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Research Paper

Hydrocarbon Pollutants Concentration in Ground and Surface Water in Orashi and Sombreiro River Basins, Niger Delta Nigeria

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ABSTRACT: *This study was carried out to assess hydrocarbon presence in ground and surface water sources in Orashi and Sombreiro River Basins in the Niger Delta. The study adopted the use of standard operating laboratory procedures in ensuring that samples were collected and analyzed appropriately. A total of six water samples were collected from 3 three locations each for the both river basins. Surface water was collected from the rivers while ground water sources were collected from boreholes in the communities for each of the basin. Parameters of interest in this study includes BTEX and Total Petroleum Hydrocarbon (TPH). The result of the study showed that Benzene, toluene, ethyl benzene, xylene (BTEX) value is found to be higher in wet season compared to dry season. This is however not the case with Total Petroleum Hydrocarbon (TPH). The study also noted that Petroleum presence was ascertained in the water samples of the two basins in all the sample locations for both seasons, which indicates an effect on the water quality arising from petroleum exploration within the basins. In the light of this the study recommends that Multi-national and other companies involved in exploration and exploitation of petroleum should as a matter of urgency develop or adopt global acceptable remediation technologies to remediate polluted water resources. This must be done to address incessant pollution of water resource in the area.*

KEYWORDS: *Petroleum, Ground, Surface, Water Sources, Hydrocarbon, Pollutants*

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I. INTRODUCTION

Orashi/Sombreiro River basin is an integral part of the larger Niger Delta area where petroleum exploration and exploitation is on-going. The Orashi/Sombreiro River basin has played host to two oil flow stations (Ebocha and Egbema) for about five decades and is further surrounded by five other flow stations, the farthest of which is not more than fifteen kilometers' from any part of the basin. The Mgbede, Ebocha, Egbema, Awarra, Orsu and Izombe oil fields operated by the Nigerian National Petroleum Corporation, Nigerian AgipOil Company, the Shell Petroleum Development Company of Nigeria and Chevron Nigeria respectively are all located within the watershed.

The operations of these industries releases a barrage of substances like heavy metals, petroleum hydrocarbons, and petroleum-derived waste and other toxics at levels that most times exceed both the national and international guidelines. Discharges of petroleum hydrocarbons and petroleum-derived waste have caused environmental pollution, adverse human health effects and widespread environmental degradation (Fowzia&Fakhruddin., 2018). Activities associated with oil and gas production have had great impacts on the environment especially the surface and groundwater resources. In other words, contamination of surface water and groundwater by organic and inorganic chemicals, and/or microorganisms has occurred in most parts of the Niger Delta region. Water resources in the region have experienced changes which may have significant impact on human and aquatic life. However, the majority of petroleum hydrocarbon contamination and/or pollution incidences have not been properly documented over the years (Ite, Harry, Obadimu, Asuaiko&Inim, 2018).

Hydrocarbons can enter water through direct spills or from a spill originally occurring on land and subsequently reaching water bodies through the effects of wind, rain, surface or sub-surface flow (United Nations Environment Programme, 2011). Water bodies have been heavily polluted following the reoccurrence of spillage. This has adversely affected both human and aquatic life. Most micro-population die following large scales spillages, while sub lethal levels of oil following several lower scaled spillages have general affected aquatic resources. In Orashi/Sombreiro River basin, it is common to see floating layers of oil on rivers, creeks and marshes. These hydrocarbons reach these water bodies through direct spills or from a spill originally

occurring on land and subsequently reaching the water bodies through surface or sub-surface flow. These contaminants have adverse impacted on the quality of surface and groundwater in the basin, though the nature and severity of such impacts is dependent on the specific chemical composition and physical characteristics of the hydrocarbon involved and the degree of concentration/dilution.

Artisanal refining in which crude oil is boiled and the resultant fumes are collected, cooled and condensed in tanks is one practice that have adversely impacted on the surface and groundwater quality in Orashi/Sombreiro River basin. The distilleries are heated on open fires fed by crude oil that is tipped into pits in the ground. It has been reported that petroleum refining contributes solid and liquid wastes in the environment (Ogbuagu, Okoli, Gilbert, Madu, 2011; Amangabara&Njoku, 2012). Some of these wastes could contain toxic components such as the polynuclear aromatic hydrocarbons (PAHs), which have been reported to be the real contaminants of oil and most abundant of the main hydrocarbons found in the crude oil mixture (Amangabara&Njoku, 2012). This activity not only contaminates groundwater in the immediate vicinity but also spread pollution beyond the refinery area as crude left behind after the refining process are been picked up by higher tides and transported over a wider area.

