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The Impact of Oil Exploration Activities on Soil, Water and Shrimps of Maa-Or Gbor in Korokoro Community, Rivers State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript

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ABSTRACT

Crude oil exploration and its associated spillage pose a major threat to the environment in Nigeria and if not checked and managed properly, could lead to total annihilation of the ecosystem especially in the Niger Delta Region. Therefore, this study examines the impact of oil spill on soil, water and shrimps from Maa-or gbor. Water and soil samples were collected in the upstream, midstream and downstream, while shrimps from the river were also collected. They were digested with nitric acid. The heavy metal components were analyzed using atomic absorption spectrophotometer while physiochemical parameters were determined using different analytical methods. The result of the metals concentration in the soil showed that the values of some of the metals analyzed were within the acceptable limit of FAO/WHO except for Cu, Mn and Fe values. The result of water quality showed that pH values of the stations were in the range of 6.08-6.20 and a mean value of 6.15± 0.05 for the three stations, which is lower than the limit (6.5- 8.5) recommended for drinking water. Also the result showed that Station C had the highest conductivity value when compared with other stations, and significantly differs when compared with station B. However, the values of the electrical conductivity in all the stations were lower than that of FEPA

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acceptable limit of 250, while the mean value for the stations was 60.9± 3.42. Trace metals concentration in shrimps was below FAO/WHO acceptable limit. The result obtained for water quality index was147. This value is above the recommended standard for drinking water, thus indicates poor quality water status of Maa-or gbor and unfit for human consumption.

Keywords: Trace metals; shrimps; surface water; soil.

1. INTRODUCTION

Environmental deterioration as a result of human activities has increased in the recent years; this deterioration has adversely affected the lives of plants and animals on land, water and air and even livelihood of people. This negative effect of human activities to the environment has drawn the attention of many scientists and environmental activist. It has aroused considerable interest across the globe and especially in oil producing countries like Nigeria and in the Niger Delta region [1]. The exposure to risk has not been helped by the players in the oil industry who jostle for the 'liquid gold' thereby putting pressure on the oil producing communities and the surrounding environment. A critical factor that leads to discharge of oil to the environment are the unethical engineering operations practiced by the industries involved [2]. In some parts of the world, oil spillage from exploration activities has led to environmental degradation in the past decades; this includes contamination of water bodies, destruction of flora and farm lands [2].

There is no doubt that the Nigerian oil industry has affected the country in a variety of ways even as it fashioned a remarkable economic landscape of the country [3]. Petroleum exploration and production also have adverse effects on livelihood. Fishing and farming, which are the traditional means of livelihood of host communities have been affected due to spill into the water bodies and soil [4]. The negative impact on the socio-economic life and the environment of the immediate oil bearing communities and its inhabitants has left a balance sheet of ecological and socio-physical disaster [5,6]. These environmental consequences of oil spillage, the increasing trend in the concentration of heavy metals and changes in the physiochemical parameters were evaluated in this research.

2. MATERIALS AND METHODS

The study was carried out in Korokoro Community River which is found in the brackish water environment and situated on the upper reaches of the Kpite Community with Latitude 4^o 42' 59.99" N and Longitude 7^o 17' 60.00" E. The river is locally used for capturing aquatic lives, such as fish and shrimps. The study area experiences long wet season, which last from March to October and a short dry season, which last from November to February [7]. The major occupation of resident of the study area is farming and fishing and domestic use of the water. Soil and water samples were collected at the upstream, midstream and downstream of Korokoro River popularly known as Maa-or gbor River with well-labelled distilled plastic sampling bottles of 1 liter each. The plastic bottles used for water samples collection were cleaned to prevent contamination. Shrimp species were captured around the same location of the referenced point using cast net. The soil samples in replicates were oven dried for 24hours at the temperature of 70^{o}C, the dried samples were grind using a porcelain mortar and pestle. The powdered samples were sieve with 200um. Shrimps of 10g immediately after sampling were stored in a container and preserved in crushed ice and thereafter transferred to the laboratory and frozen -15°C until analyzed. 2.8 grams of each ground soil sample were weighed out in analytical weighing balance into different 250ml conical flask. 1ml of concentrated nitric acid (HNO_3) and 3ml of concentrated Perchloric acid were mixed together and added to each sample. Heat on a heating mantle for three (3) hours until all the fumes were given off. The beaker was allowed to cool, and the samples were then filtered. Thereafter transferred to separate 50ml volumetric flask and made up to the mark with distilled water. All the sediment samples were treated similarly. Water samples were digested with concentrated nitric acid. 10ml of nitric acid was added to 50ml of water in a 250ml conical flask. The mixture was evaporated to half its volume on a hot plate after which it was allowed to cool and then filtered.

