

## Geospatial Distribution and Environmental Effects of Petrol Stations in Hadejia Town, Hadejia Local Government Area, Jigawa State, Nigeria.

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### ABSTRACT

*Proliferation of petrol stations in Hadejia town, Hadejia Local Government Area, Jigawa State is on the rise with consequences for human health and the environment. Therefore, the study assessed the geospatial distribution and environmental effects of petrol stations in Hadejia town, Hadejia Local Government Area, Jigawa State. The spatial distribution of 34 petrol stations was analysed in the study. Simple random sampling method was used to select respondents for the study. The geographical coordinates of filling stations were obtained using a handheld Geographical Position System (GPS) receiver. Nearest Neighbour Analysis was used to determine and establish the pattern of arrangement of filling stations in Hadejia as clustered, random or dispersed. The Proximity analysis tools and Near Analysis tool were used to calculate distance and additional proximity information between the filling stations and other planning regulations. Query by location was performed using selection menu in ArcGIS environment to determine stations that are within a distance of 400m from other stations. Data obtained are summarized using descriptive statistics. The results show that the distribution for Nguru road is random with an expected mean distance of 0.0364 metres to the filling station, while the observed mean distance is 0.0445m, a z-score of 1.341399 and p-value of 0.179791. The results also show that Malam Madori and Azare roads also showed dispersed distributions with expected mean distances of 0.0143m and 0.0281m respectively, observed distances of 0.0512 and 0.0635 metres, z-scores of 9.821639 and 6.375681 and p-values of 0.0000. The result shows that only filling stations 2, 16 and 17 were located within the 15m buffer zone of Hadejia high ways. The major waste disposal method adopted by respondents in the study area is burning. The study recommends adoption of GIS methods in physical development control and location allocation, strict compliance by petrol stations with all public safety regulations and public enlightenment campaigns on the hazards associated with petroleum products.*

**Keywords:** Analysis, Filling stations, Geospatial distribution, Proximity.

### 1. INTRODUCTION

Nigeria is one of the biggest oil-producing countries in the world with a very huge crude oil deposits, both tapped and untapped (Hanekom, 2001) and also one of the biggest consumers of oil products in Africa with about 40 million litres said to be consumed

everyday (Darlington, 2012). Virtually all aspects of daily life activities of individuals and nations, including environmental health, depend on machines powered by petroleum products. The most popular among these products are Premium Motor Spirit (PMS, petrol), Automotive Gas Oil (AGO, gas) and

Dual-Purpose Kerosene (DPK, kerosene). Among other uses, these products power and lubricate all types of transport vehicles and industrial machines. In homes, the products power machines that generate electricity for lighting, heating and cooking. Kerosene is particularly useful as a source of energy for cooking in most Nigerian homes (Magaji, 2020).

Petrol filling station is defined as any facility or equipment used for the sale or dispensing of petroleum products for motor vehicles (Joseph, 2005). Most filling stations sell petrol or diesel, some carry specialty fuels such as liquefied petroleum gas (LPG), natural gas, hydrogen, biodiesel, kerosene, or butane while the rest add shops to their primary business. Since the petrol filling stations have spatial dimensions, it is expected that they should be sited in an organized and sustainable manner (Abler *et al.*, 1973; Joseph, 2005). Filling stations are particularly hazardous workplaces, which require licensing by Local Authorities because they store and sell a highly flammable liquid. Equipment failures in filling stations or gas stations lead to accidents which pose significant threats to people and property. Therefore, safety standards for filling stations need to be developed based on risk or locational analysis (Douti *et al.*, 2019). More than 2.3 million lives and properties worth about 4.5 billion are lost to fire outbreaks emanating from mishandled petroleum product (WHO, 2004; Mshelia *et al.*, 2015). Hence, considering the high risk and dangers associated with petroleum product as a highly inflammable product, its exploration, transportation, offloading, storage and sale points and facilities must be handled carefully (Mshelia *et al.*, 2015).

