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Table of Contents: Volume 11 Number 5 May 2019

ARTICLE

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Full Length Research Paper

Spatial distribution and operations of petrol stations in the Kassena-Nankana district (Ghana) and associated health and safety hazards

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This study was conducted in Paga to assess the spatial distribution and operations of petrol stations and the associated health and safety hazards. Coordinates of the stations and the distances between them and the nearest residences were elicited and analysed using a GPS and ArcGIS software. Distances between fuel stations' boundaries and the middle of the N10 highway and the distances between filling stations' underground tanks and the nearest houses/institutions were determined using the same technique. Qualitative data were derived using structured questionnaires and semi structured interviews to provide information on perceptions of residents on the potential dangers associated with the presence of filling stations to assess the extent to which the location and operations of the stations conformed with government policy and guidelines. The study revealed that the inventoried filling stations were all located along the highway and distributed across both sides. The ratio of the total number of filling stations to the stretch of the highway (km) was 4:1. The study also showed that the guidelines for siting filling stations were not adhered to by most of the stations in the area. This posed a serious threat to the health and safety of the locals; more so, as they were predominantly sited close to residences and places of public assembly. The study also revealed that albeit there was good level of public awareness and knowledge amongst the locals of issues relating to hazards associated with the presence of the filling stations in the area, no action was undertaken by the people to draw the attention of local authorities to the problem, and prompt them to remedy it. The study therefore recommended the need for the regulatory agencies to take immediate remedial actions in response to the haphazard siting of filling stations in the area, and the country as a whole.

Key words: Petrol stations, hazards, government policy and guidelines, perception, township.

INTRODUCTION

The impacts of human activities on the environment have intensified over recent decades due to increased population and industrial activities such as petrol stations. A petrol station is a facility where fuel and lubricants for

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automobiles are sold (Afolabi et al., 2011). Beside industrial development, globally, the transport sector is presumed to be the major consumer of fuel to facilitate people's movement (Thomas et al., 2016). Hence, increasing vehicles trigger an increasing demand for fuel and by extension fuel stations (Abdul Hamid et al., 2009). Thus, in many countries, there is heavy presence of petrol stations due to urban growth (UN, 2010).

In Ghana, petrol stations have increased astronomically (Monney et al., 2015). Paga, the district capital of the Kassena-Nankana West District of the Upper East Region of Ghana is among the district capitals whose land use and land cover changes are driven to a considerable extent by the construction of filling stations. Paga is a peculiar case in this regard since it shares international boundary with Burkina Faso. Refuelling vehicles at the transit point and smuggling petroleum products into Burkina Faso and the landlocked countries have led to the proliferation of filling stations in Paga, thereby raising concerns about the associated negative environmental impacts and safety hazards.

Research has shown that there are pressing concerns about the health and safety and environmental quality emanating from filling stations (Nieminen, 2005; Monney et al., 2015) and the negative sides of petroleum (especially, fuel for refuelling vehicles) on the ecosystem. Hence, the location points of petrol stations must be strategically and consciously done to minimise their impacts on both human and their immediate environs (Thomas et al., 2016). Research has further shown that one of such environmental impacts on the earth's biosphere is the release of pollutants and greenhouse gases into the environment and the damage of ecosystems through oil spillage (Timothy, 2006), gasoline delivery to stations, vehicle refuelling, combustion products from vehicle engines within fuel stations (Isabel et al., 2010). According to Sergio (2008), these emitted gases are hazardous to human health.

Besides the flammability of petrol vapour, filling stations carry a risk of fire or explosion which are not common to other types of retail outlets. Petrol vapour may ignite when exposed to sparks from an electrical switch, a lighted cigarette or a static electrical discharge (HSA, 2017). According to WHO report (2004), more than 2.3 million lives and properties worth about 4.5 billion are lost to fire outbreaks emanating from mishandled petroleum product (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).

It is against this background that this study was conducted to examine the spatial distribution of filling stations, the relative distances between residents and fuel stations, and the environmental and health risks associated with the siting and operation of these filling stations. The research was further justified by the fact that, hitherto, there has been no published data on this aspect of research in the area.

