



Environmental Impact Assessment and 3-D Seismic Geophysical Evaluation of an Oil Mining Area in Degema and Brass, South-south Nigeria

^{1a}*Ibrahim Olanrewaju Ibrahim, ²Ngozi-Chika CS, ²Ashioba C, ³Adamu Enemona Kogh, ⁴Rotimi Micheal Sunday, ⁵Basirat Oluwatoyin Olatinwo and ⁶Bolaji Seun Adebowale

¹Planning and Design Department, Lower Niger River Basin Development Authority, Ilorin, Kwara state, Nigeria

²Department of Geology, Dennis Osadebay University, Asaba, Delta state, Nigeria

³Elcrest Exploration and Production Nigeria Limited, OML 40 AMT, Lagos, Nigeria

⁴Royalty Engineering Construction Limited, Ilorin, Kwara state, Nigeria

⁵Department of Urban and Regional Planning, Federal Polytechnic, Offa, Nigeria

⁶Health, Safety and Environment Manager, Dreamfo Housing Limited, 49, Brockly view, SE23 ISL, London, United Kingdom

*Corresponding Author: Ibrahim Olanrewaju Ibrahim; Ibrahim.olanrewaju@lnrbda.gov.ng

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Abstract: Assessment of shallow water offshore and 3D seismic data acquisition were carried out in Akuku-Toru, Degema and Brass to assess the feasibility of hydrocarbon production under existing environmental condition. Samples were taken at defined intervals for laboratory inference on the condition of the area. Changes in the acoustic properties reflected towards the surface of each rock layer. Hydrophone nodes on the sea floor received this reflected energy. The study has shown the fault line is longitudinal across its profile, while the horizons are showing deep dissection across the strata. Existing environmental condition showed measured ocean currents were observed at the surface with magnitude of 1.1 m/s. The total annual rainfall in the area is more than 2,203mm with high relative humidity. The maximum Air temperature values recorded was 31.350°C-31.960°C. Longshore current recorded speed averaged 0.2 m/s. The tide levels in the project area ranged between 0.15m and 1.57m and air quality was quite good for the area. Surface water microbiology recorded mean counts of 2.18×10^2 cfu/m. The study concluded that the area of study is environmentally favorable under its existing condition for the hydrocarbon exploration, production, construction and fabrication of oil and gas platforms for maximum hydrocarbon production.

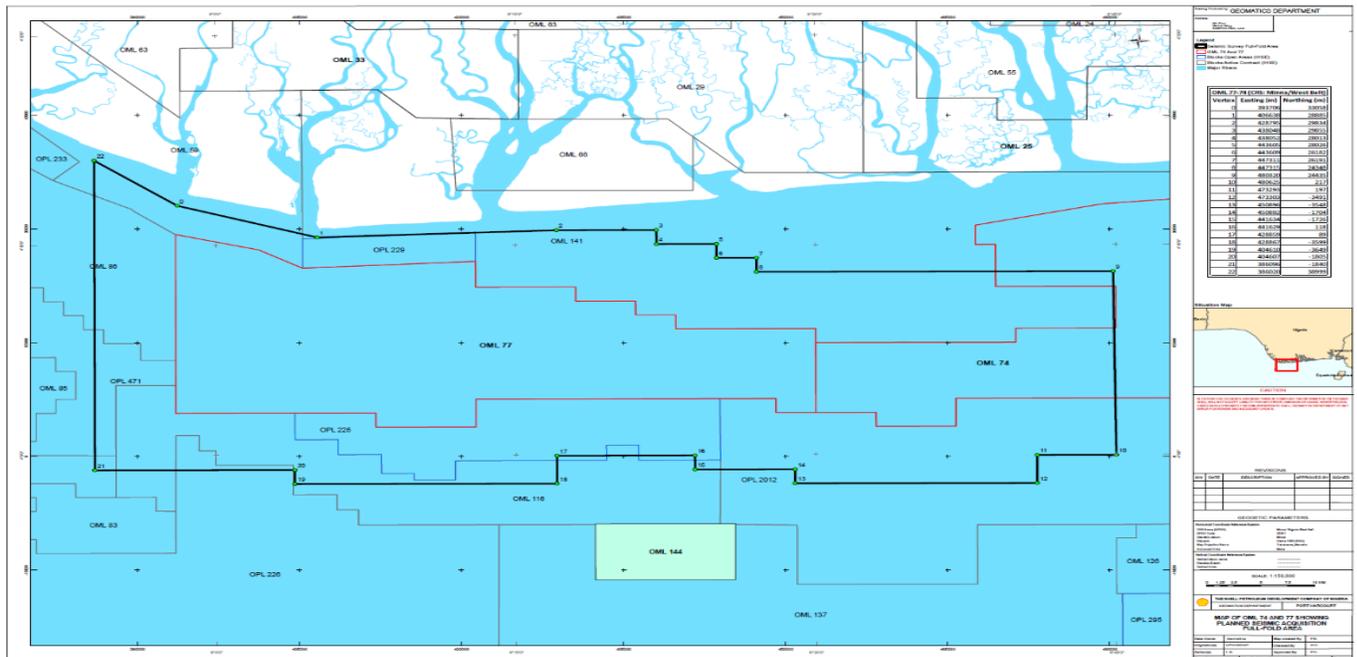
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INTRODUCTION

The current environmental status of the study area is important for the availability of reliable data on the situation at inception and prevailing climatic condition before the intervention. Moreso, seismic surveys are the only feasible technology available to accurately image the subsurface rock layers before hydrocarbon wells are drilled (Ibrahim *et al.*, 2023) for pipeline installation. It is the least intrusive and most cost-effective means to demonstrate the likely occurrence of recoverable hydrocarbons. It increases the likelihood that exploratory wells will successfully tap hydrocarbons and thus reduces associated risks, environmental catastrophe and the overall carbon footprint for further exploration. Various 2D streamer seismic data have been acquired over the study area and 3D streamer seismic data as well as an Ocean Bottom Cable (OBC) 3D seismic data. However, both the shallow and the deeper

exploration opportunities have not been fully explored and properly evaluated. The new seismic dataset is planned to address both the imaging in the shallow reservoirs. Some of the prospects in the study area have been explored and the fields are producing.