Some authorized ministries or agencies responsible for licensing of filling stations in Nigeria include Petroleum Products Pricing Regulatory Agency (PPPRA), which is an

agency established in 2003 to monitor and regulate the supply, distribution and prices of petroleum products in Nigeria. The Department of Petroleum Resources (DPR) is also an agency with the statutory responsibility of ensuring compliance to petroleum laws, regulations and guidelines in the Oil and Gas Industry. It is however noticeable that despite the availability of standards regulating the location of petrol filling stations in Nigeria's urban centres, most of the petrol filling stations are still located in a manner that is chaotic and has the potential for hazards (Yisa and Olubadewo, 2014). In locating petrol stations, it is important to take some precautionary measures like locating them at required distances from buildings, places of public assembly such as markets, hospitals and schools, areas of high traffic congestions and residential buildings. This should be in accordance with the guidelines provided by the Department of Petroleum Resources and Fire service safety rules of 400m distance between petrol stations to the nearest residential buildings to shun possible hazards (Mohammed *et al.*, 2014).

However, a trend in most Nigerian cities is the proliferation of petrol filling stations (Afolabi *et al.*, 2011). The proliferation is the consequence of the fast growth of urban population that is accompanied with similar growth in the demand for petroleum products, increased number of vehicles and more people engaging in petrol retailing businesses (Afolabi *et al.*, 2011; Magaji 2020). In addition, epileptic public electricity supply has necessitated the use of petrol-powered generators in many public and private buildings to generate their electricity needs. The proliferation has become haphazard and potentially risky.

With Geographic Information System (GIS), it is possible to graphically capture, display and analyze the compliance of the distribution of the filling stations with the

guidelines for their location as specified by the DPR. This has been undertaken for several Nigerian cities such as Kano (Mohammed *et al.*, 2014), Minna (Yisa and Olubadewo, 2014), Borno (Mshelia *et al.*, 2015), Kaduna (Tah, 2017) and Bauchi (Magaji, 2020). All these studies reported violations of the spatial regulations of the DPR. However, there is a dearth of information on such studies for Hadejia town.

It is against this background that the study aims to assess the geospatial distribution and environmental effects of filling stations in Hadejia town, Hadejia Local Government Area, Jigawa State. Specifically, the objectives would be achieved through identifying and mapping all the petrol filling

## 2.1 Study Area

Hadejia town is situated in the North-eastern part of Jigawa State. It covers an area of 4,352 square kilometres and falls between latitude 12° 27' N - 12° 45' North and longitude 10° 003' E - 10° 2' East. It lies within the northern margin of the Sudan Savannah zone of northern Nigeria and has a population of 105,628 persons, according to 2006 population census. The climate is a tropical continental type, with two distinct seasons of wet and dry.

## 2.2 Methodology

Following a reconnaissance survey, a list of filling stations was obtained from the Department of Petroleum Resources (DPR),

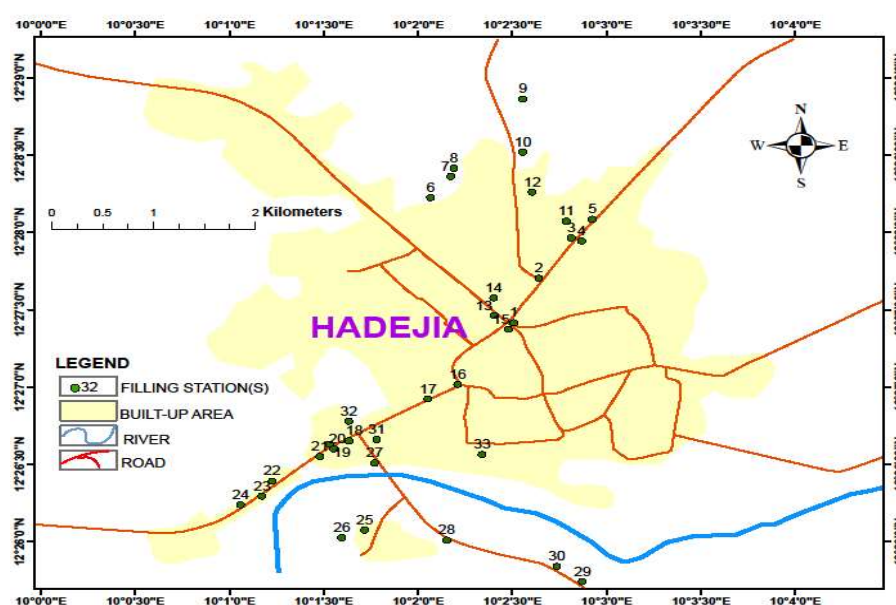


Figure 1: Geographical Location of the study Area

stations in the study area, determining the conformity of the petrol filling stations with physical planning standards and examining the perceptions of residents on the potential dangers associated with the proliferation of filling stations.

