Analysis of Physicochemical Properties of Water Soluble Fractions of Automative Gas Oil (AGO), and Premium Motor Spirit (PMS) in Fresh and Brackish Water Habitat

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Abstract

Petroleum-derived hydrocarbons are considered one of the main pollutants in aquatic ecosystems, leading to physical and chemical changes due to the dissolution of water-soluble components of petroleum. This study investigated the physicochemical properties of water-soluble fractions (WSFs) of Automotive Gas Oil (AGO) and Premium Motor Spirit (PMS). The heavy metal content, total petroleum hydrocarbons (TPH), and polycyclic aromatic hydrocarbons (PAH) content of the WSFs were determined using standard procedures. The WSFs were found to be acidic, with mean pH values of 5.50 ± 0.02 and 6.10 ± 0.02 for AGO and PMS in brackish water, respectively, and 5.30±0.02 and 5.80±0.02 for AGO and PMS in freshwater, respectively. The electrical conductivity (EC) values were 28611.50±0.50 µS/cm for AGO and 28609.00±0.50 µS/cm for PMS in brackish water, and 198.00±0.56 µS/cm for AGO and 196.00±0.56 µS/cm for PMS in freshwater. The total dissolved solids (TDS) content was less than 8.00 mg/L in all samples. Dissolved oxygen (DO) levels were 5.00±0.01 mg/L and 6.00±0.01 mg/L for AGO and PMS in brackish water, and 4.60±0.01 mg/L and 4.40±0.01 mg/L for AGO and PMS in freshwater, respectively. DO was significantly higher in WSFs of PMS compared to AGO in both freshwater and brackish water. In contrast, biochemical oxygen demand (BOD) was significantly higher in WSFs of AGO than in WSFs of PMS in both habitats. The WSFs of AGO and PMS also contained cations and anions such as Ca^{2+} , Mg^{2+} , K^+ , Na^+ , HCO_3^- , SO_4^{2-} , and NO_3^- . Heavy metals such as Ni, Mn, Fe, Zn, Cu, Pb, Cr, and Cd were also present. Routine monitoring of the physical and chemical properties of ponds, streams, and rivers in oil-bearing communities was recommended to help mitigate the impacts of petroleum-derived pollutants.

Keywords: hydrocarbons, heavy metals, dissolved oxygen, cations, anions.

1. INTRODUCTION

The water-soluble fractions (WSFs) of oil refer to the portion of oil that dissolves into water after prolonged contact between oil and water. When oil spills are not promptly cleaned up, the soluble components of crude oil and its refined derivatives enter aquatic environments (Edema, 2009). These WSFs represent the portion of oil that remains in the water column following natural weathering and mechanical dispersion. Compared to whole oil, WSFs are chemically simpler. From an ecological standpoint, the concentration of oil components dissolved in water is

particularly significant. Edema (2012) emphasized that it is the dissolved fraction rather than the emulsified or adsorbed forms that poses the greatest toxicity to aquatic organisms. This is because the dissolved components are easily taken up by organisms at the base of the food chain, leading to bioaccumulation in higher trophic levels. Sadani, Faraji, Hajian, and Mehrizi (2011) noted that toxicological studies on crude oil often focus on WSFs, as these components most readily enter aquatic environments and exert immediate effects on aquatic life. WSFs are primarily composed of low molecular weight hydrocarbons, especially aromatic compounds that are relatively more water-soluble. They may also contain smaller amounts of higher molecular weight substances with lower solubility (Nwanchukwu and Osuagwu, 2014). According to Nwankwoala and Obirie (2018), mononuclear aromatics make up about 89% of crude oil WSFs, with BTEX compounds (benzene, toluene, ethylbenzene, and xylene) accounting for 87.6%. In the case of leaded Premium Motor Spirit, 46 volatile compounds have been identified in its WSF, with aromatic hydrocarbons mainly BTEX being the dominant dissolved substances. The polycyclic aromatic hydrocarbon (PAH) portion is primarily composed of naphthalene and its methylated derivatives. Automotive gas oil contains a higher concentration of aromatic hydrocarbons compared to crude oil, and these aromatics exhibit greater water solubility than alkanes of similar molecular weight. Automotive gas oil also includes BTEX compounds (Liu and Kujawinski, 2015). Additionally, petroleum WSFs and their derivatives may contain various anions, cations, and heavy metals (Edema, 2012). This study aims to investigate the physical and chemical properties of the water-soluble fractions of automotive gas oil and Premium Motor Spirit in both fresh and brackish water environments.

2. MATERIALS AND METHODS

The refined petroleum products were obtained from Total Petrol Station in Port Harcourt, Rivers State.

Preparation of Water Soluble Fractions (WSFs) of Automotive gas oil and Premium motor spirit

Water-soluble fractions of AGO and PMS were prepared using an oil-to-water ratio of 1:3. 500 ml of AGO oil was mixed with 1500 ml of water samples (fresh water), and the mixture was stirred using a magnetic stirrer for 24 hours at room temperature. After stirring, the mixture was allowed to stand for a minimum of 3 hours to obtain a clear interphase between oil and water. The oil was decanted, and the mixture was then poured into a glass stopper-separating funnel and allowed to stand overnight. Pure and clear WSF obtained at the lower part of the funnel was syphoned into capped bottles to make the stock (100% WSF). The procedure was repeated using PMS until sufficient quantities of WSFs of AGO and PMS were obtained and stored in dark brown screw-cap bottles prior to analysis. The process was repeated using brackish water Okwuego, *et al* (2021) and Okwuego, (2023).

Physico-Chemical Analysis of Water soluble fractions:

Standard analytical procedures were used in the determination of selected physical, chemical, and biological water quality parameters of the samples. Selected physicochemical analyses such as pH, temperature, turbidity, conductivity, total suspended solids (TSS), nitrates, total hardness, magnesium, calcium, dissolved CO₂, etc. were carried out Okwuego,*et al* (2021:2024:2025).

