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ENVIRONMENTAL IMPACT OF INDISCRIMINATE LOCATION OF PETROL RETAIL STATIONS IN URBAN MINNA, NIGER STATE NIGERIA

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ABSTRACT

The study aim's at assessing the environmental impact of indiscriminate location of petrol retail stations in urban Minna. The study Map out the Petrol Retail Stations in Minna Township, Examined the distributional pattern of the petrol retail stations and assess their conformity with planning standards; even though most petrol retail station do not comply with the standard of 50-meter distance from well water sources. The research adopted field survey, coordinate of the stations were obtained using Geographical Positioning System (GPS) to collect primary data; Garmin™ Etrex

Introduction

In recent times, there has been a tremendous proliferation of petrol retail outlets at strategic locations due to high demand for fuel and the justification for such unprecedented increase is due to the country's population and the attendant increase in the purchase of vehicles (Taylor, Sichinsambwe, & Chansa, 2016). The attractive price of petrol both at control price and black-market price makes more people to go into petrol retailing businesses (Tah, 2017). Petrol retail businesses today are the key driver of industrial activities as its upsurge our economy so much creating job opportunities for residence in areas and communities where these petrol stations are located (Mwenda and Oloko, 2016).

The deregulation policy of the petroleum sector introduced in 2003 by president Olusegun Obasanjo has caused drastic changes in the industry, owing to this policy there is free entry in the oil marketing industry and this has seriously generated a ripple effect increasing competition among Oil Marketing Companies due to a general price war and increase of fuel stations along major roads (Godfrey, 2015). Given this development, many marketers take advantage of this to build service stations haphazardly without considering the possible environmental effect of the locations of the stations (Akinsulire & Fadare, 2020).

Since 1996, statistics shows that there has been a rapid increase in the establishment of fuel stations across the world for example, in Asia-Pacific region there are about 17,281 fuel stations compared to 10,938 in 2012 and 34,200 in 1996 (International Association for Natural Gas Vehicles-IANGV, 2017). Similar is the story for North America with fuel stations increasing from 47 in

handheld Global Positioning System (GPS) receiver of 4.5 m accuracy. A Buffer width of 250meters recommended by Palfrey and Bradley, was used to provide a buffer zone. Results were presented on imageries and Maps. (GIS) was also used in identifying the existing petrol filling stations as well as conducting queries to assess the level of compliance of the petrol filling stations with extant planning standards. The research throws light on to the physio-chemical analysis of Well water sources in Minna metropolis, eight different well were compared: The parameters such as water temperature, total dissolved solid, pH, conductivity and Total petrol hydrocarbon (TPH) were analysed. In this study, Total petroleum hydrocarbon concentration affects different aspects of the water quality, it can be concluded that eight (8) underground water sources out of the ten (10) shows the presence of Total Petroleum Hydrocarbons (TPH). Only one well (Well 5) with 4.8 TPH concentrations was within the permissible limit of 5.0 mg/l. The study recommends wells that are to be used for domestic purposes should be cited far away from Petroleum Filling stations so as to reduce the number of Hydrocarbons that may get into the underground water sources and in unavoidable cases, water treatment should be embraced.

Keywords: Keywords: Filling stations; water quality, Physicochemical Parameters, spatial distribution, Total Petroleum Hydrocarbons (TPH).

1996 to 1,919 in 2017 as posited by author above. Also, International Association for Natural Gas Vehicles-(IANGV, 2017) vigorously pointed out that between 1996 and 2016, the number of fuel stations across the globe increased astronomically about 2,432% with fuel stations in Africa increasing about 17,500%. The high rise of these petrol retail stations especially in Africa raises some much questions about the kind of land and spaces on which these stations occupy (Marian, 2019).

Statements of Research Problem

Minna metropolis is one of the towns in Nigeria that is faced with the action of indiscriminate siting of petrol retail stations, the proliferation of petrol retail stations along `the major roads and within Minna metropolis is quite disturbing (Yisa *et al*., 2019). A drive through major roads and within Minna city indicate that Niger state urban development board (NUDB) and the Department of Petroleum Resources (DPR) does not comply with its own statutory requirements of the regulations and guidelines in the establishment of Petroleum Retail Stations in Urban Minna (Niger State Urban Development Board - NUDB, 2016). Planners should at all times assess possible hazards in planning and promote ways of avoiding or mitigating damage that might cause hazards, risk and vulnerability (Mshelia *et al*., 2015).
However, there are relevant research done by various scholars on Petroleum Filling Stations and their Impact on the Environment both local and international. Peprah (2018) investigated the level of compliance to standards set by the Ministry of Energy, and Town and Country Planning Department on existing oil and gas station in Tarkwa Ghana, using multi-criteria decision analysis and GIS approach. Mshelia *et al.* (2015) Assessed environmental effects of Petrol Stations at Close Proximities to residential buildings in Maiduguri and Jere, Borno State

Nigeria. (Emakoji & Otah, 2018) worked on analysing the location of filling station in Afikpo-Ebonyi State Nigeria against the laws and regulations guiding their establishment; (Odekunle *et al*., 2019) in their studies analysed the impacts of petroleum filling Stations in Minna Metropolis using global position system (GPS) to determine their spatial locations, all these studies reported violations of the spatial regulations of the Department of petroleum resources (DPR) and Urban planning standards, it is therefore against this background that the study fills the research gap by examining the spatial pattern of these petrol stations and the associated water hazards in Urban Minna.

Aim and Objectives of the Study

The aim of the study is to assess the environmental impact of indiscriminate location of petrol retail stations in Minna.

The specific objectives of the study are to:

i. Examine the distribution of petrol retail stations within Minna;
ii. Analyse the proximity of well water sources by measuring their distances from storage tank;
iii. Analyse the physiochemical properties of water source samples to ascertain the effect of petrol retail stations locations on them; and
iv. Compare results with WHO and National standards for drinking water.