However, both the shallow and the deeper exploration opportunities have not been fully explored and properly evaluated, thus this EIA study to identify the key potential impacts of the project study area and proffer mitigation measures for Environmental Management is crucial for all fabrication and construction of oil and gas platforms to this effect. The effect of pollution on the location area such as the swamps, mangrove was obvious as indicated by other workers (Doust, 1989) for the environmental evaluation. The study areas are shallow water offshore terrain with its 3D seismic data acquisition activity carried out off the coast of Niger Delta in water depths of about 7m and close to the shoreline to above about 70 m away from the shoreline distance (Fig. 1). The planned surface coverage area for this seismic survey is about 2,218 sqkm^s (Fig. 2).



data gathering were subsequently taken to the laboratory for analyses. Results obtained were interpreted and used to describe the existing baseline of the study area. Degema study area was thus evaluated for the feasibility of hydrocarbon production under the existing environmental condition.



Fig. 2 Typical Source (Air Gun Shooting) Vessel used for the Seismic data collection

Sound signals were generated from arrays of towed energy sources (Figs. 2 and 3). The released air forms bubble which expands and contracts in a predictable fashion, emitting sound waves. The pressure variation in the water as a function of time caused by the high-pressure bubble. Individual energy sources were configured into arrays. These arrays have an output which are more desirable than that of a single bubble and serve to focus the sound output primarily in the downward direction which is useful for the seismic method. This array-effect also minimizes the sound emitted in the horizontal direction. The downward propagating sound travels to the seafloor and into the geologic strata below the seafloor. Changes in the acoustic properties between the various rock layers resulted in a portion of sound being reflected towards the surface of each layer. The nodes which were laid on the sea floor received this reflected energy. Fifteen experimental samples of the area of study were collected and used for this study.

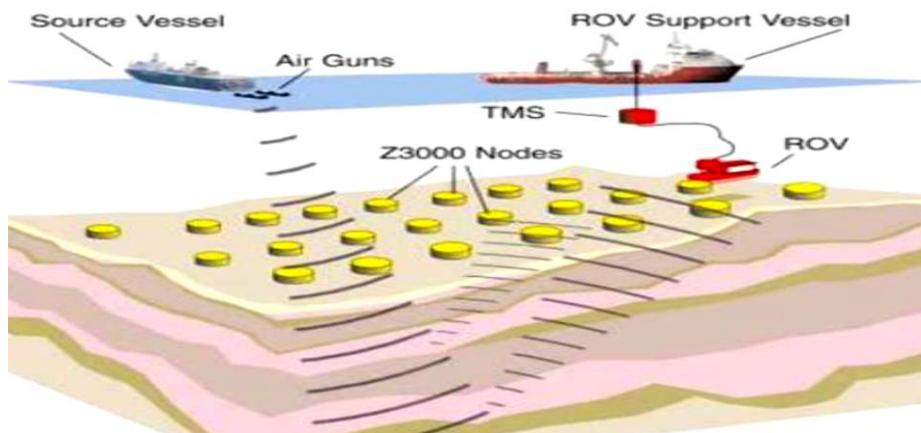


Fig. 3 Generated waves into the bedrock from the ocean bottom node

RESULTS AND DISCUSSION

The assessment of the project study area was done with greater accuracy and precision to reflect the aim of unraveling the suitability and Environmental condition of the area putting into consideration the climatic variability and feasibility of the study. The following environmental factors were therefore evaluated to establish the feasibility of carrying out the study with little or no harm to the ecosystem.

3.1 Wind Pattern

In the study area, surface wind is characterized by small diurnal variation influenced by sea breezes resulting from the warming of the sea. It reaches maximum level during the night due to radiation cooling leading to instability in the surface layer. The wind speed is usually a gentle breeze (0.4 - 1.4 m/sec) followed by light breeze (1.6 - 3.3 m/sec), and moderate breeze (5.5 - 7.9 m/sec). Winds above 10 m/sec occur but only during thunderstorms. These results conform with the obtainable findings from the Forcados-yokri, Burutu area that recorded SW wind with speeds of 3.1-4.6 m/s (Ibrahim et al 2025). During this study, the wind speed ranged at an average rate of 3.8 m/s in the northeast but 2.5 - 5.3 m/s with 3.9 m/s in the southwest and all fall within the climatic wind data for the area.

