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Research article

Sustained impact of the activities of local crude oil refiners on their host communities in Nigeria

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ABSTRACT

The local refining of crude oil has become a lucrative but disturbing business in the Niger Delta region of Nigeria. Deep inside the forest of the Niger Delta camps are built and used for the local refining of crude oil. The economic benefits this brings to the refiners are clear, however the host communities are severely hit by the activities of the 'local crude oil refiners'. Farmlands have been destroyed and fishing settlements evacuated as a result of pollution of the rivers and estuaries, with loss of lives and properties. This research investigates the impact of the activities of the local refiners on their host communities' farmlands, rivers and estuaries. A quantitative research method was adopted in this study through the administration of questionnaires to local stakeholders (chiefs, the youth, farmers, traders, fishermen/fisherwomen and residents of affected communities). Quantitative data was collected from three communities in the Niger Delta with local refineries and the data was analysed using descriptive and inferential (Chi Square and Correlation) methods. The study demonstrates the high impact of the activities of the refiners on farmlands and fishing areas of the host communities and makes recommendations to all stakeholders in the upstream and downstream sectors of the petroleum industry. In addition, recommendations are made to the Nigerian government, on ways to address the impact of local refining on host communities.

1. Introduction

The exploration for, and exploitation of, crude oil has been Nigeria's mainstay for over five decades (Sam and Zabbey, 2018), accounting for over 90% of foreign exchange earnings to the economy (Tukur Umar and Hajj Othman, 2017). Nigeria is the sixth largest exporter of crude oil (Albert et al., 2018), with the Niger Delta accounting for over 37.4 billion barrels of crude oil reserve in addition to hosting one of the most bio-diverse ecosystems found globally (Atubi, 2015; Chikere and Fenibo, 2018; Sam and Zabbey, 2018). The Niger Delta region of Nigeria is the site of the third largest mangrove forest in the world with extensive fresh and saltwater swamps and a rich variety of plant and animal species (Anejionu et al., 2015; Kuenzer et al., 2014).

However the Niger Delta region of Nigeria is one of the most environmentally impacted regions of the world caused by crude oil as a result of poor regulations (Sam and Zabbey, 2018; Tukur Umar and Hajj Othman, 2017) coupled with the activities of non-standard crude oil refiners (Gundlach, 2018) who are major agents of pollution (Dominic, 2016). The release of petroleum products into land (onshore) and marine (offshore) environments is damaging to the ecosystem and toxic to marine life (Eneh, 2011; Lopes et al., 2009; Ojewumi et al., 2018).

Since the discovery of crude oil in Nigeria, 13 million tonnes have reportedly been spilled into the environment of the Niger Delta causing considerable contamination of the land and coastal environment (Sam and Zabbey, 2018). This type of pollution occurs through numerous sources that are either anthropogenic or natural (Aislabie et al., 2004; Brakstad et al., 2017; Mahjoubi et al., 2018; Marinescu et al., 2011). Spillage as a result of pipeline ruptures, accidental leakages and incorrect handling from production sites (Ojewumi et al., 2018) contaminates the soil and water in the immediate environment (Ojewumi et al., 2017). Additionally, waste from nonstandard refining sites is released without treatment into adjoining rivers causing considerable damage to aquatic life and surrounding vegetation (Asimiea and Omokhua, 2013). In the study carried out by Kuenzer et al. (2014), they declared that the greatest threat to the Niger Delta and its inhabitants is pollution by hydrocarbons. In addition, Yabrade and Tanee (2016) reported that local refining of crude oil in Nigeria's Niger Delta has contributed to an increase in the toxicity level of the soil, which has led to alteration of its chemical

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properties and if not stopped, will have potentially devastating effects on Saltwater Wetland Ecosystems.

In order to "conserve and sustainably use the oceans, seas and marine resources" and to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forest" as stipulated in goals 14 and 15 of the United Nations Sustainable Development Goals (ICSU, 2015; Hasan et al., 2019), a good understanding of the threat to the environment and possible mitigating solutions amongst the local community is the first priority. In this research, the aim was to determine the impact of the activities of local crude oil refiners in the Niger Delta on their host communities, and how it could best be mitigated. The Research question that this study sought to answer was: What is the environmental impact of non-standard crude oil refineries on the, farmlands, crop yields, fishing areas, fishing yields, water supply?

The rest of this research paper is divided into four sections comprising of: (2) literature review (3) study methodology; (4) results and discussion (5) conclusion.

