



Determination of total petroleum hydrocarbons status in sediment column of Kolo Creek, Ogbia, Bayelsa state, Nigeria

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Abstract

This study investigated the concentrations of total petroleum hydrocarbons in sediments of the Kolo Creek, Ogbia of Bayelsa State, Nigeria. The study was carried out to assess the level of pollution of the Creek by collecting samples from four different stations within the creek. The samples were extracted with dichloromethane (DCM) using soxhlet extraction apparatus followed by subsequent clean up in column chromatography and analyzed using Gas Chromatography-flame ionization detector (GC-FID) for the determination of total petroleum hydrocarbons (TPH). The study revealed that the concentrations of total petroleum hydrocarbons ranged from 102.5112 to 126.4288 mg/kg in January, 114.2975 to 140.6604 mg/kg in March and 127.8051 to 160.4837 mg/kg in May while the mean levels ranged from 114.8711±12.397 to 142.5244±14.050 mg/kg during the months of investigation. The order of occurrence of total petroleum hydrocarbons in the stations were 4 > 2 > 1 > 3. The mean values of total petroleum hydrocarbons recorded in the Kolo Creek at the different stations were above the required limit in the sediments that is acceptable to FME of 30 mg/kg and also DPR of 50mg/kg although still far lower than the intervention value of 5,000mg/kg. The results indicated that the Ogbia axis of Kolo Creek is under pollution attack and hence the need for urgent steps for remediation to avert any serious environmental and health hazards that may arise as a result of the presence of total petroleum hydrocarbons.

Keywords: Kolo Creek, total petroleum hydrocarbons, pollution, sediment, oil bunkering

Introduction

The upsurge in petroleum activities in the Niger Delta Area of Nigeria, has brought about remarkable deterioration, degradation and eventual pollution of the natural environments like lakes, creeks, estuaries, streams, rivers, seas and oceans that are found within the region. The notable consequences of oil exploration and exploitation activities are seen in the soil, water and air of the Niger Delta Region and the inhabitants (Adewuyi *et al.*, 2011; Edori *et al.*, 2020) [3, 18, 15]. The discovery of crude oil in 1956 in Nigeria at Oloibiri in Ogbia Local Government Area of the present Bayelsa State has brought about untold contamination and pollution of the environment due to the activities associated with it and the several products linked with its production (Ali *et al.*, 2019; Edori *et al.*, 2020) [5, 15].

The creeks and other water bodies receive on daily basis enormous quantity of petroleum hydrocarbons due to crude oil exploration and exploitation activities, artisanal refining, pipeline vandalism and explosion, surface runoffs tank leakages, transportation and industrial discharges (Edori and Marcus, 2019) [16]. These activities has consequently resulted on the inhabitants dwelling along the coasts of these water bodies by affecting the nutritional, economic, recreational services, ecological and even domestic lives that these water bodies provides for the occupants of these communities (Isibor and Freeman, 2016; Inyang *et al.*, 2018) [25, 24]. The consequences of contamination and pollution resulting from hydrocarbons released into the water environments of the Niger Delta area of Nigeria has reached a stage that require urgent attention. Scholarly research (Barry, 2007, Gay *et al.*, 2010) [8, 23] has shown that petroleum hydrocarbons are quite hazardous, toxic and harmful to human and other creatures that make use of the aquatic environments. Other possible human health effect associated with petroleum hydrocarbons are skin rashes and irritation, respiratory effects, probable miscarriages and infertility in women, deficiencies at birth and cancer of the various organs of the body (Hurtig and San Sebastian, 2002; Aguilera, 2010, Sudakin *et al.*, 2011; Ezekwe and Edoghotu, 2015, Edori and Marcus, 2019) [22, 4, 47, 19, 16].

