Journal of Environmental Protection, 2022, 13, 750-765
https://www.scirp.org/journal/jep
ISSN Online: 2152-2219
ISSN Print: 2152-2197

Assessment of Locational Compliance Status of Petroleum Products Handling Facilities in Niger Delta Region, Nigeria

Njideka Jia, Ify L. Nwaogazie*, Prince Mmom

Centre for Occupational Health, Safety & Environment (COHSE), University of Port Harcourt, Port Harcourt, Nigeria
Email: *ifynwaogazie@yahoo.com

How to cite this paper: Jia, N., Nwaogazie, I.L. and Mmom, P. (2022) Assessment of Locational Compliance Status of Petroleum Products Handling Facilities in Niger Delta Region, Nigeria. *Journal of Environmental Protection*, **13**, 750-765.
https://doi.org/10.4236/jep.2022.1310048

Received: September 21, 2022
Accepted: October 23, 2022
Published: October 26, 2022

Abstract

This study was aimed at assessing the locational compliance status of petroleum handling facilities in the Niger Delta to the specifications of the Nigerian Upstream Petroleum Regulatory Commission (NUPRC) locational standards. A cross-sectional research design was employed using a Standard checklist of seventeen compliance specifications of NUPRC. A walk-through survey was carried out in 118 identified facilities in three locations: Eket in Akwa-Ibom State, Port Harcourt in Rivers State and Warri in Delta State, respectively. The data obtained were analyzed using inferential and descriptive statistics, Kendall Tau-B and Principal Component analyses. The results indicate that the Petroleum Product facilities complied with 6 (35.29%) out of 17 specifications while 11 (64.70%) specifications were violated. Locations compliance of stations in the Niger Delta region is generally poor, but Stations in Port Harcourt recorded a higher compliance rate compared to Eket and Warri. Results of Kendall's tau-b and Principal Component analysis indicated positive association between all the land space locational compliances. This study attributes the poor compliance rate to rapid urbanization, overpopulation, proliferation of filling stations and poor monitoring by regulatory agencies. It is recommended that, NUPRC should improve its monitoring and enforce regulatory operational specifications.

Keywords

Locational Compliance, Petroleum Handling Stations, Monitoring. Filling Stations, Niger Delta

1. Introduction

The use of Petroleum Products in meeting the enormous demand for energy generation has continued to increase despite recent technological advancement in the developments in Biofuel. This indicates that the use of fossil fuel will continue for many more years despite the new technologies and the need for more filling stations will be inevitable [1]. However, these facilities are highly hazardous due to the high flammability and explosive nature of the stored and dispensed petroleum products, [2]. In the past decades, several explosions and fires have occurred in different parts of the world with catastrophic consequences resulting in large numbers of fatalities, huge losses to assets with adverse impact to the environment. Examples include: the Indian Oil Corporation Ltd explosions and the Pemex Gas Facility explosion and fire in Mexico, in 2012, which reportedly killed 26 people among several other damages [3]. Several explosions have also taken place in Nigeria in recent times. An explosion at a gas filling station at Lafia, Nasarawa State caused 9 fatalities in 2018 [4].

Scientific studies have attributed the large number of casualties caused by these explosions to factors such as the poor compliance to Land Use Acts due to lack/inadequate enforcement of Land Use by the appropriate agencies and the inadequate fire and explosion risk assessment which failed to address the safety of the neighboring communities [5] [6] [7]. Poor siting of petroleum product facilities has been often blamed on limited land area due to rapid urbanization and overpopulation [8] [9] [10]. [11] Showed that 86% of the filling stations did not comply with the 100 m Minimum Setback from Health care Facilities while 84% did not meet the Minimum Safe Distance to other filling stations in Kaduna Metropolis as required by the NUPRC Standards. However, [6] reported that more than 50% of the sampled filling stations complied with the 400 m distance requirement to another filling station. [2] rated buildings within 100 m of petrol stations as moderately at risk of fire and explosion while those within 50 m were rated as high risk.

The Niger Delta region is characterized by intensive oil and gas activities which elicited rapid urbanization and overpopulation [12]. Consequently increased demand for petroleum products has resulted in an alarming rate of proliferation of Filling stations and remodeling of single Liquid product-based handling stations into dual product-based facilities (combined Petrol and Liquefied Petroleum Gas filling stations), thereby increasing the vulnerability of workers and communities adjacent to these stations to fire and explosion hazards, [13] [14]. The region has equally had its share of poor compliance and inadequate enforcement of Land Use Act, [8].

There is therefore a need for effective assessment of the Locational compliance status of these petroleum handling facilities to the regulatory specifications of the Nigerian Upstream Petroleum Regulatory Commission (NUPRC).

2. Materials and Methods

2.1. Study Area

The study area was the Niger Delta Region which is situated in the southern part of Nigeria where the River divided into many tributaries before emptying into the Atlantic Ocean. Niger Delta Region, sits on the Gulf of Guinea on the Atlantic Ocean between Latitude 3˚N and 6˚N and Longitude 5˚E and 8˚E. It is made up of nine States. Three cities namely Warri in Delta State, Port Harcourt in Rivers State and Eket in Akwa-Ibom State were selected for this study (See **Figure 1**).

Eket is an industrial city with an estimated population size of over 200,000. The Latitude of Eket is 4.646736 and longitude 7.942942. It is the second largest urban population in Akwa Ibom State [15]. Port Harcourt is the capital city of Rivers State located between latitudes 4˚51'30"N and 4˚57'30"N and longitudes 6˚50'00"E and 7˚00'00"E. with an estimated population size of about 3 million persons [16]. Warri is the Headquarter of the Warri South Local Government Area in Delta State. The Latitude of Warri is 5.544230 and longitude is 5.760269. It has a land area of approximately 1520 square kilometers.

2.2. Study Design

This study adopted a descriptive cross-sectional design according to [17]. The Flowchart for the Study design is shown in **Figure 2**.

