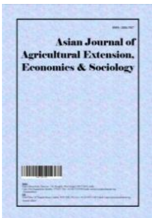

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Oil Pollution, Water Quality and Livelihood Sources in the Kolo Creek Area, Bayelsa State Nigeria

L. Ushie[1], Chukwu-Okeah G. O.[1*] and Imiete G.[1]

[1]*Department of Geography and Environmental Management, University of Port Harcourt, Nigeria.*

Authors' contributions

This work was carried out in collaboration among all authors. Author LU initiated and designed the study and did the first draft of the manuscript. Author COGO performed the statistical analysis, wrote the discussions and analysis of the study. Author IG did the literature of the study and also proof read as well as edited the work. The last draft was a contribution by all authors.

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ABSTRACT

Aim: This study was conducted in Kolo creek, Ogbia, Bayelsa state to ascertain the effects of oil pollution on water quality and its attending consequences on the people's livelihood sources.
Study Design: The study adopted the quasi experimental and cross sectional research design.
Methodology: A total of 587 respondents were used as the sample for the study, where 587 copies of the questionnaire were designed, distributed and returned filled and used for analysis. Water quality analysis was done for consumable water quality and Aquaculture.
Results: The study revealed that oil pollution affects water quality in the area, given rise to a decline in food production and low fish catch amongst others. It also revealed that total heterotrophic bacteria level in the communities exceeds the WHO permissible limit for water quality and hence the water is not fit for consumption. All the parameters tested for Aquaculture based analysis were found to be within the WHO permissible limit for aquaculture except for TSS and DO for Otuasega community. Statistically, the study revealed that there is a statistically significant difference in the quality of water in the sampled communities and the World Health

*Corresponding author: E-mail: giftchukwuokeah@yahoo.com;

Organisation (WHO) standard for consumable water quality. The study also revealed that oil exploitation affects livelihood sources of Ogbia people.
Recommendation: The study recommends that the people's livelihood sources should be revitalized, through full remediation and support to the locals to bring to end agitations and illegal activities which hamper National economy and growth and development.

Keywords: Oil pollution; water quality; livelihood sources; water.

1. INTRODUCTION

Oil is one of the world's most important forms of energy which is essential to economic development and human progress. Currently, Nigeria earns over 95 percent of its foreign exchange from the sale of oil on the global market. The history of an oil-producing nation can never be complete without reference to the attendant impact of oil exploration.

Oil brings wealth and socio-economic development to oil-producing states and regions, albeit with some fundamental challenges. The Niger Delta is the location of massive oil and gas deposits. Oil has been extracted in the Niger Delta by the multinational oil companies and some Nigerian companies since 1958.

The Niger delta has been blessed with physical and human resources, including the bulk of Nigeria's oil and gas deposits, good agricultural land, extensive forest, excellent fishes, as well as with a well-developed industrial base, a strong banking system, a larger force and a vibrant private sector [1]. Thus, the oil sector is the most attractive sector of the Nigerian economy today. But in spite of the huge funds accruing from the oil and gas sector of the Nigerian economy, the Nigerian state has not been able to meet up with the expectations of the citizenry. It is the failure of various governments in power to fulfill the socio-economic aspirations of the people that have culminated in the crises and violent disputes between different ethnic nationalities in the country. The region's tremendous potential for economic growth and sustainable development remains unfulfilled and its future is threatened by deteriorating economic conditions (World Bank, 1995).

Oil spill affects the environment negatively and has been identified as the most damaging. Documented evidence of petroleum spillage suggest that it leads to the oiling and tarring of beaches, death of sea birds and the destruction of intertidal marine communities The economy is also affected because of the cost of cleanup exercise, loss of the revenue that would have been generated by the spilled oil and also death of both plant and animals in the area [2].

In water, oil on the water surface could prevent natural aeration and lead to the death of trapped marine organisms. In some cases, fish may ingest the spilled oil or other food materials impregnated with oil and as such become inedible and unpalatable. Oil spill on the land could lead to retardation of vegetation growth for some time and in extreme cases, to the destruction of vegetation. This, in turn, has fostered hostility towards the oil companies, especially at times when neither the government nor the oil companies act quickly to accommodate or alleviate the effect of the degradation of the environment (Aghalino, 2000).

