Review Article

Advance in Environmental Waste Management & Recycling

A Review of Petroleum Waste Management and Environmental Quality Status of Niger Delta

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Abstract

This paper provides a review and assessment of many researches and documentaries on Niger delta petroleum waste management. What new strategy or operational techniques would be added to improve waste management and environmental quality of Niger delta is our concern. Poor waste management, lack of environmental impacts assessment (EIA) and remediation neglects in the three sectors of oil and gas operations (upstream, midstream and downstream) are responsible for environmental pollution in the Niger delta. There is need to adopt continuous, operational, and periodic EIA with immediate remediation in the three operational sectors. This will end the old method of remediation only after a crisis. Application of Remove, Reduce, and Reuse to petroleum waste water should be considered. Avoidance of gas flaring near residential areas is obvious. Replacing unlined waste water pits with lined pits, solid waste dumps with sanitary landfills and partial waste treatment with full treatment are inevitable in sustainable management of petroleum wastes. Oil companies and the Nigeria National Petroleum Corporation (NNPC) could establish research grant for environmental studies to have the findings reported to them directly. Niger delta operational areas with maximum toxicity should be mapped out as brown fields and declared "no farm areas".

Keywords: Petroleum wastes, Petroleum sectors, Pollution, EIA, Treat, Reuse

Introduction

The extensive oil exploration in the Niger Delta Nigeria, has led to a series of environmental issues, resulting to several journal publications and commentaries. This situation has not only caused extensive documentaries locally but has attracted significant global attention and documentations. Despite all government policies and regulatory guidelines and authorities (Table 1), the Niger delta over the past two decades has been subjected to greater environmental crises and insecurity. This is largely the outfall of poor waste water management and unsustainable oil and gas operation in the Niger delta. All the publications, commentaries and documentaries locally and globally appear not to be making significant impacts on the waste management system and environmental quality of Niger delta. This paper presents a review and critical assessment of publications and documentaries on Niger delta environmental degradation. What impact is the quantum of research and documentaries making on improving waste management and environmental quality of the Niger delta is the research question. What new strategy or new operational techniques would be necessary to improve waste water management and environmental quality of Niger delta is our goal.

Table 1: Regulatory authorities for oil operations in Niger Delta

Authorities	Work Description
Federal ministry of Environment (FEM)	Responsible for administering environmental impact assessments (EIAs) relating to public and private projects, including oil and gas projects
NATIONAL Environmental Standard and Regulation Agency (NESREA)	Responsibility for enforcing compliance with the provisions of international agreements, protocols, conventions and treaties on the environment.
Nigerian Content Monitoring Board (NCMB)	Responsible for supervising, coordinating, monitoring and managing the development of Nigerian content in the Nigerian oil and gas sector in accordance with the requirements and prescriptions of the NCDA.
Department of Petroleum Resources (DPR)	Technical Supervision of oil and gas exploration, exploitation and refining.
NOSDRA) National Oil Spill Detection and Response Agency	Responsible for preparing, detecting and responding to oil spillages

Niger Delta consist of diverse ecosystems of mangrove swamps, fresh water swamps and forest, and is the largest wetland in Africa and among the most important wetland and marine ecosystems in the world [1]. The Niger Delta region is situated at the apex of the Gulf of Guinea on the west coast of Africa, along the Atlantic

coast of southern Nigeria [2, 3]. It is located in West Africa (Fig. 1a) between latitude 3° and 6°N and longitude 5° and 8°E [4]. The region is the largest wetland in Africa and among the third largest in the world [5]. According to him, 2,370 sq/km of the Niger Delta area consists of rivers, creeks, estuaries and stagnant swamps which cover approximately 8600 sq/km. The Delta mangrove swamp spans about 1900 sq/km as the largest mangrove swamp in Africa.

