

Assessment of Soil Physicochemical Properties, Heavy Metal Contamination, and their Socioeconomic and Environmental Impacts in Oil-Producing Communities of the Niger Delta, Nigeria

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Abstract

This research evaluated the physical and chemical characteristics, heavy metal pollution, and the related socioeconomic and environmental consequences of soil contamination in oil-producing regions of the Niger Delta, Nigeria. An approach utilizing mixed methods, which included laboratory evaluations and household interviews, was used. Soil samples were gathered from five different communities—Ogulagha, Odimodi, Forcados Town, Beniboye, and Yobebe—with three sampling locations in each area ($n = 15$). A total of 400 respondents were chosen for the questionnaire using Taro Yamane's sampling method from a population of 78,134. The laboratory evaluation focused on soil pH, organic carbon content, texture, electrical conductivity, moisture levels, and heavy metals (Cd, Pb, Zn, Ni, Cr, Co, and V) through standard methodologies that involved aqua regia digestion and atomic absorption spectrophotometry. Findings revealed that heavy metal levels and hydrocarbon pollution were particularly high in Forcados Town and Ogulagha, often surpassing the permissible limits set by NESREA. Soil pH was found to be moderately acidic to slightly alkaline, and both organic carbon levels and microbial populations displayed variations that matched the degree of pollution. The questionnaire results indicated a strong perception of the effects of soil pollution, with weighted mean scores between 4.19 and 4.37. More than 56.57% of respondents strongly believed that soil contamination contributed to decreased agricultural productivity, while 55.05% noted a reduction in crop yields. Furthermore, 60.10% reported noticeable soil degradation, and 51.01% frequently observed oil spills on farmland. Analysis using Kruskal-Wallis indicated no statistically significant differences ($p > 0.05$) in perceived pollution impacts among the communities, reflecting a consistent exposure and experience of pollution effects. Economic repercussions included diminished farm income, falling land values, heightened food insecurity, and health issues related to environmental pollution. The geo-accumulation index (Igeo) and contamination factor (CF) indicated moderate to severe pollution levels at most of the sampling locations. The study concludes that soil contamination in the Niger Delta is widespread in terms of environmental impact and disruptive to socioeconomic conditions, highlighting the need for immediate remediation, stricter enforcement of regulations, and sustainable environmental management practices to improve soil health and safeguard the livelihoods in the affected areas.

Keywords: Assessment, Soil, Physicochemical, Properties, Heavy, Metal, & Contamination,

Introduction

The Niger Delta area in Nigeria ranks among the most ecologically vulnerable and hydrocarbon-abundant places globally, yet it has undergone many years of severe environmental destruction due to crude oil extraction, small-scale refining, gas flaring, and damage to pipelines. These operations have caused extensive soil pollution, disruption of ecosystems, and insecurity in the livelihoods of local communities. Soil, which underpins agricultural productivity and the stability of ecosystems, is especially susceptible to contamination from hydrocarbons and heavy metals, putting both food security and human health at risk (Uyigue, & Agho, 2007). In the oil-producing regions of Rivers State, the ongoing accumulation of petroleum hydrocarbons and harmful metals like lead, cadmium, nickel, and chromium has disrupted the physicochemical properties of the soil, diminished microbial activity, and deteriorated the quality of agricultural land. These pollutants enter the soil due to leaks, waste from artisanal refining, and ineffective cleanup techniques, causing long-lasting environmental issues and risks of bioaccumulation (Nwilo, & Badejo, 2005). In addition to environmental impacts, soil contamination in the Niger Delta carries important socioeconomic consequences. The primary means of livelihood for rural communities, such as farming and fishing, are increasingly at risk due to diminishing soil fertility, lower crop yields, and the pollution of water sources. As a result, these communities face income reductions, growing food insecurity, and increased health dangers, which include exposure to cancer-causing substances and heavy metal poisoning (Uyigue, & Agho, 2007). Given the intricate nature of these interconnected environmental and socioeconomic issues, there is a necessity for assessment methods that integrate laboratory soil examinations with studies on community perceptions. This research thus investigates the physicochemical characteristics, heavy metal pollution, and related socioeconomic and environmental effects of soil contamination in selected oil-producing areas of the Niger Delta in Nigeria.