The soil samples and shrimps were subjected to laboratory analysis for trace metals (Cd, Co, Cr, Cu, Fe, Mg, Ni, Pb and Zn) using an atomic absorption spectrophotometer (Varian AA240).

The temperature of water samples was measured in the field using a mercury filled centigrade thermometer. The samples were preserved and analyzed for other parameters in accordance with the Standard Methods [8,9].

3. RESULTS

The result of the Heavy metals analysis of soil, shrimps and physiochemical parameters of water are presented in the tables.

$\sum Wn=0.63 \sum QnWn =92.5$

Water quality index$=\sum QnWn/\sum Wn=146.9$

Water quality index was calculated according to Brown et al as cited in Pravesh et al[10]

4. DISCUSSION

Quality of water is accessed by the physical and chemical parameters of the water. Polluted water affects the productivity and biodiversity of aquatic organisms, it also affects the surrounding soil fertility and nutritional quality of plants/crops within the area.The quality of water in this research was determined and the result compared with the FEPA, 1999 acceptable limit. The result in Table 1 showed that the pH values of all the stations were in the range of 6.08-6.20 and a mean value of 6.15± 0.05, for the three stations, which is lower than the limit (6.5- 8.5) recommended for drinking water. The pH value for station A was significantly ($p<0.05$) lower than the value for other stations, however the value is similar to that reported by Nwachoko *et al* on the pH value of Jike-ama river [11]. This result suggest that the water could slightly be acidic, which in- turn could affect the solubility of heavy metals and the other chemicals [12]. Also low pH value could indicate the presence of pollutants (gases) that decreases the pH value in solution [13,14].

Conductivity which measures the ability of water to allow passage of electric current, and direct the proportional concentrations of cations and anions present in water. The result in Table 1 showed that Station C had the highest conductivity value when compared with other stations. The values of the electrical conductivity in all the stations were lower than that of the acceptable limit of 250, while the mean value for the three stations was 60.9± 3.42. Dara [15] noted that natural water has reasonable amount of dissolve salt and the concentration of the salt could vary depending on the water body, conductivity is correlated to the concentration of total dissolve solids which includes the cations and anions (Na, Ca, Mg, K and Cl). This study showed low mean concentrations of these ions. Decrease in the concentrations of these ions in a water body, will lead to low conductivity of the water body.

The concentration of DO regulates the flora and fauna of the water body. This investigation showed that the mean concentration of DO was 4.31±0.35 and less than the 5.0 limit. Biochemical oxygen demand (BOD) is a parameter that assesses the organic load in a water body. Many researchers have recorded minimal BOD values in polluted water. However, this study showed that the BOD concentration of Maa-or gbor river is within the limit. Nitrate values vary from 1.09 mg/l, 0.89 mg/l and 0.90 mg/l in station A, B and C respectively. However, mean value of nitrite from all the stations (0.96±0.09) was lower than that of 20mg/l of FEPA limit. This result of the physicochemical parameters of Maa-or gbor river is similar to the report of Onyegeme-Okerenta et al [16]. Cl, Nitrate and sulphate values for this work were lower than that reported by Nwachoko et al for Jike-ama River [11].

