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Research Article

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Distribution of some Organic Contaminants and Iron in Otuoke, Niger Delta Region, Nigeria

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Abstract

The distribution of organic contaminants (TPH and THC) and Fe in Otouke were determined with a total of ten (10), five borehole sediment samples and also five water samples from borehole. The study area was mapped into (1 km) length and sample collection were guided by the USEPA procedures. The samples were collected at a depth of 3.4 m interval with total borehole depth of 16 m. Physiochemical properties of sediment, such as pH, Fe, Total Hydrocarbon Content, Total Petroleum Hydrocarbon, and Polycyclic Aromatic Hydrocarbon, were determined using standard analytical methods. Also, the hydrocarbon level of the impacted sediments was also determined using particles size analysis, the borehole sediments and water: pH (5.77– 7.42), Fe (0.14 mg/L – 0.54 mg/L), Total Hydrocarbon Content (1.43 mg/L – 4.64 mg/L), and Total petroleum Hydrocarbon (0.26 mg/L – 2.86 mg/L). The presence of pH indicators and the observed results showed that the concentrations of organic contaminants in all the three layers were above the legal limit set by World Health Organization WHO. The textural characteristics possessed a mean grain size from fine sand to coarse silt, poorly sorted, skewness of near-symmetrical, meso-kurtic kurtosis to very platy-kurtic. Hence, this finding has revealed evidence that the Otuoke River is TPH, THCs and Fe contaminated. The entry of contaminants into the groundwater was significantly controlled by the characteristics of the particle size of the sediment.

Keywords: Total Petroleum Hydrocarbon TPH, Total Hydrocarbon Content THC, Otuoke, Distribution, Borehole Sediments.

Introduction

Otuoke is a primary depositional environment where a heavy supply of sediment produces steep and lateral sedimentation [1]. Recent researches acknowledged Niger Delta region is broadly degraded and do not offer the same stage of functions as the ordinary ecological surrounding. Assessments conducted based on the Danube, Ebro and Seine tributaries and some German rivers revealed that, today, 70% - 90% of world's river banks ecologically deteriorated [2]. These transitions are as a result of oil released unwittingly, intentionally from allowable limits and petroleum products constitute the key anthropogenic basis of THC and TPH in the flood plain and the tidal flats [3].

Far-reaching spills of crude oil on the environment, leaks from pipes, automobile or machine repairs/junk vehicle storage and surface fuel storage tanks, unselective spills and combustion of fossil fuel and landfills/garbage dumps containing oil and plastics and petroleum associated products in the public are some of the main routes of Total Petroleum Hydrocarbon and Total Hydrocarbon Content contamination in the study area. The effect of Total Petroleum Hydrocarbon and Total Hydrocarbon Content contamination in the environment has attracted worldwide interest among researchers because of the perceived health effects which are either carcinogenic, mutagenic or toxic [4].

High levels of TPH and THC contaminants prevailing in flood plain and tidal flat may possibly pose health threat to both flora and fauna within the surroundings. The hazard to several ecologies and their resources has been amplified because of increased environmental ruin. It has been documented that the different activities of anthropogenic activities are the major sources of TPH and THCs which deteriorating Otuoke river, and in few cases may be the result of natural occurrence of Fe [2]. The concern of residents of Niger Delta in recent times is the damage to the environment and human health caused by the occurrence of oil spills and migration of TPH and THCs contaminants into water courses [5].

Over various decades, a considerable quantity of Total Petroleum Hydrocarbon TPH and Total Hydrocarbon Content THC contaminants have deposited in the over-bank sediments of the embanked flood plain and tidal flat of the Niger Delta [6]. However, several research works conducted to evaluate these organic and heavy metal contaminants of the Niger Delta and beyond. I often attempted it in such pioneer studies to assess organic concentrations in the creeks of the Niger Delta by establishing conceptual, theoretical and empirical relationships with factors that are deduced to determine differences in rate of contamination and pollution [5] published on GIS Analysis of Organo-Contaminants and Iron Linked to Groundwater and Sediment at Boreholes in Aluu, Delta Region, Nigeria. The increase in population has led to the surge in scientific research of the Niger Delta aquatic bodies [7]. The petroleum industries, particularly in the Niger Delta area, have contributed to aquatic environmental degradation and pollution [8]. The main trust for this paper is to assess the distribution and impact of some

Organic contaminants and Fe in the study area. This knowledge can spur reform river system reserve control and administrative strategies to the Federal Government.