Niger Delta is classified as a tropical rainforest with ecosystems comprising of diverse species of flora and fauna both aquatic and terrestrial species. The region can be classified into four ecological zones; coastal inland zone, freshwater zone, lowland rainforest zone, and mangrove swamp zone [6]. It is home to some 31 million people and according to the delta occupies a total area of about 75,000 km^2 and makes up 7.5% of Nigeria's land mass (Fig. 1b) [7]. The Niger Delta region consists of 9 oil producing states (Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Ondo, Imo and Rivers as presented in fig. 1b [1]. The region is endowed with large oil and gas reserves, hence oil exploration and exploitation has been on-going for several decades in the region. The oil industry has contributed immensely to the growth and development of Nigeria's economy. However unsustainable oil exploration activities has rendered the Niger Delta region one of the five most severely petroleum damaged ecosystems in the world [5]. Studies have shown that the quantity of oil spilled over 50 years as a result of oil related activities in the Niger Delta was a least 9-13 million barrels, which is equivalent to 50 Exxon Valdez spills [8].

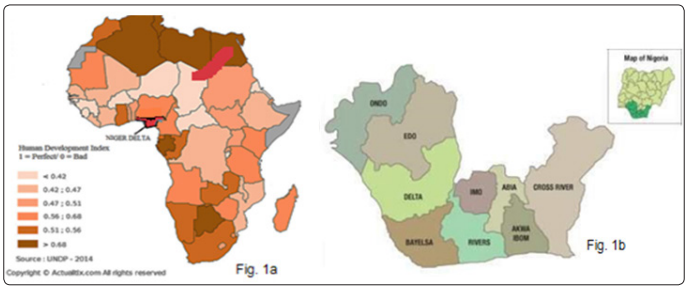


Figure 1a. Map of Africa locating Niger delta

Figure 2: Niger Delta showing the 9 oil producing states of Nigeria

The first commercial oil discovery in the Niger delta was confirmed at Oloibiri oil field in January 1956 by Shell D'Arcy (later Shell–British Petroleum) and a second oil field was later discovered at Afam [9]. In February 1958, Shell British Petroleum started exporting crude oil produced from Oloibiri and Afam oil fields in Port Harcourt [7]. Since then other oil wells were discovered in the region and were/are still being exploited by other multinational oil companies such as Mobil, Elf, Chevron, Agip, etc.

The oil industry in Nigeria is mainly confined to the onshore and offshore parts of the Niger-Delta. The industry is usually considered to be in three distinct operational areas:

The Upstream Sector: The upstream sector refers to activities in oil exploration and production that are carried out within or around the oil wells. These activities include prospecting (searching for oil deposits in commercial quantities), production (actual pumping of the discovered oil out of the Earth) and transportation (moving the unrefined crude oil to the refineries) [1].

The midstream Sector: The midstream sector is responsible for the transportation of crude oil or natural gas by pipeline, rail, barge, oil tanker, to flow stations and crude oil depots for storage. It also includes wholesale marketing of crude oil. This sector connects the upstream to the downstream.

The Downstream Sector: The downstream sector of the oil industry involves the refining of crude oil into various products like petrol, diesel, kerosene, naphtha etc, and the transportation of refined products to consumers by pipelines, sea, road, tankers and rail tankers to petrol stations. Wastes generated in these three oil sectors have impacted negatively on the surface and surficial environment of the Niger Delta. Nigeria's crude oils were studied and shown to contain relatively high concentrations of some heavy metals, Fe, Zn, Cu and Pb [10]. However, according to Uzoekwe and Oghosanine, the refined petroleum products show higher toxicity compared to crude oil since metal speciation is altered and new metals added to the matrix during the refining processes [11]. The waste streams associated with petroleum activities includes; Polycyclic aromatic hydrocarbons (PAHs): PAHs is a group of about 100 chemicals that are formed during the incomplete burning of coal, oil, gas, garbage, tobacco and other organic substances. They are also present in crude oil, plastics and pesticides [12]. PAH have been reported to be the real contaminants of oil and most abundant of the main hydrocarbons found in crude oil [13].

Total petroleum hydrocarbon (TPH) is a mixture of hydrocarbons found in crude oil [14]. Some of the chemicals found in TPH are hexane, benzene toluene, xylene, naphthalene etc [12]. The occurrence of natural radioactivity in oil and gas fields is well recognized worldwide and has been reported in Niger Delta [15].

