Total Petroleum Hydrocarbon Fractions (Components) In Surface Water and Sediments of Edagberi River, Niger Delta, Nigeria

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Abstract: **The presence of total petroleum hydrocarbons through randomly collected water and sediment samples of Edagberi River, Niger Delta, Nigeria. four stations were chosen for the study for a period of four months to appreciate the level of pollution caused by total petroleum hydrocarbons in the river. The extraction of the samples were done by the use of Dichloromethane and soxhlet apparatus and then cleaned up for analysis. Gas Chromatography-Flame Ionisation Detector (GC-FID) was used for the analysis of the samples. The results of the analysis revealed that total petroleum hydrocarbon fractions ranged between not detected to 1.7555±0.24 mg/L, and total petroleum hydrocarbons ranged between 5.8351±0.145 to 8.0639±0.806 mg/L in the surface water of the stations and ranged between not detected to 1.9392±0.51 mg/L for the hydrocarbon fractions and the total ranged from 2,4758±0.119 to 10.0085±1.299 mg/L for the months. In the sediments, hydrocarbon fractions ranged between not detected to 6.5225±1.62 mg/Kg, and the total ranged between 16.5242±0.558 to 34.8146±5.01 mg/Kg in the stations and ranged between not detected to 9.4845±2.01 mg/Kg for the hydrocarbon fractions, while the total ranged between 17.6765±1.951 to 30.7649±6.586 mg/Kg in the months. In the surface water GRO ranged between 0.0068±0.00 to 1.0285±0.46 mg/L, DRO; 3.3578±0.043 to 5.8944±0.728 mg/L and Lube oil ranged between 1.1796±0.038 to 2.8968±0.123 mg/L in the stations and in the months, GRO; not detected to 1.3009±0.075 mg/L, DRO; 1.1749±0.044 to 7.2128±1.236 mg/l. In the sediments, GRO; not detected to 5.7613±0.195 mg/Kg, DRO; 11.5140±0.350 to 27.9502±4.777 mg/Kg, Lube oil; 1.1031±0.038 to 4.1914±0.202 mg/Kg in the stations and in the months, GRO; 0.1704±0.001 to 4.0760±0.126 mg/Kg, DRO; 12.9612±1.377 to 26.7806±6.50 mg/Kg and Lube oil; 0.5633±0.002 to4.5449±0.573 mg/Kg. Although the presence of total petroleum hydrocarbons is within acceptable limits of DPR, FME and EGAPSIN in the Edagberi River, adequate steps need to be taken to forestall any impending danger that its presence may pose on the aquatic inhabitants.**

Keywords: **Edagberi River, sediments, surface water, total petroleum hydrocarbons, partition coefficient**

I. INTRODUCTION

The rise in the exploration and exploitation of crude oil in Nigeria has led to a notable increase in pollution and degradation of our natural environments such as rivers, lakes, oceans and other water bodies. The remarkable effect of oil exploration can also be seen visible in the soil and the air. This has negatively affected the ecology of the Niger Delta and its inhabitants (Adewuyi *et al*., 2011). Since the discovery of oil in Oloibiri, presently in Bayelsa State of Nigeria in 1956, it has been the main stay of the Nigerian economy. The crude oil production has brought about significant pollution to the environment from the numerous products associated with it (Ali *et al*., 2019). Among the many products of crude oil is total petroleum hydrocarbons (TPH), which is a mixture consisting of benzene, xylene, hexane, toluene, naphthalene, gasoline and other components (Akpaden and Enin, 2016).

Water quality has been greatly compromised and therefore pose great economic consequences to the growth of water dependent industries. The activities of industries that are involved in petroleum production has contributed majorly in degradation of the aquatic environment (Jackson *et al*., 2006: UNEP, 2011). The issue of water quality is of great interest and utmost importance to the inhabitants of the Niger Delta Area of Nigeria, where the surface water and the sediments have been greatly contaminated due to oil production and other forms of human activities. The wide spread demand for petroleum products such as fuel oil, gasoline, kerosene, asphalt and mineral oil has led to an unquantifiable contamination of the environment (Moslen and Miebaka, 2017). Water pollution, especially when it affects rivers leads to the compromise of recreational, economic, domestic, nutritional and the ecological values the rivers provide to inhabitants along the coast and other users of the affected river (Isibor and Freeman, 2016).

