ToxEHS

Level of Petroleum Hydrocarbons in Water and Sediments of Ikoli Creek Bayelsa State Nigeria

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Abstract

Objective: This study investigated the level Petroleum hydrocarbon in Ikoli creek, Bayelsa state Nigeria with focus on water and sediments.
Methods: Water and sediments were assessed using standard analytical procedures. Water from surface levels and sediment samples were collected from five locations in the creek. Soxhlet extraction method and liquid-liquid techniques were used in extraction of the petroleum hydrocarbons (Total Hydrocarbon Content and Total Petroleum Hydrocarbon) from the water and sediment samples collected respectively followed by column clean up. Gas Chromatography-Flame Ionization Detector (GC-FID) was use to analyzed the Target compounds and quantified by integrating the areas of both the resolved and unresolved components.
Results: Results of analysis of THC and TPH in water ranges between 0.010 to 0.254 mg/L and Total Petroleum Hydrocarbon (TPH) values ranges between 0.001 to 0.437 mg/L in water respectively. While in sediments the Total Hydrocarbon Content (THC) values ranges between 0.01 to 1.43 mg/kg and Total Petroleum Hydrocarbon (TPH) ranges between 0.001 to 0.44 mg/kg. The THC and TPH value of sediments increases across each sampling station in the study area and these hydrocarbons are repository in nature.
Conclusions: The results showed that some sampling station in Ikoli creek were slightly polluted with petroleum hydrocarbons and does not conform to acceptable international guideline, which can cause adverse effects to humans and aquatic life over time.

Keywords: TPH, THC, Petroleum, Sediments, Ikoli Creek, Soxhlet

Introduction

The release of petroleum products into the environment, affects the physical, chemical, and biological processes of the environment. Groundwater are affected when Petroleum hydrocarbons enters the soil[1-3]. Total petroleum hydrocarbons (TPHs) are groups of persistent crude contaminants to water, sediments and the quality of air in the environment which can be lethal to many living organisms. There are many entry routes of TPH contamination into water and soils which includes petroleum drilling, exploration, exploitation, transportation, offloading, refining and consumption[4]. TPH are present in petroleum based products such as Asphalt, Premium Motor Spirit (P. M.S), Automated Gasoline Oil (A. G. O) and Dual Purpose Kerosene (D. P. K). Crude oil released into water contaminates the water and sediments with hydrocarbon deposits. The stretch of TPH present in the sample (water and sediment) is a warning of pollution in that location. The term Total Petroleum Hydrocarbons (TPH) is used to describe a wide family of several hundred chemical compounds that originally come from crude oil. It is useful to measure the total amount of all hydrocarbons found together in a particular sample of water, soil, or air. The analytical method commonly used for TPH is gas chromatography-flame ionization detector (GC/FID), a modified EPA method 8015B.

Gas chromatography (GC) is one of the most powerful, popular, unique and readily versatile analytical techniques used for the separation, identification and quantitative assay of compounds in the vapour state. The aim of this study is to assess the level Total Petroleum Hydrocarbon (TPH) and Total Hydrocarbon Content (THC) in water and sediments.

Results and Discussion

Water

The result of THC and TPH are presented in Table 1 below showing the level of hydrocarbons release in Ikoli

creek. The petroleum hydrocarbons levels in water were quite low due to the volatility and the evaporative effect of the crude oil (bonny light) that was spilled into the creek. The Total Hydrocarbon Content (THC) values ranges between 0.010-0.254 mg/L and Total Petroleum Hydrocarbon (TPH) values ranges between 0.001- 0.437 mg/L in water respectively. There was a relative increase in THC and TPH values at sampling station (AGW 4), the epicentre of the sampled area of Ikoli creek where water was collected. These results are indications of oil contamination in the study areas of the Ikoli creek and the levels of THC and TPH are marginally higher at the epicentre of Ikoli creek which is statistically significant.

However, the hydrocarbon concentration levels of water in the study area was low when compared with results of scholarly literatures within Niger Delta region of Nigeria[5-21]. The Use of water for cooking and drinking purpose is one of the numerous uses to the inhabitant close to Ikoli creek and the absence of potable water or treated waters can affect the livelihood of the Inhabitants. A comparison of the concentrations of the parameters measured with international guidelines (Table 1) shows that the highest concentration of THC and TPH was 0.254 mg/L and 0.437 mg/L which is higher than the permissible limits of stated by WHO of 0.3 µg/L. Maximum contaminant level of hydrocarbon in water is 0.10 µg/L[22]. The water is thus not suitable for drinking.

