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Assessment of Hydrocarbon and Heavy Metal Contamination in Selected Coastal Communities of Akwa Ibom State, Nigeria

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***Abstract-** Environmental contamination by hydrocarbons and heavy metals from petroleum exploration remains a significant ecological concern in Niger Delta region of Nigeria. This study evaluated the physicochemical characteristics, hydrocarbon levels, and heavy metal concentrations of surface water, borehole water, soil, and sediment samples from Mbo, Udung Uko, Ibeno, and Oron in Akwa Ibom State. Standard APHA and EPA procedures were employed for laboratory analysis, and results were compared with WHO (2017) and NSDWQ (2015) limits. The results revealed high TPH (up to 150.962 ug/L) and THC (175.045 mg/L) in Ibeno and Oron waters, indicating severe petroleum contamination. Heavy metals such as Fe (11.528 mg/L), Pb (0.099 mg/L) and Cd (0.028 mgL) exceeded WHO limits, while borehole waters remained largely within standards. Soil and sediment samples also recorded elevated Fe, Zn, and Mn concentrations, confirming prolonged hydrocarbon influence. These findings suggest that petroleum activities significantly deteriorate water and soil quality in the study area. Continuous monitoring and remediation measures are recommended to mitigate environmental and public health risks.*

***Keywords:** Environmental pollution, Heavy metals, Hydrocarbon contamination, Water quality, Akwa Ibom State, Niger Delta*

I. INTRODUCTION

As Akwa Ibom State borders the Atlantic Ocean, the coastal area of the state are highly vulnerable to climate change related hazards (Udoh, 2015). Assessing and monitoring the coastal and marine changes makes provision for information relevant to managing and planning the natural environments and human infrastructures in an area (Essien et.al, 2020). Coastal shorelines worldwide are changing rapidly as a result of natural physical processes and human activities. Natural factors such as sediment supply, wave energy, and sea level are the primary causes of coastal changes, whereas human activities are catalysts causing disequilibrium conditions that accelerate changes. Coastline defined as the line of contact between land and the water body, is one of the most important linear features on the earth's surface, which has a dynamic nature (Olufemi et.al, 2017). The Southern part of Akwa Ibom State as shown in figure 1 comprises of Ikot Abasi, Eastern Obolo, Mkpat Enin, Onna, Nsit Ubium, Eket, Esit Eket, Ibeno, Mbo, Urue Offong Oruko, Udung Uko, Okobo and Oron LGAs, and has abundant mineral resources including crude oil and related minerals (Abraham et.al, 2021).

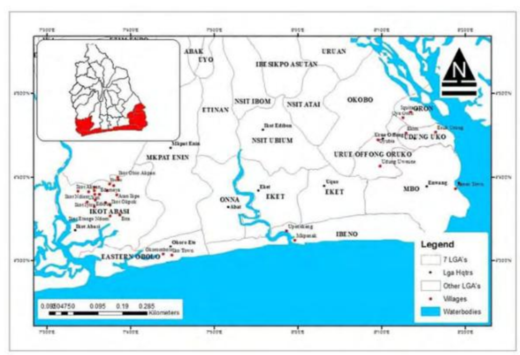

Figure1: Map showing coastal areas of Akwa Ibom State (Abraham et.al, 2021)

Hazard was modeled in the study by sources of petroleum oil spill moderated by surface characteristics, while data on crop suitability, socio-economy, environmental sensitivity, accessibility, and settlement development, were used to model vulnerability. The resulting risk layer as shown in

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figure 2 was classed into four Risk zones of very high, high moderate and marginal risk (Udoh and Ekanem, 2011)

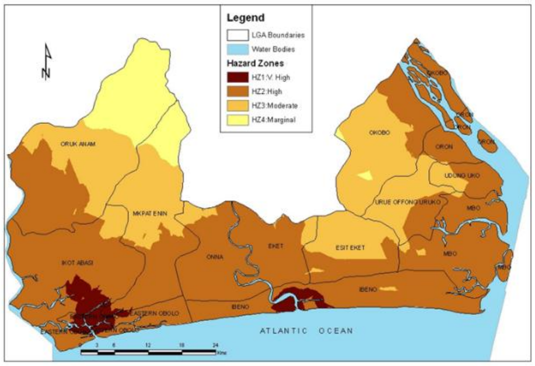

Figure 2: Hazard Map (Udoh and Ekanem, 2011)