The pattern of life of the inhabitants also contribute to the pollution and contamination of our rivers. The aquatic environment can easily be polluted, the wastes from nearby surroundings easily find their ways into the aquatic environments. Wastes, sewage and effluents can easily assess the river through runoffs (Ashiru and Ogundare, 2019). The river can also be polluted with total petroleum hydrocarbons through leakage of underground oil pipes and tanks, inappropriate handling of equipment (Akpaden and Enin, 2016), transportation activities, petroleum production and the process of refining and consumption of the products (Al-Khafaji, 2007). Other activities of man that bring about river contamination/pollution by total petroleum hydrocarbons include, refining for self-sustenance (artisanal refining) and unlawful dealing on petroleum products (illegal bunkering),

gas flaring, directly dumping of crude oil waste into the water bodies (Alinnor *et al*., 2014).

The pollution of rivers by total petroleum hydrocarbons causes oxygen deficiency, nutrients availability, asphyxiation, toxic effect, smothering or coating of the water surface which may result in death of of organisms, osmoregulation, affecting the population of species (Mendelssohn *et al*., 2012; Whitehead, 2013). The process of photosynthesis and transpiration in plants are hampered due to the penetration and blocking of the pores of leaves (Jinadu, 1989). Pollution due to petroleum hydrocarbons impairs growth and hinders development several marine organisms (Moslen and Miebaka, 2016), and its continuous contamination may lead to death of both plants and animals in the aquatic environment, which is a common occurrence in the Niger Delta region of Nigeria (Dambo, 1992). The contamination of the river (surface water and sediments) consequently lead to loss of species and biodiversities associated with rivers. The food chain cycles are lost during contamination and hence creating a new pattern of life for aquatic organisms (Burton, 2002; Markcovic, 2003).

The purpose of this work is to determine the contamination/pollution level of Edagberi River by total petroleum hydrocarbons and to provide information concerning the total petroleum hydrocarbon status of the river and proffer possible solutions from the findings.

II. MATERIALS AND METHODS

Study Area and Sample Site

The Edagberi River is located in the Ahoada West Local Government Area of Rivers State, Nigeria. The river is situated between the boundary of Rivers State and Bayelsa State. The Ahoada West Local Government Area is bounded by Yenagoa Local Government Area in the west and Ogbia Local Government Area in the south west (both local governments are from Bayelsa State), it is bounded in the east by Ahoada East Local Government Area, in the north by Ogba/Egbema/Ndoni Local Government Area and in the south by Abua/Odual Local Government Area, all in Rivers State. the river is locate between latitude 8^{o} $40^{'}$ 21.6''E and 8^{o} $41^{'}$ 26.8"E and 7^{o} $36^{'}$ 16.6"N and 7^{o} $37.2^{'}$ 18.2"N. All the local governments surrounding the river are hosts to multinational oil companies.

Four sites were chosen for sampling along the river at intervals of 2-2.5km. The sample points were selected at points easily assessable to the researcher along the coast of the river. The occupation of the inhabitants that dwell along the river coast is mainly fishing and farming. Human activities within the coast includes petty commercial trading, unauthorized crude refining, transportation/recreation activities and sand dredging.

Surface Water Sampling

Water samples were collected at a depth of 50cm from each of the four sampling sites/stations with the aid of a glass bottle and sealed with cork under the water surface. From each collection site/station, four samples were collected and pooled together to form a composite sample. Hydrochloric acid was used in preserving the collected water samples which was then stored in a one litre glass bottle that was first washed with and rinsed with dimethane chloride. The water samples collected were put into an ice park container and then taken to the laboratory and was stored at a temperature of about 4^{o} C pending time of analysis.

