigation which indicated that the spill was a result of corrosion was rejected by SPDC (Oyadongha 2020). The lack of adequate legal and regulatory provisions, unreliable infrastructure and inadequate skilled manpower in regulatory agencies weakens the agency's capacity to hold oil operators accountable. It is difficult for regulators to make a balanced judgement where the regulator relies on tools from operators to investigate the activities of operators. The funding of joint investigation is not also from an oil fund but from the operators. These poor structures also weaken the capacity of regulators to act independently in holding accountable the big players in the oil and gas industry. Multinationals are usually responsible for the funding of joint investigation, laboratory analysis and even printing of reports. Such a situation gives oil operators undue advantage in the sector to the detriment of local communities. It creates a conflict of interest and gives the perception that the regulator and the operators are working together against the interest of affected communities (Rim-Rukeh 2015; Ekperusi et al. 2020; Ekperusi and Ekperusi 2021). This is further complicated by misrepresentation or admission of errors in oil spill reporting by NOSDRA (Akpan 2020).

Legal actions against oil operators in Nigeria are defeated by technicalities, lack of adequate representation and long legal battles which in most cases, discourage affected communities from pursuing legal action. It took 13 years for local community members in Ogoni with the Dutch judiciary to get justice and settlement for a spill that occurred in 2008 and 2009. Some of the litigants did not live long to see the victory. It was only after the victory that Shell started the clean-up of the spill (Falayi 2021). The spill which was due to negligence as a result of old oil facilities in the region was initially dismissed by Shell as an act of sabotage which does not require compensation and settlement in the oil and gas industry. The existing approach to oil spill management is unreliable and inadequate. There is a need to find alternative and improved methods for oil spill assessment that is fairly acceptable to all interested parties (Rim-Rukeh, 2015; Ekperusi et al. 2020).

Mystery Spills

Any oil spill whose source of origin is unknown is referred to as a mystery spill. There are multiple reports of mystery spills recorded in the Niger Delta region every year (Shell 2020). Many factors are attributed to a mystery spill. Leakage from an illegal bunkering vessel can result in a mystery spill. Illegal bunkers pay little attention to the environment. Leakage from an illegal bunkering vessel sailing across the creeks or coastal area is of less priority to the actors, who are more concerned about reaching their destination and disposing of the oil for profit. Oil operators could also remove the source of a spill by repairing a damaged pipeline and deny the spilt products within their operational vicinity to avoid compensation or fines. CNL and Conoil dismissed the spill reported within the operational assets of both companies after fishermen sighted a spill on the Atlantic coast (Oyadongha 2021). An investigation by NOSDRA did not provide conclusive evidence on the origin of the spill (Oyadongha 2021). Oil operators are expected to clean up a mystery spill within their operational proximity but compensation and fines are largely avoided, hence the interest in denying a spill keeps increasing in the oil industry. Mystery spills can only be resolved by chemical fingerprinting and biomarker analysis of the spilt products. State and federal regulators are incapable of forensic analysis in oil spill investigations, hence the need for a chemical database becomes urgent and necessary for oil spill management in Nigeria.

In September 2019, oil mysteriously started washing up on Brazilian beaches. The oil spread across 2,000 kilometres affecting beaches in nine coastal states, killing wildlife and forcing beach closures (Duncombe, 2019). Petrobras, the Brazilian state oil company denied any involvement in the spill. The Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA), further indicated that the spill does not match any of the oil in their oil bank. A separate analysis by the Federal University of Bahia supported IBAMA's findings. This led to a further investigation to unravel the mystery spills. Samples were sent to the Woods Hole Oceanographic Institution (WHOI) in the United States for comprehensive analysis to characterize the hydrocarbons present in the oil. Other samples were sent to Norway and France for further analysis (Duncombe 2019). After comprehensive analyses involving chemical fingerprinting, oil transport models and three-dimensional mapping, the mystery oil was found to be of Venezuelan origin. The oil was narrowed down to three oilfields in Venezuela (BBC 2019). The findings were rejected by the Venezuelan government but a further analysis indicated a possible spill from a vessel carrying Venezuelan crude oil through the Brazilian coast to Europe or Asia. Due to sanctions from the United States, vessels carrying oil from Venezuela usually turn off their tracking device to avoid secondary sanctions from the United States, but the investigation was able to attribute the oil spill to a Greek-flagged ship carrying Venezuelan crude oil (BBC 2019).

