Level and impact of hydrocarbon in sediment characteristics of Imiringi oil and gas field facilities in the Niger Delta

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Abstract

This study investigated the level and impact of hydrocarbon in Imirigi oil and gas field facilities in the Niger Delta. Sediment samples were collected in four locations viz: upstream, midstream, downstream and control. The hydrocarbon content and total petroleum hydrocarbon ranged from 0.14 – 3.79mg/kg and 0.08 – 2.41 mg/kg respectively. Other results supporting the impact of hydrocarbon in Imirigi oil and gas field include pH (5.45 – 5.58), magnesium (3.57 – 4.79mg/kg), potassium (1.74 – 4.24mg/kg), conductivity (85.33 – 273.33 µS/cm), chloride (15.17 – 22.53mg/kg), nitrate (1.53 – 3.20mg/kg), sulphate (5.49 – 12.59mg/kg), phosphate (1.63 – 3.56mg/kg), total organic carbon (4.54 – 6.71%), total nitrogen (3.86 – 6.43%), calcium (13.57 – 20.66mg/kg), sodium (6.49 – 10.68mg/kg). Analysis of variance showed that there was significance difference ($P<0.05$) in the various location for the various parameters apart from pH, magnesium and potassium. This suggests that the activities of oil and gas and other anthropogenic activities are having a slight impact in sediment of surface water at Imirigi oil and gas facilities.

Keywords: Environmental Contamination, Hydrocarbon, water resources, Sediment

INTRODUCTION

Environmental pollution is a major challenge to environmental sustainability (Ogamba *et al*., 2016; Izah *et al*., 2016; Izah and Angaye, 2016). Environmental pollution is typically caused by anthropogenic activities and to lesser extent natural effects (Izah *et al*., 2015; Izah and Angaye, 2015; Aigberua *et al*., 2016a). For example, eutrophication in slow flowing surface water is mostly due to the effect of nutrient resulting from runoff after precipitation (Aigberua *et al*., 2016a). Also, discharge of effluents contain high nutrient could also cause eutrophication in addition to other contamination matrices (Aigberua *et al*., 2016a). For instance, during oil palm processing, the effluents are typically discharged into the environment (soil and water bodies) where they causes environmental contamination especially in areas producing nations that lack appropriate treatment technology (Izah *et al*., 2016). Indiscriminate use of pesticides and discharge of pesticides container could cause toxic effect especially to non-target organisms in aquatic ecosystem (Inyang *et al*., 2016a-e). This is because the remains of pesticides could be washed via runoff to the nearby surface water after heavy rainfall ((Inyang *et al*., 2016a-f, 2017a-c). Therefore, anthropogenic lead environmental contaminants are enormous.

Nigeria is a major producer of crude oil in the World. Ohimain (2013a), Aigberua *et al*. (2017) reported that Nigeria is the 12th and 7th largest producers and exporter of crude oil. As such, the activities of oil and gas is the major contributor of foreign earning (Izah and Ohimain, 2015). Ohimain (2013b, c), Aigberua *et al*. (2016b) is with the opinion that approximately 90% and 85% of Nigeria export and earning respectively are met by petroleum exploration. The Niger Delta region is the Nigerian oil and gas province. As such it's one of the most productive regions in Nigeria.

Crude oil is typically a complex mixture containing several compounds which are fractionated into different products including gasoline of various grades, lubricating oils of various weights and grades, kerosene of various grades, jet fuel, diesel fuel, heating oil and other chemicals etc (Aigberua *et al*., 2016a). These products have one thing in common thus hydrocarbon constituents. Hydrocarbon contain products from oil and gas activities typically enter the environment (soil, water) through several routes. This include the activities of militia, sabotage, illegal bunkering, pipeline vandalism and explosion resulting from natural effects such as corrosion of pipeline and storage facilities (Aigberua *et al*., 2016a). The authors further listed the general route in hydrocarbon containing products from crude oil and natural gas spills to include exploration, drilling, pipeline and oil transportation, refining, sales and distribution, illegal bunkering and sabotage.

