



The Impact of Petroleum Industry Activities in the Distribution of Molluscs in the New Calabar River: A Study of Rivers State

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ABSTRACT

This study investigated the impacts of petroleum industry activities on the distribution and health of molluscs in the New Calabar Rivers, Rivers State, Nigeria. The sampling technique used was empirical test on surface water and sediments (quantitative). The investigation used a systematic research to the study assessed the physicochemical surface water quality and soil sediment, pH, turgidity, electrical conductivity, heavy metals, organic compound of polycyclic hydrocarbon (PAHS), While the administered questionnaires responses were quantitatively assessed and analyzed into tabulated data's, column by using inferential statistics such as SPSS 26 and Relative importance (RII) for evaluations for the empirical test and socio-economic test respectively. The sampling across the (8) stations (Na 1, Oc2, Ta3, E/4, Ba5, Og6, Mg7, and Ch8), results indicate severe environmental degradation. While Ph levels (6.85 – 8.05) remained within WHO standards, Electrical conductivity (EC) reached alarming levels of 8,030, 12,490 us/cm. The study highlights that such pollutants not only cause physiological damage to adult molluscs – but also poses critical threat to highly sensitive early stages (spats, eggs and larva). The bioaccumulation (R11) and hydrocarbon (R11 = 0.96) of toxins renders mollusk unsafe for human consumption, threatening the socio-economic wellbeing of the region. The research provides framework for environmental management strategies aimed at mitigating hydrocarbon induced ecological decline in the Niger Delta.

Keywords: Impacts, Petroleum Industry, Activities, Distribution, Health, Molluscs

INTRODUCTION

Estuaries are among the world's most productive ecosystems associated with high diversity of assemblages including molluscs as one of the dominant components in terms of species richness, bio mass, and abundance. Estuaries are most commonly defined as semi-enclosed coastal bodies of water which has free connection with open sea and with which sea water is measurable diluted with fresh water derived from land drainages most estuaries are formed during first marine transgression in the Holocene approximately 15,000 years ago from existing River valleys flooded due to sea level rise (Wilson, 2002). On sea level stabilized to present levels about 6,000 years ago estuaries has been in filling with sediments, (at various rates) to assume its present feature. As an integral part of the ecosystem, molluscs are a diverse group of living organisms which evolved diverged from a very simple and common ancestors to become one of the most successful animal Phyla Molluscs are second only to Arthropoda in numerical abundance. The number of species identified under phylum molluscs vary between 80,000 to 100,000. Molluscs first appeared in geological history about 600 million year ago during Cambrian period molluscs have colonized all possible habitats from deep waters sea to high mountains. They most abundant in the Littoral zones of tropical sea. Gastropods and Bivalves constitute 98% of the total populations of Mollusca and they inhabit land, fresh water and marine environments. Molluscs are the most dominant animals in both aquatic and terrestrial environments. They are mostly active hunters, scavengers, passive feeders and deposit feeders attached to the substrate or living in burrows. Udotong (1995) note that petroleum exploration and production (E & P), activities in Nigeria date back to 1903 when mineral survey company began mineral logical studies in Nigeria with the first phases of the drilling activity undertaken by a German company known as the Nigerian Bitumen corporation following reports by natives of oil seepages along the Eastern part of Lagos. With the discovery of crude oil, it become the

mainstay of the Nigerian economy and contributes about 85% of the country's foreign exchange earnings (Udotong & Udotong, 2007).

In a natural state devoid of the impact one pollutant, marine or aquatic do thrive well in the ecosystem. This is evident in the proliferation of shell fishes (Molluscs) and other aquatic population like fishes and marine vegetation or biota "NOAA" national ocean and atmospheric, when exposed to oil, adult fish may experience reduced growth, enlarged livers, changes in heart and respiratory rates, fin erosion and reproduction impairment. Fish eggs and larvae could be sensitive to sublethal and lethal impacts. Then if its lethal impacts are not observed, oil can make shell fish and molluscs) and fish unsafe for human consumption (to eat). NOAA.