2. Literature review

The pollution of aquatic ecosystems with crude oil and other petroleum products suppresses the major functions of the fauna and flora and makes the water hazardous for drinking (Barenboim et al., 2015). It has also led to the destruction of fish habitats in the mangroves of the Niger Delta and high levels of contamination of the swamps and rivers making them unsuitable for fishing (Moses and Tami, 2014). The pollution of the soil by hydrocarbon components from local crude oil refineries, such as polycyclic aromatic hydrocarbon (PAH) has resulted in reduced agricultural productivity through the loss of soil quality, leaching and erosion (Nwaejije et al., 2017). For example, Edoho (2008) reported that hydrocarbon spills and pollution have damaging effect on farmlands, food security, marine life and health.

Basic attributes of soil quality include biological, chemical and physical properties, which depend on the landforms, climate and most importantly, humans. The actions and decisions of humans in the long run determine whether a system of agricultural production is sustainable in each soil type (Arshad and Coen, 1992). Furthermore, it is important to highlight that maintaining the functions essential to soil quality, such as its chemical and physical properties, is vital to sustainable soil and forest management (Slesak et al., 2017). Soil quality can be articulated in terms of its ability to accept, recycle and store water, energy and minerals to produce crops (Arshad and Coen, 1992). As reported by Agbogidi et al. (2007), the contamination of soil by petroleum hydrocarbons has a very significant effect in reducing some of the mineral elements in the soil.

Inoni et al. (2006) also examined the degradation of the environment of the Niger Delta from hydrocarbon pollution in their research, surveying 262 crop farmers drawn from ten communities and five local government areas in the agricultural zone of Delta state, Nigeria. Results obtained highlighted the damaging impact of hydrocarbon pollution on crop production. Elum et al. (2016) also observed that the income generated by farmers in hydrocarbon contaminated areas is significantly lower than that of non-contaminated areas.

Hydrocarbon spillages reduce land productivity, crop yield and the annual income of farmers. A 10% rise in hydrocarbon spillage can reduce crop yields by 1.3%, whilst the income of farmers would also be reduced by 5% (Odjuvwuederhie Emmanuel et al., 2006). The volatile fractions of petroleum hydrocarbons have an influential role in reducing germination and delaying seed emergence (Adam and Duncan, 2002). Lastly, Yabrade and Tanee (2016), in their research to determine the effect of local crude oil refining on soil quality, reported that the Total Hydrocarbon Content (THC) in surveyed sites had very high toxicity levels leading to changes in the chemical properties of the soil.

Crude oil spills into the soil from local crude oil refineries interfere with healthy microbial interaction, which pose high risks to human health owing to their toxic, mutagenic and carcinogenic properties (Chikere and Fenibo, 2018). Figure 1 depicts a farmland contaminated by crude oil spill from a local refinery in the Niger Delta Region of Nigeria.

Figure 1. Farmland contaminated by crude oil from a Local refinery in the Niger Delta (Author photograph).

The quality of the water in an aquatic environment is important for the survival of the flora and fauna and the overall health of the environment (Emuedo et al., 2014; Hunt et al., 2018). Pollution has a significant impact on drinking water from lakes, streams and rivers all over the world (Agoha, 2019). The local crude oil refining process produces far more waste than the standard refining process (Naanen and Tolani, 2014). Dark sludge (waste) is discharged into the environment, covering large areas and creating a wilderness effect (Naanen, 2019). Local crude oil refining activities, including the waste generated, which is disposed of into swamps and the surrounding vegetation, affect the groundwater system as well as the aquatic environment (Amangabara and Njoku, 2012).

Flares from the local crude oil refining sites are a major source of air pollution in the Niger Delta region (Naanen, 2019). The activities of the local crude oil refiners in the Niger Delta have left the mangrove vegetation, rivers, swamps and estuaries heavily polluted. Sam and Zabbey (2018), reported that spilled oil contaminates life supporting ecosystems and food chains such as streams, rivers, fishponds and mangroves, making oil pollution a major concern for local communities. Udotong et al. (2017) also discussed the fact that hydrocarbon contamination leads to poor health of fish and potentially extinction as a result of non-reproduction and to death in extreme cases. In addition, Ezekwe et al. (2014) reported that, petroleum hydrocarbons float on the surface of rivers and streams thereby suffocating fish and other aquatic creatures.

Rivers in Nigeria are a major source of drinking water for communities in the Niger Delta with no access to potable drinking water (Beshiru et al., 2018; Nwidu et al., 2008). Activities associated with crude oil exploration and production and its associated waste and discharges has brought about soil contamination, ecosystem degradation and ground water pollution (Ite et al., 2013). As reported by Winter (1998) the discharge of groundwater into rivers, streams and other flood plains in riverine terrains is affected by the interaction of groundwater from local flow systems and regional flow systems and small quantities of petrol, kerosene or diesel may potentially contaminate millions of litres of groundwater (Gilbert et al., 2018). A clean and safe water supply is needed for the socio-economic development of any community (Akpan-Idio et al., 2012). However over sixty-six million Nigerians lack access to a potable drinking water supply, which has led to the consumption of water from different sources most of which are polluted and contaminated (Beshiru et al., 2018).

