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Total Hydrocarbon Content of the Bitumen Impacted Soil in Ondo State, Nigeria

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Abstract:- Total hydrocarbon content concentrations were determined in soil collected from Agbabu, Western Nigeria, in the dry season and rainy season for two years. Samples were analyzed using the UV-vis spectrophotometer (HACH 2400). The average concentration of 146.89 ppm recorded in Dry Season of Year-1 was higher than the 100 ppm recommended for a normal soil by Regulation on the assessment of environmental pollution by European Geosciences Union. 5.36 ppm in the Rainy Season of Year-1, 5.00 ppm in the Dry Season of Year-2 and 4.92 ppm in the Rainy Season of Year-2 were lower that value recommended for a normal soil. The average concentrations recorded were higher than the values recorded at the control sampling points. These indicate that the soil of Agbabu and Temidire has been impacted with total hydrocarbon due to the bitumen deposit and other anthropogenic activities. This is dangerous for the health of the rural dwellers at Agbabu and Temidire because the total hydrocarbon can bioaccumulate and biomagnify and and affect the biota through food chain. Compounds containing total hydrocarbon cause side effects on the blood, immune system, lungs, skin and eyes. The soils of Agbabu and Temidire will not require remediation because it may recover through a natural attenuation. However, a program should be put in place by the stake holders to periodically monitor the status of total hydrocarbon in the soil of Agbabu and Temidire in Ondo State, Nigeria.

Keywords:- *Soil, Total Hydrocarbon, Season, Bitumen, Environment.*

I. INTRODUCTION

Hydrocarbon is an organic chemical compound that is composed exclusively of hydrogen and carbon atoms (Bakpo and Emejuru, 2023). Hydrocarbons are naturally occurring and form the basis of crude oil, natural gas coal, bitumen and other important energy sources (Ideriah et al., 2011; Wokoma, 2015).

They originate from plant and animal fossils that were formed by the forces of temperature and weight over time. The Nigerian bitumen has similar 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). It is believed to have formed from biodegradable and water washing of light crude. The four categories of total hydrocarbon content are aliphatic saturates, aromatics, resins, and asphaltenes (Ossai et al., 2019).

Hydrocarbon pollution has severe consequences on the environment (Obinna et al., 2014; Samuel et al., 2022). Hydrocarbon pollution of soil can occur in several ways, from natural seepage in areas where crude oil or bitumen is found in shallow reservoirs, to accidental spillage of crude oil on the ground and the flaring of gas. Regardless of the source of contamination, once hydrocarbon come into contact with the soil, they alter its physical and chemical properties. Although the degree of the alteration depends on the soil type, the specific composition of the hydrocarbon spilled. In other situations, for example a spill of heavy crude oil on clay soil, the chemicals can remain in the soil for decades, altering its permeability, causing toxicity and lowering or destroying the quality of the soil. In such a situation the soil itself will become a source of pollution. Contaminated soils can affect the health of organisms through direct contact or via ingestion or inhalation of soil contaminants which have been varporized.

Soil can also act as reservoir of residual pollution, releasing contaminants into ground water or air over extended period of time, often after the original source of pollution has been removed (UNEP, 2011) Contamination of the environment with hydrocarbon has been a topic of interest and attracted increasing attention because of the carcinogenic, mutagenic and toxic effects (Okop and Ekpo, 2012). High concentration levels of hydrocarbons present in contaminated sites could pose a health risk to humans, plants and animal lives. In recent years, the release of hazardous and toxic substances into the soil, water, sediment and air in Niger Delta, Nigeria has been a widespread problem (Chukwujindu et al., 2008).

Okop and Ekpo (2012) carried out the determination of total hydrocarbon content in soil after petroleum spillage and found out that the soils showed elevated levels of total hydrocarbon contents when compared with the reference sites and revealed the of a holistic and sustainable monitoring and remediation of the environment.

