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Study of Organic Contaminants in Surface Water Around Tank Farms in Oghareki - Oghara Community, Delta State, Nigeria

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ABSTRACT

Pollution of the aquatic environment with organic contaminants has become a world problem because they are indestructible and most of them have toxic effects on man and organism. This study covers the determination of organic contaminants such as volatile organic compounds (VOCs), total petroleum hydrocarbons (TPHs) oil and grease (O and G) in surface water around tank farms in Oghareki community, Delta State. The samples were collected for a period of twelve months (April 2022 – March 2023) at distances of 100 meters to 1 kilometer away from the tank farms. After sampling, samples were transported to the laboratory for chemical analyses. Each of the samples were tested for the presence of VOCs and TPHs by the use of Gas Chromatography coupled with Flame Ionization Detector (GC/FID) and O and G by Uv / visible spectrophotometer. Data were presented as mean triplicate of analyses and results of organic contaminants in water analyses showed mean O and G in the ranged of 0.002 – 0.006 and 0.004 – 0.007mg/L; mean TPHs in the range of 1.607 – 8.132 and 3.319 – 4.835mg/L, and mean VOCs in the range from 0.014 – 0.409 and 0.122 – 0.354mg/L for months and distances of investigations respective. Observations showed that the surface water around the tank farms are contaminated at some points and polluted at some other points when results of the study locations compared with that of the control. Results of monthly analyses were higher during the dry season than wet season. The contamination / pollution of the environment was attributed to nature of activities around the tank farms. It was therefore recommended that individuals should consider the consequences of their actions and work to improve the quality of soil and water

KEY WORDS: Volatile organic compounds, total petroleum hydrocarbons, oil and grease, pollution, contamination, and environment.

INTRODUCTION

The environment is the total living and non-living surroundings needed for life and sustainability and it is essential for health and human living (Pona, *et. al.,* 2021). Elevated levels of contaminants have been observed in the vicinity of certain industries like tank farms, refineries, ports, and near busy roads and within urban areas in general and the measured level of these contaminants serves as an index of environmental pollution (Onwukeme and Etienajirhevwe, 2020).

Concerned about the quality of water has probably been around as long as mankind from the moment industrialization began and the problem accompanying it has become a major concern (NSCA, 2020). Despite the presence of this essential ingredient (water) of life, its quality has been historically variable and frequently to the detriments of human health; Now however, a growing body of research has found that certain substances may affect human health at lower concentration than had previously been thought which has heightened public anxiety to the importance of improving and managing the quality of water for future generations (Kavitha and Dhandapani, 2018)

Analyses of water shows the presence of numerous substances in trace amounts some of which could be explained to emanate from either natural or anthropogenic that is, man-made source activities; other substances could be formed indirectly from chemical process in the atmosphere. Hence, the combination of a source to the environment varies according to its emission characteristics and the emitted substance (Imonitie and Ndego, 2021).

The pollution of water is a major global problem that requires an ongoing evaluation and revalidation of water resource policy at all levels as it has been suggested that the pollution of water is the leading worldwide causes of diseases leading to death and that it accounted for the deaths of more than 14,000 people on a daily basis (Kavitha and Dhandapani, 2018)

The acute problems of water pollution in developing countries, developed countries continue to struggle with pollution problems; for example, in the most recent international reports on water quality in the United States, 44% of assessed stream miles, 64% of assessed lake acres, and 30% of assessed bays and estuarine square miles were classified as polluted (USEPA, 2019)

Drinking of water and eating of food produced from the soil is not optional as they are essential even for a short period of time and they have been used as they are found and the water we drink at our birth and resigns only when we die is the first necessity of our existence (Department of the Environment (DoE), 2019).

Due to the rapid development and industrialization, human activities (industrial, agricultural production and urbanization) have increased and a significant amount of manmade organic contaminants / pollutants are released into the environment. The rivers are regularly subjected to elevated levels of micro-pollutants / contaminants arising from anthropogenic activities and natural processes (Li *et. al.*, 2017). Among the various micro-pollutants / contaminants, volatile organic compounds (VOCs), total petroleum hydrocarbons (TPHs) and, oil and gtrease are primarily recognized as environmental contaminants / pollutants, yet water pollution caused by these compounds is also gaining increasing interest (Wu *et. al.*, 2019).

The anthropogenic sources of VOCs and TPHs contaminants / pollutants evoke more concern than natural sources. Agricultural and municipal wastewater, urban and rural effluents are the primary sources of anthropogenic VOCs in aquatic ecosystems (Warner *et. al.*, 2019). Sometimes when VOCs are introduced into water environment, they could be diluted, become toxic and biodegradable as a result of the physical and chemical properties of the water which could result in various effects on the aquatic environment. In particular, VOCs / TPHs are not readily degraded in water systems, such as surface water and groundwater due to their mobility (Warner *et. al.*, 2019). The aim of this research is to study some organic pollutants presence in surface water around tank farms of Oghareki community, in Oghara, Ethiope West Local Government Area in Delta State, Nigeria.

METHODOLOGY

Study location

The study was conducted in Oghareki community, a sub-clan of Oghara Kingdom in Ethiope West Local Government Area of Delta State, Nigeria. Oghareki community lies within Latitude 5^0 57’2’’N and Longitude 5^0 38’25’’E. The sub – clan has a Rivers whose source is from River Ethiope, a clear fresh water body, which flows over 100km from its source at Umuaja in Ukwuani Local Government Area of Delta State through Abraka, Mosogar, Sapele to Oghareki (the study location) and empty into the Benin River. The River around the sub – clan houses different tank farms such as the Rain oil, Cybernetics oil and gas, Prudent Energy, Othniel, Salbas oil and gas, Nepal, Renol, Blacklight Energy and Stone Gas Limited. All these tank farm receives and discharges premium motor spirit (PMS) that is petrol, aviation gas oil (AGO) that is, diesel and dual purpose kerosene which is the kerosene on daily basis from barges that travel from within and outside the country. These products are discharged through the jetties build around the bank of the River. During this discharge, there are leakages of the said products into the River and the soil around the tank farms which would definitely contaminate the soil and the water. Other activities that take place around the River include sand dredging (this uses diesel engine), bunkering, and illegal refining of crude around nearby farms, transportation of illegal petroleum products using boats on the River and other anthropogenic daily activities that has led to the contamination of the River and the surrounding soil. Some of these activities (if not all) in the River and surrounding soil have negative impacts and have created contamination / pollution since the inception of these activities and is of a great concern to the inhabitants that make use of the soil and River water on daily basis.

Sample collection

Collection of water samples

Water samples were collected at ten (10) sampling locations that are, 100 meters to 1000 meters (1kilometers) from the tank farms in the surface water surrounding the tank farms and one from a control site where no industrial or anthropogenic activity is taking place. The samples were collected with the aid of a previously washed glass bottled with acid and rinsed with distilled water. The water sample was collected at each point at depth of 5cm around each point and pooled together to form a sample of one liter volume while that for the determination of organic contaminants was collected into a glass vial for that purpose. Upon collection of the samples at the samples at the various points, onsite determination of turbidity, pH, temperature, conductivity and total dissolved solids were carried out. The collected samples were transported to the laboratory in an iced cooler to keep the temperature at 4^0C and upon arrival at the laboratory; they were transferred into an ice chest refrigerator until analyses. A total of twelve samplings were carried out within the month of April 2022 – March 2023 and a total of one hundred and forty – four (144) water samples were collected for the ten locations excluding that of the control.