Issues of Environmental Degradation due Poor Management of Petroleum Waste

Environmental contamination by crude oil and its waste is wide spread in oil rich regions. The effect of poor petroleum waste management can be severe, ranging from soil degradation to pollution of surface and groundwater. These problems often lead to lower land values and loss of certain land use capacities [16].

Surface Water Contamination by Petroleum Related Waste

Water quality has become a subject of concern to every nation of the world, since water life. The United States Environmental Protection Agency, estimates that one out of every three kilometers of the stream in most developing countries are contaminated to some extent [17]. Also Andrew emphasized that despite the fact that water is in vast quantity, useful water is not readily available and when available, it's usually not sufficient to meet the demand of the people [18]. Although, water is abundant on earth surface and in the subsurface, large proportion of this water is not suitable for human consumption. Anyadiegwu and Ohia identified water pollution as the cause of the extinction of aquatic life which equally renders water unsafe for human consumption in several oil and gas operational areas of the Niger delta [19].

Water pollution is a serious problem for the entire world. All water pollution is dangerous to the health of living organisms, but sea and river pollution can be especially detrimental to the health of humans and animal [20]. In the pre-pollution era, rivers were used as primary sources of potable water by populations all over the world [21]. The current state of pollution of this natural asset poses

a great risk to human health and safety in the Niger delta. Rivers worldwide serve as recipient of great quantities of waste discharged through agriculture, industrial, domestic and petroleum related activities [22]. Wastewater from petroleum flow stations (Fig. 2) are continually being discharged indiscriminately into surface waters resulting to impairment of water quality [23]. This has led to pure and hygienic water scarcity, disruption of socioeconomic activities and poor aesthetic quality of most of the water bodies.

Figure 2: Awoba flow station not only spill oil and waste water but also flay gas

Groundwater Contamination by Petroleum Related Wastes

Groundwater has been described as the main source of potable water supply for domestic, industrial and agricultural uses in the southern part of Nigeria especially the Niger Delta, due to long retention time and natural filtration capacity of aquifers [24, 25]. Pollution of groundwater has been on the increase in the cities where industrial activities, population growth, poor sanitation, land use and other factors have continuously prevailed. It has been reported that petroleum refining contributes solid, liquid, and gaseous wastes in the Niger delta environment [26]. Groundwater dissolves many different compounds most of which could contaminate large quantity of water. A little quantity of gasoline, petrol or kerosene could contaminate millions of liters of groundwater. Some of these wastes could contain toxic components such as the polynuclear aromatic hydrocarbons (PAHs), which have been reported to be the real contaminants of oil and most abundant of the main hydrocarbons found in the crude oil mixture [13, 27].

According to Ayotamuno et al., groundwater contamination resulting from the leakage of crude oil and refined petroleum products during extraction and processing operations and from underground storage tanks (USTs) in petrol stations cause serious environmental problem in the Niger Delta region [28]. Thus, Spilled oil and petroleum products do seep gradually into sub soils to pollute groundwater. Two cases of groundwater contamination in Sherada Industrial area of Kano in July 1984, and Kachia Local Government Area of Kaduna State in October 1984 were reported. Later investigations revealed that the contamination in Kano was caused by gradual seepage of petroleum products at the premises of the Nigerian Bottling Company while that in Kaduna resulted from a previous AGO spillage. Furthermore, Anyakora and Coker documented the assessment of the petroleum contamination threat on groundwater in parts of Niger delta [29]. The result showed that PAHs concentrations ranged from 1.92-40.47µg-1 and undetectable levels of high molecular weight PAHs have been attributed to their low water solubility. This report agrees with the work of Okoli et al., who reported high levels of PAHs in ground water sourced in Okirika, Niger Delta as a result of a refinery effluent discharge [30].

Discharges of petroleum waste water from depots into unlined pits, and subsequent migration to surface and groundwater (Fig. 3a &3b) expose human population around the contaminated area to potentially dangerous toxic substances. The case under investigation is that of groundwater contamination by petroleum compounds in parts of Osisioma town near Aba in Abia state. It is suspected that petroleum compounds migrating from the large capacity unlined waste water pit of the Osisioma depot has now polluted shallow private water wells in the section of the town lying in the direction of groundwater flow from the waste pit. Water well owners affected have lamented in vain as operators of the Osisioma depot feel ignorant of the situation. This contaminants migration will continue to impact more wells until the flow intercepts a boundary condition. The affected communities have lost their source of water and now subjected to unending hardship as they depends on water supplied to them from distant communities by commercial water tucks at exorbitant rate.

