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Determination of Total Petroleum Hydrocarbons Levels in the Water and Sediments of Kolo Creek, Niger Delta Nigeria

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Abstract Surface water and sediment samples were randomly collected from three different stations in Kolo Creek for total petroleum hydrocarbons assay. The concentrations of total petroleum hydrocarbons in the creek were determined by gas chromatography-flame ionization detector after the samples have passed through extraction procedures using dichloromethane and Soxhlet apparatus and necessary clean-up. The contamination levels of total petroleum hydrocarbons in the surface water of the creek in the stations were 13.669±2.4027, 12.748±1.3306, and 18.335±3.8327mg/L for stations 1, 2 and 3 respectively with an average value of 14.927±2.528mg/L. The concentrations of total petroleum hydrocarbons in the sediment samples were 40.9446±10.309, 39.2352±12.0591 and 42.3086±11.2701mg/Kg for stations 1, 2 and 3 respectively with an average concentration of 40.8295±11.2127 mg/Kg. The concentrations were slightly above DPR approved limit in water and lower than that allowed by DPR in sediments of any water body. The partition coefficient showed that total petroleum hydrocarbons were more attracted to the sediment as compared to the surface water. Despite the fact that total petroleum hydrocarbons in the surface water and sediments of Kolo Creek has not reached an alarming state, effort should be made to avert any forthcoming danger that may come upon the aquatic organisms in the creek and humans that consume them.

Keywords Kolo Creek, sediment, water, total petroleum hydrocarbons, pollution, GC-FID

Introduction

As a result of crude oil exploration and production in the Niger Delta Region of Nigeria, total petroleum hydrocarbons will always find its way into rivers and other water bodies in the region through several ways. Several authors and investigation have revealed how total petroleum hydrocarbons finds its way into the rivers of the region and the world at large. It is reported that during the process of production total petroleum hydrocarbon may enter these water bodies through accidents, oil pipeline vandalization, effluents released by industries, commercial and private release. Total petroleum hydrocarbons may find its way into the river through oil spillage, whereby part of the fractions may float and form films while other fractions may sink to the bottom sediments [1]. Also, Iturbe *et al* [2] reported that the environments, rivers inclusive can be contaminated through contaminated soil, from pipelines, storage tanks and the disposal of untreated crude oil sediments that come from the storage tanks. The leakage of petroleum from storage tanks and other forms of discharges related to petroleum products that significantly affect the environment has been reported [3-4].

The degree of water pollution and contamination due to the exploration and production activities by the international oil companies cannot be overemphasized. These activities have resulted in frequent spillage of oil which find their way to the water bodies through drift during rainfall. Although natural hydrocarbons are present in the environment, total petroleum hydrocarbon can enter the water bodies through anthropogenic ways [5-6]. Activities of man that can bring about total petroleum hydrocarbon in rivers include gas flaring, leakage from tanks, marine vessel, ocean dumping, effluents from petrochemical industries are known point source of emission and other chemical substances like organic pollutants [7-9].

Industrial activities, illegal oil bunkering, pipeline vandalization are the main contributors of hydrocarbon pollution and contamination of the environment [10-12]. According to several studies, hydrocarbon pollution brings about complex changes in the natural ecosystem which results in the violation of the metabolic activities and destruction of the environments, organic matter and eventual decrease in the diversity of species [13]. The presence of petroleum hydrocarbons as contaminants in the affected environment will affect both plants and animals that rely on them for food. The harmful effect of these hydrocarbons in water and sediment occasioned by oil spill, illegal oil bunkering, etc., should be treated with urgency to prevent harmful effects on man and the environment [1]. These effects are inherent and widespread and long lasting in durational period [14]. Water quality in countries where oil is explored and exploited is becoming a major issue due to pollution effect of petroleum hydrocarbons [15-17]. The reduction and deterioration in water quality of these water bodies by the activities of man is unbecoming and becoming difficult to bear [18]. This has brought about serious problems to the community dwellers, which therefore make it necessary to determine the extent of pollution or contamination of these water bodies.

This study is therefore designed to determined the level of total petroleum hydrocarbons in the surface water and sediments of Kolo Creek using gas chromatography-flame ionization detector. This study is important due to environmental decay and the continuous effect of crude oil or petroleum products openly visible on the surface of water within the river.