Iyebor et al. (2020) assessed the level Hydrocarbons in Soil along Crude Oil Pipeline Route in Rivers State, Nigeria, and found out that the TPH and PAH concentrations obtained in soil exceeded their respective target values of the DPR in oil spilled soil nevertheless, below their respective intervention limits. Determination of total hydrocarbons in contaminated soil with ”Thin Layer Sorptive Extraction coupled with Attenuated Total

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Reflectance -Fourier Transform Infrared has been reported (Louati et al., 2021). The report confirmed that the use of Thin Layer Sorptive Extraction coupled with Attenuated Total Reflectance -Fourier Transform Infrared can become an effective alternative to the current methods for the determination of the total hydrocarbons in soils. Total Hydrocarbon Contents: Spatial

Variations in Aquatic Environment of Oyigbo Communities, Rivers State has been reported (Paul et al., 2022). The result showed that the sediment had more total hydrocarbon content than the surface water, which is expected because the sediment is a reservoir for the water. The sediment and surface water THC levels were lower than the WHO permissible standard which indicates low risk level.

Owing to the very large number of hydrocarbons present in crude oil and bitumen, the environmental and health impacts of all the constituent parts have not yet been fully studied or understood. Therefore, this research aimed at assessing the level of contamination of the soil of Agbabu bitumen deposit area.

II. MATERIAL AND METHOD

➢ *Sample Collection:*

Samples were collected from fifteen sampling points at Agbabu and Temidire. At each sampling point, topsoil samples were collected at six inches depth, while bottom soil samples were collected at twelve inches depth. Control sampling points were located at Okitipupa (30km away) and Owena (80km away). Samples were collected in the dry and rainy seasons of two consecutive years. 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).

III. RESULTS AND DISCUSSION

Table 1 Ave. Conc. of THC in Soil

SN	SAMPLE ID	AVE THC CONC. (ppm)- Dry Season – Year-1	Std Dev	AVE THC CONC. (ppm)- Rainy Season – Year 1	Std Dev	AVE THC CONC. (ppm)- Dry Season – Year- 2	Std Dev	AVE THC CONC. (ppm)- Rainy Season – Year 2	Std Dev
1	TO TOP	1361.67	87.51	6.40	0.36	5.26	0.40	5.33	0.44
2	TO BOT	68.97	5.71	4.20	0.36	4.84	0.25	4.37	0.18
3	T1W TOP	99.83	3.89	4.00	0.17	4.07	0.05	3.47	0.20
4	T1W BOT	40.72	3.28	2.97	0.21	3.33	0.19	3.16	0.20
5	T1E TOP	13.00	2.51	8.60	0.20	7.23	0.09	7.37	0.17
6	T1E BOT	10.10	1.65	5.20	0.36	6.22	0.11	6.44	0.28
7	T2E TOP	233.87	9.89	5.10	0.10	5.00	0.20	4.39	0.37
8	T2E BOT	151.13	3.63	3.29	0.19	3.77	0.17	3.24	0.24
9	T3E TOP	90.70	1.91	5.97	0.29	5.03	0.11	5.11	0.16
10	T3E BOT	82.50	7.51	3.60	0.10	4.47	0.21	4.20	0.28
11	T4E TOP	63.57	2.38	7.30	0.26	6.15	0.38	6.07	0.34
12	T4E BOT	52.83	2.10	5.85	0.28	4.69	0.37	4.33	0.16
13	T1S TOP	41.55	2.74	6.50	0.26	5.62	0.22	5.80	0.21
14	T1S BOT	30.93	2.27	5.25	0.30	4.12	3.98	4.14	0.33
15	T2S TOP	61.52	3.28	4.20	0.20	5.37	0.27	5.03	0.26
16	T2S BOT	12.67	0.85	3.65	0.15	4.51	0.32	4.60	0.16
17	T3S TOP	23.17	2.72	6.34	0.26	5.32	0.38	5.24	0.42
18	T3S BOT	15.62	1.62	4.75	0.13	4.66	0.39	4.10	0.16
19	T4S TOP	80.33	2.64	8.30	0.10	7.36	0.18	7.14	0.14
20	T4S BOT	30.95	1.85	6.40	0.20	4.75	0.25	4.34	0.11
21	T1N TOP	34.17	1.43	7.75	0.12	6.73	0.24	6.44	0.24