Water, used in many ways from drinking to industrial and agricultural purposes, is a natural resource which is considered as a superb solvent and a critical component that make the processes of life possible (Mitiku, 2020). The quality of global water has rapidly declined for decades due to the impact of both natural and anthropogenic factors (Reddy et.al, 2024). Water is regarded as polluted when there is change in its quality or composition, either directly or indirectly, as a result of both natural and human activities, such that it becomes unsuitable for domestic uses, agricultural, fisheries or any other purposes for which it would otherwise be quite suitable in its normal or uncontaminated state (Gambo et.al, 2018). Major sources of water pollution are discharge of domestic and agriculture wastes, population growth, excessive use of pesticides and fertilizers and urbanization. Many diseases are spreading through polluted water and affecting human health (Mote et.al, 2023; Kılıç, 2021). Problems encountered by polluted water include typhoid, cholera, bacillary dysentery, hepatitis, amoebic dysentery, skin irritation, schistosomiasis, respiratory problems, gastrointestinal disorder, diarrhoea, stomatitis, tremor, hemoglobinuria, ataxia, pneumonia, depression, liver cirrhosis, hair loss, renal failure, Parkinson's disease, Alzheimer, and neural disorder dental or skeletal fluorosis, methemoglobinemia, neurological disorder, cardiovascular disease, cancer, muscle paralysis, pneumonia, fetal malnutrition, leukemia, urticaria, anaphylaxis, bronchospasm, hemolyticanemia, thrombocytopemia, acute interstitial nephritis, serum sickness, StevensJohnson syndrome, toxic epidermal necrolysis, optic neuropathy, retinal detachment and brain abscess are some diseases caused by contaminated groundwater (Bansal, 2020; Shultana and Khan, 2022)

Numerous metals, in particular Ni, Cu, Zn, and Cd, are responsible for heavy metal pollution of the soil. It has been stated that some heavy metals, such as Mg, Ca, Zn and Fe, are important to human health, and daily dietary and pharmaceutical allowances have been suggested. Others, however, including Pb, Cd, As, and methylation forms of mercury, have been reported to have no recognised biological significance in human physiology and biochemistry and to be dangerous even at extremely low quantities (Sharma, 2015; Kithiia, 2012).

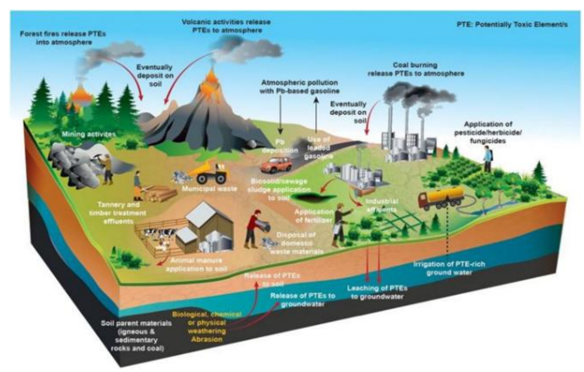

Figure 3: Potentially toxic element (PTE) sources in soil ecosystems (Sahdev and Kuldeep, 2024)

Soil pollution refers to anything that causes contamination of soil and degrades the soil quality. The soil contamination can occur due to the presence of chemicals such as pesticides, herbicides, ammonia, petroleum hydrocarbons, lead, nitrate, mercury, naphthalene, etc in an excess amount (Basha, 2023; Suarez, 2024)). Soil toxicity can have a range of negative effects on human health, including carcinogenic effects, neurological effects, and respiratory effects. Carcinogenic effects can occur due to exposure to toxic substances in soil, such as PAHs and PCBs, which have been linked to an increased risk of cancer. Neurological effects, such as learning and memory impairments, can occur due to exposure to heavy metals, such as lead and mercury, which can cross the blood-brain barrier and cause damage to the nervous system. Respiratory effects can occur due to the inhalation of toxic particles in soil, such as asbestos, which can cause lung cancer and mesothelioma (Sharma, 2015). Soil contaminants could be petroleum hydrocarbons (PHCs) derived from crude oil or refined petroleum products. The hydrocarbon components present in crude oil are parafins (Methane, Ethane, Octane), Naphthenes (Benzene, Toluene, Xylene), and PAH (Naphthalene, Anthracene, Benzopyene). Soil total petroleum hydrocarbon (TPH) includes gasoline, diesel, heavy oil, and lubricating oil. PHCs may destroy the aesthetic by inducing offensive odour, taste or appearance in environmental media. Many of the petroleum hydrocarbon pollutants are carcinogenic, mutagenic, immunotoxic and neurotoxic (Oduok and Babalola, 2024).