The management of hydrocarbon spills and their waste is guided by laws enacted by the Nigerian government. Government agencies like the National Oil Spill Detection and Response Agency (NOSDRA), the Directorate of Petroleum Resources (DPR), the National Emergency Management Agency (NEMA) and the National Environmental Standards and Regulation Enforcement Agency (NESREA) are all saddled with the responsibility of managing oil spill response (Ite et al., 2013; Olaniyan,

2015; Yakubu, 2017). The policy on pollution provides operational elements that encourage responsible environmental behaviour by all stakeholders (Yakubu, 2017). The NESREA establishment Act 2007 bans the transportation, depositing, and discarding of harmful waste in air, land and water (Yakubu, 2017). However even with these agencies and laws, the government is still not able to carry out proper enforcement.

Although Nigeria has numerous environmental regulations that guide the safe exploration and production operations in the oil industry, implementation and enforcement of these laws are poorly executed (Elenwo and Urho, 2017; Ibaba, 2010; Ite et al., 2013). This is further compounded by a lack of commitment from environmental protection agencies to effect sustainable changes in environmental protection (Elenwo and Urho, 2017). According to Ibaba (2010) poor funding from government, lack of operational facilities, corruption and low-level involvement of professionals are the reasons that environmental protection agencies cannot properly enforce the laws. In their review of the environmental laws in Nigeria, Orubu et al. (2004) identified a probable flaw in that no clear provision is made to incorporate the host communities in the process of implementing environmental protection and management schemes. Indeed, Ayeni (2019) recorded that community participation in environmental policy and decision making is a proven approach, which addresses issues of environmental degradation in their domain. This is because, over the years, indigenous communities have developed a close affinity with their environment – rivers, lakes, streams and land around them – for their livelihoods (Campese et al., 2009).

The activities of the local crude oil refiners have not gone unnoticed by the Nigerian government due to the huge economic losses they have brought to the nation (Allen, 2012; Dominic, 2016). However, the government's response in dealing with the menace has, in fact, exacerbated the damage to the environment rather than eliminating it (Channels, 2015). Pointer (2018) reported that in September 2017, the Nigerian Navy destroyed over 1,000 local refineries in the Niger Delta region. In November 2018, several local crude oil refineries in and around the Okarki community in the Ahoda West Local Government area of Rivers State, were destroyed using a swamp buggy (Nkemakolem, 2018). In addition, as discussed by Rageh (2014), while the government is making efforts to curb the activities of the local crude oil refiners, the process of throwing the refined products into rivers and swamps and setting the camps ablaze contributes to the destruction of the environment of the Niger Delta. The federal government through the head of NOSDRA, blamed the activities of local crude oil refiners for the high level of soot experienced in parts of the Niger Delta Region (Vanguard, 2018).

3. Study methodology

The study presented in this paper sought to investigate the impact of the activities of local crude oil refiners on their host communities through the use of a questionnaire which was distributed amongst residents in the Niger Delta region, specifically in the communities which host local refiners. This section initially outlines the subjects who were invited to participate in the study and the questionnaire itself.

3.1. Study area

The Niger Delta region of Nigeria, located in the southern part of the country, stretches over an area of about 75,000 sq. km, between longitude 5^{o} E to 8^{o} E and latitude 4^{O} N to 7^{o} N (Adagunodo et al., 2017). The region is a large arcuate delta (Nwaejije et al., 2017), with the biggest wetland in the African continent, freshwater swamp, lowland forest, mangrove swamps and coastal barrier islands (Edino et al., 2010). The region is made up of nine administrative states with diverse ethnic groups (Odalonu, 2016) which are Edo, Ondo, Abia, Akwa Ibom, Imo, Rivers, and Cross River. These are the oil producing states in Nigeria (Odalonu, 2016) as illustrated in Figure 2.