Determination of the Physical Properties of Water Soluble Fractions (WSFs)

pH was determined using an EIL Model 720pH meter. Electrical Conductivity (EC) was measured using the portable conductivity meter (Hanna) and the value was expressed in 4 μ s/cm

Biochemical oxygen demand and dissolved oxygen were measured using the modified oxygen depletion and Winkler's method (APHA, 2012).

Determination of Electrical conductivity (EC)

Electrical Conductivity (EC) was measured using the portable conductivity metre (Hanna), and the value was expressed in 4 μ s/cm. EC was measured using a standard solution of potassium chloride of known conductivity (0.01 NKCI, 745.6 mg in 1.0 L deionized water = 1413 μ ohms/cm) in accordance with APHA (2012).

Determination of Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand and dissolved oxygen were measured using modified oxygen depletion and Winkler's method (APHA, 2012).

Determination of Chemical Oxygen Demand (COD)

This is a measure of the oxygen proportion of the untreated matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. The COD was determined according to the method described in ALPHA (2012).

Determination of Chemical Properties of WSFs

Determination of Salinity:

The salinity of the water sample was measured in the laboratory as described in the Horiba Instruction Manual (HIM, 1991). About 20 ml of water was dispensed into a beaker, and the salinity was read by immersion of the probe after standardisation for about 3 minutes.

Determination of Hardness:

Total hardness in water was determined in accordance with APHA, 2012.

Determination of Sulphate

Sulphate was determined by the turbidimetric method. The sample was reacted with barium ions in the presence of sodium chloride and a hydrochloric acid solution containing glycerol and ethyl alcohol. The colloidal barium sulphate formed was measured at 420nm using a UV/visible spectrophotometer (APHA, 2012).

Determination of Nitrate

Two millilitres of brine reagent were added to 10 ml of sample in a 25 ml volumetric flask, and 10 ml of H_2SO_4 concentration was rapidly added. The mixture was allowed to stand for 20 minutes and made up to mark with distilled water before measurement at 470nm with a UV/visible spectrophotometer (ASTM, 2010).

Determination of Ammonium Nitrogen

6 ml of potassium sodium tartrate, 2 ml of alkaline sodium phenate solution, and 2 ml of sodium hypochlorite solution were added to 10 ml of the sample in a 25 ml volumetric flask. The mixture was made up of distilled water, and the absorbance value was set at 630nm on a UV/Visible spectrophotometer (ASTM, 2010) (Mmuo and Okwuego 2024).

Determination of Phosphate

1 ml of sample was pipetted into 10 ml of 0.7M HCl and stirred briefly. 1 ml of the molybdate reagent was then added to the vial, and the contents were stirred for two to three minutes. Exactly 5 ml of 1-butyl acetate was then added, and the contents were stirred thoroughly into an emulsion for 2 to 3 minutes. The phases were then allowed to separate, and as much of the organic as possible was transferred to a second vial containing 5 ml of 0.85M HCl. The contents of this vial were then stirred for 1 to 2 minutes, and the phases separated for 3 minutes. The Organic was then transferred to a 1-cm spectrophotometer cell, and the absorbance was measured against a reagent blank at 310 nm (ASTM, 2012).

Determination of Calcium and Magnesium

5 ml of buffer solution and 0.5 mL of KCN and hydroxylamine hydrochloride solution were added to 25 mL of water-soluble fraction (WSF) in a 250 mL conical flask. 2 drops of Erichrome Black T indicator solution were added to the mixture and titrated over a white surface with standard 0.004M EDTA. Calcium and Magnesium were determined by flame photometry (ASTM, 2010).

Determination of Heavy Metals

10 ml of WSF was transferred to a 25-mL conical flask. A mixture of perchloric acid, nitric acid, and sulpuric acid in the ratio of 1:2:2 was added to the flask. The mixture was heated for 20 minutes on the hot plate until white fumes were observed. The heating was stopped, and the mixture cooled. After cooling, 20 ml of distilled water was added, and the solution was analysed with an atomic absorption spectrophotometer (AAS) AOAC (2000).

Atomic absorption spectroscopy (AAS) Analysis

For each of the metals, atomic absorption spectroscopy was calibrated using metal standards (Cr 357.90nm, Cd 228.80nm, Zn 213.90nm, Pb 238.30nm, Mn 279.50nm, Fe 248.30nm, Cu 324.70nm, Ni 232.00nm). Samples were determined with the aid of the Atomic Absorption Spectrophotometer Analyzer 200 (USA) according to AOAC (2000). The extracts were aspirated directly into the absorption spectroscopy machine. An acetylene-air mixture was used as the flame. The working standard for each of the metals was aspirated into the flame in the order of 0.0 ppm, 0.8 ppm, and 1.6 ppm. The sample was then aspirated into the flame, and the values obtained (Mmuo and Okwuego 2024).

Determination of Total Petroleum Hydrocarbon (TPH) and Polycyclic Aromatic Hydrocarbon (PAH)

1000 ml of water-soluble fraction (WSF) was poured into a 2 L separating funnel. 30 ml of an extracting mixture of a 50:50 mix of acetone and methylene chloride was added. The solution was agitated for about 5 minutes and allowed to settle until a distinct layer extract was obtained, which was drained into a 20-ml beaker. This was repeated twice with 10mL of the extracting solvent. The extract was cleaned by passing it through a packed column with silica gel, and 10 ml of redistilled hexane was allowed to run through the column. The filtrate was concentrated to an injectable volume with an evaporator and analysed with a Hewlett-Packard (HP) 6890 gas chromatograph equipped with HP chemistry software (ASTM, 2010) and Okwuego, *et al* (2024:2025).