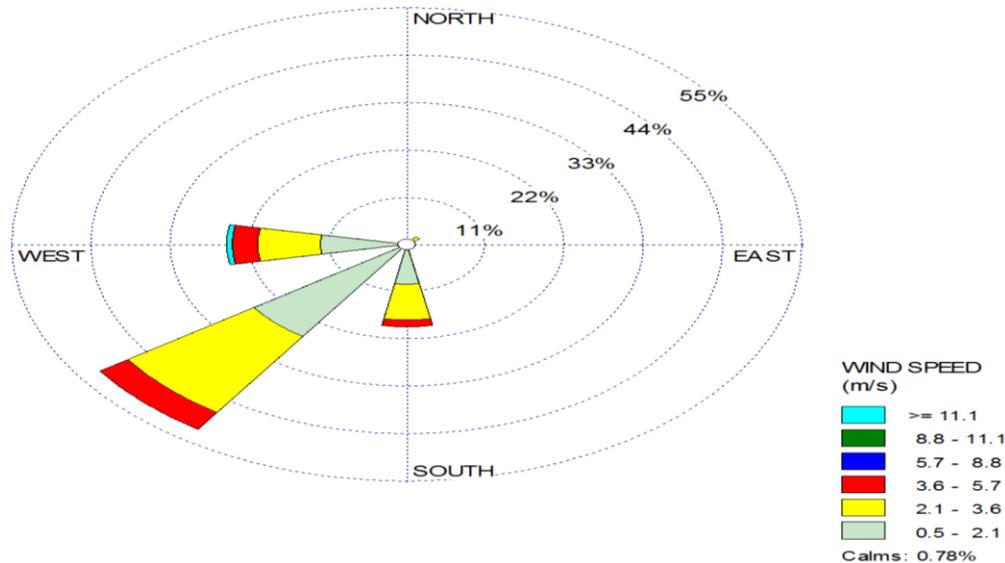


Fig. 4 Wind Speed Direction in the Study Area

This wind is usually referred to as air moving through the atmosphere at an appreciable and noticeable speed. The predominant wind direction in the synoptic area is South -westerly for a period of about eight months. Recent data (NIMET 2025 report) showed that April (1.79m/s) recorded the highest wind speed while the lowest was (Fig. 4) recorded in December (1.06m/s) every year and previous work has reported that wind speeds in the study area are generally below 2.5 m/s and hardly get to 3 m/s, with the highest values recorded at the onset of the rainy seasons in late March or early April of every year.

3.2 Ocean Currents and Tides

The Guinea current is the major oceanic current affecting the study area. The Guinea Current flows east at approximately 3°N along the western coast of Africa. Depending on the season, the primary source waters for the Guinea Current is either the Canary Current or the North. Equatorial Counter Current (NECC). For example, during the winter, the NECC is commonly very weak, while in the summer, the NECC is at its strongest. Within the Gulf of Guinea, it can reach velocities close to 100 cm/s near 5°W. Reversals occur in the Guinea current direction which is mostly prevalent during the wet season. Offshore Brass, maximum measured depth averaged currents were 0.7-0.8 m/s in the 75-105° sector. Maximum measured currents were observed at the surface, with magnitude of 1.1 m/s. Deeper offshore (~150 m depth), the currents are generally in the opposite direction. The tide levels in project area ranged between 0.15 m and 1.57 m. The tides at the estuaries, proximal to the study area have a south-westerly component and are semi diurnal with two inequalities. The spring tidal range at Brass is about 1.6 m and significant surges are infrequent. The littoral (coastal) circulation system offshore the Brass estuary

coastline is under the control of the prevailing wind systems, tides, waves and coastline orientation. The South-westerly tides produce ebb and flood tidal currents, which are in phase with the tidal cycle. Ebb currents due to their higher velocity and tidal time could result in the higher flushing of ocean waters from the tidal basin.

3.3 Seismicity

Seismicity in the Niger Delta is not well known, due to the lack of historical records and of modern seismic networks. Seismicity in mid Atlantic ridge area is well documented. Seismicity within the Mid-Atlantic ridge could be transmitted through the deep seated faults resulting in displacement of either side of the faulted blocks and could result in earthquakes. The tectonic evolution of the plates leads to the formation of fracture zones parallel to the direction of plate motion. The Benue Trough of Nigeria is bound by two offshore transform faults (the Chain and the Charcot Fracture Zones). However, no record of any seismicity is available within the Chain and Charcot fracture zones of the Gulf of Guinea, which could result in earthquakes in the project area.

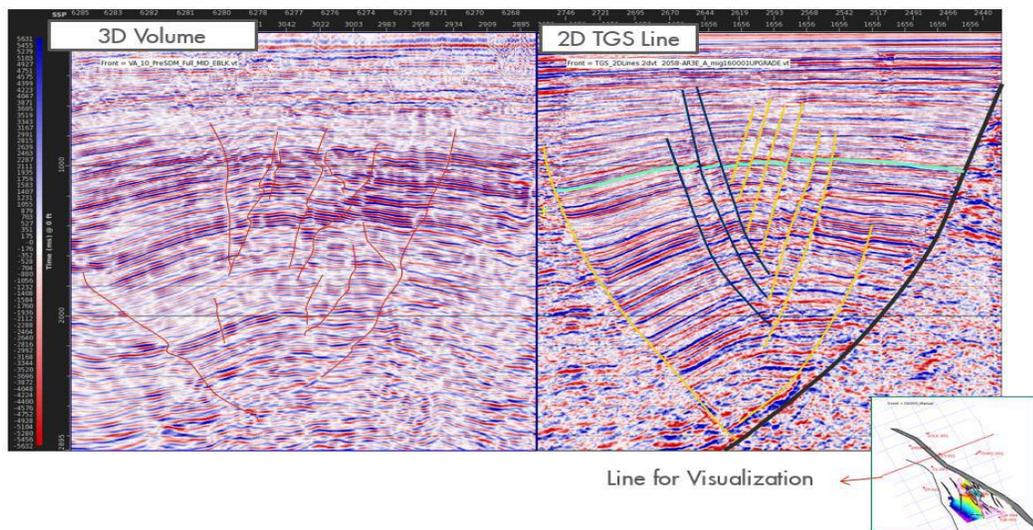


Fig. 5 Seismic image of the study area

The fault line is longitudinal across its profile, while the horizons are showing deep dissection across the 2 D profile of the area. Hydrocarbon accumulation is concentrated along the N-W (Fig. 5) side of the profile and can be further explored with more detail refinement to know the volume of concentration in the area of study. The sequence stratigraphic examination of its stratas will define the condition of the depositional condition suspected to be formed by prograding shoreline depositional condition system that formed its similarly defined Transgressive System Tract (TST) as established by previous workers in similar terrains, (Onyekiru *et al.*, 2012) and (Ekweozor and Daukoru, 1994). 3-D Seismic Interpretation and Structural Analysis of Ossu Oil Field, Northern Depobelt, Onshore Niger Delta (Opara *et al.*, 2011) attested to high hydrocarbon production in the area of the field.