Health effect of heavy metal is summarized by Kumari and Paul, 2018:

Lead: Cognitive impairment in children, peripheral neuropathy in adults, developmental delay.
Copper: Headache, nausea, vomiting, diarrhoea and kidney malfunctioning.
Zinc: Vomiting, diarrhoea, liver and kidney damage.
Nickel: Neurotoxin, genotoxic and carcinogenic agent Ni-dermatitis.
Cadmium: Kidney and liver damage, renal dysfunction, gastrointestinal damage.
Chromium: Gastrointestinal, hepatic, renal, neuronal damage.

Sedimentation is a process whereby soil particles are eroded and transported by flowing water or other transporting media and deposited as layers of solid particles in water bodies such as reservoirs and rivers (Tundu et.al, 2018). Sediments include soil, sand and mineral particles washed into the aquatic environment by storms and flood waters (Rao, 2005). The results showed that the open dumpsites have a significant impact on the groundwater with the most significant impact on GW1 and surface water within its vicinity. It is also revealed that proximity of water sources to landfill sites has significant effect on level of its pollution (Africa, et al. 2020). Sediments are the sink for heavy metals in aquatic environments. Cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), and zinc (Zn) concentrations in 5cm sediments was studied (MarSojka and Jaskuła, 2022).

Environmental Impact Assessment (EIA) as enshrined in EIA Act 1992 is an essential tool used for decision making in a developmental projects as well as a systematic process to identify, predict and evaluate the environmental effects of the proposed actions and projects; the process is applied prior to major decisions and commitments being made (Ibrahim et.al, 2020). This study employs environmental impact assessment techniques to quantitatively assess the presence of heavy metals and hydrocarbon contamination in the water, soil and sediment in the selected coastal local government areas of Akwa Ibom State.

II. MATERIALS AND METHODS

2.1 Study Area

Mbo, Udung Uko, Ibeno, and Oron are low-lying coastal LGAs between 40°30’N - 4°30’N, 7°50’E - 8°15’E with mangrove swamps, heavy rainfall (~ 2500 - 3000 mm yr-1), and active oil operations.

2.2 Methods Used for Laboratory Analysis

2.2.1 Sample Collection and Preservation

Water, soil, and sediment samples were collected from various locations (Mbo, Udung Uko, Ibeno, and Oron) using sterile, acid-washed polyethylene containers. Surface water samples were collected directly from open water bodies at about 30 cm below the surface to avoid surface debris. Borehole water samples were collected after flushing for about 5 minutes to ensure representative sampling. Soil and sediment samples were obtained using stainless-steel augers or grab samplers, air-dried, sieved (<2 mm), and stored in clean polyethylene bags.

All samples were labelled, preserved in ice chests at 4°C, and transported to the Ebic Integrated Services Laboratory (EISL) for analysis within 24 hours of collection, following APHA (2017) preservation protocols.

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2.2.2 Physicochemical Analysis

2.2.2.1 pH Determination (APHA 4500-H^+ B)

The pH of water, soil, and sediment extracts was measured using a calibrated digital pH meter (Hanna Instruments HI 2211) standardized with buffer solutions of pH 4.0, 7.0, and 10.0. For soil/sediment, samples were prepared as 1:2.5 soil-to-water suspensions, mixed thoroughly, and allowed to stand before measurement.

2.2.2.2 Electrical Conductivity (EC) — APHA 2510B

EC was determined using a conductivity meter (HACH HQ40d). The probe was rinsed and immersed in the sample, and readings were recorded in µS/cm at 25°C. EC values provide a direct indication of ionic strength and salinity of the water.

2.2.2.3 Total Dissolved Solids (TDS) — APHA 2540C

A known volume of water was evaporated in a pre-weighed dish at 180°C to constant weight. The TDS was calculated using equation (1):

$$\text{TDS (mg/L)} = \frac{(W_2 - W_1)\ x\ 1000}{V} \qquad (1)$$

Where:

W_1 = weight of dish before drying,
W_2 = weight after drying,
V = volume of sample (mL).

