

RESEARCH ARTICLE

ENVIRONMENTAL IMPACT ASSESSMENT OF OIL PRODUCING COMMUNITIES IN PART OF THE NIGER DELTA. A CASE STUDY OF IBENO, IKOT ABASI, ONNA AND ESIT-EKET LOCAL GOVERNMENT AREA IN AKWA IBOM STATE, NIGERIA

Thomas Akpan Harry, Ekemini John Peter, Nsidibe Akpan Udoduk

Department of Geology, Akwa Ibom State University P.M.B. 1167, Uyo, Akwa Ibom State, Nigeria
Corresponding Author Email: agbasi.okechukwu@gmail.com

This is an open access article distributed under the Creative Commons Attribution License CC BY 4.0, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

ARTICLE DETAILS

Article History:

Received 25 February 2022
Accepted 29 March 2022
Available online 13 April 2022

ABSTRACT

An Environmental Impact Assessment was initiated to monitor the distribution and effect of petroleum hydrocarbon pollutants on the quality of the surface water, groundwater, and sediments of Ibeno, Esit-Eket, Onna, and Ikot Abasi. Eighty-one (81) samples were randomly collected from surface water, boreholes, and soil for analyses based on the standard physiochemical parameters for comparison with the World Health Organization (WHO) standard. The variation in the average pH of water was not significant (6.5 to 8.0), well within the range for unpolluted streams. However, the total hydrocarbon content (THC) of the sediments was greater than 200 mg/kg, which is the limit, thus indicating heavy pollution by hydrocarbons. The pollution indices for the potential contaminants were also determined, in which the pollution index of surface water samples and borehole water sample is <1 indicating an unpolluted water body, while the pollution index of sediment samples was > 1, showing polluted sediments.

KEYWORDS

Conductivity; Petroleum pollution; Physiochemical parameter; Salinity

1. INTRODUCTION

The Niger Delta area, often known as the oil-producing states of Nigeria, is divided into nine states: Akwa Ibom State, Bayelsa State, Rivers State, Delta State, Edo State, Abia State, Imo State, and Ondo State. Wetlands and water bodies, as well as a dense mangrove forest and a network of streams and rivers that transverse the region, provide an aquatic grandeur, characterize the area. Mangrove forests are estimated to cover 5,000 to 8,580 km² of land in Nigeria (Nwilo and Badejo, 2007), and they continue to be important to the indigenous peoples of the country as well as the many organisms that live in these habitats.

Nigeria is the largest and most populous country in Africa, and it is situated in West Africa. With Cameroon in the east, the Republic of Niger in the north, Chad in the north-east, and Benin in the west, the country has a total size of 923,768 km² and an estimated 4.049 km of land borders. In the south, Nigeria's 853-kilometer-long coastline meets the Atlantic Ocean. The southern lowlands combine into the middle hills and plateaus, which are flanked to the south-west by mountains and to the north by plains. At Lokoja, the country's two major rivers will converge.

The Niger Delta, which is situated in the southernmost region of Nigeria and covers an area of around 70,000 km², is Africa's and the world's third largest river delta. In central Nigeria, the environment progressively transitions from a coastal belt of marshes to a continuous rainforest that combines with woodland and savannah grasslands. About 12% of the delta's land surface is covered by swamps, forests, and woodlands.

Nigeria is a multi-ethnic federation made up of 36 states and the federal capital area, which comprises Abuja, the nation's capital. There are around 250 ethno-linguistic groups in Nigeria, including the three leading groups,

but the Hausas in the north, the Igbos in the south-east, and the Yoruba in the south-west are the four dominant groups.

Nigeria was rich in natural resources such as natural gas, petroleum, tin, ore, coal, limestone, niobium, lead, zinc, timber, and huge fertile land prior to the discovery of oil in the 1950s. Agriculture was the economy's backbone, with agricultural products exported to more industrialized parts of the world. Agriculture has made way for petroleum development by 1971. As a result, between 1973 and 1981, the value of agricultural exports plummeted from about USD 1.5 billion to around USD 3 billion.

The Niger Delta has been a hotbed of oil exploration and extraction for decades. It has had terrible consequences for the region's ecosystem, as well as for the people who live there. As a result of oil contamination, the area is currently characterized by poisoned streams and rivers, forest damage, and biodiversity loss; in general, the area is an ecological wasteland. This has an impact on indigenous peoples' livelihoods, as they rely on ecosystem services for survival, resulting in greater poverty and population displacement.

While most countries confront natural dangers, Nigeria faces a slew of technology and human-caused threats, including oil spills, which have devastating short- and long-term consequences for the afflicted people. For example, a European country had ten oil spills in 40 years, but Nigeria had 9,343 spills in ten years. According to studies, at least 9–13 million barrels of oil have spilled in the Nigerian environment during the last five decades, similar to the 50 Exxon Valdez oil disasters of 1989. (260,000 barrels). This made the region one of the world's five most viciously petroleum-damaged landscapes. As a result, the ecology, arable lands, water supplies, and livelihood structures of Nigeria's immediate oil-producing communities have been impacted. Within the crude oil

Quick Response Code



Access this article online

Website:
www.contaminantsreviews.com

DOI:
10.26480/ecr.02.2022.49.56

producing environment, the influence further degenerates into a rise in poverty, crisis, and unrest. As a result, many agitation groups have formed to demand environmental justice and livelihood assistance systems.

To assess the environmental impact of oil exploration activities, to identify the impact of oil exploration activities on the environment, and to serve as a useful reference material for future studies.

1.1 Location, Geology and Accessibility of The Study Areas

The research area in Akwa Ibom State includes the local government areas of Ibeno, Onna, Ikot Abasi, and Esit-Eket. Let's start with a quick overview of the state of Akwa Ibom. The Qua Iboe River is the name of the state of Akwa Ibom in Nigeria. It is situated between latitudes 4°32'1 and 5°33'1 North and longitudes 7°25'1 and 8°25'1 East in the southern section of the country.