The impact of crude oil is typically severe to biota is such environment depending on the concentration and exposure duration. Since petroleum is typically a complex mixture of hydrocarbons viz: aromatic (Polycyclic Aromatic Hydrocarbons) (Inengite *et al*., 2010, 2012, 2013) and aliphatic, and organometallic complexes such as heavy metals (Vanadium, lead, chromium, nickel etc) (Aigberua *et al*., 2017), the associated impacts are enormous. Crude

oil could lead to loss of fertile land, wildlife, vegetation, contamination of underground and surface water i.e. aquatic ecosystem, bioaccumulation of contaminants in plants, air pollution and affecting the microbial, physiochemical, heavy metal and hydrocarbon content in such environment (Aigberua *et al*., 2016a, 2017; Ogbeibu and Iyobosa 2013; Ambe *et al*., 2015).

Therefore, this study was designed to assess the level and impact of hydrocarbon in sediment of Imirigi oil and gas field facilities in the Niger Delta.

MATERIALS AND METHODS

Study Area

Imirigi oil field is aligning surface water known as Kolo creek. In the Kolo creek, water hyacinths are one of the major aquatic plants that constitute nuisance during navigation and transportation. Based on climate, the areas have similar climatic condition to other areas in the Niger Delta. Specifically, the climatic conditions of several surface water resources in Bayelsa state have been reported in literature some of them include Kolo creek (Aghoghovwia and Ohimain, 2014; Ogamba *et al*., 2015a, 2017a), river nun (Agedah *et al*., 2015; Ogamba *et al*., 2015b, 2017b), Ikoli creek (Ogamba *et al*., 2015c; Seiyaboh *et al*., 2016c), Epie creek (Seiyaboh *et al*., 2016a; Izonfuo and Bariweni, 2001), Sagbama creek (Seiyaboh *et al*., 2017a,b).

Sample collection and preparation

Sediment samples from the surface water aligning Imirigi oil field was collected with Eckman sediment at four location viz: downstream, midstream and upstream and control. The midstream is the area close to the oil field facilities. While upstream is some meters away from the source of the creek and downstream is some distances after the midstream toward the flow direction of the water. The control was collected far distance away from the upstream, midstream and downstream. The sampling was carried out in triplicate in November 2016. The samples were packaged with aluminum fossil and transported to the laboratory in an ice pack. Prior to analysis, the samples were air-dried and sieved using mesh.

Physico-chemical analysis of the sediment

The sediment samples were analyzed following standard methods previously described by authors including pH (Bates, 1954), conductivity (Aigberua *et al*., 2016b), calcium, magnesium, potassium and calcium (Nwakaudu *et al*., 2012), organic carbon (Osuji and Adesiyan, 2005; Akubugwo *et al.,* 2007), nitrates, phosphates and sulphates (Dewis and Freitas, 1970), nitrogen (Udoh and Ogunwale, 1986), Total hydrocarbon content was analyzed using following ASTM D 9071B – 7 (Soxhlet Extraction Method) as previously described by Aigberua *et al*. (2016a).

Statistical Analysis

SPSS was used to carry out the statistical analysis. The data was expressed as mean± standard error. One way analysis of variance was used to show significance variation at P=0.05. Where significance difference exist, Duncan multiple range test statistics was used to show the source of variation.

RESULTS AND DISCUSSION

Table 1 presents the physicochemical properties of sediment samples from imirigi oil field. The pH, magnesium and potassium concentration ranged from 5.45 – 5.58, 3.57 – 4.79mg/kg and 1.74 – 4.24mg/kg respectively. There was no significance difference (P>0.05) between each of the location among the various parameters. Furthermore, conductivity, chloride, nitrate, sulphate, phosphate, total organic carbon, total nitrogen, calcium and sodium ranged from 85.33 – 273.33 µS/cm, 15.17 – 22.53mg/kg, 1.53 – 3.20mg/kg, 5.49 – 12.59mg/kg, 1.63 – 3.56mg/kg, 4.54 – 6.71mg/kg, 3.86 – 6.43mg/kg, 13.57 – 20.66mg/kg and 6.49 – 10.68mg/kg respectively. Basically there was significance difference (P<0.05) among the various locations for each of the parameters.