3.4 Noise level

Noise is an environmental stimulus that disturbs sleeps (Rim-Rukeh *et al.*, 2007). The sleep disturbances may lead to other effects like hearing impairment which can be caused due to longer exposure and can lead to tinnitus (buzzing in the ear). In all the sampling locations during the study, sources of noise were production activities and the sampling points. This may mean that those identified noise sources were properly maintained. The noise level in the study area (Table-1) is within the NUPRC regulatory limits. However, the maximum level was recorded at AQ8 with 78.2dBA and the minimum is 73.4 dBA at AQ CTL3 and still within NUPRC limits of 80-100 dBA.

Table-1 Noise level measurement of the study area

S/N	Sampled Points ID	NUPRC Limits	FMEnv limit	Unit	Noise Level
1	AQ1	80-100	90	dBA	77.4
2	AQ2	80-100	90	dBA	76.3
3	AQ3	80-100	90	dBA	76.6
4	AQ4	80-100	90	dBA	76.4
5	AQ5	80-100	90	dBA	76.5
6	AQ6	80-100	90	dBA	75.6
7	AQ7	80-100	90	dBA	74.5
8	AQ8	80-100	90	dBA	78.2
9	AQ9	80-100	90	dBA	76.3
10	AQ10	80-100	90	dBA	76.8
11	AQ11	80-100	90	dBA	75.7
12	AQ12	80-100	90	dBA	76.9
13	AQ CTL 1	80-100	90	dBA	77.9
14	AQ CTL 2	80-100	90	dBA	75.3
15	AQ CTL 3	80-100	90	dBA	73.4

3.5 Physiochemistry of Surface Water

Average water temperature ranged from 28.55°C at the top to 28.00°C at mid and bottom compared to control 28.67 °C (Table-2) higher than the top of sample station but have equivalent measurement with the mid and bottom at the samples. pH ranged from 8.50 at the top, which is higher than mid and bottom with 8.00 compared to control with 8.53, 9.00 and 9.00 (top, mid, and bottom). The pH is lower at the sample point than the control and this variation was not significance ($P < 0.05$) (Table-2). Conductivity is 39581µS/cm at the top and it was lower than that of mid and bottom samples which recorded 41900µS/cm, 43177µS/cm. when compared with the conductivity of the control station, significant variation was observed for concentration at the bottom samples due to the high conductivity obtained at the study area. Dissolved oxygen compared well at top and mid between the study area and control station. However, significant variation was observed between DO levels from bottom samples, where higher concentration was recorded at the study area (4mg/l) and Concentration at the control was (3mg/l). This indicates oxygen enrichment range brought about water current and wave action; enabling transfer of dissolved oxygen from surface to lower depth. Observed variations in pH and DO are attributed to natural variations associated with mixing, phytoplankton productivity, atmospheric inputs and other biochemical processes. Dissolved oxygen levels are considered harmful to marine biota if they fall below 2mg/l (Akporfure and Ojile, 1999). All measurements were considered normal for tropical marine waters.

Table-2 Physico-chemical properties of the project study area. (Ibrahim et al., 2025)

10	Sediment sampling position			Control Station			Significance
	Position	Mean	SD	Mean	SD	Anova	
Temperature	Top	28.55	0.49	28.67	0.40	0.98	Significant
	Mid	28.00	0.39	28.00	0.38	0.83	Significant
	Bottom	28.00	0.44	28.00	0.42	0.87	Significant
Ph	Top	8.50	0.05	8.53	0.03	0.71	Not significant
	Mid	8.00	0.05	9.00	0.06	0.67	Not significant
	Bottom	8.00	0.44	9.00	0.06	0.47	Not significant
Conductivity (µS/cm)	Top	39581.08	1844.79	40766.67	2138.54	0.55	Not significant
	Mid	41900.00	2188.23	42200.00	2951.27	0.41	Not significant
	Bottom	43177.00	1830.83	42867.00	3200.52	0.17	Not significant
	Top	0.04	0.25	0.00	0.00	-	significant

Turbidity (NTU)	Mid	1.00	2.22	0.00	0.00	-	Not significant
	Bottom	2.00	7.21	0.00	0.00	-	Significant
Dissolved oxygen (mg/l)	Top	5.91	0.09	6.00	0.00	-	Significant
	Mid	4.00	0.28	4.00	0.35	0.50	Not significant
	Bottom	4.00	0.14	3.00	0.21	0.30	Not significant
Total Dissolved Solids (mg/l)	Top	27711.65	1288.27	28537.67	1495.24	0.55	Significant
	Mid	29330.00	1531.51	29541.00	2065.86	0.41	Significant
	Bottom	30226.00	1280.17	30007.00	2240.36	0.17	Significant

3.6 Alkalinity Level

Average levels of alkalinity ranged from 13.03mg/l at the top, 11.00mg/l at mid to 11.00mg/l at bottom compared to control of 12.00mg/l at the top, 9.00mg/l to 14.00mg/l. Concentration at top and mid is significantly higher than at the control but all levels are normal for tropical marine waters. The coincidence of the highest alkalinity with the lowest DO is an indicator that the variation in DO is mainly due to differences in phytoplankton productivity. Average turbidity ranged from 0.04 at the top to 1.00 at mid and 2.00 at the bottom compared to control of 0.00, 0.00 and 0.00 at top, mid and bottom. Turbidities at top, mid and bottom are significantly higher than that of the control, but all levels were low and normal for ocean waters. Variations are associated with sediment re-suspension and hydrodynamics within the system.