This parameter reflects the total ionic load of the water.

2.2.2.4 Biochemical Oxygen Demand (BOD) — APHA 5210B

The BOD_5 test measured oxygen depletion during 5-day incubation at 20°C. Samples were incubated in BOD bottles filled completely to prevent air contact. Dissolved oxygen (DO) was determined at the start and after 5 days using the DO meter and values calculated using equation (2).

$$\text{BOD5 (mg/L)} = \text{DOi} - \text{DOf} \qquad (2)$$

where

DOi = initial dissolved oxygen,
DOf = final dissolved oxygen after incubation.

2.2.2.5 Chemical Oxygen Demand (COD) — APHA 5220D

COD was determined by closed reflux colorimetric method.. Samples were digested with potassium dichromate (K2Cr2O7) in strong acid (H_2SO_4) with silver sulfate catalyst at 150°C for 2 hours. The oxidizable matter reduced Cr^{6+} to Cr^{3+}, and the decrease in dichromate was measured spectrophotometrically at 600 nm. Results were expressed as mg O_2/L.

2.2.2.6 Total Hardness — APHA 2340C

Hardness was determined by EDTA titrimetric method.

A measured aliquot of water sample was buffered to pH 10 and titrated with 0.01 M EDTA using Eriochrome Black T indicator until the color changed from wine-red to blue. Results were expressed in mg/L $CaCO_3$.

2.2.2.7 Alkalinity and Acidity — APHA 2320B & 2310B

Alkalinity: Titration with 0.02 N H_2SO_4 using phenolphthalein and methyl orange indicators to determine bicarbonate and carbonate alkalinity.

Acidity: Titration with 0.02 N NaOH using methyl orange indicator to determine mineral acidity.

2.2.3. Heavy Metal Determination (APHA 3111B / EPA 7000B Series)

2.2.3.1 Sample Preparation

Water samples were acidified with nitric acid (HNO_3, 1%) to prevent metal precipitation. For soil and sediment, samples were digested with aqua regia ($HCl:HNO_3$, 3:1) on a hot plate at 95°C until near dryness, filtered, and diluted to 50 mL with deionized water.

2.2.3.2 Instrumental Analysis

Heavy metals — Fe, Zn, Cr, Cd, Pb, Mn, Cu, Co, Ni, Hg — were quantified using Atomic Absorption Spectrophotometer (AAS) (Model: Buck Scientific 210 VGP). Calibration curves were prepared using certified standards. Each metal's detection wavelength

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and limit of detection followed APHA/EPA specifications. All glassware were acid-cleaned, and blanks were analyzed for quality assurance.

2.2.4. Hydrocarbon Analysis

2.2.4.1 Total Petroleum Hydrocarbon (TPH) — EPA 8015

TPH was determined by Gas Chromatography-Flame Ionization Detection (GC-FID).

Samples were extracted with n-hexane, dried with anhydrous Na_2SO_4, and concentrated. Aliquots were injected into GC-FID (Agilent 6890) fitted with a non-polar capillary column. Quantification was performed by comparing peak areas with TPH standards (C10–C40 range).

2.2.4.2 Polycyclic Aromatic Hydrocarbons (PAH) — EPA 8270D

PAHs were extracted using dichloromethane, cleaned via silica gel column, and analyzed using Gas Chromatography-Mass Spectrometry (GC-MS). Individual PAHs were identified by retention time and mass spectra, and quantified against calibration standards. Detection limit: 0.01 ppm.

2.2.4.3 Total Hydrocarbon Content (THC) — APHA 5520C

THC was measured spectrophotometrically after solvent extraction with n-hexane and partitioning. The extract absorbance was read at 400 nm using UV-Visible spectrophotometer (HACH DR6000). Concentrations were derived from calibration curves prepared with known hydrocarbon standards.

2.2.5. Quality Assurance and Quality Control (QA/QC)

The following measures were followed to ensure quality assurance and quality control:

i. All reagents were of analytical grade (AR) purity.
ii. Equipment was calibrated daily using standard reference solutions.
iii. Triplicate determinations were performed for each parameter.
iv. Blanks and spiked samples were analyzed to verify accuracy and precision.
v. Results were validated against APHA (2017) and EPA (2007) standard guidelines.