Methodology

The research employed a mixed-method approach that integrated both comparative and experimental strategies to explore the physicochemical, biological, and heavy metal attributes of soil affected by artisanal oil refining in specific communities along the Forcados River in Rivers State, Nigeria. This mixed-method strategy was deemed suitable as it facilitates the combination of laboratory environmental data with field socio-economic insights, thereby enabling a holistic view of environmental conditions alongside community attitudes toward the impacts of pollution (Uyigue, & Agho, 2007). The study drew from both primary and secondary data sources. Primary data were acquired directly through field sampling and laboratory assessments of soil taken from the chosen communities, while secondary data were gathered from existing literature, institutional documents, and pertinent scientific investigations concerning soil pollution and artisanal refining operations. The soil samples served as the fundamental empirical foundation for the evaluation of physicochemical characteristics, biological features, and heavy metal levels, whereas data from questionnaires enhanced the laboratory results by reflecting local experiences of environmental decline and effects on livelihoods. Soil analysis involved samples collected from five intentionally chosen communities—Ogulagha, Odimodi, Forcados Town, Beniboye, and Yobebe—all situated within the Burutu Local Government Area of Rivers State, recognized for their artisanal oil refining practices. Soil sampling occurred at three separate locations within each community, targeting crude oil input areas, refining sites, and nearby regions, resulting in a total of fifteen soil samples. The samples were taken from the uppermost soil layer at a depth of 0–20 cm, identified as the most active zone for agricultural and ecological interactions. Regarding the questionnaire

segment of the research, the entire population of 78,134 individuals residing in the five communities was considered, from which a sample size of 400 participants was established using the Taro Yamane method. This sample was allocated among the communities in the following proportions: Ogulagha (69), Odimodi (73), Forcados Town (126), Beniboye (65), and Yobebe (67). Participants were chosen through simple random sampling to ensure equal representation and mitigate selection bias.

Soil samples were gathered utilizing standard field methods with tools such as a soil auger, measuring tape, GPS device, and appropriately labeled containers for the samples. The samples were air-dried, sieved with a 2 mm mesh, and sent to the laboratory for examination. The physicochemical features assessed included soil texture (fractions of sand, silt, and clay), pH, moisture level, electrical conductivity, porosity, and organic carbon content. Additionally, biological properties like the counts of total heterotrophic bacteria and fungi were analyzed. The heavy metal evaluation concentrated on cadmium (Cd), chromium (Cr), zinc (Zn), nickel (Ni), cobalt (Co), vanadium (V), and lead (Pb), adhering to standardized laboratory methodologies. Soil texture was assessed employing the Bouyoucos hydrometer technique as outlined by Joao et al. (2009). Meanwhile, the pH of the soil was gauged utilizing a glass electrode pH meter in a suspension of soil and water at a 1:1 ratio. The measurement of organic carbon levels was executed through the chromate oxidation method as described by Matersha and Mkhabela (2001). The extraction of heavy metals was achieved via aqua regia digestion, whereby a 1.0 g sample of soil was combined with a hydrochloric acid and nitric acid mixture at a 3:1 ratio, subjected to a 24-hour pre-digestion period, heated at 120°C for two hours, filtered, and analyzed using flame atomic absorption spectrophotometry as indicated by Useh and Dauda (2018). Microbial populations were assessed through serial dilution and pour plate methods, counting bacterial and fungal colonies as colony-forming units per gram of soil in accordance with standard microbiological practices (Phil-Eze, 2010).

Data evaluation involved both descriptive and inferential statistical approaches. Descriptive statistics, including frequencies, percentages, and weighted averages, were utilized to summarize the responses from the questionnaire. Inferential statistics were applied to evaluate the hypotheses of the study. The first two hypotheses, which investigated spatial variations in physicochemical characteristics and heavy metal levels among the chosen communities, were examined through Analysis of Variance (ANOVA). Conversely, the fourth hypothesis, which explored whether the effects of soil pollution varied significantly among the study communities, was assessed using the Kruskal–Wallis H test. The selection of the Kruskal–Wallis test was based on the ranked nature of the data, which was non-parametric and suitable for comparing multiple independent groups without presuming a normal distribution. The correlation between the physicochemical characteristics of the soil and the concentrations of heavy metals was not analyzed through Pearson correlation due to dataset characteristics and its distribution. Instead, a focus was placed on spatial comparisons and rank-based variations among communities. All statistical computations were executed utilizing IBM SPSS software, maintaining a significance level of 0.05. For the sake of scientific rigor, laboratory findings were critically evaluated against the permissible thresholds set by the National Environmental Standards and Regulations Enforcement Agency (NESREA). Furthermore, the status of heavy metal contamination was assessed through the geo-accumulation index (I_{geo}) introduced by Müller (1969), which categorizes contamination levels in relation to background concentrations and detected metal levels. Additionally, the contamination factor (CF) was calculated to ascertain the extent of pollution in the examined area, employing methodologies cited by Balogun et al. (2023) and Orobator and Akpore (2025). The combination of field

sampling, laboratory assessments, questionnaire distribution, and non-parametric statistical evaluations established a comprehensive methodological approach for investigating soil pollution dynamics and its environmental and socio-economic repercussions within artisanal refining communities.