3.7 Organic Load

Biochemical Oxygen Demand and Chemical Oxygen Demand are routinely used as indicators of organic load in surface waters. Average levels of BOD ranged from 0.72mg/l at the top, 1.00 at the mid to 0.00mg/l at bottom compared to control of 0.67mg/l at top, 0.00mg/l at mid and 0.00mg/l at the bottom. There is significant variation in the level of BOD between sample locations and control. But the result indicates that reduction of BOD as it moves to the bottom. However, the top and mid were significantly higher than the top and mid of the control points. Average levels of COD ranged from 180.49mg/l at top, 179.00mg/l at the mid to 160.00mg/l at bottom compared to control with 188.00mg/l at the top, 182.00mg/l at mid to 189.00mg/l at the bottom. There is a decrease of COD at it approach the bottom but when compare to control, there is significant increase as it approaches the bottom, but generally, it not significant at ($P < 0.05$). High levels of COD at the control may be associated with land-based and related input of materials from coastal rivers. All measurements including the control were high compared to those expected in unpolluted surface waters and are indicative of moderate levels of organic pollution. Unpolluted waters typically have BOD of 2 mg/l or less, whereas water in contact with waste water may have values up to 10 to 15 mg/l and previous workers () emphasized the health implications of trace minerals in the drinking water of some oil bearing communities in the Niger delta region.

3.8 Nutrients in Water

Nitrate and phosphate are major nutrients for phytoplankton growth in the marine environment. Spatial variations in levels of both parameters at the study location were evaluated and found out that the average levels of nitrate ranges from 1.23mg/l at the top, 1.22mg/l at the mid to 1.83mg/l at bottom compared to control of 1.00 mg/l at the top, 1.13mg/l at mid to 1.40 at the bottom. But the nitrate is higher at the top, mid and bottom compare to control. And the bottom is significance at ($p < 0.05$). There is a reduction in the level of Phosphate as it move from top to bottom with 0.30mg/l at the top, 0.28mg/l at the mid and 0.29mg/l at the bottom compared to levels at the control of 0.42mg/l at the top, 0.47mg/l at the mid and 0.42mg/l at the bottom. The top and bottom is significant at ($p < 0.05$). Nitrate concentrations in excess of 20 mg/l usually indicate pollution by human or animal waste, or fertilizer runoff (Merian, 1994). Present values are therefore normal for the study area. Most natural

waters have phosphate levels ranging from 0.01 to 0.05 mg/l. Phosphate values above 0.02 mg/l are known to accelerate eutrophication in waters (Macgill, 1994). Present values of phosphate are high and indicative of contribution from diverse sources such as sediment release, land-based inputs as well as input from vessels and crude oil operations. NO₂ ranges from 4.04mg/l at the top, 4.00 at both mid and bottom. The NO₂ is higher at the top when compare to control, but the bottom is significance at p<0.05. SO₄ has higher concentration at the mid with 826.00mg/l. The top has 801.61mg/l while bottom is 784.00mg/l. But SO₄ is lower at the control point with 730.00mg/l top, 724.00mg/l mid and 741.00mg/l at the bottom. NH₄ ranges from 0.58mg/l at the top, 0.57mg/l at the mid and 0.63mg/l at the bottom. Compare to control with 0.47mg/l at the top, 0.55mg/l at the mid and 0.65mg/l at the bottom. The concentration of NH₄ increases as it moves to the bottom. The top and mid of sample point are higher than the control but are not significance at p<0.05.

3.9 Heavy Metals

Vanadium and barium were not detected in water at the sample points and control. Average cadmium ranges from 0.02mg/l at the top to bottom compared to control of 0.01mg/l and 0.01mg/l at the mid and 0.06 bottom. Cadmium was significantly higher at the top of sample point than the control. Average zinc ranged from 0.04mg/l at the top, 0.04mg/l at the mid to 0.06mg/l at the bottom. These shows increase in the level of Zn as it moves down. Same occur at the control point. Also, at the top, the level of Zn is higher at sample point compared to control but the bottom is significance at p<0.05. Average iron ranged from 1.16mg/l at the top, 0.15 at mid to 0.16 at bottom compared to control with same 0.16mg/l and 0.03mg/l at the mid and 0.04mg/l at the bottom. Iron is higher at mid and bottom than control and both the mid and bottom are significance at p<0.05. Chromium ranged from 0.03mg/l at top and mid to 0.06 at bottom compared to control of 0.17mg/l top, 0.04mg/l at mid and 0.06mg/l at the bottom. Nickel ranges from 0.21 at the top compare with 0.62 at the control top point. The mid is 0.34mg/l and bottom has 0.15mg/l at sample point compare to control with 0.62mg/l top, 0.57mg/l mid and 0.75mg/l at the bottom (Ashraff *et al.*, 2015). Cobalt is not application in both sample and control. Higher levels of magnesium were also found at the study locations compared to control.