II. MATERIALS AND METHODS

In order to obtain samples for this investigation, three (3) stations were established along Orashi River and three stations also along Sombreiro River, this however enabled the collection of water samples for surface water analysis. Samples for the ground water quality analysis were collected as well from boreholes in communities that are very close to the sample location for the surface water along the two rivers. Parameters of interest in this study includes heavy metals such asBTEX and Total Petroleum Hydrocarbon were also sampled using standard methods for water and waste water analysis (APHA, 2005).

Surface and groundwater sample collected from Orashi and Sombreiro basin were analyzed for BTEX and Total Petroleum Hydrocarbon using gas chromatography with a flame ionization detector (FID) or mass spectrometric detector (MSD) which has the capacity to reveal the type of hydrocarbons present in water.

III. RESULTS AND DISCUSSIONS

Table 1: BTEX and Total Petroleum Hydrocarbon Presence in Surface water in Orashi/Sombreiro River basin in Wet and Dry Season

Parameters	**WET SEASON**					
	SOMBREIRO			**ORASHI**		
	Sample Locations			Sample Locations		
	SP1 Obuama	SP2 Ahoada	SP3 Ebocha	SP1 Mbiama	SP2 Old Sangana	SP3 Ndoni
BTEX (mg/L)	10.4736	1.1424	2.3858	1.1834	2.3052	2.3969
Total Petroleum Hydrocarbon (mg/L)	164.249	62.848	103.87	40.125	69.831	74.259
DRY SEASON						
Parameters	**SOMBREIRO**			**ORASHI**		
	Sample Locations			Sample Locations		
	SP1 Obuama	SP2 Ahoada	SP3 Ebocha	SP1 Mbiama	SP2 Old Sangana	SP3 Ndoni
BTEX (mg/L)	8.0054	0.9532	1.7941	0.8435	1.9463	2.0056
Total Petroleum Hydrocarbon (mg/L)	158.321	63.142	99.647	40.007	70.248	73.436

***SP = Sample point**

Table 1 shows petroleum presence in surface water in wet and dry season in Sombreiro/Orashi River basin, the water source was collected from three sections of Orashi and Sombreiro River representing the upper, middle and lower courses of the rivers. For the wet season, it is observed that the in the Sombreiro River section of the study area, benzene, toluene, ethyl-benzene, xylene (BTEX) ranged from 1.1424mg/L to 10.4736mg/L, hence the study noted that the highest BTEX value of 10.473.36mg/L was identified in sample point 1 which is Obuama community section of the Sombreiro River. Total Petroleum Hydrocarbon as observed from the table ranged from 62.848mg/L to 164.249mg/L with the highest Total Petroleum Hydrocarbon (TPH) value of 164.249mg/L noticed at sample point 1 which is Obuama community section of the Sombreiro River as well.

The table also reported that in Orashi River section of the study area that BTEX value ranged from 1.1834mg/L to 2.3969mg/L, with the highest benzene, toluene, ethyl-benzene, xylene (BTEX) value of 2.3969mg/L recorded at Sample point 3 in the Orashi River section which is Ndoni community. Total Petroleum Hydrocarbon as observed from the table ranged from 62.848mg/L to 164.249mg/L with the highest Total Petroleum Hydrocarbon (TPH) value of 164.249mg/l noticed at sample point 3 which is Ndoni community section of Orashi River. The reports above for surface water in the wet season, clearly indicates that Obuama

community in Sombreiro River section of the study, had the highest value of BTEX and TPH as well as Ndoni community in Orashi River section of the study area.

For the dry season, it is observed that the in the Sombreiro River section of the study area, benzene, toluene, ethyl benzene, xylene (BTEX) ranged from 0.9532mg/L to 8.0054mg/L, hence the study noted that the highest benzene, toluene, ethyl-benzene, xylene (BTEX) value of 8.0054mg/L was identified in sample point 1 which is Obuama community section of the Sombreiro River. Total Petroleum Hydrocarbon as observed from the table ranged from 63.142mg/L to 158.321mg/L with the highest Total Petroleum Hydrocarbon (TPH) value of 158.321mg/L noticed at sample point 1 which is Obuama community section of the Sombreiro River as well.

The table also reported that in Orashi River section of the study area BTEX value ranged from 0.8435mg/L to 2.0056mg/L, with the highest benzene, toluene, ethyl-benzene, xylene (BTEX) value of 2.0056mg/L recorded at Sample point 3 in the Orashi River section which is Ndoni community. Total Petroleum Hydrocarbon as observed from the table ranged from 40.007mg/L to 73.436mg/L with the highest Total Petroleum Hydrocarbon (TPH) value of 73.436mg/L noticed at sample point 3 which is Ndoni community section of Orashi River.

