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Levels of Total Hydrocarbon in Aquatic Plant (*Ceratophyllum demersum*) of the Polluted River Oluwa, Western Nigeria

BY

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Abstract

Total hydrocarbon content concentrations were determined in aquatic plant (*Ceratophyllum demersum*) collected from River Oluwa at Agbabu, Western Nigeria, in the dry season and rainy season of two consecutive years. Samples were analyzed using the UV-vis spectrophotometer (HACH 2400). The average concentrations of total hydrocarbon content in aquatic plant (*Ceratophyllum demersum*) in the stations in the in the four seasons ranged from 0.22 ppm and 28.39 ppm. These values are higher than the WHO permissible level of 0.001µg/g for seafood in inland waters. The average hydrocarbon content in aquatic plant (*Ceratophyllum demersum*) collected during the dry season were significantly higher than the average concentration of total hydrocarbon content during the rainy season. The statistical analysis of the correlation coefficients of the values of THC at the sampling points are significant at 0.01, implying the hydrocarbons originated from biogenic sources due to the bitumen deposit in the environment and anthropogenic sources. High concentrations of total hydrocarbon content observed in aquatic plant (*Ceratophyllum demersum*) can be deleterious to consumers, therefore, aquatic food from River Oluwa at Agabu farm settlement should be taken with caution.

Keywords: aquatic plant, concentration, total hydrocarbon content, season, Ceratophyllum demersum, River Oluwa

Introduction

One of the major causes of pollution in the rural environment is transportation, dumping, and extensive application of crude oil. Crude oil contains a complex mixture of aliphatic, aromatic, and heterocyclic compounds (Manish et al., 2019). Bitumen found in Nigeria contains hydrogen, carbon, sulphur, and oxygen, which is similar to the composition as the light crude oil. that is, hydrogen, carbon, and minor amount of sulphur and oxygen (Akinmosin et al., 2009; Fagbote et al., 2014).

Agbabu is a farm settlements in the Nigerian bitumen deposit area which is about 210 km to Lagos in the South-Western part of Nigeria. Agbabu community in Ondo State of Nigeria is located between latitude 6° 35′ 19″ N and longitude 4° 50′ 03″ E (Atikpo et al., 2021). Agbabu has a bitumen belt of cretaceous tar sand bitumen deposit of about 42.74 billion metric tons, making it the second largest in the globe (Abatyough et al., 2016). The climate is typically that of tropical with an average rainfall and temperature of 1837 mm and 27.1 °C. The area is subjected to dry and rainy Nigerian seasons. This is where bitumen was first spotted in Nigeria in 1910 and the first bitumen well NBC-7 was drilled there. There is an old tarred road running from the north end, which is the only entrance into the village by land, through the village, and ends up in a large tarred space at the south end. Farmers at Agabu and Temidire deal mainly in cash crops such as cocoa and colanut and food crops such as yam and plantain and fishing along River Oluwa which flows through whole land. These villagers depend on River Oluwa for their farming activities and other domestic use while hand-dug shallow wells and bore hole serve as their only source of potable water. The two distinct seasons in the year are dry season and rainy season. The dry season is at its peak from January to March while the rainy season is at its peak from July to the middle of September (Olaleye and Adedeji, 2005). The annual precipitation of River Oluwa ranges between 2000mm to 2500mm. Discharge records for Rivers Niger (5,589 m3s-1) and Ikpoba (39m3s-1) have been reported, but there are no discharge records for River Oluwa, like many rivers in Nigeria. The average depth of hand dug well at Oluwa bitumen deposit area was 7.5m (Ikhile, 2012)

Hydrocarbons are a class of chemicals that contain only carbon and hydrogen atoms (Ideriah et al., 2011). The four fractions of Total hydrocarbon content are: aliphatic saturates e.g. alkanes, branched, and naphthenic compounds); aromatics (polycondensed parent- and alkylated) hydrocarbons); resins; asphaltenes (Ossai et al., 2019).