Table 1: Physicochemical properties of sediment from Imirigi oil field in Niger Delta

Parameters	Control	Upstream	Midstream	Downstream
pH	5.58±0.01a	5.56±0.14a	5.49±0.02a	5.45±0.10a
Conductivity, µS/cm	85.33±0.33a	236.33±20.53bc	273.33±50.84c	169.33±21.40ab
Nitrate, mg/kg	1.53±0.03a	3.20±0.18c	2.46±0.06b	1.79±0.21a
Chloride, mg/kg	15.77±0.07ab	22.53±1.16b	17.43±0.61ab	15.17±3.98a
Sulphate, mg/kg	5.49±0.07a	12.59±1.09b	12.19±2.03b	8.30±1.17ab
Phosphate, mg/kg	3.56±0.01c	2.41±0.08b	2.08±0.29ab	1.63±0.21a
TOC, %	4.56±0.00a	6.71±0.10c	5.83±0.21b	4.54±0.46a
TKN, %	6.43±0.033d	5.55±0.14c	4.79±0.35b	3.86±0.26a
Calcium, mg/kg	14.68±0.03a	20.66±0.67b	17.41±1.07ab	13.57±2.72a
Magnesium, mg/kg	3.57±0.03a	4.79±1.06a	4.56±0.96a	4.03±0.68a
Sodium, mg/kg	6.49±0.07a	10.68±1.05b	8.41±0.64ab	6.96±1.24a
Potassium, mg/kg	1.74±0.10a	4.24±0.79a	4.11±0.83a	3.67±1.02a
THC, mg/kg	0.14±0.00a	3.30±0.35bc	3.79±0.05c	2.73±0.25b
TPH, mg/kg	0.08±0.00a	2.32±0.03c	2.41±0.08c	1.78±0.27b

Each data is expressed as mean± standard error (n=3); Different letters across the column indicate significance variation (P<0.05) according to Duncan statistics

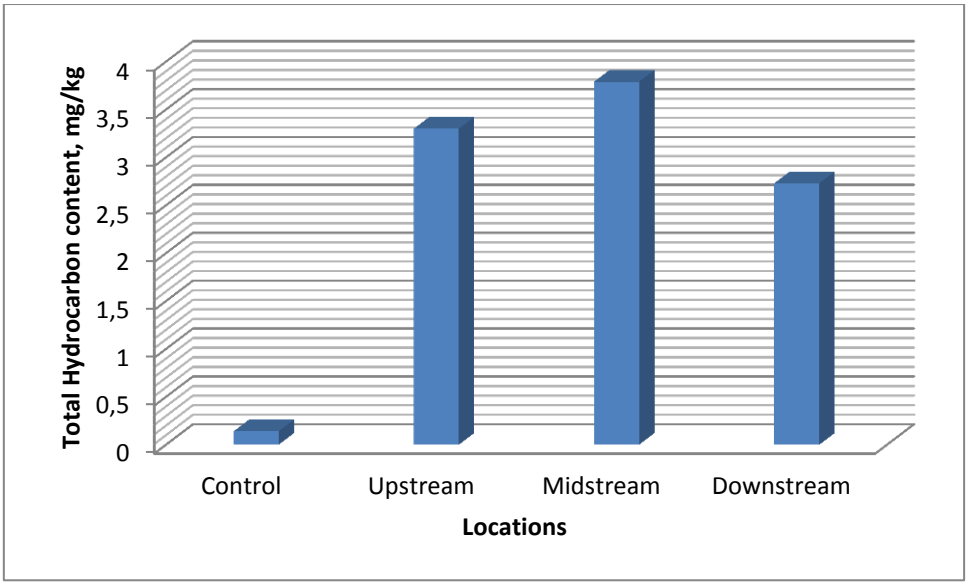

Figure 1: Total hydrocarbon content in sediment from sediment in surface water close to Imirigi oil field