## 2. MATERIALS AND METHODS

a department under the Ministry of Petroleum Resources responsible for registering and regulating filling stations. This served as a guide for verification and collection of the coordinates using Global Positioning System (GPS). Hadejia town comprises of four major routes namely; Hadejia-Azare, Hadejia-Malam Madori, Hadejia- Ringim and

Hadejia- Nguru. Thirty-four (34) petrol filling stations, located along the four major routes were covered by the study, twenty-five (25) of which were functional and nine (9) non-functional. Simple random sampling method was used to select respondents for the study. Structured questionnaires were administered to household heads (or their representatives) located within 100m radius of the filling stations while the semi structured interviews were conducted with staff working in selected petrol filling stations.

The geographical coordinates of filling stations were obtained using a handheld Geographical Position System (GPS) receiver. The average distance of each filling station to the nearest one in Hadejia was measured using the 'Ruler' menu of ArcGIS 10.5.0 software. Nearest Neighbour Analysis was used to determine and establish the pattern of arrangement of filling stations in Hadejia as clustered, random or dispersed. The Proximity analysis tools and Near (Analysis) tool were used to calculate distance and additional proximity information between the filling stations and other planning regulations such as set back from highways, incompatibility in land uses, etc. Buffers of 15m were created on the roads to determine the distance of petrol stations to the road. Query by location was performed using selection menu in ArcGIS environment to determine stations that are within distance of 400 metre from other stations.

### 3. RESULTS AND DISCUSSION

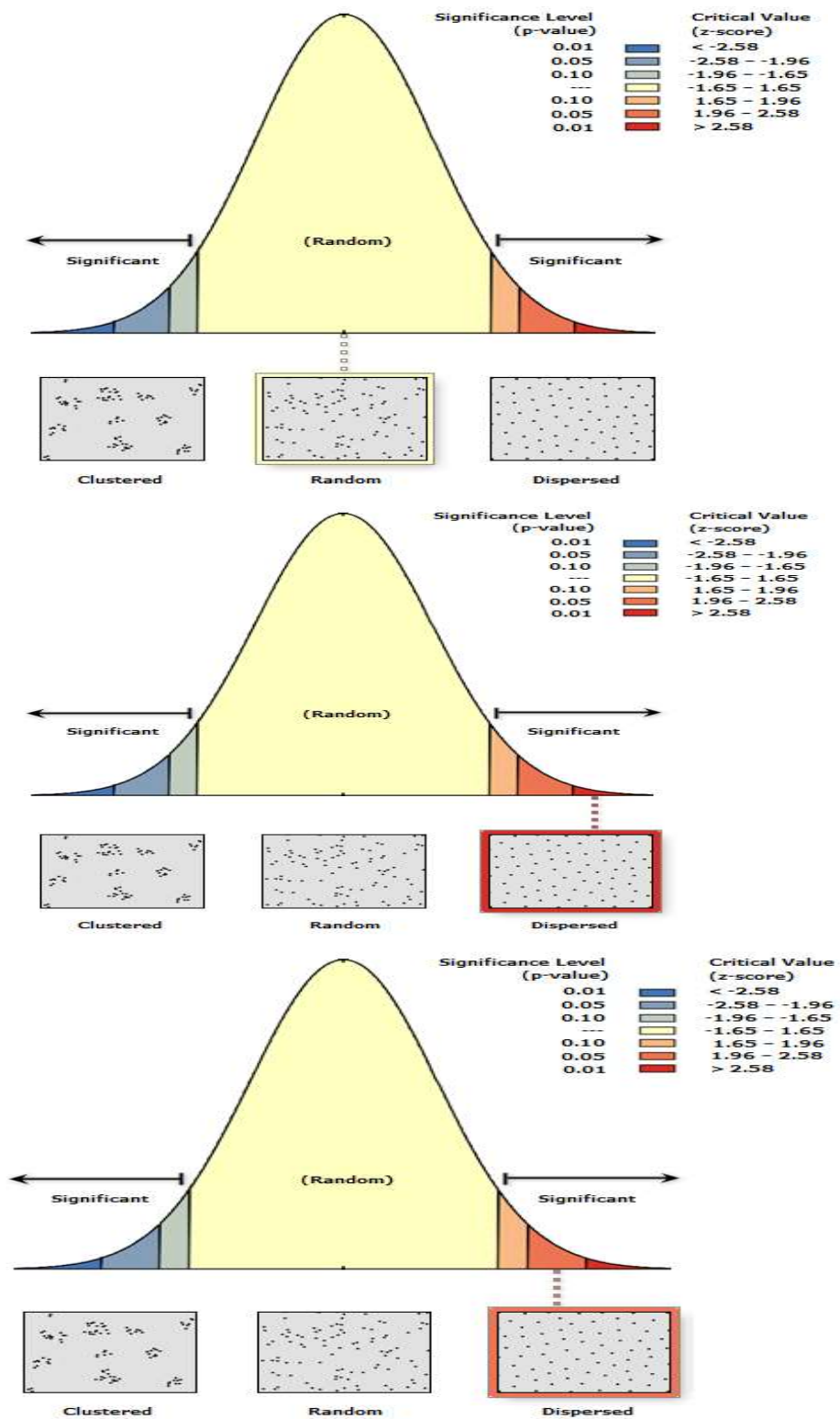
#### 3.1 Spatial distribution of Petrol Stations