Gas Spill

In August 2013, community members reported gas leakage spewing gas into the air and oil into the coastal environment from CNL gas field off the Atlantic coast in Bayelsa State. CNL denied the allegations, but community members reported the deployment of chemicals by CNL to sink oil along the coastline. The leakage was reported about 5 km from the location of a similar gas explosion in January 2012 (Oyadongha 2013). Community members decry the pollution of the air and marine environment by the gas leakage with associated oil discharge. No investigation was initiated by regulators to ascertain the cause of the spill, potential impact and possible remedial action.

Massive Fish Kills

There are several events both natural and human-induced that could result in massive fish kills in an aquatic ecosystem. During hot weather, the temperature in a water body increases and dissolved oxygen is usually consumed at a faster rate by microbial degradation of organic matter. If the dissolved oxygen in water gets below the critical threshold needed by certain species, it could trigger discomfort and other physiological processes that could lead to the suffocation of aquatic species. Also, the introduction of chemicals especially agrochemicals like fertilizers and pesticides with nitrogen and phosphorous could accelerate the growth of microbes and algae, which could increase the algal population giving rise to algal blooms. During algal blooms, oxygen levels in water decline significantly below the levels required by certain species which could lead to suffocation and death of species (USGS 2022).

Drilling and exploration activities could also result in a massive fish kill (USGS 2022). The release of naturally occurring radioactive materials (NORMs) from oil and gas wells, the illegal and unabated dumping of untreated produced water in coastal areas and other associated chemicals in oil and gas exploration could result in massive fish kills. Coastal areas are relatively large for toxic compounds release to have impacts on marine biodiversity due to dilution factor, but the release of very dangerous chemicals could affect highly sensitive species caught up in a chemical zone, resulting in death. Although there are reports of harmful algal populations in the coastal region of Nigeria and the Gulf of Guinea, their distribution and effects on marine life have not been substantiated to warrant massive species die out (Zendong et al. 2016).

Within the last few years, there have been rising cases of massive fish kills reported within coastal communities in oil-producing states of Ondo, Delta, Bayelsa, Rivers and Akwa Ibom (Chinwo 2020). In February 2020, community members and environmental advocates attributed the massive fish kill reported in the region to the illegal discharge of toxic chemicals mixed with sludge into the coastal environment

from the Forcados oil terminal in Ogulagha, Delta State which was promptly denied by Shell (Akam 2020). Worried about the implication of massive fish kills on the environment, health and economy of the affected coastal states, various stakeholders including federal lawmakers, scientists, civil societies, environmental advocates and local communities call for a thorough investigation to unravel the mystery behind the massive death of fishery products (Salem 2020). Stakeholders went further to urge the governments at the federal and state level to declare the situation as a public health emergency to avert potential crises for human health, food security, community livelihoods, and biodiversity in Nigeria (Oluwarore et al. 2020). They warned that such events maybe not be unconnected to the activities of major oil and gas companies operating within the region (Salem 2020). Personal investigation and preliminary findings from community leaders and experts in the region indicated that croaker fish and the crabs were the affected species along the coastline (Oluwarore et al. 2020). A multi-agency investigation led by NOSDRA, the Nigerian Maritime and Safety Agency (NIMASA), National Environmental Standard and Regulations Enforcement Agency (NESREA), Nigerian Institute for Oceanography and Marine Research (NIOMR) was undertaken. After weeks of preliminary investigation, the head of NOSDRA gave a press release that the massive fish death is unrelated to oil and gas activities in the region. He indicated that hydrocarbons in the investigated samples were below regulatory limits in water, sediments and fish tissue analysed. Elevated levels of heavy metals such as cadmium, chromium, copper, zinc and iron found in the samples were attributed to toxic wastes from non-extractive industrial activities (Premium Times, 2020). The press release by NOSDRA without exhaustive investigation angers local community leaders, environmental advocates and scientists who rejected the findings and regrettably indicated that the federal regulator is shielding oil operators from their nefarious activities in the region (Akam, 2020; Oduware 2020). Separate investigations carried out by ministries of the environment in the affected states were not disclosed to the general public.