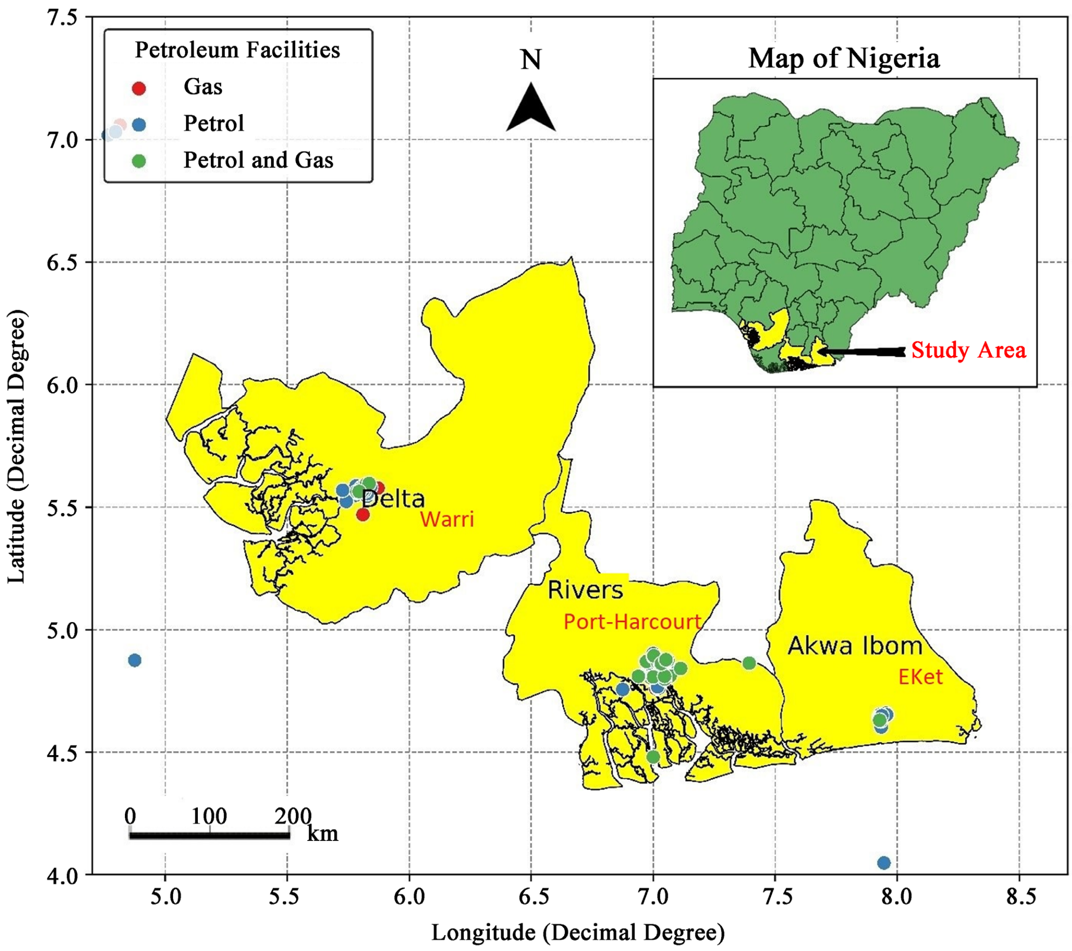

Figure 1. Map of the study location. (Source: Geographic Information System (GIS) Unit, Department of Geography, University of Port Harcourt, Rivers State, Nigeria.)

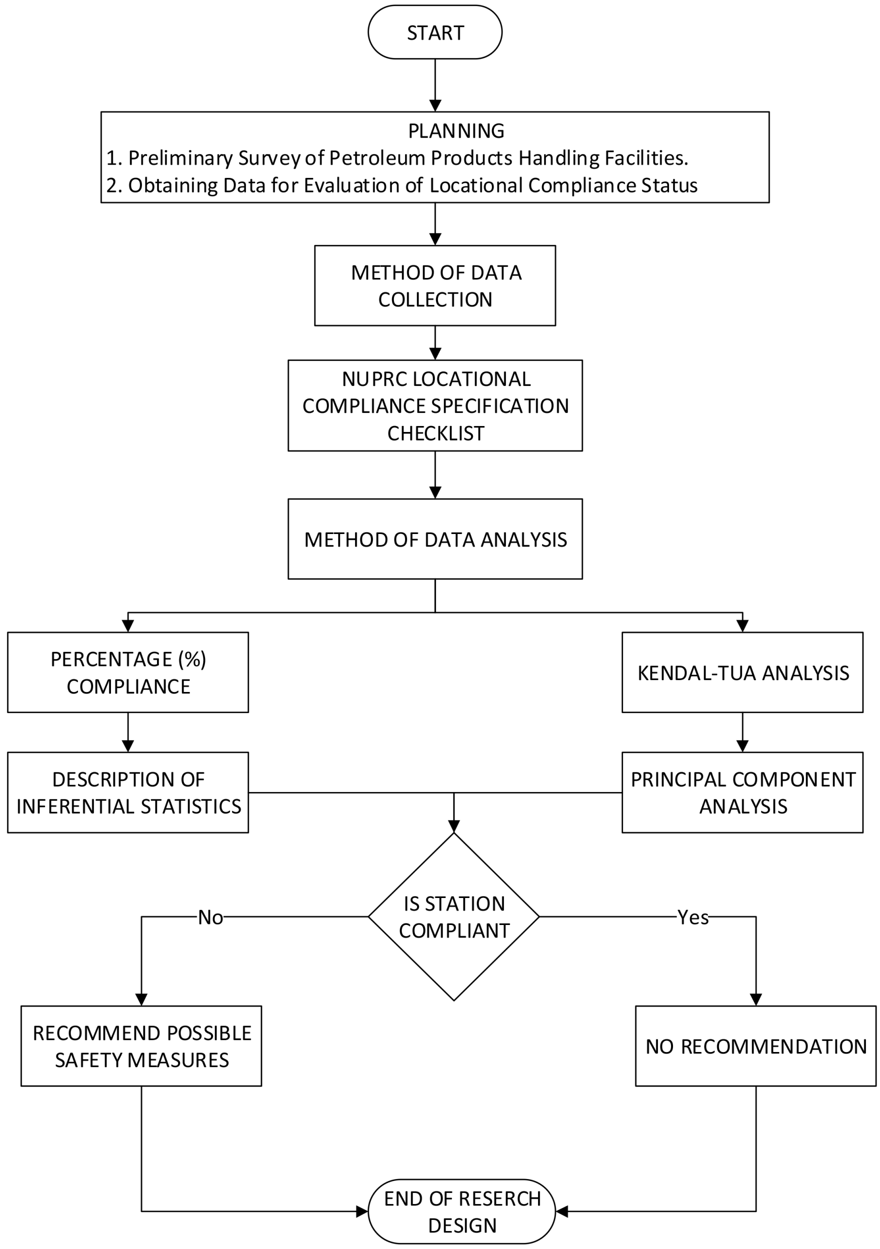

Figure 2. The flowchart for the study design.