Physio Chemical properties of Estuary or Characteristics, biota and Fisheries of Estuaries

Estuaries are among the most productive of all aquatic ecosystems and yet represent the most degraded of all marine ecosystems. In addition to their crucial Nursery function for certain fish species, estuaries also houses commercial and recreational fisheries for a number of species and are becoming increasingly important in facilitating the aquaculture of valuable fin fish, crustacean and molluscs species (Wilson, 2002). Salinity under goes pronounced changes during each tidal cycle in those estuaries with a strong tidal regime, and also throughout the year in most estuaries as fresh water discharge either increases or decreases substantially, as often occurs on a seasonal basis. The estuaries with a strong tidal flow are also highly turbulent and turbid while the estuaries environment thus poses considerable physiological and physical challenges to its fauna, it does provide an excellent environment for rapid growth by those species, that possess the osmoregulatory, physical and behavioural characteristics required to cope effectively with those stresses and the ability to exploit effectively the high productivity of these water bodies (Elliot & Quintno, 2007).

Management strategies for Estuaries:

The emphasis is placed on outlining the range of physio-chemical characteristics that distinguish the complex type of system. The resultant definition is crucial for developing effective and appropriate management plans for estuaries and their fisheries (Elliot & Quintno, 2007), noting that management strategies for the fisheries may vary among the estuaries in a given region and among jurisdictions. This also deal with fauna also emphasizes the characteristics of the very different types of estuary found throughout the world. It includes, mainly details of the permanently-open, seasonally-open and normally closed estuaries often found along the same coasts in microtidal regions for which we have extensive first-hand experience, rather than concentrating pre-dominantly on the permanent – open and often macrotidal systems in temperate regions of northern hemisphere, which have been the studies and reviews.

Definition of Estuaries: The need to have a reliable definition of an estuary led, in 1964, to the convening of a special committee of the American Association for the advancement of science to address this issue Lauff (1967) and this produced the following definition: 'An estuary is a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage'. The definition was largely based on regions of the Northern Hemisphere and did not take into account the different characteristics of estuaries along, for example, the temperate southern coasts of Australia and Africa. This is a fundamental gap in previous studies.

The Impact of Petroleum Activities/Anthropogenic in the Marine Ecosystem

The Historical perspective of the petroleum industry in Niger Delta Nigeria

The Niger Delta region covers about 75,000km² and is home to about 30million indigenous residents scattered among 40 different ethnic groups, speaking diverse languages and dialects. In 1956 Shell British petroleum (now Royal Dutch Shell) discovered crude oil at a village Oloibiri in Bayelsa State, located within the Niger Delta of Nigeria and commercial production began in 1958. Oil exploration and exploitation has been ongoing for several decades in the Niger Delta. It has had disastrous impacts on the environment in the region and has adversely affected people inhabiting that region. Studies have shown that the quantity of oil spilled over 50years was at least 9 – 13 million barrels, which is equivalent to 50

Exxon Valdez spills. The ecosystem of Niger Delta has suffered from decades of oil exploration due to neglect by federal government to legislate and enforce the management of negative economic externalities. If it is not flaring of gas (emission of CO_2) its oil pollution, contamination of drinking water, deforestation etc. The ecosystem of Niger Delta has suffered from decades of oil exploration due to neglect by Federal Government to legislate and enforce the management of negative economic externalities. If it is not flaming of gas (Emission of CO_2) its oil pollution, contamination of drinking water, deforestation etc. (Kadafa, 2012). Environmental pollution of the Niger Delta resulting from the activities of oil industries has generated much concern over the decades. A number of incidents of pollution from well blow outs (Odu 1981, tanker accidents, spills routine operations have been recorded.