A typical example is a case of mangrove vegetation in Ogbia which supports the people's livelihood source, but this has been ravaged by the cruel hands of oil exploitation activities. Presently, most youths and women in their productive age have been rendered jobless with their livelihood supports been altered. A major aspect of the effects of oil exploitation and pollution in Ogbia is the prevalence and occurrence of ailments that have surfaced in the area in recent times which were unknown to the people. Studies have also shown that there is a relationship between exposure to oil contamination and the emergence of health problems [3].

Arising from the above, the fundamental questions which this study intends to address are;

1. To what extent has oil exploitation affected water quality in the area?
2. What is the state of the people's livelihood sources?
3. Have there been measures put in place by Government and corporate organizations to mitigate the effects of oil exploitation?

Providing answers to these questions is the focus of this study.

2. REVIEW OF RELATED LITERATURE

Exploitation of crude oil resources has led to oil spillages on land and water resources (lakes, rivers and oceans). Contamination of land and water resources have impacted the quality, by making rivers that are usually the natural sources of domestic water use, wholesome for community usage. Flora and fauna, particularly fishes are destroyed. Drinking water sources are also scarce.

Water quality as defined by Agarwal [4] is the term used to describe water conformance to required standards. Water quality as defined by Kiely [5] is the measure of the physicochemical conditions and the state of the flora and fauna. There are a set of requirement regarding the quality of water to be used (Usually related to concentrations of various chemical parameters; suspended material and bacterial content). If water fulfils these requirements or standards, it is said to be of good quality for the particular consumer process. If it does not, it is deemed unacceptable and of poor quality. Water quality is, therefore, a term that implies some value judgment of the water with respect to a particular use. A single definition of water quality is therefore difficult due to the complexity of factors influencing it and the range of functions, water resources are required to fulfil.

In a study carried out by Magini [6], an Investigation of the effects of oil Spill on water quality in Emadadja was carried out by identifying a spill affected area (Emadadja) as the study area, while geographically similar but unaffected area (Egini) served as control. Water samples were collected from both surface (streams) and underground (hand- dug wells) sources. Some physicochemical properties that reflect water quality such as pH value, total hydrocarbon, dissolved oxygen, turbidity, exchangeable cations (Ca^+,Mg^{2+}, Na^+, K^+) anions (NO^{3-}, SO_4^{2-}, PO_4^{2-}, Cl^-) Heavy metals (Fe, Cd, Pb, Cr),Biological Oxygen demand (BOD),Dissolved Oxygen(DO),Chemical Oxygen demand (COD), Dissolved Carbon dioxide (CO_2) was ascertained with the use of approved techniques and findings from the sample locations compared. A significant increase as observed in temperature average of (29.38 in surface, 27.62 in the underground) decrease in pH average of (3.27 in surface samples, and 3.58 in underground), low dissolved oxygen of (1.63 mg/l in surface samples, 2.50 mg/l in underground). increased BOD of (14.69 mg/l in surface, 12.46 mg/l underground), increased CO_2 (17.86 mg/l in surface and 15.33 mg/l in underground) and increased THC content of (1.86 in surface and 1.57 in underground samples) of the oil spill affected study area of Emadadja when compared with the WHO standards and the non affected control area of Egini. Low nitrate values were observed at the study area. This may be due to utilization by the species in absence of sufficient oxygen. The presence of heavy metals and pollutants were lowest in the underground water samples than the surface water samples. Lead showed typical build upon surface water samples of the study area. Test of the null hypothesis using ANOVA showed that there was a notable difference in water quality of the study and control areas for both the surface and groundwater samples. Analysis of questionnaire on causes of oil spill revealed that old/ rusted pipes contribute 59%, sabotage, 18%, pressure on pipe, 21% and superstitious belief 2%.The results indicate that oil spill has adversely affected the water quality and aquatic live in Emadadja.

In another study carried out by Okoli [7] concerning "rural household's perception of the effect of crude oil production activities in Ogba/Egbema/Ndoni local government area of Rivers state, Nigeria". The interest of the study was to identify the view of rural dwellers on the effect on their environment, health and socio-economic lives. The study found out that oil production activities and processes have over the years affected the people. This has led to compelling people to combine farming and other activities for their overall survival. Conclusively, the farmers in the study revealed that the effects of oil production activities significantly outweigh the gain derived from the processes.