Sediments

The result of THC and TPH values for are presented in Table 2 below showing the level of hydrocarbons in sediments. The Total Hydrocarbon Content (THC) values ranges between 0.01-1.43 mg/kg and Total Petroleum Hydrocarbon (TPH) values in sediments ranges between 0.001-0.44 mg/kg. The THC and TPH value increases across each sampling station in the study area and these hydrocarbons are repository in nature. In the sediments the THC and TPH showed high level of statistical significance. Morever, when compared with the result of other petroleum hydrocarbons research studies[23-27], the study area had low levels of total hydrocarbon content and total petroleum hydrocarbon.

Table 1. Total Hydrocarbon Content (THC) and Total Petroleum Hydrocarbon (TPH) in Water.

	THC (mg/L)	TPH (mg/L)
AGW 1	0.010 ± 0.00^{a}	0.001 ± 0.00^{a}
AGW 2	0.010 ± 0.00^{a}	0.174 ± 0.00^{b}
AGW 3	0.010 ± 0.00^{a}	0.001 ± 0.00^{a}
AGW 4	0.254 ± 0.03^{b}	0.437 ± 0.035^{c}
AGW 5	0.007 ± 0.06^{a}	0.001 ± 0.00^{a}
AGSWX	0.010 ± 0.00^{a}	0.001 ± 0.00^{a}
WHO	NS	0.3

AGAQ- Sampling station, AGAQX- Control
NS- Not Stated (0.3 µg/L for C_{12}-C_{16}) for TPH.
Data is expressed as Mean ± Standard Deviation; different letters along the column indicate significant difference ($P < 0.05$).

Materials and Methods

Study Area

Agbura community is located in between Longitude 5°00 and 6°.45′ East and Latitude 5°00 and 6°.30′ North Surrounded by vegetation and water. The natives of Agbura community in Yenagoa Local Government major occupation is farming and fishing. Agbura community has a major manifold pipeline belonging to Nigeria Agip Oil Company (NAOC) that is located in longitude 006°15′15.9″ and latitude 04° 51′52.4″. The sampling stations are shown in Figure 1 below.

Sample Collection

Sediments Sample

A preliminary inspection was carried out on the site prior to sample collection in order to ensure that complications during sampling would be curtailed. Sediments soil sample were collected from various depth using an Ekman grab sampler from different sampling station in the oil spill affected areas. The Ekman grab sampler was used to collect standard size sample. 5 samples each were obtained in triplicate at five sampling station making it 25 samples to determine the background levels of petroleum hydrocarbons and a control sample was obtained in another location (Swali). Sediments samples were collected into a glass container with Teflon lid liners and screw caps. These were transported to the laboratory and stored in a refrigerator at 3-5°C prior to analysis. The Ekman grab was rinse with water and methanol after each sampling station to avoid unreliable reports.

Water Sample

Water sample were collected from five sampling station in the oil spill affected areas. 500 mL coloured

Table 2. Total Hydrocarbon Content (THC) and Total Petroleum Hydrocarbon (TPH) in Sediments.

	THC (mg/kg)	TPH (mg/kg)
AGSW 1	1.17 ± 0.02^{bc}	0.001 ± 0.00^{a}
AGSW 2	0.46 ± 0.03^{d}	0.17 ± 0.03^{d}
AGSW 3	0.22 ± 0.03^{c}	0.001 ± 0.00^{a}
AGSW 4	0.16 ± 0.03^{b}	0.44 ± 0.035^{e}
AGSW 5	0.01 ± 0.00^{a}	0.09 ± 0.05^{b}
AGSWX	1.43 ± 0.06^{e}	0.12 ± 0.07^{c}

AGSW (1-5)- Sampling station, AGSWX- Control
Data is expressed as Mean ± Standard Deviation; different letters along the column indicate significant difference ($P < 0.05$).