Gas chromatographic analysis of a sample

The concentrated aliphatic fractions were transferred into labelled vials with rubber crimp caps for gas chromatographic analysis. One microlitre of the concentrated sample was injected by means of a hypodermic syringe through a rubber septum into the column. Separation occurred as the vapour constituent partitioned between the gas and liquid phases. The sample was automatically detected as it emerged from the column at a constant flow rate by the FID whose response is dependent upon the composition of the vapour. Okwuego, *et al* (2021), Nkachukwu, *et al* (2025) and Okwuego, (2023).

Statistical Analysis

Results were expressed as the mean standard error of three replicates. All data were statistically analysed using Statistical Package for Social Sciences (SPSS) version 16.0. An analysis of variance (ANOVA) was performed in accordance with the study. Duncan's Multiple Range Test (DMRT) was used to locate the means and significant differences occurred at p<0.05,

3. RESULTS AND DISCUSSION PHYSICOCHEMICAL PARAMETERS OF WATER SOLUBLE FRACTION

PARAMTER	BRACKISH	FRESH	PERMISSIBLE LIMIT OF			
	WATER	WATER	WHO	USEPA	FAO	FEPA
Temperature	25. 00± 2	25.00 ± 2	20.0-30.0	40.0	-	-
pH	7.2 ± 0.2	6.8 ± 0.2	6-9.5	6.5 - 8.5	6.0-8.5	6.5-8.5
DO (mg/L)	6.2 ± 0.1	6.8 ± 0.1	<u>≥</u> 5.0	40.0-60.0	>4.0	5.0
BODs (mg/L)	17.53 ± 0.11	$19.99{\pm}~0.02$	2.0 - 6.0	10.0	8.0	2.0
COD (mg/L)	59.18 ± 0.04	51.06±0.20	-	-	-	-
Salinity (mg/L)	13100	0.28	-	-		-
EC (µS/cm)	28600.5±0.5	187±0.5	600.0	400.0	3000	250
Turbidity (NTU)	39.50	15.65	5.0	5.1	-	30
TSS (mg/L)	$50.96{\pm}0.14$	9.90 ± 0.14	50.0	30	-	30
TDS (mg/L)	506.55 ± 9.26	$19.84{\pm}~0.40$	1500	2000.0	2000.0	2000.0
Phosphates, PO_4^{3-} (mg/L)	3.96±0.00	0.47 ± 0.00	0.1	-	2.0	-
Nitrate NO_3^- (mg/L)	$1.24{\pm}0.4$	1.08 ± 0.4	4.5	-	5.0	20
Sulphate SO_4^{2-} (mg/L)	$2.59{\pm}0.01$	$0.82{\pm}0.01$	250	-	400	-
Hydrogencarbonate.HCO3 ⁻	2.10±0.20	1.48 ± 0.20	-	-	-	-
(mg/)						
Calcium ion, Ca^{2+} (mg/L)	0.38 ± 0.00	0.27 ± 0.00	100	-	800	0.01
Magnesium ion, Mg ²⁺ (mg/L)	1.19 ± 0.00	0.82 ± 0.00	120	-	120	0.01
NH4-N (mg/ L)	0.29±0.01	0.16±0.01	-	-	5.0	-

Table 1: Physico-Chemical Properties of Water Samples

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PARAMTER	BRACKISH	WSF (AGO)	WSF (PMS)
	WATER	BRACKISH	BRACKISH
Temperature	25. 00± 2	25. 00± 2	25.00±2
pH	7.2 ± 0.2	5.50 ± 0.2	6.10 ± 0.2
DO (mg/L)	6.2 ± 0.1	5.00 ± 0.1	6.0 ± 0.1
BODs (mg/L)	17.53 ± 0.11	45.53 ± 0.11	$39.98{\pm}0.02$
COD (mg/L)	59.18 ± 0.04	$394.31{\pm}0.04$	346.24 ± 0.04
Salinity (mg/L)	13100	13110.28	13105
EC (μ S/cm)	28600.5±0.5	28611±0.5	28609±0.5
Turbidity (NTU)	39.50±0.10	44.8±0.10	43.8±0.10
TSS (mg/L)	50.96 ± 0.14	60.98 ± 0.14	$58.84{\pm}0.14$
TDS (mg/L)	506.55 ± 9.26	511.55 ± 3.26	511.55 ± 0.4
Phosphates, PO_4^{3-} (mg/L)	3.96 ± 0.00	$8.04{\pm}0.00$	4.58 ± 0.00
Nitrate NO_3^- (mg/L)	$1.24{\pm}0.4$	3.89±0.4	3.78±0.4
Sulphate SO ₄ ²⁻ (mg/L)	2.59±0.01	5.24±0.01	$3.74{\pm}0.01$
Hydrogen carbonate HCO ₃ -	2.10±0.20	14.30±0.20	13.68±0.20
(mg/L)			
Calcium ion, Ca^{2+} (mg/L)	0.38 ± 0.00	1.02 ± 0.00	0.91±0.00
Magnesium ion, Mg ²⁺ (mg/L)	$1.19{\pm}0.00$	1.58 ± 0.00	1.21 ± 0.00
NH4-N (mg/ L)	0.29±0.01	0.29±0.01	3.44±0.01