The pollution and degradation of the water bodies results in certain grave consequences on the ecology, that ultimately bring about adverse outcome on the water environment by impacting negatively on aquatic life, fishing, recreation, tourism, transportation and other related businesses that are operational within that region (Ogri, 2001; Scheren *et al.*, 2002, Edori *et al.*, 2021) [37, 46, 13, 14]. Petroleum hydrocarbons come in contact with the aquatic environment due to oil spill, that may be as a result of equipment failure, willful damage of pipeline,

mistakes and errors from operation, sabotage, failure of pipes and storage tanks due to corrosion attack (Nwilo and Badejo, 2005; Okoye and Okunrobo, 2014) [39].

Environmental documentations have revealed that high concentrations of organic (including petroleum hydrocarbons) and inorganic chemicals have negatively affected the environment, which was due to the operational pattern of oil multinational companies and other related industries. Their impacts have been negative and adverse and have surpassed both national and international tolerable levels in diverse environments of the Niger Delta region (Adeniyi and Afolabi, 2002; Osuji and Adesiyani, 2005; Olobaniyi and Efe, 2007; Monazami Tehrani, *et al.*, 2014) [2, 42, 40, 33]. The operational pattern of petroleum industries and the artisanal refining methods develop serious environmental consequences and effects on the residents or populace and that specific environment where such activity take place. Due to oil mining works, there exist unlimited likelihood of environmental deprivation that might arise due to oil spill (Udoh and Akpan, 2010; Edori *et al.*, 2021) [48, 13, 14].

Key sources of environmental pollution due to the production of petroleum in the Niger Delta area of Nigeria are, gas flaring, oil spillage, pipeline explosion, disposal of crude oil product directly into the environment by uniform personnel, illegitimate or artisanal oil lifting, bunkering and refining and sabotage of oil facilities (Anifowase *et al.*, 2012; Kadafa, 2012) [6, 26]. The manner of oil production and exploration has brought in serious environmental impact which also comprises the properties of the oil. Likely environmental situations like temperature, and weather have consequences on the behaviour of oil in the marine environment, destroying the very essence of livelihood (Ogeleka *et al.*, 2016) [36]. Aquatic creatures, particularly invertebrates play important role in the process of purification in natural water systems. The effect of erosion and its control on the shoreline of aquatic environment are most readily affected by petroleum hydrocarbons especially when there is oil spill. This culminates into severe concerns or magnitude due to the fact that the production of food for the diversity of marine wild life is affected (Edori and Edori, 2021) [13, 14]. The negative consequence or impacts of oil spill on the environment is that it affects the habitat, life stage of invertebrates, mode of feeding, the spawning of aquatic creatures and also the capability to circumvent contamination during oil spill (Blackburn *et al.*, 2014).

This study therefore determined the levels of total petroleum hydrocarbons in the sediments of Kolo Creek.

Materials and Methods

Study Area

Kolo Creek is located in the central Niger Delta (A1agoa, 1999). It extended between latitude 4°23 and 4°36 North and longitude 6°14 and 6°16 East. By extension is the longest river beside rivers Orashi, Ase, Forcados, Nun and Taylor Creek in the Forcados and Nun catchment of Niger Delta (NDBDA, 1980) [34].