Research Questions

i. How are various fuel stations distributed in urban Minna?
ii. Are filling stations located according to established planning standards, guidelines and regulations in Urban Minna?
iii. Does the locations of petroleum filling stations in Minna has effect on groundwater sources?
iv. Does the available Well water source meet the WHO and National planning standard for drinking water source?

Justification for the Study

The resent proliferations of petrol retail station in Minna metropolis has prompted the adaption of this research. the research is justifiable because the number of filling stations in Minna metropolis is increasing astronomically as indicated by (Ahmed *et al*., 2014). These Petroleum filling stations are generally ought to be located at the periphery of cities and towns; however, with the passage of time, the residentials and commercial areas in the study area get surrounded by these petrol retail stations.

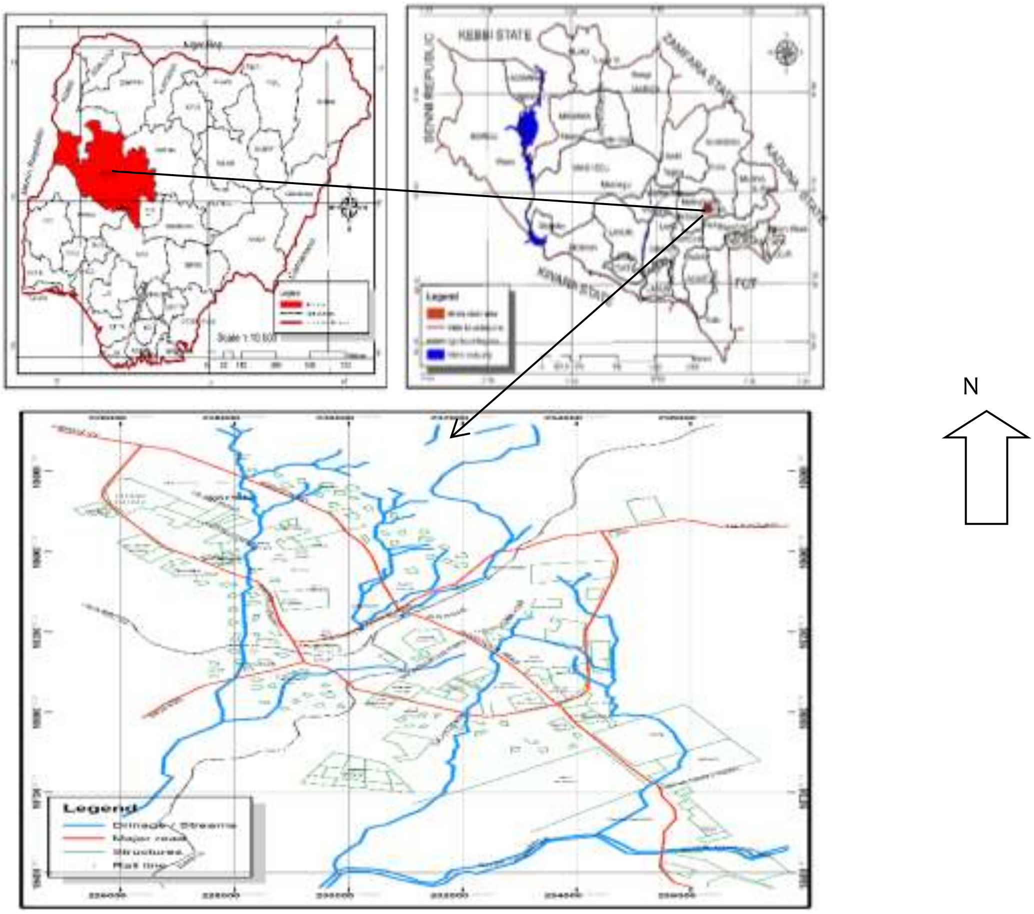
This study will assist Town planning authorities to carry out necessary actions on already existing petrol retail stations that have contravened planning standards that are ill-sited as well as verify with ease and implement standards for those yet to be constructed. Few researches have been done on the subject matter in existing literatures, it will therefore serve as a guide for individuals or developers and even the government together with other stakeholders in the urban planning and downstream petroleum industry sector and also for further research and decision making.

Scope of the Study

This study mainly focused on the evaluation of water quality parameters of well water sources close to petrol filling stations in some parts of Minna metropolis. The study covers Minna township, from Minna city gate along Minna – Paiko road, through Bosso road to Maikunkele City gate and also from Maitumbi, through the Eastern and Western bye pass. These areas were chosen because most of the filling Stations were located along the high capacity urban road in the study area and most of these vulnerable wells are within the premises of these Filling Stations.

Description of the Study Area

The Study area is located between longitude 6°31'08'E and 6° 37.31'E and latitude 9°11.11'N and 9°60.50'N of the Greenwich Meridian as indicated in Figure 1.1. Minna shares borders with the following Local Government Areas; Shiroro LGA to the North, Wushishi LGA to the West, Gbako LGA to the South-West, Katcha LGA to the South-East and Paikoro LGA to the East as shown in page 9. Minna is made up of settlements such as: Chanchaga, Shango, Maitumbi, kpakungu, Dutsen-Kura, Bosso, Maikunkere, Barkin Sale,Tudun Fulani, Keteren Gwari. **T**he Study area is located between longitude 6°31'08'E and 6° 37.31'E and latitude9°11.11'N and 9°60.50'N of the Greenwich Meridian as indicated in Figure 1.1. The study area experiences tropical continental type of climate with distinct wet and dry seasons controlled by the shifting position of the inter-tropical convergence zone. The vegetation of the study area can generally be described as typical Guinea Savanna with a mixture of trees, shrubs, herbs and tall grasses.



Fiqure1.1: The study area (Minna metropolis, Niger State, Nigeria
Source: Niger State Geographic Information System

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Literature Review

Literature on locations of filling stations or its synonymous names, i.e., petrol filling station, fuel station, gas station, petroleum outlet are virtually scanty. What prevails in the global literature is the paucity of research documentation on the technological remediation of service sites closures due to the environmental risks associated with both soil and underground water pollution (Thomas *et al*., 2016).