Figure 3a: Discharge from depot into unlinrd pit

Figure 3b: Spills from depot into surface water body

Aromatic compounds can rapidly migrate from the site of contamination and adversely affect terrestrial and aquatic ecosystems and humans. Prolonged consumption of oil polluted water is documented to have adverse effect on the health of the consumers. Water with high level of aromatic compounds may have negative effect on the kidney and liver of the consumers. Also, poor reproductive system, leukemia, increased blood pressure and reduced blood clotting are associated with oil polluted water [31].

It is known that exposure to PAHs can cause skin damage, bronchial symptoms in children and has been implicated in the pathogenesis of skin tumors as well as chromosomal disorders. Some host communities like the Ogoni have suffered from significant environmental degradation and health impacts including increase in respiratory diseases and cancer cases [32]. According to United Nations Environment Program the health of several Ogoni communities has been severely compromised as a result of surface and groundwater contamination associated with petroleum exploration and production operations in Niger delta [33]. Same UNEP (2011) report indicated high probability for a wide range of toxic responses in many host communities of the Niger Delta including behavioral abnormalities, respiratory diseases, suppressed growth, induced or inhibited enzyme, adverse physiological responses, blood disorders, negative reproductive outcomes, reduced immunity to disease and parasites, and cancers of the various organs. Increasing evidence, mainly from the Prestige oil spill, suggests that human population exposed to risks of oil / oil waste contamination may experience long term respiratory effects and chromosomal damage [34-36].

Many people, the majority being children, have gotten horrible rashes and sores on their skin from bathing in water that is severely contaminated by oil [37]. San Sebastián et al., conducted a study to contrast the cancer rates of people living near oil pits to people who live far from them [38]. Their research showed that people who lived in close proximity to the contamination had elevated rates of cancer of the stomach, rectum, skin, soft tissue, kidney, cervix, and lymph nodes. They also found a great increase in hematopoietic cancer among children who were less than 10 years of age. In the Northeast region of Ecuador, San Sebastián (2004a) noted a correlation between childhood leukemia and living in close proximity to oil fields. In the provinces of Sucumbios, Orellana, Napo, and Pastaza, which are all located in Northeast Ecuador, there were 91 cancer incidences and 42 leukemia incidences in children aged 0-14 between the years 1985-2000. Of these, 28 cases of leukemia and 27 other forms of cancer were reported in counties that were exposed to crude oil. The relative risk calculated in this study for both genders to experience leukemia in all age groups was determined to be significantly higher in areas affected by the oil contamination. This situation could very much apply to the Niger delta where human subjects burrow and aquatic organisms are subjected to oil contamination environments.

As reported by Engel et al., the vast range of health problems of American and Australian veterans related to their exposure of crude oil in the Gulf War, include infections and parasitic diseases, neoplasms, endocrine, nutritional, and metabolic diseases, mental disorders, diseases of the blood, nervous system, circulatory system, respiratory system, digestive system and genitourinary system, complications of pregnancy, skin diseases, musculoskeletal system diseases, poisoning, asthma, acute bronchitis, chronic bronchitis, malignant neoplasms of the respiratory and intrathoracic organs, malignant [39].

Toxicological impact of petroleum related waste on the aquatic ecosystem.

The effects of untreated waste water discharge into water bodies and the attendant negative impact on the aquatic and terrestrial ecosystem is well known and well documented over the years in Niger delta [40]. Presence of pollutants in natural waters alters the quality and often poses serious threats to aquatic life. Various studies have shown positive correlation between pollutions from petrochemical and refinery effluents and the health of aquatic organisms in Niger delta [41].