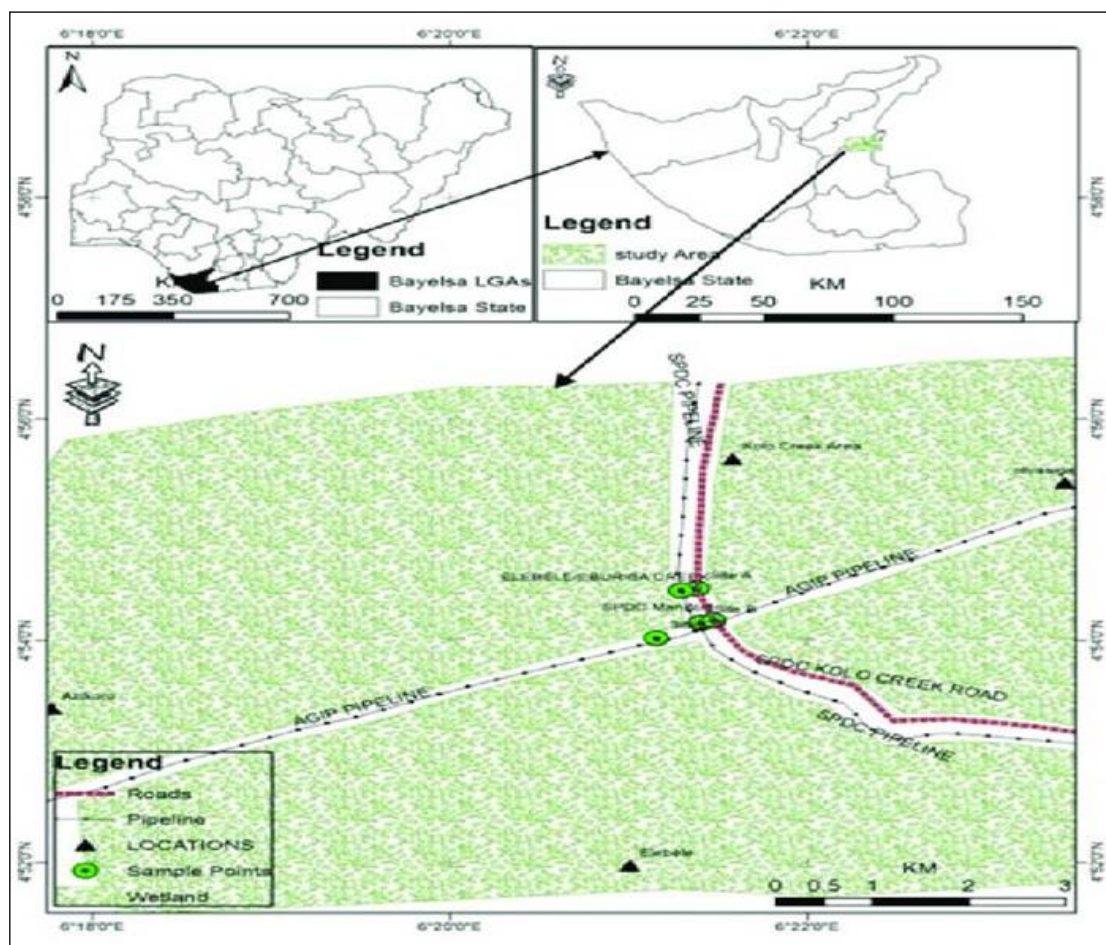


Fig 1: Map of Kolo Creek showing sampling points

Kolo Creek receive its water supply from Orashi River through a convergence at Okarki Town, Engenni, in Rivers State. It is a fresh water creek that flow north south and end by Ekole Creek closer to Dorgu Ama Okoroma Tereke in Nembe Local Government Area of Bayelsa State by a mangrove swamp forest. A reasonable percentage of Kolo Creek reside within Ogbia Local Government Area of Bayelsa State (i.e from Otuegwe to Oloibiri Town). Beside Orashi River being the major source, Kolo Creek also get other insignificant sources of water supply from other channels along its course. These sources included Abonu Creek between Imiringi and Otuegela, Otuoke Creek and Iyi Akoloman Creek (NDBDA, 1980; Okonny *et al*, 1999; Eli, 2012) [34, 38, 17].

The research was undertaken at four different stations, *viz.*; Oruma as station 1, Imiringi as station 2, Kolo 1 as station 3 and Akoloman as station 4. These communities were originally known for fishing and farming with its muddy soil that support large scale farming and host to two renowned oil fields, such as Oloibiri and Kolo Creek oil fields. Its occupants are mainly rural inhabitants (Eli, 2012) [17].

Sample Collection

Sediment samples were collected with core sediment grab sampler at the different stations of Kolo Creek at a depth range of 5 to 10cm. Four sediment samples were collected at each point of sampling and then combined together to form a sample for that location. Previously washed glass bottles were used to store the samples and then kept in an ice pack at a temperature of -4° C to prevent the evaporation of lower fractions of total petroleum hydrocarbons before analysis. The samples were then sent to the laboratory for further treatment and analysis.