Government agencies are only able to conduct targeted screening and preliminary investigations during a chemical incident in the region. The limited approach to environmental monitoring is unhelpful in resolving critical environmental, ecosystem and health issues in the region. It is usually narrow in scope and lacking in the use of current analytical tools for resolving environmental questions and proffering answers to interested stakeholders.



Figure 1—Dead fishes along the coastline (Oduware 2020)



Figure 2—Dead crabs along the shoreline (*Brachyura sp.*), (Oluwarore et al. 2020).

Black Soot

Air pollution is one of the major environmental problems confronting Nigeria, particularly the Niger Delta region. Aside from a few studies by researchers and corporate organizations, there are no comprehensive or empirical studies on the magnitude of the degrading air quality and its deleterious effects on the environment, ecosystems and people of the region (Ana 2011). Black soot or black carbon has become a persistent occurrence in the Niger Delta, especially in Port Harcourt metropolis. The sky of Port Harcourt is usually covered in dense soot. In the earlier hours of the day, black soot is seen in residential amenities and on vehicles parked overnight across the state. The city sunlight is gradually being covered by a cloud of black soot. The soot has been attributed largely to the activities of illegal refining of crude oil in the creeks by local people. There are public health concerns as soot is reported in nasal droppings from residents of the city (Brisibe 2017). Both state and federal regulators have promised to investigate the root cause and stem the situation, but progress has not been made to stop the spread of ‘soot rain’ in the city (Brisibe 2017).

Preliminary investigations from environmental officials have attributed the black soot to the burning of old tyres for scrap copper harvesting and illegal oil refining as the main culprit of black soot in the city (Brisibe 2017). Other factors attributed to the worsening air quality condition in the city include the use of generators and industrial plants for electricity supply, increase burning of wastes and increase vehicular emissions. To mitigate the black soot, federal regulators also shut down an asphalt-processing plant due to a lack of air quality control measures (Brisibe 2017).

The worsening black soot situation will increase and accelerate the environmental problems in the region. It could lead to impaired visibility, degrading air quality, respiratory diseases, increased acid rain and thermal conditions (Ana, 2011). Doctors are already raising the alarm about increasing consultations for respiratory infections in the city (Brisibe, 2017). Common health effects include breathing difficulties, bronchitis, aggravated asthma, cardio-respiratory disorder, eye and skin irritations and diseases. Severe health effects may include cancers (skin, eye and lungs) and birth defects (Brisibe, 2017; Ana, 2011). The soot situation is gradually spreading across the states in the region. Soot has been reported in Bayelsa, Delta and Akwa Ibom State (Dachen, 2022). Industrial activities and emissions from oil refineries, petrochemical plants, liquefied natural gas, chemical fertilizer, aluminium smelters, paper, cement, flour, wood, battery and textile industries, gas flaring and pipelines explosion all releases gases and particulates into the atmosphere and could be contributing significantly to the rising soot epidemics (Ana, 2011). Without a comprehensive assessment and chemical profiling of the air pollutants in the affected areas, it is difficult to tackle the soot crisis from spreading across the region.



Figure 3—Black soot in the palm of a resident in Port Harcourt (Brisibe 2017).

Additives and Unknown Chemicals

Multiple chemicals known as additives are used in the oil and gas industry. These chemicals aid the exploration, production, transport and processing of petrochemicals. Without the application of chemical additives, the production of oil and gas will be economically difficult. Each stage in the crude oil lifecycle requires a unique set of chemicals that will aid and facilitates the various operations in the oil and gas industry. The most common chemicals and additives include scale inhibitors, emulsion breakers, drag reducers, antifoam agents, polyelectrolytes, corrosion inhibitors, trimethylene glycol (gas dryers) and biocides (Devold, 2013). For example, in a production of 40,000 barrels of oil, about 2,000 litres (500 gallons) of antifoam can be used (Devold 2013). Similar volumes of other additives are also applied in the various stages of oil production. Without these essential chemicals, the production of petroleum and petrochemicals needed for powering modern society will be practically impossible. In the daily usage of these chemicals, both oil workers, local community members and the environment are exposed to a considerable quantity of the chemicals over time. Although federal regulators and oil operators outline policy and action to ensure the use of safe and approved chemicals to guarantee public and environmental health, the lack of adequate monitoring in the sector could result in sharp practices by oil operators and their contractors. Community members have voiced concern over the years that operators and their contractors apply chemicals that are not registered or approved by the regulators in the industry. This claim is difficult to verify or disapproved due to poor regulation and lack of transparency in the oil and gas industry, especially in environmental issues. Community members in Ogulagha attributed the massive fish kills in 2021 to the release of toxic chemicals mixed with sludge by SPDC. This claim was never investigated by regulators.