Cross River State borders the state on the east, Rivers State and Abia State on the west, and the Atlantic Ocean and the southernmost tip of Cross River State on the south. It has a total area of 8,412 km². From Oron in the east to Ikot Abasi in the west, the Atlantic shoreline reached 129 kilometers.

It also has a tropical climate with two distinct seasons: the dry season (November-March) and the wet season (April-October) (April-October). In August, the wet season is frequently interrupted by a brief dry spell. The study area covers more than 129 kilometers of Atlantic coastline in Akwa Ibom State. The location, which is located in a mangrove swamp forest, receives rain throughout the year, with the highest months being May and September.

The terrain of Akwa Ibom State is mostly low-lying plains and rivers, with no place reaching 175 meters above sea level. From sea level in Eket in the south to 150 meters in Obotme in the north, the ground rises steadily northward. More than 75 percent of the state is comprised of level to gently undulating sandy plains with few rivers. Seasonal lakes are found in shallow depressions and serve as a source of water for the sea.

Ibeno, Esit-Eket, Ikot Abasi, and Onna are located in southern Nigeria, specifically in the South-South region, and thus have tropical climate conditions governed by the movement of the Inter-Tropical Conveyance Zone (ITCZ) or Inter-Tropical Discontinuity Zone (ITDZ), which is the boundary between the South-Westerly (or Tropical Air Mass) and the North-Easterly trade wind. Tropical air masses prevail practically all year, with minimal seasonal variation in wind direction, due to the area's location in the Niger Delta (Olaniran, 1986).

It has a tropical monsoon climate, with bimodal peaks in rainfall between June and September/October. For the most of the year, the weather is hot and humid. The rainy season, on the other hand, begins in early March. The tropical marine air mass has a significant impact on the area's weather conditions. The dry season is therefore brief, lasting no more than three (3) months from December, when rain-bearing winds are occasionally replaced by harmattan winds. Even throughout the three dry months, there are three (3) short rains that are so predictable in their incidence and timing that they can be counted on every year.

Annual rainfall in Nigeria is highest towards the coast and falls as it approaches the country's northern border. Because to their proximity to the Atlantic Ocean, the riverine areas of Nigeria's southwest and southeast receive the most rainfall.

According to recent study, the process of evaporation draws water from the oceans into the atmosphere, which is influenced by elements such as air and sea temperatures, wind strength, and humidity (Derek and Oguntoyinbo, 1987). Between the months of May and October, the area receives more than 80% of its annual rainfall, with an average yearly total above 2500mm (Formecu, 1998). The Niger Delta receives between 1500mm and 3500mm of rain each year on average. The wettest months are December and January, with average rainfall of 20 to 75 mm, and the wettest months are June and July, with average rainfall of 300 to 700 mm (Leroux, 2001). Rainfall follows a bimodal pattern, with peaks in July and September. In this area, it is notable that rainfall during the wet season is often heavy. This encourages wet deposition of atmospheric pollutants, which also results in acid rain, with its attendant environmental concerns. Acid rain, in particular, is particularly heavy around Eket, Esit-Eket, Ibeno, Onna, and Uyo. This is due to oil drilling in the Ibeno and Eket sectors, as well as the associated gas flaring. Heavy thunder storms of the traditional variety are common in the area, which are frequently preceded by thick dark clouds. The region's rainfall pattern, which has been documented for

more than 50 years, is marked by double maxima in July and September, with the lowest values in December and February.

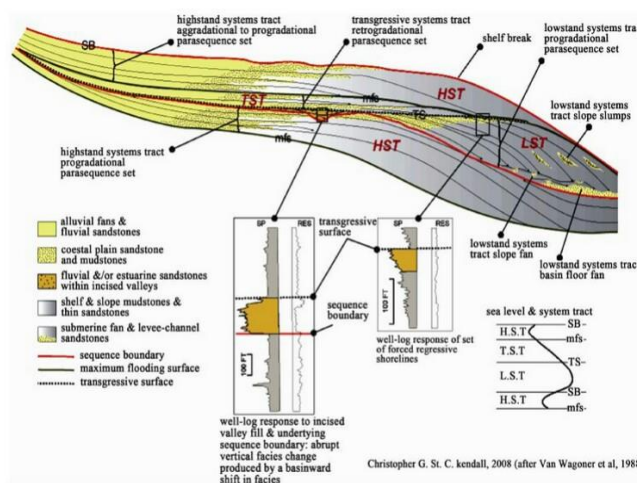


Figure 1: Showing Lithology of Niger Delta

Seasonally, the average surface wind speeds and directions change. Throughout the year, two main air masses alternate. The northeast winds prevail during the dry season, whereas the southwest winds prevail during the wet season (Folorunsho and Awosika, 1995). Early in the wet season, when early rains are torrential and accompanied by squalls, lightning, and thunder, the highest speed is recorded. Wind speeds were found to be lower at night than they were during the day.

The east and northeasterly winds make up 15 to 40% of the winds during the harmattan months (December to February). The average wind speed is usually between 1.5 and 2.5 m/s, rarely exceeding 2.8 m/s. During the wet season (February to October), the winds are southwesterly, while during the dry season (November to February), they are northeasterly (November to January). However, based on the local land winds, there are regional differences.

Humidity refers to the amount of water vapor in the atmosphere. The term "relative humidity" is commonly used to describe how humid the air is. The relative humidity values obtained in this location suggest a high level of relative humidity. This could be due to the area's proximity to the shore, the presence of cloud cover, and the effect of the area's dominant south-west trade winds (Oguntoyinbo, 1978).