Table 3: Change in Physico-chemical properties of fresh water soluble fractions

PARAMTER	FRESH	WSF (AGO)	WSF (PMS)	
	WATER	FRESH	FRESH	
Temperature	25.00 ± 2	25.00 ± 2	25.00 ± 2	
pH	6.8 ± 0.2	5.3 ± 0.2	5.8 ± 0.2	
DO (mg/L)	6.8 ± 0.1	4.6 ± 0.1	4.4 ± 0.1	
BODs (mg/L)	19.99 ± 0.02	47.99 ± 0.11	40.00 ± 0.02	
COD (mg/L)	51.06 ± 0.20	131.06 ± 0.20	81.06 ± 0.20	
Salinity (mg/L)	0.28	10.28	10.19	
EC (μ S/cm)	187±0.56	198±0.56	196±0.56	
Turbidity (NTU)	15.65±0.10	20.85±0.10	19.95±0.10	
TSS (mg/L)	9.90 ± 0.14	21.10 ± 0.14	19.20 ± 0.14	
TDS (mg/L)	19.84 ± 0.06	24.86 ± 0.06	24.84 ± 0.4	
Phosphates,PO ₄ ³⁻ (mg/L)	0.47±0.00	4.91±0.00	4.58±0.00	
Nitrate NO_3^- (mg/L)	1.08 ± 0.4	4.42±0.4	6.02±0.4	
Sulphate SO_4^{2-} (mg/L)	0.82±0.01	3.47±0.01 3.47±0.01		
Hydrogen carbonate. HCO ₃ ⁻ (mg/L)	1.48±0.20	14.10±0.01	13.68±0.01	

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Calcium ion,Ca ²⁺ (mg/L)	0.27±0.00	0.91±0.00	0.91±0.00
Magnesiumion,Mg ²⁺ (mg/L)	$0.82{\pm}0.00$	1.21±0.00	1.60 ± 0.00
NH4-N (mg/ L)	0.16±0.01	0.16±0.01	3.31±0.01

Key: nd- not detected

HEAVY METALS CONCENTRATION IN WATER SOLUBLE FRACTIONS

Table 4: Heavy metal content (1	m/L) of WSFs of AGO and PMS (I	Brackish water and Fresh water)
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Parameter	BRACKISH WATER		FRESH WATER		
	Automotive	Premium motor	Automotive	Premium	
	gas oil	spirit	gas oil	motor spirit	
$Fe (mg L^{-1})$	$0.08 {\pm} 0.00$	$0.08 {\pm} 0.00$	$0.08 {\pm} 0.00$	0.08 ± 0.00	
$Zn (mg L^{-1})$	0.07 ± 0.00	$0.08 {\pm} 0.00$	$0.07{\pm}0.00$	0.08 ± 0.00	
$Cu (mg L^{-1})$	$0.02{\pm}0.00$	0.03±0.00	$0.02{\pm}0.00$	0.03 ± 0.00	
$Mn (mg L^{-1})$	0.16±0.01	0.28±0.01	0.16±0.01	0.28±0.01	
$Cr (mg L^{-1})$	0.01 ± 0.00	0.01±0.00	$0.01{\pm}0.00$	0.01 ± 0.00	
$Cd (mg L^{-1})$	0.01 ± 0.00	nd	0.01 ± 0.00	nd	
Pb (mg L^{-1})	0.01 ± 0.00	$0.01{\pm}0.00$	0.01 ± 0.00	0.01 ± 0.00	
Ni (mg L^{-1})	$0.10{\pm}0.00$	$0.10{\pm}0.00$	$0.10{\pm}0.00$	0.10±0.00	
$V (mg L^{-1})$	nd	nd	nd	nd	

Key: nd- not detected.

Results obtained for physicochemical analysis of water samples showed a significant difference p<0.05 between the water soluble factions of AGO and PMS in brackish water and freshwater, respectively. The data in Table 3 shows that The mean pH were 5.50±0.02 and 6.10±0.02 for the water soluble fractions of AGO and PMS in brackish water respectively while the mean pH were 5.30±0.02 and 5.80±0.02 for the water soluble fractions of AGO and PMS in freshwater, respectively. The WSF of PMS had the highest pH, while the pH of automotive gas oil was lower. The pH of the WSFs was significantly different from each other (p<0.05). Conductivity 28611.50±0.50µs/cm and 28609.00±0.50µs/cm for the water soluble fractions of AGO and PMS in brackish water, respectively, while conductivity 198.00±0.56µs/cm and 196.00±0.56µs/cm for the water soluble fractions of AGO and PMS in fresh water respectively, Electrical conductivity (EC) was significantly lower in WSF of PMS in both habitat. Dissolved oxygen (DO) 5.00±0.01mg/l and 6.00±0.01mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water, respectively, and Dissolved oxygen (DO) 4.60±0.01mg/l and 4.40±0.01mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, Dissolved oxygen (DO) was significantly higher in WSFs Premium motor spirit than in WSF of automotive gas oil in both the fresh water and brackish water. All values of DO were significantly different from each other (p<0.05). Total suspended solids (TSS) 60.98±0.14mg/l and 58.84±0.14mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while Total suspended solids (TSS) 21.10±0.14mg/l and 19.20±0.14mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, Total dissolved solids (TDS) 511.55±3.26mg/l and 511.55±0.40mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while Total dissolved solids (TDS) 24.86±0.06mg/l and 24.84±0.4mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, Total dissolved solids (TDS)) was almost the same in the WSFs of the