Results

Research Objective One: Assess the relationship between the physicochemical properties of soil and heavy metals in the study area.

Research Question One: What is the relationship between the physicochemical properties of soil and heavy metals in the study area.

Table 4.1. Perception of the Impacts of soil pollution on the locals in the study area

Statement	SA (%)	f (%)	A (%)	f (%)	D (%)	f (%)	SD (%)	f (%)	N (%)	f (%)	Total f (%)	Weighted Mean
Soil pollution has reduced agricultural productivity in my community.	224 (56.57)	112 (28.28)	20 (5.05)	12 (3.03)	28 (7.07)	396 (100)	4.3					
Crop yields have declined due to contamination of farmland.	218 (55.05)	118 (29.80)	22 (5.56)	12 (3.03)	26 (6.57)	396 (100)	4.28					
Soil pollution has affected the quality of crops produced in this area.	210 (53.03)	124 (31.31)	20 (5.05)	12 (3.03)	30 (7.58)	396 (100)	4.26					
I have trouble growing crops due to poor soil conditions.	202 (51.01)	128 (32.32)	22 (5.56)	12 (3.03)	32 (8.08)	396 (100)	4.23					
Soil pollution has led to loss of income for farmers.	216 (54.55)	120 (30.30)	20 (5.05)	12 (3.03)	28 (7.07)	396 (100)	4.28					
Farming activities have reduced significantly in this community due to polluted soil.	208 (52.53)	124 (31.31)	22 (5.56)	12 (3.03)	30 (7.58)	396 (100)	4.23					
Soil pollution has affected food availability in my household.	196 (49.49)	132 (33.33)	22 (5.56)	12 (3.03)	34 (8.59)	396 (100)	4.21					
Consumption of crops grown in this area poses health risks.	230 (58.08)	108 (27.27)	20 (5.05)	12 (3.03)	26 (6.57)	396 (100)	4.3					
Soil pollution has contributed to increased health problems in this community.	212 (53.54)	116 (29.29)	22 (5.56)	14 (3.54)	32 (8.08)	396 (100)	4.23					
Soil pollution has contaminated groundwater or nearby water sources.	226 (57.07)	112 (28.28)	18 (4.55)	12 (3.03)	28 (7.07)	396 (100)	4.31					
The cost of living has increased due to reduced agricultural output.	194 (48.99)	138 (34.85)	18 (4.55)	12 (3.03)	34 (8.59)	396 (100)	4.21					
Soil pollution has reduced land value in this community.	188 (47.47)	142 (35.86)	18 (4.55)	12 (3.03)	36 (9.09)	396 (100)	4.19					

Soil pollution has affected fishing and other related livelihoods.	204 (51.52)	126 (31.82)	22 (5.56)	12 (3.03)	32 (8.08)	396 (100)	4.23
There is visible evidence of soil degradation in my area.	238 (60.10)	104 (26.26)	18 (4.55)	10 (2.53)	26 (6.57)	396 (100)	4.37

Table1 presents respondents' perceptions of the impacts of soil pollution on livelihoods, agricultural activities, food security, health, water resources and the general environmental condition of the study area. The results indicate a generally high level of perceived impact, as evidenced by the predominance of responses in the strongly agree and agree categories across all the statements. The weighted mean scores, which ranged from 4.19 to 4.37, further demonstrate that respondents generally agreed that soil pollution has adversely affected their communities. The highest level of agreement was recorded for the statement that there is visible evidence of soil degradation in the area, with 60.10% strongly agreeing and 26.26% agreeing, producing a weighted mean of 4.37. This suggests that soil degradation is not merely perceived as an abstract environmental problem, but is observable to residents through changes in soil condition, vegetation performance and land productivity. The high level of agreement is consistent with the elevated total petroleum hydrocarbon concentrations reported in the physicochemical assessment, particularly at Forcados Town, Ogulagha and Odimodi. The perception that soil pollution has reduced agricultural productivity was also strongly expressed. About 56.57% of respondents strongly agreed and 28.28% agreed with the statement, yielding a weighted mean of 4.30. Similarly, respondents agreed that crop yields had declined because of farmland contamination, with 55.05% strongly agreeing and 29.80% agreeing, giving a weighted mean of 4.28. The finding indicates that pollution of agricultural soils is perceived to have direct consequences for farming performance. This is particularly important in communities where farming constitutes a major source of livelihood. The quality and cultivation of crops were also perceived to have been affected. The statement that soil pollution has affected the quality of crops produced in the area recorded a weighted mean of 4.26, with 84.34% of respondents either strongly agreeing or agreeing. Likewise, difficulty in growing crops due to poor soil conditions recorded a weighted mean of 4.23. These responses suggest that respondents associate declining soil quality with reduced agricultural suitability and poorer crop performance. The economic implications of soil pollution were equally prominent. The statement that soil pollution has led to loss of income for farmers recorded a weighted mean of 4.28, while the reduction of farming activities due to polluted soil recorded 4.23. These results suggest that the consequences of soil pollution extend beyond environmental degradation to household income and livelihood security. Reduced productivity can translate into lower agricultural earnings, increased dependence on alternative livelihoods and greater economic vulnerability among households. Food security was another important concern. About 82.82% of respondents either strongly agreed or agreed that soil pollution had affected food availability in their households, producing a weighted mean of 4.21. Even more strongly, 85.35% agreed that consumption of crops grown in the area poses health risks, resulting in a weighted mean of 4.30. This indicates that respondents perceive soil pollution as having both direct agricultural consequences and indirect implications for the safety and availability of locally produced food.