Rana & Garg (2014) noted that location of petrol fuel stations is a very significant issue and needs to consider impact of various relevant parameters such as distance, population and access time on a location. Location theory has turn out to be an essential component of economic geography, regional science, and spatial economics and furthermore, the theory supports various forms of locational analysis and highlights the significance of spatial proximity (Marian, 2019).

Sneha *et al*. (2016) Pointed out that water quality is directly related to the physical, chemical, biological and radiological property of water and these properties of water are affected because of the pollution of water due to various human activities. According to Sneha investigation water bodies changes the standard quantity of parameters in water.

Similarly, Pawan & Pradeep (2015) carried out a study and collected water samples from 12 different sampling stations to evaluate water quality status of river Narmada, a total of 16 water quality samples were determined, minimum and maximum value of air temperature, water temperature, turbidity, pH, electrical conductivity, total dissolved solids, free carbon dioxide, total alkalinity, chloride, total hardens, Calcium Hardness dissolved oxygen, nitrate, orthophosphate, biochemical oxygen demand and chemical oxygen demand were noted from the study.

Dipankar *et al*. (2019) further investigated drinking water quality in some parts of Perak state, Malaysia, in this aspect of study a detailed physiochemical analysis of drinking water samples was conducted in different residential and commercial areas of the state.

Smutko et *al.* (2012) observed that ground water is vulnerable to contamination from numerous anthropogenic activities and these anthropogenic activities are controlled by the influence of man, one of the best-known classes of groundwater contaminants includes petroleum-based fuels such as petroleum and diesel.

MATERIALS AND METHODS

This research is designed to determine and analyse the vulnerability of residents living on water source within proximity to filling stations in Minna, Niger State Nigeria. In this study, GIS was used to examine spatial relations between water wells, their recharge zones, and the potential sources of groundwater contamination. The primary data employed in this research was collected directly from the field, that is, geographical coordinates of petroleum filling stations as well as the coordinate points of groundwater sources were obtained with the aid of a Garmin™ Etrex handheld Global Positioning System (GPS) receiver of 4.5m accuracy For the purpose of this research work, secondary data and information were obtained through the following means; published and unpublished textbooks, journals, articles, conference proceedings, internet and some agencies.

Purposive sampling was used to select seventy-eight (78) fuel station, selection was based on their close proximity to residential neighbourhoods especially those that falls within the criteria set, that is 50 meters proximity to the Filling station. Water samples were collected in 500ml plastic bottles, the samples were labelled Well 1 to Well 10 and stored in ice chest prior

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to taking them to the laboratory. Conductivity were determined using the Hydrochek Conductivity Meter CMD8000. Total dissolved solid of water samples were carried out by using TDS metre. Also, Gas chromatography (GC) was used to measure Total Petrol Hydrocarbon in water.

Results and Discussion

Distributional Pattern of the Petrol Retail Stations in Minna town

The findings revealed 78 existing petroleum filling stations at the time of study, These Petrol retail stations are located along the six (6) major roads in Minna. However, the petrol retail stations are not equally distributed between the roads as can be observed from Figure 4.1. Nmamdi Azikwe road has the highest number of stations (21) followed by Bida road with (17) and Bosso road (15) each respectively, these roads account for more than 70% of the filling stations in the area. This result is not surprising because the roads are the major roads in Minna metropolis; they are served as a link to inter-state with major cities.