Materials and Methods

Study Area

The Kolo Creek is a tributary of Orashi River and starts from Okarki, in Engenni, Rivers State and run through Ogbia Local Government Area of Bayelsa State. The sample points along the Engenni Axis of the creek lies within4^{o}58’53.1”N, 6^{o}25’52.6”E and 4^{o}57’26.3”N, 6^{o}26’10.3”E. The main occupation of the Engenni people is fishing, farming and petty trading. Major activities that take place within the Engenni Axis of the river includes, oil exploration and production, illegal oil bunkering, transportation, sand dredging and mining, laundry along the creek and recreational activities such as swimming and canoeing are visibly noticed along the creek. Oil production facilities that belongs to multi-national oil companies in the region includes flow station, oil fields, gas plants, that has constantly led to the contamination of the river. The negative environmental impact and pollution created due to oil exploitation and production within the area over the years have been of great concern to the inhabitants that make use of the creek on daily basis.

Collection of Water Sample

Water sample swere collected from three different stations in KoloCreek with the aid of previously washed glass bottles. The glass bottles were thoroughly rinsed with dichloromethane to prevent contamination with the water sample. Replicate water samples were collected at a depth of 30cm and combined together to form a sample. The water sample was preserved by the addition of 2ml of 0.2M H_2SO_4 to obtain a pH of 2. Sterile pieces of aluminum foil were used to cover the bottles in order to prevent any possible contamination or harm, the bottles were thereafter tightly covered with plastic screw. The glass bottles were transferred to an ice packed cooler to keep it at 4^{o}C. Thereafter the collected samples were transported to the laboratory for further treatment and analysis [19].

Collection of Sediment Sample

Sediment samples were collected at three different stations in KoloCreek from the top few centimeters deep. A representative sample was formed by the mixture of three points sediments within the location. The samples were collected with the aid of a hand-held van veen grab and transferred to an already prepared glass bottle and then transported to the laboratory for pretreatment and analysis. The sediment samples collected were given the same treatment similar to that of the water samples.

Extraction and Determination of Total Petroleum Hydrocarbon from Water Samples

After proper filtration, water samples were afterward subjected to extraction processes with the aid of separatory funnel. Water samples of different volumes were collected from various stations, and then extracted into a two liters (2L) glass separatory funnel using 30ml dichloromethane as solvent for the extraction process. The separatory funnel was shaken for at least 5 minutes. This was done to allow the organic layer to be completely separated from the aqueous layer. For the water to be removed the extract was mixed with 5g of anhydrous sodium sulphate. The sample was then allowed to pass through a filter paper and then collected into a beaker. The filtrate was allowed to evaporate under room temperature conditions in a fume cupboard. The filtrate was then concentrated to 3ml before the determination. The extraction procedure was repeated three times for each sample to be analyzed [20].

Extraction and Determination of Total Petroleum Hydrocarbon from Sediment Samples

10g of sediment sample was weighed with an analytical weighing balance and was then transferred into an already prepared amber bottle. A measured 5g anhydrous sodium sulphate (Na_2SO_4) was added into the already washed amber glass bottle which contains the sediment sample, and then the sediment sample was shaken with vigour for the particles to mix effectively. The anhydrous sodium sulphate was added for the purpose of reducing moisture from the sediment sample. The sediment sample was thoroughly mixed and thereafter 30ml dichloromethane was added unto it as the extracting solvent. Immediately dichloromethane was added into the amber bottle, the bottle was tightly closed and was then agitated using a mechanical shaker under room temperature condition and the sample was then allowed to settle down for at least 1hr. The sediment sample was filtered with 110mm filter paper into an already prepared clean beaker that has board, and the filtrate of the sediment sample was then allowed to concentrate to 1ml through the process of evaporation [20].

Procedure for Sample Clean-Up

The column preparation was performed with the introduction of glass-wool into a previously washed and already prepared chromatographic column. Then into an already clean beaker silica gel was introduced. Addition slurry was made into the chromatographic column followed by theaddition of anhydrous sodium sulphate into the column and then the addition of pentane thereafter. In a beaker thoroughly washed and previously cleaned, the sample that was already concentrated wasthen mixed with cyclohexane and afterward introduced into the chromatographic column that was already prepared. Pentane was used in eluting the sample which was then collected into the beaker at the bottom of the column. A Further elution of sample was done by introducing more pentane, thereafter the column was then thoroughly rinsed with more dichloromethane. The sample was then allowed to stand in a fume cupboard after the elution at room temperature conditions for evaporation to take place [20].