MATERIALS AND METHODS

Study area

The study was conducted in the Kassena-Nankana West district, Upper East Region, Ghana. It is located approximately between latitude 10.97° North and longitude 01.10° West (Figure 1). The district has a total land area of approximately 1,004 km^2. The district shares boundaries with Burkina Faso, Bongo district, Bolgatanga Municipal, Kassena-Nankana East Municipal, Bulsa district and Sissala East district to the north, north-east, east, south, south-west and west, respectively (GSS, 2010). Paga is the capital of the Kassena-Nankana West district. It is located on the border of Ghana to Burkina Faso. It is 166 km south of Ouagadougou via the N10 highway.

Data collection method

The research method used for this study was a mixed methods research strategy which integrated both quantitative and qualitative research methods. The set of data collected included both primary and secondary data. Secondary data were obtained from a critical review of existing literature relating to the study whilst the set of empirical data was elicited from a field survey. This included counting the number of filling stations, measuring the distances between petrol stations and the nearest houses, assessing stations siting with guidelines/standards. The other components of primary data gathered were related to the potential environmental and safety hazards associated with the location and operation of the filling stations in the area, the perceptions of people on the potential threat posed to their health, properties, and the environment. The data relating to the coordinates of the filling stations and the distances between the stations and the nearest residences (within 100 m radius of location) were gathered using a GPS (etrex Garmin) while the remaining aspects of the data were elicited using structured questionnaires and semi structured interviews. The set of structured questionnaires was administered to fifty (50) household heads (or their representatives) located within 100 m radius of the inventoried filling stations while the semi structured interviews were conducted with the officials of the regional offices of the Environmental Protection Agency (EPA) and Lands Commission.

RESULTS

Spatial distribution of the filling stations in Paga and its environs

A total of twenty-four (24) filling stations were identified (Table 1). Seventeen (17) were functional while seven (7) stations were under construction. The data contained in Table 1 and Figure 1 further showed that all these filling stations were located along the N10 highway. The study data also revealed that 62.5% of these stations, consisting of eight (8) functional and seven (7) uncompleted stations, were all situated in a single neighbourhood