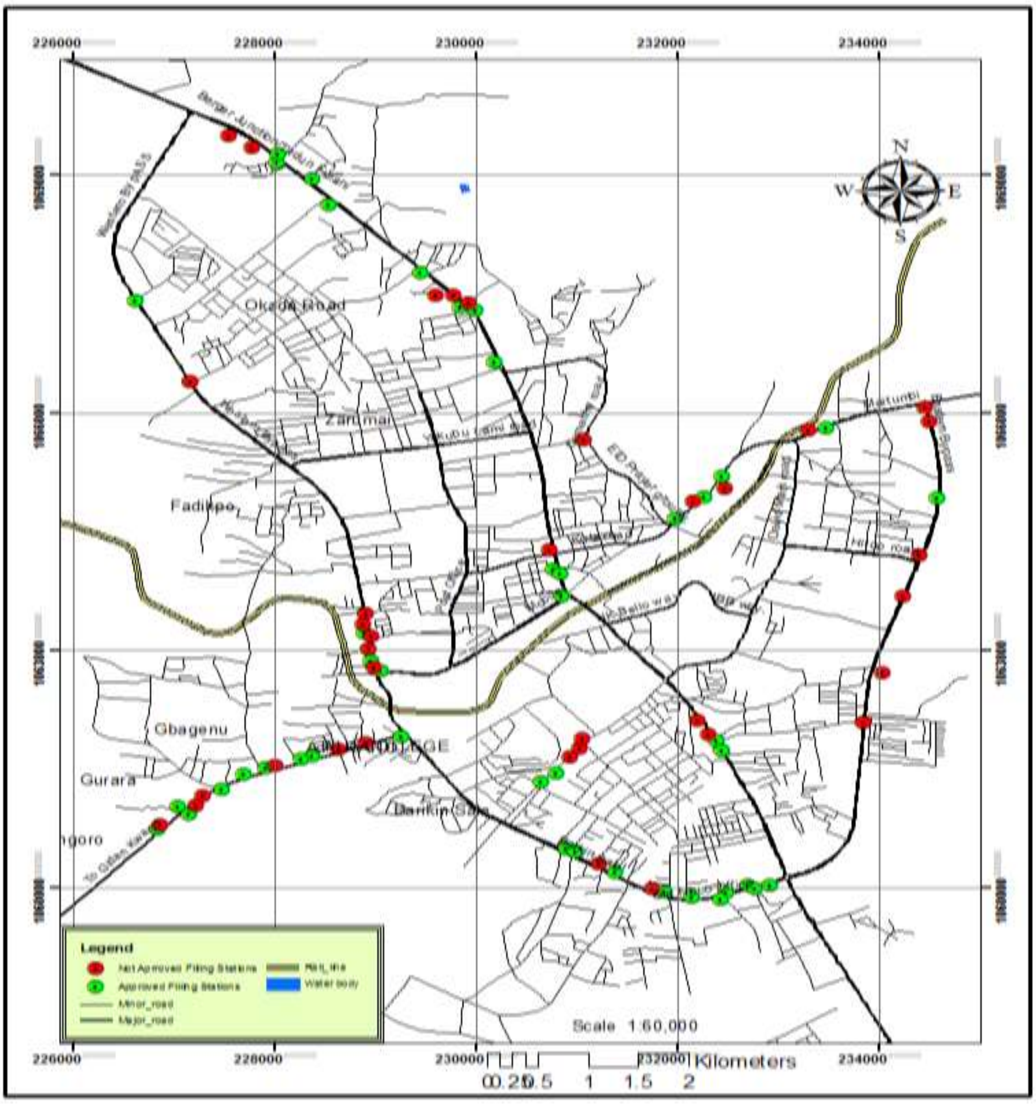

Figure 4.1: Spatial location of Petroleum Filling Stations in Minna Township.
Source: Authors Analysis, 2022

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Proximity of well water sources to location of petroleum Filling stations

The study identified a total of 30 different domestic well water sources within the proximity of less than 50meters to petroleum filling stations in Minna. Most of the wells identified were within the premises of the petroleum filling station and the wells were made available for domestic uses by residents around the filling stations.

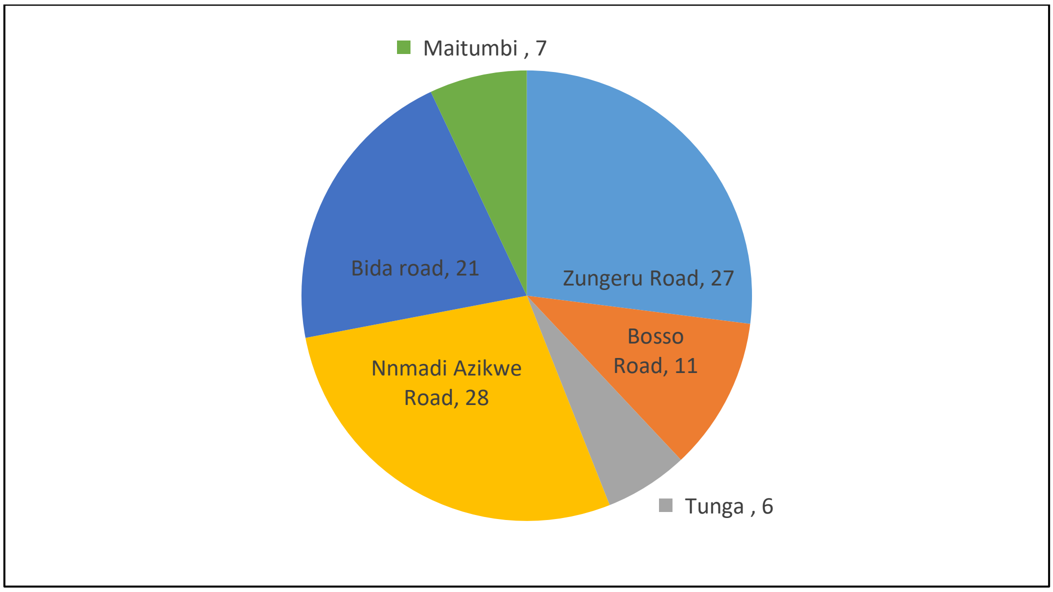

Figure 4.2: Percentage of Vulnerable Domestic Well Water Source in the Study Area.

Figure 4.2 shows the concentration of vulnerable domestic well water proximal to petroleum filling stations in Minna metropolis, majority of vulnerable domestic wells were along Nnamdi Azikiwe road with 28% of the total well identified, followed by Zungeru road with 27%, then Bida road with 21%, Bosso Road 11%, Maitumbi 7% while Tunga area has the lowest vulnerable domestic well water source with 6%.

Physiochemical analysis of water samples to check water contamination

In examining the physiochemical analysis of sampled well water, the selection of parameters and the determination of maximum allowable limits were conducted by taking into consideration the WHO and National Standard for drinking water quality. The parameter considered were Temperature, pH, conductivity, Total Dissolve Solid and Total Petroleum Hydrocarbon (TPH). The amount of TPH found in the well water sampled is a useful indicator of petroleum contamination in that water. The permissible limit for total petroleum hydrocarbons is 5.0 mg/l (WHO, 2008) However, in this study, eight (8) well water source samples out of the out of ten (10) studied had values exceeding this standard. In addition, according to (Valentinett *et al*., 2002), petroleum hydrocarbons enter underground water through several sources such leakages from underground storage tank This was evident in this study where most well water sampling points had the influx of mechanic shops as well as fuel storage tanks close to them.

Temperature (°C)

This study revealed that all the sample well water have their water temperature above the WHO and Nigeria Standard for drinking water requirement. the well with the least temperature is well number 5, located along Zungeru- Bosso road) with 28.3° and the highest are wells 1 and 3 (located at Berger Junction, Zungeru road and Saiko road) with 29.7° respectively. High water temperature enhances the growth of microorganisms and may increase taste, odour, colour and corrosion problems. However, the disparity in water temperature from World health organization (WHO, 2008) standard does not make the water to be unfit for drinking.