Crude oil has been a natural resource of high economic value since its discovery. In some cases, as in Nigeria it has become the basic mineral resource of certain states and the main bed rock of the Nation's economy with advancement of new technology has resulted in improved exploitation of new applications and uses, to such this resource that has become of global interest. This has intensified the search for oil indifferent geographical regions, enlarged production capacities in oil rich regions and processing both within the country of origin and across her borders. In the process of oil industry activities spills of different sizes have always been associated with different stages of the operations. Niger Delta region from which most of the oil is derived in Nigeria is of a different terrain. So the risk of all kinds of accident that may result environmental pollution is quite great. For more exploration, exploitation, drilling transportation processing and storage of crude oil have greatly affected the marine environment, (Doentter, 1992). The majority of oil pollution occurs in the estuarine and near shore waters. Thus petroleum hydrocarbons are the major contaminants of estuaries and coastal environments reports that offshore petroleum production facility located adjacent of the mouth of the Cross River estuary introduce small scale oil spills and leakages into the estuary by waves and tides.

Udotong, (1995) observed that petroleum exploration and production (E & P) activities in Nigeria data back 1903. When mineral survey company first phase of drilling activities undertaken by a German company as the Bitumen Corporation following reports by natives of oil seepages along the Eastern part of Lagos. With the discovery of crude oil, it became the main stay of the Nigeria economy and contribute about 85% of the country's foreign exchange earnings. The current daily crude oil production in Nigeria stands at 1.4million per day (MBPOD) (OPEC, 2024) However greater proportion of the Nigeria crude oil are lost through spills and are either not reported or grossly under reported (Utodong and Udotong 2007).

Impact of hydrocarbons on molluscs

One concern of hydrocarbon (PAHs & AHs) exposure in marine systems is the effect of polyaromatic hydrocarbons (PAHs) will have on communities and specific both at ecosystem and cellular levels. PAHs are toxic components found in crude on invertebrates as they have both carcinogenic and mutagenic qualities. PAHs readily bind to sediments as well as particulate organic matters found in the water column and have been found to persist in sediment at contaminated sites for many years, up to decades after initial exposure (Short, 2007). Bivalves can up take these contaminants through sediments in which they live or through ingestion during water filtration, where they accumulated within their tissues. Unlike some arthropods and first species, oysters are unable to quickly metabolize PAHs and because of their moves may be increasingly susceptible to long-term contamination. Oysters are ubiquitous across Murdy benthic habitats in the Northern Gulf of Mexico and persistent PAHs in sediment could exacerbate oyster assemblages' risk to detrimental effects on the individual and population level from prolong explosive to contaminates from deep water Horizon oil spill.

Statement of the Problem

Crude oil destroys the insulating ability of shell fishes like molluscs and other aquatic lives. Though shell fish (mollusk) and corals are not instantly exposed, but can come into contact with oil if it mixed into the water column-shell fish can also be exposed in the intertidal zones. The mangrove ecosystem in Nigeria is observed to have had a great deal of unchecked abandonment and destruction, resulting from natural processes and anthropogenic activities such as over-harvesting of resources, deforestation, oil exploration/drilling, illicit fishing techniques through application of passion substances such as Gammallin 20 and dynamite (Adekanbi & Ogundipe, 2009). Gas flaring, exploration, drilling,

extraction, transportation and refining of oil in the upstream and downstream sectors including waste discharge, accidental spills and operational failures as well as sabotage, oil bunkering and artisanal refining contributed serious environmental pollution and destruction of mangroves.

Discharges of petroleum hydrocarbons and petroleum-derived waste streams also exacerbate impacts on biota and widespread environmental degradation. Marine wildlife is particularly susceptible to the toxic effects of oil and is basically far more subjected to it than the land-based wildlife. Many of the notable effects occur in the intertidal zones. The mostly effected are sedentary benthic organisms. Diverse species have shown different levels of populations with expansion and habitat redistribution by more resilient biota, reshaping ecosystem.

Seafood (mollusc) is considered a renewable resource which provides economic benefits to Nigeria for centuries, if properly managed. The effects of petroleum E and P waste streams and oil spills, as well as other activities on the aquatic resources in general and seafood in particular are enormous and cannot be over emphasized. They range from poor seafood health through poor quality to extinction due to non-spawning or over-exploitation and death as a result of pollution. The resultant effect is that pollution due to petroleum E and P activities has affected seafood production and management in Nigeria. As a result of this, seafood if found, are much costlier than the conventional protein sources and are therefore not affordable to the rural poor populations who stand the risk of suffering from protein energy mal-nutrition (PEM).