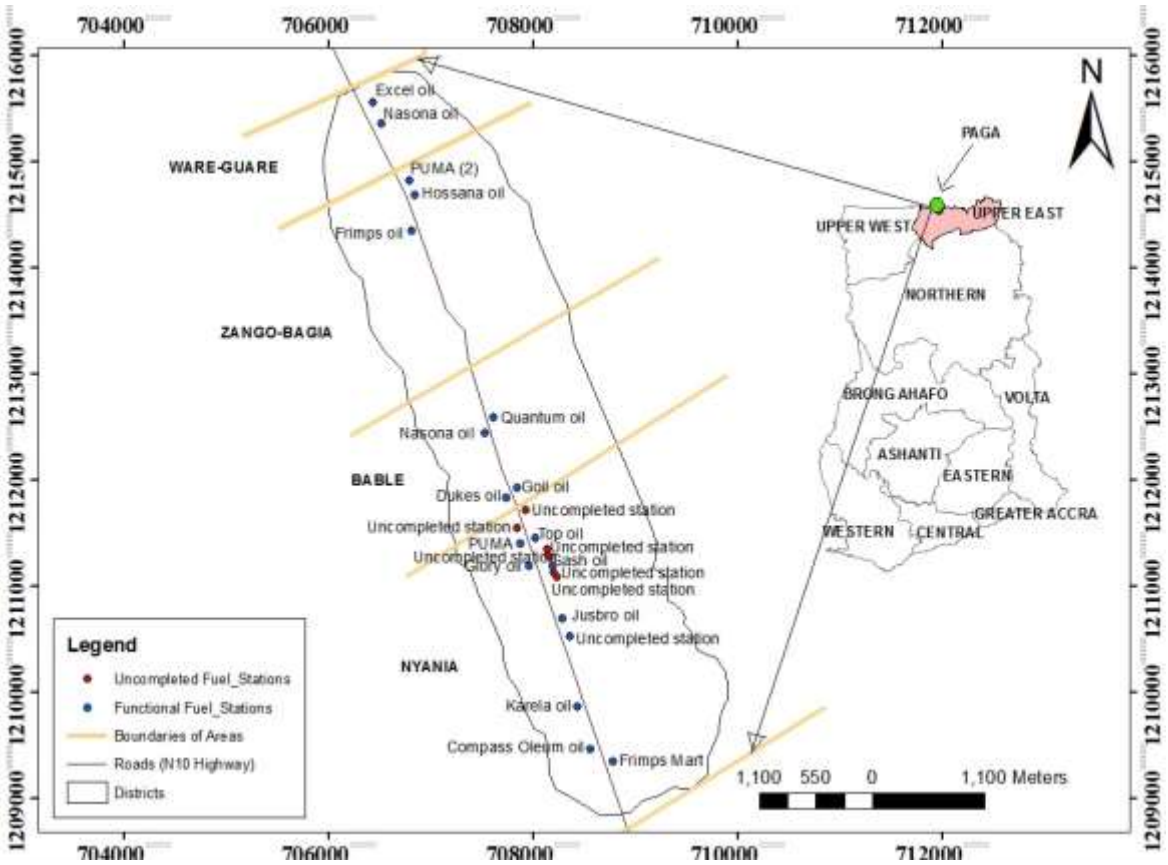

Figure 1. Spatial distribution of filling stations in Paga.

Table 1. Spatial distribution of the filling stations across Paga.

Area	Routes	Functional (fl)	Uncompleted (upl)	Total number	%
Nyania	N10 Highway	08	07	15	62.5
Bable	N10 Highway	04	-	04	16.67
Zango-Bagia	N10 Highway	03	-	03	12.5
Ware-Guare	N10 Highway	02	-	02	8.33
-	-	17	7	24	100

Percentage (%) Functional: 70.83%; Percentage (%) Uncompleted: 29.17%.

(Nyania) of the study area (Table 1). Data obtained from the field survey further indicated that the ratio of filling stations to the distance of the stretch was $\frac{24\ filling\ stations}{6.7\ km}$. This is approximately 4 filling stations per 1 km.

Distances between filling stations

The data in Table 2 and pictures provided in Plate 1 showed that 20 filling stations (83.33%) were less than 500 m from the nearest stations. This is contrary to international guidelines of 400 m. The study results therefore showed that only four (4) filling stations (16.67%) conformed to the EPA guidelines (Table 2). A detailed examination of the data also revealed that, out of the twenty (20) improperly located stations, fourteen (14) were less than 100 m from the nearest stations, while four (4) were separated from the nearest station at distances ranged between 100 and 199 m. The remaining two stations were 200 to 299 m and 300 to 399 m from

Table 2. Distance between filling stations along the N10 highway.

Route	Distance (m)					Total	EPA Requirement
	<100	100-199	200-299	300-399	>400		
Nyania	10	3	-	1	2	16	
Bable	3	-	-	-	1	4	
Zango-Bagia	1	-	1	-	1	3	500 m
Ware-Guare	-	1	-	-	-	1	
Total	14	4	1	1	4	24	
Percentage	83.33		16.67			100	

Plate 1. Sample photographs showing distances between fuel stations (from the pumps) (F = Filling station).

Table 3. Distance between filling stations and the nearest houses (within 100 m radius) **.**

Route	Distance (m)										Total No. of houses	Requirement
	<20	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	>100		
Nyania	8	5	4	6	3	1	-	3	2	24	56	
Bable	7	3	3	2	-	1	1	-	1	-	18	50 m
Zango-Bagia	-	-	1	2	1	-	3	-	-	-	7	
Ware-Guare	2	1	1	3	1	1	-	1	-	-	10	

the nearest stations, respectively.

Distance between filling stations and the nearest houses (within 100 m radius)

The data contained in Table 3 and Plate 2 showed the proximities between the petrol stations and the nearest houses. Analysis of the data therein revealed that for the Nyania neighbourhood, twenty-four (23) houses were located at distances less than 50 m from the nearest stations, as against fifteen (15) houses and three (3) houses for Bable and Ware-Guare neighbourhoods, respectively. In the Zango-Bagia neighbourhood, six (6) houses out of the ten houses recorded were situated at distances less than 50 m from the nearest stations (Table 3). Hence, from the study, out of sixty-seven houses recorded within 100 m radius across the four neighbourhoods, forty-seven houses, representing 70.17% were located at distances less than 50 m from the nearest stations.