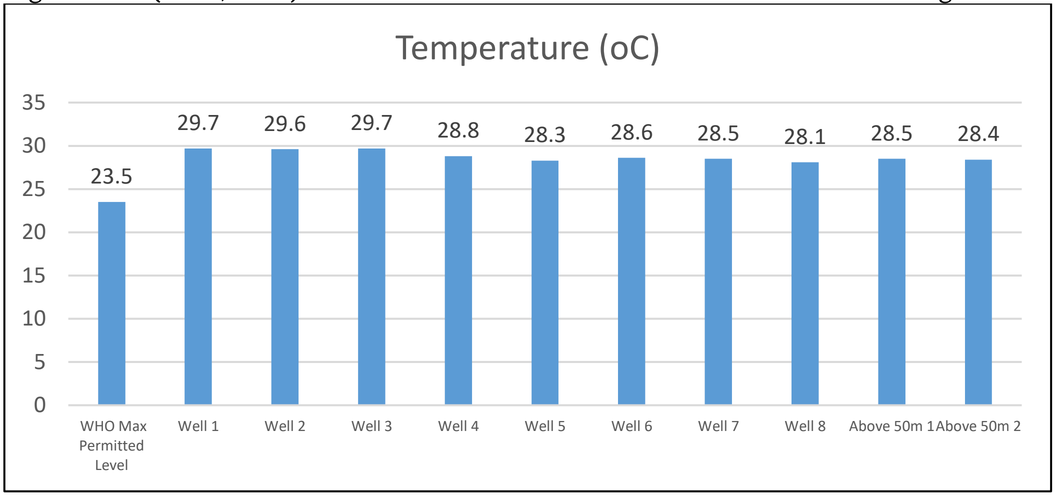

Figure 4.3: Level of Temperature of Sampled Well water in the study area.
Source: Authors Field Survey, 2022

pH level of acidity and alkalinity of water

The pH of well water normally is between 6.0 and 8.5. Figure 4.3 shows that none of the well water sample is above the WHO standard of 8.5, the least in pH is Well 1 (located at Berger Junction, Zungeru road) with a pH of 6.12 and the highest was well 3 (located at Saiko road) with 8.14. Water with pH lower than 5.0 may cause problems due to corrosion because many metals become more soluble in low pH waters. A pH value of higher than8.5 indicates that a significant amount of sodium bicarbonate may be present in the water.

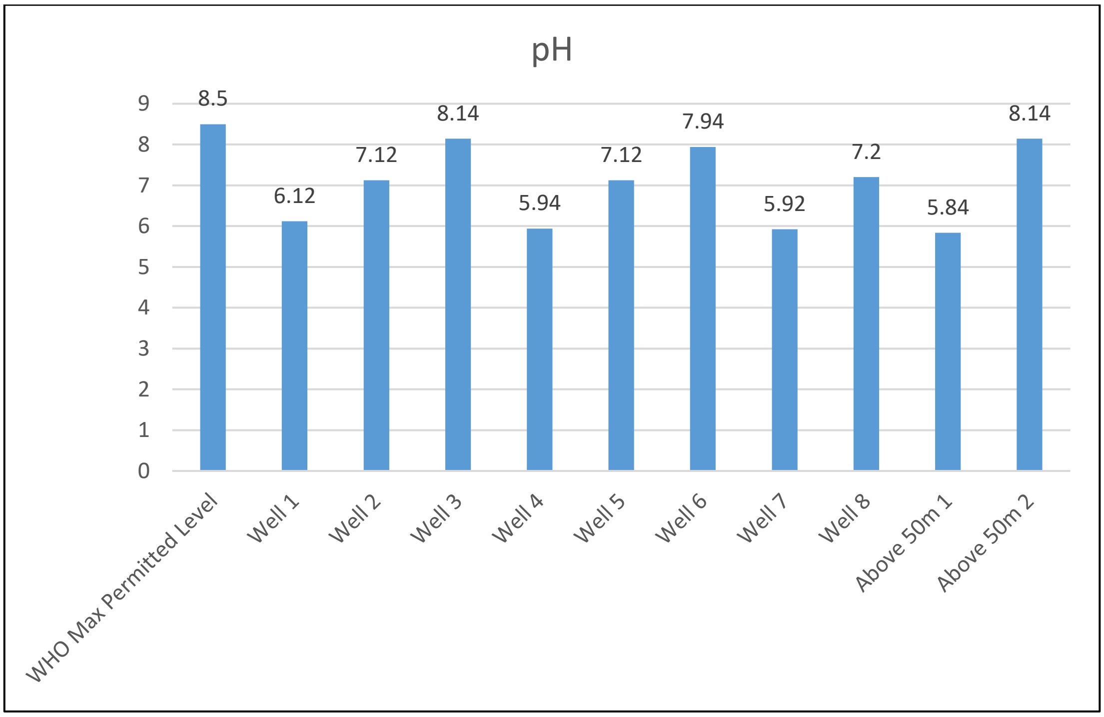

Figure 4.4: Level of pH in Sampled Well water in the study area.
Source: Authors Field Survey, 2022

Total dissolved solid (TDS)

Total dissolved solid (TDS) is the total amount of material remaining after evaporation of water. Permissive level value of less than 500 ppm (mg/L) and up to 1,000 ppm (mg/L) can be tolerated. The following samples are presented in figure 4.5 bellow; well 1 (located at Berger Junction, Zungeru road) has 638.5 ppm, well 2 (also located at Berger Junction, Zungeru road) has 686.8 ppm, well 3 (located at Saiko road) has 913.9 ppm respectively which are the major well water samples. Muoghalu and Omocho (2000) reported that high TDS values have the tendency to absorb heat from the sun thereby raising the temperature and increasing the turbidity of water. Since all these falls within 500 ppm (mg/L) and 1,000 ppm (mgl) they can be tolerated with little health effects.