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There are two sources of aliphatic hydrocarbons, anthropogenic and natural. Anthropogenic hydrocarbons come from human activities. Natural hydrocarbon can come from natural deposits or biogenic source which can be produced by organisms such as bacteria, insects, planktons, algae bacteria, terrestrial and aquatic plants (Sakaria et al., 2008). Hydrocarbons have been recognized as important pollutants that can appear in high concentration. Total hydrocarbons (THC) (alkanes, alkenes, and cycloalkanes) was one of the main pollutants in European contaminated sites forming 33.7 % of total soil contaminants (Houssein et al., 2020). Aquatic environment contaminated by hydrocarbons has an adverse effect in nature, animals, human beings, and plants. Lack of oxygen, decrease in crop yield, and effects on aquatic plants are various effects of hydrocarbon contamination in nature (Srivastava et al., 2019). Hydrocarbon-contaminated water is known to be carcinogenic, neurotoxic, and mutagenic to flora and fauna (Hu et al., 2022).

Aquatic macrophytes for the basis of aquatic ecosystems and play fundamental roles in nutrient cycling (Abu, T., 2017). Aquatic macrophytes may be classified as emergent (e.g. cattails), free-floating (e.g. water lilies), or submerged macrophytes (e.g. coontail-ceratophillum demnersum) (Oyedeji and Abowei, 2012). Ceratophyllum demersum, also called coontail or hornwort, occurs in quiet and slow-flowing waters (Figure 1). Ceratophyllum demersum has been widely used as bioindicators in heavy metals pollution, radioactive indicators, and genetic engineering (Shabnam and Saeed, 2016). It is also used as a source of food for some livestock, poultry, and fish (Abu, T., 2017).

Figure 1: Ceratophyllum Demersum

Evaluation of Total hydrocarbon levels in some aquatic media in an oil-polluted mangrove wetland in the Niger Delta has been carried out (Clinton et al., 2009). Results showed elevated Total hydrocarbon levels mean levels in water, sediment, Tympanotonus fuscatus (Periwinkle), and Periophthalmus papillio, (Mudskipper), indicating a polluted environment. Investigation has been carried out on Total Hydrocarbon Content in Water and Sediment at Effluent Discharge Points into the New Calabar River, Rivers State, Niger Delta, Nigeria (Edori, et al., 2021). The observed results showed that the concentrations of total hydrocarbons in both water and sediments were above the legal limit set by DPR, Nigeria. Total Hydrocarbon Contents: Spatial Variations in Aquatic Environment of Oyigbo Communities, Rivers State has been reported (Paul et al., 2022). The result showed some elevated concentration, especially for the sediment sample which is noticed mostly in sediments and surface waters from Komkom community samples.

This study was carried out with the following aims: to conduct assessment of the status of pollution with total hydrocarbon of the aquatic macrophyte (Ceratophyllum demersum) on the polluted River Oluwa at Agbabu farm settlement. This study is significant because despite the complete dependence of the farmers on River Oluwa the status of pollution of the aquatic plants with total hydrocarbon has not been reported.

Material Method

Sample Collection:

Samples of aquatic plant (*Ceratophyllum demersum*) were collected from four sampling points on River Oluwa at Agbabu. Samples were collected in the dry and rainy seasons of 2017 and 2018. Sampling points were geo-located with Geographical Position System (GPS) to ensure consistency.

Quality Assurance

Reagent blanks were used in all analyses to check reagent impurities and other environmental contaminations during analyses. Analytical-grade reagents were used for all analyses. All reagents were standardized against primary standards to determine their actual concentrations. All glasswares used were washed with detergent and rinsed with water before use. Instruments were calibrated before use. Quality checks were also performed on the instruments. Tools and work surfaces were carefully cleaned for each sample. Minimum of triplicate readings were taken to check precision of the analytical method and instrument

Concentration Measurement

5g of sample was weighed and enough sodium sulphate anhydrous was added to remove any trace of water. 25ml of chloroform was added to this mixture and stirred. The extracted hydrocarbon was then filtered into clean dry 100ml standard volumetric flask. The extraction was done three times and the combined extract was made up to mark. The concentration of hydrocarbon in the extract was then measured on a UV-vis spectrophotometer (HACH 2400) at a wavelength of 450nm (ASTM, 2003).