2.3. Sample and Sampling Technique

A multistage cluster sampling technique was adopted for selecting the cities from the Niger Delta region, [18]. In selecting the filling stations, inclusive criteria were applied, namely: filling stations with functioning petroleum product retail filling stations, with up to 10 persons at risk within 100 m radius of its environment and stations with dispensary capacity of 30,000 litres or more. Cochran's Formular [18], was used in estimating the sample size of 180 Filling Stations. 180 copies of NUPRC Standard Checklist containing 17 specifications (See Table A1 in **Appendix 1**) were used in collecting the data. 118 out of 180 proposed sample size participated in the survey.

2.4. Method of Data Collection

A walk-through survey was carried out in 118 petroleum handling facilities in the three states in the Niger state (Eket in Akwa-Ibom, Port Harcourt in Rivers State and Warri in Delta state). The instrument for this research was an observational checklist containing seventeen (17) NUPRC Location Compliance Specifications (See **Table A1** in **Appendix 1**). According to the NUPRC, all facilities involved in the storage, handling and direct sales of petroleum products must adhere strictly to compliance specifications to ensure safety of its workers, their investment, customers, residents, and the environment. Thus, the data from the check list survey could play a critical role in assessing the risk of fire and explosion risks associated with the location and operation of the petroleum products handling facilities.

2.5. Method of Data Analysis

The data obtained from the checklist survey were statistically analyzed using descriptive statistics, Kendall Tau-B analysis and Principal Component Analysis (PCA) using XLSTAT version 17. The data collected from the observational Checklist were presented on a modified 5-point Likert scale and rated as: 1, 2, 3, 4, and 5, to represent Extremely Satisfied, Satisfied, Neutral, Dissatisfied and Extremely Dissatisfied, respectively. Inferential and Descriptive statistics were performed on the data and percentage compliance calculated to evaluate the status of compliance for all the locations sampled. Kendall Tua-B was used to determine the association between the locational compliances and principal component analysis (PCA) was used for dimension reduction of the 17 NUPRC locational compliances. PCA was also used to assess the relationship between the locational compliances and the petroleum product handling facility type.

3. Results and Discussion

3.1. Results

3.1.1. Location Compliance Status

The result of the Location compliance analysis shows that the petrol and gas filling stations in the Niger Delta region compiled with only 6 (35.29%) out of the 17 NUPRC requirements and shown above the dotted lines and colored area in the graph in **Figure 3**. These include the maximum plot size of 35 m × 35 m (65%); maximum plot coverage (83%); minimum vehicle maneuvering area is 1100 m^2 with 9 m frontage (67%); Station building at minimum of 12 m from road boundary (75%); a minimum of 3 dispensing pumps(87%) and minimum height of wall fence (72%). This result is consistent in the three study locations, although with varying degrees as shown in **Figures 4-6** representing Location compliance of petroleum handling facilities in Eket, Port Harcourt and Warri respectively.

The highest complied specification (100%) in Eket was "maximum plot coverage is 60%"as shown in **Figure 4**. Other specifications below the dotted line and within the colored area in the graph are below 50%.

In Port Harcourt, the 72 sampled petroleum products handling facilities were compliant in 7 (41.18%) out of 17 specifications, with "Minimum of 3 dispensing pumps (one each for petrol, Diesel and Kerosene)" having the highest percentage compliance rate (88.89%) as shown in Figure 5.

In Warri, only 5 (29.24%) out of the 17 Locational compliance specifications were met, with the "minimum of 3 dispensing pumps (one for each product: petrol, diesel or kerosene) having the highest compliance rate of 86.21%.

3.1.2. Kendall Tau-B Analysis on the Associations between the Specifications

The result of Kendall Tau-B analysis showed that there are significant associations between Specifications of the Locational Compliance. The association tends to group the locational compliance into four distinct groups namely: compliance

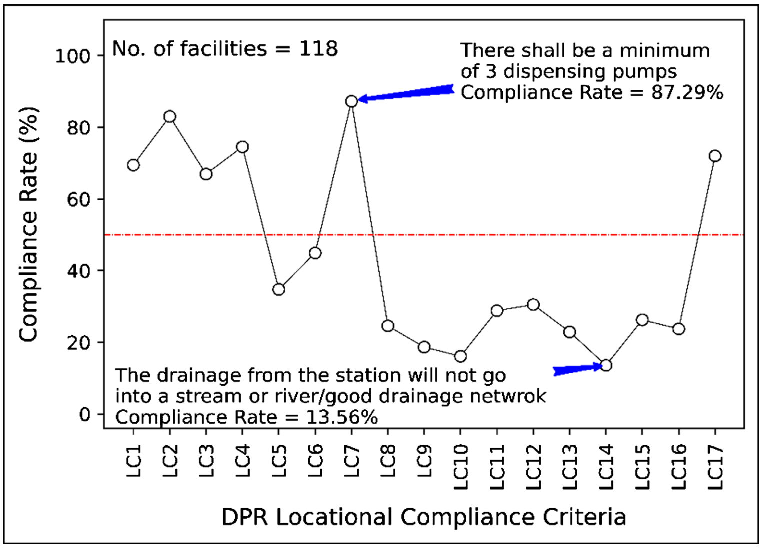

Figure 3. Location compliance of petroleum product handling stations in Niger delta region.