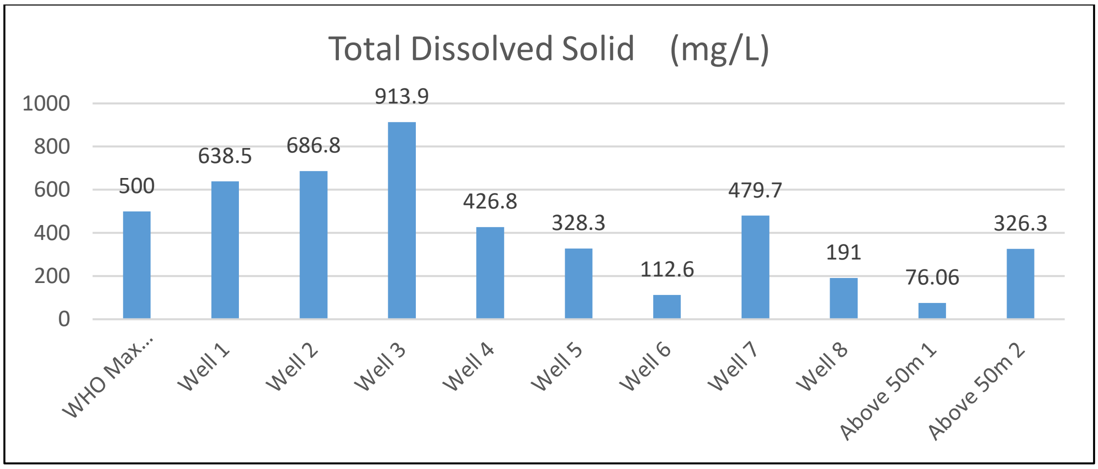

Figure 4.5: Level of TDS in Sampled Well water in the study area.
Source: Authors Field Survey, 2022

Conductivity

The Conductivity concentration as recommended by WHO standard in domestic water is 1000mg. Figure 4.6 shows that well 3 that is located at Saiko road has the highest concentration of conductivity with 1364mg followed by well 2 (located at Berger Junction, Zungeru road) with 1025mg. The least well with conductivity concentration is well 6 (located at Nnamdi Azikiwe road) with 168 mg. the findings shows that well 2 and well 3 has conductivity above the WHO limit, while other sampled wells have the limit recommended standard.

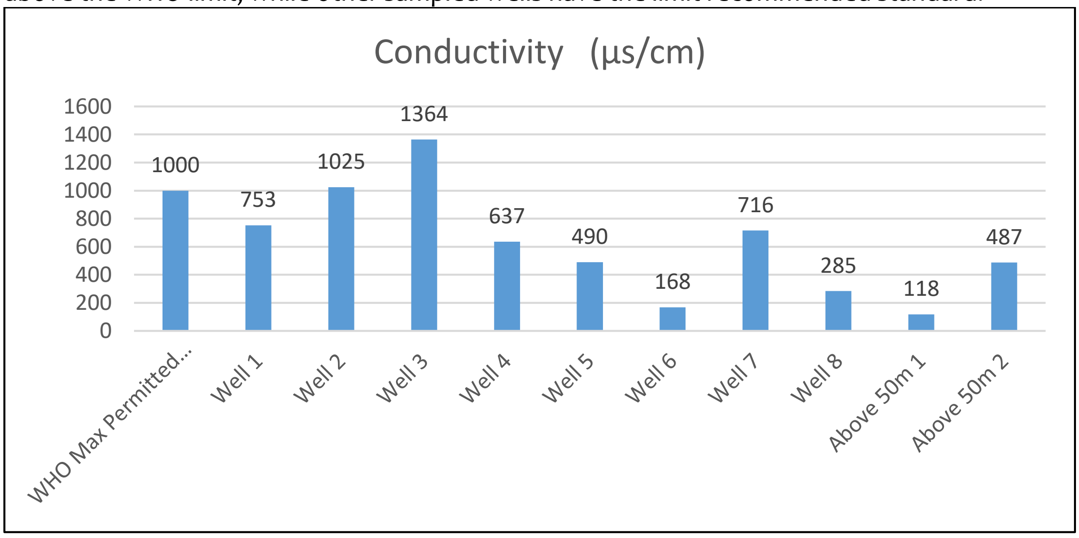

Figure 4.6: Level of conductivity in Sampled Well in the study area.
Source: Authors Field Survey, 2022

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Total petroleum hydrocarbon (TPH)

The permissible limit for Total Petroleum Hydrocarbon (TPH) concentration for drinking water is 5.0 mg/l (WHO, 2008); Figure 4.7 shows that all the sampled well was above WHO permitted limit level of drinking water, it was discovered that the highest mean concentration of TPH was 8.2 mg/l recorded at Well 6 (located at Nnamdi Azikiwe road), followed by 7.1 at well 1, (located at Berger Junction, Zungeru road). The least was well 5 (located at Bosso, Zungeru road) with 4.8mg/l. The two sampled wells were water above the 50meter setback and did not show the present of Total Petroleum Hydrocarbon. This analysis showed evidence of contamination of underground water due to the operation of petroleum filling stations in the study area.