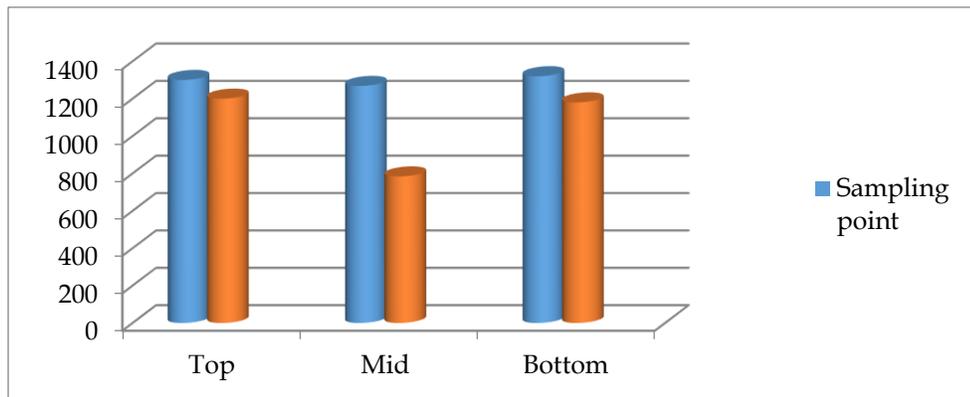


Fig. 6 Spatial variation in Concentration of Magnesium

3.10 Sediment Temperature

Sediment temperature ranged from 20.43°C at sampled points compared to 20.80°C at the control. pH ranged from 7.28 at sample compared to 7.36 at the control. The pH of the sediments is related to that of the overlying water. Typical pH values for recent sediments ranged from 6.4 to 9.5. This sediments of this study area were generally muddy, consisting mainly of silt (42.27%) and clay (57.52%) with grey colour. Redox potentials were negative ranging from 22.69mV at sampled points compared to control with -24.50mV. Typical redox potentials for recent sediments ranged from +350 to -500 mV (Nton and Adesina, 2009) and its indicative of anaerobic conditions. There

were no significant differences in the levels of physicochemical parameters compared to control. The levels of physicochemical measurements are within limits expected in natural environments within the region.

3.11 Climate and Metereology

The study area is highly influenced by the tropical wet and semi-hot equatorial climate with high solar radiation. Heavy precipitation, light winds and low atmospheric pressure are the major climatic characteristics of the study area. The climatic conditions of the study area were obtained from the Nigeria Institute of Meteorology (NIMET) Port Harcourt climatic synoptic station; closest meteorological station to location. The major climatic/meteorological elements examined are rainfall, relative humidity temperature, wind pattern, tides and sunshine hours. The mean monthly climatic data from Port Harcourt synoptic station facilitated the weather condition of the area (Figs. 7-10).

3.11.1 Rainfall

Rainfall is the quantity of rain that falls in a location over a period. This (Fig. 7) indicates that rainfall in the area is generally high and is experienced almost all year round with highest value of 355mm recorded in the month of July. Peak periods are generally experienced from June to September while least values were recorded from December to February. The total annual rainfall in the area is more than 2,203mm.

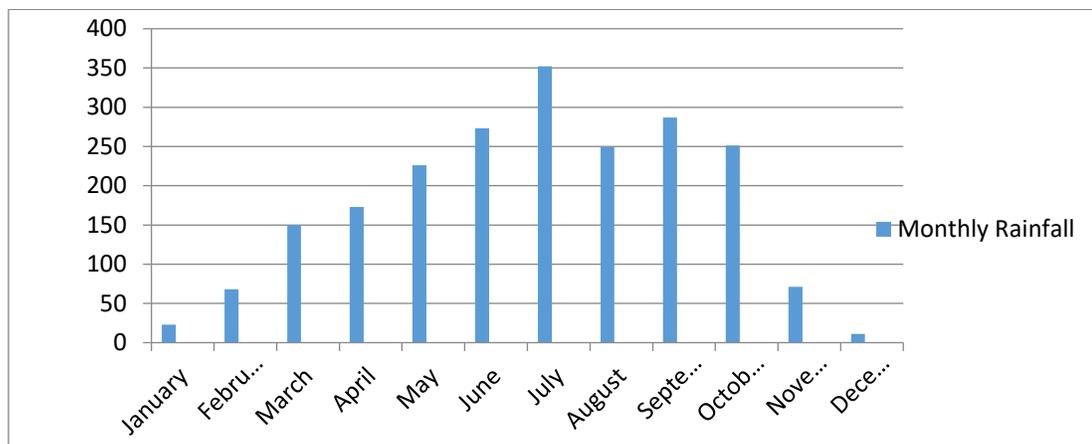


Fig. 7 Monthly rainfall pattern in the study area

3.11.2 Relative Humidity

Relative humidity is the ratio of the amount of water vapour in the air at a given temperature as compared to the maximum amount air can hold at the same temperature, expressed as a percentage. The highest relative humidity value recorded in the area is 87.0% at 10.00hrs, although higher values of up to 99% have been recorded within the climatic synoptic area in the rainy seasons. The recorded lowest value is 60.0% at 16.0hrs. Generally, relative humidity is higher during the morning hours and decreases gradually as the sun sets. Relative humidity as low as 21% during the drier periods of the harmattan winds in the months of November and December have also been recorded in the area. Relative humidity is high all the year round within the project area (Fig. 8).