Extraction of sediments sample for TPH

Soxhlet extraction method was used to extract total petroleum hydrocarbons components from sediment samples. 100g of composite sample was weighed, air dried, homogenized and sieved. The process was repeated for all other samples. The sediment sample was trapped in a filter paper and placed in a thimble and loaded into the main chamber of the soxhlet extractor and then extracted using dichloromethane (DCM) over a period of 24hrs. The extracts collected was then concentrated with a rotary evaporator at a temperature 35° C. The concentrated extracts were transferred to a previously weighed sample bottle and then evaporated to dryness (Saari *et al*, 2007) for column chromatography clean-up process.

Column preparation and sample clean-up

A column chromatography was prepared and clean up and the sample treated according to the method of Maioli *et al* (2011). Column preparation was performed by the introduction of glass-wool into an already washed chromatographic column. Thereafter an already clean silica gel were introduced into the column and 2cm layer of anhydrous sulphate was added as slurry into the chromatographic column and thereafter the addition of pentane. Cyclohexane was added into a previously washed beaker containing the concentrated sample which was thereafter introduced into the chromatographic column already prepared. The sample was eluted with pentane and then collected into the beaker below the column and more pentane was added for further elution of the sample after which the column was rinsed with dichloromethane. The sample was then allowed to stand in a fume cupboard after elution at room temperature for evaporation to take place.

Sample separation and detection

Agilent 5890 gas chromatography – flame ionization detector (GC-FID) was employed for the detection of total petroleum hydrocarbons components in sediment samples at different stations of the Kolo Creek. The temperature of the detector was kept at 400° C and the concentration of total petroleum hydrocarbons. 3ml of concentrated sample was injected through the vial of the gas chromatography for cleaning of syringe, a blank dichloromethane was first injected into the micro syringe of the gas chromatography. The clean-up process of the syringe was done thrice before the analysis of the sample. The micro-syringe was then washed with the sample before the sample was being injected into the gas chromatography column for the total separation of the different fractions of total petroleum hydrocarbons present in the sample. The quantity of total petroleum hydrocarbon content resolved at any particular chromatogram was then estimated in mg/kg for the sediments sample.

Results and Discussion

Tables 1-3 showed the results obtained from the analysis of total petroleum hydrocarbons in sediments of four different locations in the Ogbia axis of Kolo Creek in the months of January, March and May 2022 while Table 4 showed the mean levels of total petroleum hydrocarbons within the period under study. The levels of total petroleum hydrocarbons in January ranged from 102.5112 to 126.4288 mg/kg, March, 114.2975 to 140.6604 mg/kg and in May, 127.8051 to 160.4837 mg/kg and the mean levels ranged from 114.8711 ± 12.397 to 142.5244 ± 14.050 mg/kg during the months of investigation. The order of occurrence of total petroleum hydrocarbons in the stations were $4 > 2 > 1 > 3$. The mean concentrations of total petroleum hydrocarbon components from the four different station along the creek as expressed in (mg/kg) for each carbon length were as follows; C_8 , C_{34} to C_{40} , were not detected, C_9 varied from 0.6714 ± 0.494 - 8.1417 ± 0.142 , C_{10} 2.5467 ± 1.049 - 24.0707 ± 1.685 , C_{11} 0.9685 ± 0.818 - 8.3183 ± 0.446 , C_{12} not detected - 11.0244 ± 1.143 , C_{13} 2.2078 ± 1.567 - 13.3386 ± 0.835 , C_{14} 0.8735 ± 0.623 - 13.6875 ± 0.895 , C_{15} not detected - 35.1250 ± 0.535 , C_{16} 0.7574 ± 0.574 -