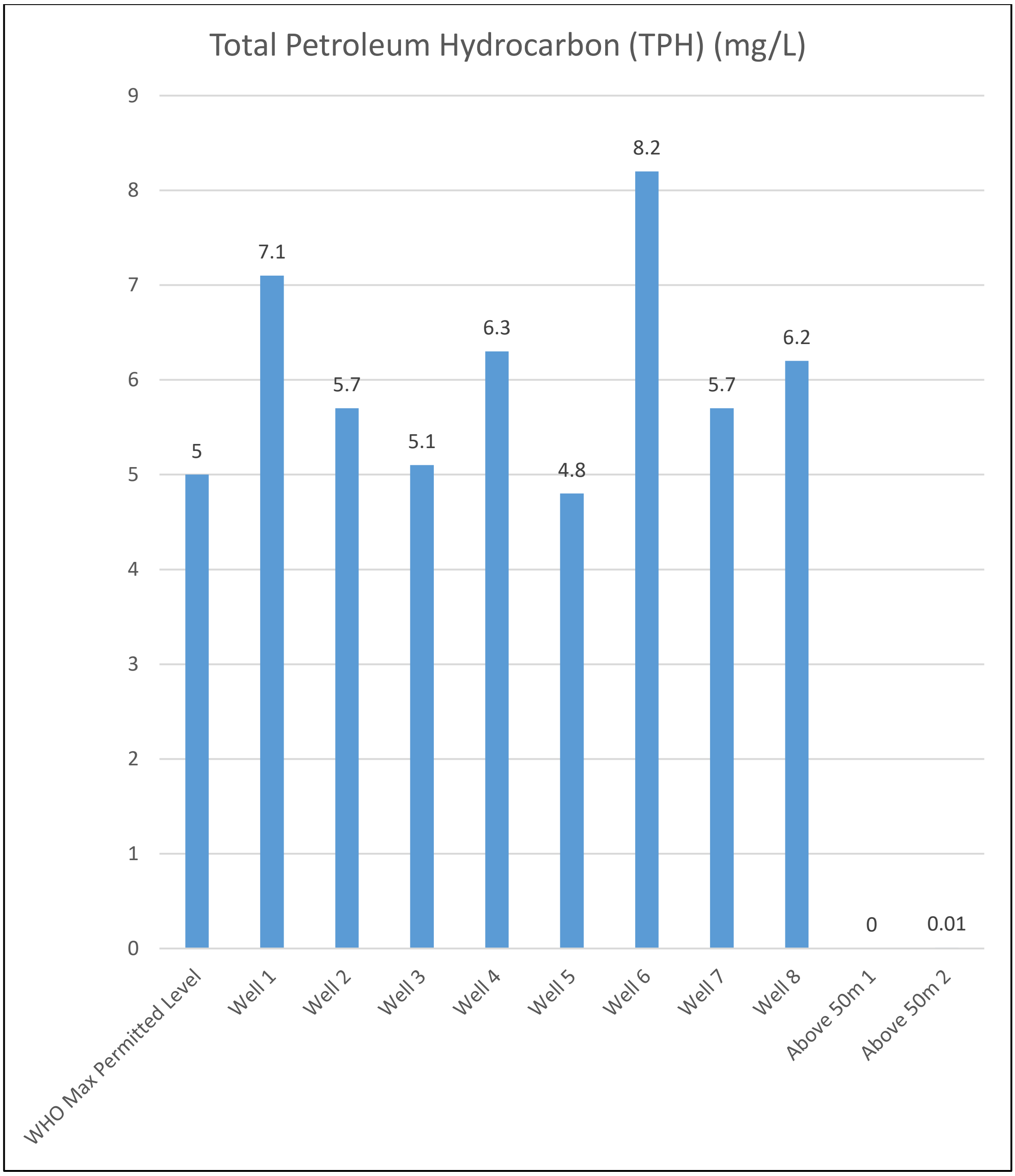

Figure 4.7: Level of TPH in Sampled Well in the study area.
Source: Authors Field Survey, 2022

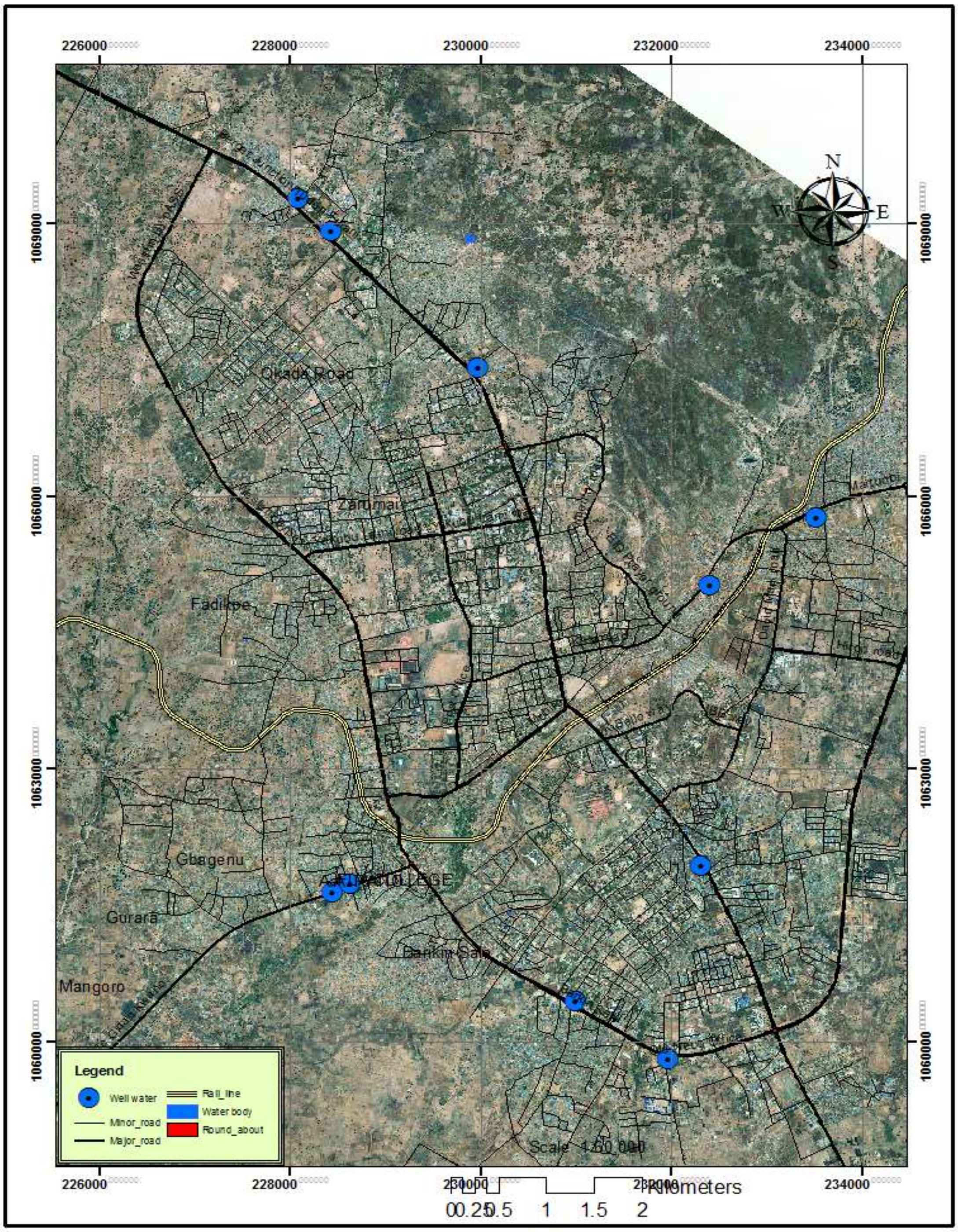

Figure 4.8: Locations of well water samples in the study area
Source: Authors Analysis, 2022