Extraction of water for the determination of VOCs and TPHs

50mL of the water sample was measured into a separatory funnel with the aid of measuring cylinder thoroughly washed with distilled water and rinsed with acetone solution. This was added with 50mL 50:50 acetone / dichloromethane mixture, corked and was shaken for about five minutes with intermittent venting to release excess pressure. The mixture was left to stand for about ten minutes to allow the organic layer separates after which it was collected into a beaker and covered with foil paper. The organic extract was the concentrated by the use of rotary evapourator. The sample was then ready for determination of VOCs / TPHs. For the determination of VOCs and TPHs, the concentrate was divided into two portions; one part was for the aliphatic components while the other for the aromatics. For the aliphatic, 25mL of n – hexane was added while for the aromatic, 25mL of dichloromethane was added and both resulting solutions were concentrated separately in the presence of two spatula full of anhydrous sodium sulphate to remove any trace of water (ASTM, 2015). The resulting concentrates were then kept for injection into a gas chromatography column (GC) couple flame ionization detector (FID).

Extraction of water sample for oil and grease analysis

100mL of water sample was measured into a separatory funnel followed with the addition of 50mL n – hexane and the resulting solution was shaken vigorously for about ten minutes with intermittent venting to remove excess pressure. The resulting mixture was collected into a centrifuge tube and was centrifuged while the upper layer of the centrifuged sample was collected and kept for the determination of oil and grease content in the waters sample, this procedure was repeated for all the water samples.

Instrumental determination of TPHs and VOCs in water samples

Extracted water samples were analyzed for the presence of TPHs and VOCs by the use of gas chromatography coupled with flame ionization detector (GC/FID) (Agilent 6890N GC/FID). 5µL of each of the extracted sample was injected into a Gas chromatography column. The GC/FID was equipped with a programmable temperature vapourizing (PVT) inlet and a column (30mm by 250µm id, film thickness is 0.25µm). Helium was the carrier gas with an initial pressure of 10psi for 10 minutes which was then ramped to 18psi at a rate of 0.2psi/min. After an initial holding temperature of five minutes, the oven temperature was increased from 5^{o}C to 180^{o}C at a rate of 10^{o}C per minute, then to 230^{o}C at 6^{o}C per minute, then to 300^{o}C at 3^{o}C per minute and maintained at 300^{o}C for five minutes. The GC/FID interface temperature was kept at 290^{o}C. The Electron Impact (EI) MS was tuned with decafluorotriphenyl phosphine (DFTPP) and operated in the selected ion monitoring mode. The ion source temperature was 230^{o}C and the quadruple temperature was 150^{o}C and data acquisition was controlled by a turbonchron chemistation. The flame ionization detector detected the compounds in the samples. The amount of the various organic components was resolved at a particular chromatogram in mg/L for water sample.

Instrumental determination of oil and grease in water samples

Each of the extract from the water samples was analyzed for the presence of oil and grease by the use of Uv/Visible spectrophotometer. This was done by measuring a required amount of each of the extract and was placed into the sample compartment of the spectrophotometer and the absorbance of the sample at a wavelength of 410nm (Onwukeme and Etienajirhevwe, 2020)

Quality assurance / quality control

Strict quality assurance and quality control measures were performed during the field sampling and laboratory analyses. All sampling containers were properly sterilized and all equipment calibrated. The concentration of targeted parameters in the laboratory blanks and procedural blanks were all below the detection limits.

STATISTICAL ANALYSIS

Data from the analysis were presented as mean triplicate of analysis as per distances and months of investigations; parametric analysis of variance was used to check the significances of the results between the months, distances and seasons of investigations and that of the control. Correlation analysis was used to check the most notable contaminants between the organic and inorganic contaminants while principal component analysis was used to check the contaminant which contributed most to the contamination of the soil and water environment.

RESULTS

Table 1: Mean organic contaminants (mg/L) found in surface water as per months of investigation

MONTHS	O and G	TPH	VOC
APRIL	0.002a	8.132a	0.409a
MAY	0.005a	7.339b	0.318b
JUNE	0.005a	3.044e	0.207c
JULY	0.006a	2.906f	0.087e
AUGUST	0.006a	2.249g	0.140d
SEPTEMBER	0.005a	4.585c	0.315b
OCTOBER	0.006a	1.607h	0.109e
NOVEMBER	0.005a	3.679c	0.016f
DECEMBER	0.006a	3.041e	0.316b
JANUARY	0.005a	8.134a	0.317b
FEBRUARY	0.005a	3.039e	0.142d
MARCH	0.006a	2.916f	0.014f

O and G = Oil and grease
TPH = Total petroleum hydrocarbon
VOC = Volatile organic compounds

Table 2: Mean organic contaminants (mg/L) found in surface water as per distance of investigation

Distance	O and G	TPH	VOC
Control	0.000a	2.974k	0.034f
100M	0.004a	4.478e	0.286b
200M	0.006a	4.184h	0.204d
300M	0.004a	4.278f	0.336a
400M	0.005a	3.847i	0.189d
500M	0.006a	4.521d	0.122e
600M	0.005a	4.750b	0.354a
700M	0.005a	4.249g	0.244c
800M	0.006a	4.835a	0.178d
900M	0.007a	3.319j	0.128e
1KM	0.006a	4.688c	0.128e

Table 3: Correlation between the organic Contaminants found in surface water

	Oil and grease	TPH	VOC
Oil and grease	1		
TPH	0.0014	1	
VOCs	0.164	0.389	1

Table 4: Principal Components of organic contaminants found in surface water

	Principal 1	Principal 2	Principal 3
O and G	0.277	0.921	0.273
TPH	0.651	-0.389	0.652
VOC	0.707	-0.002	-0.708
Eigen value	1.423	0.999	0.578
Proportion	0.474	0.333	0.193

Table 1 and 2 above showed results of organic contaminants in surface water around tank farms in Oghareki community for months and distances of investigation respectively.
Results of oil and grease in water were found in the range of 0.002 – 0.006mg/L and 0.004 – 0.007mg/L for month and distances on investigations respectively. Concentration of oil and grease as per distances of investigations showed 900 meter distance to record the highest concentration of 0.007mg/L while a 100 meter distance which was taught to record the highest concentration due to its closeness to the tank farms recorded the lowest oil and grease value of 0.004mg/L. The concentration of the oil and grease in the surface water was not proportional to the distances of investigation as this could be as a result of the movement of floating oil sheens from one point to the other due to tides caused by travelling speed boats on the surface water. The concentration of oil and grease in the control sample was 0.00mg/L which showed that oil and grease concentration at all the distances are higher than that of the control which suggested that there is contamination of the surface water with oil and grease.