7.2771±0.196, C₁₇ not detected – 38.8063±1.146, C₁₈ 0.6137±0.214 – 20.5590±1.625, C₁₉ 2.6632±0.221–14.0697±0.797, C₂₀ 0.2235±0.081 – 7.2068, C₂₁ not detected - 16.5732±1.541, C₂₂ 0.9377±0.679 – 13.4812±0.435, C₂₃ not detected – 4.4930±0.512, C₂₄ 0.1295±0.101 - 0.4122±0.294, C₂₅ not detected - 21.1783±0.471. C₂₆ 1.4740±1.056-22.5229±1.135, C₂₇ not detected - 2.7345±0.329, C₂₈ 0.3651±0.333 - 1.5318±0.286, C₂₉ not detected - 1.3373±0.174, C₃₀ 0.1440±0.034 - 4.2490±0.395, C₃₁ not detected - 1.2475±0.529, C₃₂ not detected - 0.8311±0.636 and C₃₃ not detected - 1.4119±1.233.

The average value of total petroleum hydrocarbons obtained in the Kolo Creek during the months for the four different stations were higher than the required target value of 30mg/Kg allowed by the Federal Ministry of Environment in water (FME, 1991) ^[21] and also higher than the Directorate of petroleum Resources tolerable maximum level of 50 mg/Kg but far lower than the 5000 mg/Kg intervention limit given by DPR (DPR, 2002) ^[12].

The average result recorded in the sediments of the Ogbia axis of Kolo Creek were higher, than that obtained in the work that was conducted in the sediments of Algoa Bay, South Africa by Adeniji *et al.*, (2017) ^[1] that had a range of 0.72 to 27.03 mg/Kg, that recorded by Edori *et al.* (2021) ^[13, 14] in the sediments of Orashi River that was between 22.3925±5.2104 to 50.4431±15.9916 mg/kg, that which was reported by Ashiru and Ogundare (2019) ^[7] in the sediments of Ugbo water way which had a very low concentration of 0.131mg/Kg and also that which was reported by Edori and Marcus (2019) ^[16], with a level range of 18.034 to 23.64 mg/Kg during the period of investigation in the sediments of Taylor Creek.

The average levels of occurrence of total petroleum hydrocarbons obtained in this work were lower than that reported in the study obtained in the sediments of Qua-Iboe Rivers by Inyang, *et al* (2018) ^[24], that had an average value of 606.83±229 mg/kg and that reported by Ezekwe and Utong (2017) ^[20] in the Oturuba Creek that was in the range of 1546 - 3997.9 mg/kg during in the dry season and 1727.5 - 5118.5 mg/kg in the wet season. The average levels of total petroleum hydrocarbons obtained in this investigation were far below that was reported in a study undertaken by Ogeleka *et al.*, (2016) ^[36], in Egwa which was 215700±77 mg/Kg and Odidi which was 215730±81 mg/Kg. The levels of total petroleum hydrocarbons reported in the work of Etchie *et al.*, (2011) ^[3, 18], in sediment and soil that was between 600 to 2300 mg/Kg, and that which was reportedly obtained in a study by Adewuyi *et al.*, (2011) ^[3, 18], with a mean level of 1602.4±115.3 mg/Kg in the Ubeji River, Warri, Delta State, Nigeria, and also that which was obtained in a study by Adeniji *et al.*, (2017), from sediments of the Buffalo River Estuary in the Cape Province, South Africa that was in the range of 1259 to 11,000 mg/Kg, were all higher than the result from this work.

