Impact of Illegal Crude Oil Refining in Jike-ama River of Bille Kingdom, Rivers State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author NN designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors DB and TJG managed the analyses of the study. Author TJG managed the literature searches. All authors read and approved the final manuscript.

Article Information

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ABSTRACT

Oil exploration and exploitation is a lucrative business and one of the major sources of revenue in Nigeria. Each year, hundreds of post-impact assessment (PIA) studies are conducted to assess the impact of the hazards generated by the oil industry on social environment and on human health. This hazardous impact is the associated with the activities of illegal refining of crude oil. Thus, this work examined the impact of illegal crude oil refining activities in Jike-Ama river of Jike-Ama community. Shellfish, fish, surface water and sediment samples were randomly collected in triplicates. Physiochemical parameters, heavy metal content, polycyclic aromatic hydrocarbons (PAHs) and total hydrocarbon content of the water in addition to heavy metal content and PAHs in fish, Shellfish and sediment were determined. The results of the physicochemical parameters showed that pH, total suspended solids, biological oxygen demand, turbidity and total hydrocarbon content of water were above FEPA permissible limits while chloride, nitrate and sulphate detected in water were within FEPA permissible limits. Dissolved oxygen was observed to be below FEPA permissible limit. The mean concentration of heavy metals and PAHs in sediment showed significant difference ($p \leq 0.05$) when compared with values for Shellfish and fish and were above FEPA and

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WHO permissible limits. Shellfish had higher concentrations of heavy metals and PAHs than fish. PAHs values in shellfish showed significant difference ($p \leq 0.05$). Heavy metals concentration in fish were above permissible limits except Cr, Zn and Pb. Concentration of PAHs in fish, shellfish, surface water and sediment were generally above FEPA and WHO permissible limits. This findings suggests high concentration of contaminants in Jike-Ama river.

1. INTRODUCTION

Severe damage is done to the environment as a result of artisanal refining. The refining process leads to a significant quantity of wastage being dumped in rivers and streams or on land. Two drums of crude oil translate into one drum of product once refined, leading to a lot of wastes in our environment. This work will examine the impact of toxic waste on aquatic life and surface water. Oil exploration and exploitation is very lucrative, and a major sourse revenue in Nigeria. Like most industrial activities, it produces environmental hazards that are slow poisons, in that they often take months and years to cause harm and death [1].

The covert and slow action of the hazards created by oil exploration and exploitation make it difficult to fully appreciate their contribution to the disease burden in Nigeria, especially in the oil-bearing communities, even with the emergence of non-communicable diseases as major causes of ill health in Nigeria [2].

Each year, hundreds of post-impact assessment (PIA) studies are conducted to assess the impact of the hazards generated by the oil industry on the physical and social environment and on human health. But, most of these studies are conducted without any significant contributions from health profession nals and are reported without highlighting the immediate and long-term implications of the identified hazards on the health of members of the impacted communities. The contents of the effluents have serious toxicological effects on aquatic life, environment and humans. When industrial effluent is discharged into a water body, it can cause depletion of dissolved oxygen due to transformation of organic component into inorganic compounds, loss of biodiversity through a decrease in amphipod population that is important in food chain, eutrophication and short term toxicity in fish [3].

According to Ogbuagu, et al. [3] it has been reported that petroleum refining contributes solid, liquid, and gaseous wastes in the environment. 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 [4]. Once introduced in the environment, PAHs could be stable for as short as 48 hours or as long as 400 days in soils [5]. They thus, resist degradation and, remain persistent in sediments and when in organisms, could accumulate in adipose tissues and further transferred up the trophic chain or web [6].

Artisanal refining is the process of obtaining stolen crude oil and locally refining them in the so-called 'bush refineries' (kpo fire) with the use of local resources and skills. The basic materials typically involves rudimentary illegal materials often metal pipes and drums welded together, in which crude oil is boiled and the resultant distillates are collected, cooled and condensed in tanks to be used locally for lighting, energy or transport [7].

Oil pollution in many intertidal creeks have left mangroves denuded of leaves and stems, leaving roots coated in a bitumen-like substance sometimes 1 cm or more thick. Mangroves are spawning areas for fish and nurseries for juvenile fish and the extensive pollution of these areas is impacting the fish life-cycle [7].

