



An Analysis of the Trends in the Causes of Oil Spills in the Communities of the Niger Delta from 2010 – 2024

BY

Christopher Basharu Obida

Department of Geography, Nigerian Defence Academy Kaduna

&

Elisha Emmanuel Maisamari

Nigerian Army Institute of Science, Education and Technology, Ilorin, Kwara State

Abstract

The Niger Delta is one of the richest oil producing regions of the world, accounting for a vast oil and gas reserve. It accounts for over 80% of Nigeria's foreign earnings. However, the region is replete with pervasive oil spills occurrence, with grave economic, social and environmental consequences. Many studies have explored the dynamics of oil extraction and spills in the region. What has not been done is an analysis of the putative causes of oil spills over a long period. In this study, statistical and mapping techniques were applied to an extensive database of oil spills from 2010 – 2024. The study objectives include: (i) To identify and categorize the main causes of oil spills in the Niger Delta, (ii) To assess the temporal trends of oil spills causes, (iii) To identify the relationship in the trends of oil spills causes, (iv) To determine the spatial patterns and (v) To identify oil spills hotspots in the region over the study period. Over the study period, sabotage, operational and "other" categories were identified as major causes of oil spills, each accounting for 79%, 16% and 5% of total oil spills occurrence respectively. A significant temporal variation exist in the scale and frequency of the causes of oil spills, with 2013 and 2020 accounting for the highest and lowest prevalence rates respectively. There is a weak correlation between the occurrence of sabotage as the leading cause of oil spills and operational and other causes (0.2 and 0.4), while there is a strong correlation of 0.8 between the operational and other causes. The study also showed there is no statistical trend in the occurrence of sabotage with an R^2 value of 0.01, while there is a decreasing trend in the occurrence of operational and others causes of oil spills. Communities in Bayelsa, Delta and Rivers states represents the worst affected in terms of spills hotspots in the Niger Delta. These findings provides a framework for the holistic characterization of the causes of oil spills in the Niger Delta. Therefore, the study could facilitate targeted anti-sabotage measures and improvements in operational safety and maintenance culture. It could further form the basis for future stricter regulatory and policy framework for the region, setting grounds for future in depth study of political and socio-economic drivers of oil spills occurrences.

Keywords: Oil spills, Sabotage, Operational causes, Hotspots, Trends



1. Introduction

The Niger Delta Region of Nigeria is one of the richest oil producing areas of the world, contributing over 80% of Nigeria's foreign exchange (Mba et al., 2019). Despite its significant contribution to the Nigerian economy since oil exploration began in 1958, it has been plagued by oil spills. These spills have over the years led to severe environmental degradation, loss of biodiversity, and negatively impacted the means of livelihood of impacted communities (Obida et al., 2018). Despite government regulations and intervention efforts, oil spills have continued to occur, leading to growing concerns about the causes of oil spills in the region.

The causes of oil spills in the Niger Delta has been attributed to many factors, including pipeline sabotage, illegal oil bunkering, corrosion of pipeline infrastructure, operational failures and inadequate oversight among others (Nimisnghi Sanchez et al., 2021; Osuagwu & Olaifa, 2018). The growing debates on the prevalence of these causes are skewed based on the various actors. While oil companies routinely adduce the causes to sabotage and third-party interference as the primary causes, local communities and civil societies often cite operational negligence and aging infrastructure.

This study critically examined the trend in the causes of oil spills in the communities of the Niger Delta over a 15-year period. It is particularly relevant for analysis, because the period covers important developments in regulatory policy such as the Petroleum Industry Bill 2021 (Ejokema et al., 2023), and increasing domestic and international pressure. Similarly, improvements in corporate accountability and technological advancement in oil spill prevention and detection during the 15-year period necessitate the study.

Despite many intervention efforts by government, corporate and local entities, oil spills persist pervasively in the Niger Delta. In 2020 alone, over 400 oil spill incidents have been reported, devastating thousands of hectares of land and the aquatic ecosystem (Ele, 2022). Conflicting accounts on the main causes of the spills between actors such as oil companies, civil societies and local communities are indications of the complexities of the oil spill problem. Oil companies often frame sabotage and theft as the main cause, thereby conveniently deflecting liability (Amnesty International, 2018). Conversely, local



communities and civil societies have continued to argue such claims are routinely exaggerated to avoid the payment of compensations and remediation responsibilities (FOEI, 2021). This necessitates the growing interest in oil spill research, due to its severe impacts and complexities.

There is a gap in empirical research seeking to synthesize spill data over a sustained period, while critically examining the trends in the multiple causal factors across communities in the Niger Delta region. This study sets out to fill the gap and contribute to the growing need for empirical evidence by analysing trends in primary causes of oil spills in the Niger Delta communities between 2010 – 2024. This study aims to examine the trends in the causes of oil spills in the Niger Delta from 2010 – 2024. Specific objectives include: (a) To identify and categorize the main causes of oil spills in the Niger Delta. (b) To assess the temporal trends of oil spills causes over the study period. (c) To identify the relationship in the trends of oil spills causes in the Niger Delta.

(d) To determine the spatial patterns of oil spills in the Niger Delta.

(e) To identify oil spills hotspots in the region over the study period.

2. Materials and Methods

2.1. Study Area

The Niger Delta region is in Southern Nigeria, encompassing nine oil producing states including Rivers, Bayelsa, Delta, Edo, Akwa Ibom, Edo, Ondo, Cross River, and Abia states. The vegetation of the Niger Delta is characterized by the tropical rain forest, mangrove swamps and swamp forests, making it rich in biodiversity. It serves as a critical wildlife habitat, making it a highly sensitive ecological zone, crucial for the support of livelihood of the local community (Wekpe et al., 2024b).

In terms of the climate, the Niger Delta has the equatorial climate, characterized by high temperatures and heavy rainfall all through the year. The climate is predominantly influenced by the proximity to the equator and the Gulf of Guinea. This results to warm temperatures and a small annual temperature range (Umar et al., 2021).