The category of classification of pollution by total petroleum hydrocarbons in the sediments of water bodies as given by Massoud *et al.*, (1996) ^[32] and Ritchie *et al.*, (2011) are in four categories. The categories are (10-15 mg/Kg) as unpolluted, (15-50 mg/Kg) as slightly polluted, (50-200 mg/Kg) as moderately polluted while (> 200 mg/Kg) as heavily polluted. The level of occurrence of total petroleum hydrocarbons recorded in this study were within the category of 50-200 mg/Kg which showed moderate pollution. The levels of occurrence of total petroleum hydrocarbons in the Ogbia axis of Kolo Creek may be as a result of high level of artisanal crude refining, oil exploration and exploitation, other businesses associated with crude oil predominant in the region and the powerlessness of relevant agencies of government to monitor and provide proper clean-up processes. Sediment is known as a natural sink due to its ability to absorb contaminants in the aquatic ecosystem. The contamination or pollution of the marine environment, especially the sediment occur, it could result in the loss of aquatic species and also a complete of significant effect on the biodiversity of the ecosystem of the aquatic environment that is involved (Markovic, 2003) ^[31]. This result in significant effects on the food chain at both the bottom and upper ranks of the ecological setting (Burton, 2002) ^[10]. The resultant effect of the hydrocarbon contamination on the marine setting could pose direct harm or poisonous effect on the organisms that dwell at the bottom and could also impact negative consequences on higher animals and even humans as a result of consuming fishes or making use of such contaminated water. Hence, it is very necessary to subject the sediments of any marine environment to proper quality analysis for appropriate monitoring of the aquatic ecosystem (USEPA, 1992) ^[49].

In spite of the rise in the amount of rainfall, the total petroleum hydrocarbons in the sediments of the creek were not re-suspended or released into the water phase, for they were stuck within the beds of the sediments and were not remobilized into the surface water column. This observation is not in agreement with that recorded by Lick (2009) ^[29]. This possibly arose due to the shallow, stagnant nature and the slow flow rate of the creek which do not encourage turbulence and re-suspension of the trapped hydrocarbon fractions. This observation is in agreement with the observation of Edori and Edori (2021) ^[13, 14] in the Orashi River while investigating on the temporal distribution and variation of total petroleum hydrocarbons. This observation also agreed with that reported by Cao *et al.* (2005) ^[11] and Ololade *et al.* (2009) ^[41] in shallow rivers or water bodies which encourage sedimentation, because of the link with suspended particles and solid materials.

Total petroleum hydrocarbons could manifest hazardous consequences even at very low level of 10-2-15 mg/dm³ range and portends vital noticeable effects on aquatic organisms during their stages of growth and development (Kurylenko and Izosimova, 2016) ^[28]. The existence of total petroleum hydrocarbons in the sediments of the creek could result into serious environmental variations or changes in the natural ecology of the system and as a result cause alteration in the metabolic processes of aquatic organisms and thereby resulting in the reduction of

species that make use of the environment and consequently creating general instability within the affected ecosystem (Kurochkina, 2008) [27]. The proper growth and development of phytoplanktons could be affected and drastically reduced due to the occurrence of petroleum hydrocarbons in the sediment of the creek or any water body. Hydrocarbon fractions presence in the aquatic environment could take a long period before it could be flushed out completely from the system. The pattern of flushing out of hydrocarbon contaminants involve such processes like, dissolution, evaporation, dispersion, emulsification, biodegradation and sedimentation that finally leads to the deposition of hydrocarbon components at the river or creek bottom. This lead to severe consequences on the life of aquatic organisms. Total petroleum hydrocarbons could be covered up in the bottom sediment or river bed for several years without any major alterations in its existence (Wild and Jones, 1995; Reddy *et al.*, 2002) [50, 43].

Table 1: Total Petroleum Hydrocarbons in Sediments of Sample Collected from Four Different Stations of Kolo Creek in January