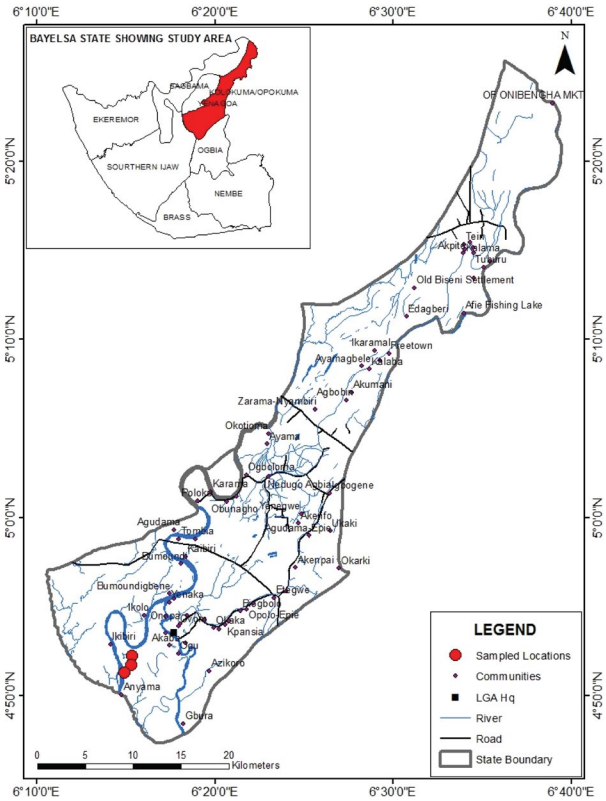

Figure 1. Map of the study area (showing Ikoli Creek; Bayelsa State in Yenagoa LGA withsampling locations)[28].

amber bottle with cover were used to collect water sample from Ikoli Creek. 5 samples were obtained from each sampling station in triplicate at five sampling station making it a total of 25 samples to determine the petroleum hydrocarbons levels and a control sample was obtained in another location (Swali).

Total Hydrocarbon Content

Soxhlet Extraction Method

The entire water layer on the sediments sample was air-dried and sieved through a 2 mm mesh size sieve before being thorough mixed, especially the composite samples. Foreign object like sticks leaves and stones were discarded. 10 grams of sample was blended with 10 grams of anhydrous sodium sulphate, the homogenized sample was transferred to an extraction thimble and covered with glass wool. The extraction cap was to drain freely for the duration of the extraction period.

Extraction

The Soxhlet apparatus containing the extraction thimble and sample was set with the attachment of a 250 mL boiling flask containing 90 mL of n-hexane. The heating control on the heating mantle was adjusted so that a cycling rate of 20 cycles/h was obtained. Extraction was carried out for a period of 4 hrs. Afterwards, a clean 250 mL boiling flask was oven dried at 105°C for 2 hrs, after which it was cooled in the dessicator at room temperature. With the use of tongs, the boiling flask was removed from the dessicator and weighed on a calibrated weighing balance. At the end of the 4 hrs extraction period, the organic extract was filtered through grease-free cotton, into the pre-weighed boiling flask with the aid of hand gloves. The flask and cotton wool were then rinsed with n-hexane and added to the 250 mL boiling flask.

The boiling flask was connected to the distilling head apparatus and solvent was distilled by immersing the lower half of the flask by heating the mantle. The temperature of heating device was adjusted to complete the distillation in less than 30 minutes. The solvent was disposed off in a glass bottle designated for storing organic waste before appropriate waste disposal.

After whole distillation, the distilling head was quickly removed, followed by the immediate removal of the flask from the mantle, before the flask was then cooled in a dessicator for 30 minutes and weighed. The gain in weight of the boiling flask was determined by substracting the initial from the final weight of flask.

Calculation:

Calculate the concentration of HEM (Hexane Extractable Material) in the soil sample as follows:

$$\text{HEM (mg/kg wet weight)} = \frac{\text{gain in weight of flask (mg)}}{\text{Weight of wet solid (g)}} \times 1000$$

Total Petroleum Hydrocarbon in Oily Water

Extraction

Measure out 250 mL of water sample into a separatory funnel, rinse the container (sample) with dichloromethane, adding 25 mL of dichloromethane to 250 mL part of the water sample, shake to mix vigorously so as to have the organic material. The process involves a Buckner separatory funnel and the process of extraction (liquid-liquid extraction).