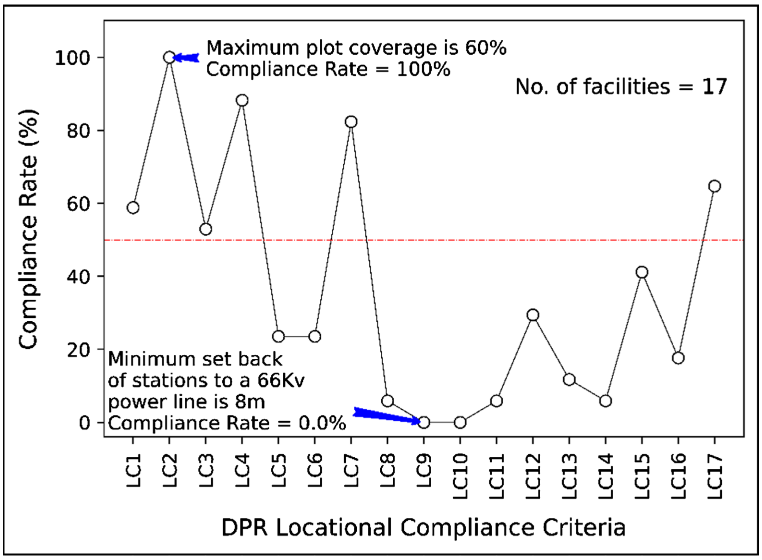

Figure 4. Location compliance of petroleum product handling station in Eket.

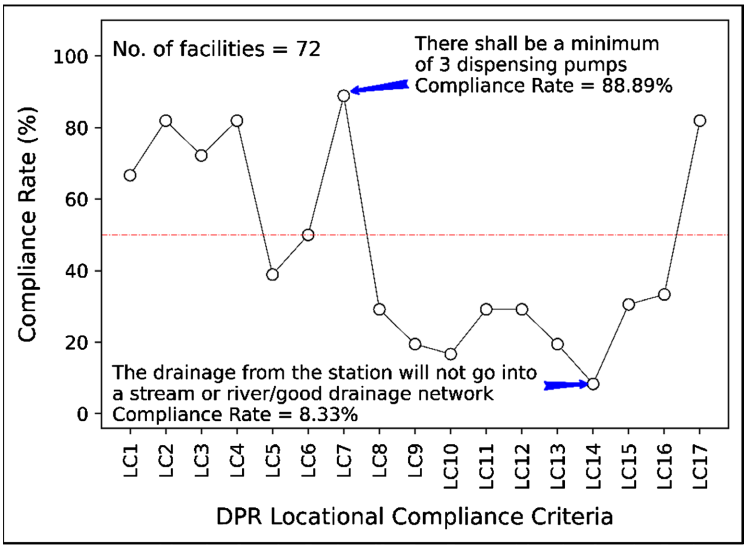

Figure 5. Locational compliance in petroleum handling stations in Port Harcourt.

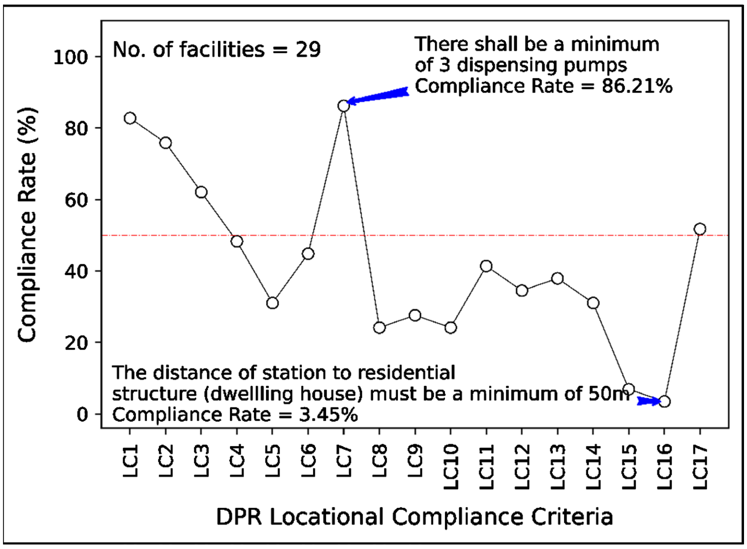

Figure 6. Location compliance of petroleum product handling stations in Warri.

to land space (LC1 - LC4), compliance to Right of Way to Electrical Power line (LC8 - LC10), compliance to minimum distance to other stations (LC11 - LC13) and compliance to other structure nearby (LC15 - LC17). See Table 1 (significant associations in bold print).

3.1.3. Principal Component Analysis, PCA

Principal Component Analysis was used in reducing the dimension of the NUPRC locational compliance specifications and seven principal components were retained based on the Eigne value criteria which accounted for 71.26% of the total variability (See **Appendix 2** for Table A2). These include compliances associated with: Electrical Power line, land space, distance to other structures; distance to other stations among others. Then, Varimax rotation was applied to the seven principal components to explain the factor loading as shown in Table 2.

Table 1. Kendall's Tau degree of association between DPR locational compliance.

Variables	LC1	LC2	LC3	LC4	LC5	LC6	LC7	LC8	LC9	LC10	LC11	LC12	LC13	LC14	LC15	LC16	LC17
LC1	1.00																
LC2	0.64	1.00															
LC3	0.61	0.65	1.00														
LC4	0.29	0.33	0.35	1.00													
LC5	0.07	−0.05	0.00	0.10	1.00												
LC6	0.15	0.08	0.08	−0.03	0.06	1.00											
LC7	−0.07	0.07	−0.03	0.13	0.09	−0.01	1.00										
LC8	−0.01	−0.01	0.03	−0.11	0.02	0.05	−0.07	1.00									
LC9	0.04	0.03	0.00	−0.04	0.03	0.11	−0.08	0.66	1.00								
LC10	0.02	0.02	−0.01	−0.10	−0.06	0.08	−0.07	0.63	0.89	1.00							
LC11	−0.08	−0.15	−0.04	−0.12	−0.01	−0.06	0.06	0.19	0.24	0.29	1.00						
LC12	0.23	0.29	0.25	0.08	−0.16	0.15	0.10	0.04	0.10	0.13	0.09	1.00					
LC13	−0.06	−0.11	−0.08	−0.16	0.06	−0.12	−0.03	0.16	0.12	0.16	0.57	0.01	1.00				
LC14	0.01	−0.11	−0.11	−0.22	−0.03	0.03	−0.23	−0.02	0.17	0.13	0.25	0.06	0.39	1.00			
LC15	0.10	0.03	0.00	0.07	0.20	0.00	−0.01	0.03	0.11	0.08	0.01	0.02	0.07	0.13	1.00		
LC16	0.08	0.14	0.06	0.08	0.47	0.12	0.03	0.10	0.14	0.04	−0.03	−0.01	0.04	0.05	0.21	1.00	
LC17	0.06	0.18	0.13	0.17	−0.06	0.00	0.11	−0.05	−0.08	−0.06	−0.12	0.06	−0.10	−0.06	−0.03	0.00	1.00

Values in bold are different from 0 with a significance level, alpha = 0.05; (Abbreviations LC1 - LC17 are explained in **Appendix 1**).