Sediment Sampling

A core sediment grab sampler was used to collect sediment samples from the four selected sites/stations about 6-12cm depth within the river. In each sampling site, four samples were collected and combined together to form a composite sample of 360g. In order to avoid contamination, properly washed glass bottle (clear and plain) were used to keep the sediment samples and stored in an ice park at 4^{o} C for the analysis of total petroleum hydrocarbons. The sampling method was repeated for every sample site/station. Thereafter the sampled sediment was taken to the laboratory for analysis at interval period of two weeks after collection.

Extraction of Water Samples, Total Petroleum Hydrocarbon Determination, Sample Clean-up Separation and Detection

Filtered water samples were passed through the process of extraction by the use of separatory funnel. One litre sample of water that was previously filtered was poured into a separatory funnel with a glass stopper containing about 40 ml dichloromethane (DCM) which is the solvent used in extraction. In order to totally separate the organic layer from the aqueous layer, the separatory funnel was shaken vigorously for a period of 6-10 minutes. The components that has been equilibrated in the separatory funnel was kept for about 10 minutes to settle out. In each of the sample, the extraction procedure was repeated for at least three times. Filtration was used to separate the phases, leaving out the organic layer. The use of rotary evaporator with water bath under temperature of 40^{o} C was used to concentrate every sample extract. The extracts that were concentrated were then transferred to a previously weighed bottle and then allowed to evaporate to dryness (Manahan, 2003; LAWI, 2011).

The extracted water sample was put into a chromatographic column that is packed with silica gel slurry and 3cm anhydrous sulphate layer at the top to completely remove any polar organic substance that may be in the solvent. With 25ml n-hexane, the column of the chromatography was eluted in order to get the various hydrocarbon components. The eluates were concentrated to 3ml with the aid of a rotary evaporator at 4^{o} C to evaporate to dryness. The method of Maioli *et al*., (2011) was then used in treating the samples.

A prepared 4ml terachloroethylene was used to dissolve the extract and an Agilent 6890 gas chromatography with flame ionization detector (GC-FID) was then used in the determination of the concentration of total petroleum

hydrocarbons components in the water samples of the river. The temperature of the detector was kept at 350^{o}C. The GC-FID measured the total petroleum hydrocarbons concentration by summing up all the aliphatic and aromatic hydrocarbons.

Sediment Samples: Extraction and Clean-up Procedure

100g of the composite sample was measured out after the sample have been air dried. A properly sieved and homogenized part of the dried sample was put into a filter paper and then loaded with the aid of a thimble into a soxhlet extractor. The solvent for extraction is Dichloromethane. At the end of 24 hours the extract was taken out and concentrated through the use of a rotary evaporator at 40 ^{o}C. The collection of the extract was done using a bottle that was weighed previously. The collected extract was then evaporated to dryness using the method of Saari *et al*., (2007).

A column chromatography was prepared and cleaned up and the sample treated as in the case of surface water sample according to the method of Maioli *et al*., (2011). Then an Agilent 6890 gas chromatography with flame ionization detector (GC-FID) was used to analyze the extract. The determination of the concentration of total petroleum hydrocarbons in the sediment sample was done by using 3 ml of the concentrated extract. The detector temperature was fixed at 400^{o}C and the concentration of the total petroleum hydrocarbons components in the sediment samples were measured as the sum of the aliphatic and the aromatic hydrocarbons.

III. RESULTS AND DISCUSIONS

The results of the mean individual component concentrations of total petroleum hydrocarbon fractions in the surface water of Edagberi River are shown in Tables 1 and 2. Table 1 presented the fractional components of total petroleum hydrocarbons in the various stations while Table 2 showed the fractional components in months. The concentrations of the total petroleum hydrocarbon fractions ranged from BDL to 1.3152±0.05 mg/L and a total of 5.8351±0.145 mg/L in station 1, station 2, ranged between not detected to 0.8169±0.013 mg/L for the fractional components and a total of 6.5468±0.166 mg/L, station 3; ranged between not detected to 1.7555±0.24 mg/L for the fractional components and a total of 6.7046±0.904 mg/L and in station 4; total petroleum hydrocarbon fractions ranged between not detected to 1.0869±0.10 mg/L. the hydrocarbon fractional components in December ranged from not detected to 0.8266±0.045 mg/L and a total of 2.4758±0.119 mg/L, in February, the fractional components ranged from not detected to 1.7101±0.09 mg/L and a total of 4.8848±0.455 mg/L, in April, fractional components ranged from not detected to 1.7180±0.52 mg/L and a total of 8.7601±1.677 mg/L and in June, fractional components ranged between not detected to 1.9392±0.51 mg/L and a total of 10.0085±1.299 mg/L.