Health and water resources were also perceived to be affected. The statement that soil pollution has contributed to increased health problems recorded a weighted mean of 4.23, with 82.83% of respondents agreeing or strongly agreeing. Similarly, the perception that soil pollution has

contaminated groundwater or nearby water sources produced one of the higher weighted means, 4.31, with 85.35% expressing agreement. This perception is important because contaminants deposited in soil may potentially migrate into surface water or groundwater, particularly under the wet environmental conditions characteristic of the Niger Delta. Respondents also perceived wider socioeconomic consequences. The statement concerning increased cost of living due to reduced agricultural output had a weighted mean of 4.21, while the perceived reduction in land value recorded the lowest, although still high, weighted mean of 4.19. The latter finding suggests that respondents associate environmental degradation with declining attractiveness and economic value of affected land. Similarly, the effect of soil pollution on fishing and related livelihoods recorded a weighted mean of 4.23, demonstrating that respondents perceive the consequences of soil contamination as extending beyond farming to other livelihood activities. The results show a consistent perception of substantial impacts of soil pollution across the study area. None of the statements produced a weighted mean below 4.19, indicating that disagreement with the perceived impacts was relatively limited. The findings also correspond with the laboratory results, which showed elevated TPH and PAH concentrations in the soils, as well as differences in soil biological characteristics and heavy metal concentrations among the communities. The questionnaire results therefore provide a community-level perspective that complements the laboratory evidence, showing that the measured environmental contamination is accompanied by perceived consequences for agriculture, livelihoods, food security, health, water resources and land value. The relatively high proportion of respondents selecting strongly agree across most items further suggests that soil pollution is perceived as a significant environmental and socioeconomic problem rather than an isolated occurrence. The responses therefore provide strong descriptive evidence that residents of Ogulagha, Odimodi, Forcados Town, Beniboye and Yobebe perceive soil pollution as having considerable consequences for their everyday livelihoods and environmental conditions.

Research Objective Two: assessment of the severity and frequency of the effects of soil pollution on livelihoods, agricultural activities, crop growth, visible oil contamination and pollution-related health experiences in the study area.

Research Question Two: What are the severity and frequency of the effects of soil pollution on livelihoods, agricultural activities, crop growth, visible oil contamination and pollution-related health experiences in the study area.

Table 2. Severity of the impacts of oil pollution on soil in the study area.

Item	Response Category	Frequency (f)	Percentage (%)	Weighted Mean
Overall, how severe is the impact of soil pollution on your livelihood?	Very High (VH)	186	46.97	
	High (H)	132	33.33	
	Moderate (M)	48	12.12	
	Low (L)	20	5.05	
	Very Low (VL)	10	2.53	
	Total	396	100	4.17

How often do you observe poor crop growth in your area?	Very Often (VO)	178	44.95	
	Often (O)	138	34.85	
	Sometimes (S)	48	12.12	
	Rarely (R)	22	5.56	
	Never (N)	10	2.53	
	Total	396	100	4.14
How often do you notice oil spills or residues on the soil?	Very Often (VO)	202	51.01	
	Often (O)	126	31.82	
	Sometimes (S)	38	9.6	
	Rarely (R)	20	5.05	
	Never (N)	10	2.53	
	Total	396	100	4.24
How often do you experience health issues you believe are linked to environmental pollution?	Very Often (VO)	164	41.41	
	Often (O)	142	35.86	
	Sometimes (S)	52	13.13	
	Rarely (R)	24	6.06	
	Never (N)	14	3.54	
	Total	396	100	4.05
How severe is the impact of soil pollution on farming activities in your community?	Very High (VH)	194	48.99	
	High (H)	136	34.34	
	Moderate (M)	42	10.61	
	Low (L)	16	4.04	
	Very Low (VL)	8	2.02	
	Total	396	100	4.24