The study area is characterized by a dense network of pipelines and associated oil and gas infrastructure (Ele, 2022; Raji et al., 2013). This makes the region vulnerable to oil spills. Overall, the study area holds enormous socio-economic and ecosystems services significance, hence the need for the in-dept understanding of trends, spatial distribution and dynamics of oil spills.

2.2. Data Sources

The data used for this study was primarily sourced from the (National Oil Spills Detection and Response Agency (NOSDRA), which is the official government agency responsible for maintaining oil spills data. Oil spill data from 2010 – 2024 were downloaded from the NOSDRA website available at (<https://nosdra.oilspillmonitor.ng/oilspillmonitor.html>). The information provided include spill dates, quantity, location, cause of spill and the type of infrastructure. These details are determined by a process called the Joint Investigation Visit (JIV) comprising of NOSDRA staff, oil companies' representatives, local authorities and community members, to ensure transparency (Ukiwo, 2018). This validates the data used in this study.

2.3. Characterization of the Causes and Trend of Oil Spills in the Niger Delta

Descriptive statistics was used to summarize the data, to provide insights into the causes, distribution and magnitude of oil spills (Amakama et al., 2021). Frequency counts and percentages by causes were performed. In addition, summary statistics and time series analysis to determine temporal trends of oil spills causes were performed (Obida et al., 2018; Wekpe et al., 2024b)

2.4. Identification of Relationships in the Trend of Causes of Oil Spills

Initially, a correlation analysis was performed in the XLSTAT Software to determine the relationships and inter-dependence between the different causes of oils spills. Subsequently, a regression analysis was employed to determine temporal relationships and trends in the causes of oil spills, over the 15-year study period. To test for association in the distribution of the leading causes of oil spills the study area, a Mann-Whitney Test



also known as Wilcoxon Rank Sum non-parametric test was used. This statistic was used because it does not assume a normal distribution and could be applied on independent variables. The null hypothesis states that there is no difference in the distribution between the leading causes of oil spills over the study period, while the alternative hypothesis states that there is a significant difference in the distribution between the causes of oil spills.

2.5. Identification of the Spatial Patterns and Oil Spills Hotspots

Quantum Geographic Information System Software, an advanced geospatial analytical suit was used for spatio-temporal mapping of oil spills to determine spatial trends in oil spills over time (Obida et al., 2018; Umar et al., 2019; Wekpe et al., 2024a). Kernel Density Estimation and Gestis-Ord Gi statistics was used to map oil spills concentration and statistically significant hotspots (Chen & Yang, 2019; Wekpe et al., 2024b). Generated maps shows high-risk areas for sabotage and operational failures, patterns of spills hotspots and regional disparities in oil spills occurrences (Anyanwu et al., 2025).

3. Results

3.1. Identification and Categorization of the Causes of oil spills in the Niger Delta from 2010 – 2024

Descriptive statistics was applied on the 14,105 oil spills data from January 2010 to December 2024 to categorise the causes of oil spills in the communities of Niger Delta. Figure 4.1 shows the categories of the causes of oils in the region from 2010 to 2024. The figure indicates sabotage as the leading cause of oil spills in the Nger Delta, accounting for 79% (11,062) of all oil spills occurrences in the area during the study period. Similarly, operational causes accounts for 16% (2,314) of total oil spills in the area as the second leading cause of oil spills. Conversely, other causes account for 5% (729) as least cause of oil spills in the Niger Delta communities.

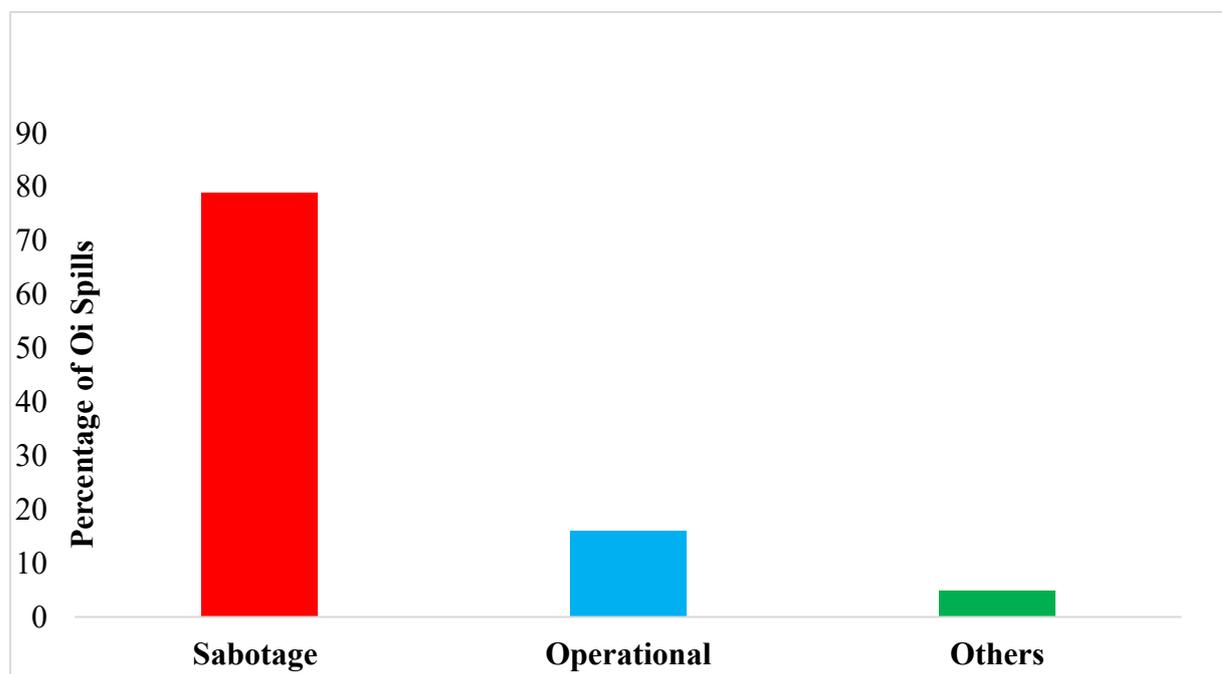


Figure 4.1. Percentage of Oil Spills Causes in the Niger Delta (2010 – 2024).