Though, through the polluter pay principle (PPP), the oil company operators are required to pay compensation for economic crops as well as cleanup any oil spill with in their prospects, whether it is spilled by them or not. The oil producers trade section (OPTS) of the Nigerian National Petroleum company (NNPC) sets rates for compensation payments for economic crops but for seafood (Mollusca).

Aim and Objectives of the Study

The aim of this reach is to investigate the effects of hydrocarbon activities on water and sediments and its impacts on molluscs and their distribution in the estuary ecosystem of the New Calabar River of Rivers State. The objectives of the study are:

1. Determination of physicochemical parameters of surface water and heavy metals levels.
2. Determination of organic compounds such as Polyhydric Aromatics Hydrocarbons (PAHs) and Total Petroleum Hydrocarbon Hydrocarbons (TPH) and in Surface Water.

Research Questions

1. What are the levels of physicochemical parameters of surface water and heavy metals?.
2. What are the levels of organic compounds such as Polyhydric Aromatics Hydrocarbons (PAHs) and Total Petroleum Hydrocarbon Hydrocarbons (TPH) and in Surface Water?

RESEARCH METHOD

Research Paradigm: A research paradigm is a method, model or pattern for conducting research. It is a set of ideas beliefs or understanding with in which theories and practices can function. In conducting this research, one considered or forward: 'world views or paradigms' contain a set of beliefs or assumptions that guide our inquiry, and hence explain how we view the world, and thus, go about conducting research (Guba & Lincoln, 2005).

Research Approach: A research approach: Is the procedures selected by the researcher to collect, analyze. and interpret data. There are three types of research approach and there are quantitative, qualitative and mixed methods. Although, quantitative research uses deductive reasoning and involves the collection and analysis of numerical data to describe, explain, predict or control phenomena of interest, with numerical data inclusive of text, video or audio qualitative approach is in construct, it involves the collecting and analyzing of non-numerical data to understand concepts, opinions or experiences, using inductive reasoning. In considering the problem under investigation in the study and general objectives that the study has been executed, the research approach for this project or study is quantitative research.

Population of Study: Population is the identification of characteristics which members of the universe have in common, and that will identify each unit as being a member of a particular group. The target population is the group of Individuals that the intervention intends to conduct research in and draw conclusions from. It is also defined simply as the entire population or sets that will be considered qualified for data analysis - the entire group of people or objects to which the researchers wishes to generalize the study's findings. There is the need to consider the fact that there has to be a subset of the target population that could be referred to as the final participants from whom data is obtained by surveying either cellits members or sample drawn from it. This is the accessible population of the study the target populations straddles or traverses five (5) Local government areas of Rivers State. The access populations are Choba and Mgbuodohua Rumuelimini in Obio Akpo Local Government Area. Bakana, and old Bakana are in Degema Local Government Area. Namasibi Kiri, Elem Kalabari, Asaritoru local government Area, Ochokorocho – Degema local government area and Tamgbu funjun and Others - Okrika / Bonny government area. The New Calabar River greatly impacts on various accessible populations in the five (5) local governments areas of River State. These above mentioned communities and there satellites communities are the traditional communities along the River, and whose in habitants livelihood is dependent on the estuaries and mangroves ecosystems in several ways.

Sampling Design / Techniques: Sampling can be probabilistic and non-probabilistic, and while in probabilistic sampling each element has a known probability of being included in the sample the non probabilistic sampling does not allow the researcher probability (Kothari, 2004). Two fundamental sampling designs exist that is, the probability and non-probability sampling, with the former including forms of randomization device's and the later not including that (P. N. Ede, 2009). The sampling design for this study shall be simple random sampling for the quantitative data in the study as the design is aimed at satisfying data collection to suit the mixed-method approach that requires both qualitative and quantitative data.