The Niger Delta region of Nigeria, as depicted in Figure 3, is noted for its high level of crude oil production (Okpo and Eze, 2012). With this

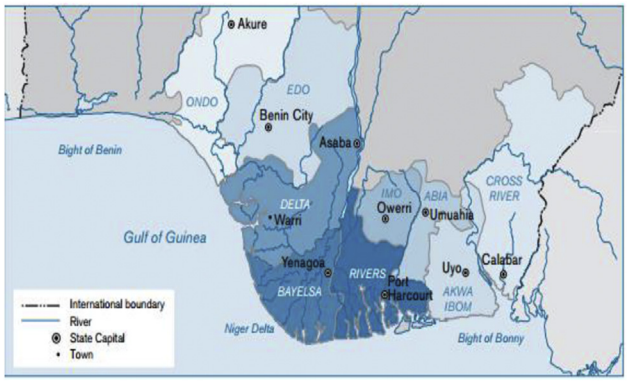

Figure 2. States of the Niger Delta (Katsouris and Sayne, 2013).

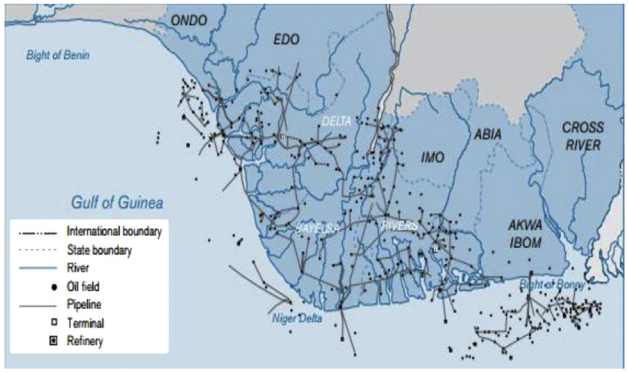

Figure 3. Oil installations in the Niger Delta (Katsouris and Sayne, 2013).

abundance, the region still suffers from supply shortage of petroleum products like gasoline, kerosene, diesel oil and lubricating oil simply because of the high demand for diesel and other petroleum products (Igbani and Bebeteidoh, 2015; Bebeteidoh et al., 2020). The inadequate supply of refined petroleum products (diesel, kerosene and gasoline) has led to increases in prices, leading consumers to opt for cheap, low quality, adulterated fuels (Raghunath et al., 2015; Gawande and Kaware, 2013), that are locally refined through non-standard processes.

Marais et al. (2014), Anifowose et al. (2014) and Yeeles and Akporiaye (2016) all reported that the local and non-standard refining of crude oil, which is illegally acquired from government owned facilities through vandalizing of pipelines, comes with damaging effects on the environment of the Niger Delta. Odalonu (2016) also discussed the negative effects that the actions of the local non-standard refineries have on the economy of the country, local communities and individuals. While research has been carried out in the areas of the economic impact of vandalising crude oil pipelines in Nigeria's delta region, there is a dearth of research on the negative imapct on the regional ecosystem and national security, due to spillages on land, in rivers and the sea, and the impact of the activities of the refiners on their host communities.

3.2. The questionnaire instrument

The questionnaire developed for this study was designed to investigate the perceived impact of the activities of local crude oil refiners on the community and the environment. It was divided into two sections, namely demographic and environmental groupings. The demographic section contained questions relating to the age, gender, and occupation of respondents, whilst the questions in section two related to the effect of the activities of the local crude oil refiners on the environment. The environmental impact of non-standard refining methods was assessed by

respondents on a six-point Likert type scale ranging from 1 = strongly disagree (SD) to 6 = strongly agree (SA). The respondents were asked to assess six statements relating to environmental impact (Allen and Seaman, 2007; DeWees et al., 2020). The six-point scale was aggregated into a two-point scale of Disagree or Agree for ease of presentation. Also, Boone and Boone (2012) established that Likert Scale is composed of four or more Likert-type items that are combined into a single composite score/variable during the data analysis process.

The environmental impact statement questions in the questionnaire are detailed below:

- S1- The activities of the non-standard refiners has affected my community farm lands?
- S2- The activities of the non-standard refiners has affected the level of farm yields?
- S3- The activities of the non-standard refiners has affected my community fishing areas?
- S4- The activities of the non-standard refiners has led to reduction of fishing yields?
- S5- The major source of water supply is usually polluted by crude oil waste from non-standard refineries?
- S6– I am concerned about the method of disposal of refined waste by the non-standard crude oil refiners?