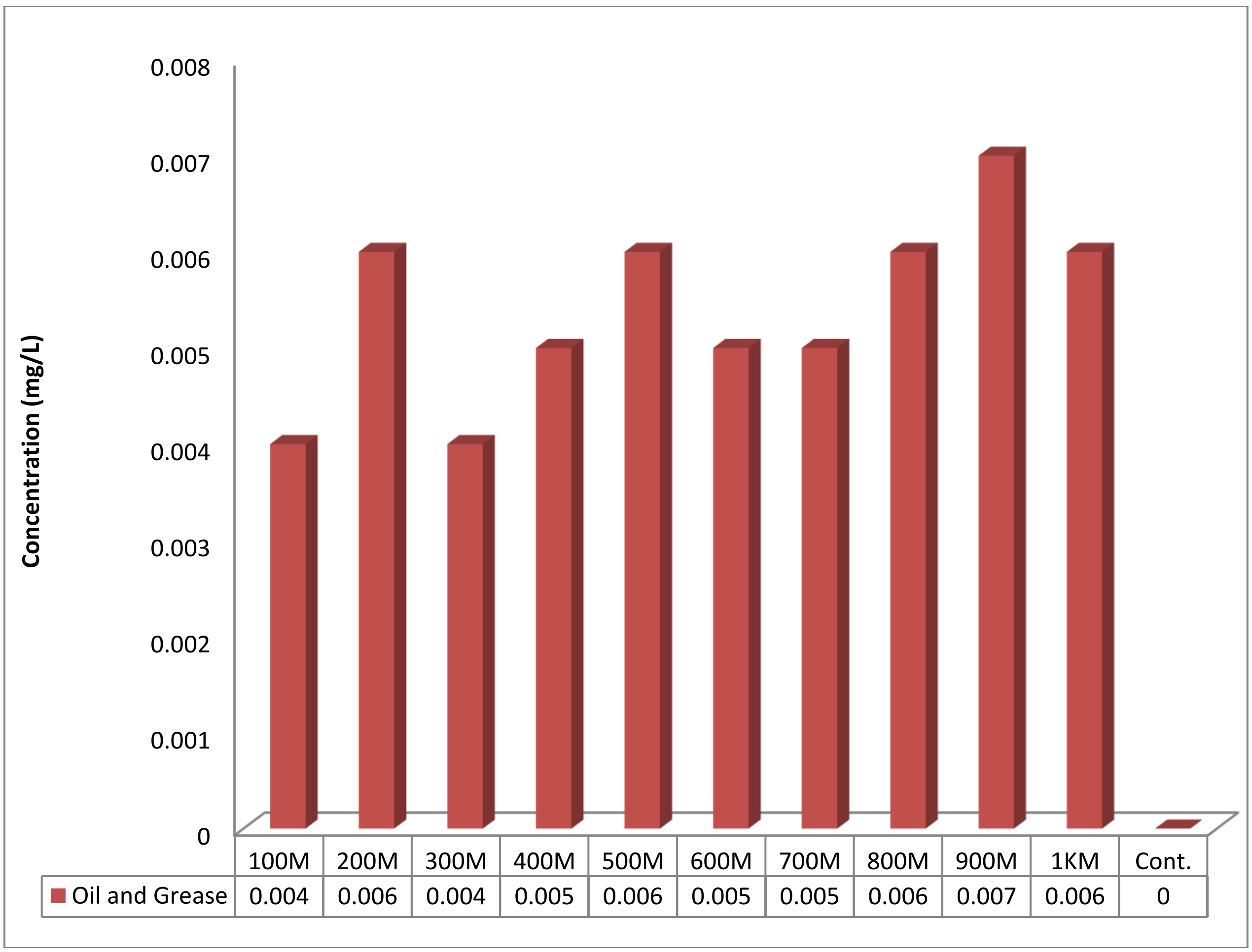
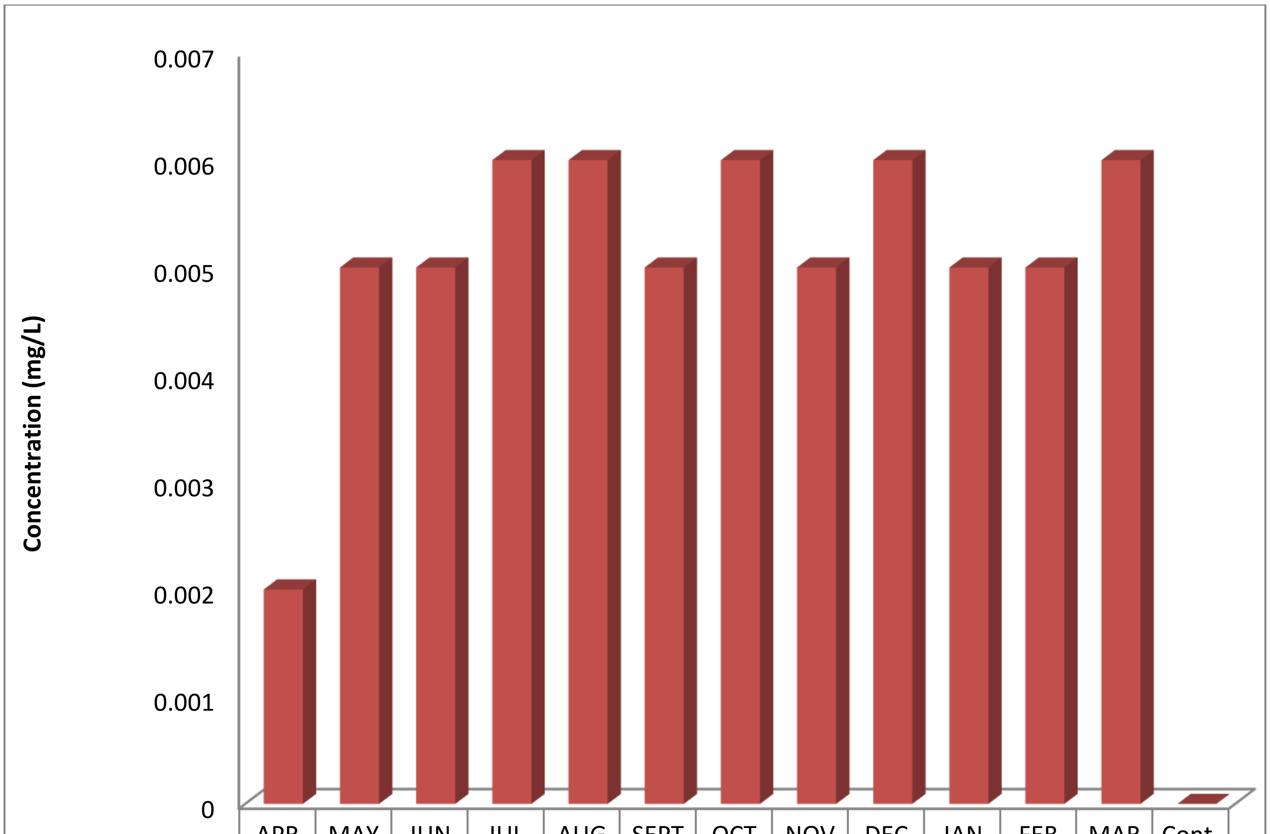


Figure 1: Oil and grease concentration in surface water as per distances

Statistical analysis of the oil and grease concentration of the surface water with that of the control showed that there is no significant difference between them. Statistical analysis of the concentration of the oil and grease among the various distances also showed that there are no significant differences among them. This observation showed that there is no pollution of the surface water with oil and grease but there is a little contamination since oil and grease was presence on the surface water.