According to the classification of Dibofori-Orji *et al*., (2018), Gasoline range organic (GRO) is between C_6-C_{10}, Diesel range organic is between C_{11}-C_{28} and Lube oil range is between C_{29}-C_{40}. The total GRO in the stations showed that station 1; 0.0068±0.00 mg/L, station 2; 0.2922±0.01 mg/L, station 3; 1.0285±0.46 mg/L and station 4; 0.9899±0.04 mg/L. in the months, December; 1.3009±0.075 mg/L, February; not detected, April; 0.0068±0.00 mg/L and June; not detected. The total DRO in the stations showed that station 1; 4.5691±0.131 mg/L, station 2; 3.3578±0.043 mg/L, station 3; 3.9208±0.204 mg/L and station 4; 5.8944±0.728 mg/L. in the months, totals were, December; 1.1749±0.044 mg/L, February; 3.3788±0.222 mg/L, April; 5.9653±1.144 mg/L and June; 7.2128±1.236 mg/L. The total Lube oil range in the stations revealed that station 1; 1.2592±0.123 mg/l, station 2; 2.8968±0.123 mg/L, station 3; 1.7555±0.24 mg/L and station 4; 1.1796±0.038 mg/L. In the months, December; not detected, February; 1.5070±0.233 mg/L, April; 2.7880±0.533 mg/L and June; 2.7957±0.63 mg/L.

The results in Tables 1 and 2 showed that Diesel range organic had the highest concentration followed by lube oil range and then Gasoline range organic. This observation may be due to the fact that most illegal artisanal refining sites within the area produce diesel range than the other ranges. The volatile nature of the lower fractions may have also accounted for its low presence in the river (Daniel and Nna, 2016; Edori and Kpee, 2019). The nature of the hydrocarbon pollution in the river samples may have suggested that the origin is anthropogenic (Daniel and Nna, 2016). The average of the total petroleum hydrocarbons in this study is lower than the recommended allowable limit of 10 mg/L of the Directorate of Petroleum Resources (DPR, 2011). The results obtained in this study falls between the same range obtained by Edori and Kpee (2019) and higher than that obtained from water samples in River Ethiope in Delta State, Nigeria which was between (0.004±0.003-0.008±0.008) mg/L (Ikpe *et al*., 2016). The results were far lower than that obtained by Wokoma (2014), from the surface water of a polluted tidal creek of the range 15.6±1.86-23.4±2.55 mg/L. Odd hydrocarbon fractions of C_{21}-C_{39} were not detected in this study.

Table 1: Mean (X ± SD) concentrations (mg/L) of Total Petroleum Hydrocarbons in Surface water of Edagberi River from different Stations

Carbon Length	Stations			
	1	2	3	4
C8	-	0.2356±0.01	-	0.1477±0.03
C9	0.0016±0.00	0.0400±0.00	1.0285±0.46	0.0322±0.00
C10	0.0052±0.00	0.0166±0.00	-	0.8100±0.01
C11	0.0059±0.00	0.0552±0.001	-	0.2592±0.002
C12	0.0109±0.001	0.2337±0.003	-	0.2194±0.001
C13	0.0087±0.00	0.1973±0.001	-	0.1402±0.002
C14	0.0032±0.00	0.0699±0.001	-	-
C15	0.0053±0.00	-	-	-
C16	0.0018±0.00	-	-	-

