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Examining the Environmental Effects of Oil Spillage in Nembe, Bayelsa State

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Abstract: *This study examined the environmental effects of oil spillage in Nembe, Bayelsa State by determining the particle size distribution of the soil, determining the nutrients composition of the soil contaminated with oil spill and the soil of a nearby control site in the study area, comparing the composition of the soil from the polluted site and that from the control site, and comparing the heavy metal present in the polluted soil in the study area with the NESREA standards. The study adopted laboratory research design in generating data for the analyses. Ten samples each were collected from two communities in Nembe, Okoroba and Etieme both from top soils and at depth. From the analyses it was found that there is a slight but insignificant variation on the pH of the soils, which averaged from the (top soil) 6.12 and 5.73 for the control Etieme and the affected soil of Okoroba respectively. The soils are all slightly acidic and this acidity cannot be attributed entirely to the oil spill since the control is equally acidic. Soil gotten from the top at Okoroba had a loamy sand (LS) texture. This has a a high proportion of sand, while the sub soil gotten from the same location had a silt loam (SL) texture, with a balanced mixture of s and, silt and clay. Soil gotten from the top at Etieme had a silt loam texture while the subsoil had a silt clay loam texture(SCL), which contain a high proportion of clay compared to sand and silt. This fraction averaged 66.72% in Etieme soil and 76.72% in Okoroba soil while clay decreased from 21% in Etieme to 16.70 in Okoroba. From the test of hypothesis, it was found that the oil spill concentration of the soil in the polluted site and the soil in the control site are not significantly different from each other; also the heavy metal concentration of the soil in the polluted site did not significantly deviate from the NESREA standards. Nevertheless, it should be known that heavy metals have the ability to bio-accumulate and biomagnify, hence the metal concentrations of this site will come to deviate from that of the NESREA standards over time if precautionary measures are not taken. It was also confirmed that oil spill has detrimental effect on both man and his environment. Comparison of the analytical data gotten from the polluted soil with the data gotten from the control nearby soil shows that there was no significant difference between the soil nutrient in the polluted site and the soil in the control site. The study therefore concluded that effect of oil spill on land as an aspect of the environment in Nembe is still minimal hence the need to urgently* *tackle the problem of oil spill was recommended so as to nip these negative effects by the bud before it goes out of hand.*

KEYWORDS: examination, environmental effects, oil spillage, Nembe, Bayelsa State

INTRODUCTION

Background of the Study

Oil spills are a significant environmental issue with severe impacts on ecosystems, communities, and public health. There are inherent risks associated with oil extraction, transportation, and storage, resulting in frequent oil spillage incidents around the globe. There has been severe environmental degradation caused by these spills, which has long-term ecological and socioeconomic consequences (National Research Council, 2003). Oil spills have been proven to cause significant damage to marine life, coastal ecosystems, and biodiversity. For example, the 2010 Deepwater Horizon oil spill in the Gulf of Mexico led to the release of millions of barrels of oil, resulting in extensive contamination of marine habitats and severe impacts on fish populations and other marine organisms (National Research Council, 2003).Similarly, the Exxon Valdez oil spill in Alaska in 1989 had long-lasting effects on the region's wildlife and ecosystems, leading to declines in fish and bird populations and persistent contamination of coastal environments

In the continental context, oil spills have been shown to negatively impact marine life, coastal ecosystems, and biodiversity. Africa has a substantial presence in the global oil industry, with several countries heavily dependent on oil production for economic growth. There have also been numerous oil spillage incidents on the continent, particularly in regions with substantial oil reserves. As a result of these spills, ecosystems and communities have suffered devastating effects, which present significant challenges to sustainable development (Fingerman, 2012).

In Nembe kingdom, measures have been implemented to address oil spillage and its associated environmental impacts but the problem persists. The challenges that have led to the continued occurrence of oil spillage in the region include: pipeline vandalism, inadequate maintenance, and limited enforcement of regulations. Furthermore, the restoration and rehabilitation of affected areas, particularly in the Niger Delta region, present significant challenges due to the complexity of the ecosystems and the socio-economic factors involved (Onyema, Chukwu, and Uwah,2018). Understanding the environmental effects of oil spillage in this region is crucial for developing effective strategies to mitigate and prevent future incidents.