Description and Geology of the Study Area

The study area Otuoke River and its environment is within the lower section of the floodplain deposits of the sub-aerial Niger Delta [9]. Geographically, it lies between latitudes 4°46'N and 5°51'N and longitudes 6°15'E and 6°23'E. The area bordered on the North by Yenagoa, the capital of Bayelsa State and on the south by Brass and Nembe local government areas of Bayelsa State, to the West by Southern Ijaw and Ahoada-west local government areas of Bayelsa State and Rivers State, respectively.

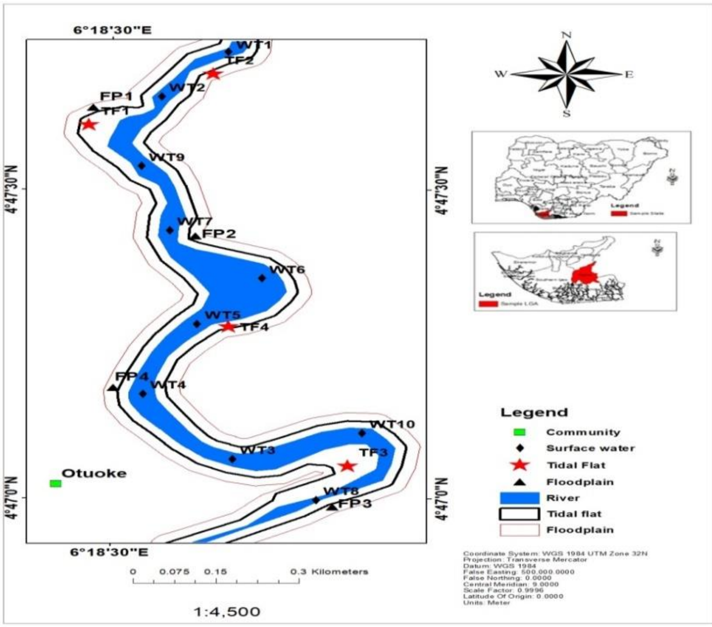

Figure 1: Map of the Study Area: showing the Locations of Samples Collected

Geology of the Study Area

The study area lies in the coastal Niger Delta sedimentary basin. Various authors have described the geology of the Niger Delta in details. Formation of the Delta started during the Early Paleocene and resulted mainly from the buildup of fine-grained sediments eroded and transported by the river Niger and its tributaries. The Tertiary Niger Delta is a sedimentary structure formed as a complex regressive offlap sequence of clastic sediments ranging in thickness from 9,000 - 12,000 m. Starting as separate depocenters, the Niger Delta has coalesced to form a single united system since Miocene. Stratigraphically, the Niger Delta is sub-divided into Benin, Agbada and Akata Formations in order to increase age. The Benin Formation is the water-bearing zone of the area [10]. Quaternary deposits overlay it (40-I50 m thick) and comprise a rapidly alternating sequence of sands and silty clays with the latter becoming increasingly more prominent seawards [11]. Clayey intercalations within the Benin formation have given rise to multi-aquifer system in the area [11].

Materials and Methods

Method of Sampling and Sample collection

A total of thirty-five samples, ten water samples at a depth of one meter, five water samples from the borehole at depth of 16.4 m. Five sediment samples from flood plain at depth of 1 m and five tidal flat sediment sample at depth of 1 m and five sediment samples from borehole at depth of 16.4 m were collected and analysed in triplicate for organo-contaminant characteristics. The selection of the borehole followed the design provided by [12]. The sample collections were done in triplicate in a standard field format. To prevent photo-oxidation, the extracted sediment samples were tightly sealed in a black polythene container and the extracted water was stored in sample bottles. For the determination of pH, Total Petroleum Hydrocarbon, Total Hydrocarbon Content, Polycyclic Aromatic Hydrocarbon, Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, and Iron in the study area. The water in the core samples were drained for 24 hours in sample bottles and sealed for laboratory analysis. The water samples were subjected to chemical analyzes for organo-contaminants Iron and pH, Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, as an organo-contaminant indicator. The American Public Health Association Method (APHA) was followed to perform the chemical analysis of the water samples. Here, sediment samples were analyzed following the liquid-liquid extraction procedure. For a start, 30 mL of dichloromethane (DCM) was used for extraction.

Laboratory Analysis

Sequential Extraction Procedure

At the end of the water extraction, the air-dried and sieved sediments were deployed for size analysis of particle. For particle size analysis, sediment samples were air-dried and transferred to a Gilson ASTM test sieve particle size analyzer (Model SS-34, United Kingdom) for segregation into fractions [13].