III. RESULTS AND DISCUSSION

3.1 Physicochemical Properties of Water

Table 3.1 - Physicochemical parameters of water samples

Location	pH	EC(µS cm^{-1})	TDS(mgL^{-1})	BOD(mgL^{-1})	COD(mgL^{-1})
Mbo	6.24	9	4	2.84	8.14
Udung Uko	6.09	22	11	1.20	4.57
Ibeno	7.90	33100	16500	6.88	68.22
Oron	6.86	296	149	7.20	14.28
Borehole Mbo	6.28	17	8	2.88	5.42
Borehole Oron	5.68	58	29	4.42	8.12

Table 3.2 - Physicochemical parameters of water samples (contd.)

Location	Total hardness (mgL^{-1})	Alkalinity (mgL^{-1})	Acidity (mgL^{-1})
Mbo	6.0	6	12
Udung Uko	16.0	6	12
Ibeno	30.0	120	10
Oron	44.0	12	10
Borehole Mbo	4.0	8	20
Borehole Oron	20.0	2	24

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Ibeno and Oron showed extreme EC and TDS, exceeding WHO's/SON's 1000 µS cm-1 and 500 mgL-1 limits, evidencing saline or hydrocarbon intrusion. Hardness (as CaCO3) were all below 150 mg L-1 SON standard. All the sampled water fall between hardness of 0 to 50 mgL-1 hence considered soft (Martins and Idowu, 2020). BOD5 values were all below 20 and 30 mgL-1 specification for domestic and industrial effluent stipulated in Bureau of Indian Standards (Rao, 2006). Alkalinity is due to the presence of bicarbonates, carbonates and hydroxides of metal ions such as calcium, magnessium, carbonates and hydroxides of metal ions such as calcium, magnessium, sodium and potassium (Rao, 2005).

3.2 Heavy Metals in Water

Table 3.3 - Heavy-metal concentrations (mg L-1)

Location	Fe	Zn	Cd	Pb	Mn	Cu
Mbo	0.001	0.001	0.001	0.001	0.001	0.001
Udung Uko	0.001	0.001	0.001	0.001	0.001	0.001
Ibeno	11.528	5.781	0.028	0.099	6.120	3.462
Oron	0.036	0.011	0.001	0.001	0.021	0.029
Borehole Mbo	0.001	0.001	0.001	0.001	0.001	0.001
Borehole Oron	0.001	0.001	0.001	0.001	0.001	0.001

Chromium, Cobalt and Mercury have values below 0.001 mg L-1 in all the studied area. Ibeno exhibited Fe = 11.53 mgL-1 and Pb = 0.099 mgL-1 - over 35 times and 10 times above WHO limits (0.3 and 0.01 mgL-1). Ibeno also had values for Zn, Cd, Mn and Cu above permissible limits for drinking water. The following quality specifications are given for Cadmium 0.003 mg L-1, Copper 1 mg L-1, Chromium 0.05 mg L-1, iron 0.3 mg L-1 (SON, 2007). Cadmium is toxic to the kidney, chromium cause cancer, copper causes gastrointestinal disorder (Martins and Idowu, 2020).

Similar study was carried out by Jonah and Anyanwu, 2023 who assessed heavy metal content of five randomly selected hand dug wells in Ikpe community, Akwa Ibom State, Nigeria discovered that chromium ranged from 0.001 to 0.20 mg/L, cadmium (0.001-0.008 mg/L), nickel (0.01-0.08 mg/L), manganese (0.001-0.6 mg/L), zinc (0.36-1.90 mg/L), iron (0.1-0.8 mg/L), lead (0.001-0.02 mg/L) and arsenic (0.00-0.004 mg/L). Concentrations of these heavy metals exceeded acceptable limits, except lead and arsenic.

In another study, borehole water samples from Uyo metropolis were screened for heavy metals. The results revealed a mean iron concentration of 0.551 mg/L of the composite water samples, surpassing the guidelines set by the World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ), indicating a pervasive risk to consumers. Additionally, elevated levels of nickel (0.298 mg/L) were detected in several samples, further exacerbating the public health implications (Shaibu et al, 2024).