Carbon Length	Stations			
	1	2	3	4
C8	-	-	-	-
C9	8.0007	5.5479	7.7107	-
C10	7.0592	4.8666	1.6001	21.9819
C11	17.2651	7.7622	2.0843	-
C12	8.0992	9.5871	-	-
C13	8.6819	12.4412	8.0882	-
C14	11.0725	14.9370	8.9602	-
C15	34.3999	18.3337	-	-
C16	7.0683	6.3433	-	19.2586
C17	2.9040	37.3150	-	10.3421
C18	12.0197	3.8500	18.3827	-
C19	2.6468	2.5800	14.9091	3.7997
C20	4.2586	0.1427	7.2068	-
C21	-	-	4.3220	14.7462
C22	-	-	8.2007	13.9281
C23	-	-	3.8423	-
C24	-	-	-	-
C25	-	-	4.3282	21.0185
C26	-	-	3.8295	20.9651
C27	-	-	2.2880	-
C28	-	-	1.1425	0.3886
C29	-	-	1.1243	-
C30	-	-	3.7186	-
C31	-	-	0.7730	-
C32	-	-	-	-
C33	-	-	-	-
C34	-	-	-	-
C35	-	-	-	-
C36	-	-	-	-
C37	-	-	-	-
C38	-	-	-	-
C39	-	-	-	-
C40	-	-	-	-
Total	123.4759	123.7067	102.5112	126.4288

Table 2: Total Petroleum Hydrocarbons in Sediments of Sample Collected from Four Different Stations of Kolo Creek March

Carbon Length	Stations			
	1	2	3	4
C8	-	-	-	-
C9	8.3367	6.5273	7.9171	-
C10	6.8439	5.2286	2.0301	24.1209
C11	19.1182	8.3379	1.9855	0.9042
C12	9.0042	11.1020	-	-
C13	8.0096	13.1230	8.0334	3.1102
C14	13.2714	12.8897	10.0297	1.2124

C15	35.3011	21.0052	-	-
C16	7.2233	4.8829	0.8831	17.9856
C17	1.8800	39.0026	-	11.1376
C18	11.5473	5.5627	21.0082	-
C19	2.4017	3.8463	12.9978	4.9911
C20	4.4112	0.1934	9.6438	-
C21	-	-	5.1245	16.4569
C22	1.2286	3.1175	8.7076	12.8922
C23	0.0996	-	4.5421	-
C24	-	0.6685	0.0392	0.4201
C25	-	-	4.7455	20.6987
C26	2.0009	3.0029	4.2189	22.9651
C27	-	-	2.8427	1.0046
C28	0.2897	-	1.6312	0.4381
C29	-	0.2110	1.3387	-
C30	0.1244	-	4.3624	1.3745
C31	-	-	0.9842	-
C32	-	-	-	0.9482
C33	-	-	1.2318	-
C34	-	-	-	-
C35	-	-	-	-
C36	-	-	-	-
C37	-	-	-	-
C38	-	-	-	-
C39	-	-	-	-
C40	-	-	-	-
Total	131.0918	138.7015	114.2975	140.6604

Table 3: Total Petroleum Hydrocarbons in Sediments of Sample Collected from Four Different Stations of Kolo Creek May

Carbon Length	Stations			
	1	2	3	4
C8	-	-	-	-
C9	8.0876	7.3658	7.0882	2.0141
C10	7.9783	5.8892	4.0100	26.1094
C11	20.3201	8.8548	2.5153	2.0012
C12	9.5549	12.3841	-	1.1219
C13	8.4281	14.4517	8.5256	3.5132
C14	15.5756	13.2358	11.2091	1.4082
C15	35.6741	21.5210	-	-
C16	7.5398	5.0023	1.3890	18.8856
C17	2.3104	40.1012	-	13.1032
C18	13.3745	5.7429	22.2862	1.8410
C19	2.9411	4.3667	14.3021	5.9365
C20	5.1024	0.3344	10.1103	1.0202
C21	-	-	5.6561	18.5166
C22	1.5846	3.7215	9.3069	13.6232
C23	0.3122	0.0211	5.0945	-
C24	1.0087	0.5682	0.3494	0.3487
C25	-	-	5.8467	21.8177
C26	2.4210	3.8053	4.0169	23.6385
C27	-	-	3.0727	1.5687
C28	0.8057	1.3421	1.8216	0.6391
C29	-	0.5593	1.5493	-
C30	0.9243	0.4321	4.6661	1.8315
C31	0.6859	1.2352	1.9853	-
C32	0.9926	-	-	1.5452
C33	-	-	3.0038	-
C34	-	-	-	-
C35	-	-	-	-
C36	-	-	-	-