Sampling Frame: The sampling frame is the list from which units are drawn for the sample. The list may be an actual units, as in a phone from which phone numbers were sampled or some other descriptions of the population. Also, it is a list of elements in the population from which the sample were drawn. The two major communities of Bakana, Choba with six (6) others selected Satellite Communities, along the new Calabar River of Rivers State in the Niger Delta, was identified as the main case study, hence samples was drawn purposively by simple, random sampling method to satisfy approach of the study. The two communities selected were the central point of focus because they are traditional owners of the territories along the case study River, and had their livelihood relatively dependent on the estuaries and mangrove ecosystems.

Sample Size: Sample size is a group of subjects that are selected from the general population which is considered a representative of the real populations for that particular study. To derive the sample size for this study, the general and accessible population for the study were determined in line with the study's aim and objectives, available census data and were projected to the current year, using the exponential formula. The accessible populations to obtained from the two case studies were summed up to arrive at cumulative accessible population figure and the proportion of individual case study also ascertain. "The Taro Yamane" was applied to arrive at the sample size: for the study to determine the appropriate of sample that was derived from each case study in accordance with their respective determined proportions. The 1991 census was hence relied upon for the target population that was projected to the current year (2025) using exponential formulae:

$$P_n = P_o (1+r)^n$$

Where

- P_n = projected Population
- P_o = base year Population
- 1 = a Constant
- r = growth rate of the population at the given year
- n = number of years to be projected

Hence, the base year population is determined from recorded 1991 population figures. of Bakana community zone in Rivers State (down & stream) and Choba community of the(upsteam) in Rivers State, using the national growth rate of 6.5% as contained in the gazette of the national population commission for a period of 32 years (1991-20231). The purported population is 348,968. The determination of a representative sample for the study was thus derived with Taro Yamane formula and the proportion of each area across the estuary was used to calculate

The sample size for each zonal area

Hence, is approximately = 400 – The sum cumulative sample size for upstream and mid/down stream of the new Calaber river in River State. Thus, the proportion of Bakana was 56.18% the sum total, while Choba was 43.82% of the total. Integrating this to the cumulative size of 400, the sample size of Bakana was 56.18% of 400, to which was 224.72. Hence that of Choba was 43.82 of 400, the outcome was 175.28

Instrumentation and Data Collection: Instrumentation and data collection are described as the tools and method use to gather and record information for your research or evaluation project. However, the data were collected through the use of questionnaire

Techniques for Data Analysis: The data base was compiled or assembled in the project/study was with the statistical Package for regression and correlation. The study used other descriptive tools such as Univariate and multivariate statistic. Univaricate Statistic that include measure of Central tendency (percentage, mean, mode, and frequency); and measures of dispersion (range and variance). The data here in analyzed were, graphs, and possibly charts to display differences in the measured.

RESULTS AND DISCUSSION

Assessment of Physicochemical Parameters of Surface Water

Rate of significant of physico-chemical activities that complement the Impact of Hydrocarbon / petroleum on molluscs species of the Estuary Ecosystems

The data here generated from the respondents through their perception of the impact of the physico-chemical contents, of the petroleum activities on the molluscs species of the estuary. The study is intended to elicit the root causes of the significant depletion of the molluse species of the marine environment. The survey study took to cognizance the physico-chemical parameters such as water content, metal content, pH, BOD, dissolved oxygen, hydrocarbon content, and intertidal flow.

The data from the respondents at the field is presented in table

The Rate of Significance of Physico-chemical parameters that complement the Impact of hydrocarbon/petroleum activities on Molluscs Species of the Estuary

S/N	Parameter of Survey Study	Very insignificant		Insignificant		Neither insignificant nor insignificant		Significant		Very significant		RII Ranking
		Bakana Area	Zonal Area	Choba/Ozoba Zonal Area	Bakana Zonal Area	Choba/Ozoba Zonal Area	Bakana Zonal Area	Choba/Ozoba Zonal Area	Bakana Zonal Area	Choba/Ozoba Zonal Area	Bakana Zonal Area	
1	Hydrocarbon content	7 (4%)	0	9 (5%)	11 (7%)	17 (9%)	48 (30%)	53 (29%)	28 (18%)	97 (53%)	70 (45%)	340 (0.94%) ^{1st}