Table 2. Factor loading scores.

	D1	D2	D3	D4	D5	D6	D7
LC1	−0.004	0.838	0.081	−0.008	−0.147	0.112	−0.024
LC2	0.022	0.843	0.001	−0.088	0.060	0.072	0.130
LC3	0.011	0.862	−0.021	−0.029	0.023	−0.003	−0.018
LC4	−0.063	0.511	0.165	−0.169	0.265	−0.286	0.188
LC5	−0.029	−0.002	0.827	0.007	0.119	−0.041	−0.155
LC6	0.078	0.058	0.125	−0.164	−0.011	0.826	−0.089
LC7	−0.088	−0.051	0.096	0.099	0.838	0.082	0.173
LC8	0.838	−0.007	0.034	0.024	0.029	−0.039	−0.091
LC9	0.932	0.021	0.073	0.085	−0.067	0.063	0.017
LC10	0.924	0.001	−0.047	0.125	−0.039	0.058	0.027
LC11	0.226	−0.050	−0.058	0.796	0.162	−0.049	−0.143
LC12	0.083	0.351	−0.231	0.214	0.180	0.524	0.222
LC13	0.085	−0.059	0.068	0.847	−0.060	−0.110	−0.051
LC14	0.014	−0.094	0.043	0.558	−0.569	0.200	0.189

Continued

LC15	0.072	0.033	0.501	0.112	−0.256	−0.036	0.383
LC16	0.096	0.084	0.778	0.004	0.016	0.151	0.041
LC17	−0.032	0.089	−0.088	−0.138	0.139	−0.045	0.818

(Abbreviations LC1-LC17 are explained in **Appendix 1**).

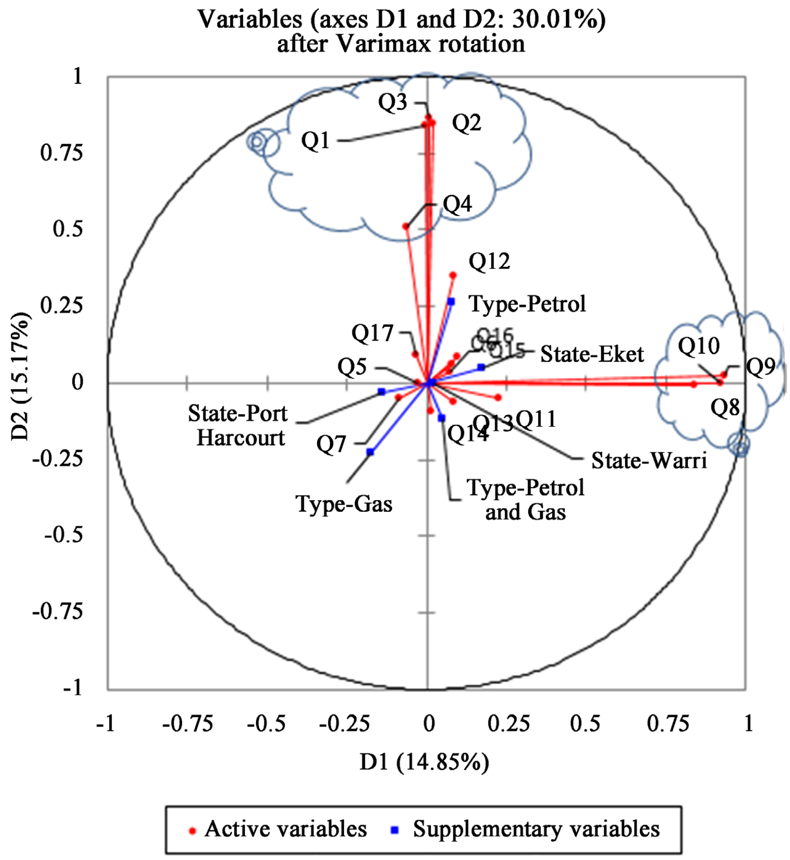

Figure 7. The relationship between locational compliances and petroleum product handling type for principal components 1 and 2A.

Further insight into the relationship between the locational compliance and the petroleum product handling facilities type was demonstrated by using Correlation Circle as shown in Figure 7 and Figure 8, respectively.

3.2. Discussion

3.2.1. Locational Compliance Status

The overall Locational Compliance result (35.29%) shows gross noncompliance to the specifications which affirms earlier studies elsewhere in Nigeria such as 44.1% overall land space and set back compliance result in Anambra State [10]. A closer look at the six most complied specifications indicates that, these requirements may be those necessary for the efficient daily business operational activities of the facilities and confirms that most stations operating in the Niger Delta region were constructed on at least one plot of land (15.3 m × 35 m). The