The oil and grease concentration for the months / seasons of investigation followed the same trend as that of the distances of investigation as the concentration of oil and grease ranged from 0.002 – 0.006mg/L for the months of April to September (wet season) and 0.005 – 0.006mg/L for October to March (dry season). The results of the months of investigations were higher than that of the control (0.00mg/L) which suggested contamination of the surface water since oil and grease was detected. Statistical analysis of the monthly / season's results with that of the control showed that there is no significant difference between them. Inter monthly / seasonal statistical analysis also showed that there is no significant differences among them which showed that there is no pollution but since there is the presence of oil and grease in the surface water and was absent in the control, it therefore means that there is little contamination even though the concentration is minimal. The presence of the oil and grease in the surface water can be attributed to the leakages of petroleum products during discharges at the jetty from where they flow into the surface of the water; during bunkering, crude oil find its way into the water body during rain fall through erosion and during other illegal sales of petrol, diesel and kerosene around the bank of the river.



	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	Cont.
Oil and Grease	0.002	0.005	0.005	0.006	0.006	0.005	0.006	0.005	0.006	0.005	0.005	0.006	0

Figure 2: Oil and grease concentration in surface water as per months

The results of oil and grease in this present study were higher than those of Khozanah *et. al.,* (2021) that determined oil and grease in sea waster of Jakarta Bay and its surrounding; Iyama *et. al.,* (2020) that assessed the oil and grease (pollution load) of Woji Creek water body; Eljaiek-Urzola *et. al.,* (2019) that determined Oil and Grease Marine water; Muhammad *et. al.,* (2017) that determined oil and grease in waters of Ramsar Gazetted Mangrove and Kugamoorthy (2016) who analysed oil and grease in groundwater of Valikamam area of Sri Lanka.

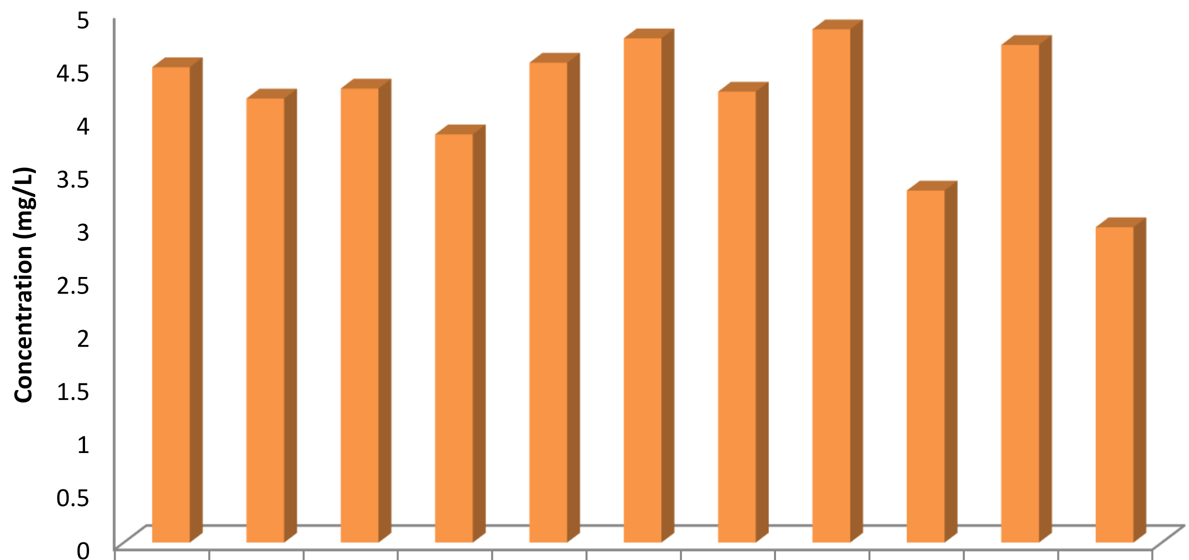
Oil, including its products and wastes can enter water from a variety of sources occurring at every stage of production, transportation, refining, and use. Oil finds its way to the surface water through discharges of sludge from oil tankers, disposal of oil-containing waste water from ships, accidental rupture or grounding of oil tankers, dumping of waste oil, natural oil seeps, leaks from storage facilities and pipelines, atmospheric fallout and improper discharge of wastes such as produced water, drilling mud, cuttings and refinery effluents (Ekpu, 2020). Oil pollution can have a devastating effect on the water environment; it spreads over the surface in a thin layer that stops oxygen getting to the plants and animals that live in the water (Iyama *et. al.,* 2020). A high concentration of oil and grease is known to causes deterioration of the performance of the sewage treatment system. Oil and grease produce layers on the water surface that lowering dissolved oxygen in water and obstruct light penetration for photosynthesis (Sanghamitra *et. al.,* 2021).

The presence of total petroleum hydrocarbons (TPH) in surface water around tank farms of Oghareki community are shown in 4.9 and 4.10 for the months and distances of investigations respectively. The results showed TPH in the range of 1.607 – 8.132mg/L and 3.319 – 4.835mg/L for the months and distances of investigation respectively. The results were observed to be spatial as it neither decrease nor increase with respect to the distances of investigation. The highest concentration of TPH was recorded at 800 meters (4.835mg/L) while the lowest was at 900 meters (3.319mg/L). The TPH values at the various distances were all higher than that of the control (2.974mg/L) which suggested contamination / pollution of the water body. Statistical analysis of the TPH values at the various distances with that of the control showed that there is contamination of the surface water with TPH. Statistical analysis among the distances of investigation also showed that there are significant differences among themselves.

Results of TPH for the months of investigations were all higher than those of the control as statistical analysis also showed that there are significant differences among them. This also suggested that there is contamination of the surface water as per months / seasons of investigation. These differences could be attributed to anthropogenic activities taking place around the tank farms. The presence of TPHs in surface water can come as a result of release of petroleum products in which they are contained in to the water body such as through leakages from boats being used for transportation in the water, leakages from barges supplying petroleum product at the jetties of the tank farms and other form of deposits which results from the burning of fossil fuels in such an environment (Onwukeme and Etienajirhevwe, 2020). Also, boat building activities, sometimes sewage disposal, and bunkering around the surrounding could have also contributed to the high concentration of TPH in the surface water which results in the reduction of aquatic organisms due to depletion of oxygen which would have interfered with the spawning sites of some / most organisms.