2	Water content	0	0	0	0	22 (12%)	20 (13%)	17 (9%)	12 (7%)	144 (79%)	126 (80%)	340 (0.94%) ^{1st}
3	Metal content	0	0	7 (4%)	11 (7%)	15 (8%)	33 (21%)	31 (17%)	16 (10%)	130 (71%)	97 (62%)	340 (0.88%) ^{2nd}
4	BOD	0	16 (10%)	0	0	23 (12%)	35 (22%)	24 (19%)	10 (7%)	137 (75%)	95 (61%)	340 (0.87%) ^{3rd}
5	Dissolved oxygen	0	14 (9%)	12 (7%)	12 (8%)	11 (6%)	82 (52%)	8 (4%)	21 (13%)	152 (33%)	28 (18%)	340 (0.80%) ^{4th}
6	Intertidal flow	7 (4%)	0	20 (11%)	24 (15%)	25 (14%)	42 (27%)	78 (43%)	41 (26%)	53 (29%)	50 (32%)	340 (0.76%) ^{5th}
7	Change in pH	72 (39%)	0	36 (20%)	33 (21%)	33 (18%)	25 (16%)	42 (23%)	52 (33%)	0	47 (36%)	340 (0.59%) ^{6th}

Source: Researcher's Field Records [2024]

Respondent agreements on Estuarine Ecosystem depletion is caused by Petroleum Industry activities or man

The Petroleum Industry is operated by human being a focal player in environmental transformation is tipped to be active in most of the processes that causes depletion. Furthermore, the survey was embarked on to evaluate estuarine depletion with regards to man's daily activities and its impact on the molluscs population.

The Level of Agreement over the Petroleum Industry activities by Man on the depletion of Estuary Ecosystem

S/N	Level of Agreement over the Petroleum Industry activities	Bakana Zonal Area		Choba/Ozoba Zonal Area		Cumulative	
		No	%	No	%	No	%
1	Strongly disagree	0	0	0	0	0	0
2	Disagree	0	0	0	0	0	0
3	Neutral	0	0	9	6	9	3
4	Agree	56	31	50	32	106	31
5	Strongly agree	127	69	98	62	225	66
	Total	183	100	157	100	340	100

Source: Researcher's Field Records [2025]

Based on the data analysis, indicates that there was no responses for strongly agree and "disagree" options, whereas a total of 9 respondents, representing 3% of 340 respondents in the affirmed the neutral option in their responses, hence 56 and 50 from the two zonal areas in Rivers State, with a summed up cumulative frequency of 106 respondents, representing 31% of 340, took the agree option that petroleum industry activities are caused by man that depletes the estuary ecosystem. infurtherance, 127 and 98 respondents from Bakana and Choba zonal areas respectively in Rivers State representing 69% and 62% with a cumulative frequency of 225 (66%) out of 340 respondents in the Survey accepted the "strongly agree" option considering the fact that estuary ecosystem depletion is caused by petroleum industry activities from man.

The Level of Agreement of Petroleum Industry activities by Human on the depletion Estuary Ecosystem

Frequency of the occurrence of anthropogenic activities that depletes the molluscs estuarine ecosystem by natural processes. The anthropogenic activities that occur through natural processes that

depletes the molluscs population. The numerous changes that are associated, natural stress as a result of tidal flow, climate change, flooding, rainfall and several others.

Discussion of Findings

Assessment of Physicochemical Parameters of Surface Water Levels of the Physicochemical Parameters of Surface Water

The pH and temperature: pH values ranged from 6.85 (Ch8) to 8.05 (Na1), remaining within the WHO acceptable range of 6.5–8.5. These values reflect slightly acidic to moderately alkaline conditions, indicative of buffering capacity within natural limits. Temperatures were consistent (28.3–28.5 °C), slightly elevated above the WHO baseline (25 °C), possibly due to regional climate or thermal discharge (Boyd, 1990).

Turbidity and Salinity: Turbidity ranged from 1.94 NTU (Ta3) to 8.25 NTU (Og6). Except for Og6 and Ch8 (5.33 NTU), values mostly met the WHO threshold of 5 NTU. Elevated turbidity may indicate suspended solids, erosion, or runoff impacts (EPA, 2001). Salinity levels were exceedingly high (3.32–7.14 ‰) across all sites, significantly surpassing the freshwater limit of 0.6 ‰, suggesting saltwater intrusion or tidal influence, typical of estuarine environments (UNEP, 2006).