two refined petroleum products. Turbidity 44.80±0.10NTU and 43.80±0.08NTU were obtained for the water soluble fractions of AGO and PMS in brackish water, respectively, and Turbidity 20.85±0.10NTU and 19.95±0.08NTU were obtained for the water soluble fractions of AGO and PMS in freshwater, respectively. The WSF of automotive gas oil had a higher turbidity compared to the WSF of g Premium motor spirit, which had the least turbidity, the turbidities of the two WSFs were significantly different from each other (p < 0.05). Biological oxygen demand (BOD) 45.53±0.11mg/l and 39.98±0.11mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water, respectively, while Biological oxygen demand (BOD) 47.99±0.11mg/l and 40.±0.02mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater, respectively, Biochemical Oxygen demand (BOD), on the other hand, was significantly higher in WSFs of automotive gas oil than in WSFs of Premium motor spirit in both WSFs from the two habitats. Salinity of 13110.28mg/l and 13105mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water, respectively, while salinity of 10.28mg/l and 10.19mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater, respectively. The results were reflective of the sources of the water used in preparing the WSFs. There were differences in the ionic concentrations of the different WSFs. Nitrate 3.89±0.4mg/l and 3.78±0.00 mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while Nitrate 4.42±0.4mg/l and 6.02±0.4mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, Sulphate 5.24±0.01mg/l and 3.74±0.10mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while Sulphate 3.47±0.01mg/l and 3.47±0.10mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively Hydrogen carbonate 14.30±0.20mg/l and 13.68±0.20mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while Hydrogen carbonate 14.10±0.01 mg/l and 13.68±0.01mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, The cations present in the two WSFs include calcium (Ca²⁺) and magnesium (Mg²⁺), Calcium 1.02±0.00mg/l and 0.91±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water, respectively, while Calcium 0.91±0.00mg/l and 0.91±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater, respectively, The concentration of Ca²⁺ in the WSFs of the two refined petroleum products was the same in the WSFs of freshwater. Magnesium 1.58±0.00mg/l and 1.21±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water, respectively, a change in concentration of 0.39 ± 0.00 mg/l and 0.78 ± 0.00 mg/l were obtained for the water soluble fractions of AGO and PMS for both WSFs. The change in concentration of Mg in WSF of Premium motor spirit was significantly higher than the Mg concentration in automotive gas oil (p > 0.05). Ammonium 0.29±0.01mg/l and 3.44±0.01 mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water, respectively, while Ammonium 0.16±0.01mg/l and 3.31±0.01mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater, respectively. Heavy metals were also detected in all the WSFs (Table 4). Iron (Fe), 0.08±0.00mg/l and 0.08±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while iron (Fe) 0.08±0.00mg/l and 0.08±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, zinc (Zn), 0.07±0.00mg/l and 0.08±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while zinc (Zn), 0.07±0.00mg/l and 0.08±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater copper (Cu) 0.02±0.00mg/l and 0.03±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while copper (Cu) 0.02±0.00mg/l and 0.03±0.00mg/l were obtained for the water soluble fractions

of AGO and PMS in freshwater respectively, Manganese (Mn) 0.16±0.01mg/l and 0.28±0.01mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while Manganese (Mn) 0.16±0.01mg/l and 0.28±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, chromium (Cr) 0.01±0.00mg/l and 0.01±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while chromium (Cr) 0.01±0.00mg/l and 0.01±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively cadmium (Cd) 0.01±0.00mg/l and (nd) mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while cadmium (Cd) 0.01±0.00mg/l and (nd) mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, lead (Pb) 0.01±0.00mg/l and 0.01±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while lead (Pb) 0.01±0.00mg/l and 0.01±0.00 mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, nickel (Ni) 0.01±0.00mg/l and 0.01±0.00 mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while nickel (Ni) 0.01±0.00 mg/l and 0.01±0.00 mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, vanadium (V) was not detected for the water soluble fractions of AGO and PMS in brackish water and freshwater respectively.

TOTAL PETROLEUM HYDROCARBONS (TPH) AND POLYCYCLIC AROMATIC HYDROCARBONS (PAH) PRESENT IN THE WSFS

Parameter	BRACKISH WATER		FRESH WATER		FEPA limit
	AGO	PMS	AGO	PMS	
TPH (mgL ⁻¹)	6.34	4.03	6.33	4.02	10.00
PAH Components					0.00
Acenaphthalene (mg L ⁻¹)	< 0.001	< 0.001	< 0.001	< 0.001	0.00
Benzo(k) fluroranthene (mg L ⁻¹)	0.000	< 0.001	0.000	< 0.001	0.00
Acenaphthylene (mg L ⁻¹)	0.000	< 0.001	0.000	< 0.001	0.00
Anthracence (mg L ⁻¹)	0.003	< 0.001	0.003	< 0.001	0.00
Benz(a) anthracene (mg L^{-1})	0.003	0.003	0.003	0.003	0.00
Benz(b) fluoranthene (mg L^{-1})	0.002	0.002	0.002	0.002	0.00
Benzo(ghi) perylene (mg L ⁻¹)	< 0.001	< 0.001	< 0.001	< 0.001	0.00
Benzo(a) pyrene (mg L ⁻¹)	0.001	< 0.001	0.001	< 0.001	0.00
Chrysene (mg L ⁻¹)	< 0.001	< 0.001	< 0.001	< 0.001	0.00
Dibenz(ah) anthracene (mgL ⁻¹)	< 0.001	< 0.001	< 0.001	< 0.001	0.00
Fluoranthene (mgL ⁻¹)	< 0.001	< 0.001	< 0.001	< 0.001	0.00
Fluorene(mgL ⁻¹)	< 0.001	< 0.001	< 0.001	< 0.001	0.00
Indoene $(1,2,3, cd)$ pyrene (mgL^{-1})	< 0.001	< 0.001	< 0.001	< 0.001	0.00
Phenthrene (mgL ⁻¹)	< 0.001	< 0.001	< 0.001	< 0.001	0.00
Pyrene (mgL ⁻¹)	< 0.001	< 0.001	< 0.001	< 0.001	0.00
Perylene (mgL ⁻¹)	< 0.001	< 0.001	< 0.001	< 0.001	0.00
Total (mgL ⁻¹)	0.009	0.005	0.009	0.005	0.00

Table 5: Total petroleum hydrocarbon (TPH) and Polycyclic Aromatic Hydrocarbon content