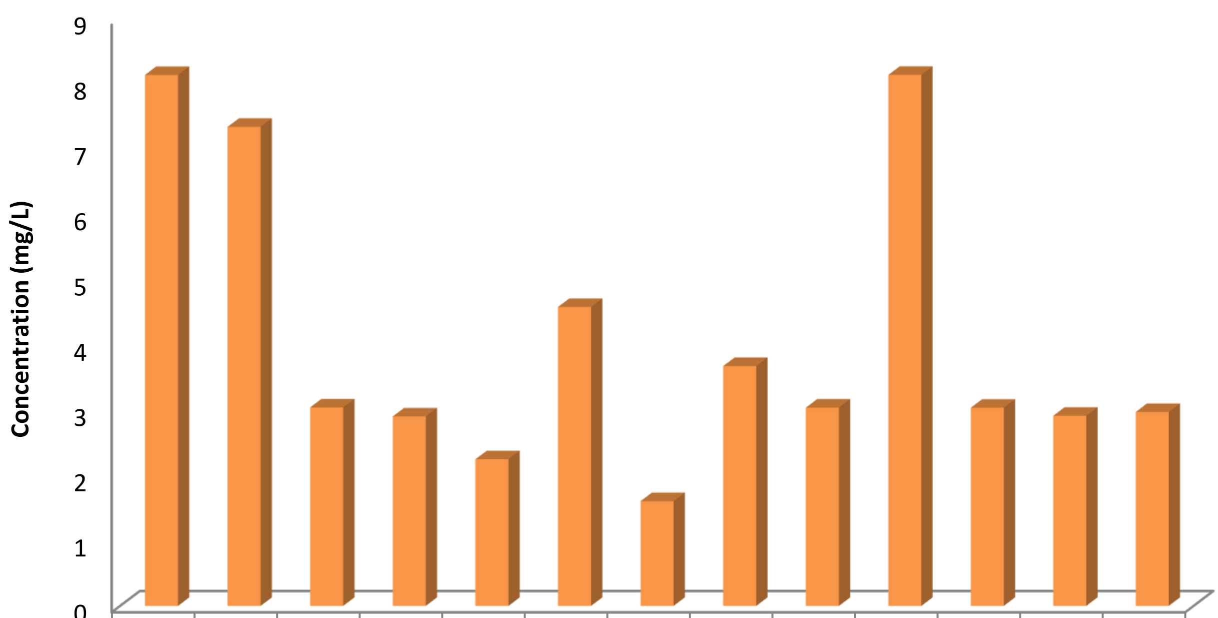
The results of TPH in this present study corroborate of those of Agbaire and Tubotu

(2021) who studied the distribution of TPH water of two Niger Delta communities but were higher than those of Ibeto and Nwuga (2018) that evaluated aliphatic and total petroleum hydrocarbons in groundwater in industrial area of coal camp



	100M	200M	300M	400M	500M	600M	700M	800M	900M	1KM	Cont.
TPH	4.478	4.184	4.278	3.847	4.521	4.75	4.249	4.835	3.319	4.688	2.974

Figure 3: TPH concentration in surface water around tank farms as per distance



	APRIL	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	Cont.
TPH	8.132	7.339	3.044	2.906	2.249	4.585	1.607	3.679	3.041	8.134	3.039	2.916	2.974

Figure 4: TPH concentration in surface water around tank farms as per months

The results of this present study were found to exceed the targeted and intervention values that is, 0.05mg/L and 0.60mg/L respectively of the Department of Petroleum Resources (DPR) for regulation of ground / surface water (DPR, 2018). This is an indication of contamination of the surface water with TPH. The total petroleum hydrocarbons in the surface water were composed of thirty five (35) aliphatic compounds ranging from carbon length nC_8 – nC_{40} (n- Decane – n-Tetracontane), Pristane and Phytane, and sixteen poly-nuclear aromatic hydrocarbons (PAHs). Analysis of the TPH revealed that the 74.5% of the entire TPH is C_8 – C_{40} and some of the dominance fractions are C_{31}, C_{33}, C_{37}, C_{38}, C_{39}, and C_{40}. The poly-nuclear aromatic hydrocarbons present in the surface water samples are naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, chrysene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthrene, benzo(a)pyrene, indo(1,2,3-cd)pyrene, dibenz(a,h)anthracene and benzo(g,h,i) perylene. The aliphatic hydrocarbon (C_{8} – C_{40}) where in dominance (that is about 74.5%) compared to the poly-nuclear compounds (25.5%). Among the poly-nuclear compounds, dibenz(a,h)anthracene was in dominance (recorded the highest concentration) followed by indeno(1,2,3-cd)pyrene and benzo(g,h,i)perylene while naphthalene was the least dominance (recorded lowest concentration) followed by acernaphthylene.

Most petroleum hydrocarbons pollution on surface waters could result in anoxic condition which in most times affects the general metabolism of most marine organisms by the formation of fumes that reduces the supply of dissolved oxygen that leads to death of aquatic organism in the aquatic environments. The health effects of exposure to PAHs present in water depends on the health effects that can be caused by exposure to PAHs depend on how much has entered the body, how long you have been exposed to PAHs, and how the body responds to PAHs and the effects caused may be either short or long term though it is not clear that PAHs cause short-term health effects as other compounds commonly found with PAHs may be the cause of short-term symptoms such as eye irritation, nausea, vomiting, diarrhea, and confusion. Long-term exposure to low levels of some PAHs has caused cancer in laboratory animals. Benzo(a)pyrene is the most common PAH that has caused cancer in animals (Agbaire and Tubotu, 2021). Studies of workers exposed to mixtures of PAHs and other compounds have been noted to result in an increased risk of skin, lung, bladder, and gastrointestinal cancers. The information provided by these studies is limited because the workers were exposed to other potential cancer-causing chemicals besides PAHs. Although animal studies have shown adverse reproductive and developmental effects from PAH exposure, these effects have generally not been seen in humans.

Results of volatile organic compounds (VOCs) in surface water around tank farms of Oghareki community are shown in table 4.9 and 4.10 for months and distances of investigations respectively. VOCs results were found in the range of 0.014 – 0.409mg/L and 0.122 – 0.354mg/L for months and distances of investigations respectively. For the distances of investigation, all the results were higher than that of the control (0.034mg/L) as the highest VOCs (0.354mg/L) was obtained at 600 meters while the lowest (0.122mg/L) was obtained at 500 meters distance from the tank farms. The VOCs concentration where dispersed that is, spatial as it was not relative to the distances from the tank farms. Statistical analyses of the VOCs results were found to be significantly different from that of the control which showed that there is contamination of the surface water with organic compounds. Inter distance statistical analyses found some distances to be significantly different from themselves while some were not that is, 500 meters / 900 meters / 1km distances with VOCs of 0.122mg/L / 0.128mg/L / 0.128mg/L, ; 300 meters / 600 meters with VOCs of 0.336mg/L / 0.354mg/L and 200 meters / 400 meters / 800 meters with VOCs of 0.204mg/L / 0.189mg/L / 0.178mg/L respectively, are not significantly different in contribution to the contamination of the surface water but they showed significant difference when compared to 100 and 700 meters distances.