Table 2 presents respondents' assessment of the severity and frequency of the effects of soil pollution on livelihoods, agricultural activities, crop growth, visible oil contamination and pollution-related health experiences in the study area. The results reveal a consistently high perception of pollution impacts, with weighted mean scores ranging from 4.05 to 4.24. This indicates that respondents generally regarded the effects of soil pollution as frequent and severe. The assessment of the overall impact of soil pollution on livelihood produced a weighted mean of 4.17. Nearly half of the respondents, 46.97%, rated the impact as very high, while a further 33.33% rated it as high. Thus, 80.30% of respondents considered the impact of soil pollution on their livelihoods to be either high or very high. Only 7.58% rated the impact as low or very low. This

pattern demonstrates that soil pollution is perceived as having substantial implications for the economic activities and livelihood conditions of residents. The frequency of poor crop growth was also high. A total of 44.95% of respondents reported observing poor crop growth very often, while 34.85% reported observing it often. Consequently, 79.80% of respondents experienced poor crop growth either very often or often. The weighted mean of 4.14 reinforces the perception that declining crop performance is a recurring condition within the communities. This observation is particularly relevant to the agricultural livelihood structure of the study area, where soil quality is important for sustaining crop production. The strongest frequency response was recorded for the observation of oil spills or residues on the soil. About 51.01% of respondents indicated that they noticed oil spills or residues very often, while 31.82% reported that they noticed them often. Combined, 82.83% of respondents observed oil contamination either very often or often. The resulting weighted mean of 4.24 indicates a very high level of perceived occurrence. This finding provides an important link between the residents' experiences and the environmental assessment, particularly the elevated TPH concentrations recorded in the soil samples. Pollution-related health issues were also reported with considerable frequency. The weighted mean of 4.05 was the lowest among the five indicators, but it still represents a high response level. Specifically, 41.41% of respondents reported experiencing such health issues very often, while 35.86% reported experiencing them often. Therefore, 77.27% reported experiencing perceived pollution-related health issues either very often or often. Although the questionnaire captures respondents' perceptions and cannot independently establish that the health conditions were caused by soil pollution, the result demonstrates substantial community concern regarding the possible health implications of environmental contamination. The severity of the impact on farming activities produced a weighted mean of 4.24, equal to the highest score recorded in the table. Nearly half of the respondents, 48.99%, classified the impact as very high, while 34.34% classified it as high. Together, 83.33% of respondents therefore considered the effect of soil pollution on farming activities to be high or very high. Only 6.06% considered the impact low or very low. This finding suggests that agricultural activities are among the most strongly affected livelihood components in the study area. Overall, the results demonstrate a clear pattern of high perceived severity and frequency of soil pollution impacts. The highest weighted means were recorded for the perceived severity of impacts on farming activities (4.24) and the frequency of observing oil spills or residues (4.24), followed by poor crop growth (4.14) and livelihood impacts (4.17). Health-related experiences recorded a slightly lower weighted mean (4.05), although most respondents still reported them as occurring often or very often. Taken together, Table 4.8 indicates that soil pollution is perceived by residents as a persistent environmental problem with important consequences for livelihoods, farming, crop productivity and community wellbeing. The high proportions of respondents reporting very high, high, very often and often responses provide strong descriptive evidence that the effects of oil-related soil pollution are experienced at the community level. These perceptions complement the laboratory findings on TPH, PAHs, heavy metals and soil biological properties presented in the preceding tables.

Hypothesis One: Soil pollution does not have any significant impact on the study area**Table 3: Summary of the Kruskal Wallis Test for the impact of soil pollution on the study area**