Despite community concerns about the quality of fish, the results show that the accumulation of hydrocarbons in fish is a serious health issue in the region and that the fisheries sector is suffering due to the destruction of fish habitat in the mangroves and highly persistent contamination of many of the creeks, making them unsuitable for fishing: A number of entrepreneurs had set up fish farms in or close to the creeks, their businesses have been ruined by

an ever-present layer of floating oil [7]. Most people in the Niger Delta communities are exposed to petroleum hydrocarbons in outdoor air and drinking water, sometimes at elevated concentrations, according to UNEP [7] the water table around Bolo and its environs is already being impacted by crude oil related activities; They are also exposed through dermal contacts from contaminated soil, sediments and surface water. Since average life expectancy in Nigeria is less than 50 years, it is a fair assumption that most members of the current Niger Delta communities have lived with chronic oil pollution throughout their lives.

2. MATERIALS AND METHODS

2.1 Sample Collection

Fresh Samples of fish and Shellfish were collected from the local fishermen in Jike-Ama community of Bille Kingdom, Surface water and sediment samples were collected from same river. Samples were collected in triplicates, cleaned up and stored in an ice chest before transportation to the laboratory.

2.2 Determination of Heavy Metals

The sampling was carried out according to APHA (American Public Health Association). 20 grams of soft tissue was removed using dissecting knife and samples where freeze dried and ground to homogenous mixture using a porcelain mortar and pistle. One gram of sample in triplicate was digested in HCL and HNO_3 in the ratio of 3:1.

2.3 Atomic Absorption Spectroscopy Analysis (AOAC 2000)

Trace elements in the samples were determined with Atomic absorption spectrophotometer. The digested samples were aspirated directly into the absorption spectroscopy machine.

2.4 Determination of PAHs

Two grams of samples were weighed into a clean extraction container. 10 ml of extraction solvent (Dichloromethane) were added into samples and mixed thoroughly and allowed to settle the mixture was carefully filtered into extraction bottle using filter paper fitted into buchner funnel. The filtered extract was concentrated to 2 ml and then transferred for clean up.

2.5 Clean-up/Separation

Moderately packed glass wool was placed at the bottom of chromatographic column. 2 g of activated silica slurry in 10 ml methylene chloride was prepared and placed into the chromatographic column. The column was pre eluted with 20 ml of pentane and the sample was thereafter transferred to the column.

2.6 Physiochemical Analysis [8]

Standard analytical procedures were used in determination of selected physical, chemical and biological water quality parameters of the samples. Selected physiochemical parameters such as pH, turbidity, total suspent solids (TSS), Nitrates, chlorides, dissolved oxygen, biological oxygen demand etc were carried out. The pH was measured using Estech prob. turbidity was measured using turbidometer. DO and BOD were measured using titrimetric method of Analysis.

3. RESULTS AND DISCUSSION

In the aquaticecosystem productivity and biodiversity are greatly affected by crude oil pollution of water. In Jike-Amariver crude oil contamination affects physical and chemical qualities of the water body and in turn affects aquatic life, interrupting the complex food web and thus affecting the use of the river.

Table 1 showed the mean values of physicochemical parameters. The concentration of pH for the crude oil polluted water falls below the range recommended by FEPA for drinking water. This implies that the oil polluted water is slightly acidic and could increase the solubility of heavy metals and other chemicals. Dissolved oxygen concentration was lower than FEPA limit, thus suggesting contamination of the water by huge amount of organic load which requires high level of oxygen for oxidation and breakdown. Total suspended solid (TSD) concentration was slightly above the FEPA permissible limit. Turbidity, total hydrocarbon content (THC) and biological oxygen demand (BOD) concentrations were higher than the FEPA permissible limit. Chloride, nitrate and sulphate values were below FEPA permissible limits. This findings is similar to the report Okerenta, et al. [9]. They noted that oil spill could increase the concentrations of physiochemical parameters.

Table 2 showed mean values of heavy metals detected. The result showed that mean values of the heavy metals in sediment had higher concentration when compared to shellfish, fish and surface water. The values of heavy metals concentrations in sediment showed significant difference ($p \leq 0.05$) in copper, manganese, iron and cadmium when compared toother samples. Chromium concentration in fish, copper concentrations in fish and shellfish, manganese concentration in water, zinc concentration water, cadmium concentration in fish, lead concentrations in fish and water were within FEPA and WHO permissible limits while chromium concentration in water, shellfish and sediment, copper concentration in water and sediment, manganese concentrations in fish, shellfish and sediment, cadmium concentration in water, shellfish and sediment, lead concentration in water, shellfish and sediment with iron and nickel concentrations in all samples were above FEPA and WHO permissible limits. This is similar to the report of Aderinola, et al. [10]. They investigated heavy metal contamination in surface water, sediment, fish and shellfishs of Lagos Lagoon. Investigation showed that Lagos Lagoon has been subjected to trace contaminants capable of causing damage to the aquatic ecosystem.