Petrol stations located near houses/places of public assembly

The data in Table 4 and Plate 2 showed that some of the filling stations were sited close to places of public

Plate 2. Sample photographs showing distances between fuel stations and houses/public places.

Table 4. Distance between filling stations and the nearest houses to them (within 100 m radius).

Route	Distance (m)										Total No. of houses	Requirement
	<20	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	>100		
Nyania	8	-	-	-	-	-	-	-	-	4	56	50 m
Bable	7	3	3	2	-	1	1	-	1	-	18	
Zango-Bagia	-	-	1	2	1	-	3	-	-	-	7	
Ware-Guare	2	1	1	3	1	1	-	1	-	-	10	

Table 5. Distances between fuel station boundaries and the middle of the highway.

Area	Distance		Requirement
	Number of filling stations		
	<7 m	>7 m	
Nyania	10	5	7 m
Bable	4	-	
Zango-Bagia	2	1	
Wure-Guare	2	-	
Total	18	6	
Percentage	75	25	

assembly. In Ware-Guare, the recorded places of public assembly were two (2) schools and a football match broadcasting centre, while in Nyania these places were five (5) drinking spots, one (1) school, a police barrier, and a water production company. In Bable and Zango-Bagia, the places of public assembly were a Junior Secondary School, the district police station headquarters, for the former, and a drinking spot, a food vender, three (3) schools, a motel, and a football match broadcasting centre for the latter. A detailed analysis of the data further showed that out of the seventeen (17) places of public assembly, fifteen (15), representing 88.24% were sited at distances less than 90 m from the nearest stations. However, out of these fifteen (15) places, ten (10) were sited less than 50 m from the nearest filling stations.

Distances between the fuel stations boundaries and the middle of the N10 highway

Table 5 shows that out of the twenty-four (24) petrol

Table 6. Distance between the Filling Stations Underground Tanks and the nearest houses/institution (excluding the uncompleted ones).

Route	Distance (m)				
	< 5	5-10	15-20	20-30	30
Nyania	1	_	3	1	6
Bable	-	1	2	-	-
Zango-Bagia	-	-	2	-	1
Ware-Guare	-	-	1	-	1

Plate 3. Sample photographs showing distances between filling stations' underground fuel tanks and houses/assembly places (H=house, T=Underground fuel tank).

stations that were identified in this study, eighteen (18) were less than 7 m from the middle of the N10 highway. This was contrary to international guidelines of 7 m. A detailed analysis of the data showed that Nyania recorded 10 filling stations in this regard, as against 4 in Bable. Zango-Bagia and Ware-Guare recorded two (2) filling stations apiece.

Distance between the filling stations' underground tanks and the nearest houses/institution

Table 6 and Plate 3 also show that the underground fuel storage tanks of some of the recorded filling stations were located close to the nearest houses/places of public assembly. A close examination of the data contained therein shows that in Nyania, one (1) filling station was less than 5 m from the nearest house, while three (3) and one (1) filling station were 15 to 20 m and 20 to 30 m from the nearest houses/places of public assembly, respectively. In Bable, one (1) filling station had its storage tank situated between 5 and 10 m from the nearest house, as against two (2) and one (1) filling station which had their fuel storage tanks, respectively located at 15 to 20 m and 20 to 30 m from the nearest houses. In Zango-Bagia and Ware-Guare, one (1) and two (2) filling stations, respectively had their fuel storage tanks situated between 15 and 20 m from the nearest habitations.