Thus, the contents of the effluents have serious toxicological effects on aquatic environment and humans. Refinery and petrochemical (Fig. 4a & 4b) effluents containing oil when discharged into water body can cause depletion of dissolved oxygen due to transformation of organic component into inorganic compounds, loss of biodiversity through a decrease in amphipod population that is important in food chain and eutrophication. Short term toxicity in fishes includes lymphocytosis, epidermal hyperplasia and hemorrhagic septicaemia [42]. According to Orisakwe and Nduka, physico-chemical parameters of domestic water of refinery host communities in Niger delta shows serious pollution burden from the effects of refinery effluent [39]. A study of Ubeji creek in Niger delta revealed that fish and aquatic life were absent at the site of effluent discharge and downstream to Ubeji River [43].

Figure 4a: Eleme Refinery

Figure 4b: Eleme Petrochemical

There is serious environmental pollution due to refinery and petrochemical operations; the prevalence of gas flaring, noise and vibrations as well as soil contaminations with liquid and solid waste disposal from these industries is of great concern. Aside from oil spill and gas flaring, Oluwatomiwa et al., observed that insufficient wastewater treatment of oil refineries and petrochemicals and the discharged effluents become another potential source of pollution that has not received enough attention from the government and the public in Nigeria [44].

Soils and Sediments Contamination

Oil and oil products are the most priority pollutants of the Niger delta environment (Fig. 5), because of their toxicity, spreading scale and high migration ability. Oil fields development and exploitation, and violation of the hydrocarbon transportation rules result in the pollution of natural ecosystem, particularly soil cover [45]. Thus, Soils and sediments are the ultimate sink for most petroleum contaminants, such as benzene, toluene, ethyl benzene, and xylenes (BTEX), aliphatic and PAHs [7]. Ite, and Semple, stated that Petroleum hydrocarbon contamination of soils and sediment is of a global concern because of the toxicity and refractory character of the aromatic components in the absence of oxygen [46].

Figure 5a: A typical Oil Spill Site

Figure 5b: Eleme Refinery

PAHs, one of the toxic contaminants present in crude oil and its products/waste, make up about 5% by volume, and are a widespread class of environmental chemical contaminants of anthropogenic or natural origin. Soil contamination occurs during offshore drilling and oil production operations due to leakages from well heads and pipelines, overflow from gathering stations, petroleum products, improper treatment and disposal of petroleum wastes, and leakages from underground petroleum storage tanks.

The discharges of petroleum hydrocarbon and petroleum contaminated production wastes into freshwater environments and overflowing of oily wastes in disposal pits during heavy rains has deleterious effects on soil and sediments [32]. Furthermore, long-term contamination of soils by crude oil, produced water and drill cuttings and the consequent environmental impact has changed geochemical, hydrological, geophysical and biological conditions of ecosystem throughout the Niger delta region as been reported by

a number of authors [47-51]. Ekundayo et al., studied the effects of crude oil spillage on growth and yield of maize (Zea mays L.) in soil in some parts of Niger delta [47]. Their results showed that in crude oil polluted soils, germination was delayed and the germination percentage was significantly affected by oil pollution.

Achuba studied the effect of crude oil contaminated soil at various sub-lethal concentrations (0.25, 0.5, 1.0 and 2%) on the growth and metabolism of cowpea (Vignaunguiculata) seedlings [48]. The results showed that crude oil induced environmental stress in the seedlings. Also, Al-Qahtani carried out an experiment to determine the effects of oil refinery sludge on plant on growth and soil properties [51]. The results of the effect of oil refinery sludge on Vincarosea (Catharonthusroseus) and soil chemical composition showed that the dry matter yield decreased significantly with increasing application of sludge and the decrease in yield was significant. Soil salinity and sodicity showed slight increases with the application of oil refinery sludge. Mineral elements of plants such as N and P decreased significantly with the application of oil refinery sludge than in control treatment. Above results suggest that the Niger delta over the past few decades, has prevailed with poor environmental quality status, subjecting the inhabitants into poverty [52].