The study done by Mogborukor [8] on "Oil exploration and exploitation impact on Water Quality and Vegetal resources in a Nigerian Rain forest ecosystem", the study revealed that as a result of distortions in the environment due to oil spillages and contamination of agricultural lands, the qualities of surface and well waters, bottom sediments, river banks soils and some species of plants in areas of oil exploitation and exploration needed to be ascertained. Hence, Samples of well and surface water, bottom sediments and riverbank soils were collected during the month of June and September 2013. These samples were sent to the laboratory for physio-chemical analysis. The result shows that the values of some samples in some locations were slightly higher than the WHO permissible level for portable water, the same was found in chemical parameters, indicating some level of pollution due to oil spillage. Riverbanks soil values were slightly higher than those of the bottom sediments. Of the twenty-four species of plants evaluated, twenty were impacted slightly due to absorption of toxic nutrients from spilled oil and four non-impacted by oil pollution.

3. METHODOLOGY

This study adopted the use of both the experimental and the survey research designs, data for the study were sourced from both primary and secondary data sources, basically field measurements and the questionnaire. A total of 578 persons were sampled for the study from the three communities of interest which are; Imiringi, Elebele and Otuasega communities. Water samples were collected for analysis based on consumption. Samples for physico-chemical analysis were placed in a 2-litre plastic container which shall be thoroughly rinsed three times with the water sample to be analyzed and sealed and labeled appropriately. Samples for the heavy metal analyses were placed in 150ml plastic container and concentrated nitric acid (HNO3) added to adjust the pH to 2. Biochemical oxygen demand (BOD) samples shall be collected in 250ml brown reagent bottles, sealed to exclude air bubbles while the dissolved oxygen (DO) samples shall be fixed immediately with Winkler's I and II reagents. All samples were labeled according to sample locations and purpose, preserved in a cool box and transported to the laboratory for analyses. The parameters of interest here are; THB, total coliform, Total hardness, zinc, lead, BOD, E coli, TPH.

Standard field methods were used in the sample collection at each sample location as recommended by DPR [9]. To ensure the integrity of some unstable physicochemical parameters, in-situ measurements of pH and total dissolved solids (TDS) were carried out in the field using water quality checker Horiba U-10 and water probes. Water samples collected were stored in ice-packed coolers and preserved in accordance with Part VII Section D of EGASPIN [9]. All water samples for heavy metals were preserved by the addition of concentrated HN03.

The parameters of interest in the study are THB, total coliform, total fungi, Zinc, lead, BOD, E coli, TDS, pH and Total petroleum hydrocarbon.

Two hypothesis was put forth to guide the study, which are;

1. Water quality in Imiringi, Elebele and Otuasega differs significantly with the World health Organization standard for water quality
2. Oil exploitation has a negative impact on livelihood sources of Ogbia people.

Chi-Square analytical tools were used to test the stated study hypotheses.

4. RESULTS AND DISCUSSION

4.1 Physico-chemical and Microbiological Analysis of Consumable Water Quality Parameters

The parameters tested are THB, total coliform, Total fungi, BOD, Zinc, Lead, E coli, TDS, Conductivity, pH and Total petroleum hydrocarbon.

The results of the water quality laboratory analysis of the various water samples collected from the sampled communities in the area are presented in the table below.

The Total heterotrophic bacteria levels in borehole water in the area were between 4000 cfu/ml and 34000 cfu/ml. The highest value was recorded in Elebele with a THB value of 34,000 indicating a high amount of bacteria count in water, this was followed by Otuasega and Imiringi having the least amount of THB.

Table 1. Result of physico-chemical/microbiological analysis

Communities	THB	TF	TC	BOD Mg/l	Zn	Pb	E. coli	TDS	Cond.	pH	TPH
Imiringi	4000	130	14	0.8	0.204	<0.001	Nil	70.0	128	6.53	229.30
Elebele	34000	900	17	2.4	0.222	<0.001	17	180	111	6.59	132.55
Otuasega	4400	390	14	0.8	0.221	<0.001	Nil	180	126	6.73	178.77

Source: Researchers field work (2015)

Total fungi levels in borehole water in the area ranged between 130 and 900, with Elebele having the highest amount of 900 cfu/ml and Imiringi having the lowest value of 130 cfu/ml, the result shows that total fungi value differs amongst the different sampled communities.

Total Coliform level in borehole in water in the area range between 14 and 17, the highest value is recorded in Elebele with a value of 17, indicating high amount of coliform in water. Otuasega and Imiringi have 14 each.