Table 2: BTEX and Total Petroleum Hydrocarbon presence in Ground water in Orashi/Sombreiro River basin in Wet and Dry Season

Parameters	**WET SEASON**					
	SOMBREIRO			**ORASHI**		
	Sample Locations			Sample Locations		
	SP1 Obuama	SP2 Ahoada	SP3 Ebocha	SP1 Mbiama	SP2 Old Sangana	SP3 Ndoni
BTEX(mg/l)	1.24312	1.70204	1.53982	2.14135	0.94068	0.36823
Total Petroleum Hydrocarbon(mg/l)	42.759	49.159	86.215	90.429	21.003	35.279
DRY SEASON						
Parameters	**SOMBREIRO**			**ORASHI**		
	Sample Locations			Sample Locations		
	SP1 Obuama	SP2 Ahoada	SP3 Ebocha	SP1 Mbiama	SP2 Old Sangana	SP3 Ndoni
BTEX (mg/l)	0.83143	1.29340	1.02612	1.38216	0.62032	0.25192
Total Petroleum Hydrocarbon (mg/l)	41.391	47.016	82.934	87.002	22.376	37.003

*****SP = Sample point

Table 2 above shows petroleum presence in ground water in wet and dry season in Sombreiro/Orashi river basin, the water source was collected from three communities in line with the upper, middle and lower courses of the Rivers. For the wet season, it is observed that the in the Sombreiro River section of the study area, benzene, toluene, ethyl benzene, xylene (BTEX) ranged from 1.24312mg/L to 1.70204mg/L, hence the study noted that the highest BTEX value of 170204mg/L was identified in sample point 2 which is Ahoada community section of the Sombreiro River. Total Petroleum Hydrocarbon as observed from the table ranged from 42.759mg/L to 86.215mg/l with the highest Total Petroleum Hydrocarbon (TPH) value of 86.215mg/L noticed at sample point 3 which is Ebocha community section of the Sombreiro River.

The table also reported that in Orashi River section of the study area that benzene, toluene, ethyl-benzene, xylene (BTEX) value ranged from 0.36823mg/l – 2.14135mg/L, with the highest BTEX value of 2.14135mg/l recorded at Sample point 1 in the Orashi River section which is Mbiama community. Total Petroleum Hydrocarbon as observed from the table ranged from 21.003mg/l - 90.429mg/l with the highest Total Petroleum Hydrocarbon (TPH) value of 90.429mg/l noticed at sample point 1 which is Mbiama community section of Orashi River section. The reports above, clearly indicate that Mbiama community in Orashi River section of the study, had the highest value of BTEX and TPH as well as Ahoada and Ebocha communities in Sombreiro River section of the study area which had highest values for benzene, toluene, ethyl benzene, xylene (BTEX) and Total Petroleum Hydrocarbon (TPH) respectively.

For the dry season, it is observed that the in the Sombreiro River section of the study area, benzene, toluene, ethyl benzene, xylene (BTEX) ranged from 0.83143mg/l to 1.29340mg/l, hence the study noted that the highest benzene, toluene, ethyl benzene, xylene (BTEX) value of 1.29340mg/l was identified in sample point 2 which is Ahoada community section of the Sombreiro River. Total Petroleum Hydrocarbon as observed from the table ranged from 41.391mg/l to 82.934mg/l with the highest Total Petroleum Hydrocarbon (TPH) value of 82.391mg/l noticed at sample point 3 which is Ebocha community section of the Sombreiro River.

The table also reported that in Orashi River section of the study area that BTEX value ranged from 0.25192mg/l to 1.38216mg/l, with the highest BTEX value of 1.38216mg/l recorded at Sample point 1 in the Orashi River section which is Mbiama community. Total Petroleum Hydrocarbon as observed from the table

ranged from 22.376mg/l to 87.002mg/l with the highest Total Petroleum Hydrocarbon (TPH) value of 87.002mg/l noticed at sample point 1 which is Mbiama community section of Orashi River.

Hypotheses Testing

The stated hypotheses for the study are as follows;

1. There is no statistically significant variation in hydrocarbon pollutants concentration in surface water in dry and wet season in Orashi and Sombreiro Rivers.
2. There is no statistically significant variation in hydrocarbon pollutants concentration in ground water in dry and wet season in Orashi and Sombreiro Rivers

The stated hypotheses were tested using Analysis of Variance statistical tool.

Table 3: ANOVA test for variation in Hydrocarbon Pollutants Concentration in Surface Water in Dry and wet Season for Sombreiro and Orashi River Basin

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	40399.47	3	13466.49	14.94523	2.45E-05	3.098391
Within Groups	18021.12	20	901.056			
Total	58420.58	23				

The ANOVA table above reveals that calculated F statistic value for the analysis is 14.94523 while the critical value is 3.098391. Therefore, since the calculated F statistic value of 14.94523is greater than the critical value of 3.098391 at $F^3{}_{20}$ degree of freedom, hence the null hypothesis H_0 of no significant variation is rejected and the alternate hypothesis H_1 is accepted. From the result the study has revealed that there is a statistically significant variation in hydrocarbon pollutants concentration in Surface water in dry and wet season in Orashi and Sombreiro Rivers.