Statement of Problem

Nembe, situated in Bayelsa State, Nigeria grapples with a significant environmental challenge stemming from recurrent oil spills. The deleterious effects of these spill permeate the ecosystem, affecting both the natural habitat and the communities dependant on it. This significantly affects

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the local populace. Despite being home to diverse ecosystems such as mangrove swamps, freshwater swamps, and rainforest, has been transformed into an ecological wasteland.(Nwilo and Badejo, 2016)

Oil pollution has resulted in the contamination of streams and rivers, destruction of forests, and significant biodiversity loss, fundamentally altering the landscape in Nembe. This transformation has profound implications for the indigenous people whose livelihoods depend on the ecosystem services for survival, contributing to increased poverty and the displacement of communities(Osuji et al., 2018).

Furthermore, oil spillage in Nembe has a significant impact on terrestrial ecosystems, such as farmland and forests. As a result of contaminated soil, local communities that depend on farming face serious risks to agricultural productivity. Additionally, oil spill incidents release toxic chemicals and air pollutants, posing a health hazard for nearby communities. This includes an increased prevalence of respiratory diseases, skin disorders, and reproductive problems among the affected population (Adeyemi, Okoh, and Fasae, 2018).

Isukul, Ideozu, and Udom, (2023), studied the effect of crude oil spill on plankton abundance in Santa Barbara river, his findings showed a decrease in the distribution and abundance of the plankton species in the Santa Barbra River. The results indicate pollution caused by hydrocarbon spillage.

Few research have been done to determine other environmental effects of oil spillage and the socioeconomic condition of resident living in Nembe. This research aims to cover this area in other to help in identifying potential health hazard and implementing measures to protect public health and safety.

Aims and Objectives

The aim of this study is to examine the environmental effects of oil spillage in Nembe, Bayelsa State. To achieve this aim, the following objectives were pursued:
1. to determine the particle size distribution of the soil in Nembe, Bayelsa state,
2. to determine the nutrients composition of the soil contaminated with oil spill and the soil of a nearby control site in the study area,
3. to compare the composition of the soil from the polluted site and that from the control site, and
4. to compare the heavy metal present in the polluted soil in the study area with the NESREA standards.

Research Hypothesis

In order to carry out this study, the following hypothesis was postulated tested:
H_o: There is no significant difference between the heavy metal concentration in the soil of the site contaminated with oil spill and the NESREA standards for heavy metal concentration in the soil.

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Study Area

The field is located in OML 29, which is about 90 km South West of Port Harcourt within a tributary of the Brass River in a typical mangrove environment. The study area is located within Nembe in the Niger Delta area, Nigeria. The Niger Delta lies between longitudes 5° and 8.4°E and latitudes 3° and 6°N within the coastal area of the Gulf of Guinea, covering an area of about 75,000 km2 with an overall regressive fill of about 12,000 m. Based on the dominant sedimentologic characteristics influenced by depositional conditions, the sedimentary pile is divided into three age-diachronous lithostratigraphic formational units, the Akata, Agbada and Benin Formations ranging in age from Eocene to Recent. The Akata Formation which occurs as the basal unit of the delta is composed of thick deep marine shale. Unconformably Overlying the Akata Formation is the Agbada Formation composed of alternating sand and shale beds as occur as the foreset of the delta. On top of the delta sequence is the Benin Formation characterized by friable sands formed in delta plain environments.

The head quarter of Nembe local government is located in the town of Nembe in the east of the area at 4°32’22’’N 6°24’01’’E. Nembe local government area in Delta state has a land area which covers a geographical area of 760km2 with a population of about 130,931 (NPC Census, 2006)
Fishing is one of the major occupations of the inhabitants of the communities under study. Fishing activity is carried out at both commercial and subsistence forms.