Key: nd- not detected

IIARD – International Institute of Academic Research and Development

The PAH components in the WSFs of AGO and PMS include Acenaphthalene, Benzo(k) fluroranthene, Acenaphthylene, Anthracence, Benz(a) anthracene, Benz(b) fluoranthene, Benzo(ghi) perylene, Chrysene, Dibenz(ah) anthracene, Fluoranthene, Fluorene, Indoene (1,2,3, cd) pyrene, Phenthrene, Pyrene, and Perylene (table 5)

PHYSICOCHEMICAL PARAMETERS OF WATER-SOLUBLE FRACTIONS

A physicochemical parameter study is very pertinent as it gives an exact picture of the quality of the water as the values obtained are compared to standard values. The quality of the water in this study was determined by a comparison of its physicochemical parameters with those of the FEPA permissible limit as stated by FEPA (1991) and Chinweuba et al(2024). These parameters are essential to monitor during hydrocarbon pollution in an ecosystem since they could adversely affect the survival of the organisms used as biomonitors. The concentration of hydrogen and hydroxyl ions in water causes many chemicals to be absorbed by crustaceans. The mean pH was 5.50±0.02 and 6.10±0.02 for the water soluble fractions of AGO and PMS in brackish water, respectively, while the mean pH was 5.30±0.02 and 5.80±0.02 for the water soluble fractions of AGO and PMS in freshwater, respectively. Most of the pH values obtained in both the fresh water and brackish water overlaying solutions were acidic and could have contributed to the toxicity of the automotive gas oil and petrol. Biological oxygen demand (BOD) is the amount of dissolved oxygen required by aerobic microorganisms to break down or oxidise organic materials present in water. A high BOD implies a low DO because the DO is depleted by the microorganisms as they require it to break down the organic pollutant. The mean BOD obtained in this study was: Dissolved oxygen (DO) 5.00±0.01mg/l and 6.00±0.01mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively and Dissolved oxygen (DO) 5.60±0.01mg/l and 5.40±0.01mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater, respectively. These results were significantly different from each other. The dissolved oxygen content of the WSF was found to decrease below the Chinweuba et al(2024) and FEPA (1991) acceptable level of 5mg/l for water quality for the sustenance of aquatic organisms, which suggests contamination of the water by the huge amount of organic load (petroleum products), which requires a high level of oxygen for chemical oxidation and breakdown. The level of DO is influenced by temperature, pH, and BOD. The solubility of oxygen decreases as temperature increases. The dissolved oxygen tension in aquatic organisms in water contaminated with organic pollutants has been shown to be due to the diversion of the dissolved oxygen meant for respiration to the oxidation of organic pollutants. The extent of the depletion of oxygen in the water is often a function of the concentration of organic pollutants in it. Conductivity is a measure of the ability of water to pass electric current and is hence directly proportional to the levels of cations and anions present in it. Conductivity 28611.50±0.50µs/cm and 28609.00±0.50µs/cm for the water soluble fractions of AGO and PMS in brackish water, respectively, while conductivity 198.00±0.56µs/cm and 196.00±0.56µs/cm for the water soluble fractions of AGO and PMS in fresh water, respectively. Electrical conductivity (EC) was significantly lower in the WSF of Premium motor spirit and automotive gas oil in the WSF of fresh water when compared to the WSF of the brackish water habitat. Natural water contains a reasonable amount of dissolved salts, and the concentration of these salts varies from one water body to another. Electrical conductivity has also been correlated to the concentration of total dissolved solids (TDS) or salts, which typically include cations such as sodium, calcium, magnesium, potassium, and anions such as chloride, sulphate and bicarbonates. Total suspended solids (TSS) are solid materials that include organic and inorganic materials that are suspended in

water. This includes silt, algae, plankton, and bacteria (Murphy, 2007). TSS is a significant factor in observing water quality. High concentrations of TSS can lower water quality by making it less clear and absorbing light; the water then becomes warmer, which reduces its ability to hold oxygen necessary for aquatic life. Also, because TSS absorbs light, the level of light penetration will dwindle, which has been shown to reduce the rate of photosynthesis in aquatic plants with an attendant decrease in dissolved oxygen production. The TSS observed in this study shows that Total suspended solids (TSS) 60.98±0.14mg/l and 58.84±0.14mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water, respectively, while Total suspended solids (TSS) 21.10±0.14mg/l and 19.20±0.14mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater, respectively, and were slightly above the permissible limit of 30mg/l as stated in FEPA (1991) and Chinweuba et al(2024). This confirms the presence of pollution in the WSF from petroleum hydrocarbons for both habitats. Turbidity is the optical determination of water clarity. The turbidity observed in this study shows that the mean turbidity 44.80±0.10NTU and 43.80±0.08NTU were obtained for the water soluble fractions of AGO and PMS in brackish water, respectively, and Turbidity 20.85±0.10NTU and 19.95±0.08NTU were obtained for the water soluble fractions of AGO and PMS in freshwater, respectively, while when compared to the permissible limit of 1NTU stipulated by FEPA, it exceeded it. This result confirms the presence of pollutants at the test site. Turbidity can also inhibit photosynthesis by blocking sunlight. Halted photosynthesis means a decrease in plant survival and reduction in DO output level. Exchangeable ions analysed include cations and anions. Exchangeable ion concentrations ranged from Salinity 13110.28mg/l and 13105mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while Salinity 10.28mg/l and 10.19mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, Nitrate 3.89±0.4mg/l and 3.78±0.00 mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while Nitrate 4.42±0.4mg/l and 6.02±0.4mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, Sulphate 5.24±0.01mg/l and 3.74±0.10mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while Sulphate 3.47±0.01mg/l and 3.47±0.10mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively Hydrogen carbonate 14.30±0.20mg/l and 13.68±0.20mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while Hydrogen carbonate 14.10±0.01 mg/l and 13.68±0.01mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, Calcium 1.02±0.00mg/l and 0.91±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while Calcium 0.91±0.00mg/l and 0.91±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, Magnesium 1.58±0.00mg/l and 1.21±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while Magnesium 1.21±0.00mg/l and 1.60±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively Ammonium 0.29±0.01mg/l and 3.44±0.01 mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water, respectively, while Ammonium 0.16±0.01mg/l and 3.31±0.01mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater, respectively. Ammonium in the overlaying solutions in both environments tested for the WSFs of PMS was relatively high, and it is known to be toxic to aquatic life at increased concentrations; its toxicity is complicated by temperature and pH. There was no change in the concentration of ammonium for WSFs of AGO in both habitats, which indicates that it was absent in AGO. Generally higher values were observed for cations and anions in the WSF of the pollutant than in the control water, although both results were