Impacts on plants and ecology

Crude oil also contains heavy metals and much of the heavy metal content of crude oil is associated with pyrrolic structures known as porphyries. Porphyries are complex chemical compounds that have large heterocyclic organic ring structure. Soil contamination by crude oil or its waste derivatives releases heavy metals into the soil which can be assimilated by plants. Heavy metals are regarded as serious pollutants of aquatic ecosystems, because of their persistence toxicity, and ability to be incorporated into food chains [53]. According to Peciulyte et al., for a low metal contaminated soil, using maize and vetch plants as metal accumulator, after three weeks of growth, a negative effect on the length of shoots and roots was observed [54].The biomass of the plant seedlings was significantly smaller in the metal-contaminated soil in comparison with the controls. This implies that greater of Niger delta soil may have approached maximum toxicity due to accumulation of metal contaminants from petroleum wastes. Such land areas could be mapped and declared brown fields and no farm areas.

Impacts on Air Quality and the Atmosphere

Gas flaring (Fig. 6) has been the order since the beginning of petroleum exploitation in the Niger delta oil fields. Fifty to 100 of these gas flares can be found in Niger delta today. Worldwide, oil companies have been burning the gas associated with crude oil production for years. The World Bank estimated that the annual volume of natural gas being flared and vented globally in 2011 is about 140 billion cubic meters [55]. The associated gas flared into the atmosphere contains GHGs, as well as other poisonous substances such as dioxins, benzene, toluene, nitrogen, and sulphur dioxide. These poisonous gases cause acid rain, and impacts surface and groundwater. The result is poverty associated with serious health problems such as cancer, asthma, blood disorder, chronic bronchitis, and respiratory illness to the people living near the gas flaring points [20]. In 2002, the World Bank launched global partnership to cut gas flaring. In response to global and local pressure, Nigeria pledged in 1984 to eliminate gas flares and set 2008 as the target date, but this target was not achieved till today. "Nigeria has brought their gas flaring down by about 10 billion cm3/year yet there's still a lot of it [56].

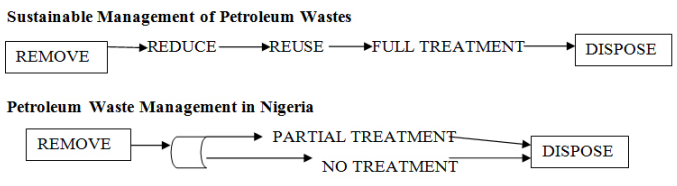
Discussion

Different countries adopt their own managerial strategies for oil and gas related waste based on their individual treatment objectives and regulatory bodies. Advanced countries have better treatment objectives and technology aimed at removing, reducing or reusing (recycling) petroleum wastes, and does not surfer much environmental impacts. Environmental contamination occurs during drilling and oil production operations due to leakages from well heads and pipelines, overflow from gathering stations, petroleum products, improper disposal of petroleum wastes and leakage from underground petroleum storage tanks. When these occur, environmental remediation must take place, aimed at the clean up or degradation of contaminants from environmental media impacted. At this point, the consciousness, readiness and capability of the operators to effective remediation become a challenge. In developing region like the Niger delta, awareness of the impacts poses a primary challenge as regular impacts assessment is lacking or neglected. In most cases, it is the operators that release the contaminants to the environment through discharge of untreated or partially treated operational wastes water.

Remediation of oil contaminated environment can be ex situ or in situ.

Various authorities have documented different methods for the management of petroleum related waste which include; Barrier walls and permeable reactive barrier, Steam injection and bio-slurry methods. Others include Bioremediation, Phytoremediation, Nanotechnology and Sludge treatment. From the ongoing review, oil spills upstream and midstream, and insufficient wastewater treatment from refineries and petrochemical plants, leakages from flow stations, depots, petrol stations and transport and storage facilities (depots), are all potential source of oil contamination in surficial environment that have not received enough attention in the Niger Delta. In some developed nations the target is to remove, reduce or reuse (recycle) petroleum waste where possible. Souza et al. stated that development of new technologies for petroleum waste recycling, which are consistent with the current needs is of high economics and environmental interest [57].