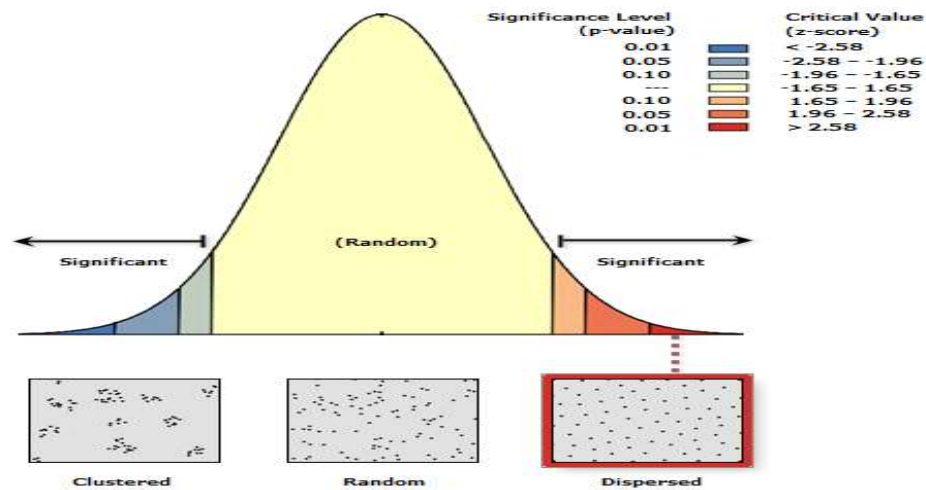
The results of spatial distribution of petrol stations in the study area are presented in Figure 2. For Nguru road, the distribution is random with an expected mean distance of 0.0364 metres to the filling station, while the observed mean distance is 0.0445m, a z-score of 1.341399 and p-value of 0.179791.

Ringim road shows a dispersed distribution with the expected mean distance to the filling station at 0.0303 metres. Observed mean distance is 0.0406 metres, with a z-score of 2.234319 and p-value of 0.025462. The results also show that Malam Madori and Azare roads also showed dispersed distribution with expected mean distances of 0.0143m and 0.0281m respectively, observed distances of 0.0512 and 0.0635 metres, z-scores of 9.821639 and 6.375681 and p-values of 0.0000. This means that majority of the stations are not in close proximity to each other across the town. However, this result disagrees with the findings by Magaji (2020) who found that majority of the petrol stations in Bauchi town were clustered. The random and dispersed distribution of these filling stations maybe attributed to the population and economic activities of the town.