Separation and Detection of Sample

The detection of total petroleum hydrocarbons in the water and sediment samples was done through the use of Agilent 5890N model of gas chromatography-flame ionization detector (GC-FID) to ascertain the different levels of contamination in the stations under study [21]. The sample was concentrated to 3mlbefore being injected into the gas chromatography vial for thorough cleaning of syringe, then blank dichloromethane was also injected through micro-syringe into the gas chromatography. The cleaning of the micro-syringe was done three times, thereafter the analysis of the sample was performed. The micro-syringe was again rinsed with the sample after which the sample was then injected into the gas chromatography for the complete separation of the components of total petroleum hydrocarbons in the sample. When the components present in the sample have been totally separated, the quantity of total petroleum hydrocarbon content that was resolved at any particular chromatogram was then measured in mg/Kg for the sediment sample and ml/L for water sample.

Partition Coefficient

The bioavailability of total petroleum hydrocarbons in sediments of the Kolo Creek is solely a function of its distribution pattern between the sediment phase and the surface water phase. It lies on the level of total petroleum hydrocarbon in the sediment phase and surface water phase. The distribution spread of the petroleum hydrocarbon fractions within the water phase and the sediment phasewas calculated using partition coefficient. The partition coefficient is represented mathematically as

$$\mathrm{Kd} = \frac{concentration\ of\ TPH\ in\ Sediment}{concentration\ of\ TPH\ in\ water}$$

This relationship shows which of the phases that total petroleum hydrocarbon prefers for stability.

Results and Discussion

The results of the mean concentrations or degree of contamination of total petroleum hydrocarbons in surface water in the various stations of Kolo Creek are shown in Table 1. In Table 1, the degree of contamination in Station 1 was 13.699±2.4207ml/L, Station 2; 12.748±1.3306ml/L, and Station 3; 18.335±3.8327ml/L. The concentrations in the stations showed that Station 3 > Station 2 > Station 1. The average concentration of total petroleum hydrocarbons in the various stations was14.927±2.528ml/L.

The average level of total petroleum hydrocarbons in the surface water of Kolo Creek in the stations used for the study were slightly above the required limit of 10.00mg/L in water given by FEPA and DPR [22-23]. The average value of total petroleum hydrocarbons recorded in this work were higher than that of Edori *et al*. [24] in the Edagberi River which was as low as 5.351±0.145-8.0639±0.806mg/L and that of Edori and Kpee [25] in the Taylor Creek which ranged between 2.461±2.687-10.00974.145mg/L in the stations investigated. The results obtained by Isibor and Freeman [26] concerning total petroleum hydrocarbons in Egboko River Warri, Delta State, Nigeria fall within the range of not detected – 0.007±0.001mg/L which was far lower than that obtained from this work. However, the concentrations of total petroleum hydrocarbons obtained in the study carried out by Etchie *et al*., [27] had a value range between 22- 96mg/L, Daniel and Nna [28] had the range of 9.82000±0.233-24.85462±8.058mg/L, Sari *et al*., [29] in an oil field at Wonocolo obtained a value of 211,025.73μg/L were all above the values observed in this study.

Oil naturally floats on the surface of water, therefore it disperses quickly within the river system, as a result, organisms are prone to be affected by both the floating oil and the dissolved oil in the water system [30]. Total petroleum hydrocarbons when found in the water bodies have toxic effects. These effects come as a result of a layer of oil formed at the surface, which prohibits the proper diffusion and mixing of oxygen in the water by coating it. This process of limited oxygen causes asphyxiation and smothering of organisms, which may result in death. The presence of oil may also interfere in the process of photosynthesis and transpiration by plants through the blocking of the pore spaces in leaves through penetration or sealing of the pores [29, 31-32].

The half-life of total petroleum hydrocarbons in the surface water may last between 4-226 days, this may result in accumulation [33]. This situation is detrimental and hinders the metabolic processes of microorganisms and hence metabolic activities becomes limited [29]. The oily nature of total petroleum hydrocarbons affects sea birds by rendering them flightless when they come in contact with it. This may lead to loss of insulating properties of the feathers and in the process of preening the feathers, some total petroleum hydrocarbons may even end up in their stomach thus resulting to death sometimes [34].