found to fall within the maximum permissible limit stipulated by FEPA (1991). Therefore, there is a significant difference between the concentrations of cations and anions (p<0.05) in both WSF of the toxicants in the two habitats. Therefore, the result of this study confirms the presence of organic pollutants (petroleum products) in the water soluble fractions.

HEAVY METAL CONCENTRATION IN WATER-SOLUBLE FRACTIONS

Heavy metals are trace metals, of which some are required for proper body maintenance mechanisms. However, their presence in excess amounts results in their bioaccumulation and toxicity because of their non-biodegradable nature. Results obtained from this study showed that there were detectable amounts of heavy metals in the water-soluble fractions of petroleum hydrocarbons. The average heavy metal concentration in water-soluble fractions of petroleum hydrocarbons is shown in Table 4. A total of nine heavy metals were analysed, namely iron (Fe), cadmium (Cd), chromium (Cr), nickel (Ni), zinc (Zn), manganese (Mn), copper (Cu), vanadium (V), and lead (Pb). Both water soluble fractions of petroleum hydrocarbons in the two habitats contained a detectable amount of metal elements analysed in varying concentrations Heavy metals were also detected in all the WSFs (Table 4). Iron (Fe), 0.08±0.00mg/l and 0.08±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while iron (Fe) 0.08±0.00mg/l and 0.08±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, zinc (Zn), 0.07±0.00mg/l and 0.08±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while zinc (Zn), 0.07±0.00mg/l and 0.08±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater copper (Cu) 0.02±0.00mg/l and 0.03±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while copper (Cu) 0.02±0.00mg/l and 0.03±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, Manganese (Mn) 0.16±0.01mg/l and 0.28±0.01mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while Manganese (Mn) 0.16±0.01mg/l and 0.28±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, chromium (Cr) 0.01±0.00mg/l and 0.01±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while chromium (Cr) 0.01±0.00mg/l and 0.01±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively cadmium (Cd) 0.01±0.00mg/l and (nd) mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while cadmium (Cd) 0.01±0.00mg/l and (nd) mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, lead (Pb) 0.01±0.00mg/l and 0.01±0.00mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while lead (Pb) 0.01±0.00mg/l and 0.01±0.00 mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, nickel (Ni) 0.01±0.00mg/l and 0.01±0.00 mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while nickel (Ni) 0.01±0.00 mg/l and 0.01±0.00 mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively, vanadium (V) was not detected for the water soluble fractions of AGO and PMS in brackish water and freshwater respectively. The maximum permissible limits defined by FEPA (1991), Nwankwo et al (2025) and Oragwu et al (2024) were used to assess the potential health risk of heavy metals in the polluted water.

Edema (2006) also reported that heavy metals detected in the WSF of crude oil include Pb, Cu, Zn, Cd, Ni, Cr, and V. Cadmium and lead have been reported as the most toxic heavy metals in the aquatic ecosystem (Van den Broak *et al.*, 2002) Ochie *et al*(2025) and Okwuego *et al* (2025.

The presence of heavy metals in water-soluble fractions invariably confirms levels of pollution by petroleum hydrocarbons, AGO, and PMS.

TOTAL PETROLEUM HYDROCARBON CONTENT (TPH) IN WATER

A comparison between Total petroleum hydrocarbon content (TPH) in water soluble fractions of the two toxicants clearly indicates a significant difference (p<0.05) between TPH for both study habitats. The mean values of total petroleum hydrocarbons (TPH) 6.34 ± 0.00 mg/l and 4.03 ± 0.00 mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water, respectively, while Total petroleum hydrocarbons (TPH) 6.33 ± 0.00 mg/l and 4.02 ± 0.00 mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water, respectively, while Total petroleum hydrocarbons (TPH) 6.33 ± 0.00 mg/l and 4.02 ± 0.00 mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater, respectively. The TPH levels in oil-polluted water soluble fractions were below the maximum permissible limit of 10mg/l given by FEPA (1991), Nwankwo *et al* (2025), Ochie *et al*(2025) and Okwuego *et al* (2025). The presence of TPH confirms the occurrence of oil pollution in the water soluble fractions.