3.3. Implementation and participants in the study

Preparation for the research study started in June 2018, with a pilot study which involved the administration of an initial 30 questionnaires. This allowed corrections to be made to the initial questionnaire before it was used for the larger study. The corrected study questionnaire was administered using the Jisc Online Surveys (formerly Bristol Online Surveys) from July 2018 until it closed on the 31st December 2018. The questionnaires were given to community chiefs, youths, farmers, traders, fishermen/fisherwomen, government employees and residents of the affected communities. The rationale for selecting the respondents was that they are indigenous peoples and live within the affected communities. The respondents also possess the required experiences for the research questions under investigation, consequently this constituted convenient sampling. Analysis of the questionnaires was done using descriptive and inferential (Chi Square and correlation) statistical methodologies in the IBM SPSS statistics software package. Reliability is the internal consistency of the items that make up the scale used in any questionnaire survey, to ascertain if they are measuring the same construct (Pallant, 2010). Cronbach's alpha coefficient was used to compute the reliability of the questionnaire items. DeVellis (2003) suggest that Cronbach's coefficient of a scale should be above 0.7. The Cronbach coefficient obtained for the questionnaire items in this study is 0.92, and this provides confidence that the scale used for the study is measuring the same construct. Nominal data also known as categorical data, was used in this research work because it can be used for classifying items or separating them into groups rather than each item having a numeric value (Gilbert and Prion, 2016).

A total of 487 adults participated in the larger study, which relied primarily on quantitative methods of data collection and analysis (Chen et al., 2020; Coderoni and Perito (2020); Edino et al., 2010; Liu et al., 2020; Okeke-Ogbuafor et al., 2018). The questionnaires were administered to three communities in the Niger Delta, namely the Ologbobiri community in the Southern Ijaw Local Government Area of Bayelsa State, Akinima and the Okarki communities both in the Ahoda West Local Government Area of Rivers State. The communities were selected because they are riverine in nature and are involved in farming and fishing as a way of earning a living. The selected communities host a number of local refineries and crude oil locations upstream that are owned by multinational corporations.

4. Results

This section presents the results of the questionnaire study. Initially the demographics of those who completed the survey are considered followed by the responses to the environmental questions. The discussion then considers the environmental questions in turn with regard to the impacts of the local refining activities and makes recommendations for environmental protection and government actions.

4.1. Demographics of the respondents and survey responses

Table 1 summarises the demographics of the respondents to the questionnaire study. Of the 487 completed questionnaires, thirty-two percent of respondent's fell into the age range of 42–45 years and only 3.3% of respondents were over 66 years old. Males made up the majority of the respondents with 61.6% and females 38.4%. Some 75.4% of the respondents are married, while fishermen/fisherwomen, farmers and government employees made up 68.2% of the respondents. Traders were 8.4%, chiefs and youths were 4.7% and 12.9% of respondents respectively.

Table 2 summarises the responses to the six environmental questions, S1 to S6. The responses to these questions are discussed in detail in the sections that follow.

4.1.1. Factor Analysis

Factor analysis was carried out on the data. The Kaiser-Meyer-Olkin (KMO) was 0.820, Bartlett's test was significant ($p = 0.001$) and the determinant was 0.008. The data satisfies all the conditions for Factor Analysis. One factor was extracted with an eigenvalue of 4.13 and it account for 68.8% of the variability of the six statements. The minimum loading was 0.763 and the maximum was 0.905. So, the six statements came from one underlying construct namely effect of non-standard refinery on the environment. How each statement has affected the environment is then examined.

4.1.2. Responses of respondents to the six environmental questions, S1 to S6

- **'The activities of the non-standard refiners have affected my community farm lands (S1) and yields (S2)?'**

The activities of the local crude oil refiners have affected the farmlands and product yields of the host communities. Some 78% of respondents agreed that the activities of the local refiners affect their farmlands while 64% agreed that it also affects their farm yields, as shown in Table 2, with summary statistics of S1 and S2 shown in Table 3.

- **'The activities of the non-standard refiners have affected my community fishing areas (S3) and fish yields (S4)?'**

The activities of the local refiners have affected the fishing areas of their host communities. An overwhelming majority of respondents (96%) agreed that the activities of the local refiners had significantly affected their fishing areas, while 94% agreed that they had also affected their catches, as shown in Table 2, with summary statistics of S3 and S4 shown in Table 3.

- **'The major source of water supply is usually polluted by crude oil waste from non-standard refineries (S5)?'**

The extent to which the source of water supply in the study area is affected by crude oil waste from nonstandard refining sites. Some 93% of respondents (see Table 2) agreed that, waste generated and disposed from local refineries affects their source of water. The summary statistics of S5 are shown in Table 3.

Table 1. Demographics of respondents.

Variables	Categories	Frequency	Percent
Age Bracket	18–25 years	40	8.2
	26–33 years	58	11.9
	34–41 years	130	26.7
	42–55 years	158	32.4
	56–65 years	85	17.5
	66 years and above	16	3.3
	Total	487	100
Gender	Male	300	61.6
	Female	187	38.4
	Total	487	100
Marital Status	Married	367	75.4
	Single	90	18.5
	Divorced	9	1.8
	Widow/Widower	21	4.3
	Total	487	100
Occupation	Fisherman/Fisherwomen	107	22
	Trader	41	8.4
	Farmer	103	21.1
	Youth/Student	63	12.9
	Business	28	5.7
	Government Employee	122	25.1
	Chief	23	4.7
	Total	487	100

- **'I am concerned about the method of disposal of refined waste by the non-standard crude oil refiners (S6)?'**

The poor waste disposal methods of the local crude oil refiners in and around their production sites. Some 96% of respondents (see Table 2) agreed that the local crude oil refiners have a very poor waste disposal regime, with a summary statistic of S6 shown in Table 3.