The biological oxygen demand levels in borehole water in the area were between 0.8 mg/l and 2.4 mg/l. The highest value was recorded in Elebele with a BOD value of 2.4 mg/l indicating high amount of BOD in water, Otuasega and Imiringi both have the same BOD value of 0.8 mg/l.

Zinc levels in borehole water in the area ranged between 0.204 and 0.222, with Elebele having the highest amount of 0.222 and Imiringi having the lowest value of 0.204, the result shows that Zinc level value differs amongst the different sampled communities.

Lead level in borehole water in the area is <0.001 in all the sampled communities, this shows that lead level in all the sampled communities are the same. *E. coli* level in bore hole in water, it is shown that the presence of *E. coli* is only noticed in Elebele with a value of 17 *E. coli* counts.

Total dissolved solids level in water in the area ranged between 70.0 and 180. The highest value was recorded in Elebele and Otuasega with a TDS value of 180 mg/l indicating high amount of TDS in water, Imiringi had the least amount of TDS with a value of 70,0 mg/l.

The Conductivity level of water in the area ranges between 111 and 128, with Imiringi having the highest amount of electrical conductivity in water with a value of 128, while the water from Elebele has a conductivity value of 111 and Otuasega 126.

The pH level of water from the different sample communities in the area ranges between 6.53 and 6.73 with Otuasega having the highest pH value of 6.73, while Imiringi has a pH value of 6.53 and Elebele a pH value of 6.59. Total petroleum hydrocarbon level in water from the different communities in the area ranges between 132.55 and 229.30, with Imiringi having the highest amount of total petroleum hydrocarbon in water with a value of 229.30, while water from Otuasega has a TPH value of 178.77 and Elebele a TPH value of 132.5.

4.2 Water Quality Parameters and World Health Organization (WHO) Standards for Water Quality

This section presents the results of water quality parameters for consumable water and compares it with the World Health Organisation Standard (WHO) for water quality.

The Table 2 reveals that total heterotrophic bacteria in the sampled communities exceeds the WHO permissible limit for water quality and hence renders the water not fit for consumption. In the case total fungi, the result of the analysis revealed that total fungi in all the sampled communities exceeds the WHO permissible limit for water quality and hence renders the water not fit for consumption.

Total coliform as revealed in the sampled communities are within the WHO permissible limit for water quality and this, therefore, implies that the water is suited for consumption. The biological oxygen demand level in water from the sampled communities in the area is higher than the acceptable WHO permissible limit, this, therefore, implies that since BOD level in the water is not in accordance with WHO standard, the water is polluted and therefore may have health implications on persons who drink this water.

Zinc level in the water in the sampled communities reveal that there are all within the WHO permissible limit for water quality, in the case of lead, it is revealed that the amount of lead in the water sampled from the communities also falls within WHO permissible limit and as such implies that the water quality is good for consumption.

The table also revealed that E.coli, total dissolved solids, conductivity, pH and Total petroleum Hydrocarbon levels in the sampled communities are within WHO permissible limit, although total petroleum hydrocarbon limit was not specified but using DPR standards it shows it's above acceptable standard.

Table 2. Water quality parameters and World Health Organization (WHO) standard for water quality

Parameters	Imiringi	Elebele	Otuasega	WHO
THB	1000	71,000	4000	100
TF	440	900	390	0
TC	0	27	19	100
BOD	1.6	3.42	2.91	0
Zn	0.041	0.051	0.044	3
Pb	0.001	0.001	0.001	0.01
E.coli	Nil	Nil	Nil	Nil
TDS	110	100	180	500
Conductivity	128	263	187	1000
pH	8.20	7.90	8.15	6.5- 8.5
TPH	156.3	131.0	114.6	Not specified

Source Researcher field work (2015)

4.3 Perception of the Impact of oil Pollution on Sources of Livelihood

This section reveals the people's perception of the impact of oil pollution on their environment and it's attending implications on their sources of livelihood.

From Table 3, knowledge of the effect of oil exploitation on the environment is agreed to by 54.3% of the respondents, while 45.7% of them stated that they do not have knowledge of the effect of oil exploitation on the environment.