C17	0.0261±0.00	0.0639±0.00	-	-
C18	0.1940±0.004	0.4318±0.01	-	0.0443±0.00
C19	1.1783±0.06	0.1280±0.003	0.0933±0.001	0.6956±0.016
C20	0.8592±0.009	0.7354±0.002	0.3403±0.003	1.0196±0.50
C21	-	-	-	-
C22	0.1937±0.001	0.3904±0.001	0.1139±0.00	0.5647±0,007
C23	-	-	-	-
C24	0.1368±0.00	0.2439±0.001	0.6990±0.08	0.9722±0.04
C25	-	-	-	-
C26	1.3152±0.05	0.5370±0.002	1.3530±0.03	0.8930±0.06
C27	-	-	-	-
C28	0.6300±0.004	0.2722±0.003	1.3211±0.09	1.0862±0.10
C29	-	-	-	-
C30	0.6153±0.003	0.8169±0.013	1.7555±0.24	1.0690±0.036
C31	-	-	-	-
C32	0.1835±0.001	0.5904±0.010	-	0.1106±0.002
C33	-	-	-	-
C34	0.4529±0.01	0.7645±0.02	-	-
C35	-	-	-	-
C36	0.0066±0.00	0.7250±0.08	-	-
C37	-	-	-	-
C38	0.0007±0.00	-	-	-
C39	-	-	-	-
C40	0.0002±0.00	-	-	-
Total	5.8351±0.145	6.5468±0.166	6.7046±0.904	8.0639±0.806

Table 2: Mean (X ± SD) Concentrations (mg/L) of Total Petroleum Hydrocarbon in Surface Water of Edagberi River within the Sampled Months

Carbon Length	Months			
	December	February	April	June
C8	0.3986±0.003	-	-	-
C9	0.0757±0.00	-	0.0016±0.00	-
C10	0.8266±0.045	-	0.0052±0.00	-
C11	0.3144±0.012	-	0.0059±0.00	-
C12	0.4531±0.02	-	0.0109±0.001	-
C13	0.3375±0.01	-	0.0087±0.002	-
C14	0.0699±0.002	-	0.0032±0.00	-
C15	-	-	0.0053±0.00	-
C16	-	-	0.0018±0.00	-
C17	-	-	0.0261±0.00	0.0639±0.001
C18	-	-	0.0577±0.001	0.6125±0.01
C19	-	1.0384±0.08	0.5565±0.06	0.5004±0.05
C20	-	0.0247±0.00	1.4150±0.13	1.5004±0.061
C21	-	-	-	-
C22	-	0.5087±0.05	0.6770±0.06	0.0769±0.001
C23	-	-	-	-
C24	-	0.0922±0.002	0.6242±0.08	1.3354±0.04
C25	-	-	-	-
C26	-	1.7101±0.09	1.0576±0.43	1.3304±0.006
C27	-	-	-	-
C28	-	0.0047±0.00	1.5263±0.38	1.7785±0.50
C29	-	-	-	-
C30	-	0.5993±0.15	1.7180±0.52	1.9392±0.51
C31	-	-	-	-
C32	-	0.0140±0.001	0.6096±0.009	0.2607±0.03
C33	-	-	-	-
C34	-	0.1687±0.012	0.4529±0.004	0.5958±0.09
C35	-	-	-	-
C36	-	0.7250±0.07	0.0066±0.00	-
C37	-	-	-	-
C38	-	-	0.0007±0.00	-
C39	-	-	-	-
C40	-	-	0.0002±0.00	-
Total	2.4758±0.119	4.8858±0.455	8.7601±1.677	10.0085±1.299