Perceptions of residents of the potential dangers associated with the proliferation of filling stations

The study findings revealed that most of the respondents (96%) were aware of the proliferation of filling stations in the area as against 4% who claimed to be unaware (Figure 2). Figure 3 also shows that 78% of the respondents perceived that the distances between some of the filling stations and the nearest ones to them were inadequate. This conforms to the results revealed on the inadequate distances between filling stations. An

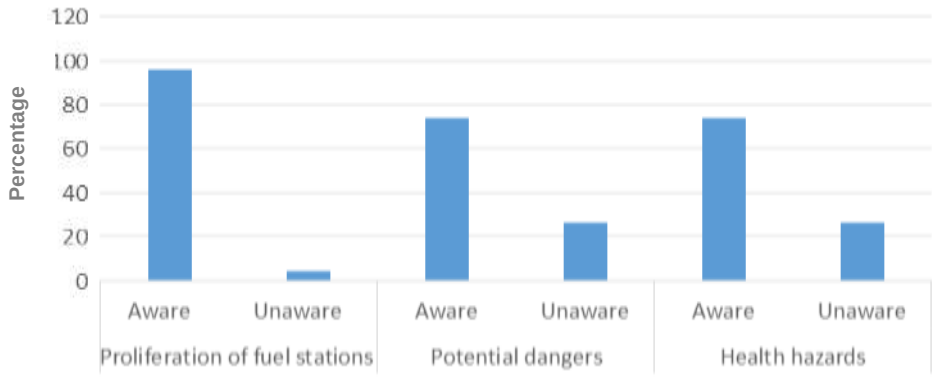

Figure 2. Level of awareness of locals of the potential dangers associated with fuel stations.

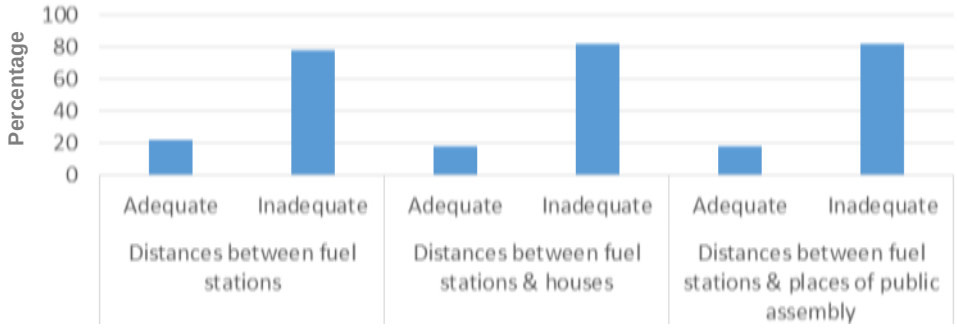

Figure 3. Perception of locals of the adequacy of the siting of stations.

overwhelming majority of 82% of the respondents revealed that the distance between the filling stations and most of the houses were inadequate (Figure 3). The same percentage of respondents (82%) stated that the distances between the filling stations and the places of public assembly were inadequate (Figure 3). These were in line with the data collected from the field work. As to the awareness of the potential dangers associated with the filling stations in the study area, good many respondents (74%) claimed to be aware as against 26% who claimed to be unaware (Figure 2).

Besides, Figure 2 also shows that 74% of the sample respondents were aware of the health hazards associated with the proliferation and siting of the filling stations. The health hazards mentioned by the respondents included respiratory diseases as a result of chronic exposure to dust (22% of respondents), chronic exposure to volatile organic compounds (54%), and chronic exposure to vehicle exhausts (24%) which are as shown in Figure 4. The findings in Figure 6 also show that 82% of respondents claimed to be exposed to noise pollution because of the existence and operation of these filling stations. The noted sources of noise pollution were the power generators used at the filling stations and the incoming and outgoing vehicles as the sources of the noise pollution, as presented in Figure 7. Other environmental problems recorded in relation to the establishment and operation of the filling stations represented in Figure 5 were the removal of vegetation cover (felling of trees), surface water pollution, soil pollution, and groundwater pollution as the main concerns in this regard. Sixty-four percent (64%) of the respondents were not aware of the potential safety hazards associated with the filling stations and the proximity of people's residences to them, and specifically pointed out fire outbreaks at those filling stations and high accident risks as a result of intense vehicular movements in the area (Figures 8 and 9).