Results and Discussion

Table 1: Average Concentration of THC in 2017

S/N	SAMPLE ID	AV. THC CONC. (ppm) - Dry Season (2017)	AV. THC CONC. (ppm) - Rainy Season (2017)
1	PLANT-OLSW-1	1.12	0.34
2	PLANT-OLSW-2	1.22	0.22
3	PLANT-OLSW-3	1.33	1.13

4	PLANT-OLSW-4	0.91	0.28

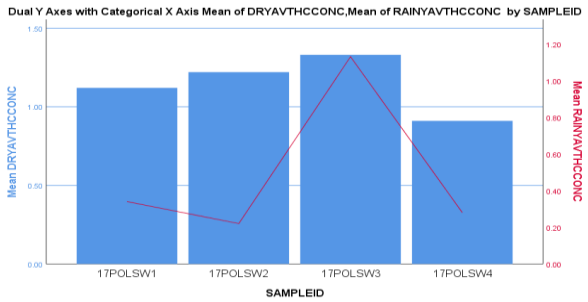

Figure 2: Average Concentration of THC in 2017

Table 2: Average Concentration of THC in 2018

S/N	SAMPLE ID	AV. THC CONC. (ppm) - Dry Season (2018)	AV. THC CONC. (ppm) - Rainy Season (2018)
1	PLANT-OLSW-1	28.39	5.34
2	PLANT-OLSW-2	15.65	6.23
3	PLANT-OLSW-3	21.03	3.56
4	PLANT-OLSW-4	11.46	4.24

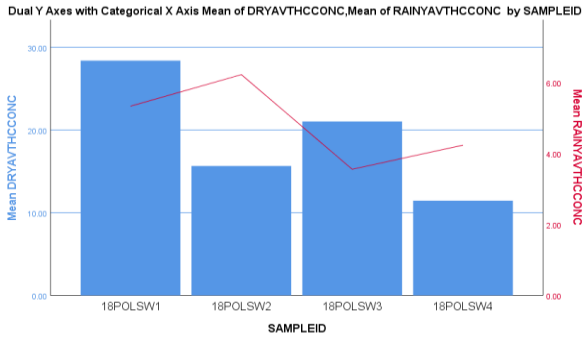

Figure 3: Average Concentration of THC in 2018

The average concentrations of total hydrocarbon content in aquatic plant (*Ceratophyllum demersum*) in the dry season of 2017 are shown in the Table 1 and Figure 2. In the dry season, the lowest average total hydrocarbon content was 0.91ppm at station PLANT-OLSW-4 while the highest average total hydrocarbon content value was 1.33 ppm at PLANT-OLSW-3. The trend of the average concentrations of the average total hydrocarbon content at the stations in the dry season was PLANT-OLSW-4< PLANT-OLSW-1< PLANT-OLSW-2< PLANT-OLSW-3. The average concentration of hydrocarbon at the sampling point PLANT-OLSW-3 was the highest probably due to high level of activities at the sampling point.

In the rainy season of 2017, the lowest average total hydrocarbon content was 0.22 ppm at station PLANT-OLSW-2 while the highest average total hydrocarbon content value was 1.13 ppm at sampling point PLANT-OLSW-3. The trend of the average concentrations of hydrocarbons at the stations in the rainy season was PLANT-OLSW-2< PLANT-OLSW-4< PLANT-OLSW-1< PLANT-OLSW-3. The average concentration of total hydrocarbon content in aquatic plant (*Ceratophyllum demersum*) in the stations in the dry season was 1.15 ppm, while the average concentration in the rainy season was 0.50 ppm.

The average concentrations of total hydrocarbon content in aquatic plant (*Ceratophyllum demersum*) in the dry season of 2018 are shown in the Table 2 and Figure 3. In the dry season, the lowest average total hydrocarbon content was 11.46 ppm at station PLANT-OLSW-4 while the highest average total hydrocarbon content value was 28.39 ppm at PLANT-OLSW-1. The trend of the average concentrations of the average total hydrocarbon content at the stations in the dry season was PLANT-OLSW-4< PLANT-OLSW-2< PLANT-OLSW-3< PLANT-OLSW-1. The average concentration of hydrocarbon at the sampling point PLANT-OLSW-1 was the highest probably due to the nearness to where a well for exploitation of bitumen is located. This indicates that the total hydrocarbon content in aquatic plant (*Ceratophyllum demersum*) in the environment came from both biogenic and anthropogenic sources.