For pH, the required standards were prepared and used in the measurement. Standard suspensions required were prepared and used to analyse pH (Orion Model 290 pH meter, United Kingdom).

For TPH resolution, water extracted in a 1L flask was transferred to a 500 mL funnel of separation. An extraction solvent of 1 M dichloromethane of 50 mL was used. The content was shaken strongly for 5 mins and allowed to settle for the organic layer to separate. The organic layer was mixed with 5 g of anhydrous sodium sulfate and made up to 250 mL. This extraction was repeated three times and the concentrate made up to 10 mL was evaporated at room temperature. The concentrated extract concentrate was oven-dried to dryness at 110 °C to compute TPH.

For THC determination, water extracted in a 1L flask was transferred into a 500 mL funnel of separation. Consequently, 5 mL of 1 M sulfuric acid was used for acidification and the content reacted for 3 mins with 25 mL of n-hexane. The organo-layer was allowed to settle out of the solution. The content was extracted into a 250 mL timed distillation flask and deployed to a reflux condenser attached to it. The reflux technique was applied to generate 10 mL. The THC was computed using a pre-weighted flask shortly after the solvent was evaporated to dryness. All analyses were triplicated in a standard laboratory format as provided [13].

For Fe determination using (Perkin Elmer AAS PinAAcle 9, Canada), The extracted water samples were digested in a fume hood using 1 M nitric acid solution. Blanks and standard solutions of 0.5 mg/L, 1 mg/L, 5 mg/L and 10 mg/L were prepared and used for AAS runs. These water samples were filtered and made up to 100 mL and deployed to the AAS for the analysis of total Fe [14]. Sigma Aldrich United Kingdom provided high-quality consumables for the analyses.

Spatial Data and GIS Analysis

To prepare the location map of Otuoke, they prepared a shape file using Google Map Pro. The GPS coordinates used for the exercise got from fieldwork. The National Geographic World Map is the base map. For Spatial distribution map preparation, an Excel data sheet of the parameters prepared and converted to GIS spatial GIS tables. Save these tables as shape files for the inverse distance-weighted interpolation in 3-D deployment and raster analysis.

Results and Discussion

Particles Size Analysis

The particle size analysis of Borehole sediment in Otuoke River, obtained to characterize the grain size variation and the tendency of flow of organic contamnants in both surface and underground of the study area (Table 1).

Sample code	Number of Samples	Mean (M_z)	Sorting (D)	Skewness (SKw)	Kurtosis (K)	Sediment Characteristics
1	5	3.53	2.96	0.06	0.72	Very fine sand
2	5	3.70	2.97	-0.03	0.41	Coarse silt
3	5	3.90	3.01	0.20	0.87	Very fine sand
4	5	3.43	2.64	0.01	0.62	Fine sand
5	5	3.53	2.65	0.02	0.63	Fine sand

Table 1: Descriptive Statistical Analyses for Borehole Sediments

The textural characteristics of the study area shows that, as progressed from the flood plain to the Tidal flat the particles size of sediments range from fine silt to find sand fraction. Based on the mean, sorting coefficient, skewness, and kurtosis indicate medium to fine sand, the textural characteristics of the sediments based on the mean, sorting coefficient, skewness, and kurtosis indicate medium to fine sand.

Determination of Geochemical Parameters

Table 2 present the distribution of Fe, the pH as organic contaminant indicator, organic Contaminants (THC, and TPH) concentration in Borehole sediments, and showing the mean and standard deviations of all organic parameters.

			Geochemical Analysis of Borehole sediments and Underground water samples Parameters (Average)			
Samples	**Media**	**Depth (m)**	**pH**	**Fe (mg/l)**	**THC (mg/l)**	**TPH (mg/l)**
1	Very fine sand	3.2	5.77	0.54	1.75	0.26
	Water		6.73	0.22	3.18	1.73
2	Coarse Silt	6.4	6.24	0.46	1.43	0.17
	Water		7.14	0.36	4.64	2.86
3	Very fine sand	9.6	6.57	0.38	1.98	0.38
	Water		7.45	0.14	2.91	3.75
4	Fine sand	12.8	5.80	0.52	2.12	0.54
	Water		6.97	0.23	3.12	1.82
5	Fine sand	16.0	5.42	0.37	2.30	0.76
	Water		7.74	0.18	2.84	2.15
Mean	Sediments		5.96	0.45	1.92	0.42
	Water		7.20	0.22	3.35	2.46
Standard Deviation	Sediments		0.44	0.07	0.33	0.23
	Water		0.39	0.07	0.74	0.84

Table 2: Fe, Organic Contaminant Indicators, Organic Contaminants (mg/L) and pH concentration in Borehole sediments.