Table 1: Oil spill data of Shell Petroleum Development Company (SPDC) from 1995 - 2005

Year	Number of Spills	Volume in Barrels (bbl.)
1995	235	31,000
1996	326	39,000
1997	326	39,000
1998	240	80,000
1999	248	50,000
2000	320	20,000
2001	330	30,000
2002	302	76,960
2003	262	19,980
2004	221	9,916
2005	236	8,317
Total	2,944	377,194

Ibeno, Onna, and Esit-current Eket's climate has fostered lush tropical rain forests. Secondary forests of mostly wild oil palms, woody shrubs, and diverse grasses in growth have nearly totally replaced the native vegetation. The state of Akwa Ibom is said to have the most oil palms per capita in Nigeria.

The Basement Complex and the Sedimentary Series are the two primary categories of bedrock geology found in Nigeria's outcropping rocks. The Basement Complex includes the Migmatite-Gneiss Complex, Schist Belts, Pan-African Granites, Younger Granite Complex, and Tertiary-Recent

Volcanic Rocks. Nigeria's sedimentary rocks were deposited in eleven (11) currently recognized basins and cover half of the country's surface area. All of the sites, excluding two in the far north (Sokoto and Chad), were established during the late Jurassic-early Cretaceous epoch and are linked to the opening of the Gulf of Guinea. The basins can be divided into two types tectonically: Marginal Sag Basins and Intra-Continental Basins. The Niger Delta region and Benin are included in the marginal sag basins (Dahomey). During the Aptian-Albian period, these basins were developed in response to the tensional regime that accompanied the entrance of the Equatorial Atlantic Ocean. The marginal sag structure is the result of sediment loading collapsing the margin on the oceanward side. All other basins in Nigeria are included in the Intra Continental Basin. Other than the Sokoto Basin, which is a representative interior Sag Basin, others were generated by distension resulting in grabens limited by normal faults or by localized tension caused by large-scale transcurrent faults. Basal continental facies are overlain by marine facies, which are eventually overlain by continental sediments in these basins' sedimentary fills.

During the formation of the Imo shale during the Paleocene-transgression and the subsequent seaward build-up of a delta complex in the Eocene, the Niger Delta Basin emerged at the tertiary level. Later, the principal lithofacies units were divided into three diachronous formations: Akata-marine, Agbada-paralic, and Benin continental-fluvial. On the delta's flanks, channels were cut and clay-filled from time to time. The principal progradational sequences associated with deltaic settings are made up of a number of repeating cycles, each of which is marked by an erosive surface, the shallowest facies, and then a deepening that leads to a compacted horizon. Delta progradation out onto the mud-prone shelf is generally caused by eustatic sea level fall and/or increasing sediment input.

The Agbada Formation has the greatest listric growth faults and associated structures, which constitute the dominant structural style in the Niger Delta Basin. They tend to die out in the Akata-Shales, which have been plastically deformed in response to the rising overburden of paralic sediments, as well as in the Benin formation over 3,000m. Simple rollovers, predominantly dip-closed, to rollovers dissected by faults, predominantly fault-closed, to collapsed crest structures, dip-closed but dissected by numerous synthesis and antithetic faults closely spaced down to basin faults on a semi-regional flank are among the structural styles found in the Niger Delta. In the basin, stratigraphic and combination traps play a supporting function (Owa, 2001).

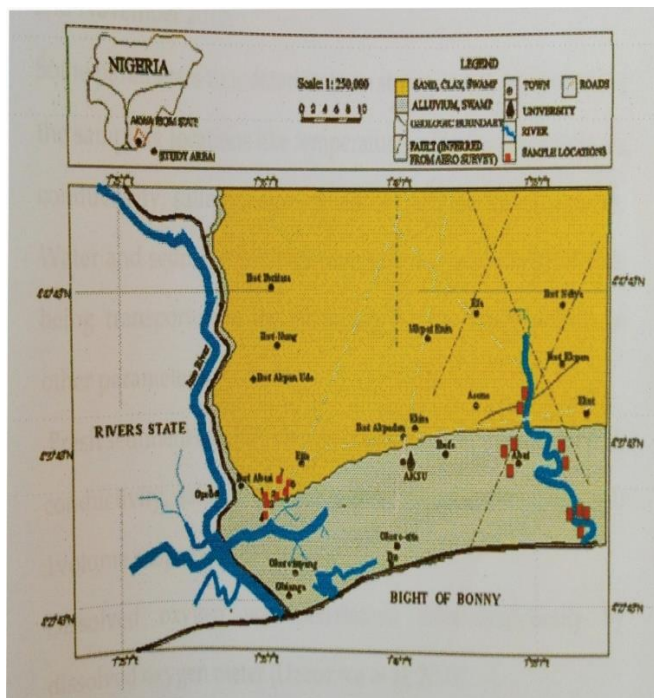


Figure 2: Showing locations of sample collection

The Imo-Kwa Ibo River Basin, a long northwest-southeast rectangular basin, contains the Ibeno, Esit-Eket, and Onna Local Government Areas. The Deltaic, Benin, Ogwashi-Asaba, and Ameki formations, in that sequence, underpin the basin, followed by the Imo Shales (Offodile, 1992).

The Benin and Ameki formations are the largest aquiferous units. The Imo shales encircle the Imo-Kwa Ibo Basin on the north, whereas the Benin

formation and Niger Delta alluvial deposits appear to be in hydrological contact (and hence provide combined aquiferous layers) on the south.

The research region is defined by flood plains and sandy ridge complexes separated by muddy swamps. The depth of the groundwater varies between 1.5 and 6.0 meters, and the natural near-surface soil is made up of relatively loose sand.

2. METHODOLOGY

This study involved desk study, field investigation, laboratory analyses, and result presentation to investigate the physiochemical parameters of surface water, groundwater, and sediments in the study areas. The desk study is centered on extensive reviews of many previous works and publications, whereas the field investigation involves sample collection and measurements of physiochemical properties of surface water, groundwater, and sediments using standardized and high-precision instruments and equipment for their studies. The measured values were compared with standards set for standard drinking water (WHO, 2006). The concluding segment of the study involves the discussion of results from laboratory analysis of samples, representation of quality state with plots, and the interpretation of plots to unveil the sources of contaminants in the surface, groundwater, and also the sediments.