Trace metals are required for proper body metabolic function. However in excess, they accumulate and could be toxic because they are difficult to be degraded [17]. The result of this research study in Table 2 showed that the values of most of these metals analyzed were within the acceptable limit of FAO/WHO [18] except for Cu, Mn and Fe values. Iron whose value in all the stations were above the acceptable limit is a component of haemoglobin and facilitate the oxidation of carbohydrates, fats and proteins [19], its deficiency could lead to low haemoglobin content and anaemia [20]. Iron overload could cause idiopatic haemochomatosis [21]. Table 3 shows the concentration of trace metals analyzed in shrimps. The concentrations of the metals (Ni, Pb, Cd, Cr, Co, Cu and Mg) were lower that the acceptable limit. The result was similar to the finding Balfour et al [22]. They reported that the metal concentrations of the Penaeus shrimp specie sampled in 2009 in Trinidad were below the maximum admissible limits for human consumption according to International and Local standards. This study showed that the concentrations of these metals in shrimps were lower than the permissible level of FAO/WHO [18]. However, low metal

Table 1. Showing results for physiochemical parameters of Maa-or Gbor River

Parameters	Station A (upstream)	Station B (midstream)	Station C (downstream)	FEPA Limit
PH	6.08 ± 0.0^{bd}	6.17 ± 0.2^{ac}	6.20 ± 1.0^{ac}	6.5-8.5
Conductivity(µʃ/cm	64.7 ± 0.2^{bc}	$56.4 \pm 0.5^{*ad}$	67.6 ± 1.8^{bc}	250
TDS	34.3 ± 0.1^{bc}	$29.9 \pm 1.0^{*ad}$	32.6 ± 0.2^{bc}	
Chloride (mg/l)	23.1±0.2	21.5±0.5	20.8±1.0	60
Total Hardness(mg/l)	11.0 ± 0.5^{bc}	$18.0 \pm 0.2^{*ad}$	$14.0 \pm 0.2^{*bc}$	
Temperature (^{o}C)	27.0±0.0	26.0±0.1	27.0±1.0	
Nitrate (mg/l)	1.09±0.2	0.89±1.0	0.90±0.5	20
Phosphate (mg/l)	0.65 ± 1.1^{bc}	$0.71 \pm 1.0^{*ad}$	0.69 ± 0.0^{cb}	
Sulphate (mg/l)	4.56 ± 0.5^{bc}	2.79±0.2*ad	4.66 ± 0.2^{cb}	50
Calcuim (ppm)	1.04 ± 1.0^{bc}	$0.87 \pm 1.0*^{ad}$	0.98 ± 0.0^{cb}	0.01
Magnesium (ppm)	0.99±0.2	0.89±0.5	0.90±1.0	
Sodium (ppm)	0.78±1.7	0.86±0.2	0.95±2.0	0.01
Potassium (ppm)	1.06±1.0	1.10±0.9	0.98±1.0	
BOD (mg/l)	2.07±0.5	2.00±0.5	2.40±0.2	2.0
Dissolved oxygen(mg/l)	4.14±0.2	4.00±2.0	4.80±0.0	5.0

*Values are expressed as mean ± standard deviation at 95% confidence level and p≤0.005.Values with super script * differ significantly when comparing station A with other stations. Values with different superscript ab differ significantly when comparing station B with other stations. Values with superscript cd differ significantly when comparing station C with other stations. values without superscript showed no difference*

Table 2. Result of trace metals concentration in soil at different sections

Trace metals (mg/l)	Station A (upstream)	Station B (midstream)	Station C (downstream)	FAO/WHO accepted limit
Nickel (mg/l)	<0.01	<0.01	<0.01	0.14
Lead (mg/l)	<0.01	<0.01	<0.01	0.20
Cadmium (mg/l)	<0.01	<0.01	<0.01	0.10
Chromium (mg/l)	<0.01	<0.01	<0.01	0.1
Cobalt (mg/l)	<0.01	<0.01	<0.01	2.00
Iron ()mg/l)	1.073±0.0	1.028±1.0	0.987±0.0	0.88
Zinc (mg/l)	1.054±0.8	1.011±0.5	1.006±0.5	99.40
Copper (mg/l)	1.006 ± 0.0^{ad}	0.981 ± 0.4^{ad}	$0.452 \pm 1.0^{*bc}$	0.05
Magnesium (ppm)	0.961 ± 0.0^{bd}	$0.639 \pm 0.5^{*ad}$	$0.391 \pm 1.0^{*bc}$	0.50