Table 4: ANOVA test for variation in Hydrocarbon Pollutants Concentration in Ground Water in Dry and wet Season for Sombreiro and Orashi River Basin

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	16501.62	3	5500.54	14.92048	2.48E-05	3.098391
Within Groups	7373.141	20	368.6571			
Total	23874.76	23				

The ANOVA table above reveals that calculated F statistic value for the analysis is 14.92048 while the critical value is 3.098391. Therefore, since the calculated F statistic value of 14.92048 is greater than the critical value of 3.098391 at $F^3{}_{20}$degree of freedom, hence the null hypothesis H_0 of no significant variation is rejected and the alternate hypothesis H_1 is accepted. From the result the study has revealed that there is a statistically significant variation in hydrocarbon pollutants concentration in ground water in dry and wet season in Orashi and Sombreiro Rivers.

IV. DISCUSSION OF FINDINGS

The dry season surface water value of benzene, toluene, ethyl benzene, xylene (BTEX) value in Sombreiro and Orashi River basin ranged from 0.9532mg/L to 8.0054mg/L and from 0.8435mg/L to 2.0056mg/L. Total Petroleum Hydrocarbon (TPH) in Sombreiro and Orashi River basin ranged from 63.142mg/L to 158.321mg/L and from 40.007mg/L to 73.436mg/L. Benzene, toluene, ethyl benzene, xylene (BTEX) value for wet season surface water in Sombreiro River basin ranged from 1.1424mg/L to 10.4736mg/L and from 1.1834mg/L to 2.3969mg/L while Total Petroleum Hydrocarbon (TPH) ranged from 62.848mg/L to 164.249mg/L and from 62.848mg/L to 164.249mg/L. Benzene, toluene, ethyl benzene, xylene (BTEX) value is found to be higher in wet season compared to dry season. This is however not the case with Total Petroleum Hydrocarbon (TPH).

The dry season groundwater value of benzene, toluene, ethyl benzene, xylene (BTEX) in Sombreiro and Orashi River basin ranged from 0.83143mg/L to 1.29340mg/L and from 0.25192mg/L to 1.38216mg/L respectively while the value of Total Petroleum Hydrocarbon (TPH) ranged from 41.391mg/L to 82.934mg/L and from 22.376mg/L to 87.002mg/L. on the other hand, benzene, toluene, ethyl benzene, xylene (BTEX) wet season groundwater value for Sombreiro and Orashi River basin ranged from 1.24312mg/L to 1.70204mg/L and

from 0.36823mg/l – 2.14135mg/L respectively while the value of Total Petroleum Hydrocarbon (TPH) ranged from 42.759mg/L to 86.215mg/L and from 0.36823mg/L to 2.14135mg/L respectively. However, the study also reported that a statistically significant variation exists in hydrocarbon pollutants concentration in ground and surface water in dry and wet season in Orashi and Sombreiro Rivers.

Similar studies carried out by Anyakora& Coker (2009) observed that PAHs concentrations ranged from 1.92 to 40.47μg l-1, hence the findings of the study as stated above is in line with the present study findings. This study finding however is also in consonance with the findings of Nwaichi& James (2012) who observed an increase in the concentration of benzene in water samples collected from Ogale communities in Rivers State of Nigeria. The study carried out by Okogbue, Oyesanya, Anyiam&Omonona (2017) is in agreement with the findings of this study as it revealed that offshore waters in the Niger Delta were contaminated with total petroleum hydrocarbon (TPH) and benzene, toluene, ethyl-benzene, xylene (BTEX).

V. CONCLUSION AND RECOMMENDATIONS

Water resources in Orashi and Sombreiro River basins are contaminated with total petroleum hydrocarbon (TPH) and benzene, toluene, ethyl-benzene, xylene (BTEX). This suggests that petroleum exploration and exploitation activities going on in the study area affects the quality of both groundwater and surfaces water in the area.

The unsustainable development, utilization of petroleum hydrocarbon resources, and improper disposal of petroleum hydrocarbon–derived chemical wastes have indeed polluted the water resources in the area. The values of total petroleum hydrocarbon (TPH) and benzene, toluene, ethyl-benzene, xylene (BTEX) exceeds maximum permissible limit for various regulatory agencies.

The study however makes the following recommendations**;**

1. Multi-nationals and other companies involved in exploration and exploitation of petroleum should as a matter of urgency develop or adopt global acceptable remediation technologies to remediate polluted water resources. This must be done to address incessant pollution of water resource.
2. Legislations prohibiting the pollution of any environmental resources particularly water resources should be reviewed and defaulters should be made to face severe penalties. Oil firms should be made to comply with the applied laws and practices. These legislations should be strictly enforced without compromise.

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