The methods and techniques used are divided into the following sections:

1. Preliminary or desk study
2. Fieldwork/investigation and sampling
3. Laboratory analysis

2.1 Desk Study

This stage comprises of a general overview of the previous work carried out in the areas by individuals, corporate bodies, companies and institutions with regards to water quality, sediment quality, physical and chemical properties of surface and groundwater, the WHO's standards for quality drinking water as well as physiochemical parameters. It also comprises of the preparation of maps of the study areas to complement a successful work plan.

2.2 Field Investigation

This took place in two stages:

- (a) Pre-field Stage: This stage involved carrying out a reconnaissance survey to identify the available locations, highlighting the challenges and ways of overcoming them, and creating awareness before the actual field exercise.
- (b) Fieldwork: This stage involved the gathering of the necessary tools and equipment needed for a successful field exercise and the sampling of the selected surface water, groundwater, and sediments at different locations using GPS and in-situ measurements of the pH of the water.

2.3 Sample Collection

Sampling points were selected randomly across the study areas. These samples include borehole samples, surface water samples, and sediment samples. At each sampling point, water samples were collected in polyethylene bottles at a depth of 30 cm below the surface, while sediment samples were taken by the Van Veen grab sampler (Loring and Rantala, 1992).

The samplings were undertaken in the dry season months of October and November, 2015. Some parameters that deteriorate on storage were determined at the sampling locations, like temperature, pH, dissolved oxygen, conductivity, salinity, and redox potential, using a multicombi meter. Water and sediment samples were stored in iced coolers before being transported to the laboratory for the determination of other parameters.

Parameterization of Physiochemical Parameters pH stands for "potential hydrogen" and is measured on a scale comparable to that of temperature. This indicates that the pH ranges from 0 to 14, indicating how acidic or basic a body of water is on a logarithmic scale. The lower the number, the higher the acidity of the water. The greater the number, the more fundamental the concept is. The pH value of 7 is regarded as neutral.

Conductivity is a measurement of water's ability to carry electrical current. This ability is proportional to the ion concentration in the water.

Electrolytes are substances that dissolve into ions. The conductivity of water increases as the number of ions present increases. Similarly, the less ions in the water, the less conductive it becomes. Microsiemens or millisiemens per centimeter are the most common units of measurement.

Salinity is a significant influence to conductivity since it is the total concentration of all dissolved salts in water.

TDS (Total Dissolved Solids): TDS is made up of all ion particles smaller than 2 microns added together (0.0002cm). TDS is almost equal to saltiness in clean water, but it can include organic solutes (such as hydrocarbons and urea) in addition to salt ions in wastewater or contaminated areas. Milligrams per liter (mg/l) is the unit of measurement for total dissolved solids.

Dissolved Oxygen: The amount of free, non-compound oxygen contained in water or other liquids is referred to as dissolved oxygen. Too much or too little dissolved oxygen can harm aquatic life and degrade water quality. Milligrams per liter (mg/l) is the most common measurement.

Redox potential, also known as oxidation-reduction potential, is a measure of a chemical species' ability to acquire electrons and hence be reduced. Volts (V) or millivolts (mV) are used to quantify redox potential (mV).

Total Hydrocarbon Content (THC): THC is a term that describes the amount of hydrocarbon contaminants that have been measured in the environment.

2.4 Sample Preparation

Different sample preparation methods were employed in these analyses.

2.5 Apparatus for pH Determination

1. Buffer solution, pH 4 and 7
2. pH meter

stirring bar and magnetic stirrer

Procedure: The pH electrode and meter were calibrated using a two-point calibration with buffer solutions of pH 7 and 4.

2.6 Determination of Conductivity

Apparatus

1. Conductivity meter
2. Potassium chloride

Procedure: To calibrate the conductivity meter, a standard solution was made as follows: In a 1-liter volumetric flask, 5.1g of potassium chloride was weighed and diluted to one liter with pure water. The conductivity cell was suspended in the standard potassium chloride solution in a tiny beaker, about 1.5cm above the bottom of the beaker and out of touch with the beaker walls. The conductivity test was completed.

2.7 Determination of Total Dissolved Solids (TDS)

The water sample is filtered using a typical glass fiber filter, and the filtrate is evaporated to dryness in a weighted dish and dried at 180 degrees Celsius. The total dissolved solids are represented by the weight gain over the empty dish. apparatus:

1. Platinum, high-silica glass, stainless steel, and aluminum evaporating dishes
2. Millipore filtration unit or Buchner funnel and suction flask
3. Paper made of glass fiber
4. Bath water that is hot

For one (1) hour, heat an adequate size evaporating dish in an oven at 1800C, cool in a desiccator, and weigh. Pass a well-mixed sample through the filter and measure the volume. Any leftover solids in the measuring cylinder should be washed away with three 10mL amounts of laboratory water, then filtered. In a hot water bath, evaporate the filtrate to dryness in a pre-weighed evaporating dish. Cook for at least 1 hour at 1800 degrees Celsius in an oven, then cool in a desiccator and weigh.

2.8 Determination of Redox Potential

The potential difference between a platinum electrode and a reference electrode is used to determine the redox potential.

Apparatus:

1. A pH meter with a millivolt display is required.
2. Platinum electrode
3. A saturated calomel electrode.

Immerse the platinum and calomel electrodes in the sample held in a beaker during the procedure. After the reading is established, which should take no more than a few minutes, record the potential in millivolts (mV). Between measurements, rinse the electrodes with water.

2.9 Determination of Total Hydrocarbons (ASTM method D5369)

1. Filter 5g of sample after extracting it for some time with 20ml of dichloromethane. Due to its consistency, efficiency, and ability to interfere with BTEX RTW, C5-C9, dichloromethane (DCM) revealed to be the most suited solvent for this extraction over hexane, acetone, and toluene.
2. Make a standard solution with 500 mL dichloromethane and 0.5 mL diesel oil. This results in 1000 ppm THC.
3. At 400ml, measure the absorbance of the standard and sample extract.