When total petroleum hydrocarbons are allowed to accumulate, there are consequences to the aquatic plants and animals in that environment. The presence of total petroleum hydrocarbons (oil) on the surface of any river or water body reduces the amount of dissolved oxygen, and at higher degrees have significant effect on higher aquatic lives. The resultant effect leads to unfavourable breeding sites for some aquatic organisms or species and even affect the roots of mangrove plants through oxygen deprivation by the process of smothering [35-36]. The growth of aquatic organisms that feed on phytoplanktons, algae and zooplanktons are drastically affected when total petroleum hydrocarbons are present in a water body [37].

Table 1: Mean (X ± SD) concentrations (ml/L) of Total Petroleum Hydrocarbons in Surface Water of Kolo Creek from different Stations

Carbon Length (ml/L)	**Stations**		
	1	**2**	**3**
C8	-	-	0.171±0.001
C9	-	1.148±0.031	0.307±0.005
C10	-	-	0.317±0.006
C11	-	-	1.020±0.401
C12	1.001 ± 0.01	-	1.020±0.401
C13	0.134±0.008	-	0.920±0.060
C14	0.062±0.001	-	0.067±0.001
C15	0.429±0.050	1.089±0.019	0.088±0.001
C16	-	0.182±0.008	1.396±0.500
C17	1.351±0.300	0.105±0.005	0.762±0.071
C18	1.294±0.290	0.243±0.008	0.728±0.070
C19	4.890±1.100	1.132±0.200	0.271±0.008
C20	1.424±0.350	0.886±0.036	3.855±1.000
C21	-	-	0.332±0.002
C22	0.169±005	0.534±0.056	0.168±0.002
C23	-	-	0.001±0.000
C24	0.621±0.061	1.010±0.009	2.499±0.500
C25	-	-	0.836±0.072
C26	0.423±0.052	1.602±0.360	0.756±0.065
C27	-	-	0.004±0.000
C28	0.634±0.070	0.844±0.082	1.538±0.510
C29	-	-	0.000±0.000
C30	0.640±0.073	1.551±0.290	0.455±0.481
C31	-	-	0.006±0.000
C32	0.142±0.001	1.240±0.190	0.661±0.074
C33	-	-	0.004±0.000
C34	0.485±0.050	1.182±0.036	0.004±0.000
C35	-	-	0.004±0.000
C36	-	-	0.030±0.001
C37	-	-	-
C38	-	-	-
C39	-	-	-
C40			
Total	13.699±2.421	12.748±1.331	18.335±3.833

The results of the average concentration/level of pollution of total petroleum hydrocarbons in the sediments of the sampled stations of Kolo Creek are shown in Tables 2. The degree in which the creek was contaminated and polluted in the stations as shown in Table 2 were, Station 1; 40.9446±10.309ml/Kg, Station 2; 39.2352±12.0591ml/Kg and Station 3; 42.3086±11.2701ml/Kg. The contamination level showed that; Station 3

> Station 1 > Station 2. The differences observed in the level of contamination in the three stations were small. The average concentration of total petroleum hydrocarbons present in the creek was 40.8295±11.2127ml/Kg.

The average concentration of total petroleum hydrocarbons recorded in the sediments of the Kolo Creek stations were above the limit allowed by the Federal Ministry of Environment of 30.00mg/Kg [38] and below the level allowed by the Directorate of Petroleum Resources of 50mg/Kg and much lower than the its intervention limit of 5000mg/Kg [39]. The mean contamination level of total petroleum hydrocarbons obtained in this study were lower than that recorded by Etchie *et al.*, [27], which had the range 600-2300mg/Kg in an environment close to a rural settlement, Inyang *et al.*, [40], in the Qua-Iboe River, Akwa Ibom State, Nigeria of the range 273.06-826.62mg/Kg in the stations studied; on the Port Sudan habour and Bashayer marine terminal of the Sudanese Red Sea coast of 215-1320mg/Kg and Samuel and Ayodele [41] of 41900mg/Kg in the Benin River South-South, Nigeria. However, the recorded values of total petroleum hydrocarbons obtained in this work in the sediments of the stations were higher than that obtained by Edori and Marcus [42] in the Taylor Creek, whose values ranged between18.035±3.527-30.768±10.850mg/Kg in the stations and also that of Edori *et al.*, [24] in the Edagberi River of the range of 17.6765±1.951-30.7649±6.586mg/Kg and also that obtained by El-Tokhi and Mostafa [43] in the Gulf of Suez, Egypt.