Level of Concentration organic of contaminants

pH

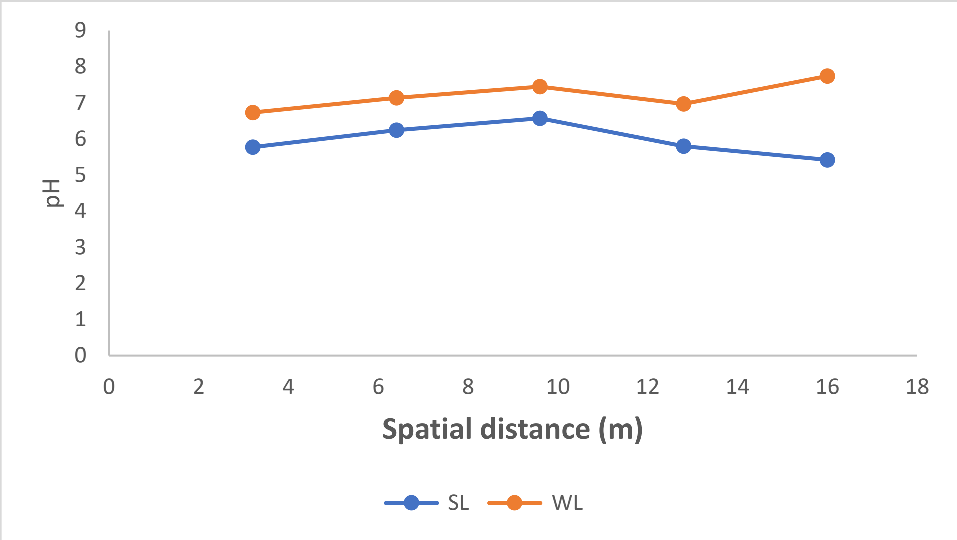

Figure 2: Plot of pH vs spatial distance for Borehole sediment (Soukeme E.)

Result of the pH of the borehole sediments (Table 2). pH ranged between 5.42-6.57 with both lowest and highest values occurring at BH5 and BH3, while the pH in the borehole water is evaluated in all the depth points (BH1 - BH5) had shown the variation of the two categories of samples in figure 2. The level of acidity decreases as depth progressed vertically downwards, and the two values diverted. 5.42 pH of sediment indicated the level concentration of THC and TPH as soil water. The results are summary pH value in water observed, highest value 7.45 occurred at 16m depth, while lowest value 6.73 occurred at 3.2m depth. Altering the pH of an environment from neutral to pH 6.0 and 8.0 had very little or no effect [15]. The textural characteristics of the borehole sediments based on the mean, sorting coefficient, skewness, and kurtosis indicate medium to fine sand. These sediments are poorly sorted and negatively skewed in grain size. The kurtosis indicates sediment grains are platykurtic to poorly sorted. These features indicate deposition in environment controlled by tidal system in the study area.