Table 4.1 shows the summary statistics of the cause of oils spills based on the total 14,105 analysed oil spills incidents. The table presents a clearer description of the disparity in the means and variance of the 3 causes of oil spills in the Niger Delta. The results represented in a boxplot as shown in Figure 4.2 clearly demonstrates that in the entire 15-year study period, the minimum annual sabotage contribution to oil spills (335) is greater than the maximum contribution of operational causes (247) of oil spills. The figure thus clearly shows sabotage as one major cause of oil spills in the Niger Delta.

Table 4.1. Summary Statistics of the Causes of Oil Spills in the Niger Delta (2010 – 2024).

Statistic	Sabotage	Operational	Others
No of observations	15	15	15
Minimum	335.000	107.000	15.000



Maximum	1310.000	247.000	146.000
1st Quartile	515.000	113.500	24.000
Median	654.000	137.000	35.000
3rd Quartile	898.500	202.000	62.000
Mean	737.467	154.267	48.600
Variance (n-1)	89054.124	2341.924	1291.114
Standard deviation (n-1)	298.419	48.393	35.932

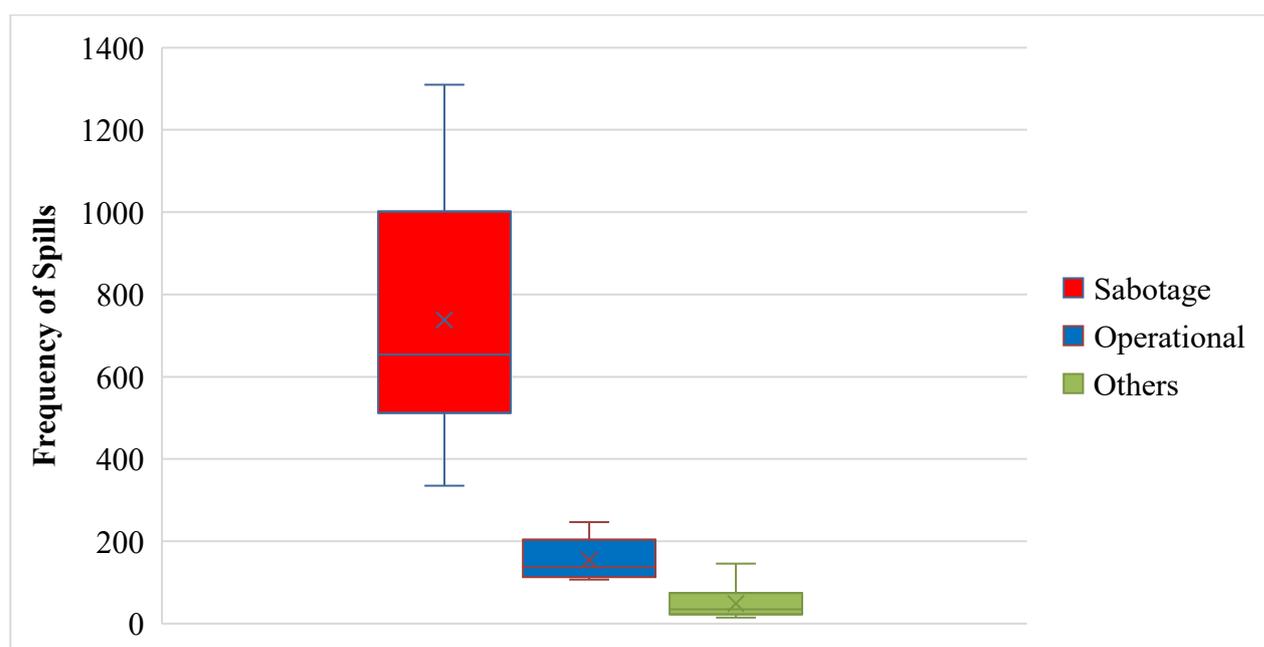


Figure 4.2. Causes of Oil Spills in the Niger Delta (2010 – 2024).

3.2. Temporal Trend of Causes of Oil Spills in the Niger Delta from 2010 – 2024

Initially, to understand the general trend in oil spills occurrences in the Niger Delta, descriptive statistics was used to show the annual frequency of oil spills in the study area. Figure 4.3 shows the annual distribution of the 14,105 analysed oil spills. The figure



shows general variation in oil spills occurrences over the study period, with 2013 and 2020 having the highest and lowest oil spills occurrence respectively. The figure shows that over the 15-year study period, there is no obvious general increasing or decreasing trend.