Table 3 showedthe values of PAHs detected in the samples. The result showed high molecular and low molecular PAHs. Benzo (b) flouranthene had highest mean concentration in sediment whiledibenz (ah) anthracene had lowest mean concentration in sediment. In shellfish benzo (a) anthracenehad highest mean concentration while flouranthrene had lowest mean concentration. Anthracene in fish had highest meanconcentrationon while pyrene had the lowest mean concentration. In water benzo (a) anthracene had highest mean concentration while lowest concentration was found in benzo(a) pyrene. PAHs in shellfish samples showed significant difference ($p \leq 0.05$) compared to PAHs in fish sample. High concentrations in fish, shellfish and sediment was due to bio accumulation over time. In this study, total PAHs concentrations in all samples were above FEPA and WHO permissible limits. A total of eight carcinogenic PAHs were detected in shellfish and fish, these carcinogenic PAHs include benzo (k) flouranthene, chrysene, benzo (a) pyrene, indeno (1,2,3-cd) pyrene, benzo (a) anthracene, benzo (b) flouranthene, benzo (g,h,i) pyrene and dibenz (a,h) anthracene. Shellfish indicated very high mean concentration of benzo (a) anthracene much more than in fish. This could be because shellfish is a bottom feeder organism. Shellfish being ashell fish accumulated heavy metals and polycyclic aromatic hydrocarbons more than the fish. This is similar to research report by Alami, et al. [11], thetinvestigated bioaccumulation of polycyclic aromatic hydrocarbons in water, sediment, Invertebrates (crayfish shrimps and crabs) and twelve species of fish in Lagos Lagoon. When compared with reports from other parts of Nigeria and other parts of the world, the study noted that sediment and invertebrates had higher concentration of PAHs than fish from Lagos lagoon. This is an indication that shell fish (shellfish) has the capacity much more than fin fish (fish) in accumulation of heavy metals in their adipose tissue. These trace metals and polycyclic aromatic hydrocarbons bio accumulate in tissue of these organisms and can effect productivity in fish and shellfish. The high contaminant concentrations also affect availability of these organisms in the Jike-Amariver as sea food availability has been greatly affected. These high concentrations of heavy metals and polycyclic aromatic hydrocarbons also cause mutation and death of organisms. Carcinogenic PAHs concentration in fish and shellfish are of health risk to residents of Jike-Ama community who consume the fish and shellfish. The mean level of heavy metals and polycyclic aromatic hydrocarbons concentrations of sediment in Jike-Amariver detected were

Table 1. Physiochemical parameters of water in mg/L

S/No	Parameter	Mean + Standard	1991 FEPA Limit
1	pH	6.09 + 0.122	6.5 – 8.5
2	Dissolved oxygen (DO)	2.40 + 0.53	5
3	Total suspended solid (TSD)	31.17 + 2.84	30
4	Turbidity	48.52 + 1.65	30
5	Biological oxygen demand (BOD)	3.76 + 0.48	2
6	Chloride	3.76 + 0.18	60
7	Nitrate	7.46 + 0.52	20
8	Sulphate	8.50 + 0.40	50

Table 2. Heavy metal concentrations (mg/kg) in fish, shellfish, water and sediment

	Cr	FEPA Limit	WHO Limit	Cu	FEPA Limit	WHO Limit	Mn	FEPA Limit	WHO Limit	Fe	FEPA Limit	WHO Limit
Fish	10.26+1.02bcf	0.15	0.15	1.62+0.43adf	3	1-3.0	0.98+0.20adf	0.5	0.5	52.40+0.74bdf	-	-
Water	0.00+0.00*adf	0.05	0.05	0.49+0.17adf	0.05	0.05	0.10+0.01adf	-	-	2.80+0.15*adf	1	1
Shellfish	11.96+1.19bcf	0.15	0.05	7.97+1.67*bcf	3	3	1.60+0.43bcf	0.05	0.01	65.69+7.39*bcf	0.3	0.5
Sediment	17.43+4.41*bde	2	1.5	15.57+3.84*bde	1	0.05	4.61+1.23*bde	0.05	0.05	104.13+7.06*bde	0.3	0.3
	Ni	FEPA Limit	WHO Limit	Zn	FEPA Limit	WHO Limit	Pb	FEPA Limit	WHO Limit	Cd	FEPA Limit	WHO Limit
Fish	0.47+0.44acf	0.5	0.6	31.11+7.41bde	75	10.75	1.59+0.58bdf	2	2	0.11+0.03adf	0.2-1.80	0.005
Water	0.40+0.17acf	0.2	0.2	0.02+0.01*adf	1.5	1.5	0.00+0.00adf	0.05	0.05	0.15+0.06adf	0.01	0.005
Shellfish	0.91+0.10acf	0.5	-	14.38+3.53bce	-	Oct-75	14.38+3.53*bcf	0.05	0.05	34.61+4.70*bcf	-	-
Sediment	25.12+14.82*bdc	0.02	0.02	41.50+8.63bde	3	3	41.50+8.6*bde	0.05	0.05	55.58+12.2*bde	0.003	0.003