Table 4 reveals the people's position towards the trend of oil exploitation and environmental degradation in the area, 21.6% of the respondents stated that they were comfortable with the trend, 63.2% stated that they were not comfortable and 15.2% had no contribution to this, implying that they had no idea of the issue.

Table 5 above reveals the impact of oil exploitation activities in the area, it showed that 19.1% of respondents stated that it has brought about pollution of the environment, 49.9% stated that it has caused a reduction in their income, 16.5% of the respondents were of the view that it has brought about a situation of no job opportunity and 14.5% of the respondents that it is associated with low farm output.

Table 3. Knowledge of the effect of oil exploitation on the environment

Response	Frequency	Percentage %
Yes	319	54.3
No	268	45.7
Total	587	100

Source: Researchers field work (2015)

Table 4. Position towards the trend of oil exploitation and environmental degradation

Response	Frequency	Percentage %
Comfortable	127	21.6
Not comfortable	371	63.2
Neutral	89	15.2
Total	587	100

Source: Researchers field work (2015)

Table 5. Impact of oil exploitation activities

Response	Frequency	Percentage %
Pollution	112	19.1
Low income	293	49.9
No job opportunity	97	16.5
Low farm out put	85	14.5
Total	587	100

Source: Researchers field work (2015)

Table 6. Effect of oil exploitation on soil and water

Response	Frequency	Percentage %
Decline in food output	135	22.9
Low fish catch	219	37.3
Presence of water borne disease	102	17.4
Unfavorable environment	131	22.3
Total	587	100

Source: Researchers field work (2015)

Table 7. Crude oil exploitation effect on the community

Response	Frequency	Percentage %
Species extinction	42	7.2
Increased surface erosion	78	13.3
Ecosystem Disruption	196	33.4
Loss of aquatic lives	271	46.2
Total	587	100

Source: Researchers field work (2015)

Table 8. Effect on oil exploitation on the socio economic life of the people

Response	Frequency	Percentage %
Yes	427	72.7
No	160	27.3
Total	**587**	**100**

Source: Researchers field work (2015)

Table 6 revealed the effect of oil exploitation on soil and water in the area, it showed that 22.9% of the respondents stated that it has brought about a decline in food production, 33.7% of the respondents stated that it is the cause of low fish catch, 17.4% are of the view that it is responsible for the presence of water borne diseases in the area and 22.3% stated that it has brought unfriendly environment in the area.

Table 7, reveals the effect of crude oil exploitation on the community, 7.2% of the respondents agreed that it has brought about species extinction from the area, 13.3% stated that it has brought about increased surface erosion in the area, 33.4% of the respondents stated that it has led to ecosystem disruption and 46.2% of the respondents stated that it has caused the loss of aquatic lives.

Table 8, reveals the peoples view of the effect of oil exploitation on the socio economic life of the people of the area. 72.7% of the respondents agreed that oil exploitation has an effect on the socio economic life of the people and 27.3% of the respondents stated that oil exploitation does not affect their socio economic life.

4.4 Hypothesis Testing

In this section effort was made to validate the hypothesis of the present study that is to test for rejection or acceptance of the stated hypotheses.

1. Water quality in Imiringi, Elebele and Otuasega differs significantly with the World health Organization standard limit for water quality
2. Oil exploitation has a negative impact on the sources of livelihood of Ogbia people.

4.4.1 Hypothesis one

This was tested using the Chi-Square statistical tool.

Table 9. Chi-Square analysis for difference in consumable water quality between Imiringi and WHO standard for water quality

Observed	Expected	O-E	$(O-E)^2$	$\frac{(O-E)^2}{E}$
1000	100	900	810000	8100
440	0	440	193600	193600
0	100	-100	10000	100
1.6	0	1.6	2.56	2.56
0.041	3	-2.959	8.7557	2.92
0.001	0.01	-0.009	0.000081	0.0081
0	0	0	0	0
110	500	-390	152100	304.2
128	1000	-872	760384	760.384
8.20	8.5	-0.30	0.09	0.0106
156.3	0	156.3	24429.7	24429.7
				X^2 = 227299.8

df = (11-1) (2-1)
(11-1) (2-1)
10x1 =10
Therefore we conclude that X^2 calculated value is 227,299.8, while the critical value at 10 degree of freedom and 95% significant level is 18.31. The calculated X^2 value 227,299.8 is greater than the critical value of 18.31, this therefore implies that we reject the null hypothesis which states that there is no statistically significant difference in the quality of water in Imiringi and that of the World Health Organisation (WHO) standard and accept the alternate hypothesis which states that there is statistically significant difference in the quality of water in Imiringi and that of the World Health Organisation (WHO) standard