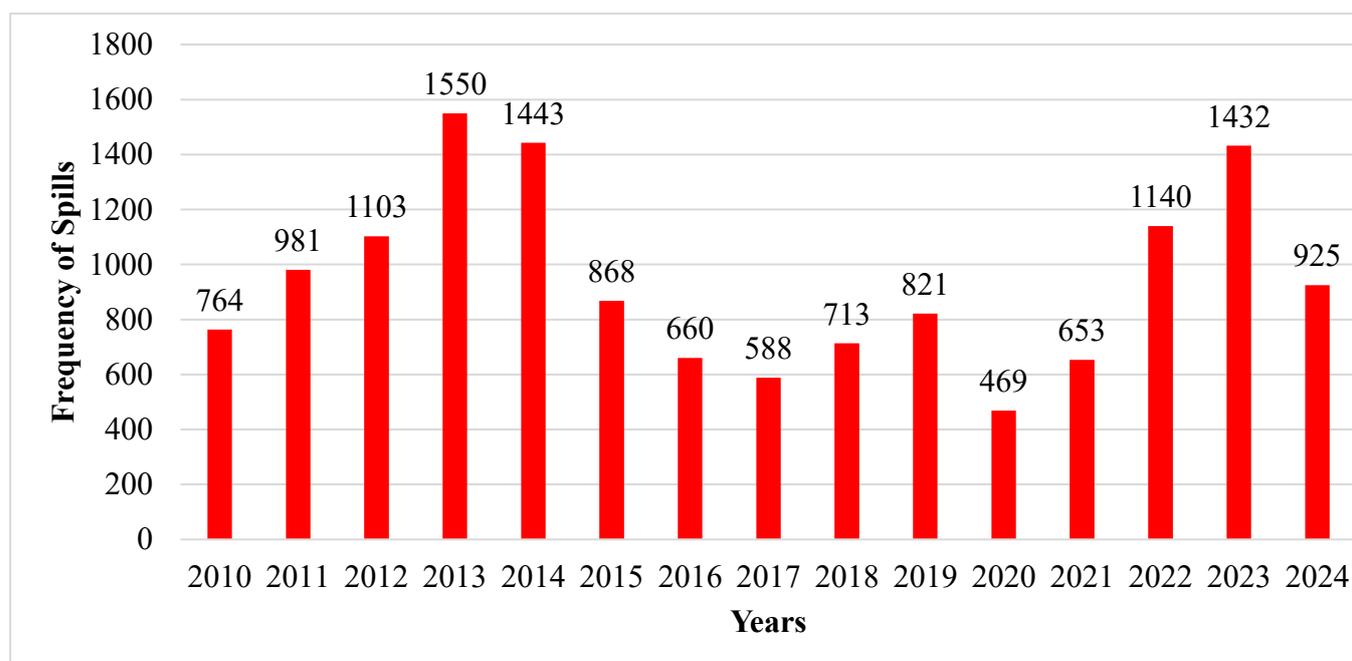


Figure 4.3. Temporal Trend of Oil Spills in the Niger Delta (2010 – 2024).

The trend shown in Figure 4.3 demonstrate many factors could be contributing to oil spills occurrence in the study area. Similarly, Figure 4.4 shows the temporal trend of oil spills according to causes over the study period. Expectedly, having accounted for 79% of all the 14,105 analysed spills, the figure shows sabotage as the highest contributor to oil spills over the study period and area. Across the study period, sabotage is the singular most prevalent cause of oil spills in the Niger Delta. The figure shows there is a marked variation between sabotage and operational causes of oil spills. Conversely, while there is no increasing or decreasing trend in sabotage, there is subtle decreasing trend in operational causes of oil spills as shown in the figure. For example, since 2010 which has the highest number of spills caused by operational reasons, there has been relatively consistent decrease in operational causes of oil spills. Similarly, other causes of oil spills contribute the least to the temporal oil spills frequency. Figure 4.4, like the operational causes of oil spills, also shows other causes category which represents spills with either



unknown or natural causes appears to show a decreasing trend over the study period.

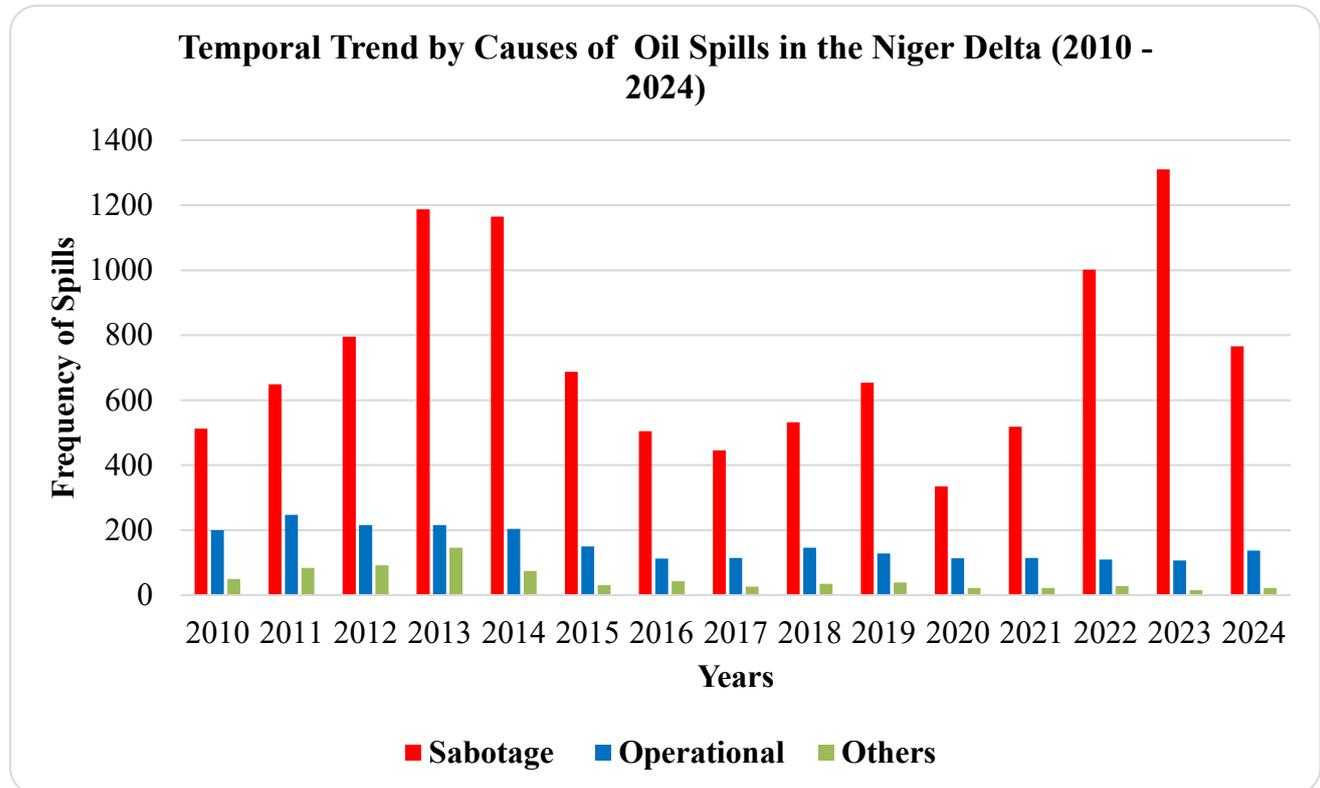


Figure 4.4. Temporal Trend by Causes of Oil Spills in the Niger Delta (2010 – 2024).