3. RESULTS AND DISCUSSIONS

The variation of physiochemical parameters of the study area for surface samples is shown in table 1. For borehole samples, the parameters are represented in table 2 and for sediment samples in table 3, respectively.

In table 1, the conductivity variation of surface water gave values ranging from 7.37mS/cm, which is the lowest value, to 165.1mS/cm, which is the highest value compared to WHO's limits of 5.0mS/cm. Therefore, conductivity values greater than 5.0 mS/cm in surface water are said to be anomalous. In this particular case, the highest conductivity value is 165 mS/cm. For the pH variation of surface water, it gave values ranging from 5.2 as the lowest value to 6.38 as the highest value, compared to WHO's limits, which is 6.5-8.5. From these values, it can be said that the surface waters have a low pH and the tendency of the surface waters to be polluted is possible. The majority of aquatic creatures prefer a pH range of 6.5 to 9.0. From these values gotten from the analysis, the range of the pH values can be said to be influenced by acid rain precipitation.

The dissolved oxygen of the surface water from the analysis gave values of between 3.5 mg/L and 4.4 mg/L, compared to the WHO's limit of 5.0 mg/L in surface waters. From the given dissolved oxygen values, it indicates a low oxygenated environment. Dissolved oxygen comes from the atmosphere and from photosynthesis by aquatic plants and is depleted through chemical oxidation and respiration by aquatic animals and microorganisms.

The Total Dissolved Solids (TDS) of the studied surface water gave values ranging from 3.05g/L as the lowest value to 82.7g/L as the highest value compared to WHO's limits of 500g/L. This value can be attributed to the influence of surface runoff from urban areas. From the values, the surface waters have a low concentration of total dissolved solids.

The redox potential of the surface waters at the different sampling locations gave values of 55mV, 43mV, 52mV, 40mV, 69mV, and 62mV, which is indicative of an oxidizing environment, also 149mV and 106mV, which show a highly oxidizing environment, while 33mV, 32mV, and 29mV are indicative of an oxygen depleting environment.

Table 2 shows the results of the physiochemical parameters of the borehole sample. The pH gave values ranging from 4.32, the lowest value, showing a low level of pH which is acidic, to a range of 6.61, almost to the neutral point of a pH scale, compared to the WHO's limit, which is 6.5-8.5.

The conductivity of the borehole water gave values ranging from 2.26 mS/cm, showing low conductivity, to 75.3 mS/cm, showing high conductivity compared to WHO's standard, which is 5.0 mS/cm. The salinity values indicate non-saline borehole water while the total dissolved solids gave values between 1.226 and 37.5 compared to the WHO's limits, which is 500g/L.

Table 2: Showing different sampling locations, sample codes, sample types and their number

S/N	Sample ID	Locality	Sample Type	Sample No.
1	A1	Ibeno	Surface water	3
2	A2	Inua Eyen Ikot River	Surface water	3
3	A3	Ibeno Terminal	Surface water	3
4	A4	Esit-Eket	Surface water	4
5	A5	Akiah, Esit Eket	Surface water	2
6	A6	Ikot Akpatek, Onna	Surface water	3
7	A7	Mkpok River, Onna	Surface water	3
8	A8	Udoh River, Onna	Surface water	4
9	A9	Ikot Akpatek, Onna	Surface water	2
10	A10	Uta Ewa, Ikot Abasi	Surface water	3
11	A11	Udo Stream, Ikot Abasi	Surface water	3
12	W1	Ibeno	Borehole Water	3
13	W3	Mkpanak, Ibeno	Borehole Water	2
14	W4	Ikot- Udota, Esit-Eket	Borehole Water	3
15	W5	Ikot Akpatek, Onna	Borehole Water	3
16	W6	Ikot Abasi	Borehole Water	4
17	W7	Ikot Abasi	Borehole Water	4
18	W8	Ikot Abasi	Borehole Water	2
19	B1	Ibeno	Sediment	4
20	B12	Inua Eyen Ikot	Sediment	3
21	B2	Ibeno	Sediment	3
22	L4	Ibeno Terminal	Sediment	4
23	L8	Esit-Eket	Sediment	4
24	L10	Ikot Akpatek, Onna	Sediment	3
25	L12	Mkpok	Sediment	2

The dissolved solids gave values of 3.52 mg/L, showing that the dissolved oxygen is depleting gradually to values of 3.64 to 4.45 compared to WHO's limits of 5.0 mg/L. The Redox Potential gave values of 51,98,76,153,25,105, and 64 at different sampling locations, showing an oxygenated environment.

For Table 3, which shows the results of the sediment analysis, the pH value ranged from 4.38 to 6.29 compared to the WHO's limit, which is 6.5-8.5. The redox potential of the sediments gave values of 49 mV to 150 mV at

different sampling locations. The values are indicative of an oxygenated environment. The Total Hydrocarbon Content gave values of 0.5-379.5-484.6 mg/kg compared to the WHO's limit, which ranges from 200 mg/kg to 1200 mg/kg. From the values, it shows that the sediments are polluted as a result of oil pollution in the area. From the interpretation of the results, it is clear that the values gotten from the surface waters show that the environment is not intensely polluted, which can be said also for the borehole samples that were analyzed.