The mode of occurrence of total petroleum hydrocarbons in the sediments of the Kolo Creek within the stations investigated was a clear indication that its origin was anthropogenic. High presence of petroleum hydrocarbons in the sediments causes reduction in the diffusion of gases which has a far reaching, negative effect on the plants and animals that inhabit the bottom of the creek [36, 44]. The presence of total petroleum hydrocarbons on the sediments of the creek hinders the process of decay of the creek litters, which encourages the accumulation of organic matters on the bed (bottom) of the creek. This assertion aligns with Ekweozor and Snowden [45], that hydrocarbons in the marine environment prolongs the decay process of mangrove litters. The presence of total petroleum hydrocarbons on the sediments affects the development of primary producers in the creek such as phytoplanktons, algae and zooplanktons [46]. The contamination of of waterbodies by total petroleum hydrocarbons can result in death of sea animals and also reduce the presence of these sea animals by their migration to areas that are less affected [47].

Total petroleum hydrocarbons presence in sediments produces ecological damage to the river system, the effect of such toxicity can last for a long period [48]. These effects have the potential of impairing on the mode of life of the biological organisms in the community and may possibly affect other organism that depend on the bottom dwellers for food [49]. When hydrocarbons are retained in the cells of organisms, the functions of the membrane may be altered and there arises the disruption in the energy processes of any organism that depends on the water body for life processes. There is also the impairment of the organisms' adaptive ability to cope with the natural environment [50-51].

Table 2: Mean (X ± SD) concentrations (ml/Kg) of Total Petroleum Hydrocarbons in Sediments of Kolo Creek from different Stations

Carbon Length (ml/L)	**Stations**		
	1	**2**	**3**
C8	0.1449±0.004	-	0.1783±0.005
C9	0.4466±0.016	-	-
C10	1.3160±0.621	5.4955±2.036	1.7178±0.191
C11	2.2479±0.710	-	1.0841±0.101
C12	0.6628±0.030	-	0.7469±0.190
C13	0.2082±0.007	-	1.8424±0.200
C14	1.2846±0.500	0.8951±0.046	1.9394±0.201
C15	7.1314±2.350	2.3564±0.512	0.6164±0.052
C16	2.1738±0.680	5.0075±2.011	1.9674±0.201
C17	4.3886±1.500	0.6441±0.028	0.5067±0.050

C18	1.8465±0.401	3.4790±1.002	0.4555±0.038
C19	2.3413±0.730	3.5705±1.004	6.1143±2.300
C20	1.7638±0.370	3.6786±1.006	1.8574±0.192
C21	3.5942±1.030	0.1865±0.010	4.4660±2.001
C22	0.3235±0.041	4.1002±1.082	1.6386±0.180
C23	0.5010±0.026	-	1.0055±0.100
C24	0.7375±0.032	2.2427±0.500	0.1794±0.005
C25	0.7180±0.028	0.0046±0.000	0.0802±0.001
C26	1.6095±0.170	0.9767±0.072	8.1436±3.000
C27	-	-	-
C28	1.2974±0.140	3.1483±1.320	0.2309±0.005
C29	0.3698±0.015	-	6.8902±2.310
C30	2.7862±0.69	0.5346±0.056	0.0912±0.001
C31	0.0840±0.006	-	-
C32	0.7841±0.048	0.9972±0.740	0.1033±0.004
C33	-	-	-
C34	1.4101±0.151	1.2193±0.600	0.4531±0.042
C35	-	-	-
C36	0.7729±0.040	0.6984±0.034	-
C37	-	-	-
C38	-	-	-
C39	-	-	-
C40	-	-	-
Total	40.9446±10.309	39.2352±12.0591	42.3086±11.2701

The partition coefficient of TPH in the the Kolo Creek is shown in Table 3. Partition coefficient is a relationship that shows the phase of preference of total petroleum hydrocarbons in any given water body. The results obtained revealed that total petroleum hydrocarbons have preference for sediments due to its hydrophobic nature. From the results, values less than one givean indication that the total petroleum hydrocarbon fraction prefers the water phase while any value greater than one is an indication that the fraction is sediment loving. The results in Table 3 showed that the C_{12} fraction is hydrophilic, that is preferring the water phase to the sediment phase. The results also indicated that C_{16}, C_{18}, C_{22}, C_{28}, C_{30} and C_{32} fraction can prefer any phase. This may be due to the fact that even numbered hydrocarbons have the ability to exist in any phase depending on the prevalent condition at the time of sampling. This may be due to the flow pattern at the point of sampling in the creek or disturbances associated with the area or as a result of fresh discharge into the creek at the time of sampling.