The organic extract is collected into receiving container via passing the organic extract through a column containing cotton wool, silica gel and anhydrous sodium sulphate. The silica-gel aids the cleanup of the extract by disallowing the passage of debris from the extract while the anhydrous sodium sulphate act as a dehydrating agent to rid the extracts of every form of moisture/water from the sample since the two immiscible liquids.

The collected organic extract is injected into the Gas Chromatogram. 1 μL of the concentrated sample extract is injected by means of hypodermic syringe through a rubber septum into the column. The various fractions of the aliphatic compound (C_8 to C_{40}) are automatically detected as it emerges from the column by the FID detector whose response is dependent upon the composition of the vapour. The results are expressed in ppm or mg/L which is equivalent units.

TPH in Solid Sample

Extraction

2 gram of sample was weighed into a clean extraction container. 10 mL extractions solvent (pentane) was added into the sample, shake carefully and allowed to settle. The mixture were carefully filtered into clear solvent rinsed extraction bottles using filter paper into Buchner separating funnels, the extracts were concentrated to 2 mL and then transferred for cleanup/separation.

Cleanup/separation

1 cm of moderately packed glass wool was placed at bottom of 10 mm ID × 250 mm long chromatographic column.

Slurry of 2 gram activated silica in 10 mL methylene chloride was prepared and placed into the chromatographic column. To the top of the column was added 0.5 cm of sodium sulphate. 10 mL of methylene chloride were used to rinse the column additional.

The column was pre-eluted with 20 mL of pentane, this was allowed to flow through the column at a rate of about 2 minute until the liquid in the column was just above the sulphate layer.

Immediately 1 mL of the extracted sample was transfer into the column. 1 mL of pentane was used to rinse the extraction bottle and the column. The stop-clock of the column was opened and the eluant was collected with a 10 mL graduated cylinder. Just prior to exposure of the sodium sulphate layer to air, pentane was added to the column in 1-2 mL increments. Accurately measured volume of 8-10 mL of the eluant was collected and was labeled aliphatics.

Gas Chromatography with a Flame Ionization Detector

The concentrated aliphatic fractions were transferred into the labeled glass vials with Teflon or rubber crimp caps for Gas chromatography analysis.

Concentrated sample was introduced by means of 1 μL hypodermic syringe through a neoprene septum into the column separation occurs as the vapour constituent partition between the gas and liquid phases. The sample was automatically detected as it emerges from the column (at constant flow rate) by the FID detector whose response is dependent upon the composition of the vapour.

Helium was used as the carrier gas at a 1.0 mL min^{-1} flow rate, and a 10 : 1 split ratio was used[29,30].

Quality Assurance and Quality Control

For proper precision and accuracy appropriate quality assurance precautions and procedures were implemented to ensure reliability of the results. The concentration values for the target.

Compounds were within the assigned reference value of 95% confidence interval for selected hydrocarbon concentrations. To ensure proper instrument reading and accuracy in procedure, Gas Chromatography HP5890 was used.

Statistical Analysis

Data were expressed as mean ± standard deviation, the statistical analysis was carried out using one-way analysis of variance (ANOVA). The statistical Package for the Social Science (SPSS) version 20. Duncan's multiple range test was used to determine the source of observed difference. Differences were considered significant at a probability level of 0.05.

Conclusion

From the present study hydrocarbon levels were slightly high in some sampling station. These high concentrations of hydrocarbons can have undesirable health effects on humans consuming the water and can affect aquatic lives. Mitigating measured should be put in place to reduce hydrocarbons into the immediate environment. From the results of this study, there is an indication that Ikoli creek in some sampling station was slightly polluted with petroleum hydrocarbons as a result of leakage of crude oil from the pipeline. Furthermore comparison with standards for specific industrial purposes and for drinking showed that the Ikoli Creek water is not potable water for drinking and not suitable for domestic uses.

Conflict of Interest

Ighariemu Victor declares that he has no conflicts of interest with the contents of this article. Donatus Chuka Belonwu declares that he has no conflicts of interest with the contents of this article. Matthew Owondah Wegwu declares that he has no conflicts of interest with the contents of this article.

Ethical Approval

This article does not contain any studies on human participants or animals performed by any of the authors.

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