Table 3: Physiochemical parameters of surface water samples

WHO's Limit	6.5- 8.5	5.0 m/cm		500 g/L	5.0 mg/L	
Sample	pH	Conductivity(μ S/cm)	Salinity (%)	TDS(g/L)	D.O(mg/L)	Redox Pot. (mV)
A1	5.83	7.37	0.4	3.71	3.93	55
A2	6.27	7.66 mS/cm	0.46	3.05	4.32	43
A3	5.94	11.45	0	5.91 mg/L	4.5	149
A4	6.38	10.33 mS/cm	0.56	5.18	4.31	33
A5	6.26	165.1	0.01	82.7 mg/L	4.26	69
A6	6.29	5.29 mS/cm	0.28	2.68	4.02	62
A7	5.2	10.98	0	5.41mg/L	4.44	106
A8	5.82	10.42 mS/cm	0.57	5.22	4.13	29
A9	6.36	45.3	0	22.6 mg/L	4.34	40
A10	6.06	20.5	0	10.37 mg/L	4.01	32
A11	5.8	71.1	0	35.6	4.5	52

Table 4: Physiochemical parameters of groundwater samples						
WHO's Limit	6.5- 8.5	5.0 m/cm		500 g/L	5.0 mg/L	
Sample ID	pH	Conductivity (µS/cm)	Salinity (%)	TDS (g/L)	D.O (mg/L)	Redox Pot. (mV)
W1	6.13	36.24	0	18.11	4.4	51
W3	5.34	8.7	0	4.33	4.45	98
W4	5.83	2.46 mS/cm	0.12	1.226	3.64	76
W5	4.32	42.9	0	21.2	4.27	153
W6	6.61	10.1	0	5.04	4.09	25
W7	5.32	75.3	0	37.5	3.52	105
W8	6.3	8.57	0	4.26	4.43	64

Table 5: Results of sedimentary analysis			
WHO's Limit	6.5-8.5		200mg/kg - 1000
Sample ID	pH	Redox Pot. (mV)	THC (mg/kg)
B1	5.09	112	99.69
B12	5.89	64	484.6
B2	5.61	88	<0.5
L4 (QIT)	5.52	79	<0.5
L8(Esit-Eket)	5.23	105	<0.5
L10	4.38	150	379.5
L12	6.29	54	299.3
L14	5.21	49	486.9
L16	5.75	115	99.59

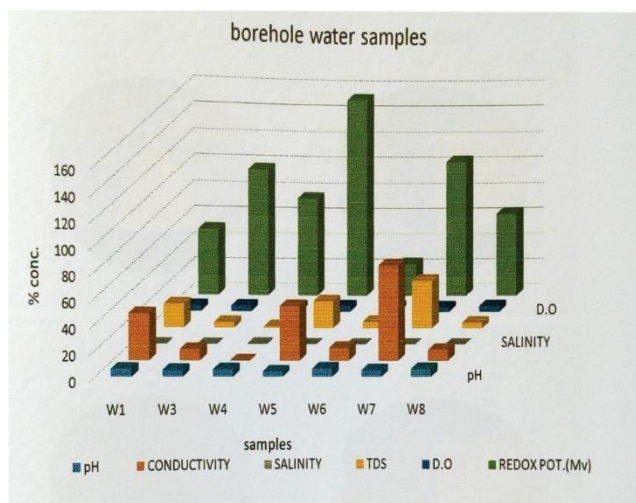


Figure 3: Bar chart representation of physiochemical parameter values of borehole water sample

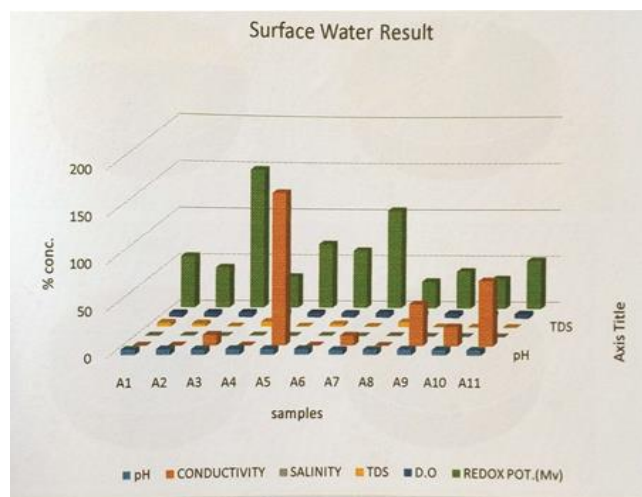


Figure 5: Bar chart representation of physiochemical parameters of surface water sample

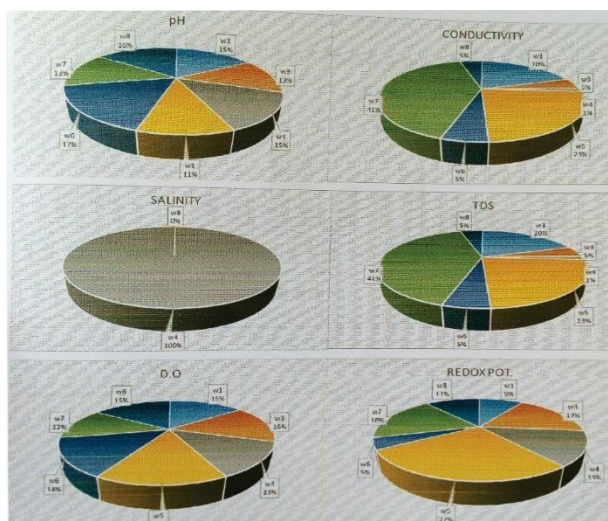


Figure 4: Pie chart representation of physiochemical parameters of groundwater sample

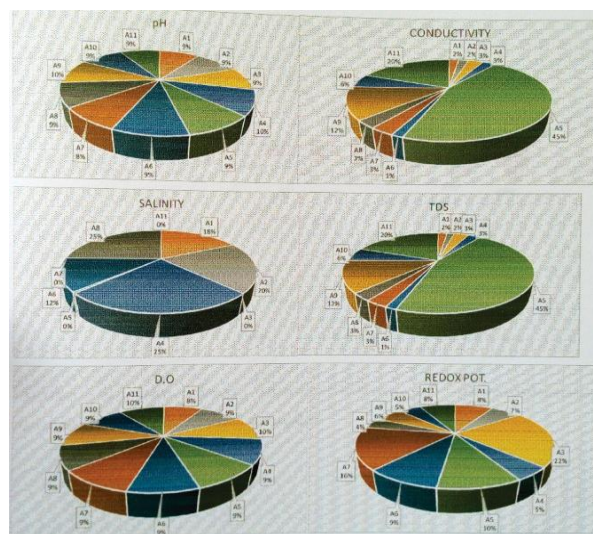


Figure 6: Pie chart representation of physiochemical parameters of surface water samples