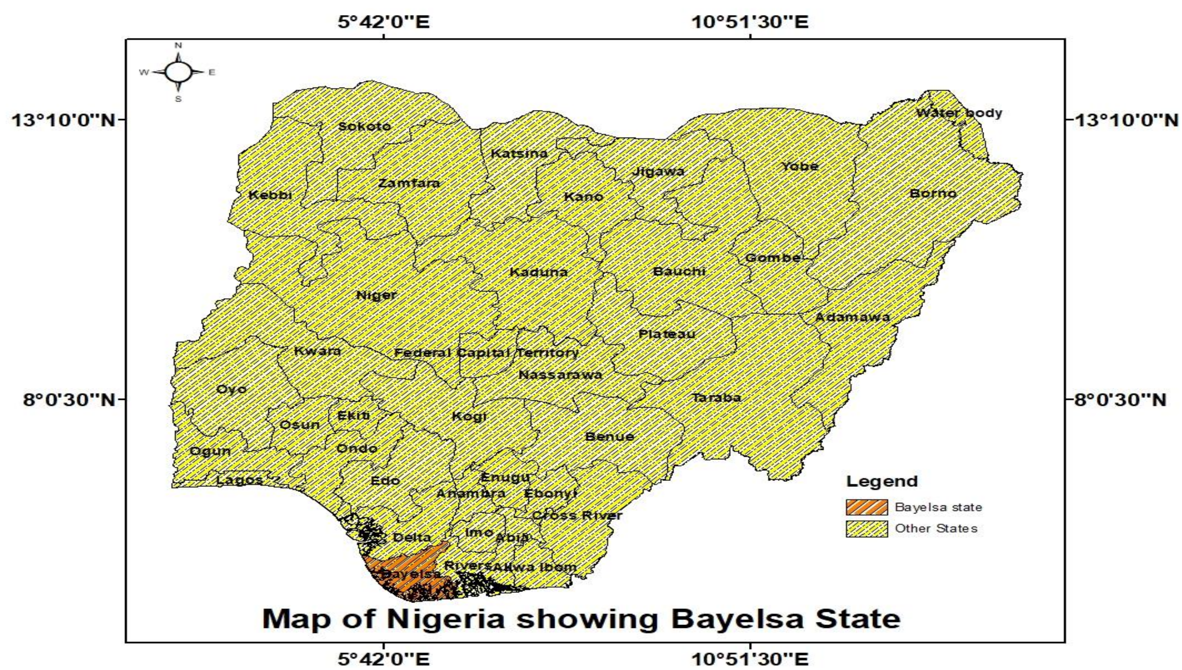

Fig 1.1 Map of Nigeria showing Bayelsa State

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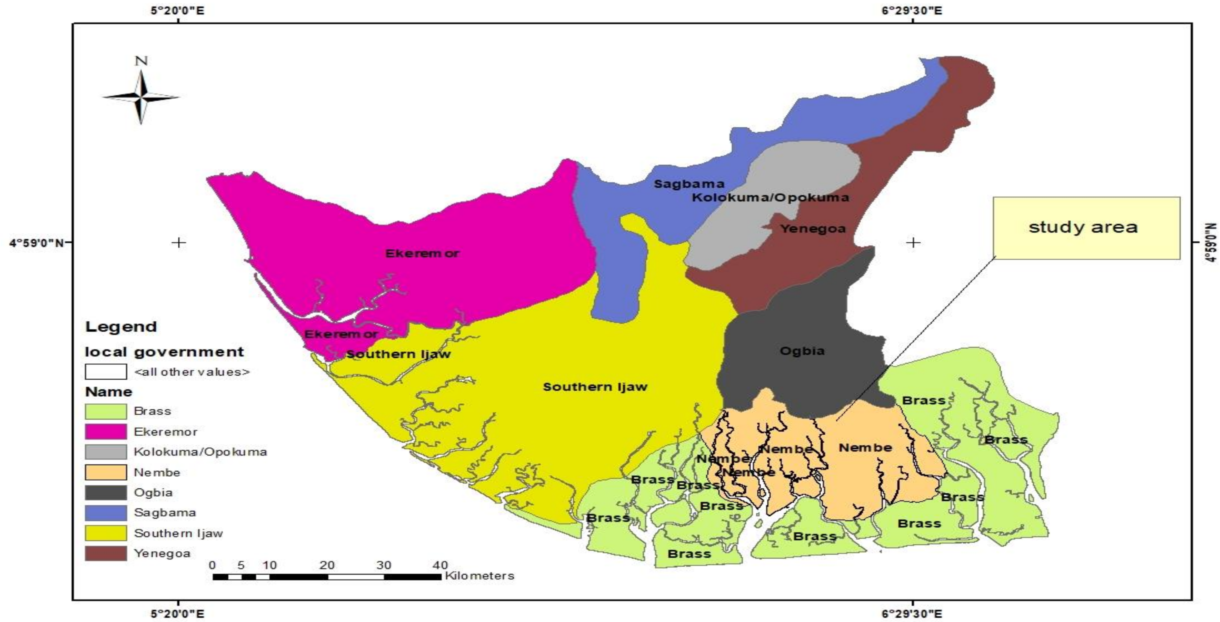