3.3. Determining the Relationship in the Trends of Oil Spills Causes in the Niger Delta from 2010 – 2014

To determine statistical relationships and association between the causes of oil spills in the study area, a regression analysis was performed, and the details of the summary statistics is shown in Table 4.2. The results shows a weak correlation between sabotage and operational and other causes, with correlation values of 0.2 and 0.4 respectively. Conversely, Table 4.2 shows a strong relationship between operational and other causes of oil spills, with a correlation value of 0.8, which could be due to the similar decreasing trend of these causes of oil spills over the study period.



Table 4.2. Correlation Matrix of the Causes of Oil Spills (2010 – 2024).

	Sabotage	Operational	Others
Sabotage	1	0.2	0.4
Operational	0.2	1	0.8
Others	0.4	0.8	1

Figure 4.5 shows the summary of the regression plot of the 3 categories of the causes of oil spills in the study area over a 15-year period. The graph reveals a relatively flat regression line for sabotage, the leading cause of oil spill in the Niger Delta. Conversely, as expected, operational and other causes of oil spills shows a decreasing trend in oil spills occurrence over the study period. Table 4.3 which is the summary of the goodness of fit of the three variables of causes of oils spills reveals the statistical evidence. The table shows sabotage has an R^2 value of 0.01, denoting a very weak or neutral trend, while operational causes with an R^2 value of 0.7 shows a strong downward trend in the contribution of operational causes of oil spills. Similarly, the other cause of oil spills shows an average R^2 value of 0.5 denoting a moderate correlation in terms of decreasing trend over the years.

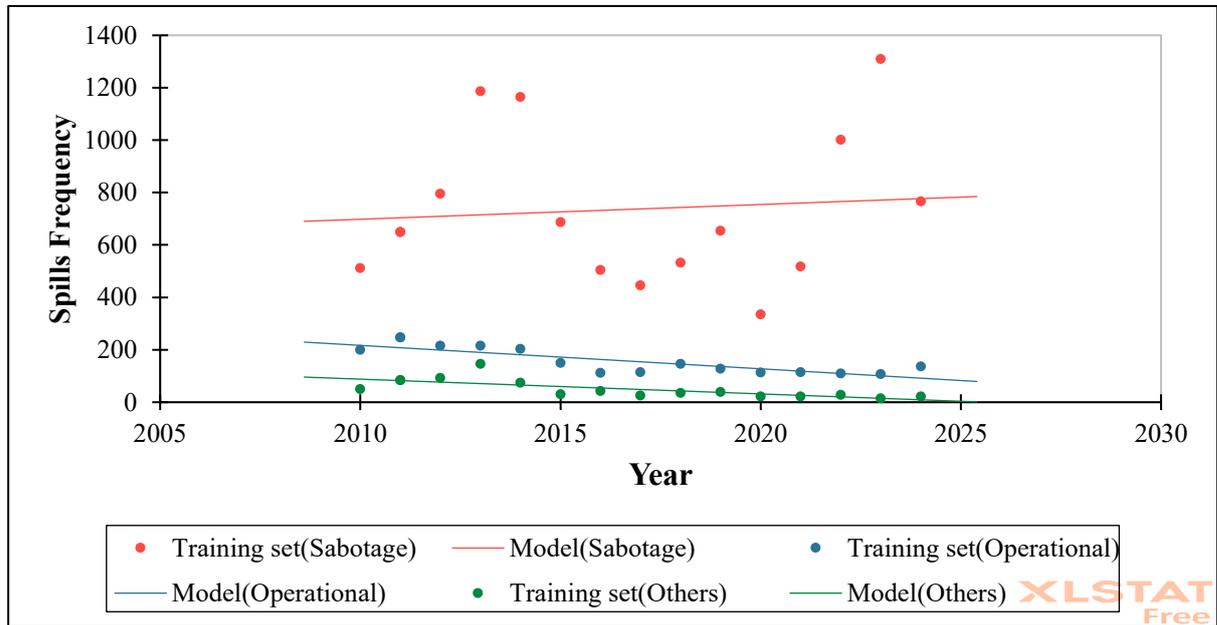


Figure 4.5. Regression of the Causes of Oil Spills in the Niger Delta (2010 – 2024).

Table 4.3. Goodness of Fits Statistics for Causes of Oil Spills (2010 – 2024).

	Sabotage	Operational	Others
R ²	0.01	0.7	0.5
F	0.10	27.86	12.46

Having identified the trends, and the leading causes of oil spills in the communities of the Niger Delta, Mann-Whitney two tailed non-parametric test was applied determine the relationship in the trend between the 2 leading causes, sabotage and operational causes. Tables 4.4 and 4.5 is the summary statistics and the results of the Mann-Whitney test. The results show a p-value of <0.0001, which is lower than the significance level alpha of 0.05, the null hypothesis is rejected. Figure 4.6 reveals the graphical evidence in support of the test statistics. The figure shows a marked difference in the median, means and overall distribution of oil spills caused by sabotage and operations. This confirms sabotage as the dominant and most significant cause of oil spills in the Niger Delta.



Table 4.4. Summary Statistics for Sabotage and Operational Causes of Oil Spills in the Niger Delta (2010 – 2024).