Values are expressed as mean $\pm$ standard deviation; values with different superscript letter a,bc,de,f in some column are significantly different at the 0.05 level ($p \leq 0.05$)
*Differ significantly when comparing fish with water shellfish and sediment; a,b differ significantly when comparing water with fish, shellfish and sediment
c,d differ significantly when comparing shellfish with fish, water and sediment; While e,f differ significantly when comparing sediment with fish, water and periwink

Table 3. PAH concentrations (mg/kg) in fish, shellfish, water and sediment in mg/kg

S/N	PAHs	Water	Fish	Shellfish	Sediment
1	Naphthalene	2.11 0.0bdf	0.10 0.01*acf	0.13 + 0.08*acf	4.74 1.20*bde
2	Acenaphthylene	1.29 0.29acf	0.02 0.02acf	0.33 0.30acf	6.07 2.67*bde
3	Acenaphthalene	2.93 0.11bde	0.14 0.10*acf	0.44 0.40*acf	2.63 1.41bde
4	Flourene	1.75 0.11bdf	0.03 0.01*adf	1.12 0.22*bcf	2.35 0.03*bde
5	Phenanthrene	2.38 0.16bdf	0.11 0.01acf	0.67 0.51acf	7.55 1.93bde
6	Anthracene	2.06 0.98acf	0.28 0.05acf	0.94 1.31acf	6.52 2.36*bde
7	Flouranthene	3.55 0.35bdf	0.01 0.01*acf	0.01 0.01*acf	10. 45 2.65*bde
8	Pyrene	3.94 0.56bde	0.00 0.00*acf	0.49 0.45*acf	2.60 1.24bde
9	Benzo (a) anthracene	4.96 .98bcf	0.03 0.02*adf	2.84 0.68bcf	12.17 2.70*bde
10	Chrysene	2.04 0.45bdf	0.03 0.01*acf	1.80 0.27bcf	4.90 1.19*bde
11	Benzo (b) flouranthene	2.23 0.17acf	0.00 0.01acf	0.99 0.52acf	28.98 4.56bde
12	Benzo (k) flouranthene	3.43 0.49ace	0.19 0.05acf	1.05 0.76acf	5.75 3.43*bde
13	Benzo (a) pyrene	0.83 0.89acf	0.02 .03	1.65 1.66acf	7.21 2.50*bde
14	Indeno (1, 2, 3 –cd) pyrene	2.97 1.25bdf	0.14 0.12	1.76 0.31acf	7.06 2.29*bde
15	Dibenz (a h) anthraeene	2.87 0.72bdf	0.01 0.02ace	0.68 0.40*ace	0.01 0.01ace
16	Benzo (g h) perylene	2.38 0.60bdf	0.02 0.00adf	1.82 0.54*bcf	3.58 0.15*bde

Values are expressed as mean $\pm$ standard deviation, values with different superscript letter a,bc,de,f in some column are significantly different at the 0.05 level ($p \leq 0.05$)
*Differ significantly when comparing water with fish, shellfish and sediment; a,b differ significantly when comparing fish with water, shellfish and sediment
c,d differ significantly when comparing shellfish with fish, water and sediment; While e,f differ significantly when comparing sediment with fish, water and shellfish

generally high and above FEPA and WHO permissible limits. Such high concentration of polycyclic aromatic hydrocarbon and heavy metals in sediment and shellfishs native to Jike-Amariver gives evidence of crude oil contamination of the aquatic ecosystem.

4. CONCLUSION

Environmental pollution resulting from crude oil activity in the environment altering the natural quality of the aquatic ecosystem has an adverse effect on the food chain. It is therefore concluded from this research that there is evidence of heavy contaminant pollution on the test site (Jike-Amariver) with presence of high levels of hydrocarbons and heavy metals pollutants. The study reveals that physiochemical parameter of Jike-Ama has been affected by illegal crude oil activities and possible incidence of oil spillage. By virtue of this study shell fish and fin fish native to the river and creeks are likely to contain high level/concentrations of trace metals and PAHs above permissible limits as stipulated by FEPA 1991 and WHO 1984 permissible limits.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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