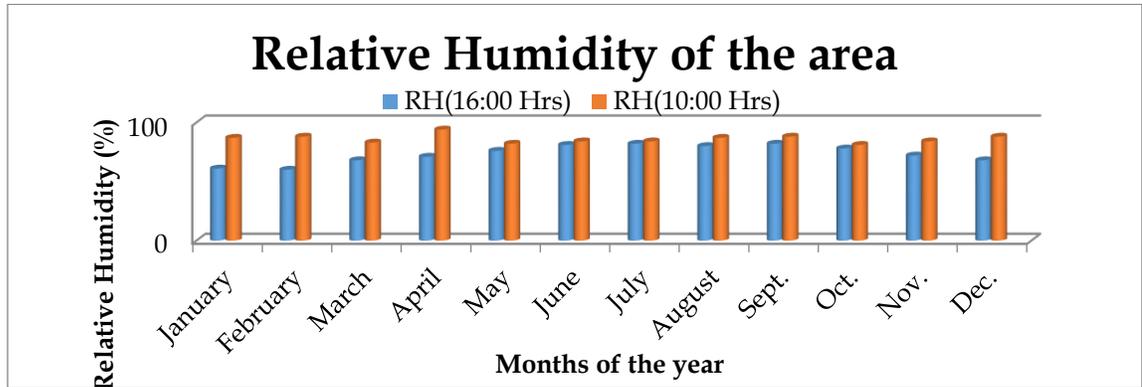


Fig. 8 Mean Monthly Relative Humidity Distribution

3.11.3 Air Temperature

Air Temperature is the degree of hotness or coldness of the air in given area or location. The synoptic area experiences moderately high incidence of solar radiation and long periods of sunshine. Climatic data (NIMET, 2025) (Fig. 9) showed that both maximum and minimum temperature values are moderately high with the lowest values occurring during the period of June to October. The maximum mean Air temperature values (31.350C - 31.960C) in the area are experienced in the months of January to May. Sunlight in the area also follows this pattern (Fig. 10).

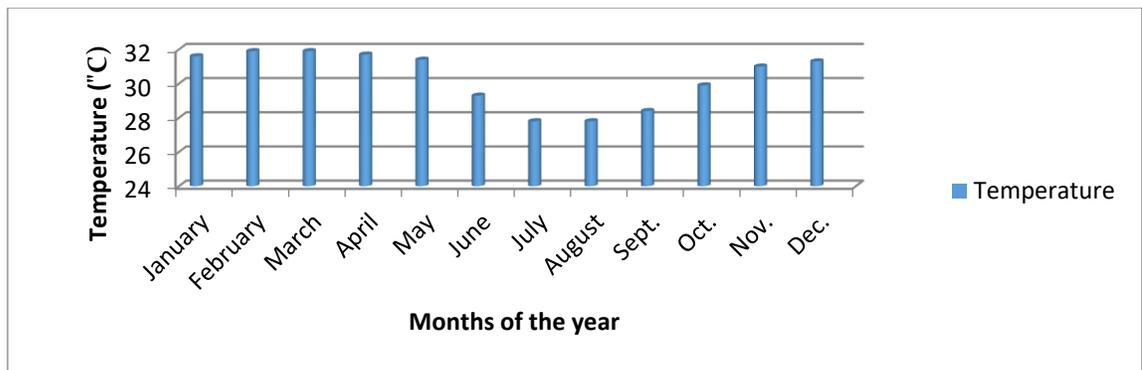


Fig. 9 Air temperature across the study area

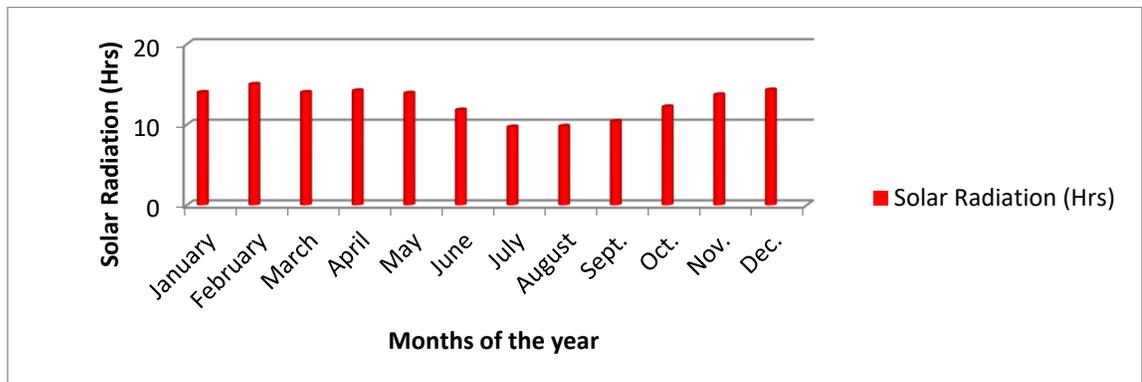


Fig. 10 Mean Monthly solar radiation pattern of the area

3.12 Longshore Current

Longshore currents affecting the project area follow a west-east current direction. Longshore currents attain speeds averaging 0.2 m/s. The coastline east of the area point trends almost west-east with the result that the south-westerly waves break obliquely with the open side to the east. The waves arriving along the east - west trending coastline is obliquely incident to the coast and hence produce a west-east longshore current. The major near-shore drift cells affecting the area consist of a west-east littoral cell of the eastern Niger delta. Sediment supply to the littoral drift is essentially by the Niger delta tributaries.

3.13 Waves Height in the Area

Wave heights ranged from 0.5 to over 2 m with periods ranging between 6 - 10 m along Brass beach. Wave conditions in the offshore waters gave highest wave heights (Hs) of 2.5 m in water depths of about 30 m. Waves are dominant from the southerly sectors. The months of April - June represent a period where waves over 2 m were measured. In August a significant fraction of waves exceeds 2 m in height. The wet season (May to October), on average, experiences larger waves in comparison to the dry season, with offshore wave height (Hs) generally greater than in the dry season.

3.14 Tides

The tide levels in project area ranged between 0.15 m and 1.57 m. The tides at the estuaries, proximal to the project area have a south-westerly component and are semi diurnal with two inequalities. The spring tidal range at Brass is about 1.6 m and significant surges are infrequent. The littoral (coastal) circulation system offshore the Brass estuary coastline is under the control of the prevailing wind systems, tides, waves and coastline orientation. The South-westerly tides produce ebb and flood tidal currents, which are in phase with the tidal cycle. Ebb currents due to their higher velocity and tidal time could result in the higher flushing of ocean waters from the tidal basin.