4.2. Inferential statistics of environmental impact statements

This section presents the statistical analysis of the questionnaire data including examination of the correlations between the demographic data and the environmental impact results and between the different environmental impact statements.

4.2.1. Association between demographic factors and environmental impact statements

A Chi-Square test of association was conducted to ascertain whether there is any association between the demographic factors and the way that the environmental impact statements were answered. The results of the analysis are shown in Table 4. There are four demographic factors and six environmental impact statements making a total of 24 Chi-Square tests. Alpha level was set at 5% (0.05) and p values below 5% (0.05) were significant. On this basis, 10 of the 24 tests were found to be significant. For example, age bracket was significantly associated with the statement that non-standard refineries have affected the level of farm yields (harvest) [$\chi^2 = 14.99$, $p = 0.01$ (<0.05), Cramer's $V = 0.175$]; but it was not significantly associated with any of the other statements. Gender was

Table 2. Effect of local crude oil refiners on the environment.

Effect of the activities of the local crude oil refiners on the environment?	Count/%	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Disagree	Agree
The activities of the non-standard refiners has affected my community farm lands? (S1)	Count	10	39	58	210	85	85	107	380
	Row %	2.1	8.0	11.9	43.1	17.5	17.5	22	78
The activities of the non-standard refiners has affected the level of farm yields (harvest)? (S2)	Count	11	92	70	154	86	74	173	314
	Row %	2.3	18.9	14.4	31.6	17.7	15.2	36	64
The activities of the non-standard refiners has affected my community fishing areas? (S3)	Count	8	8	5	72	202	192	21	466
	Row %	1.6	1.6	1.0	14.8	41.5	39.4	4	96
The activities of the non-standard refiners has led to reduction of fishing yields? (S4)	Count	9	9	9	64	186	210	27	460
	Row %	1.8	1.8	1.8	13.1	38.2	43.1	6	94
The major source of water supply is usually polluted by crude oil waste from non-standard refineries? (S5)	Count	11	10	15	69	201	181	36	451
	Row %	2.3	2.1	3.1	14.2	41.3	37.2	7	93
I am concerned about the method of disposal of refined waste by the non-standard crude oil refiners? (S6)	Count	8	9	3	41	207	219	20	467
	Row %	1.6	1.8	0.6	8.4	42.5	45.0	4	96

Table 3. Summary statistics of the six environmental statements.

Statements	Summary Statistics			
	Mean	Median	Mode	Std. Deviation
The activities of the non-standard refiners has affected my community farm lands (S1)	4.18	4.00	4	1.21
The activities of the non-standard refiners has affected the level of farm yields (harvest) (S2)	3.89	4.00	4	1.37
The activities of the non-standard refiners has affected my community fishing areas (S3)	5.11	5.00	5	0.99
The activities of the non-standard refiners has led to reduction of fishing yields (S4)	5.13	5.00	6	1.04
The major source of water supply is usually polluted by crude oil waste from non-standard refineries (S5)	5.02	5.00	5	1.09
I am concerned about the method of disposal of refined waste by the non-standard crude oil refiners (S6)	5.23	5.00	6	0.97

significantly associated with two statements namely those regarding community farmlands [$\chi^2 = 12.82$, $p = 0.001$ (<0.05), Cramer's V = 0.162] and farm yields (harvest) [$\chi^2 = 10.41$, $p = 0.001$ (<0.05), Cramer's V = 0.146]. Marital status was only significantly associated with one of the statements, namely non-standard refineries have affected level of farm yields (harvest) [$\chi^2 = 11.52$, $p = 0.01$ (<0.05), Cramer's V = 0.154]. Occupation was significantly associated with all six of the environmental statements. Cramer's V is a measure of the strength of the association that ranges from a minimum value of zero to a maximum value of one (Acock and Stavig, 1979). All of these tests indicated that the perception of the effect of the environmental impact statements is associated with demographic factors, however, the strength of the association is variable, as shown by the Cramer's V test.