*Values are expressed as mean ± standard deviation at 95% confidence level and p≤0.005.Values with super script * differ significantly when comparing station A with other stations. Values with different superscript ab differ significantly when comparing station B with other stations. Values with superscript cd differ significantly when comparing station C with other stations. values without superscript showed no difference*

Table 3. Trace metals concentration in shrimps

Trace metals	Values	FAO/WHO acceptable limit (2010)
Nickel (mg/l)	<0.01	0.14
Lead (mg/l)	<0.01	0.20
Cadmium (mg/l)	<0.01	0.10
Chromium (mg/l)	<0.01	0.1
Cobalt (mg/l)	<0.01	2.00
Iron (mg/l)	0.186±0.0	0.88
Zinc (mg/l)	0.093±0.0	99.40
Copper (mg/l)	<0.01	0.05
Magnesium (ppm)	<0.01	0.50

Table 4. Water quality index concentration of Maa-or Gbor River

Parameters	Observed Value(Vn)	WHO Std(Sn)	Wn (Reciprocal Sn)	Qn	QnWn
PH	6.15	*7*	*0.142*	*85.0*	*12.07*
Conductivity(μʃ/cm)	60.9	*500*	*0.002*	*72.18*	*0.144*
TDS	32.3	*500*	*0.002*	*6.46*	*0.012*
Chloride (mg/l)	21.8	*250*	*0.004*	*10.72*	*0.042*
Total Hardness(mg/l)	14.3	*75*	*0.013*	*32.06*	*0.417*
Temperature (C)	26.7	*25*	*0.040*	*206.4*	*8.256*
Nitrate (mg/l)	0.96	*50*	*0.020*	*1.92*	*0.038*
Phosphate (mg/l)	0.68	*10*	*0.100*	*8.80*	*0.88*
Sulphate (mg/l)	4.00	*250*	*0.004*	*4.60*	*0.018*
Calcuim (ppm)	0.96	*75*	*0.013*	*3.28*	*0.04*
Magnesium (ppm)	0.93	*50*	*0.020*	*5.86*	*0.117*
Sodium (ppm)	0.86	*200*	*0.005*	*7.43*	*0.037*
Potassium (ppm)	1.05	*200*	*0.005*	*102.5*	*0.467*
BOD (mg/l)	2.15	*4.00*	*0.250*	*309.73*	*77.432*
Dissolved oxygen (mg/l)	4.31	*88*	*0.011*	*17.0*	*0.018*

accumulation in shrimps in Maa-or gbor river in Korokoro may be attributed to the fact that salt water organism is more resistant to poisoning [23]. Also Babatunde et al [4] noted that the rate of bioaccumulation of heavy metals in aquatic organisms depends on the ability of the organisms to digest the metals, the concentration of such metal in the river, the feeding habits of the organism, age and lipid content in the tissue of the organism. The heavy metals concentration in shrimps was below the FAO/WHO acceptable limit.

The water quality index (WQI) was established from the various important physical and chemical parameters. The values of the various parameters for the calculation of WQI are presented in Table 4. The water quality index (WQI) for Maa-or Gbor River was 146.9. Bhargava [24] classification of water quality noted that WQI values between100 - 200 is poor water and unsafe for drinking. This water quality rating study clearly showed that, the status of the Maa-or Gbor River is unsuitable for human consumption as the index is above the safe value of drinking water.

5. CONCLUSION

The study assesses the status of some trace metal in soil and shrimp. The metals concentration was low in shrimps. The study showed that the water quality was poor and not suitable for drinking.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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