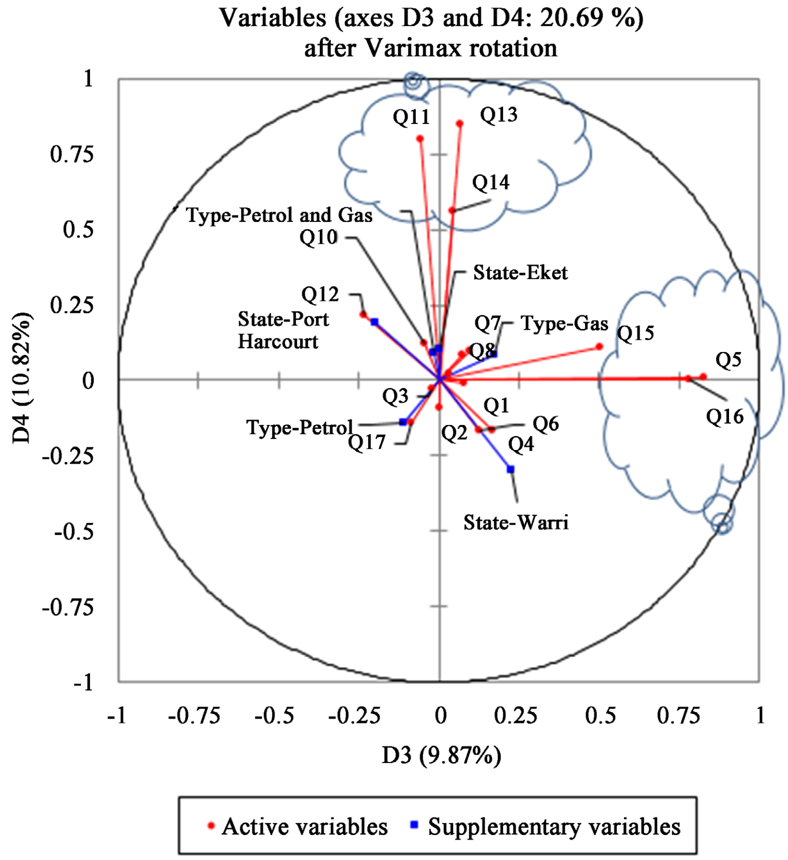

Figure 8. The relationship between locational compliances and petroleum product handling type for principal components 3 and 4.

majority of facilities had at least 3 dispenser pumps amounting to 87% compliance rate, unlike the 38.9% lowest compliance rate in Anambra State [10]. This is commendable and showed that the facility owners understand the risk implications of interchanging the dispensing pumps with different products.

The worst complied Specification (14%) was the provision of proper drainage system (oil/petrol interceptor) to prevent runoffs from stations to empty into the stream. This environmental requirement is obviously neglected by the Facility owners in the entire Niger Delta region as similar results were observed in the three study locations. Most Filling stations violated the minimum setback distance from the Electrical lines Right of Ways (ROW) as only 24.58% of these facilities in the study locations had their facilities 32 m away from the 330 kv power line, Thus, affirming the low compliance rate (39.47%) for the same specification [13] contrarily to 71.5% [10]. This disparity could be attributed to the resultant effect of rapid urbanization, overpopulation and proliferation of filling stations culminating into scrambling for available space such that empty lands like the Electrical Power line ROW are not spared. Unfortunately, poor/inadequate enforcement of Land Use Act by the appropriate government agencies has made matters worse as opined by earlier authors [1] [11].

Compliances to minimum set back distance to residential/commercial buildings (23.73%) or public infrastructures (26.27%), all mirrored poor compliances as obtained by earlier authors, (18.42% by [13] 16.7% [19] 32.35% from places of worship, [20] and 3% to schools, 4% to hospital [21], Although in contrast, [6], revealed 100% compliance to distance to schools, hotels/Guest houses in Dutse town in Jigawa state. This poor compliance confirmed the earlier observations by some authors that arbitrary changing of Land Use by Residents/Facility owners has brought the filling stations too close to the residential areas and this could play a significant role in increasing the severity of the impact in event of a fire and explosion incident due to the types of building materials used in construction and the distance between the buildings [9] [2].

The result also showed poor compliance (30.51%) to the 15 m setback distance requirement from nearest dispensing pump to the edge of the road and this is consistent in all the three study locations namely: Eket (29.41%), Port Harcourt (29.17%) and Warri (34.48%) as shown in **Figures 4-6**. Thus, affirming the results of earlier studies in Rivers State, 33% [8] and 30.15% [22]. In contrast, [6] and [23] reported 100% and 71.6% respectively. The requirement is important because it plays significant role for flow of traffic especially during fuel scarcity and long queues develop in front of the PFS.

Gross noncompliance (22.88%) was observed for specification on 400 m setback distance to other Filling Stations and this was consistent in all the three study locations (as shown in **Figures 4-6**): Eket (1.76%), Port Harcourt (19.44%) and Warri (37.93%)). The result agrees with findings by [6] [8] [11] and [23]. Furthermore, the same pattern of noncompliance (28.81%) was observed for the specification on not more than 4 filling stations on a 2 km Stretch, thus, confirming the fact that there is proliferation of filling stations. All the three study locations showed low compliance level of 5.88%, 29.17% and 41.38% for Eket, Port Harcourt and Warri respectively. Other authors [23] and [6] reported high noncompliance levels as well. The results suggest a strong association between the two Compliance Specifications and this is confirmed by the Kendall Tau-B and Principal Component analyses.

3.2.2. Kendall Tau-B Analysis of NUPRC Location Compliance Specifications

The degree of associations between location compliances (see **Table 2**) shows a strong degree of association between minimum plot-size of fuel station which is 35 m × 35 m (LC1) and maximum plot coverage is 60% (LC2), which is statistically significant ($\tau b = 0.64$, p-value < 0.000). The result indicates that stations in the Niger Delta region which had large land area had built-up space that was not more than 60% of the total land space while those with small land area had more than 60% built-up space. The result also showed that there was a positive association between minimum plot-size of fuel station which is 35 m × 35 m (LC1) and minimum vehicle maneuvering area is 1100 m^2 with a minimum frontage of 9 m facing the primary street (LC3), which was statistically significant (τb = 0.61, p-value < 0.000). The association showed that stations that had small land space also had very small maneuvering for vehicle. Table 1 showed that there was also strong positive association between minimum vehicle maneuvering area (1100 m^2) with a minimum of 9 m frontage are facing the primary street (LC3) and maximum plot coverage is 60% (LC2), which was statistically significant (τb = 0.65, p-value < 0.000). Generally, the result shows a positive association between all the land space locational compliances which is statistically. Stations which complied to LC1 also complied with LC2, LC3 and LC4 and those that failed to comply with one land space criteria failed on the other land space criteria.