Results obtained in this research agrees with an earlier work in which heavy metal pollution of seawater, sediment and shrimps of Qua Iboe River, Ibeno, Akwa Ibom State, Nigeria was studied. The mean concentrations of heavy metals in seawater were 0.628, 0.072, 0.381, 0.486 and 0.631mg/l for Pb, Cu, Cd, Cr and Ni respectively for dry season and 0.427, 0.049, 0.214, 0.289 and 0.408mg/l for Pb, Cu, Cd, Cr and Ni in wet seasons. The corresponding values in the sediments were 3.552, 1.327, 2.578, 2.829 and 4.926mg/g for Pb, Cu, Cd, Cr and Ni respectively for dry season and 2.121, 0.943, 1.517, 1.777 and 3.675mg/g for Pb, Cu, Cd, Cr and Ni respectively in wet season (Solomon et al, 2021).

3.3 Hydrocarbons in Water

Table 3.4 - Total petroleum hydrocarbon and Total hydrocarbon content in water

Location	TPH (µg L^{-1})	THC (mg L^{-1})
Mbo	34.24	40.36
Udung Uko	9.13	12.75
Ibeno	132.93	139.63
Oron	150.96	175.05
Borehole Mbo	0.001	2.96

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Borehole Oron	0.001	1.08

Result obtained from this study indicated that THC in surface water of Ibeno and Oron exceeded the EGASPIN 50 mg L-1 specification standard.

The result agrees with earlier study conducted in which the total petroleum hydrocarbon content in surface water and sediment of Qua Iboe River was assessed. The results showed variation of total petroleum hydrocarbon (TPH) content from 90 to 250 µg/L in the water and 270 to 830 mg/kg in the sediments, with mean value of 168.33±59.29 µg/L and 606.83±229.48 mg/kg respectively. The average amount of TPH in the water samples collected from all the sampling points was generally lower than the EU standard limit of 300 g/L. However, the levels in the sediments exceeded the EGASPIN target value (50 mg/kg) for mineral oil but were below the intervention value (5,000 mg/kg), this indicates a serious impact of oil industrial activities on the area. Hence, our findings have indicated evidence that Qua Iboe River is under pollution threat and underscore the need for early remediation if adverse health defects are to be prevented (Inyang et al, 2018).

Another study which entailed determination of Total Hydrocarbon Content (THC) and Total Petroleum Hydrocarbon (TPH) in borehole water of Eket Local Government Area, Akwa Ibom State was compared. The results showed the variations of total petroleum hydrocarbon (TPH) from 784.395 ± 0.07 to 1120.500 ± 0.05 mg/L. While THC ranges from 938.21 ± 0.08 to 1,583.294± 0.02 mg/L. The average amount of TPH and THC in the water samples collected from all the sampling stations were generally higher than both the DPR limit (50 mg/L) and federal ministry of Environment (FMEnv.) (Nsi et al, 2022).

However, Akpan, 2024 who asseseds the physicochemical parameters in water samples from Qua Iboe River, Ikot Ekpene stretch, Akwa Ibom State reported that the levels of all the parameters determined were within UNICEF and WHO (2008) permissible limits.

Yet in related study, groundwater samples were taken from boreholes in Obrikom community and analyzed for Total Petroleum Hydrocarbons (TPH). Results obtained are compared with the European Union Environmental Protection Agency (EUEPA) and Nigerian Upstream Petroleum Regulatory Commission (NUPRC) Intervention standards. Results from the laboratory analysis of Total petroleum Hydrocarbon (TPH) of groundwater sample show that the mean concentration of TPH (444.20µg/L) was above EUEPA but less than NUPRC standards. The study shows that four of the five groundwater samples exceeded the stringent reference standard (Erifeta et al, 2024)

3.4 Hydrocarbons in Soil

Table 3.5 - Total petroleum hydrocarbon and Total hydrocarbon content in Soil

Location	TPH (µg L^{-1})	THC (mg L^{-1})
Mbo	34.67	37.52
Udung Uko	6.13	8.52
Ibeno	58.51	71.26
Oron	45.54	52.54

3.4 Hydrocarbons in Sediment

Table 3.6 - Total petroleum hydrocarbon and Total hydrocarbon content in Sediment

Location	TPH (µg L^{-1})	THC (mg L^{-1})
Mbo	13.05	18.81
Udung Uko	23.32	33.28
Ibeno	30.33	39.46
Oron	25.91	34.16

PAH in soil and sediment was below 0.01 ppm.