In the rainy season of 2018, the lowest average total hydrocarbon content was 3.56 ppm at station PLANT-OLSW-3 while the highest average total hydrocarbon content value was 6.23 ppm at sampling point PLANT-OLSW-2. The trend of the average concentrations of hydrocarbons at the stations in the rainy season was PLANT-OLSW-3< PLANT-OLSW-4< PLANT-OLSW-1< PLANT-OLSW-2. The average concentration of total hydrocarbon content in aquatic plant (*Ceratophyllum demersum*) in the stations in the dry season was 19.13 ppm, while the average concentration in the rainy season was 4.84 ppm.

In 2017 and 2018, average concentrations of total hydrocarbon content in aquatic plant (*Ceratophyllum demersum*) on River Oluwa were in the dry season than the rainy season probably due to higher volatility of total hydrocarbons and higher domestic activities along the river. Values obtained in the 2018 were higher than 2017 probably due to higher domestic activities.

The statistical analysis of the correlation coefficients of the values of total hydrocarbon content at the sampling points are significant at 0.01 significance level using the bivariate Pearson correlation of IBM SPSS 25.0. This implies that the hydrocarbons originated from the same source at all sampling points. These sources are biogenic sources due to the deposit bitumen in the environment and anthropogenic sources.

The national permissible limit of total hydrocarbon/oil grease for inland water is 10mg/l while the WHO permissible level of THC in seafood is 0.001µg/g (Clinton et al., 2009). The values of average total hydrocarbon content recorded in this

study ranged from 0.22 ppm to 28.39 ppm. These values are higher than the WHO permissible level of 0.001µg/g for seafood in inland waters. This indicates that River Oluwa was contaminated with total hydrocarbon and the continuous consumption of seafood from the area is unsafe and may pose a health hazard.

Correlations

		PLANTOLSW1	PLANTOLSW2	PLANTOLSW3	PLANTOLSW4
PLANTOLSW1	Pearson Correlation	1	.977*	.999**	.984*
	Sig. (2-tailed)		.023	.001	.016
	N	4	4	4	4
PLANTOLSW2	Pearson Correlation	.977*	1	.965*	.999**
	Sig. (2-tailed)	.023		.035	.001
	N	4	4	4	4
PLANTOLSW3	Pearson Correlation	.999**	.965*	1	.973*
	Sig. (2-tailed)	.001	.035		.027
	N	4	4	4	4
PLANTOLSW4	Pearson Correlation	.984*	.999**	.973*	1
	Sig. (2-tailed)	.016	.001	.027	
	N	4	4	4	4

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Conclusion

Total hydrocarbon content in aquatic plant (*Ceratophyllum demersum*) on River Oluwa at Agbabu farm settlement originated from both biogenic and anthropogenic sources. Average concentration of THC measured in the dry season were higher than rainy season. The average concentration of THC ranging from 0.22 ppm and 28.39 ppm were higher than the permissible level for seafood in inland waters. However, the values are lower that the values obtained by Clinton et al. (2009) on Evaluation of the Total Hydrocarbon levels in some Aquatic media in an oil-polluted mangrove wetland in the Niger Delta, however, the values obtained were in the same range of 0.01 mg/kg and 20.75 mg/kg recorded by Chukwumati and Asiegbu (2023) in their study titled Accumulation of hydrocarbons and some heavy metal contents on sediments and plants from crude oil polluted mangrove ecosystem in Okrika, Nigeria. The aquatic plant (*Ceratophyllum demersum*) on River Oluwa at Agbabu farm settlement has been slightly polluted with total hydrocarbon content. Aquatic foods from River Oluwa can pose a great danger to the health of inhabitants of Agabbu bitumen deposit area and should be consumed with caution.

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