In general, total petroleum hydrocarbons with its oily nature does not properly mix with water (has hydrophobic tendencies) and therefore sinks to the bottom of the creek and settle down, thereby making the concentration of the sediment higher than that of the surface water [32]. Oil have low solubility in water, the temperature and natural composition of petroleum (crude oil) also might have contributed to the phase preference [52-54]. Alkanes (total petroleum hydrocarbons) have less affinity for water, hence its low solubility [54-55]. Large quantity of petroleum hydrocarbons, that find their way into the creek were through direct disposal, gas flaring, automobile discharges, through runoffs from agricultural farms and self-sustaining refining (illegal bunkering) sites [56], sink and settle at the bottom of the creek (sediment). This is so because the sediment acts as a reservoir of total petroleum hydrocarbons [40, 57]. The noticeable result occurred simply because of the affinity of total petroleum hydrocarbons for sediments. This assertion is in agreement with Alagoa *et al*., [58].

Due to runoffs from adjoining farmlands and self-sustaining refining sites, total petroleum hydrocarbons appear on the surface of water. This come along with mud, debris, plant materials, and mixes with the hydrocarbons and sink to the bottom of the creek, and since the sediment acts as a reservoir, it contributes to the higher concentration of total petroleum hydrocarbons in the sediments [59]. When the oil appears on the surface, the hydrocarbons quickly penetrates through the water depth and settle at the bottom through the process of emulsification and dissipation, thereby increasing the degree of contamination of the sediment as compared to the surface water [13].

Table 3: Partition Coefficient of Total Petroleum Hydrocarbon between Sediment and Water Phases in Kolo Creek

Carbon Length	Stations		
	1	2	3
C8	-	-	1.0427
C9	-	-	-
C10	-	-	2.0348
C11	-	-	8.0903
C12	0.6621	-	0.7323
C13	1.5537	-	2.0026
C14	20.7194	-	28.9463
C15	16.6233	2.1638	7.0045
C16	-	27.5137	1.4093
C17	3.2484	6.1343	0.6650
C18	1.4270	14.3143	0.6259
C19	0.4788	3.1542	22.5620
C20	1.2386	4.1519	0.4818
C21	-	-	13.4518
C22	1.9142	7.6783	9.7536
C23	-	-	1005.50
C24	1.1876	2.2205	0.0718
C25	-	-	0.0959
C26	3.8050	0.6097	10.7720
C27	-	-	-
C28	2.0463	3.7302	0.1501
C29	-	-	6890.20
C30	4.3534	0.3447	0.0627
C31	-	-	-
C32	5.5218	0.8042	0.1563
C33	-	-	-
C34	2.9074	1.0316	113.2750
C35	-	-	-
C36	-	-	-
C37	-	-	-
C38	-	-	-
C39	-	-	-
C40	-	-	-

The – sign indicates that the total petroleum hydrocarbon fraction was not found in one or both phases.

Conclusion

The work revealed that petroleum hydrocarbons were present in both surface water and sediment samples collected from different stations of Kolo Creek. The contamination degree of total petroleum hydrocarbons concentration in water and sediments of Kolo Creek were primarily due to illegal oil bunkering activities, gas flaring and transportation in the area. The high concentration of total petroleum hydrocarbons found in the creek originated from anthropogenic activities and its resultant input into the creek. The presence of petroleum hydrocarbons fractions in the creek impacted negatively on the aquatic organisms and the life of the inhabitants of the area. The presence of total petroleum hydrocarbons in the surface water and sediments of the creek has given rise to pollution and degradation of the environment which has caused imbalance in the aquatic ecosystem in the creek. Proper restoration steps should therefore be taken by the relevant agencies of government to put the creek in a condition that will be useful to the dwellers along the creek and other organisms that make use of the creek.

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