Electrical Conductivity (EC) and Total Dissolved Solids (TDS): EC values ranged between 8,030–12,490 $\mu\text{S}/\text{cm}$ (Fig. 4), and TDS ranged from 6,589–8,743 mg/l both dramatically exceeding WHO standards (EC: 1000 $\mu\text{S}/\text{cm}$; TDS: 600 mg/l). These high values suggest significant ionic pollution from industrial or domestic wastewater, agricultural leachates, or saline influence.

Total Hardness (TH) and Alkalinity: TH levels (344.17–715.82 mg/l) were above the acceptable range of 100–300 mg/l, confirming water hardness, likely from abundant calcium and magnesium ions. Such hardness can influence soap effectiveness and pipe scaling (APHA, 2012). Alkalinity (8–24 mg/l) was significantly below the WHO limit of 250 mg/l, indicating poor buffering capacity and increased vulnerability to acidification (Boyd, 1990).

Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), and Nitrite (NO_2^-): The figure in 8 shows dissolve oxygen concentrations ranged from 3.84 mg/l (Oc2) to 5.52 mg/l (Ba5). Most sites met the 5 mg/l threshold, except Oc2, Ta3, and Na1, suggesting potential organic loading. BOD values ranged from 0.81–4.87 mg/l, with five stations (E14, Ba5, Og6, Mg7, Ch8) exceeding the WHO limit of 2 mg/l, indicating significant microbial degradation activity and organic pollution (Chapman, 1996). Nitrite (NO_2^-) concentrations were well within the WHO limit of 50 mg/l but showed relatively higher values at Ba5 (1.55 mg/l) and Og6 (0.92 mg/l), pointing to possible sewage contamination or incomplete nitrification (UNEP, 2006).

Sulphate (SO_4^{2-}) and Phosphate (PO_4^{3-}): Figure 8 shows that sulphate levels were high (57.48–853.07 mg/l), exceeding the 250 mg/l limit at most stations, indicating industrial inputs or mineral dissolution. Na1 had the highest sulfate level (853.07 mg/l). Phosphate concentrations remained low (≤ 0.11 mg/l), well within the standard (0.5 mg/l), suggesting minimal eutrophication risk (EPA, 2001).

Calcium and Magnesium: Calcium (122.9–207.36 mg/l) levels exceeded the WHO threshold (100 mg/l) (Fig.8), contributing to the high TH values. Magnesium was within acceptable limits at all stations except Ch8 (9.24 mg/l), which was significantly lower, possibly due to geological variation.

Heavy Metals (Ni, Pb, Cr): In figure 7, Nickel concentrations (0.36–0.67 mg/l) far exceeded the 0.02 mg/l guideline, posing serious health concerns. Lead (Pb) was critically high at all locations (0.034–0.501 mg/l), especially at Na1 (0.501 mg/l), against the 0.01 mg/l WHO limit. Elevated Pb levels may result from industrial effluents or leaded materials. Chromium levels were very low (< 0.001 –0.027 mg/l) and within the acceptable range (0.05 mg/l), indicating limited Cr pollution.

Petroleum Hydrocarbons (TPH) and Polycyclic Aromatic Hydrocarbons (PAH): TPH concentrations were below the threshold of 30–300 mg/l across all stations, ranging from 0.156 (Ba5) to 3.331 mg/l (Na1), suggesting hydrocarbon contamination likely due to oil-related activities, albeit at manageable levels. PAH concentrations were highest at Oc2 (0.909 mg/l), indicative of hydrocarbon pollution from combustion or spillage.

Chloride and Alkalinity: Chloride values (5,434–11,362 mg/l) were significantly higher than the 250 mg/l WHO guideline across all locations. This suggests widespread saltwater intrusion, poor dilution, or anthropogenic contamination, typical in coastal or estuarine regions (Chapman, 1996).