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22	T1N BOT	26.23	2.00	4.36	0.15	5.38	0.10	5.86	0.43
23	T2N TOP	25.88	1.65	7.20	0.20	6.30	0.40	6.02	0.24
24	T2N BOT	21.30	0.67	4.97	0.13	4.41	0.22	4.61	0.16
25	T3N TOP	106.97	1.63	5.00	0.44	6.00	0.13	4.22	0.28
26	T3N BOT	32.18	1.91	3.50	0.20	4.73	0.09	5.24	0.38
27	T4N TOP	36.67	1.26	6.36	0.05	4.14	0.11	4.26	0.18
28	T4N BOT	173.20	1.92	4.72	0.11	3.58	0.26	3.28	0.28
29	AG – MILE2 - TOP	656.50	7.70	5.35	0.13	3.73	0.20	5.47	0.20
30	AG – MILE2 - BOT	727.83	2.02	3.73	0.15	3.16	0.14	4.22	0.26
31	OKCTR (Top)	5.92	0.50	7.30	0.26	2.43	0.07	2.50	0.11
32	OKCTR (Bot)	6.65	0.66	5.65	0.05	1.73	0.19	1.21	0.04

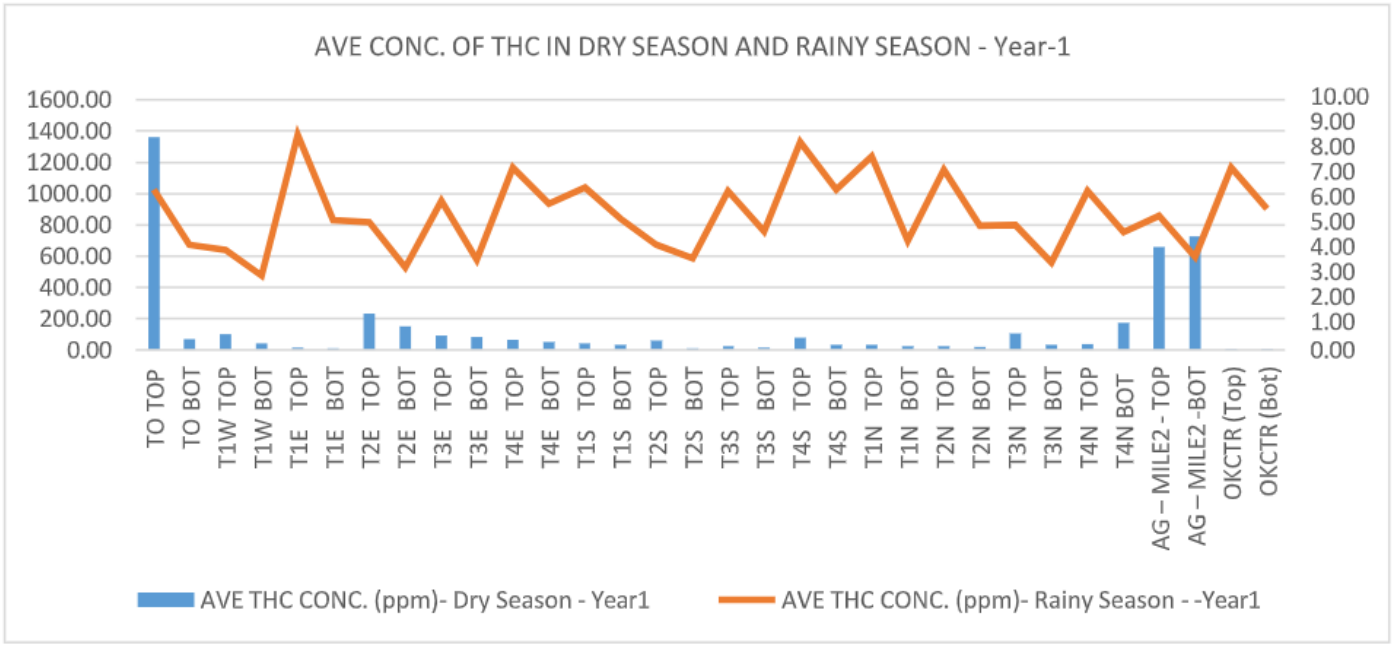

Fig 1 Concentration of THC in Soil – Year 1

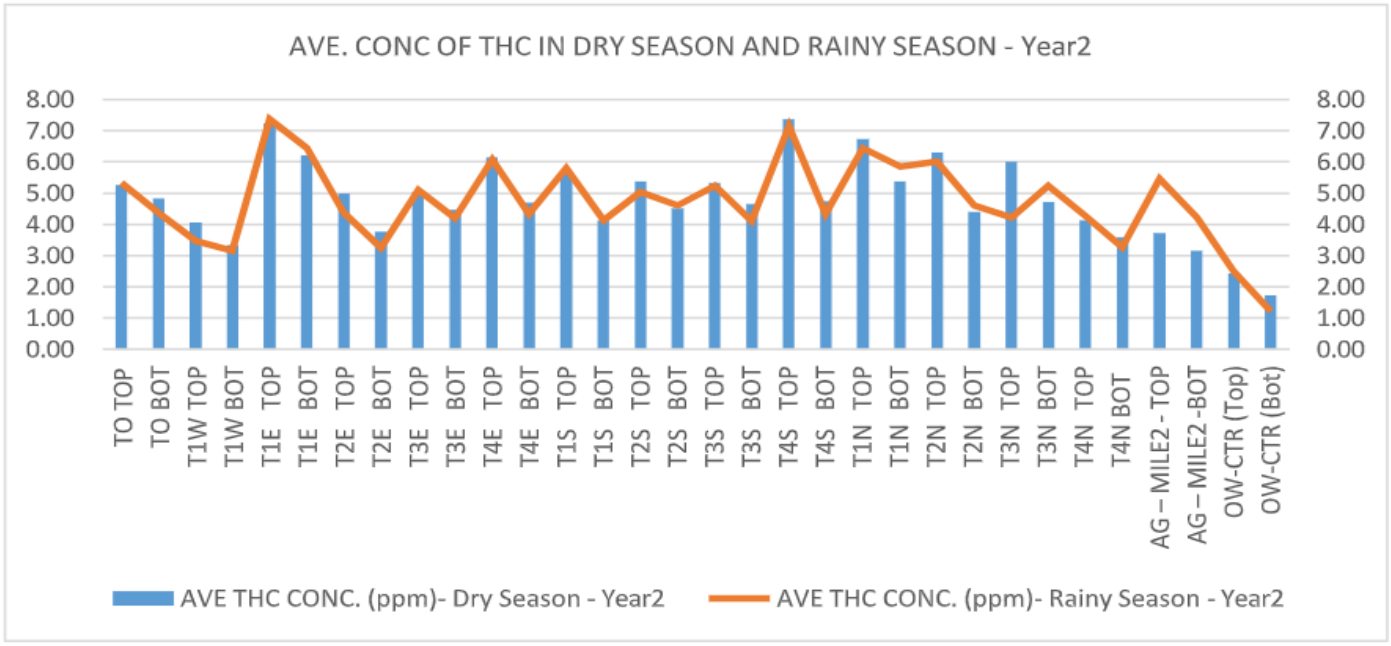

Fig 2 Average Concentration of THC in Soil – Year2

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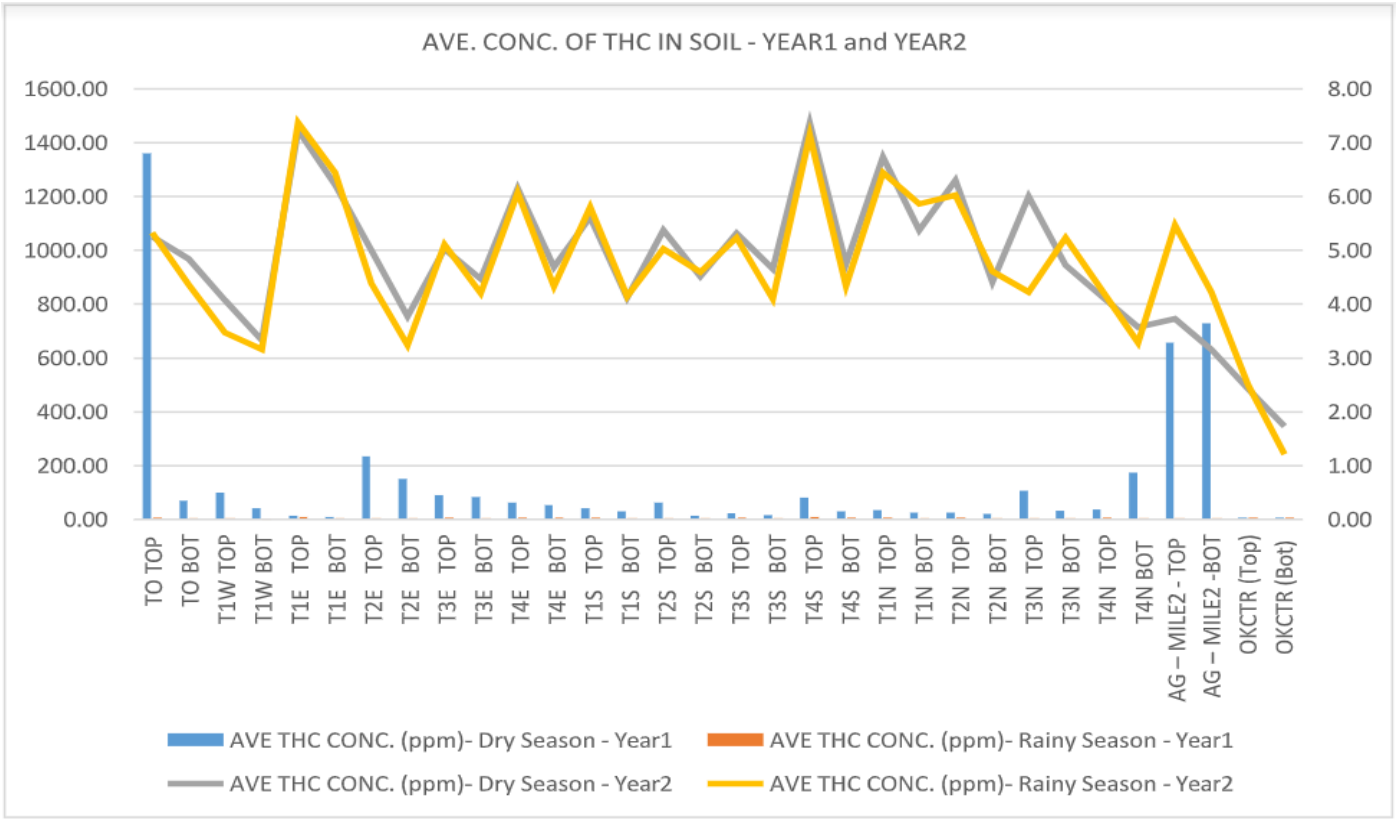