4.2.2. Correlation (Spearman rho) amongst environmental impact statements

The relationship amongst the responses to the environmental impact statements of the effect of non-standard refiners are shown in the correlation matrix in Table 5. All the bivariate relationships are significant at the 1% level. This shows that there is a complex relationship amongst the statements and how they affect each other. For example, the highest correlation is 0.862 between S3 and S4, indicating that non-standard refiners have affected community fishing areas which in turn has led to reduction of fishing yields. However, this is not a cause and effect relationship as other factors may also affect fishing yields, such as the effect of farmlands which also has a significant relationship with fishing yields ($r = 0.492$, $p < 0.01$). The next highest correlation is 0.819 between S1 and S2, indicating that effects on farmlands influence farm yields. In turn, farm yield also has a significant correlation with pollution of the water supply by crude oil waste and the disposal of refined waste by non-standard refiners, with 0.458 and 0.356 respectively. Furthermore, there was significant correlation between S3 and S6 ($r = 0.501$, $p < 0.01$), indicating that the effect of the disposal of refined waste affects community fishing areas. Nevertheless, other factors may also affect the fishing areas of communities in the riverine areas as well as farmlands. Equally, there was correlation between S5 and S6 ($r = 0.574$, $p < 0.01$), indicating that the method of waste disposal affects the major source of water. All these indicate that the environmental impact of the activities of the non-standard refiners are complex and interrelated.

4.2.3. Discussion

The aim of the study was to determine the impact of the activities of local crude oil refiners in the Niger Delta on their host communities. This study showed that activities of local crude oil refiners have affected the farmlands and product yields of their host communities. The transportation of crude oil to the local crude oil refineries and the refining process applied by the local crude oil refiners have resulted in pollution of the soil by hydrocarbon components. This has led to the loss of soil quality, leaching and erosion. Hydrocarbon pollution damages farmlands and has a major effect on food security. Farmers in the study area also depend on rivers and streams for irrigation purposes, but with the runoff from local refineries which drains crude oil and refined products into them makes the water hazardous for irrigation and other farm activities. The incessant pollution of the soil has affected product yields of the farmers. A rise in hydrocarbon spillage could reduce product yield and the income of farmers.

This study documents that majority of respondents agreed that the activities of the local crude oil refiners have significantly affected their fishing areas, catches and have become a source of concern. Pollution of the rivers and streams by hydrocarbons damages the aquatic ecosystem which destroys the habitat of fishes. The pollution of rivers and streams by crude oil and other petroleum products from local refineries could also affect the health of fishes which in turn affects the fishermen and fisherwomen. Spilled petroleum hydrocarbon floats on the surface of the streams and rivers thereby suffocating aquatic creatures and fishes.

With rivers and streams acting as the major source of drinking water in the affected communities, the pollution of such streams and rivers by crude oil becomes a major source of concern for host communities. Clean

Table 4. Chi square association between demographic factors and environmental impact statements.

Demographic	Environmental Impact statement	Chi-Square Test		Strength
		Value	P value	Cramer's V
Age Bracket	The activities of the non-standard refiners has affected my community farm lands?	7.671	0.175	0.126
Age Bracket	The activities of the non-standard refiners has affected the level of farm yields (harvest)?	14.992	0.010	0.175
Age Bracket	The activities of the non-standard refiners has affected my community fishing areas?	4.756	0.446	0.099
Age Bracket	The activities of the non-standard refiners has led to reduction of fishing yields?	2.294	0.807	0.069
Age Bracket	The major source of water supply is usually polluted by crude oil waste from non-standard refineries?	2.235	0.816	0.068
Age Bracket	I am concerned about the method of disposal of refined waste by the non-standard crude oil refiners?	6.486	0.262	0.115
Gender	The activities of the non-standard refiners has affected my community farm lands?	12.823	0.001	0.162
Gender	The activities of the non-standard refiners has affected the level of farm yields (harvest)?	10.407	0.001	0.146
Gender	The activities of the non-standard refiners has affected my community fishing areas?	0.001	0.977	0.001
Gender	The activities of the non-standard refiners has led to reduction of fishing yields?	0.310	0.578	0.025
Gender	The major source of water supply is usually polluted by crude oil waste from non-standard refineries?	0.176	0.675	0.019
Gender	I am concerned about the method of disposal of refined waste by the non-standard crude oil refiners?	0.102	0.750	0.014
Marital Status	The activities of the non-standard refiners has affected my community farm lands?	2.910	0.406	0.077
Marital Status	The activities of the non-standard refiners has affected the level of farm yields (harvest)?	11.523	0.009	0.154
Marital Status	The activities of the non-standard refiners has affected my community fishing areas?	0.716	0.869	0.038
Marital Status	The activities of the non-standard refiners has led to reduction of fishing yields?	1.759	0.624	0.060
Marital Status	The major source of water supply is usually polluted by crude oil waste from non-standard refineries?	2.669	0.445	0.074
Marital Status	I am concerned about the method of disposal of refined waste by the non-standard crude oil refiners?	4.403	0.221	0.095
Occupation	The activities of the non-standard refiners has affected my community farm lands?	31.384	0.001	0.254
Occupation	The activities of the non-standard refiners has affected the level of farm yields (harvest)?	59.242	0.001	0.349
Occupation	The activities of the non-standard refiners has affected my community fishing areas?	19.452	0.003	0.200
Occupation	The activities of the non-standard refiners has led to reduction of fishing yields?	16.505	0.011	0.184
Occupation	The major source of water supply is usually polluted by crude oil waste from non-standard refineries?	26.092	0.001	0.231
Occupation	I am concerned about the method of disposal of refined waste by the non-standard crude oil refiners?	17.736	0.007	0.191