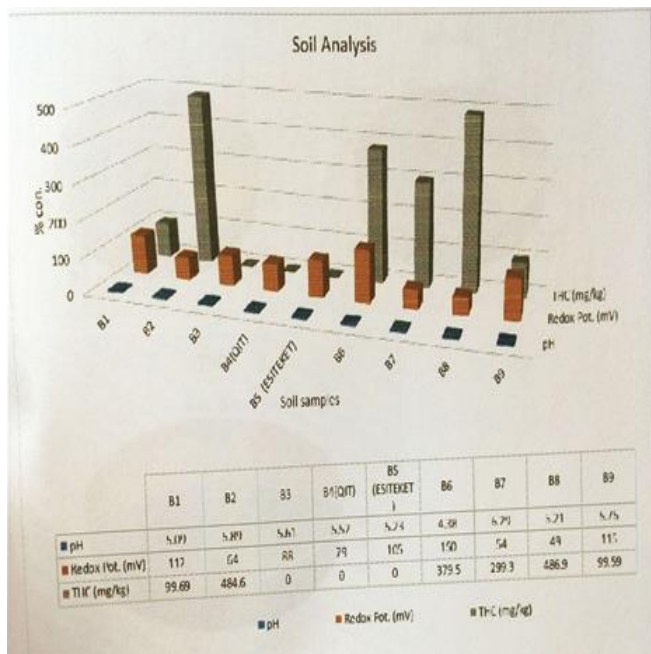


Figure 7: Bar chart representation of physiochemical parameters of sediment samples

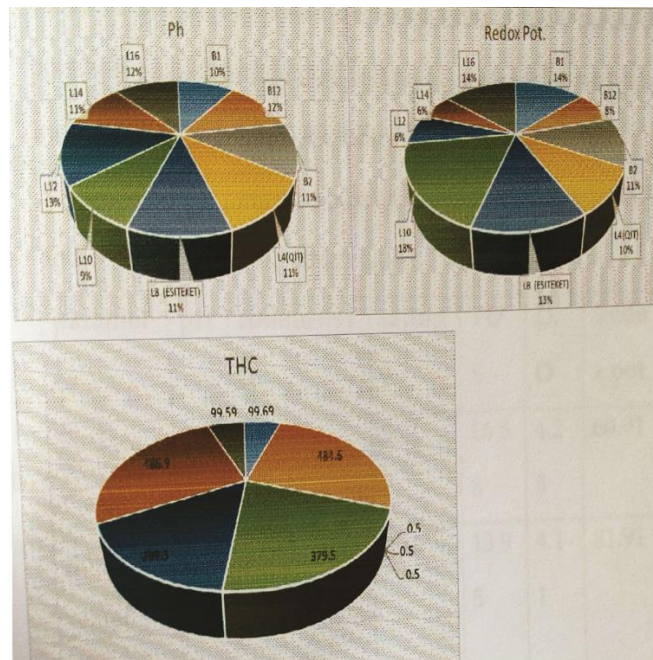


Figure 8: Results of Sediments analysis represented in pie chart

Table 6: Showing the mean variation of the physiochemical parameters of the samples at different locations							
Parameter	pH	Conductivity	Salinity	TDS	DO	Redox Pot.	THC
Surface water	6.0	33.23	0.21	16.58	4.25	60.91	
Borehole water	5.7	21.67	0.21	13.95	4.11	81.91	
Sediment	5.44				90.7	90.7	205.7

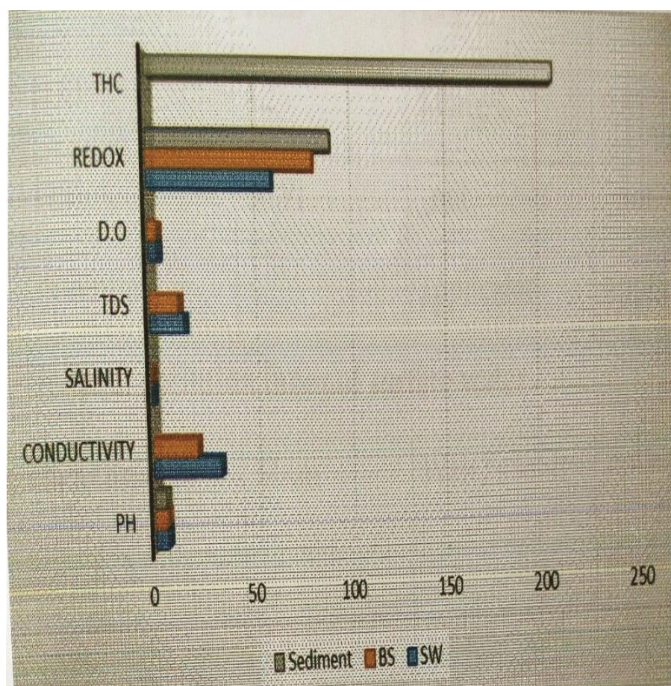


Figure 9: Mean variation of physiochemical parameters of surface water, borehole water and sediments samples

Table 7: Pollution index of surface water sample			
Parameter	Mean	WHO's Limit	Pollution Index
pH	6.02	6.5-8.5	0.92
Conductivity	33.23	5.0	6.646
Salinity	0.21	Not Applicable	Not Applicable
TDS	16.58	500g/L	0.0332
D.O	4.25	5.0mg/L	0.85
Redox Potential	60.91	Not Applicable	Not Applicable

Table 8: Pollution index of borehole water sample			
Parameter	Mean	WHO's Limit	Pollution Index
pH	5.7	6.5-8.5	0.87
Conductivity	21.67	5.0	4.33
Salinity	0.12	Not Applicable	Not Applicable
TDS	13.95	500	0.028
D.O	4.11	5.0	0.822
Redox Potential	81.91	Not Applicable	Not Applicable

Based on the physiochemical parameters of the surface water, borehole water sample, and sediment sample, the pollution index was determined. But first, the mean of the physiochemical parameters at different locations was calculated as shown in the table below. Table 6 depicts the mean variation of the samples' physiochemical parameters at various locations.