Firefighting equipment produced with various flame retardants are used extensively in controlling fire outbreaks in the industry. Research has shown that several brands of flame retardants used in controlling fire outbreaks contain persistent and emerging contaminants with profound health implications (Laitinen et al. 2014). The use of these equipment complicates the chemical burden in the environment, creating a cascade effect on soil and aquatic biota with potential effects on public health. In many incidents within the region, investigations usually focus on aromatics in petrochemicals and a few impurities like heavy metals. Although aromatics make up the large components of crude oil that are of public health concern, other petrochemical compounds like olefins, synthetic gases, naturally occurring radioactive materials and emerging contaminants should also be included in chemical investigations.

Developing A Chemical Database

The long history of conflicts related to chemical management in the oil and gas industry made the case for the development of a chemical database to aid the investigation of environmental, health and other socio-economic issues in the industry necessary and relevant. The development of a chemical database would require commitment from all stakeholders to create the appropriate legal, regulatory and institutional framework for the effective implementation and execution of such a programme.

Legal and Regulatory Framework

There is a need for the provision of a legal and regulatory framework to support the infrastructure and management of the proposed chemical database for it to be successful. The Nigerian Upstream Petroleum Regulatory Commission (NUPRC) formerly the Department of Petroleum Resources and NOSDRA have regulations related to chemical registration, testing and use in the industry, but there is no policy, regulation or legislation supporting the establishment and functioning of a chemical database to support chemical investigation openly and transparently. Although crude oil assay is submitted to NUPRC during oil well development, NOSDRA, state regulators and other stakeholders do not have access to such information. So, the first step in the proposition and establishment of a chemical database would be to introduce a robust legal and regulatory framework for its existence.

The Nigerian government recently just succeeded in updating the archaic legislation in the oil and gas industry recently. The new law can be amended to create a section for the chemical database management. The NOSDRA Act can also be amended to cater for the chemical programme. Stakeholders in the sector can also propose a new bill to the national assembly for the establishment of a chemical database to complement existing legislation and regulations in the sector. The new law or amendment will cover the need for the chemical database, the infrastructure, the institutional and management structure, function and procedure needed for the use and maintenance of the database. It will also provide provisions for the funding and the smooth running of the new department or agency of government.

Institutional Framework

There is a need to establish a multi-stakeholder institutional framework codified in the legal system for the establishment of a chemical database for the industry. The institution or agency that will develop, manage and maintain the chemical database should have representatives of all interested stakeholders at the management level and competent and skilled manpower at the technical level. The agency or institution should have qualified staff with hands-on knowledge of analytical and environmental chemistry, petroleum engineers, ecologists and laboratory technicians competent to handle the various aspect of machines, equipment and chemicals in various environmental matrices for the effective running of the agency. Recruitment into the agency should be based solely on a merit system and sound knowledge of what is required to handle the task in the agency rather than federal character, quota system and nepotism. There should be an independent funding instrument in the legal framework for the agency including remuneration of staff to discourage undue advantage from stakeholders and provide a level playing field for the agency to succeed. The critical role and job of the agency require trust and confidence in the fact that investigations conducted and report released should be respected by all parties concerned. Like the Clean Network Associates which was established by multinationals to combat oil spills in the region, the new agency should be created as an autonomous institution to provide sound, independent and reliable investigation, analysis and report on environmental and public health issues associated with the petrochemical industry.