Variable	Observations	Minimum	Maximum	Mean	Standard deviation
Sabotage	15	335.00	1310.00	737.47	298.42
Operational	15	107.00	247.00	154.27	48.39

Table 4.5. Mann-Whitney 2 Tailed Test Between Sabotage and Operations Causes of Oil Spills (2010 – 2024).

U	225
U (standardized)	4.647
Expected value	112.500
Variance (U)	580.991
p-value (Two-tailed)	<0.0001
Alpha	0.05

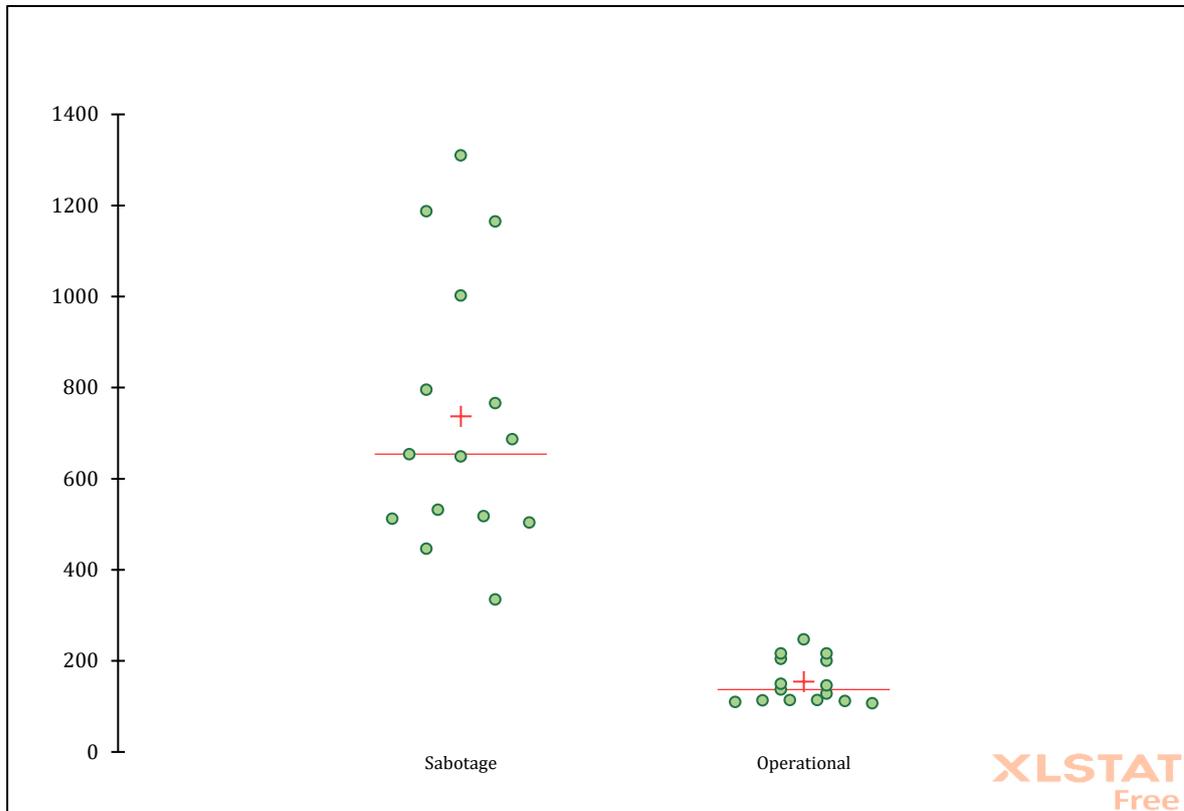


Figure 4.6. Statistical Distribution of Sabotage and Operational Causes of Oil Spills in the Niger Delta (2010 – 2024).

3.4. Spatial Patterns and Oil Spills Hotspots in the Communities of Niger Delta from 2010 – 2024

Figure 4.7 shows the spatial trends in the communities of Niger Delta. The figure reveals configuration of spills largely occurring on pipelines, hence the straight patterns. While, pipelines are not the only vulnerable oil infrastructure, the figure reveals it is the most vulnerable. Other disparate oil spills locations are likely from oil infrastructures such as flow stations and depots, an indication of overall vulnerability of oil and gas infrastructure in the region. The figure also reveals, all the 3 causes of oil spills are characterized by a large spatial variation, however, sabotage appears to be less prevalent offshore, likely due to logistical challenges or issues around investigation and accurate reporting. Generally, the figure provides a more relatable picture on the details and prevalence of the different



causes of spills, further consolidating the statistical findings, largely focused on temporal, rather than spatial trends.