#### 3.2 Proximity between Petrol Stations

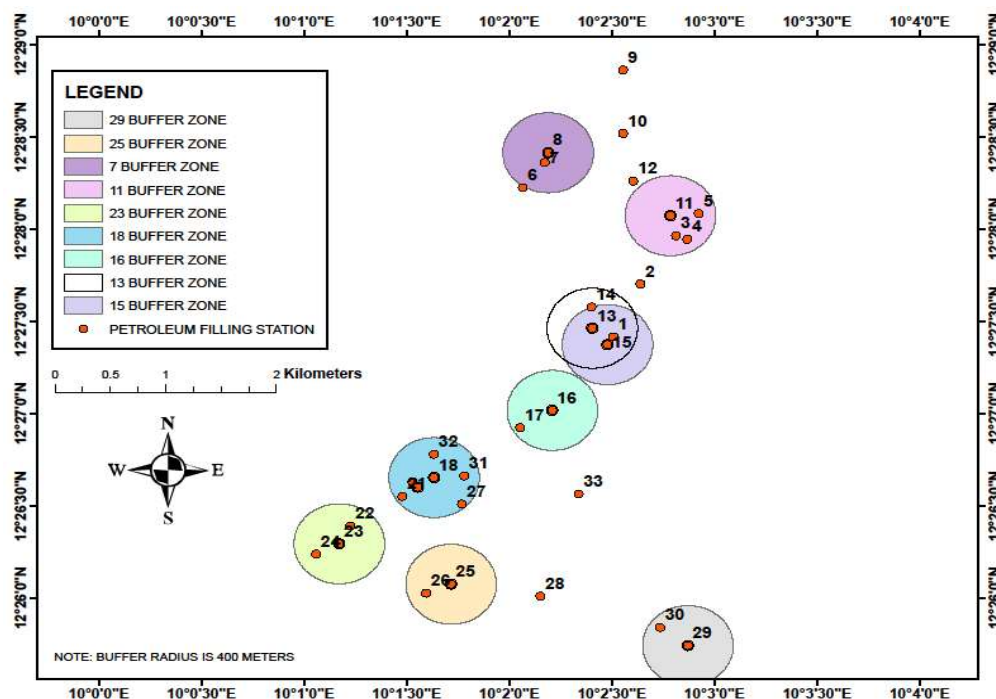
The result of proximities determined between sampled petrol stations is shown in Figure 3. The result shows that 74.3% of the sampled petrol stations did not adhere to the 400m distance required by DPR between petrol filling stations. The result shows that only 25.7% of the sampled stations were located in conformity with the guidelines. This level of non-compliance is significantly higher than the 24% percent reported by Tah (2017) for Kaduna, but much less than the 97 % in Ilorin. Mshelia *et al.*, (2015), in a study of environmental effects of petrol stations at





**Figure 2:** Spatial distribution of petrol stations in the study area.

*Source: Author's Computation*



**Figure 3:** Proximities between sampled petrol stations

*Source: Author's work (2021)*

Maiduguri and Jere, Borno State, Nigeria, showed that most of the petrol stations were located close to each other and did not comply with DPR guidelines. This is because of the weakness in the physical development control effectiveness by the State Development Board which is overwhelmed

by personnel, perception, political and funding problems (Bogoro and Nghalmi, 2014). Similarly, the collaboration between the DPR, the Ministry of Lands and Housing, and the State Development Board appears to be weak (Bogoro and Nghalmi, 2014).