Concentration of Fe

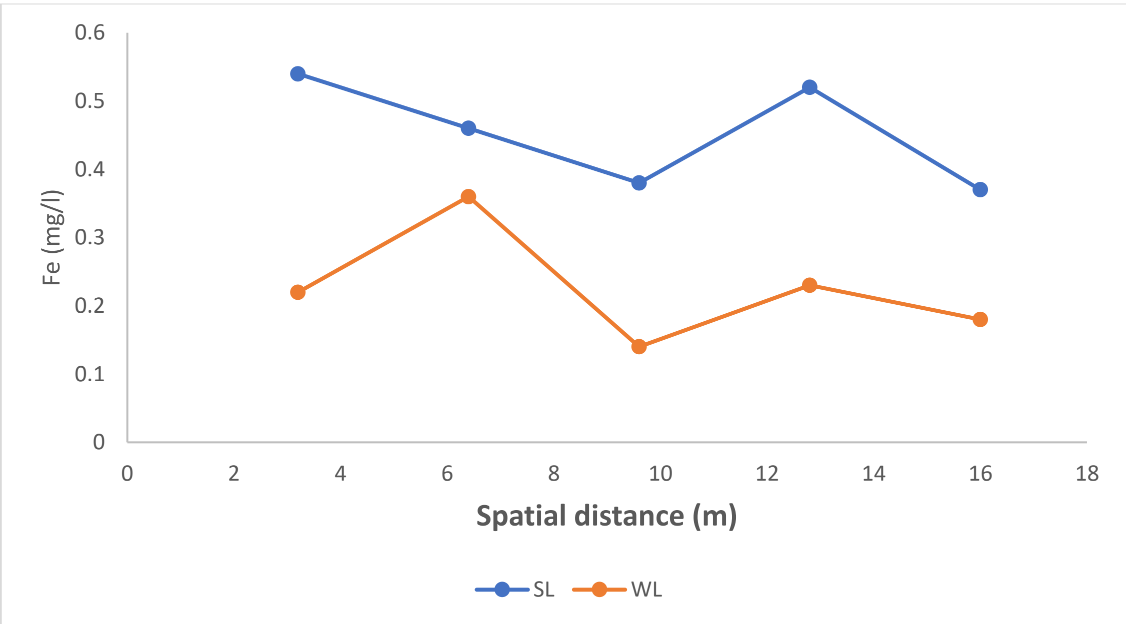

Figure 3: Plot of Fe vs spatial distance for Borehole sediment (Soukeme E.).

The result shows that, nearly all the analysis returned a value for iron Fe. The values range from 0.37 mg/L – 0.54 mg/L in sediment samples, the mean iron content is 0.45 mg/L, and the standard value 0.07 mg/L. Fe concentration in water range from 0.14 mg/L–0.36 mg/L, mean value 0.22 mg/L with standard deviation of 0.07. The WHO recommended range of 0.1–0.3 mg/L as the highest desirable and maximum permissible limits, respectively. Compared to the WHO recommended a range of 0.1–0.3 mg/L as the highest desirable permissible limits. Iron in the water and sediment remains higher than the acceptable limits provided by regional and international regulators. Therefore, the Fe content reported herein is comparable to those reported in some contaminated sections of the delta region in Nigeria [16]. This high Fe content may be aligned with the presence of iron-fixing bacteria brought in during sediment deposition. It may also be due to the high affinity of Fe to the sand fractions of the sediment. The heterogeneous configuration of the aquifer may explain the erratic distribution of Fe in the region.

Concentration of THC

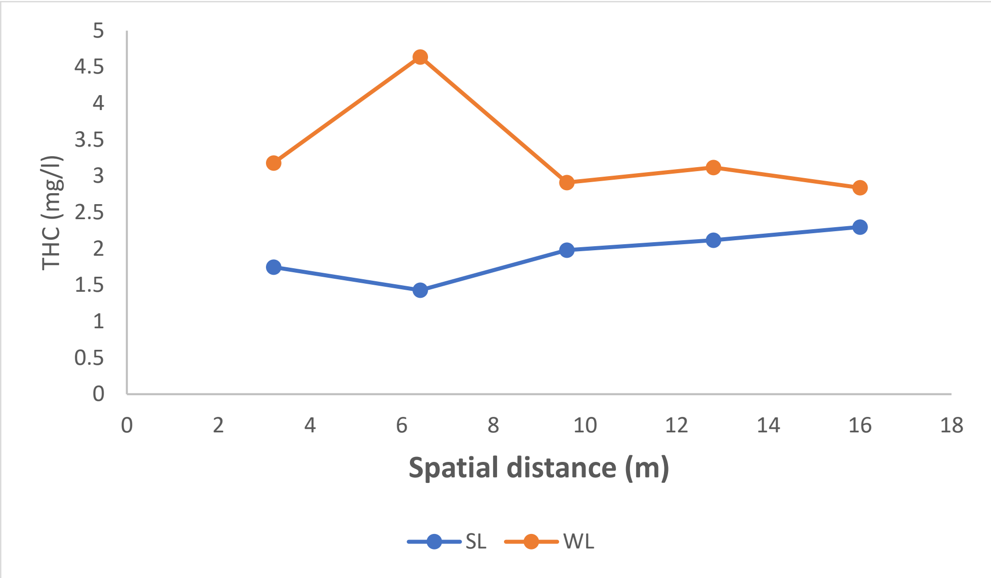

Figure 4: Plot of THC vs spatial distance for Borehole sediment (Soukeme E.).