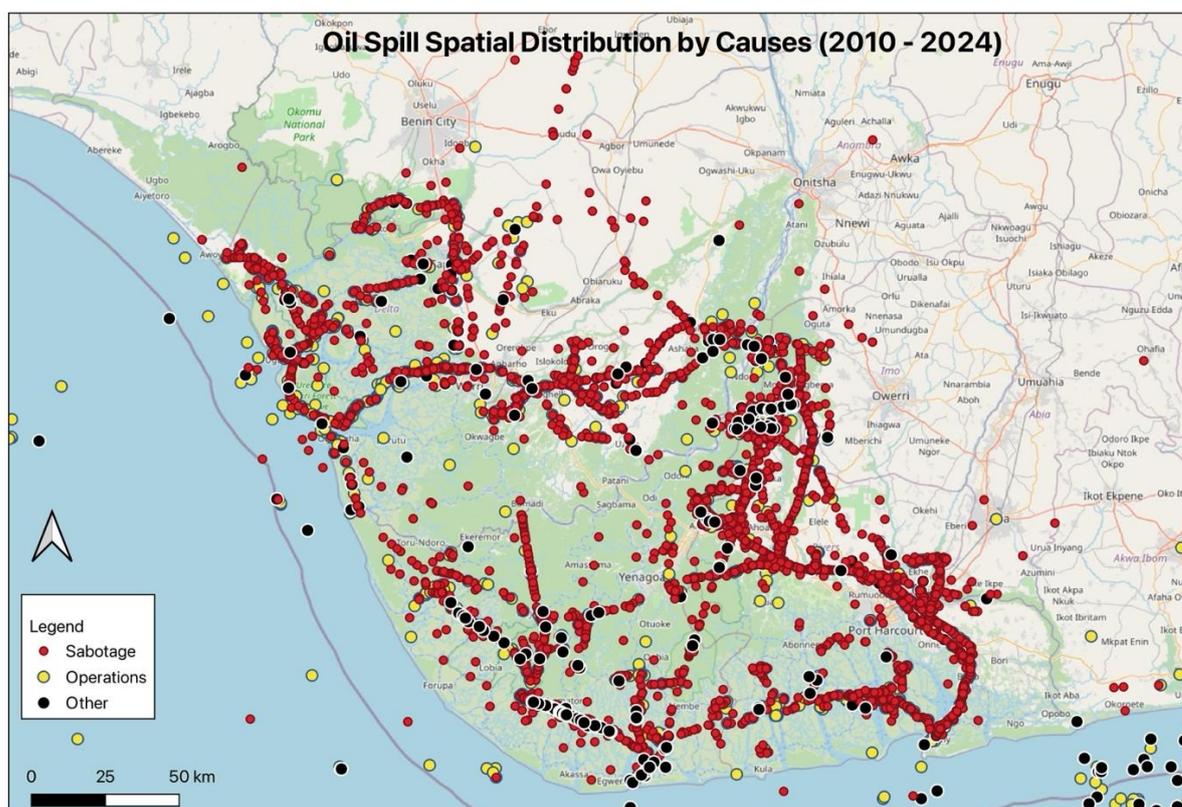


Figure 4.7. Spatial Distribution of Oil Spills by Causes from 2010 – 2024.

Conversely, Figure 4.8, employing the advanced Kernel Density Estimation method, an advanced geostatistical technique reveals oil spills hotspots location in the communities of Niger Delta. Unlike Figure 4,7 which reveals patterns of spills occurrence, the figure identifies areas with statistically significant high frequencies of oil spills. The figure reveals Bayelsa, Rivers and Delta states as the worst affected states witnessing oil spills. Communities such as Igbematoru, Lobia, Akassa and Akinima of Bayelsa, Ebocha, Omoku, Akabuka,Ahoad, Bodo, Onne, Rumuoumaya all in Rivers, and Ugorodo, Ugheli, Ogulagha in Delta state are all notorious oil spills. While a single oil spill should attract concerns, however, Figure 4.8 provides a framework for evidence-based mitigation and interventionist framework in resolving the challenges associated oil spills in the region.

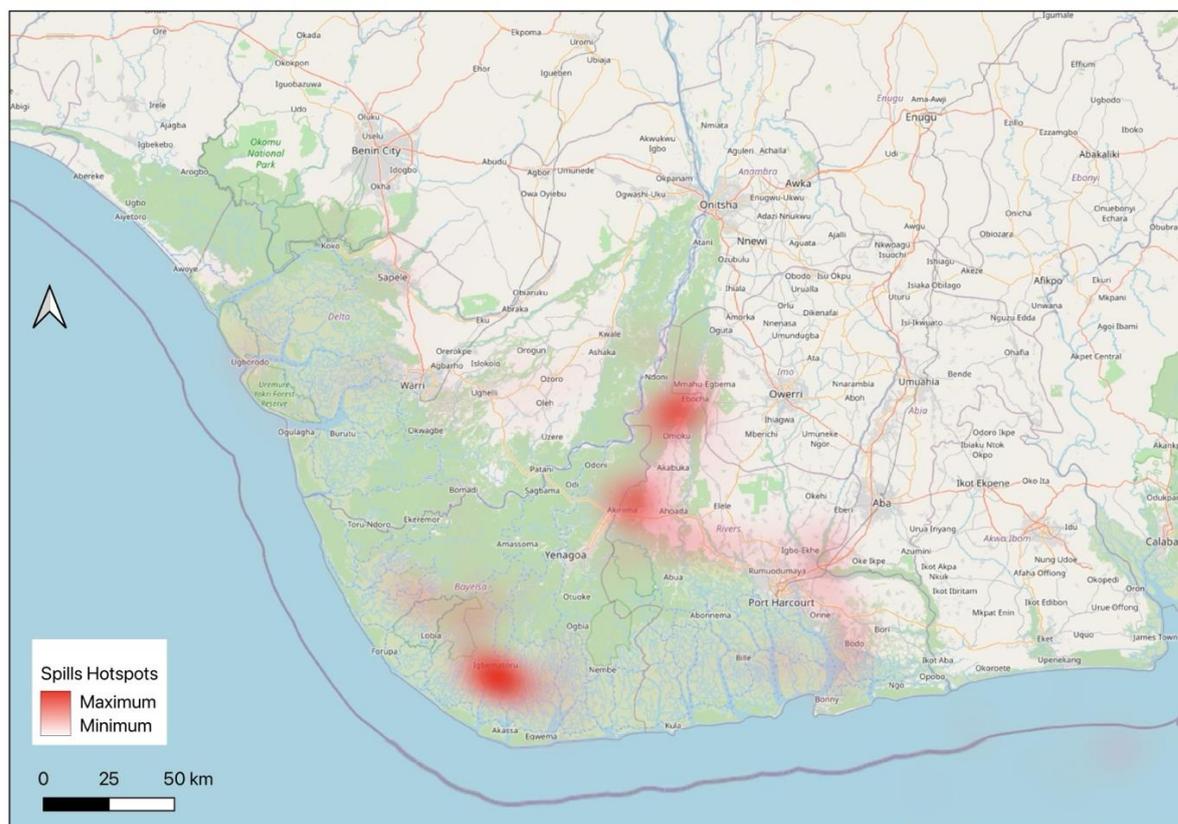


Figure 4.8. Oil Spills Hotspots in the Communities of Niger Delta from 2010 – 2022.