Fig 1.2 Map of Bayelsa State showing Nembe Kingdom

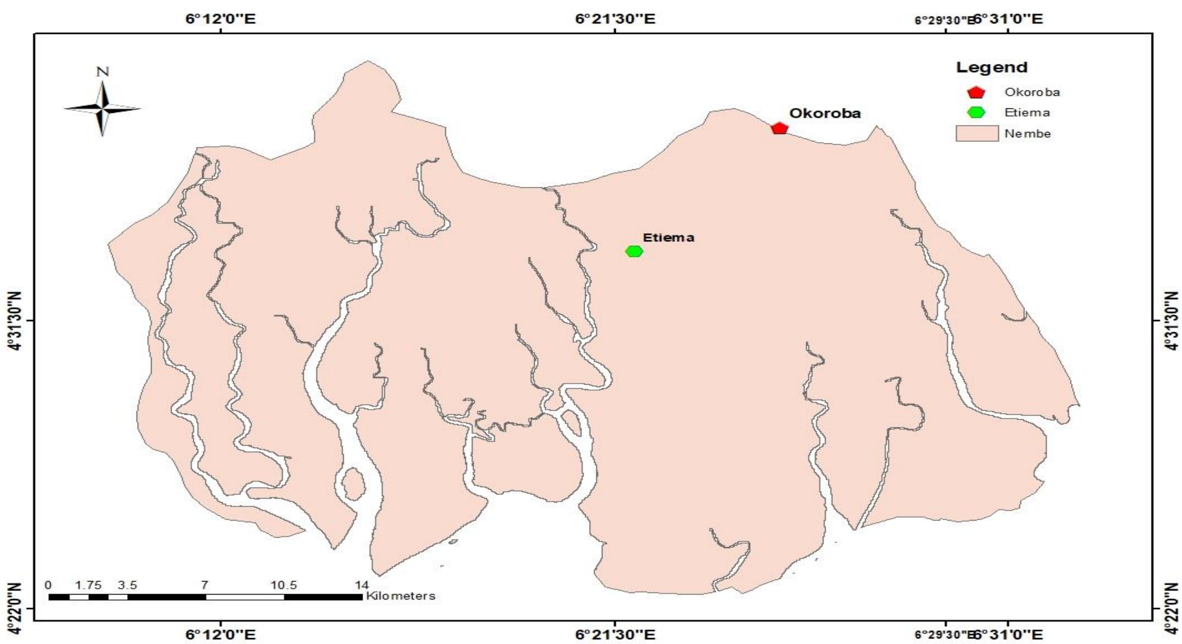

Fig 1.3 Map of Nembe Kingdom showing Etiema and Okoroba

Summary of Review of Related Literature on the Environmental Effects of Oil Spillage

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The finding from the literature on environmental effects of oil spillage were collated and summarized herein. Osuagwu and Olaifa (2015), found that oil spill affects fish production negatively; Aghalino and Eyinla, (2009) has it that oil spill causes environmental pollution such as drying up of vegetation, deprivation of plant and animal life among other negative effects. Ojimba (2012), reported that it reduces the size and quality of a farmland; Adamu et al., (2021) stated that oil spill causes a declining trend in normalized difference vegetation index; while Opafunso and Oniyide, (2010) incidence of high level of depletion of vital nutrient in the soil, necessary for plant growth due to oil spill. Osuagwu et al (2014), opined that incessant oil spillage pollutes groundwater; Amaechi et al (2022), also found that crude oil affect crop production by reducing soil fertility and this increases food insecurity. Increase in heavy metal caused by oil exploration degrade the soil (Duru et al., 2013); and oil spill degrade surface water resources (Njoku et al., 2021). Ipingbemi (2009) asserted that oil spill poses harm to human health when oil spill contaminated food is ingested, this was supported by the findings of Isukul et al (2023), that oil spill leads a decrease in the distribution and abundance of the plankton species. Literature really abound that spells out the negative effects of oil spills on the environment hence making it a matter of great environmental concern.