Table 10. Chi-Square analysis for the difference in consumable water quality between Elebele and WHO standard for water quality

Observed	Expected	O-E	$(O-E)^2$	$\frac{(O-E)^2}{E}$
71,000	100	70,900	50,268,100	502,681
900	0	900	810,000	810,000
27	100	-73	5329	53.29
3.42	0	3.42	11.696	11.696
0.051	3	-2.949	8.696601	2.89887
0.001	0.01	0.009	0.000081	0.0081
0	0	0	0	0
100	500	-400	160000	320
263	1000	-737	543169	543.169
7.90	8.5	-0.6	0.36	0.00424
131.0	0	131.0	17161	17161
				X^2 = 1,330, 773

df = (11-1) (2-1)
(11-1) (2-1)
10x1 =10
Therefore we conclude that X^2 calculated value is 1,330, 773, while the critical value at 10 degree of freedom and 95% significant level is 18.31. The calculated X^2 value 1,330, 773,is greater than the critical value of 18.31 we therefore reject the null hypothesis which states that there is no statistically significant difference in the quality of water in Elebele and that of the World Health Organisation (WHO) standard and accept the alternative hypothesis which states that there is statistically significant difference in the quality of water in Elebele and that of the World Health Organisation (WHO) standard

Table 11. Chi-Square analysis for the difference in Consumable water quality between Otuasega and WHO standard for water quality

Observed	Expected	O-E	$(O-E)^2$	$\frac{(O-E)^2}{E}$
4000	100	3900	15,210,000	152100
390	0	390	152100	152100
19	100	-81	6561	65.61
2.91	0	2.91	8.4681	8.4681
0.044	3	-2.956	8.7379	2.9126
0.001	0.01	0.009	0.000081	0.0081
0	0	0	0	0
180	500	-320	102400	204.8
187	1000	-813	660969	660.969
8.15	8.5	-0.35	0.1225	0.0144
114.6	0	114.6	13133.16	13133.16
				X^2 = 318275.9

df = (11-1) (2-1)
(11-1) (2-1)
10x1 =10
Therefore we conclude that X^2 calculated value is 318,275.9 while the critical value at 10 degree of freedom and 95% significant level is 18.31.
The calculated X^2 value 318,275.9is greater than the critical value of 18.31 we therefore reject the null hypothesis which states that there is no statistically significant difference in the quality of water in Otuasega and that of the World Health Organisation (WHO) standard and accept the alternate hypothesis which states that there is statistically significant difference in the quality of water in Otuasega and that of the World Health Organisation (WHO) standard

Table 12. Analysis of the impact of oil exploitation on the sources of livelihood of Ogbia people

Response	Men	Women	Total	%
Yes	231	196	427	73.9
No	64	87	151	26.1
Total	295	283	578	100

4.4.2 Hypothesis two

This was tested using descriptive statistics as shown on Table 12.

Table 12 shows the response of the people to the socio economic impact of oil exploitation in Ogbia. It revealed that a total of 427 respondents representing 73.9% of which 196 respondents are women and 231 respondents are men agreed that oil exploitation activity in the area affects the sources of livelihood of the people; while 151 respondents representing 26.1% said no. This therefore validates the fourth hypothesis of the study which states that there is a statistically significant impact of oil exploitation on livelihood sources of Ogbia people and invalidates the null hypothesis of no statistically significant impact on the livelihood of the people.

5. CONCLUSIONS AND RECOMMENDATION

Pollutant concentration on a global scale have been identified as a major cause of disease spread especially in developing nations and therefore calls for a review of previous ways of handling environment-related issues. This has necessitated the need for this study which concludes that to a great extent, there is no significant effect of oil exploitation on consumable water as well as on water quality for aquaculture, notwithstanding that the number of suspended solids in the examined rivers are extremely high and has its own negative implications. The study also revealed that exploitation of oil in the area over time has a significant effect on the socio-economic life of the people as it has destroyed the people's livelihood sources hence increasing their vulnerability to the challenges of food scarcity. The study recommends that the people's livelihood sources should be revitalized to bring to end agitations and illegal activities which hamper National economy and growth.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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