Perceived Impact of Soil Pollution	Ogula ha Mean Rank	Odimo di Mean Rank	Forcad os Town Mean Rank	Benibo ye Mean Rank	Yobe be Mean Rank	H	d f	Sig. (p)	Decisio n
Reduced agricultural productivity	198.42	201.36	194.18	192.47	203.61	0.842	4	0.933	Not significant
Decline in crop yields	195.76	203.84	198.52	190.63	201.24	0.967	4	0.915	Not significant
Reduced crop quality	202.31	197.46	195.72	194.18	200.36	0.713	4	0.95	Not significant
Difficulty growing crops	196.84	204.17	199.63	191.52	197.88	0.924	4	0.921	Not significant
Loss of farmers' income	201.73	198.42	202.15	189.76	197.94	1.126	4	0.89	Not significant
Reduction in farming activities	197.62	201.84	195.37	193.46	201.68	0.648	4	0.958	Not significant
Reduced household food availability	200.16	197.82	202.47	191.34	198.17	0.886	4	0.926	Not significant
Health risks from consuming crops	203.48	196.37	200.16	188.94	201.02	1.384	4	0.847	Not significant
Increased health problems	199.62	202.18	195.74	190.82	201.67	0.971	4	0.914	Not significant
Groundwater/water-source contamination	204.37	198.63	201.26	189.42	196.36	1.483	4	0.829	Not significant
Increased cost of living	198.74	201.62	202.18	191.37	196.26	0.934	4	0.92	Not significant
Reduced land value	201.83	197.16	200.72	192.46	198.03	0.754	4	0.944	Not significant

Effects on fishing livelihoods	203.16	199.42	196.84	190.37	200.21	1.174	4	0.882	Not significant
Visible soil degradation	204.73	196.84	201.36	188.72	198.35	1.562	4	0.816	Not significant
Overall livelihood impact severity	201.42	198.73	202.61	190.16	197.92	1.247	4	0.87	Not significant
Poor crop growth frequency	197.38	203.62	198.47	192.18	199.36	0.837	4	0.934	Not significant
Frequency of oil spills/residues	205.17	198.46	202.83	188.94	196.71	1.684	4	0.794	Not significant
Pollution-related health issues	200.82	202.37	197.16	190.63	201.04	1.014	4	0.908	Not significant
Severity of impact on farming	203.64	197.82	201.37	189.46	199.18	1.391	4	0.846	Not significant
Overall environmental impact	201.37	200.16	198.84	191.27	199.34	0.762	4	0.944	Not significant

Table 3 presents the results of the Kruskal-Wallis's test conducted to determine whether the perceived impacts of soil pollution differed significantly among Ogulagha, Odimodi, Forcados Town, Beniboye and Yobebe. The analysis covered the 20 indicators used to assess the effects of soil pollution on agriculture, livelihoods, health, food security, water resources and the general environment. The results show a remarkably consistent pattern across all the indicators. None of the Kruskal-Wallis tests produced a statistically significant result at the 0.05 level. The calculated H values ranged from 0.648 to 1.684, with corresponding p-values ranging from 0.794 to 0.958. Since all the observed p-values are greater than 0.05, there is insufficient statistical evidence to conclude that the perceived impacts of soil pollution differ significantly among the five communities. For the agricultural indicators, reduced agricultural productivity produced $H = 0.842$, $p = 0.933$, while decline in crop yields produced $H = 0.967$, $p = 0.915$. Reduced crop quality and difficulty growing crops similarly showed non-significant differences, with $H = 0.713$, $p = 0.950$ and $H = 0.924$, $p = 0.921$, respectively. These results indicate that perceptions concerning declining agricultural performance were broadly similar across the five communities. The socioeconomic effects also followed the same pattern. Loss of farmers' income recorded $H = 1.126$, $p = 0.890$, while reduction in farming activities recorded $H = 0.648$, $p = 0.958$. Reduced household food availability had $H = 0.886$, $p = 0.926$, and increased cost of living recorded $H = 0.934$, $p = 0.920$. The absence of significant differences suggests that the socioeconomic consequences associated with soil pollution were perceived similarly by residents irrespective of their community. Health and environmental indicators also showed no significant spatial variation. Perceived health risks from consuming locally grown crops produced $H = 1.384$, $p = 0.847$, while

increased health problems recorded $H = 0.971$, $p = 0.914$. Similarly, perceived groundwater or nearby water-source contamination had $H = 1.483$, $p = 0.829$. These results suggest that concerns about the health and water-related consequences of soil pollution were relatively uniform across the study locations. The indicators specifically measuring the frequency and severity of pollution also failed to demonstrate significant differences. Overall livelihood impact severity recorded $H = 1.247$, $p = 0.870$, poor crop growth frequency recorded $H = 0.837$, $p = 0.934$, and frequency of observing oil spills or residues produced $H = 1.684$, $p = 0.794$. The severity of the impact on farming activities also remained statistically similar across the communities, with $H = 1.391$, $p = 0.846$. The mean ranks further reinforce this interpretation (Wadi, Nweke, Silver, Alagjozovska, Segalerba, & Ibatova, 2026). Although some differences can be observed in the ranks, the differences are relatively small. For example, the mean ranks for frequency of oil spills or residues ranged from 188.94 in Beniboye to 205.17 in Ogulagha. Similarly, the mean ranks for visible soil degradation ranged from 188.72 in Beniboye to 204.73 in Ogulagha. These variations were not sufficiently large to produce statistically significant Kruskal-Wallis statistics. The overall environmental impact also showed no significant spatial difference, with $H = 0.762$, $df = 4$, $p = 0.944$. This is particularly important because it indicates that the general perception of environmental consequences was broadly consistent across all five communities. The impacts of soil pollution on the locals in the study area do not significantly vary among the study communities. Since the p-value for every indicator is greater than 0.05, the null hypothesis is not rejected. Therefore, the study concludes that there is no statistically significant spatial variation in the perceived impacts of soil pollution among Ogulagha, Odimodi, Forcados Town, Beniboye and Yobebe. This finding suggests that, although the communities may differ in their measured levels of soil contamination and individual mean ranks, residents generally experience or perceive the consequences of soil pollution in a similar manner. The result points to soil pollution as a common environmental and livelihood concern across the study area rather than a problem restricted to a particular community.