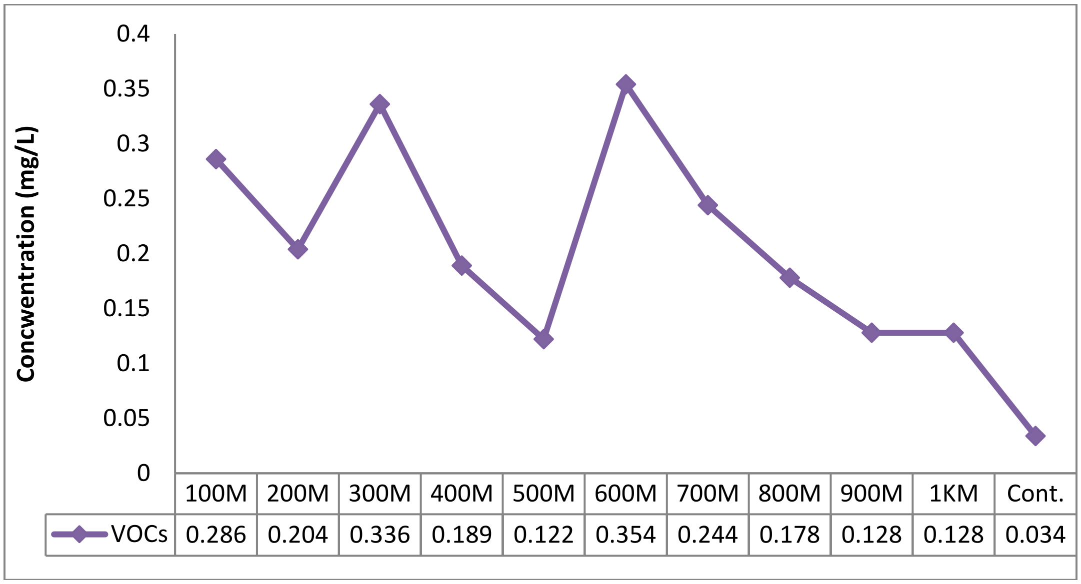


Figure 5: VOCs concentration in surface water as distances

For the months of investigation, the results were higher than that of the control site (0.034mg/L) except for the month of March and November that recorded 0.014 and 0.016mg/L VOCs respectively. The results of VOCs were observed not to follow the seasonal variation that is, wet and dry season as the results were dispersed / spatial in concentration. This could be as a result of their volatility irrespective of the seasons / months of investigations. Statistical analyses there are significant differences between the results of the monthly investigations and that of the control with exception of the months of March (0.014mg/L) and November (0.016mg/L) that showed no significant differences between them and the control (0.034mg/L). Inter monthly statistical analyses of the results showed that there are no significant differences between VOCs concentration for the months of January, May, September and December (0.317, 0.318, 0.315 and 0.316mg/L respectively); February and August (0.142 and 0.140mg/L respectively), March and November (0.014 and 0.016mg/L respectively) and, July and October (0.089 and 0.109mg/L respectively). All these are collectively and significantly different from those of April (0.409mg/L) and June (0.207mg/L). The differences observed in the results of volatile organic compounds for of the months and distances of investigation in comparison to that of the control can be attributed to the anthropogenic activities taking place in the around the tank farms by which raw wastewater containing VOCs are discharged in the surface water body and other natural phenomenon which must have also contributed to the high concentrations observed.

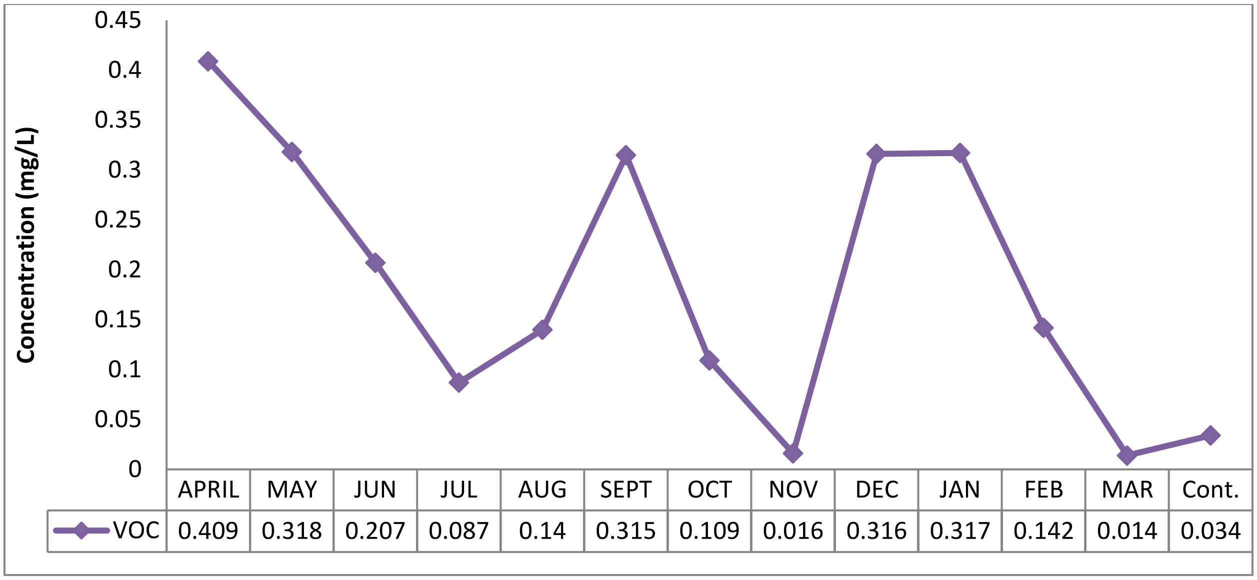
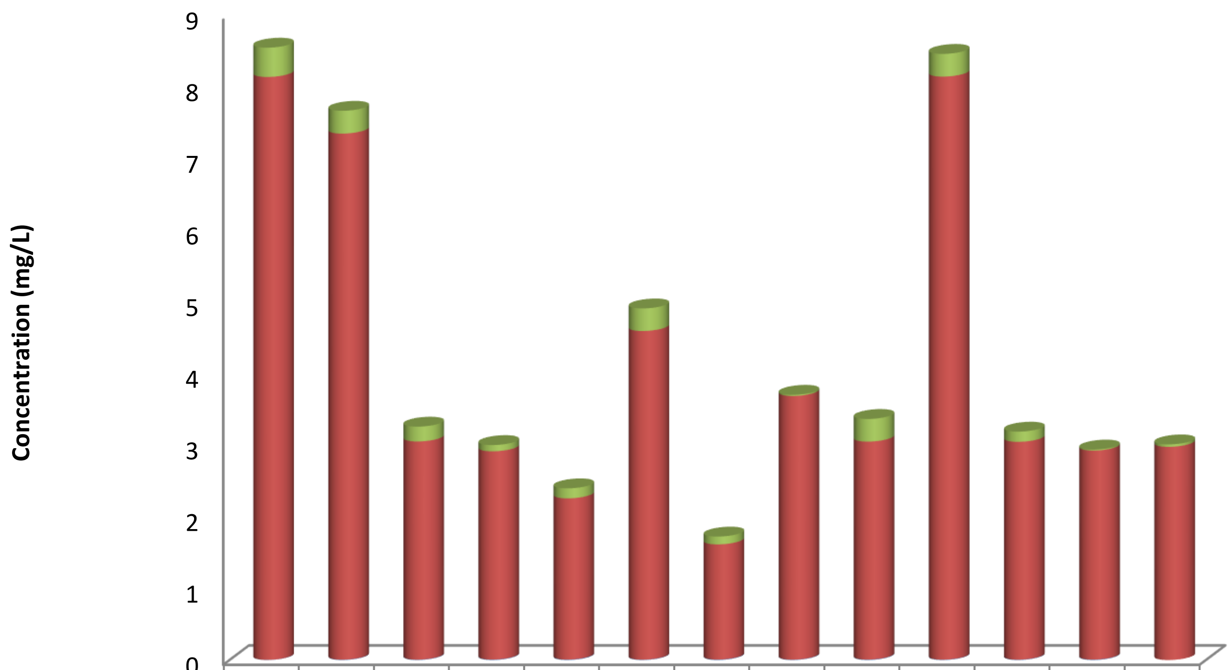