Fig 3 Average Concentration of THC in Soil – Year 1 and Year2

➢ *Correlations*

Table 2 Correlations

		THCDRY-Year 1	THCRAINY-Year 1	THCDRY – Year 2	THCRAINY-Year 2
THCDRY-Year1	Pearson Correlation	1	-.039	-.112	.048
	Sig. (2-tailed)		.832	.543	.795
	N	32	32	32	32
THCRAINY-Year1	Pearson Correlation	-.039	1	.513**	.498**
	Sig. (2-tailed)	.832		.003	.004
	N	32	32	32	32
THCDRY-Year2	Pearson Correlation	-.112	.513**	1	.902**
	Sig. (2-tailed)	.543	.003		.000
	N	32	32	32	32
THCRAINYYear 2	Pearson Correlation	.048	.498**	.902**	1
	Sig. (2-tailed)	.795	.004	.000	
	N	32	32	32	32

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

The average concentrations of THC in the bitumen impacted soil of Agbabu are shown in the Table 1. Figure 1 shows the average concentrations of THC in Soil in Year 1. In the dry season of Year-1, the lowest average total hydrocarbon content was 10.10ppm at station T1E-BOT while the highest average total hydrocarbon content value was 1,361.67ppm ppm at T0-TOP.

The highest average concentration was recorded at T0-TOP because it was the closest to the bitumen well NBC-7 where bitumen was first exploited (Fagbote and Olanipekun, 2010; Olabemiwo et al., 2016; Akinsulore and Akinsulore, 2021). This indicates that the bitumen deposit in the environment must have contaminated the soil with total hydrocarbon. The concentrations recorded were higher than the values at the control sampling points, also indicating contamination of the soil of Agbabu and Temidire. The concentrations of total hydrocarbon in the topsoil is higher than the values in the bottom soil because of its strong sorption towards soil organic matter (Liu et al, 2017).

In the rainy season of Year-1, the lowest average total hydrocarbon content was 0.67 ppm at station T2N-BOT while the highest average total hydrocarbon content value was 87.51 ppm at T0-TOP. The highest average concentration was also recorded at T0-TOP because it was

the closest to the bitumen well NBC-7. The concentrations recorded at the sampling points were close to the values recorded at the control sampling points. This indicates that apart from biogenic and petrogenic sources of total hydrocarbon contamination in the soil, there are anthropogenic sources. The concentrations of total hydrocarbon in the topsoil was also higher than the values in the bottom soil.