The result also showed that stations that failed on one Right of Way to Electrical Power line also failed on the other Electrical Power line right of way, and vice versa. The result also showed that there was positive association between the number of stations within 2 km stretch on both sides of the road will not be more than 4 (LC11) and the distance between stations will not be less than 400 m (LC13), which was statistically significant ($\tau b = 0.57$, p-value < 0.000).

3.3. Dimension Reduction using Principal Component Analysis (PCA)

The result of the PCA shows specifications 8, 9, and 10 loaded strongly on principal component 1 as the factor loading scores were greater than 0.4. These measure the compliances associated with an Electrical Power line Right of Way. Specifications 1, 2, 3, and 4 loaded strongly on principal component 2, and they are associated with Land Space Specifications. Locational compliance 5, 15, and 16 loaded strongly on principal components 3, and these are specifications for minimum setback distance from other close by structure. Locational compliance 11, 13 and 14 strongly loaded on principal component 4, and these three compliances had to do with clustering of petroleum product handling facilities in a particular zone. Data from the PCA provides an indication that compliance requirement could be evaluated base on these four key criteria.

The correlation circle as presented in Figure 7, showed the relationship between locational compliance and petroleum handling facilities type. This data indicates that principal component 1 retained locational compliances 8, 9, and 10 which had strong positive relationship between themselves as obtained in the Kendall tau-B. The correlation circle represent higher compliance by LPG stations to the Electrical Power line ROW specifications compared to the poor compliance by Petrol only and combined Petrol and LPG stations. The data also revealed a better compliance by Port Harcourt based petroleum product handling facilities to the Right of Way to Electrical Power line compared to Eket and Warri petroleum product handling facilities. Figure 8 show the correlation circle for principal component 3 and 4. The result from the correlation circle showed that locational compliance 5, 15, and 16 loaded strongly on that principal component 3. The correlation circle also showed that principal component 4 loaded locational compliances 11, 13, and 14 to its axis. The result from the correlation circle showed that petroleum handling facilities complied more with not having a cluster of stations in Warri than stations in Port Harcourt and Eket. Generally, Filling stations in the Niger Delta region tend not to be clustered in a particular zone.

4. Conclusions

The result showed an overall high rate of poor compliances as only 6 (35.29%) out of the 17 compliance specifications were met by the stations in the three study locations. The specification on drainage had the lowest compliance rate (13.56%) while the specification for at least 3 dispensing pump (for Petrol, kerosene and diesel) had the highest compliance rate (87.29%). Comparing the compliance rates among the study locations indicates that stations in Port Harcourt had the highest compliance rate while Warri had the least. Results of Kendall tau-b analysis revealed the degree of association between the Locational compliance specifications. Principal component analysis reduced the dimension of the specifications into seven components and showed that compliance could be analyzed based on four key components (Electrical Power Line ROW, minimum plot size, minimum setback distance and number of stations within an area). The correlation circle confirmed the relationship between the specification compliances and the type of petroleum product handling facilities.

Due to the gross non-compliances, it is recommended that facility owners must maintain strict safety measures and emergency response strategies to safeguard against fire and explosion incidence. The NUPRC Regulators should enforce the Land Use Act and defaulters should be prosecuted. New Permits for development of Petroleum Product facility or modification of existing ones should not be granted except that the requirements of Location compliance standards are fully met. Government and non-governmental organizations should carry out public engagement and sensitization programs to dissuade encroachers from areas mapped out for the development of petroleum products facilities.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Oyinloye, M.A. and Abiola, O.E. (2021) Locational Impact of Petrol Filling Stations Close to Residential Buildings in Ife Central, Nigeria. *International Journal of Humanities and Social Sciences*, **8**, 29-36. https://doi.org/10.14445/23942703/IJHSS-V8I2P106

[2] Wadembere, I. and Apaco, J. (2020) Urban Spatial Risk Assessment of Fire from Fueling Stations on Buildings Case Study: Lubaga Division, Kampala City, Uganda. *Journal of Building Construction and Planning Research*, **8**, 57-72. https://doi.org/10.4236/jbcpr.2020.81005

[3] Sharma, R.K., Gurjar, B.R., Wate, S.R., Ghuge, S.P. and Agrawal, R. (2013) Assessment of an Accidental Vapour Cloud Explosion: Lessons from the Indian Oil Corporation Ltd. Accident at Jaipur, India. *Journal of Loss Prevention in the Process Industries*, **26**, 82-90. https://doi.org/10.1016/j.jlp.2012.09.009

[4] Silas, D. (2018, September 11) Nassarawa Gas Explosion: Gov Al-Makura Announces Official Death Figure. *Daily Post*. https://dailypost.ng/2018/09/11/nasarawa-gas-explosion-gov-al-makura-announces-official-death-figure/

[5] Afolabi, O., Olajide, F. and Omotayo, S. (2011) Assessment of Safety Practices in Filling Stations in Ile-Ife, South Western Nigeria. *Journal of Community Medicine and Primary Health Care*, **23**, 9-15.

[6] Yunus, S. (2019) Analysis of Locational Compliance and Fire Safety Preparedness among Petrol Filling Stations in Dutse Town, Jigawa State. *Confluence Journal of Environmental Studies*, **1**, 107-118. https://www.researchgate.net/publication/337487658_Analysis_of_Locational_Compliance_and_Fire_Safety_Preparedness_among_Petrol_Filling_Stations_in_Dutse_Town_Jigawa_State

[7] Tahmid, M., Dey, S. and Syeda, S.R. (2020) Mapping Human Vulnerability and Risk Due to Chemical Accidents. *Journal of Loss Prevention in the Process Industries,* **68***,* Article ID: 104289.

[8] Arokoyu, S.B., Ogoro, M. and Jochebed, A. (2015) Petrol Filling Stations Location and Minimum Environmental Safety Requirements in Obio-Akpor LGA, Nigeria. *International Journal of Innovative Science and Research Technology*, **2**, 21-39.