### 3.3 Distances from Petrol Stations to Highways

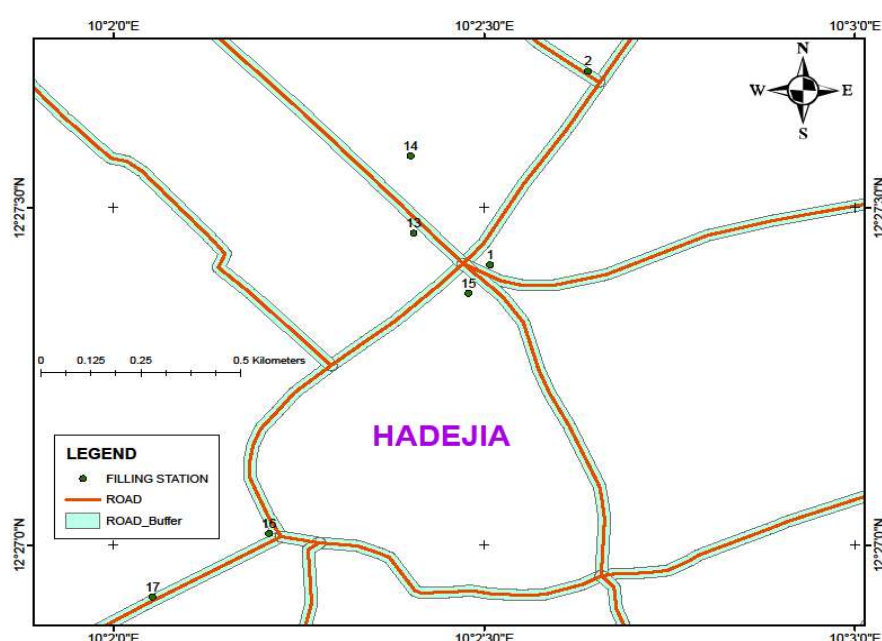
The result of distances determined from sampled petrol stations to highways in the study area is shown in Figure 4.

The result shows that only three filling stations (2, 16 and 17) were located within the 15m buffer zone of Hadejia high ways. This suggests that there is significant non-compliance in terms of compliance with the

### 3.4 Distances between Sampled Petrol Stations to Nearest Houses/Shops

The result of distances determined between sampled petrol stations to nearest houses/shops is presented in Table 1.

The result shows that 84.8% of the petrol stations were located at < 50m to houses and shops, while 15.2% were sited 50m > to the houses/shops around them. This shows that most of the petrol stations in the study area



**Figure 4:** Distance from sampled petrol stations to Highways

*Source: Author's work (2021)*

**Table 1:** Distances between sampled petrol stations to the nearest houses/shops

Routes	< 10m	10-19m	20-29m	30-39m	40-49m	>50m	Total	DPR Requirement
Nguru Road	4	2	1	-	2	1	10	50metres
Malam Madori	1	-	-	1	-	2	4	
Ringim	4	2	-	5	-	1	12	
Azare	3	2	-	-	1	1	7	
Total Routes = 4	12	6	1	6	3	5		
			Non complied		84.8%	Complied		15.2%

*Source: Fieldwork 2021*

DPR requirement of keeping a minimum distance of 15m from highways.

do not comply with the DPR standards on the proximity to residential areas. This violation of the DPR proximities requirement guideline by the petrol stations and residents

in terms of location sites increase the residents' vulnerability to petrol related hazards.

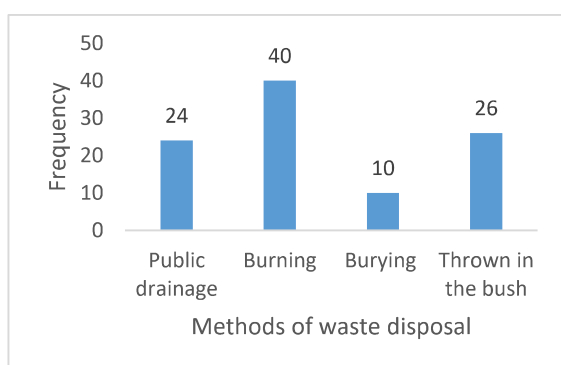
### 3.5 Distances between Petrol Stations to the Nearest Public Assembly

The result of distances determined between sampled petrol stations to the nearest public assembly is presented in Table 2.

**Table 2:** Proximities of sampled Petrol Station to the Nearest Public Assembly

Routes	< 20m	20-39m	40-49m	50-79m	80-99m	>100m	Total	DPR
Nguru Road	1	5	-	-	3	1	10	Requirement
Malam Madori	-	1	1	2	-	-	4	
Ringim	2	1	-	1	6	2	12	90metres
Azare	3	-	-1	2	1	-	7	
<b>Total Routes = 4</b>			<b>Non comply</b>	<b>60.6%</b>	<b>Complied</b>	<b>39.4%</b>	<b>33</b>	

*Source: Fieldwork 2021*



**Figure 5:** Waste Disposal Methods adopted  
*Source: fieldwork 2021.*

The results show that most petrol stations (60.6%) do not comply with the DPR requirement of 90m from the nearest public assembly such as markets, parks and banks. This results shows that most of them are located within 20 – 79m. This may be because most of the users of petrol station products are within those public assemblies. Only about 39.4% complied with the DPR requirements of 90 meters. As a matter of importance and rule, petrol stations are expected to be sited away from places where people gather for any form of activities (Magaji, 2020).