The concentrations of individual fractional components of total petroleum hydrocarbons in the sediments of Edagberi River is shown in Tables 3 and 4. Table 3 showed the fractional components in the stations while Table 4 showed in months. The concentration of total petroleum hydrocarbons fractional components revealed that station 1 ranged between not detected to 1.8307±0.10 mg/Kg, station 2; not detected to 10.5627±2.06 mg/Kg; station 3; not detected to 6.5225±1.62 mg/Kg and station 4; not detected to 5.9112±1.56 mg/Kg. In the months, individual components concentration ranged between not detected to 9.4845±2.01 mg/Kg in December, not detected to 5.6783±1.01 mg/Kg in February, not detected to 2.3280±0.51 mg/Kg in April and not detected to 6.0373±2.10 mg/Kg in June. The total petroleum hydrocarbons in the stations were, station 1; 16.5242±0.558 mg/Kg, station 2; 34.8146±5.01 mg/Kg, station 3; 21.6727±3.243 mg/Kg and station 4; 20.5157±3.02 mg/Kg. in the months, December; 23.6056±2.535 mg/Kg, February; 19.9945±1.699 mg/Kg, April; 17.6765±1.951 mg/Kg and June; 30.7649±6.586 mg/Kg.

Grouping the fractional components according to Dibofori-Orji *et al*., (2018), revealed that Gasoline range organic (GRO), for station 1; 0.8188±0.006 mg/Kg, station 2; 5.7613±0.195 mg/Kg, station 3; not detected and station 4; 1.8081±0.011 mg/Kg. In the months, December;

4.0760±0.126 mg/Kg, February; 3.9531±0.25 mg/Kg, April; 0.1704±0.001mg/Kg and June; 1.8081±0.011 mg/Kg. Diesel range organic (DRO) in the stations were, station 1; 11.5140±0.350 mg/Kg, station 2; 27.9502±4.777 mg/Kg, station 3; 20.2744±3.193 mg/Kg and station 4; 26.7806 mg/Kg. In the months, December; 18.4433±2.372 mg/Kg, February; 15.4781±1.447 mg/Kg, April; 12.9612±1.337 mg/Kg and June; 26.7806 mg/Kg. Lube oil range for the stations, station 1; 4.1914±0.202 mg/Kg, station 2; 1.1031±0.038 mg/Kg, station 3; 1.3982±0.05 mg/Kg and station 4; 2.1762±0.075 mg/Kg. In the months, December; 1.0863±0.037 mg/Kg, February, 0.5633±0.002 mg/Kg, April; 4.5449±0.573 mg/Kg and June; 2.1762±0.075 mg/Kg.

The results in Tables 3 and 4 revealed that diesel range organic > Lube oil range > Gasoline range organic. This may be due to the volatile nature of the Gasoline range organic (low molecular weight, ranging between $C_6 - C_{10}$). The level of contamination of total petroleum hydrocarbons in the sediments of this work is within the range of values approved by the Federal Ministry of Environment which is 30 mg/Kg (FME, 1991) and that of Environmental Guidelines and Standard for Petroleum Industry in Nigeria (EGAPSIN, 2002), of 50 mg/Kg. The average value recorded in the Edagberi River fall below what Samuel and Ayodele (2014) obtained from the study of Benin River, Edo State, Nigeria which was 41900 mg/Kg. The recorded value of Edori and Marcus (2019), in Taylor Creek were between 23.642±12.399 – 30.768±10.850 mg/Kg in the various months were within the values of the present work.

In general, where oil exploration and production takes place, petroleum hydrocarbons are bound to contaminate and pollute the environment (Dibofori-Orji *et al.*, 2018). Petroleum hydrocarbons, whether it is present in surface water or sediments, has the ability to hinder lifeforms of aquatic organisms through bioaccumulation and blockade of olfactory cells (Al-Shwafi, 2008). Petroleum hydrocarbon pollution, due to illegal oil activities, unwanton discharge of petroleum products from illegal operators, and improper handling from transporters and those involved in oil business, the environment, especially the rivers becomes environmentally unfriendly to the inhabitants (Hafidz *et al*., 2012, Suratman et al, 2013). The presence of toal petroleum hydrocarbon fractions have posed great danger to the dwellers along the Edagberi River. This observation is corroborated by (Edori and Kpee, 2019, Edori and Marcus, 2019).