4. Discussion

The study reveals sabotage as the leading cause of oils spills, contributing 79% of the total 14,105 spills occurrences from 2010 – 2024. It demonstrates the dominance of sabotage over operations and other categories with 16%, and 5% respectively. The prevalence of sabotage in the Niger Delta could be due to some underlying factors such as weak regulatory frameworks in the oil gas governance value chain. However, the scale of sabotage is unlikely to be only caused by gaps in regulations. Other underlying factors such as systemic socio-economic deprivation such as social inequality, unemployment, and pervasive poverty in the communities of the Niger Delta could contribute to the patterns of sabotage. Overall, the economic, environmental, and social consequences of oil exploitation and exploration have led to a cycle of deprivation for the communities of



the Niger Delta, which could be contributing to sabotage as the leading cause of oil spills in the Niger Delta.

The pervasive oil spills in the communities of Niger Delta has dire consequences for the human and environmental health. Oil spills have led to severe environmental degradation, contaminating land, water, farmlands, fisheries, human health and overall ecosystems services. Human exposure to oil spills can cause a range of health problems, these include respiratory issues, skin, neurological defects and potential long-term health complications. Similarly, oil pollution of have linked to widespread environmental degradation. While operations and other causes of oil spills require attention, addressing sabotage through a compressive and effective framework comprising, government, the oil companies and the local communities, is essential.

The study also revealed a variation in number of spills contributed by the causes of oil spills over the 15-year period. The variation is more dominant in sabotage as the leading cause of oil spills in the Niger Delta. It was revealed that the operations and other causes showed little variation, by showing a consistent decreasing trend. This could be likely due to improvements in maintenance of oil infrastructure and operation practices and associated improvements in identification of the cause of oil spills thereby reducing the others category over the study period. The variation in number spills contributed by sabotage with the highest in 2023 (1,310) and lowest in 2020 (335), indicates sabotage is determined by complex factors as earlier suggested.

The decreasing trend in both operational and other causes of oil spills over the study period will need to be sustained. It has been argued that the PIA may potentially contribute to this trend due to holistic approach in resolving problems in the entire oil and gas sector. Some of the laudable components of the PIA include institutionalization of effective corporate governance, strengthening institutional regulatory framework, provision for the sustainable development of the host communities and a comprehensive environmental management plan among others. It can then be argued that the relationship between operations and other causes of oil spills which both showed a decreasing trend may be due to improvements in overall operations by oil companies. However, since cases of sabotage



has also increased in the same period, the holistic impact of the PIA is still a subject of further interrogation.

Expectedly, an assessment of the trends between the 2 leading causes of oil spills which include sabotage and operations, shows a significant statistical difference. This indicates addressing sabotage will overall have positive impact on oil spills trend in the Niger Delta.

The spatial patterns of oil spills in the communities of Niger Delta show a distinct pattern with costal states of Bayelsa, Rivers and Delta as worst affected and oil spills hotspot. This could be partly explained as argued by the theory of political ecology, these states are critical in oil exploration and exploitation, due to the density of such extractive activities. The theory argued that preference for economic and political dominance over the welfare of the local communities may contribute to the observed pattern. This argument is supported by the theory of environmental criminology, which argues the vagaries of the environment as principal in in the occurrence of crime such as sabotage. The density of the oil and gas infrastructure in the region, coupled with low levels of sustainable livelihoods could contribute to the observed oil spills trend, particularly, sabotage.

5. Conclusion

This study evaluated the trends in the causes of oil spills in the Niger Delta from 2010 – 2024, critical insights into the dominant factors contributing to environmental degradation in the Niger Delta were revealed. Findings showed sabotage as the leading cause of oil spills. It accounted for 79% of total spill incidents, extensively exceeding operational failures with 16% and other causes with 5% respectively. The study revealed the occurrence of sabotage remained steadily high all through the study period, with no significant trend ($R^2 = 0.01$), thus suggesting persistent security and socio-economic challenges driving the phenomenon.

Conversely, operational and other causes of oil spills showed a declining trend with R^2 values of 0.7 and 0.5 respectively. These decline maybe likely due to improvement industry standards and regulatory procedures. Notable variations in spills frequency was revealed with 2013 recording the highest incidence and 2020 the lowest, showing the



possibility of influence by changing socio-political and economic circumstances.

A weak relationship between sabotage and operational/other causes with correlation coefficient of 0.2 and 0.4 respectively, implies these factors operate independently, while a strong correlation between of 0.8 between operational failures and other causes indicates overlapping factors facilitating their occurrence.

The persistent dominance of sabotage highlights the need for a multi-faceted intervention effort. These include enhanced surveillance, alternative means of livelihood programmes, community engagements and stricter enforcement of anti-sabotage regulations. Meanwhile, the decline in operational and other and other spills suggests an improvement in the overall maintenance and stakeholders' management practices, which should be expanded and sustained. In addition, communities in Bayelsa, Rivers and Delta states have been identified as notorious oil spills hotspots and could be the focus of any intervention efforts.

This study contributes to the understanding of spatiotemporal dynamics of oil spills in the communities of the Niger Delta. It emphasizes the need for urgent effort at addressing sabotage, while sustaining efforts to reduce operational failures and other causes. Future research could explore the political and socio-economic drivers of sabotage and evaluate policy interventions focused at the reduction of spill incidents in the region.

Declarations

Acknowledgment

We thank NOSDRA for providing and granting access to the oil spill data.

Competing interest

The manuscript is an original contribution that has not been published before, whole or in part, in any format, including electronically. All authors will disclose any actual or potential conflict of interest including any financial, personal, or other relationships with other people or organizations that could inappropriately influence or be perceived to influence their work, within three years of beginning the submitted work.



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