### 3.6 Waste Disposal Methods adopted by Respondents

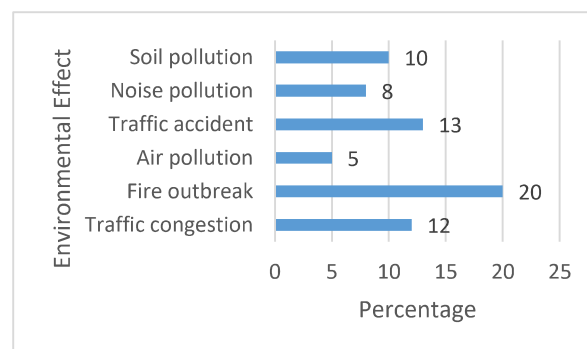
Methods of waste disposal adopted by petrol stations in the study area are presented in Figure 5.

As shown in the figure, 40% burn waste generated, followed by disposing the waste in the bush (26%). while only about 10% of the respondents bury waste, disposal into public drainages was also adopted as method of

waste disposal.

### 3.7 Awareness of danger associated with petrol stations

The results of respondents' awareness of dangers associated with petrol stations are shown in Figure 6.



**Figure 6:** Awareness of danger associated with petrol stations  
*Source: fieldwork 2021*

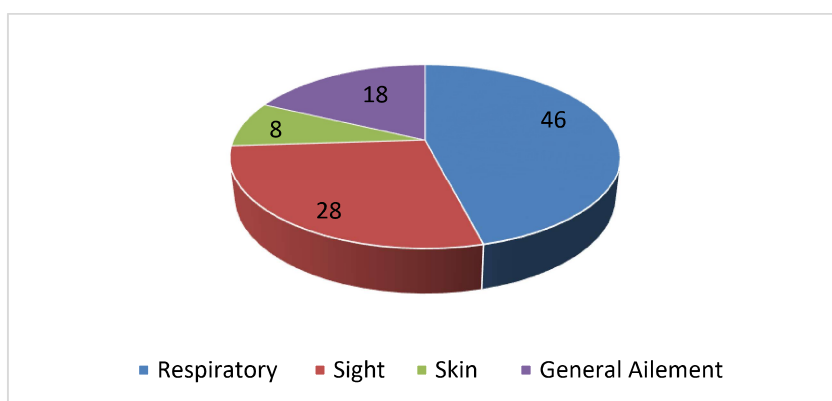
The result shows that 20% of the workers are aware of the danger of fire outbreak in a petrol station, while 13% are aware of the dangers of traffic accident, traffic congestion (12%), soil pollution (10%) and air pollution (5%).

### 3.8 Effects of pollution



The effects of pollution as perceived by respondents, is shown in Figure 7. The results indicate that 45% of the respondents believe that the location of petrol stations caused respiratory problems for petrol station staff and other inhabitants, 28% agree it affects their sight, 18% believe it causes general ailments while 4% believe it cause skin diseases.

distance required between petrol stations and highways was also violated. In addition, the required proximities between the petrol stations and residential/public areas were violated. In addition, the major waste disposal method adopted by respondents is burning, which has been shown to have negative effects on the environment as well as pose serious fire hazard risks. The study



**Figure 7:** Health Effect of Petrol Station on Workers

*Source: Fieldwork 2021*

The European Environmental Agency (1994) agrees that apart from creating environmental hazards, petrol can also pose health hazards if it is inhaled, ingested or come into contact with the skin or eye. Exposure to petroleum vapour with a concentration of between 500ppm and 1000ppm can cause irritation to the respiratory tract and could lead to narcotics effects with symptoms including headache, nausea, dizziness and mental confusion (EEA, 1994).