C37	-	-	-	-
C38	-	-	-	-
C39	-	-	-	-
C40	-	-	-	-
Total	145.6219	150.9347	127.8051	160.4837

Table 4: Mean Total Petroleum Hydrocarbons in Sediments of Sample Collected from Four Different Stations of Kolo Creek within the Months

Carbon Length	Stations			
	1	2	3	4
C8	-	-	-	-
C9	8.1417±0.142	6.4803±0.743	7.5720±0.352	0.6714±0.494
C10	7.2938±0.492	5.3281±0.423	2.5467±1.049	24.0707±1.685
C11	18.9011±1.257	8.3183±0.446	2.1950±0.230	0.9685±0.818
C12	8.8861±0.600	11.0244±1.143	-	0.3740±0.058
C13	8.3732±0.277	13.3386±0.835	8.2157±0.220	2.2078±1.567
C14	13.3065±1.839	13.6875±0.895	10.0663±0.918	0.8735±0.623
C15	35.1250±0.535	20.2866±1.397	-	-
C16	7.2771±0.196	5.4095±0.662	0.7574±0.574	18.7099±0.534
C17	2.3648±0.420	38.8063±1.146	-	11.5276±1.160
C18	12.3138±0.774	5.0519±0.853	20.5590±1.625	0.6137±0.214
C19	2.6632±0.221	3.5977±0.750	14.0697±0.797	4.9091±0.874
C20	4.5907±0.367	0.2235±0.081	8.9870±1.273	0.3401±0.086
C21	-	-	5.0342±0.548	16.5732±1.541
C22	0.9377±0.679	2.2797±1.631	8.7384±0.452	13.4812±0.435
C23	0.1373±0.130	0.0070±0.001	4.4930±0.512	-
C24	0.3362±0.275	0.4122±0.294	0.1295±0.101	0.2563±0.184
C25	-	-	4.9734±0.641	21.1783±0.471
C26	1.4740±1.056	2.2694±1.638	4.0218±0.159	22.5229±1.135
C27	-	-	2.7345±0.329	0.8578±0.649
C28	0.3651±0.333	0.4474±0.326	1.5318±0.286	0.4886±0.108
C29	-	0.2568±0.231	1.3373±0.174	-
C30	0.5244±0.400	0.1440±0.034	4.2490±0.395	1.0687±0.778
C31	0.2286±0.198	0.4117±0.228	1.2475±0.529	-
C32	0.3309±0.210	-	-	0.8311±0.636
C33	-	-	1.4119±1.233	-
C34	-	-	-	-
C35	-	-	-	-
C36	-	-	-	-
C37	-	-	-	-
C38	-	-	-	-
C39	-	-	-	-
C40	-	-	-	-
Total	133.5712±10.401	137.7809±13.757	114.8711±12.397	142.5244±14.050

Conclusion

The high level of total petroleum hydrocarbons in the Ogbia axis of Kolo Creek probably was due to the operational activities of the Kolo Creek sub-station at Imiringi or the illegal oil bunkering and marketing that in place within the entire coast of the creek. Other possible sources of petroleum hydrocarbons in the creek could be from transportation activities, effluents released from the adjoining communities or from leakage of tanks. The high level of petroleum hydrocarbons contents observed in the sediments has provided evidence of severe crude oil contamination of the creek. Such hazardous condition always imply severe environmental degradation and ecological imbalance which could result in massive health defects among indigenes living within the study area. The deplorable state of the environment could expose its citizens to severe health problems such as, anaemia, brain damage, cancer of the lungs and kidney, liver necrosis, leukemia, nephritis, mental deficiency, retarded growth mostly amongst children and even death. Furthermore, there is urgent need for a robust and efficient action by relevant agencies of government and other concerned bodies to put up a process that could restore the creek to its original form and purity.

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