Souza et al. also showed that petroleum waste-clay mixtures have potential application in clay-based products. For instance, Pinheiro et al., documented that oily sludge in Brazil is being treated with bentonite clay which is converted into solid petroleum waste [57, 58]. This solid petroleum waste is disposed into sanitary landfills after treatment. In Kuwait, Al-Hubail and El-Dash, reported the four technologies that exists in the oil industry for disposal of waste water; seepage pits, sealed pits, underground effluent injection well and recovery reservoir pressure well [59]. Kuriakose et al. stated that purified refinery waste can be a substitute for processing oil in natural as well as synthetic rubber compounding [60]. It also found that 17% of lighter oil can be recovered from the oily sludge. After the removal of lighter oil, the residue was converted to industrial grade bitumen which is an important component in making paint.



There is the need for petroleum industries to recycle their waste as much as possible. Produce water could be treated and reused in the system; waste oils can equally be extracted and reused as well. However bioremediation is key for environmentally friendly targeted remediation and management of petroleum related waste. The new technology, use of nanomaterial presents an interesting alternative to the existing remediation technologies and their superior performance is due to increased surface area for reaction, higher reactivity and possibility of in-situ treatment. However, nanotechnology is still applied in Nigeria, but largely at the demonstration of interest stage while smaller and less rich countries like Nepal, Bangladesh and Sri Lanka are seriously pursuing research in nanotechnology [62, 63]. Hence more research work needs to be carried out to ascertain its suitability in managing petroleum waste in the Niger Delta. Nwachukwu, in his work also stated that permeable reactive barrier (PRB) and use of barrier walls to create a no flow boundary can be effective in the Niger delta areas where water table is near surface, if the technology would be affordable [31].

Greater priority must be attached to increase reduction of gas flaring particularly in locations close to residential areas as shown in fig. 6. We have mentioned countries where seepage pits, sealed pits, underground effluent injection well and recovery reservoir pressure well is used in disposing petroleum waste water. We have also mentioned countries where petroleum waste sludge is treated with bentonite, converting it to solid waste for disposal into sanitary landfill. It is important to state that there is no single engineered sanitary landfill in the Niger delta and neither in the whole country. What stops these multinational oil companies operating in Niger delta from establishing UNEP standard sanitary landfills in their operational areas just for managing their waste and that of their host communities? It is time for all unlined waste pits in Niger delta oil and gas operational areas be closed, treated and reclaimed. It is also time to replace unlined waste water pits with lined pits; solid waste dumps with sanitary landfills and partial waste water treatment with full waste treatment prior to disposal or reuse.

Some critical issues that hinder proper management of petroleum related waste in the Niger Delta are as follows:

- In Niger delta, studies show that petroleum industries neglect compliance with regulatory laws and status for petroleum waste treatment and disposal.
- Non-availability of waste treatment/disposal facilities in some cases which constitute a serious dilemma in the management of these waste streams.
- Non availability of analytical instruments in petroleum industries laboratory to measure some toxic contaminants present in petroleum waste.
- Insufficient awareness of the impacts of oil waste on the environment

Conclusion

There is urgent need to adopt new operational and policy enforcement waste management strategies in the three sectors of oil and gas operation in the Niger Delta. The new strategies should include Continuous Environmental Impacts assessments (CEIA), Operational Environmental Impacts Assessments (OEIA) and Periodic environmental impacts assessments (PEIA) to motivate immediate remediation of any impacted areas. The above new EIA/ remediation strategy if considered will be superior to the existing crises motivated remediation. Oil and gas operators need not wait for a crises situation to manifest before embarking on a remediation program. The era of environmental ignorance is gone, and oil and gas operational communities in Niger delta are now conscious of their natural environment [64-78].

It is important to note the fact, that pollution prevention pays more than remediation. In order to achieve sustainable management strategies for petroleum waste, the regulatory bodies must compel the multinational oil companies to endorse an agreement of full regulatory compliance (FRC) waste treatment. Oil companies must maintain a formidable department of environmental protection (FDEP). After decades of oil and gas activities in the Niger delta, greater emphasis should now be on environmental studies and remediation programs. Oil companies in Nigeria have no significant records of research funding or program for environmental research grant. Remove – Reduce - Reuse approaches to petroleum waste water management needs to be effectively practiced in the Niger delta, for total reduction of toxic carcinogenic contaminants and to improve environmental quality.

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