Table 3: Mean (X ± SD) concentrations (mg/Kg) of Total Petroleum Hydrocarbons in Sediments of Edagberi River from different Stations

Carbon Length	Stations			
	1	2	3	4
C8	0.2085±0.001	0.3713±0.004	-	2.8737±0.100
C9	0.2991±0.002	2.8333±0.101	-	0.2785±0.003
C10	0.3112±0.002	2.5567±0.09	-	0.2756±0.002
C11	0.1165±0.00	1.8957±0.006	-	0.0549±0.00
C12	0.0011±0.00	0.4021±0.03	-	0.9437±0.05
C13	0.8740±0.003	2.0587±0.68	-	0.1766±0.006
C14	0.0447±0.00	3.1033±0.79	0.9438±0.04	1.1010±0.07
C15	0.8184±0.001	0.4497±0.06	0.9621±0.02	0.8487±0.04
C16	0.6581±0.02	1.7750±0.18	1.8218±0.03	-
C17	0.8251±0.04	-	0.4805±0.05	0.1708±0.00
C18	0.2426±0.007	0.7014±0.05	6.5225±1.62	0.2407±0.003
C19	0.6481±0.05	4.4043±0.81	3.8249±0.91	0.3393±0.004
C20	0.6671±0.009	1.1179±0.10	2.0792±0.32	1.0942±0.032
C21	-	-	-	-
C22	1.4312±0.05	0.6548±0.009	0.5621±0.07	0.0436±0.00
C23	-	-	-	-
C24	2.5445±0.07	0.8109±0.002	1.5866±0.05	3.9617±1.00
C25	-	-	-	-
C26	1.8518±0.06	10.5627±2.06	0.2733±0.003	5.9112±1.56
C27	-	-	-	0.0069±0.00
C28	0.7908±0.04	0.0137±0.00	1.2177±0.08	0.5103±0.05
C29	-	-	-	-
C30	0.2005±0.001	0.6240±0.008	1.3982±0.05	0.7578±0.06
C31	-	-	-	-
C32	1.8307±0.10	0.4791±0.03	-	0.6907±0.04
C33	-	-	-	-
C34	1.8384±0.08	-	-	0.1263±0.00
C35	-	-	-	0.0263±0.00
C36	0.3218±0.021	-	-	0.0072±0.00
C37	-	-	-	0.0283±0.00
C38	-	-	-	-
C39	-	-	-	0.0477±0.00
C40	-	-	-	-
	16.5242±0.558	34.8146±5.01	21.6727±3.243	20.5157±3.02

Table 4: Mean (X ± SD) concentrations (mg/Kg) of Total Petroleum Hydrocarbon in Sediments of Edagberi River within the Sampled Months

Carbon Length	Months			
	December	February	April	June
C8	2.9117±0.11	-	0.1704±0.001	0.3713±0.003
C9	0.5775±0.004	2.2471±0.16	-	0.5862±0.001
C10	0.5868±0.012	1.7060±0.09	-	0.8506±0.007

C11	0.1715±0.00	1.1909±0.05	-	0.7049±0.01
C12	0.9449±0.06	-	-	0.4021±0.006
C13	0.9451±0.08	2.0587±0.23	0.1055±0.00	-
C14	1.3142±0.09	1.8140±0.10	0.7753±0.003	1.2893±0.031
C15	0.4618±0.002	-	1.3623±0.50	1.2547±0.04
C16	0.2353±0.001	-	1.0863±0.08	1.5574±0.50
C17	0.4061±0.02	-	0.7608±0.04	0.1046±0.001
C18	0.1764±0.001	0.6630±0.006	0.8306±0.02	6.0373±2.10
C19	1.2962±0.03	1.8600±0.11	0.5256±0.001	5.8089±2.09
C20	1.8491±0.022	0.6800±0,006	1.8814±0.05	0.5479±0.05
C21	-	-	-	-
C22	0.4819±0.004	0.0050±0.00	1.1362±0.06	1.0686±0.09
C23	-	-	-	-
C24	0.6583±0.05	0.5177±0.001	2.3280±0.51	5.4002±1.02
C25	-	-	-	
C26	9.4845±2.01	5.6783±1.01	1.0475±0.10	2.3887±0.56
C27	0.0069±0.00	-	-	-
C28	0.0111±0.002	1.0105±0.05	1.2921±0.05	0.2187±0.002
C29	-	-	-	-
C30	0.9303±0.033	0.1239±0.00	1.1735±0.07	0.7527±0.004
C31	0.0188±0.00	-	-	-
C32	0.0204±0.00	0.4394±0.002	2.2746±0.50	0.2411±0.001
C33	-	-	-	-
C34	0.0073±0.00	-	0.7750±0.002	1.1824±0.07
C35	0.0263±0.00	-	-	-
C36	0.0072±0.00	-	0.3218±0.001	-
C37	0.0283±0.001	-	-	-
C38	-	-	-	-
C39	0.0477±0.003	-	-	-
C40	-	-	-	-
Total	23.6056±2.535	19.9945±1.699	17.6765±1.951	30.7649±6.586