METHODOLOGY

This study adopted both laboratory research design in generating data and subsequent analyses.

Soil Sampling and Data Collection

From each of the two communities, ten samples were randomly collected at depth of 0-15 cm (topsoil) and ten at depth 15-30 cm (sub-soil). The ten samples from each depth were then bulked to obtain a representative sample of that depth of that community. The samples from Okoroba were designated At and As, while those from Etieme (the control) as B^s and B^t with (t) representing topsoil and (s) subsoil, respectively.

The representative samples were taken to the laboratory, air dried, sieved through 2m sieve and stored in plastic bags for analysis. pH was measured as described by Smith and Smith (1998) using a model 3020 pH meter. Twenty grams of the soil sample were weighed and suspended ni 50 ml, of distilled water and properly stirred before taking measurements. The particle size distribution was determined by hydrometer method (Bouyouocas, 1951) Exchangeable Cations (EC) were first extracted by the ammonium acetate extraction method (Jackson, 1962). Then sodium (Na) and potassium (k) were determined using flame photometry while calcium (Ca) and (Mg) were determined by the Versenate titration method as described by Jackson (1962). Exchange acidity was determined by the titration method using phenolphthalein as indicator. The Cation Exchange Capacity (CEC) was determined by summation of exchangeable base and exchangeable acidity (Jackson, 1962). Organic Carbon (OC) was analyzed by the wet combustion method of Wakley

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and Black (1934). Available Phosphorus (P) was determined by the molybdenum blue color method of Udo and Ogunwale (1978).

DATA PRESENTATION, ANALYSIS AND DISCUSSION OF FINDINGS

This section analyzes, presents and discusses the data generated from the laboratory analysis and field observation.

Particle Size Distribution of the Study Area

The table 4.1 presents the particle size distribution of the soil in Nembe

Table 4.1: Soil Particle Sizes

Sample	Sand	Silt	Clay	Texture	pH
A^T	81.52	1.30	16.50	LS	5.73
B^T	70.52	13.30	15.50	SL	6.12
A^S	82.52	3.30	13.50	SL	5.78
B^S	59.52	11.30	28.50	SCL	5.13
Mean A (t+s)	82.02	2.30	15.00		5.74
Mean B(t+s)	65.02	12.30	22.00		5.62

Table 1 show the particle size distribution of the soil. There is a slight but insignificant variation on the pH of the soils, which averaged from the (top soil) 6.12 and 5.73 for the control Etieme and the affected soil of Okoroba respectively. The soils are all slightly acidic and this acidity cannot be attributed entirely to the oil spill since the control is equally acidic. The acidity is typical of the soils of southern part of Nigeria and is ascribed to the excessive precipitation which leads to leaching loses of most of the basic cations in the soil (James and Wild, 1975). These lost cations are then replaced by hydrogen ion (H*) (Ngobiri et al., 2007).

Soil gotten from the top at Okoroba had a loamy sand (LS) texture. This has a a high proportion of sand, while the sub soil gotten from the same location had a silt loam (SL) texture, with a balanced mixture of sand , silt and clay. Soil gotten from the top at Etieme had a silt loam texture while the subsoil had a silt clay loam texture(SCL), which contain a high proportion of clay compared to sand and silt.

This fraction averaged 66.72% in Etieme soil and 76.72% in Okoroba soil while clay decreased from 21% in Etieme to 16.70 in Okoroba. This high sand content of the soils is characterized by sand formed on unconsolidated coastal plain sand and sandstone (FDALR, 1987). However, the significant effect of the oil spill on the sand content of affected soils of Okoroba when compared with that of the control can be observed from Table 1 and 2. Since sandy soil is not fit for crop production, the presence of oil-spill which significantly increased the percentage sand has adverse

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effect on the fertility of the affected soils. This is as a result of a probable high drainage of oil into the lower horizon of the soil causing aeration problem as the air pores will be blocked with oil and prevent the easy flow of nutrients to the soil (Chinda and Braide, 2000).