Compare results with WHO and National Standards for drinking water quality

Chemical analysis was performed at Niger State Environmental Protection Agency's laboratory. Samples were prepared using standard methods required for gas chromatography analysis. The results obtained were compared with the World Health Organization (WHO) and National standard for drinking water quality specifications in table 4.1 bellow.

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Table 4.1 Results of Physicochemical analysis

PARAMETER	WHO/NSDWQ Max Permitted Level	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Well 7	Well 8	Above 50m 1	Above 50m 2
Temperature (°C)	23.5	29.7	29.6	29.7	28.8	28.3	28.6	28.5	28.1	28.5	28.4
Conductivity (µs/cm)	1000	753	1025	1364	637	490	168	716	285	118	487
Total Dissolved Solid (mg/L)	500	638.5	686.8	913.9	426.8	328.3	112.6	479.7	191	76.06	326.3
pH	8.5	6.12	7.12	8.14	5.94	7.12	7.94	5.92	7.2	5.84	8.14
Total Petroleum Hydrocarbon (TPH) (mg/L)	5.0	7.1	5.7	5.1	6.3	4.8	8.2	5.7	6.2	0	0.01

: Authors Survey, 2022

Table 4.1 above, revealed that all the sample well water has their water temperature above the WHO and National Standard's requirement. The well with least temperature is well number 5 which has a temperature of 28.3° and the highest are wells number 1 and 3 with water temperature of 29.7° respectively, this indicate that all of the well water sampled Temperature were above the WHO and National standard for drinking water. Also, pH Study confirmed that all the water samples are in slight acidic range, I can say near about neutral, well 1 with pH of 6.12 and the highest were well 3 with pH of 8.14 and 7.94. It was also discovered that total dissolved solid; well 1(638.5 ppm), Well 2(686.8 ppm), well 3 (913.9 ppm) respectively which are majorly samples from well water. Whereas, conductivity of Tested water was higher in well 3, with conductivity of 1364(µs/cm) followed by well 2 with 1025(µs/cm). The study showed that Total Petroleum Hydrocarbon is present in all the sampled well, except for the two (2) sampled well that were above 50meters proximity to the petroleum retail stations which is an evidence of contamination of underground water.

Summary of Findings

The findings revealed that 78 existing petrol filling stations within the area of coverage as at the time of this study are located along six (6) major roads in Minna. However, the filling stations are not equally distributed between the roads. The study identified a total of 30 different domestic well water sources within the proximity of less than 50meters to petroleum filling stations in Minna. Most of the well identified were within the premises of the petroleum filling station and were made available for domestic uses by residents close to the filling stations and some were within the next closest building less than 50 meters. The findings show that the majority of vulnerable domestic wells water were along Nnamdi Azikwe road with 28% of the total well identified, followed by Zungeru road with 27%, then Bida road with 21%, Bosso Road 11%, Maitumbi 7% while Tunga area has the lowest venerable domestic well water source with 6%. The findings show that out of the seventy-eight (78) identified petroleum filling stations in Minna Township only thirty-two (32) has approval from the Niger State Urban Development Board, and forty-six (46) did not have approval from the board. In examining the physiochemical analysis of sampled well water, the selection of parameters and the determination of maximum allowable limits were conducted by taking into consideration the

WHO guideline for domestic water quality. The parameter considered were Temperature, pH, conductivity, Total Dissolve Solid and Total Petroleum Hydrocarbon (TPH). The study further revealed that all the sample well water have their water temperature above the WHO requirement and National Standards for drinking water. The well with least temperature is well number 5 which has a temperature of 28.3^o and the highest are wells number 1 and 3 with water temperature of 29.7^o respectively. The study indicates that none of the pH of well water sample exceed WHO standard of 8.5, the least is Well 1 with pH of 6.12 and the highest were well 3 with 8.14.

CONCLUSION AND RECOMMENDATIONS

In Conclusion, this study has successfully analysed various Physicochemical Properties of water samples Collected from 10 major water sources and also presented the levels of physicochemical parameters such as Temperature, pH, Conductivity, Total dissolved solids (TDS) and Total Petroleum Hydrocarbons (TPH) contents in the well water samples collected. The outcome of this study raises issues of public health and safety; therefore, the following recommendations are made.

1. wells used for domestic purposes should be cited far away from Petrol retail stations so as to reduce the number of Hydrocarbons that may get into the underground water sources and in unavoidable cases, water treatment should be embraced. Water quality should be controlled in order to minimize acute problem of water related diseases, which are endemic to the health of man.
2. State legislature should enact law forbidding either government or individuals from given out plots of land for location of petrol stations within Minna Township. Any attempt by either of the two sides to convert the use of any land within the township should be resisted by the Niger state planning Authority and the court.
3.To control the sitting of fuel stations at unauthorized places, Niger state planning Authority and department for petroleum resources (DPR) should ensure that building permit and authorization for the siting of fuel stations are only issued to applicants having proof of location based on the urban planning standards and land use regulations of Nigeria and the land-use plan of Minna town.
4. Ministry of Environment in collaboration with all the petrol retail stations should constantly mount public enlightenment campaign using posters, bill boards and media houses to educate the public on the hazards associated with petroleum products with respect to human health and the environment so as to discourage residing close to petrol retail stations.

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