3.15 Sediment quality Assessment

Total Organic Carbon (TOC) ranged from 1.39% at sampled points compared to control of 1.37% (Table-3). There was significant difference between study locations and control. TOC levels varied widely but were relatively higher at the study location compared to control. Studies has shown (USEPA, 2002) USEPA recommended the following assessment categories for TOC (or organic pollution) in sediments: Low: $\leq 1\%$, Intermediate: 1 to 3%, High: $>3\%$. TOC values encountered were lower than 1% indicating that organic pollution is low in the sediments. Low organic carbon levels are usual in the Gulf of Guinea. The low TOC levels may be attributed to the nature of sediments. Nitrate and phosphate are major nutrients for algal growth and bacterial mineralization of organic matter in sediments. Nitrate ranged from 0.63mg/kg at sampled points compared to 0.70mg/kg at the control station. Phosphate ranged from 0.35mg/kg at sampled points compared to levels at the control of 0.21mg/kg. There was no significant difference in concentrations between study location and control. Previous work showed (Singh et al. 2014) availability of inorganic nutrients, particularly nitrogen and phosphorous, is often a primary control on crude oil hydrocarbon degradation in marine systems. The low levels of nutrients recorded may be explained by prevailing negative redox conditions of the sediments.

Table-3 Sediments properties of the study area (Ibrahim *et al.*, 2025)

Parameters	Sample mean	Sample SD	Control mean	Control SD	ANOVA	Significance
TOC (%)	1.39	0.69	1.37	0.42	0.61	Not Significance
NO ₃ mg/kg	0.63	0.30	0.70	0.20	0.70	Not Significance
PO ₄ mg/kg	0.35	0.16	0.21	0.07	0.34	Not Significance
NH ₄ mg/kg	0.29	0.14	0.33	0.10	0.72	Not Significance
Sand	Nil	Nil	Nil	Nil	Nil	-
Silt	42.27	6.46	37.83	28.73	0.00	Significance
clay	57.52	6.50	62.14	28.75	0.00	Significance

Dissolved oxygen measurement was compared at top and mid between the study area and control station. However, significant variation was observed between DO levels from bottom samples, where higher concentration was recorded at the study area (4mg/l) and Concentration at the control was (3mg/l). This indicates oxygen enrichment range brought about water current and wave action; enabling transfer of dissolved oxygen from surface to lower depth. Observed variations in pH and Dissolved Oxygen are attributed to natural variations associated with mixing, phytoplankton productivity, atmospheric inputs and other biochemical processes. Dissolved oxygen levels are considered harmful to marine biota if they fall below 2mg/l (U.S. Environmental Protection Agency, 2008). All measurements were considered normal for tropical marine waters.

3.16 Surface Water Microbiology

Microbiological characteristics of the sediments in the proposed seismic data acquisition project area was done (Table-3). The THB and TF were in the order of 10² cfu/ml with mean counts of 2.18 × 10²cfu/ml, 3.33 × 10²cfu/l and 2.10 × 10²cfu/ml, 1.12 × 10²cfu/ml in the study area and control respectively. The THB and TF microbial load is suggestive of the availability of utilizable organic substrates in the surface water. Similarly, the hydrocarbonoclastis were not identified in the seawater including the control stations. The absence of the hydrocarbon utilizing organisms corroborates with the non-detection of BTEX and PAH in the sediments. SRBs were not identified in the seawater samples across the study area and control and indicates the unlikelihood of biogenic souring during the operation phase of the project.

Table-3 Microbiological result of surface water in the study area

Parameters	Sample		Control		ANOVA	Significance
	Mean	Std	Mean	Std		
HUF (cfu/ml)	NIL	NIL	NIL	NIL	NIL	Non-significant
HUF (cfu/ml)	NIL	NIL	NIL	NIL	NIL	Non-significant
THB (cfu/ml) x10 ²	2.18	0.20	2.10	0.19	0.97	Non-significant
THF (cfu/ml) x10 ²	3.33	3.35	1.12	0.07	0.00	Significant
Faecal Coliform (cfu/ml)	0.18	0.47	0.22	0.67	0.12	Non-significant
SRB	NIL	NIL	NIL	NIL	NIL	Non-significant

CONCLUSION

In conclusion, the prevailing environmental condition of the study area is favorable for the hydrocarbon production in the study area with little or no harm to the ecosystem just as seismic data measurement has equally shown favorable structures for production activities. Moreso, the wind speed measured was just 0.4 - 1.4 m/sec for the gentle one, light breeze of (1.6 - 3.3 m/sec), and moderate breeze (5.5 - 7.9 m/sec) respectively and an average ocean current of 0.7-0.8 m/s all points to significant favorable environmental condition of the area. Hydrocarbon accumulation is concentrated along the N-W side of the profile based on the seismic profile of the area. Average water temperature ranged from 28.55°C at the top to 28.00°C at mid and bottom compared to control station of 28.67 °C. The pH is lower at the sample point than the control and this variation was not significant i.e., $P < 0.05$. Conductivity is 39581 μ S/cm at the top and it was lower than that of mid and bottom samples which recorded 41900 μ S/cm and 43177 μ S/cm. Biochemical oxygen demand ie average levels of BOD ranged from 0.72mg/l at the top, 1.00 at the mid to 0.00mg/l at bottom sediment. In a nutshell, the major climatic/meteorological elements examined ie rainfall, relative humidity temperature, wind pattern, tides, sunshine hours and other important environmental factors have all revealed a favorable project study area for hydrocarbon production, construction and fabrication of all Engineering platforms that will have little or no effect on the environment. It is also recommended that periodic measurements will be needed from the pre-commissioning to site abandonment phase of the job schedule.

CONFLICT INTEREST

The authors declare that there are no conflicts of interest associated with this research work.

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