Discussion of Findings

The connection between soil physicochemical characteristics and heavy metals in the examined region

The results shown in Table 4.1 highlight a notable perceived connection between soil contamination and its effects on agricultural yield, crop quality, public health, and environmental factors. The consistently high weighted mean scores, varying from 4.19 to 4.37, indicate that participants predominantly link degraded soil conditions with negative impacts on both livelihoods and ecological systems. Particularly, observable soil degradation ($WM = 4.37$), contamination of groundwater ($WM = 4.31$), and diminished agricultural output ($WM = 4.30$) received the highest rankings, pointing out that the repercussions of changes in soil physicochemical properties—likely influenced by pollutants like total petroleum hydrocarbons (TPH) and heavy metals—are both evident and significant at the community level. These results correspond with recognized data that connects soil physicochemical decline with increased concentrations of heavy metals and hydrocarbon pollution in oil-producing areas. For example, the United Nations Environment Programme (2011) reported extensive soil pollution in the Niger Delta, indicating that petroleum hydrocarbons and related heavy metals notably modify soil structure, decrease fertility, and hinder agricultural productivity. Likewise, research by Iwegbue et al. (2013) on heavy metals in Niger Delta soils identified heightened levels of cadmium, lead, and chromium in soils from communities affected by oil, showing strong links between soil pH, organic matter content, and metal mobility.

The belief that soil contamination has affected groundwater (WM = 4.31) is further supported by findings from Ehirim and Nwankwo (2010), who indicated that hydrocarbon seepage in the Niger Delta results in the leaching of harmful substances into groundwater sources. This reinforces the relationship between soil physicochemical attributes and health risks to the environment. Additionally, the widespread agreement that consuming crops presents health dangers (WM = 4.30) corroborates findings from Aigberua et al. (2017) regarding heavy metals in food crops of the Niger Delta, which showed bioaccumulation of heavy metals in crops cultivated on contaminated lands. (Nweke. & Amachere, 2026). This implies that the physicochemical decline of soil not only influences agricultural production but also creates pathways for human exposure to hazardous substances. The results validate that modifications in soil physicochemical properties—particularly those affected by oil-related contaminants—are significantly linked to increased heavy metal levels and broader environmental and health effects. Merging community perceptions with laboratory findings enhances the reliability of this connection (Wadi, Prosper, Nweke, Sangtang, Haris, & Rautaray, 2026).

The intensity and occurrence of the impacts of soil contamination on livelihoods, agriculture, and health

The results presented in Table 4.2 demonstrates that soil contamination is regarded as both significantly serious and commonly occurring within the research area. The weighted average scores, which fall between 4.05 and 4.24, show that participants consistently viewed the effects as “high” to “very high” and experienced “often” to “very often.” The primary concerns identified include the regular sighting of oil spills (WM = 4.24), significant adverse effects on agricultural practices (WM = 4.24), and considerable disruption to livelihoods (WM = 4.17). These results align with previous research conducted in the Niger Delta, which emphasizes the ongoing and repetitive nature of oil-related soil pollution. For instance, a report by the Niger Delta Development Commission in 2006 indicated that repeated oil spills and inadequate remediation efforts have caused long-term soil deterioration and diminished agricultural output in local communities. In a similar vein, Ordinioha and Brisibe in 2013 discovered that communities facing frequent oil pollution reported increased health-related issues, which supports the high frequency of health problems linked to pollution (WM = 4.05) noted in this research. The elevated rates of poor crop development (WM = 4.14) confirm findings from Osuji and Onojake in 2004, which indicated that hydrocarbon contamination significantly hinders soil aeration, nutrient accessibility, and microbial functions, resulting in hindered plant growth. Additionally, the regular observation of oil residues (82.83% noting often/very often) corresponds with findings from Amnesty International in 2018, which stressed the extensive and recurrent nature of oil spills in the Niger Delta and the sluggish recovery efforts for the environment. The strong perception of impacts on livelihoods (WM = 4.17) and disruptions to farming (WM = 4.24) further reflect the research by Uyigue and Agho in 2007, which recorded how environmental degradation compels rural families to pursue alternative, often less sustainable means of survival due to decreasing agricultural yields. The findings suggest that soil pollution is not merely a rare or isolated occurrence but rather a persistent environmental challenge with far-reaching effects on agriculture, health, and socioeconomic stability. The alignment between community perceptions and empirical research highlights the validity of these results. (Nweke, Ihejirika & Deebom, 2018)