Microbial Hydrocarbon Degraders (HUB and HUF): Hydrocarbon-utilizing bacteria (HUB) were present at all stations (0.013–0.3%)(Fig 10), while hydrocarbon-utilizing fungi (HUF) appeared only at Na1 (0.2%), Oc2 (0.2%), Ta3 (1%), and EI4 (3%). The presence of these microbial populations suggests a natural response to hydrocarbon contamination, reflecting ongoing biodegradation processes.

CONCLUSION

The physicochemical profile reveals widespread contamination across the sampled sites. Key concerns include elevated heavy metal concentrations (Pb, Ni), high salinity, excessive TDS and EC, and hydrocarbon presence. While some parameters like phosphate, chromium, and PAHs are within safe limits, the overall water quality is compromised, likely due to anthropogenic activities, industrial discharges, and saltwater intrusion. The dendrogram effectively discriminates between polluted and less-impacted sites, supporting its utility in sediment quality monitoring. The use of HCA complements conventional assessments by highlighting spatial among multi-pollutant indicators, aiding in the prioritization of remediation or control actions. This study in the course of the laboratory and field experience observed and adduced that the estuary ecosystem globally is being threatened by depletion and same applies to Niger Delta region, where as the livelihood and well being of the rural inhabitants do significantly hinged on the deltaic area exclusively. This study is intended to provoke, promotes and prescribe environmental sustainability that is targeted at mitigating the estuary depletion, population decline of the molluscs and sustaining human livelihood and well being that are derived from estuary resources ecosystem. The study was designed to justify the depletion of the molluscs population root causes of the depletions from hydrocarbon activities to explore the species components of the estuary ecosystem and accruals or benefits that are derivable of the resource.

This study has remarkable evoked and added to knowledge environment remediation and sustainability that should be adopted as action plans and part of the frame work of the management of the ecosystem of the Niger Delta region. This is the reason that provoked the investigation of the decline in the population of the invertebrate species (molluscs) and attendant effects of hydrocarbon in the estuary of the Niger Delta. The physicochemical profile reveals wide spread contamination across the sample sites. Key concerns include elevated heavy concentrations (Pb, Ni), salinity, excessive TDS and EC, and high hydrocarbon presence. While some parameters like phosphate, chromium, and PAHs are within safe limits, the over all water quality is compromised, likely due to anthropogenic activities, industrial discharges, and salt water intrusion. The dendrogram-effectively discriminates between polluted and less-impacted sites, supporting its utility in sediment quality monitoring. The use of HCA complements conventional assessments by highlighting among multi-pollutants indicators, aiding in prioritization of remediation or control actions.

The petroleum industry's operation in the New Calabar River have placed a grievous and multi-faceted impact on the abundance, distribution, and ecological dynamics of molluscs population for the estuary ecosystem and the livelihoods and wellbeing of dependent localities. This study has systematically explained the manner activities such as gas explorations and production, vandalization of pipeline, illegal refining, transportation, extraction and refining introduce a gamut of environmental stressors heavy metal pollutants, hydrocarbon pollutions and habitation degradation/loss that disrupts the fragile ecological balance of the New Calabar river. The invertebrate (molluscs) species, as a sensitive bio indicator and relevant component of the aquatic food chain, have proven especially susceptible to harmful perturbations, reduced or decreased species population densities, manifesting in transformed species composition and spatial deviation in distribution. Objective 8 achieved and some part of objective

9. This study has profoundly demonstrated that oil & gas exploration, production, illegal refining, pipeline vandalisation, other Industries activities, climate changes, chronic effluent discharges, for instance of depletion / contamination and extractive activities like dredging, have significantly reduced molluscs populations and distabilize their ecological roles, such as prey for higher trophic levels and nutrient recycling.

RECOMMENDATIONS

Based on the findings of the study, the researcher recommends that:

1. Government should foster relationship between petroleum industries operators, environmental bodies and governmental (MDA) statutory agencies to provide financial support and carry out conservation programmes and policies, in the two zonal areas of the New Calabar River.
2. The restoration of the mollusc population and boost, sustainable coexistence between industries operator activities the estuary ecosystems

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