Figure 6: VOCs concentration in surface water as months

A total of 30 volatile organic compounds were detected in the surface water which are bromochloroethane, carbon tetrachloride, chloroform, chlorobenzene, dichloro-bromoethane, 1,2-dichlorobromobenzene, 1,4-dichlorobenzene, 1,1-dichloroethylene, styrene, tetrachloroethylene, 1,2,4-trichlorobenzene, vinyl chloride, o-xylene, p-xylene, m-xylene, 1,2-dichloropropane, toluene, trichloroethylene, ethyl benzene, 1,2-dichlorobenzene, 1,2-dibromobenzene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, dichloromethane, bromoform, dibromochloro-ethane, benzene, cis-1,2-dichloroethylene, bromochloromethane, dibromochloromethane. Among the volatile organic compounds, p-, o- and m- xylenes were in abundance while the least were chlorobenzene, chloroform and diclorobromomethane respectively.

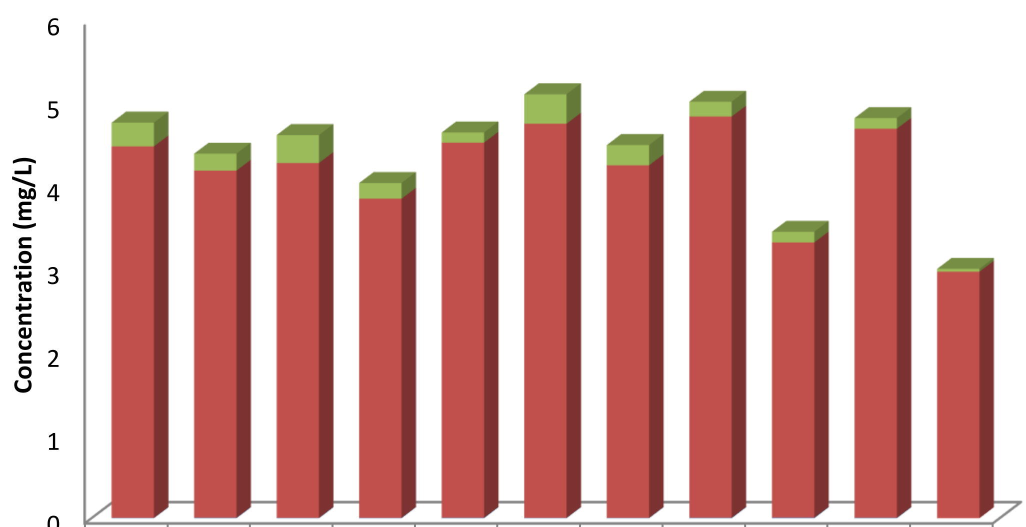
One of the primary concerns with volatile organic compounds is that at relatively low amounts some of them can be carcinogenic, leads to damage to the circulatory system and nervous system and other major organs when food they contaminate are consumed and they could create slight odor (ATSDR, 2019). Volatile organic compounds are also considered among major contaminants in water matrices that in addition to physiological adverse effects on the human body such as cancer, genetic mutations, eye irritation, nasopharyngeal mucosa, dizziness and headache, and short-term memory loss (Xin *et. al.*, 2022). Domestic use of inadequately treated VOCs contaminated groundwater is potentially harmful to human beings. Trichloroethylene and vinyl chloride are most toxic and carcinogenic among all VOCs (Radheshyam and Puneeta 2018).

Comparison of the contamination of the surface water with organic components that is, oil and grease (O and G) volatile organic compounds (VOCs) and total petroleum hydrocarbons (TPHs) showed TPHs to be in abundance followed by VOCs while O and G was the least for both the months and distances of investigations.



	APR.	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	Cont.
VOCs	0.409	0.318	0.207	0.087	0.14	0.315	0.109	0.016	0.316	0.317	0.142	0.014	0.034
TPHs	8.132	7.339	3.044	2.906	2.249	4.585	1.607	3.679	3.041	8.134	3.039	2.916	2.974
Oil and grease	0.002	0.005	0.005	0.006	0.006	0.005	0.006	0.005	0.006	0.005	0.005	0.006	0

Figure 7: Variation of organic contaminants in surface water as per months of investigations



	100 M	200 M	300 M	400 M	500 M	600 M	700 M	800 M	900 M	1KM	Cont.
VOCs	0.286	0.204	0.336	0.189	0.122	0.354	0.244	0.178	0.128	0.128	0.034
TPHs	4.478	4.184	4.278	3.847	4.521	4.75	4.249	4.835	3.319	4.688	2.974
Oil and grease	0.004	0.006	0.004	0.005	0.006	0.005	0.005	0.006	0.007	0.006	0

Figure 8: Variation of organic contaminants in surface water as per distances of investigations

The contamination / pollution of the surface water with organic components followed the order of oil and grease<volatile organic compounds<total petroleum hydrocarbons.

The correlation between the organic contaminant found in the surface water around the tank farms is as shown in table 3 above. Observation showed that there is no relationship among the contaminants in their contribution to the contamination of the surface water as each parameter contributed individually and spatially. This showed that the pollution of the surface is anthropogenic that is, it is based on the human activities being carried out in the region.