3.5 Soil and Sediment Contamination by Heavy Metals

Table 3.7 - Heavy metals in soil (mg kg-1)

Location	Fe	Zn	Pb	Cr	Cd	Mn	Ni
Mbo	87.97	20.10	1.75	0.73	1.09	9.69	0.58
Udung Uko	25.93	12.08	1.70	0.61	1.02	6.92	0.58
Ibeno	147.04	79.72	2.25	0.95	1.44	49.64	0.66
Oron	114.42	26.94	1.97	0.75	1.26	13.18	0.62

Table 3.8 - Heavy metals in sediment (mg kg-1)

Location	Fe	Zn	Pb	Cr	Cd	Mn	Ni
Mbo	20.21	11.80	1.10	0.37	0.70	1.40	0.42
Udung Uko	14.64	10.60	1.23	0.65	0.64	0.99	0.42
Ibeno	23.10	26.75	1.28	0.50	0.84	6.05	0.53
Oron	18.65	12.20	1.31	0.41	0.82	4.17	0.41

Metal enrichment (Fe, Zn, Mn) in soil confirms long-term accumulation. Elevated Pb and Cd suggest chronic exposure risks through fish consumption and drinking water.

pH is soil and sediment in the study area were between 6.32 to 7.69; however sediments in Udung Uko and Ibeno recorded high pH of 8.25 and 12 respectively.

Values for Cobalt and Mercury were found to be less 0.001 mg/kg in all the soil and sediment studied.

Similar study at mechanic workshops in Uyo revealed lead 2.658 mg/kg, Iron 11.262 mg/kg, Copper 0.827 mg/kg, cadmium 2.203 mg/kg, manganese 2.015 mg/kg, zinc 27.116 mg/kg in mechanic village soils and Lead 4.065 mg/kg, Iron 12.612 mg/kg, copper 0.694 mg/kg, cadmium 1.873 mg/kg, manganese 1.894 mg/kg, zinc 25.617 mg/kg at soil in Atiku Abubakar avenue in Uyo (Daniel et al, 2025)

Another study conducted to assess the status of lead (Pb), arsenic (As), copper (Cu), cadmium (Cd) and mercury (Hg) in soils around the main dumps in Uyo, Eket and Ikot Abasi urbans in Akwa Ibom State revealed concentrations of Pb (4.52 - 18.96 mgkg-1), As (0.53 - 5.03 mgkg-1), Cu (5.44 - 26.12 mgkg-1), Cd (2.46 - 11.62 mgkg-1) and Hg (0.01 - 3.81 mgkg-1) which were all less than the USEPA/NESREA maximum permissible limits for agricultural soils, but much higher than the WHO maximum safe limits for agricultural soils (Uduak and Umoh, 2022).

Heavy metal values from soil and plant samples were higher than the safe standard recommended by WHO/FAO except for Cobalt. This implies that it is risky to consume vegetables grown on and around dumpsites since it can accumulate toxic metals (Tommy et al, 2022).

While the Target Value represents the lower (safe) point that should be aspired for, the Intervention Value represents a higher point from which that medium is adjudged unsafe, thereby indicating that some form of remedial action may be required (EGASPIN, 2018).

1. Environmental Implications

a. Water Quality: exceeds WHO/NSDWQ limits for Fe, Pb, Cd, and hydrocarbons.
b. Soil Fertility: reduced microbial activity from hydrocarbon toxicity.
c. Health: potential neurological and renal damage from Pb/Cd.
d. Socio-economic: loss of fisheries and potable-water resources.

VI. CONCLUSION

Ibeno and Oron communities show significant hydrocarbon and metal pollution relative to WHO/NSDWQ standards. The extremely high EC, TDS, COD, and hydrocarbon values in Ibeno and Oron indicate severe pollution from petroleum operations.
Borehole waters remain largely safe. Immediate remediation, strict effluent control, and continuous monitoring are imperative.

VII. RECOMMENDATIONS

- Apply bioremediation and phytoremediation on impacted soils.
- Conduct quarterly monitoring of metals and hydrocarbons.
- Enforce EGASPIN compliance for petroleum operators.
- Organize public-health surveillance for exposed residents.

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