Table 5. Correlation matrix of environmental impact statements.

Environmental Impact Statements		S1	S2	S3	S4	S5	S6
S1	The activities of the non-standard refiners has affected my community farm lands?	1					
S2	The activities of the non-standard refiners has affected the level of farm yields (harvest)?	0.819**	1				
S3	The activities of the non-standard refiners has affected my community fishing areas?	0.503**	.550**	1			
S4	The activities of the non-standard refiners has led to reduction of fishing yields?	0.492**	.530**	0.862**	1		
S5	The major source of water supply is usually polluted by crude oil waste from non-standard refineries?	0.414**	.458**	0.626**	0.620**	1	
S6	I am concerned about the method of disposal of refined waste by the non-standard crude oil refiners?	0.353**	0.356**	0.501**	0.551**	0.574**	1

** Correlation is significant at the 0.01 level (2-tailed).

and portable drinking water is needed for the socio-economic growth of any community, but this is not the case for these communities. Rather they are left to drink from streams and rivers in and around their communities. Also, with a good number of Nigerians lacking access to portable drinking water the government should provide clean portable drinking water for the affected communities. This is as it will reduce sickness from water borne diseases and pollution. The provision of clean portable drinking water will achieve Sustainable Development Goal six (SDG6) of the United Nations.

Local refinery waste disposal methods are also a major source of concern to respondents. Waste generated from the refining of crude oil by local refineries is disposed into nearby streams, rivers and surrounding vegetation. This high level of waste is attributed to the crude method of refining employed. This waste does not only contaminate the nearby streams and rivers they also contaminate the ground water. Also, governments response to dealing with this menace has greatly contributed to high level of pollution. The discharge of seized petroleum products from camps of local crude oil refineries into streams and rivers have also led to contamination of the water and death of fishes and damage to the aquatic ecosystem.

5. Conclusion

This study found evidence that the activities of local crude oil refiners have led to high levels of environmental pollution in the communities sampled due to their refining techniques and waste disposal methods as most of the respondents agreed with all six environmental impact statements. Moreover, 90% of the respondents agreed with four of the six statements. This is also evidence from the results of the descriptive and inferential statistics which indicate that the environmental impact of the non-standard refiners is complex and interrelated. Fishing routes and farming areas were affected, which has also affected the livelihood of fishermen/fisherwomen and farmers. The study also concludes that the environmental protection agencies have not done enough in their constitutional role of protection and enforcement of environmental laws most probably as a result of insufficient funds. Also, the response of government, whereby refined products from local refineries which are seized are either poured into rivers or on land, also pollutes the environment.

5.1. Recommendations

A few recommendations were made based on this study. These are primarily actions that should be taken by or administered through the Nigerian Government. The study recommends that.

- The environmental protection agencies should be properly funded and empowered to carry out their constitutional duty of protection and enforcement
- The seized products from local refineries should be handed over to the state-owned National Petroleum Corporation (NNPC) which is empowered to refine petroleum products.
- The government of Nigeria should carry out continuous public enlightenment in the Niger Delta, using the National Orientation Agency (NOA), print and electronic media on the implications of pipeline vandalism and illegal refining of crude oil.
- Given that most respondents agreed with the six environmental impact statements, urgent measures should be put in place for remediation of soil in affected communities.
- There is need for proper synergy between the Environmental protection agencies the Police, Civil Defence and Military in the enforcement of environmental protection laws.

5.2. Limitations of study

This is an observational study, not a closed study where most factors are controlled. The respondents were limited to those who have access to the internet.

Declarations

Author contribution statement

O. L. Bebeteidoh: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

S. Kometa, K. Pazouki, R. Norman: Contributed reagents, materials, analysis tools or data.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

Data associated with this study has been deposited in Data In Brief.

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