Table 5 showed the partition coefficient between the sediment and surface water of the Edagberi River. The result revealed that petroleum hydrocarbons have preference for sediments. Values obtained from the table above greater or equal to one indicated that more of that particular fraction was found in the sediment while values less than one indicated more of the fraction was found in the water sample. A dash indicated not found in both or one of the phases. Petroleum hydrocarbon fractions have affinity to the sediment phase due to its hydrophobic nature. During rainfall, the fractions mixes with mud and debris and when drifted to the rivers sinks to the bottom sediment (Adewuyi *et al*., 2011; Edori and Kpee, 2019), thereby increasing the concentration of the sediment more than that of the surface water. The results also showed that C_{30} fraction was more on the surface water as compared to the sediment in all the stations. This observation may possibly be that the C_{30} fraction is hydrophilic. Results from station 4, showed that C_{10}, C_{11}, C_{22}, C_{28} and C_{30} were more in the water phase. This may be due to disturbances and mode of flow associated with that part of the river. The sediment is where total petroleum hydrocarbon is reserved if pollution occurs in the river and therefore put the concentration of total petroleum hydrocarbon higher than that of the surface water (Kachel, 2008; Filho *et al*., 2013). Naturally, the sediment is the sink for pollutants in marine environment and hence the higher concentration as compared to the surface water (Udoh and Akpan, 2010).

Table 5: Partition Coefficient of Total Petroleum Hydrocarbon between Sediment and Water Phases in Edagberi River

Carbon Length	Stations			
	1	2	3	4
C8	-	1.58	-	19.46
C9	186.94	-70.83	-	8.65
C10	59.85	-154.02	-	0.34
C11	19.75	34.34	-	0.21
C12	0.10	1.75	-	4.30
C13	100	10.43	-	1.26
C14	13.97	40.40	-	-
C15	154.42	-	-	-
C16	365.61	-	-	-
C17	31.61	-	-	-
C18	1.25	1.62	-	5.43
C19	0.55	34.41	40.99	0.49
C20	0.78	1.52	6.11	1.07
C21	-	-	-	-
C22	7.39	1.69	4.94	0.08
C23	-	-	-	-
C24	18.60	3.32	2.27	4.07
C25	-	-	-	-
C26	1.41	19.67	0.20	6.62
C27	-	-	-	-
C28	1.26	0.05	0.92	0.47
C29	-	-	-	-
C30	0.33	0.76	0.80	0.71
C31	-	-	-	-

C32	9.98	0.81	-	6.25
C33	-	-	-	-
C34	4.06	-	-	-
C35	-	-	-	-
C36	48.76	-	-	-
C37	-	-	-	-
C38	-	-	-	-
C39	-	-	-	-
C40	-	-	-	-

IV. CONCLUSION

The study revealed the presence of total petroleum hydrocarbons in the Edagberi River at a very low level of concentration both in the surface water and the sediments. The level of contamination in comparison to DPR, FME and EGAPSIN were within acceptable limits both in the water and sediment mediums. The oil production and exploitation activities in the area brought about the contamination of the river by total petroleum hydrocarbons. The government should make adequate provision to checkmate these activities (legal or illegal) that has prevailed in the area over the years. This will help to forestall any impending danger that may arise on the part of the aquatic organisms of the river and humans that make use of the river on daily basis for life sustenance.

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