#### 4. CONCLUSION AND RECOMMENDATIONS

This study assessed the geospatial distribution of petrol station and its environmental effect in Hadejia town, Hadejia LGA, Jigawa State. The findings show that the geospatial distribution of the petrol stations were random and dispersed. More than half of the petrol stations do not meet the minimum requirement of 400m distance between petrol stations. The 15m

therefore recommends adoption of GIS methods in physical development control and location allocation, strict compliance by petrol stations with all public safety regulations and public enlightenment campaigns on the hazards associated with petroleum products.

#### REFERENCES

- Abler, R., Adams, J.S. and Gould, P. (1971) Spatial Organisation: The Geographer's View of the World, Englewood Cliffs, NJ: Prentice-Hall.
- Afolabi, O.T, Olajide, F.O, Omotayo, S.K (2011). Assessment of Safety Practices in Filling Stations in Ile-Ife, South Western Nigeria. *Journal of Community Medicine and Primary Health Care*. 3(2), pp. 09-15.
- Bogoro and Nghalmi (2014). Knowledge, attitude and practices of development control in millennium quarters,

- Yelwa, Bauchi, Nigeria. *Journal of Research in Environmental and Earth Sciences*. 1(1), 1-11.
- Darlington Omeh, (May, 2012) "How to Setup Petrol Filling Station in Nigeria, the Detailed Requirements" Comments on Oil and Gas, Nigeria.
- Department of Petroleum Resources (DPR, 2010). *Procedure Guide for the Issuance of License, Establishment and/or Operations of Industrial Consumers, Petrol Stations, Kerosene and Liquefied Petroleum Gas (LPG)*. Revised Edition. Pp. 1-11
- Douti A. (2019). Spatial Distribution and operation of Petrol Stations in Kassena-Nankana District (Ghana) and associated Health and Safety Hazards. *Journal of Toxicology and Environmental Health Sciences*. 11(5), pp 50-61.
- E.F.O.A., (1999). European Fuel Oxygenates Association: Guidance for the Design, APEA/IP.1999. [www.efoa.org](http://www.efoa.org). Pp. 5 – 9.
- Environmental Agency PPG 1 & 7, (1994). General guide to the prevention of pollution, controlled waters and Fuelling stations: Construction and Operation. European Directive 94/63 EC. In: Guidance for the Design, Construction, Modification and Maintenance of Petrol Filling Stations APEA/IP. 1999. [www.efoa.org](http://www.efoa.org).
- Hanekom, P. (2001). *Guidelines for the Construction and Upgrade of Filling Stations and Associated Tank Installations*. Agricultural, Conservation, Environmental and Land Affairs, Diamond Corner Building, 68 Eloff and Market Street, Johannesburg. South Africa. Pp. 1 – 17.
- Magaji, I.M and Wali Umar (2020). Spatial Distribution of petrol filling station in Bauchi Town, Bauchi State, Nigeria. *Biogeosystem Technique*, 7(1), 38-44
- Joseph, F. S. C. (2005). At Risk: Natural Hazards, People's Vulnerability, and Disasters. *Journal of Homeland Security and Emergency Management*. (Psh) The Berkeley Electronic Press, New York. Vol. 2(2) Art. 4. Pp 1 – 5.
- Mohammed *et al.*, (2014). GIS-Based Analysis of the Location of Filling Stations in Metropolitan Kano against the Physical Planning Standards. *American Journal of Engineering Research*. Vol 3. Issue 9. pp 147-158.
- Mshelia, A.M, Abdullahi J, Dawha, D.E (2015). Environmental Effects of Petrol Stations at close Proximities to Residential Building in Maiduguri and Jere, Borno State, Nigeria. *Journal of Humanities and Social Sciences*. Vol. 20 Issue 4, pp 1-8.
- Tah, D.S. (2017). GIS-Based Locational Analysis of Petrol Filling Stations in Kaduna Metropolis. *Science World Journal*. 12 (2), 8-13.
- Yisa J and Olubadewo O.O (2014). *Assesment of Geospatial Distribution of Filling Station in Minna and its Environs Niger State*, Nigeria IBB University Lapai