From the Borehole, the concentration of total hydrocarbon Content of sediment observed ranged from 1.43 mg/L–2.30 mg/L, with the mean concentration of 1.92 mg/L. water samples collected from the borehole recorded the THC ranging from 2.84 mg/L–4.64 mg/L, while the mean was 3.33 mg/L figure 4. The permissible limit of 0.03 mg/L set by the World Health Organisation. The high concentrations of Total Hydrocarbons Content obtained in sediments from Borehole in Otuoke may be attributed to crude oil exploration around the floodplain and the Tidal flat in the study area and operations of illegal refineries. The distribution pattern of contaminants in the groundwater is controlled by the textural characteristics of the borehole sediments.

Concentration of TPH

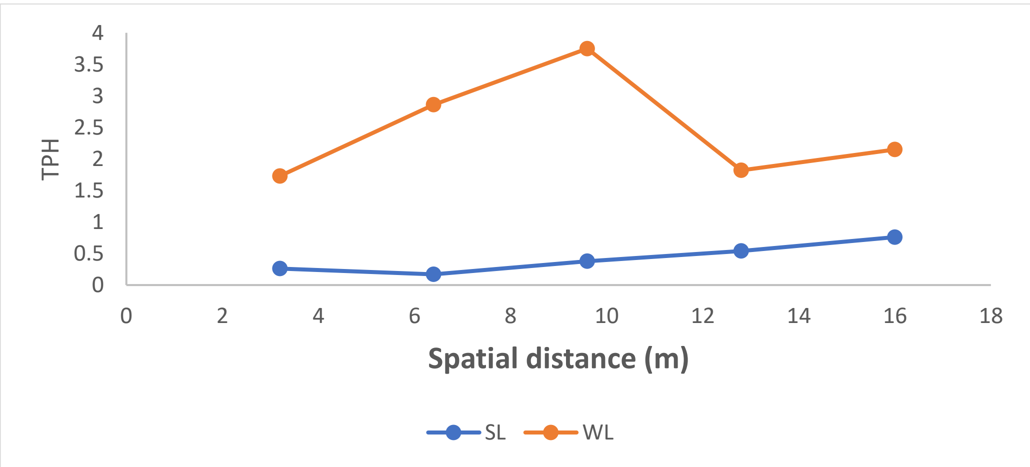

Figure 6: Plot of TPH vs spatial distance for Borehole sediment (Soukeme E.)

Result of the analysis of the level of concentration of TPH at various depths of the sediment samples in (Table 2). TPH concentration value in sediment 0.17mg/l-0.76 mg/L, highest value 0.76 mg/L at depth of 16.0m, and the mean value 0.42 mg/L. TPH concentration in water ranged from 1.73 mg/L–2.86 mg/L, highest concentration value 2.86 mg/L with the mean value 2.46 mg/L. The result of the analysis indicates that TPH is contaminated at all depth of the borehole in the study area. High concentrations of TPH obtained at various depths when compared to WHO recommended limit. Wide Variation of TPH concentration in sediment is due the particle size distribution trending down to depth. However, it reveals that domestic and industrial wastewater evacuation industrials are the main responsible sources of surface water, sediment, and groundwater pollution in Otuoke river.

Conclusion

Distribution of Organic contaminants and Fe is studied by using sediments and water from the borehole between the flood plain and tidal flat of Otuoke and evaluated by using geochemical parameters with particle size analysis (Table 2). Findings from the study revealed that the THC TPH and Fe at all depth were exceeded the limits stipulated by WHO. The study revealed a spatial increasing trend in THC, TPH and Fe which may have been suggested to be the fate of persistence increase nonpoint sources of contamination in Otuoke Although, this contamination of TPH THC, and Fe may be attributed by the illegal refining of crude along the flood plain, domestic effluent into the river and probably oil pipe leak activities of the flow station in upstream of Imiringi axis. Findings revealed that TPHs and THCs are adsorbed in sediments however textural characteristics of the sediments which allow for proper transport of THC, TPH and Fe from flood plain to tidal flat to the river will make the study area to undergo deep pollution in near future if no proper control measures take effect on the study area. The TPH and THCs contamination levels may have serious health implications, so water-borne diseases studies on the indigenous people of Otuoke community is imperative. Therefore, governmental efforts should be ascertained in the study area to control illegal crude sources and put preventive measures in place so that there will be improvement or reduction in contamination of Otuoke. Further research works should be carried out to the study area “the extent of migration of THC and TPHs using 1-d and 2-D integral resistivity methods” in the region.

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