PAH CONCENTRATIONS IN WATER

The bioavailability of PAHs depends largely on their molecular mass; hence, their solubility decreases as their molecular masses increase (Johnsen et al., 2005). The mean concentration of PAHs analysed in water soluble fractions were Polycyclic Aromatic Hydrocarbon (PAHs) 0.009±0.001mg/l and 0.005±0.01 mg/l were obtained for the water soluble fractions of AGO and PMS in brackish water respectively while similar result Polycyclic Aromatic Hydrocarbon (PAHs) 0.009±0.001mg/l and 0.005±0.001mg/l were obtained for the water soluble fractions of AGO and PMS in freshwater respectively. This could also have contributed to the toxicity of the petroleum products. The PAH components in the WSFs of AGO and PMS include Acenaphthalene, Benzo(k) fluroranthene, Acenaphthylene, Anthracence, Benz(a) anthracene, Benz(b) fluoranthene, Benzo(ghi) perylene, Chrysene, Dibenz(ah) anthracene, Fluoranthene, Fluorene, Indoene (1,2,3, cd) pyrene, Phenthrene, Pyrene, and Perylene. This indicates a significant difference in levels of PAHs in both WSFs of the petroleum hydrocarbons in both habitats. The levels of PAHs in watersoluble fractions well exceeded the maximum permissible limit stipulated by FEPA (1991). Bostrom et al. (2002) reported the carcinogenic effects of PAHs in animal studies, with findings that PAHs have been linked to skin, lung, bladder, and stomach cancers. This suggests that the presence of PAH constitutes a risk to living organisms in the WSF from both sources and also confirms the presence of petroleum pollutants in water-soluble fractions. The results of this study are consistent with other studies. Edema and Okungbowa (2012) that analysed the WSFs of two crude oil samples and detected the presence of Fe, Cu, Cr, Pb, V, Zn and Mn. Edema, (2009) analysed the WSF of crude oil from Ogini well-head and found it to contain the following ions, Na^+ , Mg^{2+} , Ca^{2+} , NH_4^+ , NO_3^- , Cl^- and SO_4^{2-} . It was found that Fe, Cd, Pb, Mn, Ni and V were present. Similar results were obtained by Edema (2012). When the ionic characteristics of water soluble fractions of Olomoro well-head crude oil was analysed, it was found to contain the cations Ca2+, Mg²⁺, Na⁺ and K⁺ and NH4⁺ and the anions Cl⁻, SO4²⁻ and NO3⁻. Heavy metals present include Cr, Pb, Cu, Zn, Mn and V. Analysis of ionic contents of WSF of Amukpe well-head crude oil showed the presence of Cl⁻, NO3⁻, SO42⁻, HCO3⁻, Na⁺, K⁺, Ca²⁺ and Mg²⁺. The study also found the heavy metals, iron, copper, manganese, chromium, lead, vanadium and zinc. This is consistent with the result of this study. The presence of heavy metals in petroleum and products refined from it have been traced to source rocks and depended on the geological age of the rocks Okorie E.A et al (2025) (Ahmad, et al, 2010 and Oti, 2016). Studies of the ionic characteristics of WSFs of Automotive gas oil (AGO) and Premium motor spirit (PMS) are scarce but the analysis

of the refined products showed the presence of Cd, Cr, Cu, Pb and Zn (Akpoveta and Osakwe, 2014). According to Tijjani, Ike, Usman, Malami and Matholo (2012), automotive gas oil (AGO) showed higher concentration of the heavy metals Cu, Zn, Mn, Si, Na and Fe than Premium motor spirit (PMS). The study reported a higher constitute of TPH in WSF of Premium motor spirit (PMS) than in Automotive gas oil (AGO). This study showed higher TPH concentration in WSF of Automotive gas oil (AGO) than in Premium motor spirit (PMS) Okwuego, et al (2021). High levels of metals such as Zn, Cr, Fe, Hg, Mn and Pb are associated with petroleum polluted waters (Achudume, 2009). Refinery effluents contain NH_4^+ , NO_3^- and SO_4^{2-} including the heavy metals Ni, Pb, Zn, Fe, Cu and Cr. Ground water contaminated with petroleum products showed high level of chemical pollutants (Nwachukwu et al, 2014) and Ochie et al (2025). In addition to changes in chemical characteristics, there were variations in physical characteristics of the WSFs such as pH, EC, TDS, Turbidity, DO and BOD. Several studies show that petroleum pollution cause changes in physical characteristics of water (Achudume, 2009; Aghoghovwia, 2011; Uzoekwe et al, 2011). The WSF of automotive gas oil had the highest TPH content followed by WSF of Premium motor spirit (PMS). This finding is consistent with that of Pinedo, Ibanez, Lijzen and Irabien (2013), which observed higher TPH concentration in crude oil, than refined petroleum products with Premium motor spirit (PMS), however having the least TPH concentration. Although some heavy metals are considered toxic, others play important roles in metabolic processes in living organism. Trace elements such copper, cobalt, nickel, zinc, chromium and manganese are essential for growth and normal development of plants and are involved in many enzymatic metabolic reactions (Rusin, et al, 2015). Others such as cadmium, lead and mercury are toxic to plants even in low concentrations (Lee et al, 2010). The heavy metal content of the WSFs in this study are within the maximum permissible limits set by WHO (2011). Similar results were also obtained by Edema (2012). While EC, Turbidity and TDS are within the maximum limit set by WHO (2011), others such as pH and DO are below the limit while BOD is above the limit. There is no generally set maximum limit to cover all TPH constituents. Limits are set for each hydrocarbon component based on several factors. Examples include benzene 10µgL-1, toluene 700µgL-1 ethylbenzene 300 µgL-1 and xylene 500 µgL-1. For aromatic with carbons atoms between 12 - 35 acceptable maximum limit is 0.09mgL-1 (UNEP, 2011).

4. CONCLUSION

Physicochemical monitoring involves the temperature, level of suspended solids, total dissolved solids, turbidity, hardness, conductivity, pH, Biochemical Oxygen Demand (BOD) and at times Chemical Oxygen Demand (COD). Pollutants in water and depending on the concentration give negative readings of these physical factors. Oil pollution altered the physical and chemical properties of water. This has significant implication for aquatic ecosystems especially for aquatic flora and fauna. Oil spillages which are frequent in the Niger-Delta region of Nigeria lead to pollution of streams, rivers and ponds which the communities hosting oil facilities depend on. Regular monitoring of such water bodies was therefore recommended.

Oil companies must ensure that they maintain high standard of cooperation to reduce accident that leads to oil spills.

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