Database Development

The key components in the development of the chemical database are discussed below;

Petrochemical Profiling - The first step in building the chemical database is to develop a comprehensive list of chemical contaminants in the oil and gas industry. There are broadly two categories of chemicals in

the industry. They include petrogenic chemicals and synthetic or market chemicals. Petrogenic are natural chemicals associated with petroleum, while synthetic chemicals are chemicals purchased for use in the oil industry. Petrogenic chemicals include petroleum, inorganics like metals associated with petroleum, NORMs and gases. Petroleum is a complex mixture of many organic compounds consisting of aromatic and aliphatic hydrocarbons. There are no exhaustive protocols for the analysis of the exhaustive complex list of compounds found in crude oil, so it is very important to select and profile the essential compounds of environmental and health concern with unique markers for the identification and classification of petrogenics based on their origin and locality. There are already existing analytical protocols for the many synthetic and emerging chemicals used in the industry while efforts are ongoing to develop fast and more reliable protocols for emerging contaminants.

Existing Database - Existing regulations in the industry require oil operators to collect and submit vital information including crude oil fingerprints for existing wells to NUPRC. Unfortunately, this information only exists with NUPRC and the oil operators. NOSDRA, the main federal regulator for oil spill management does not have access to the data which could be essential in determining chemical pollution especially mystery spills in the region. This existing information on oilfields should be updated and transferred to the new chemical database under the new agency for efficient delivery of the mandate of the new institution.

Target and Non-Target Analysis - The creation of a chemical database will require not just conventional knowledge of chemical analysis, but advanced techniques in analytical chemistry. In recent times, the application of conventional analysis for target analytes has not provided reliable and satisfactory outcomes in the sector. Preliminary investigations that are solely focused on heavy metals and hydrocarbon analysis with scanty analysis of NORMS are no longer providing the answers to issues of concern, especially to communities where oil is extracted. During chemical incidents such as oil spills, mystery spills or massive fish kills regulators and oil operators run hydrocarbon and heavy metals analyses using reference materials to investigate the source of the incident. This approach known as target screening is useful when looking for a shortlist of predetermined organic compounds while ignoring other compounds that could be of serious environmental and health concern. The wide range of chemicals especially new and emerging chemicals used in the oil industry requires more than traditional knowledge of chemical analysis, to investigate and proffer solutions to chemical-related issues in the petrochemical industry. A non-target analysis (NTA) is essential to investigate the presence of all the organic compounds within a sample for the discovery of new or emerging contaminants, metabolites or biomarkers in a sample (Llorca and Rodríguez-Mozaz 2013; Cavanna et al. 2018). NTA analysis can be applied as a standalone method for chemical analysis or used as a complementary approach where target analysis is insufficient to provide further insights for critical investigations (Llorca and Rodríguez-Mozaz 2013; Cavanna et al. 2018). The advancement in analytical tools such as high-resolution mass spectrometry (HRMS) with benchtop instruments like Time-of-Flight (ToF) and Orbitrap with high sensitivity, high resolving power and accurate mass measurement is increasing the frontiers in organic chemical analysis for a better understanding of chemical exposome (Cavanna et al. 2018). Resolving critical questions in recent times on chemical safety in the global petrochemical industry now requires the combination of conventional and new techniques and tools in analytical chemistry. The Nigerian oil and gas industry should not be left behind in proffering answers to stakeholders where conventional analytical methods are no longer reliable.

Access, Operation and Maintenance

The new agency charged with the management of the chemical database, including access, security and maintenance, should be able to provide access to the database to all stakeholders in the sector when a dispute arises regarding the authenticity of results. There should be a clearly defined process for accessing the database by third parties, especially for criminal, educational, or research purposes. Access by law enforcement, academic and research scholars should be available and the process should be well defined

to improve the development of the sector in criminal and legal matters, research and development for the industry. The level of access, security and maintenance by third parties should be well defined before choosing the digital platform or server on which the database will be built.

Conclusion

The Nigerian oil and gas industry is marred by conflict concerning chemical management, especially for public and environmental health issues. As more uncertainty began to emerge with regulatory investigations on the analysis of environmental samples for chemical safety, public health and environmental management there is a need to provide new tools and techniques to provide answers to critical questions that are beyond the boundary of conventional chemical analysis. As more chemicals are developed and used in the petrochemical industry, conventional analytical techniques will be inadequate to provide the relevant knowledge and insight to protect human health and the environment. The creation of a new agency with the sole mandate to develop, operate and manage a chemical safety database is essential in the petrochemical industry as we move into the future.

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