From the mean values above, the pollution index of the different samples was determined. The table below shows the pollution index of surface water.

Based on the physiochemical parameters of the surface water, the pollution index was determined, which gave a value of 0.92, which is less than the value for an unpolluted water body. Also, the pollution index of borehole water was determined, which gave a value of 0.87, which is less than the value for an unpolluted water body. However, the lower pollutant index for the wet season could be attributed to dilution from the surface runoff. Meanwhile, the pollution index of the sediments gave a value of 1.03, which is greater than the value of 1, which is the value for a polluted surface. From these results, the total hydrocarbon content is more abundant in the sediments than in the surface water and the borehole water sample because the sediments have organic matter and fine-grained particles and have been reported to show high affinity for petroleum absorption.

4. CONCLUSION

In the water and sediments of Ibena, Ikot Abasi, Esit-Eket, and Onna in South Eastern Nigeria, the variation of physiochemical parameters such as pH, dissolved oxygen, conductivity, salinity, redox potential, total hydrocarbons, and exchangeable cations was explored. The significance of

this inquiry is that these local governments are located inside the Niger Delta's petroleum region, which has been subjected to extensive petroleum exploitation for many years as a result of oil bunkering near the Atlantic Ocean. The pH change was not substantial based on the physiochemical parameters analyzed, and it was within the WHO guideline of 6.5 to 8.0 for unpolluted streams and rivers. The total hydrocarbon content (THC) of the sediments was more than 200 mg/kg, which is the limit specified for a badly polluted area with petroleum. The pollution index of the surface water was calculated using the physiochemical parameters of the water and yielded a value less than 1 for an unpolluted surface water body, but a pollution index of 1.34 for the sediments, which may be attributable to petroleum pollution.

The dissolved oxygen fluctuation was not substantial, but it was higher above the WHO standard of 5.0 mg/L for surface waters, indicating a highly oxidized environment. The sediments at various places might be classified as substantially polluted based on their average total hydrocarbon content.

In addition, this project gives objective quantitative and qualitative data for creating an appropriate remediation effort. The findings of this study indicate that bioremediation is the best option for long-term environmental remediation.

REFERENCES

- Alakpodia, I. J. 2000. Soil Characteristics under Gas Flares in Niger Delta, Southern Nigeria. *Geo- studies forum*, 1-9.
- Amanze-Mwachukwu, C. 2007. Oil Pipeline sabotage in Nigeria, 112.
- Awodola, A. M. 1997. Drought and Desertification in Nigeria, 112-115.
- Azaiki, S. 2007. Oil, Gas and Life in Nigeria. Y-books publishers, Lagos, Nigeria.
- Baumol, W. J. and Oates, W. G. 1988. *The Theory of environmental policy* (second edition). Cambridge University press.
- Coase, R. H. 1960. The problem of social cost. *Journal of Law and Economics*, page 1-40.
- Collier, P. and Hoeffler, A. 2002. Greed and Grievances in Civil War. *Oxford economic paper*, 563 - 595.
- Derek H. and Julius O. 1987. *Climatology of West Africa*. Rowan and little field publishers.
- Elvidge, C.D. 2009. A fifteen-year record of global natural gas flaring derived from satellite data, 595 - 622.
- Folorunsho, R. and Awosika L.F. 1995. Meteorologically induced changes along the Nigerian coastal zone and implications for integrated coastal management, 804-811.
- Formecu, A. 1998. *The Assessment of Vegetation in Nigeria*, 95.
- Ibaba, S. I. 2005. *Understanding the Niger Delta crises*, Port Harcourt. Amethyst and colleagues' publishers.
- Marcel, L. 2001. *The Meteorology and climate of tropical region*. 66, 221-231.
- Meade, J. 1973. *The theory of economic externalities*. Brill archives.
- Naanen B. 1995. Oil Producing minorities and the restricting of Nigerian federation. The case of Ogoni people. *Journal of common wealth and comparative politics*. 33, 46-78.
- Ndiyo, N.A. 2008. *Poverty to sustainable development of a community-based approach*. University of Calabar printing press.
- Ntuekpo, D. S. 1996. *Spillage: Bene of Petroleum ultimate water technology and environment*. Mayer publishers, 222.
- Nwilo, P. and Badejo O.T. 2007. *Impacts and management of Oil Spill Pollution along the Nigerian Coastal Areas*.
- Offidile, M. E. 1992. An approach to groundwater study and development in Nigeria, 36-39.
- Ogbodo, H. 1992. *Oil, environment and resource conflicts in Nigeria*. All green publishers, 305.
- Okonta, I. 2001. *Where vultures feast: 40 years of shell in the Niger Delta*. Kraft Books Limited, Ibadan.
- Olaniran, O. J. 1986. The Diurnal variation of light, moderate and heavy rainfall at Ilorin, Nigeria. 41, 251-257.
- Olabaniyi, S. B. 2007. Comparative assessment of rainwater and groundwater quality in an oil producing area of Nigeria: environmental and health implications. *Journal of Environmental Health research*, 6, 111-118.
- Onuogha, P. 2007. Sea food contaminated by oil spillage, 12, 21-22.
- WHO. 2006. *Guidelines and standard for drinking water*. Third edition, WHO, Geneva.
- Tyonongo, A. M. 2008. Economic implications of environmental degradation on the society. *International journal of Economics and Development issues*, 33-38.
- Uzoukwu, I. 2005. *Physiochemical profile study of a portion of the Ulasi*.