In the dry season of Year-2, the lowest average total hydrocarbon content was 3.16 ppm at station AGMILE2-BOT, while the highest average total hydrocarbon content value was 7.36 ppm at T4S-TOP. The concentrations recorded at the sampling points were higher than the values recorded at the control sampling points.

In the rainy season of Year-2, the lowest average total hydrocarbon content was 3.16 ppm at station T1W-BOT, while the highest average total hydrocarbon content value was 7.14 ppm at T4S-TOP. In Year-2, the highest concentrations were recorded in both dry and rainy seasons at the sampling point T4S-Top because the sampling point was close to anthropogenic activities of a local palm oil mill. The concentrations recorded at the sampling points were higher than the values recorded at the control sampling points.

The average concentrations of total hydrocarbon content in the soil of Agbabu and Temidire were higher in the dry season than the rainy season probably due to higher anthropogenic input total hydrocarbon to the soil due to higher domestic activities.

The statistical analysis of the correlation coefficients of the values of total hydrocarbon content at the sampling points were carried out using the bivariate Pearson correlation of IBM SPSS 25.0. The correlation coefficient of total hydrocarbon in the dry season in Year-1 to the rainy season of Year-1 is -0.039, to the dry season of Year-2 is -0.112, to the rainy season of Year-2 is 0.048. The correlation coefficients are not significant at 0.01 significance level. This implies that the hydrocarbons originated from different sources at all sampling points and different seasons. These sources are biogenic and petrogenic sources due to the deposit bitumen, brief exploitation of the bitumen in the environment, and anthropogenic sources.

The Regulation on the assessment of environmental pollution, the following are presented as guide values for total oil hydrocarbons content in soil: - normal: less than 100 mg/kg; - alert values for sensitive soils: 200 mg/kg; - alert values for less sensitive soils: 1000 mg/kg; - intervention values for sensitive soils: 500 mg/kg; - intervention values for less sensitive soils: 2000 mg/kg (DOTAF, 1994; Mihail and Andreea-EGU, 2017). The average concentration of the total hydrocarbon in the Dry season of Year-1 is 146.89 ppm. The concentration total hydrocarbon is higher than 100 mg/kg recommended for a normal soil. This is dangerous for the health of the rural dwellers at Agbabu because the total hydrocarbon can bioaccumulate and biomagnify and and affect the biota through food chain. High level of total hydrocarbon content have been said to cause headaches and dizziness and most times nervy disorder often called “peripheral neuropathy” which comprises of numbness in the feet and legs. It has also been proven that compounds containing total hydrocarbon causes side effects on the blood, immune system, lungs, skin and eyes (ATSDR, 1999). The average concentration of 5.36 ppm in the Rainy Season of Year-1, 5.00 ppm in the Dry Season of Year-2, and 4.92 ppm of Rainy Season of Year-2 were lower than 100 mg/kg recommended for a normal soil.

IV. CONCLUSION

Total hydrocarbon in the soil of Agbabu originated from both biogenic and anthropogenic sources. Average concentration of THC of measured in the dry season were higher than rainy season. The average concentration of 146.89 ppm recorded in Dry Season of Year-1, 5.36 ppm in the Rainy Season of Year-1, 5.00 ppm in the Dry Season of Year-2 and 4.92 ppm in the Rainy Season of Year-2 are in agreement with the values reported by Aigberua et al. (2016) in Evaluation of Total Hydrocarbon Content and Polycyclic Aromatic Hydrocarbon in an Oil Spill Contaminated Soil in Rumuolukwu Community in Niger Delta, and Bakpo and Emejuru (2023) on Analysis of Hydrocarbon Pollution in the Soils of Bomu and Yorla Oil Fields, Rivers State, Nigeria. Average concentration of total hydrocarbon obtained in soil of Agbabu and Temidire in Dry Season Year-1 was higher than the maximum recommended for a normal soil by Regulation on the assessment of environmental pollution by European Geosciences Union. This implies that the soil in the environment was polluted with total hydrocarbon. However, the average concentration recorded in the remaining seasons were lower than the recommendation for a normal soil. The average concentrations recorded were higher than the values recorded at the control sampling points. This indicates the soil of Agbabu and Temidire has been impacted with the bitumen deposit and other anthropogenic activities. The soils of Agbabu and Temidire will not require remediation because it may recover through a natural attenuation. However, a program should be put in place by the stake holders to periodically monitor the status of total hydrocarbon in the soil of Agbabu and Temidire in Ondo State, Nigeria.

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