The Spatial variation in perceived impacts of soil pollution

The results of the Kruskal–Wallis test presented in Table 4.3 indicate that there are no significant statistical differences regarding the perceived effects of soil pollution among the five communities ($p > 0.05$ for every indicator). This implies that the impacts of soil pollution are similarly felt throughout the area under study, even though there may be differences in the levels of contamination observed. This result aligns with findings from regional studies like those by the United Nations Environment Programme (2011), which determined that oil contamination in the Niger Delta is prevalent and not limited to specific areas. Likewise, Nriagu et al. (2016) noted in their analysis of environmental contamination in the Niger Delta that the patterns of pollution in the region are widespread due to interlinked water systems and repeated incidents of spills. The absence of significant differences might also indicate that environmental exposure and economic activities are comparable across these communities. As stated by Ibaba (2010), rural areas involved in oil extraction commonly face similar environmental issues, resulting in uniform viewpoints on the effects of pollution. Consequently, the endorsement of the null hypothesis strengthens the understanding that soil pollution is an extensive and inherent problem in the study region, rather than being confined to a particular locale. This carries substantial implications for policy, suggesting that remediation efforts should encompass the entire region instead of targeting specific communities. Throughout the three analytical elements, the findings uniformly illustrate that soil pollution in the examined area is severe, prevalent, and collectively experienced. The significant consensus among participants, along with corroborating laboratory findings and alignment with previous empirical research, shows that degradation of soil physical and chemical properties—largely resulting from hydrocarbon pollution and related heavy metals—has extensive repercussions for agriculture, public health, and community livelihoods. The lack of marked spatial diversity further accentuates the widespread nature of the issue, emphasizing the necessity for thorough environmental management tactics throughout the Niger Delta area.

Conclusion

This research explored the connection between soil physical and chemical characteristics, heavy metal pollution, and the intensity and frequency of the negative effects of soil contamination on communities' livelihoods, agricultural practices, and health in selected regions of the Niger Delta. The results indicate that soil pollution is extensive and severe, with considerable consensus among the respondents concerning its detrimental influences on farming output, food safety, water supplies, and human well-being.

The elevated weighted mean results across various indicators confirm that soil degradation can be quantified through laboratory assessments and is also visibly affecting local residents. This is consistent with established scientific findings that oil extraction activities in the Niger Delta have resulted in significant soil, groundwater, and ecosystem contamination, which often surpasses acceptable environmental limits. The detection of heavy metals like lead, cadmium, and chromium at levels exceeding safety thresholds further highlights the environmental and health hazards linked to continuous exposure. Furthermore, the findings indicate that the consequences of soil contamination—especially regarding agricultural practices and local economies—are both common and grave. The lack of meaningful differences among various communities indicates that soil pollution is a widespread issue throughout the region instead of being confined to specific areas. This supports previous research showing that pollution in the Niger Delta is extensive due to years of oil extraction and poor environmental management. The research concludes that the degradation of soil physicochemical properties and the presence of heavy metals are closely related and have substantial effects on environmental health, food availability, and community well-being.

The ongoing nature of these effects emphasizes the pressing necessity for robust environmental policies, effective cleanup methods, and sustainable agricultural strategies in the area.

Recommendations

1. The government and pertinent organizations should initiate and thoroughly carry out extensive cleanup programs aimed at soils that have been polluted in the Niger Delta. Methods such as bioremediation, phytoremediation, and soil washing should be implemented to enhance soil health and lower heavy metal levels, aligning with guidelines for long-term ecological recovery in areas affected by oil activities.
2. It is essential to maintain ongoing assessments of soil quality and rigorously apply environmental laws through agencies like NESREA. Frequent evaluations of physicochemical metrics and heavy metal levels should be undertaken to guarantee adherence to ecological standards and to avert further pollution of agricultural land and aquatic resources.

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