Test of Hypothesis
Hypothesis one
H_0: There is no significant difference between nutrient concentration of the soil in Nembe and that of the control site.
The decision is to reject the null hypothesis if the f-critical is less than the f-statistic, otherwise it should be accepted.
To determine the nutrients composition of the soil contaminated with oil spill and the soil of a nearby control site in the study area,
To compare the composition of the soil from the polluted site and that from the control site,

Table 4.2: Result for Soil Analysis

Parameter	Sample A^s	Sample B^s	Sample A^t	Sample B^t	Mean A (t+s)	Mean B (t+s)
Ca	1.10	32.70	12.02	5.10	6.43	18.90
K	0.10	0.30	0.10	0.30	0.10	0.30
Na	1.32	1.05	1.32	1.25	1.32	1.15
Mg	0.75	2.75	5.55	0.35	3.15	1.55
Ea	0.48	0.32	0.40	0.46	0.44	0.39
ECEC	3.90	37.27	19.37	7.61	11.64	22.44
Bs	87.3	99.14	97.93	94.4	92.73	88.80
Organic Carbon	2.11	0.55	1.58	1.62	1.85	1.08
Organic Matter	3.2	0.88	2.74	2.7	3.18	11.82

Mg: Magnesium, K: Potassium, Na: Sodium, Ea: Exchangeable Acidity, ECEC: Exchangeable Cation Exchange Capacity, A^s :Okoroba subsoil B^s : Etieme subsoil A^t :Okoroba topsoil, B^t :Etieme topsoil

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Table 4.3: Wilcoxon Signed Ranked Test for comparing the nutrient concentration of soil in the polluted site with the soil in the control site.

		N	**MEAN RANK**	**SUM OF RANKS**
Soil from the control site – soil from polluted site	Negative Ranks	5[a]	3.60	18.00
	Positive Ranks	4[b]	6.75	27.00
	Ties	0[c]		
	Total	9		

a. soil from the control site < soil from the polluted site
b. Soil from the control site > soil from the polluted site
c. Soil from the control site = soil from the polluted site
Source: researcher field work, 2015.

Table 4.4. Result for the Statistics
Test statistics

	Soil from the control site – soil from the polluted site
Z	-.533[b]
Asymp.sig. (2- tailed)	.594

a. Wilcoxon Signed Rank Test.
b. Based on Positive Ranks.
Source: Researchers field work

The above result above shows that there is no significant difference between the nutrient concentration of the soil in the polluted site and the soil in the control site. This is because the p-value, 0.594 is greater than 0.05. Hence, we accept the null hypothesis and reject the alternate hypothesis that the oil spill concentration of the soil in the polluted site and the soil in the control site are not significantly different from each other.
In other word, it can be emphatically said that soils in the polluted site are not contaminated with oil spill and as such be used for agricultural activity.

Hypothesis Two
H_0: There is no significant difference between the heavy metal concentration in the soil of the site contaminated with oil spill and the NESREA standards for heavy metal concentration in the soil. To compare the heavy metal concentration of the polluted soil from the study area with the NESREA standard.

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Table 4.5: Result of soil analysis.

Parameter mg/kg	**Soil A**	**Soil B**	**NESREA STANDARD**
Sulphate	32.90	6.14	5.0
Phosphate	3.89	0.67	NS
Manganese	1.010	0.911	NS
Iron	112.65	117.95	NS
Cadmium	0.021	<0.001	3
Chromium	0.033	<0.001	100
Nickel	0.864	0.435	70
Nitrate	12.33	2.33	NS
Lead	5.81	0.94	164
Zinc	2.91	0.215	421
Copper	1.037	<0.003	100
Chloride	0.040	7.09	250

Source: Researcher Field Work, 2024,

Table 4.6: Mann-Whitney Test

	NESREA standard	**N**	**Mean Rank**	**Sum of Rank**
Soil NESREA	Soil sample	15	15.20	288.00
	NESREA standard	15	15.80	237.00
	Total	30		