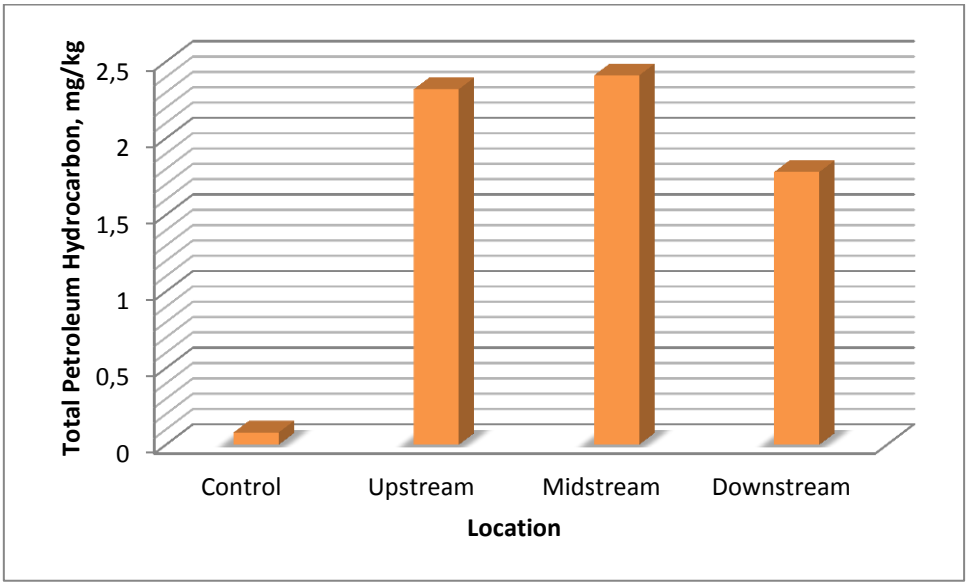

Figure 1: Total Petroleum Hydrocarbon in sediment from sediment in surface water close to Imiringi oil field

The concentration of total hydrocarbon content and total petroleum hydrocarbon in the sediment from surface water close to Imirigi oil field is presented in Figure 1 and 2 respectively. Total hydrocarbon content and total petroleum hydrocarbon ranged from 6.49 – 10.68mg/kg, 0.14 – 3.79mg/kg and 0.08 – 2.41 mg/kg respectively. There was significance difference ($P<0.05$) among the various locations for both parameter.Absence of significant variation ($P>0.05$) between the various locations (including control) for pH, magnesium and potassium concentration in the sediment suggest the activities of oil and gas is not having effect on the sediment quality of the area. However, the concentration of conductivity, nitrate, and total hydrocarbon content sulphate were significantly lower in the control compared to downstream. Again, the level of total organic carbon were significantly lower in control and downstream, while sodium concentration were significantly lower in control, midstream and downstream. The concentration of phosphate and total nitrogen were significantly higher in the control. This suggests that the impacts of anthropogenic activities in the surface sediment aligning Imirigi oil field differed pending on the surface of impacts. Higher concentration of nutrients such as nitrate, sulphate, organic carbon, sodium suggests that the sediment is rich in nutrient. The concentration of hydrocarbon is low to cause major impacts in the surface sediment. As such there is hydrocarbon pollution. The values of total hydrocarbon and other general physicochemical characteristics recorded in this study had some similarity with the values reported in sediment in Bayelsa state. For instance, Seiyaboh *et al*. (2016a) reported pH (6.67 – 6.77), conductivity (435.17 – 1189.50 $\mu hmoscm^{-1}$), Nitrate (2.87 – 7.59 mg/kg), sulphate (1.06 – 3.81 mg/kg), phosphate (0.09 – 0.42 mg/kg), calcium (3.92 – 6.88 mg/kg), magnesium (2.46-4.82 mg/kg), sodium (2.18 – 4.82 mg/kg), potassium (1.59 – 3.34 mg//kg), total nitrogen (2.64 – 9.20 %), total organic carbon (8.48-22.54%) and total hydrocarbon level (1.20 – 4.68mg/kg) in sediment from Epie creek. Seiyaboh *et al*. (2016b) reported the sediment characteristics of Orashi river to include pH