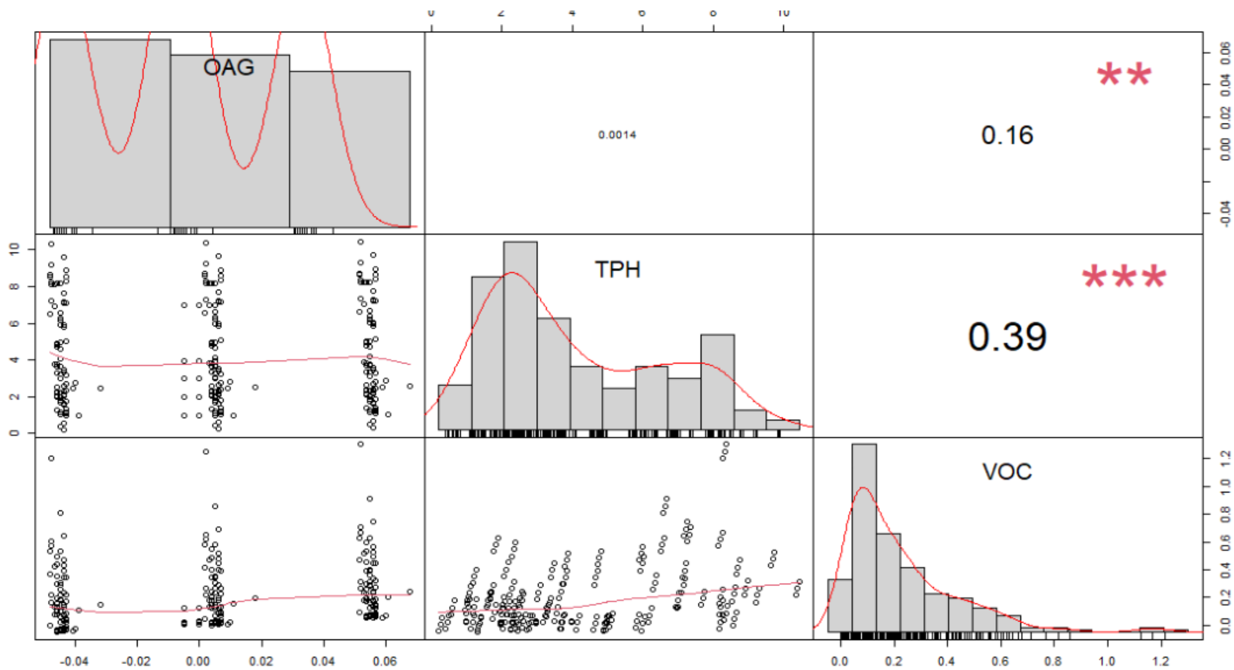


Figure 9: Correlation between organic contaminants in surface water

Observation and statistical analyses showed that VOCs was 16.4 and 39% correlated with oil and grease, and total petroleum hydrocarbon respectively while total petroleum hydrocarbons was 0.14% correlated with oil and grease. This little or no correlation observed among the organic contaminants is irrespective of the distances from the tank farms and months / seasons of investigation showed that the source of the contaminants could be from different sources such as anthropogenic activities from the tank farms, bunkering activities, dredging of sand by which contaminants are deposited from fumes, the use of fertilizers and pesticides on soil which must have been washed down to the water through erosion by rain fall.

Table 4 above and figure 10 below showed results of principal component analysis the pictorial / graphical view of the principal component that is, the organic component and their individual contribution to the contamination / pollution to the surface water around the tank farms. Among the organic contaminants detected, volatile organic compounds (VOCs) had the highest contribution with 71% to the contamination of the surface water followed by total petroleum hydrocarbons (TPHs) with 65.1% while the lowest contributor with 28% was oil and grease.

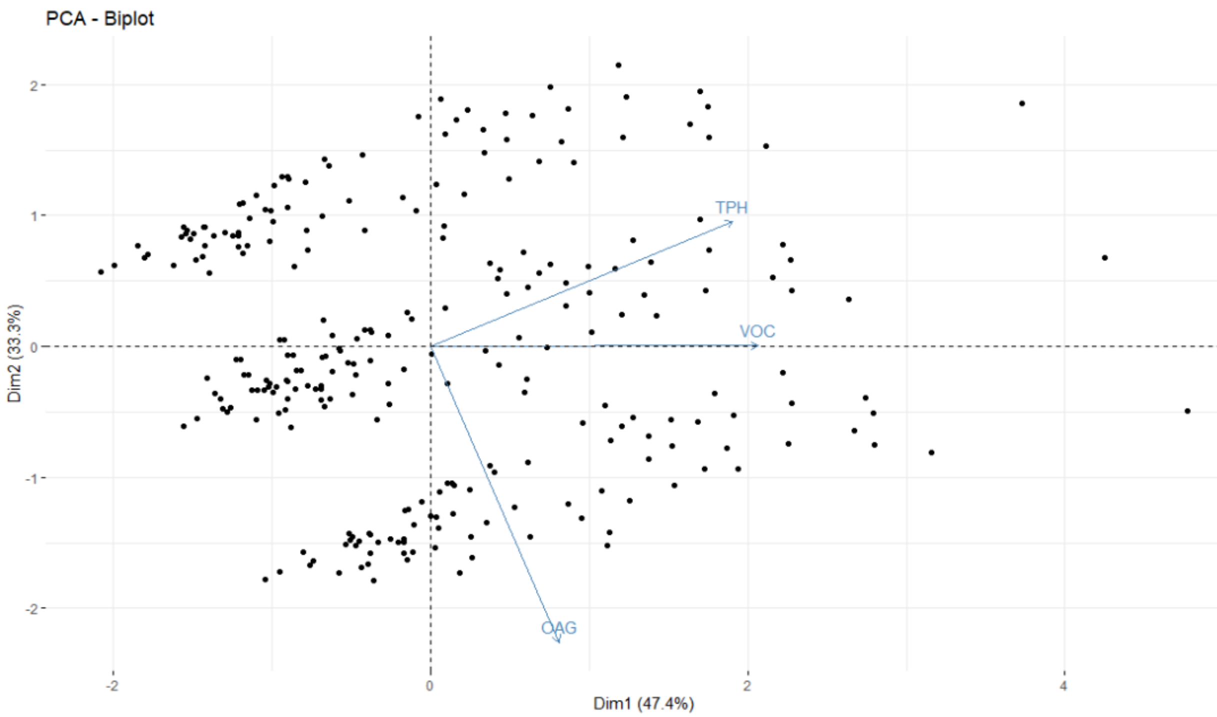


Figure 10: Principal component analyses of organic contaminants in surface water.

CONCLUSION AND RECOMMENDATION

The impacts of the presence of tank farms around the surface water of the Oghareki community cannot be overemphasized as the water environment was contaminated with the various contaminant / pollutants at distances closed to the tank farms. The presence of oil and grease was present but minimal in both the surface water which could be as a result of the flow of water from one point to the order in the river water. The total petroleum hydrocarbons were more in abundance compared to the volatile organic compounds since the volatile organic compounds are also hydrocarbons but the total petroleum hydrocarbons may not be volatile. Among the various contaminants / pollutants, total petroleum hydrocarbons were in abundance followed by volatile organic compounds, while oil and grease were the least. The contamination / pollution of the water environment thus followed the order of TPHs>VOCs>metals>oil/grease.

The use of water is obligatory and without it there is no life. It should therefore be of concern to effectively manage water for a sustainable future. Illegal refining of petroleum products known as bunkering has been the order of the day but this practice should be discouraged as this has also contributed to the pollution of the water environment. The management of water pollution problems cannot be overemphasized hence we must avoid the reoccurrence of the pollution problems we are facing today.

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