Source: Researcher field work, 2024

Table 4.7: Result for Test Statistics
Test Statistics

	Soil NESREA
Mann-whitney U	108.000
Wilcoxon W	228.000
Z	-.187
Asymp. Sig. (2-tailed)	.852
Exact sig. [2*(1-tailed Sig.)]	.870[a]

a. Not corrected for ties
b. Grouping variables : NESREA standard

Source: Researchers field work, 2024

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The above result shows that there is no significant difference between the heavy metal concentrations of the soil in the polluted site and the NESREA standard. This is because the p - value, 0.852 is greater than 0.05. Hence, we accept the null hypothesis that the heavy metal concentration of the soil in the polluted site did not significantly deviate from the NESREA standards.
Nevertheless, it should be known that heavy metals have the ability to bioaccumulate and biomagnify. Suffice it to say, that the metal concentrations of this site will come to deviate from that of the NESREA standards over time if precautionary measures are not taken.

SUMMARY OF FINDINGS

Oil spill has detrimental effect on both man and his environment. In this study, soil samples were collected from a polluted site and an unpolluted site at different soil level. The samples were both analyzed to determine the level soil nutrients and also the presence and level of heavy metals in the soil.

A depletion in the soil nutrients and the increase in the heavy metal concentration can affect the productivity of the land use for agricultural purposes. Comparison of the analytical data gotten from the polluted soil with the data gotten from the control nearby soil shows that there was no significant difference between the soil nutrient in the polluted site and the soil in the control site.

Heavy metal analysis on the polluted site were compared with NESREA standards. The result also showed that there was no significant difference between the soil sample on the polluted site and NESREA standard.

The soil in the polluted allows for agricultural purpose due to the proper and sustainable measures put in place to mitigate the effect of oil spill on the soil.
Further study was done using questionnaire. The was done to decern the environmental effects of oil spill on the soil and also the socioeconomic effects of oil spill on the living condition of residents in Nembe.

DISCUSSION, CONCLUSION AND RECOMMENDATION

Discussion of Findings

Oil spillage refers to the accidental or deliberate release of liquid petroleum hydrocarbons, such as crude oil or refined petroleum products, into the environment. These spill can have devastating effect on the environment and also socioeconomic effects in a country.

Oil spillage is a severe threat to marine life, causing immediate and long-term harm to various aquatic organisms. According to Osuagwu and Olaifa, 2015, Oil spill affect fish production negatively. Fingas, 2014 stated, Oil spills lead to immediate suffocation and smothering of marine organisms. When oil coats the water's surface, it creates a physical barrier, obstructing the exchange of oxygen. This results in fish and invertebrates suffocating due to the lack of oxygen. The toxic components of oil, such as volatile organic compounds and polycyclic aromatic hydrocarbons (PAHs), can be inhaled by marine organisms, causing damage to their respiratory systems. This damage impairs their ability to extract oxygen from the water, leading to breathing difficulties (NOAA, 2018). Oil spills can disrupt the reproductive systems of marine life. Exposure to oil and its toxins can lead to reproductive impairments in various species, affecting their ability to reproduce successfully. This can have long-term consequences on population dynamics (NOAA, 2018). Oil spills lead to long-lasting ecological disruption. Marine ecosystems suffer habitat destruction, loss of biodiversity, and disturbances in food chains. Some ecosystems may take decades to recover fully, with some changes being irreversible (Peterson, Rice, Short, Esler, Bodkin, Ballachey and Iron 2003). The toxins from spilled oil enter the food web. Small marine organisms absorb these toxins, and as larger predators consume them, the contaminants accumulate and magnify in concentration. This poses risks to higher trophic levels, including marine mammals and birds (Anderson, Taylor and Dietze 2018). Also oil pollution alters the chemical composition of the water, affecting its pH, salinity, and dissolved oxygen levels. These changes can further stress aquatic organisms and disrupt the delicate balance of aquatic ecosystems (NOAA, 2018). This can result in shifts in the biodiversity of affected areas. Sensitive species may be lost, and oil-tolerant or invasive species might thrive. This can have long-term consequences for the structure and functioning of aquatic ecosystems (Peterson et al., 2003).