(6.53 - 7.05), electrical Conductivity (124.31 – 590.01 µS/cm), nitrate (0.72 – 3.76 mg/kg), Sulphate (0.33 - 0.85 mg/kg), Phosphate (0.24 - 0.43 mg/kg), Calcium (3.68 – 8.03 mg/kg), magnesium (1.99 – 6.86 mg/kg), Sodium (2.23 – 4.47 mg/kg), potassium (1.41 – 3.62 mg/kg), Nitrogen (2.52 - 4.63 mg/kg), Organic carbon (7.78 - 10.51 mg/kg) and Total Hydrocarbon Content (4.96 - 9.62 mg/kg). Seiyaboh *et al*. (2016c) reported the physicochemical characteristics of sediment from Ikoli creek to include pH (6.46 – 7.25), nitrate (2.11 – 3.15 mg/kg), conductivity (134.33 – 600.00 µhmoscm^{-1}), phosphate (0.13 – 0.39 mg/kg) sulphate (0.28 – 1.31 mg/kg), nitrate (0.130 – 0.146mg/kg), calcium (2.53-6.76 mg/kg), potassium (1.07-1.76mg/kg), sodium (1.07-2.84 mg/kg), magnesium (1.21 – 3.82 mg/kg), total hydrocarbon content (2.31-6.81 mg/kg), organic carbon (3.35-8.27%). Seiyaboh *et al*. (2017a) reported physicochemical quality of sediment from Sagbama creek to include pH (6.73 – 6.87), Conductivity (423.53 – 2033.56 µhmoscm^{-1}), nitrate (2.43 – 4.57mg/kg), sulphate (1.30 – 4.20mg/kg), phosphate (2.43 – 5.10mg/kg), calcium (4.04 – 6.20mg/kg), magnesium (4.77 – 6.12mg/kg), sodium (4.21 – 8.62mg/kg), potassium (1.65 – 2.80mg/kg), total nitrogen (3.35 – 5.50%) and organic carbon (6.73 – 10.73 %). The comparable total hydrocarbon content reported in this study compared to the values reported by Seiyaboh *et al*. (2016a,b) in non-oil and gas facilities suggest that there is no major hydrocarbon pollution assictated to the activities of oil and gas from Imirigi oil field at the period of the study. Furthermore, Gijo *et al*. (2017) have reported total hydrocarbon content in the range of 19.11 – 1125.9mg/kg (wet season) and (17.80 – 1118.5mg/kg (dry season) from sediments of the nun river estuary in a makeshift oil refineries. This suggest low hydrocarbon in surface water around Imirigi oil field.

Typically, sediment is a valuable resource especially to most aquatic organisms. To large extent, the characteristics of sedimentary deposits affect the assemblage of benthos in such environment (Gijo *et al*., 2017). Also the packing degree of the sediment potentially determines the stability of the bed which is vital for the kind of benthic invertebrates that will inhabit an area, particularly the burrowers and filter feeders (Gijo *et al*., 2017). High concentration of hydrocarbon in the water and sediment may like bioaccumulate by pelagic and benthic organisms. But in the this study the concentration of hydrocarbon is low, therefore the tendency that it could cause health related hazard is very minimal.

CONCLUSION

Nigeria is a major producer of crude oil. The Nigerian oil and gas facilities are predominately found in the Niger Delta in both onshore and offshore. Crude and natural gas products contain hydrocarbon. In the value chain of crude oil and natural gas viz: exploration to utilization of refined products, spill hydrocarbon spills following corrosion of pipeline and storage facilities, vandalism and sabotage of facilities, illegal bunker among other. So when the hydrocarbon enters the environment (soil, water and air) it could impacts seriously on both biotic and abiotic components of the ecosystem. This study was designed to assess the level and impacts of hydrocarbon in sediment of surface water close of Imirigi oil field facilities. The study found high total hydrocarbon content and total petroleum content upstream midstream and downstream compared to the control. The hydrocarbon level is comparable to the values previously reported in sediment of other surface water in Bayelsa state. Furthermore, the concentration of hydrocarbon were higher in the midstream stream (area close to the oil field facilities) compared to other locations, suggesting slight impact of the activities of Imirigi oil field facilities in the sediment of surface water aligning it.

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