[9] Mshelia M., Abdullahi, J. and Dawha, D. (2015) Environmental Effects of Petrol Stations at Close Proximities to Residential Buildings in Maiduguri. *IOSR Journal of Humanities and Social Science*, **20**, 1-8. https://www.iosrjournals.org

[10] Ulasi, J.O., Uwadiegwu, B.O. and Okoye, C.O. (2020) Assessment of the Level of Compliance of Petroleum Filling Stations to Development Control Standards on Land Space/Size and Setbacks in Anambra State. *Civil and Environmental Research*, **12**, 77-87.

[11] Dogara, S.T. (2017) GIS-Based Locational Analysis of Petrol Filling Stations in Kaduna Metropolis. *Science World Journal*, **12**, 8-13.

[12] Numbere, A.O. (2021) Impact of Urbanization and Crude Oil Exploration in Niger Delta Mangrove Ecosystem and Its Livelihood Opportunities: A Footprint Perspective. In: Banerjee, A., Meena, R.S., Jhariya, M.K. and Yadav, D.K., Eds., *Agroecological Footprints Management for Sustainable Food System*, Springer, Singapore, 309-344. https://doi.org/10.1007/978-981-15-9496-0_10

[13] Ojiako, J.C.., Ekebuike, A.N. and Ndu, C.G. (2016) Locational Analysis of Filling Stations in Portharcourt Local Government Area Area, River State, Nigeria Using G GIS Approach. *International Journal of Advanced Engineering*, *Management and Science (IJAEMS)*, **2**, 1655-1658.

[14] Kebut, C., Mburu, C. and Kinyua, R. (2021) Assessment of Implementation of Fire Risk Reduction Rules at Petroleum Dispensing Stations in Kisumu County, Kenya. *Open Journal of Safety Science and Technology*, **11**, 55-65. https://doi.org/10.4236/ojsst.2021.112005

[15] Kadafa, A.A. (2012) Environmental Impacts of Oil Exploration and Exploitation in the Niger Delta of Nigeria. *Global Journal of Science Frontier Research Environment & Earth Sciences,* **12**, 19-28.

[16] Obisesan, A. and Weli, V.E. (2019) Assessment of Air Quality Characteristics across Various Land-Uses in Port-Harcourt Metropolis. *Journal of Environmental Pollution and Management*, **2**, Article No. 106. https://doi.org/10.46654/ij.24889849.s61121

[17] Abah, A.J. and Onuoha, B.C. (2020) Quality of Work Life and Employee Affective

Commitment of Filling Stations in Rivers State. *International Journal of Advanced Academic Research*, **6**, 93-113. http://www.ijaar.org

[18] Nwaogazie, I.L. (2021) Probability and Statistics for Science and Enginnering Practice. 4th Edition, Print Konzults, Uniport Printing Press, De-Adroit.

[19] Habila, J., Isaac, I., Olivia, O.N. and Kalu, A.U. (2021) Appraisal of the Level of Compliance to Development Control Standards among Petrol Filling Stations in Minna, Nigeria. *International Journal of Scientific Research in Multidisciplinary Studies*, **7**, 32-36.

[20] Olapeju, O. and Farotimi, A.O. (2017) Assessing the Location and Spatial distribution of Petrol Filling Stations in Ilaro Ogun State. 5*th National Conference of School of Environmental Studies*, Ilaro, 8-11 July 2017, 1-15.

[21] Odipe, O.E., Lawal, A., Adio, Z., Karani, G. and Sawyerr, O.H. (2018) GIS-Based Location Analyses of Retail Petrol Stations in Ilorin, Kwara State, Nigeria. *International Journal of Scientific & Engineering Research,* **9**, 790-794.

[22] Ekpenyong, R.E., Shaibu, M.E. and Etim, E.R. (2019) Geospatial Analysis and Assessment of the Distribution of Petrol Stations in Uyo Capital City, Nigeria to Safeguard Human and Environmental Health. *International Journal of Social Sciences,* **13**, 82-102.

[23] Oloko-Oba M, Badru R, Popoola O.S, Samson S.A, Alaga T.A. and Ogunyemi S.A. (2016) Assessment of Filling Station in Ilorin, Kwara State, Nigeria Using Geospatial Techniques. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, **1**, 69-74.

Appendix 1

Table A1. Locational compliance specifications.

Number	Locational Compliance Specifications
LC1	Minimum plot-size of fuel station shall be 35 m × 35 m
LC2	Maximum plot coverage is 60%
LC3	Mini vehicle maneuvering area is 1100 m^2 with a minimum frontage of 9 m facing the primary street
LC4	Buildings inside the station must be at a minimum of 12 m from the road property boundary.
LC5	Petrol pumps must be located at a minimum of 30 m from residential buildings.
LC6	There should be a minimum distance of 10 m UST and dispensing pumps
LC7	There shall be a minimum of 3 dispensing pumps (one for each of the petrol, diesel and kerosene)
LC8	Minimum set back of stations to a 330 kv line is 32 m
LC9	Minimum set back of stations to a 66 kv power line is 8 m
LC10	Minimum set back of stations to a 132 kv line is 16 m
LC11	The number of stations within 2 km stretch on both sides of the road will not be more than 4.
LC12	Distance from the edge of the road to the nearest pump (not less than 15 m).
LC13	The distance between stations will not be less than 400 m
LC14	The drainage from the station will not go into a stream or river/good drainage network
LC15	Stations must be located at a minimum of 150 m from any public building such as school, place of worship, market place, hospital etc.
LC16	The distance of station to residential structure (dwelling house) must be a minimum of 50 m.
LC17	Wall fence demarcating the station (minimum height of 1.5 m high).

Appendix 2

Table A2. Eigen Value and Percentage variability of principal components.

Principal Component	Eigenvalue	Before Varimax Rotation		After Varimax Rotation	
		Variability (%)	Cumulative %	Variability (%)	Cumulative %
F1	2.9234	17.1966	17.1966	14.8472	14.8472
F2	2.7138	15.9633	33.1599	15.167	30.0141
F3	1.6516	9.7155	42.8754	9.8725	39.8866
F4	1.5419	9.0702	51.9456	10.8155	50.7021
F5	1.2498	7.3519	59.2975	7.5945	58.2967
F6	1.0712	6.301	65.5985	6.7848	65.0815
F7	0.963	5.665	71.2635	6.182	71.2635