Also, Opafunso and Oniyide, 2010 stated, there is a high level of depletion of vital nutrient in the soil, necessary for plant growth. Oil contamination can alter the physical and chemical properties of soil. It can lead to reduced soil fertility and hinder the growth of plants in the affected area. The presence of oil can affect the soil's texture and structure, making it less suitable for vegetation (Michel, 2015). Oil spills can harm soil microorganisms that play a crucial role in nutrient cycling. Microbial populations can decline in response to oil contamination, affecting the breakdown of organic matter and nutrient availability (Atlas and Hazen, 2011). Oil contamination in soil can persist for years, making it challenging for ecosystems to recover. The residual oil can continue to have adverse effects on soil quality, plant growth, and the overall health of the terrestrial environment (NRC, 2003). This affect crop production by reducing soil fertility and increase food insecurity (Amaechi et al., 2022).

According to Adamu et al., 2021, Oil spill causes a declining trend in normalized difference vegetation index. Oil spills physically coat and smother vegetation. This results in the suffocation of plants and algae, reducing their ability to photosynthesize and obtain nutrients. As a consequence, affected vegetation may wither and die. The toxic components of oil, such as polycyclic aromatic hydrocarbons (PAHs), can be absorbed by vegetation. These compounds can harm plant cells and disrupt normal metabolic processes. This leads to immediate damage and the

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weakening of affected plants (Michel, 2015). This reduces the size and quality of a farmland (Ojimba, 2012).

Also, Oil can physically coat the feathers, fur, or scales of wildlife, leading to immediate damage. This can reduce the insulation and buoyancy of birds and marine mammals, making them vulnerable to temperature changes and impairing their swimming abilities (NOAA, 2018). Wildlife may ingest oil while attempting to clean themselves or while feeding in contaminated areas. Ingested oil can be toxic, causing internal damage, organ failure, and other health issues (Galarza et al., 2014). Birds and marine mammals can experience respiratory problems when exposed to volatile organic compounds and other toxic fumes released by the oil. This can hinder their ability to breathe and can lead to illness (Goldstein, Osofsky, and Lichtveld 2014). Incestent oil spillage pollutes groundwater (Osuagwu et al., 2014). Soil contamination from oil spills can pose health risks to humans, especially when oil-related toxins leach into groundwater or affect crops that are consumed. Monitoring and addressing these risks are crucial (ATSDR, 1999).

CONCLUSION

Based on the research conducted, Oil spillages are toxic to the environment and oil industries in the location are the major source of this pollution. Oil spillage also have socioeconomic repercussions on the lives of resident in the area. Disruption in local economies, loss of local economies, loss of livelihood and increased unemployment rate were among the immediate consequences observed in the community.
Additionally, the environmental consequence of oil spillage are evident in the some community; this has lead loss of soil nutrient and increase in heavy metal concentration within the area. Also, oil spills on soil surface are carried by rain water into nearby streams, affecting the aquatic lives within the area.
Looking ahead, future research endeavour should emphasize greatly on exploring additional environmental aspect such as air and water quality. Furthermore, researchers should carefully consider and investigate other relevant parameters that have not been explicitly addressed in this study. The findings underscore the urgent need for proactive measures to mitigate the adverse effects of oil spills on both socioeconomic and environmental front. Policy intervention aimed at enhancing preparedness, response capabilities and accountability mechanisms are imperative to minimize the risk of future disasters and safeguard the well-being of affected communities and ecosystem.

Recommendation

Based on the available data and the outcome of the analysis, the following recommendations were made:

- Enhance existing regulations and enforcement mechanisms to ensure responsible practices in the oil industry, promoting accountability and preventing future spills.

- Establish funds to provide financial assistance and compensation to residents affected by oil spills, supporting their recovery and helping to rebuild their socioeconomic conditions.
- Conduct further awareness campaigns to educate local communities about the risks associated with oil spills and the importance of sustainable practices, fostering a sense of responsibility and collective action.
- Develop and implement programs to enhance the resilience of local communities affected by oil spills, including economic diversification, education, and healthcare initiatives.
- Oil companies should involve the communities in the maintenance and monitoring of the pipelines with the ultimate goal of improving the life of members of the community.

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