DISCUSSION

Spatial distribution of filling stations in Paga and its immediate environs

The spatial distribution of filling stations (4 filling stations in 1 km) contradicts international standards, that is, 2 stations within 1 km (Ogunkoya, 2016). An enquiry into

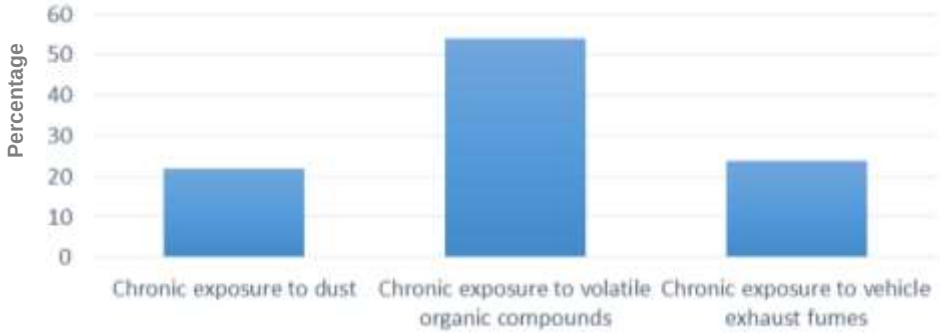

Figure 4. Perception of respondents of the health hazards they are exposed to.

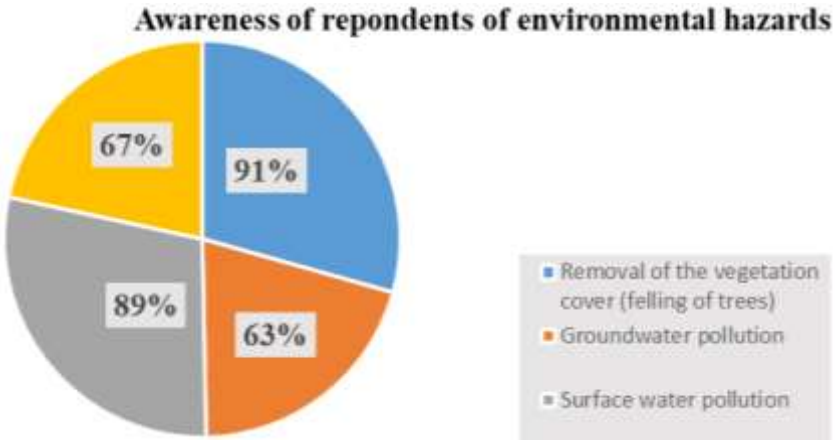

Figure 5. Respondents' awareness of environmental hazards.

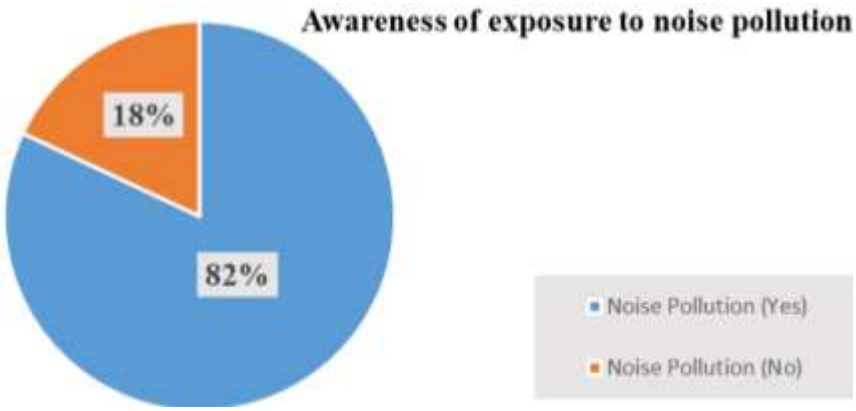

Figure 6. Respondents' awareness of their exposure to noise pollution.

the siting pattern from the Regional Lands Commission revealed that the lands were predominately managed by the locals. Besides, information gathered showed that the Paga township had no land planning scheme for proper layout of the area. This situation has led to the haphazard siting of filling stations. The study revealed that the siting of the petrol stations was not subjected to any proper supervision by the regulatory institutions. This illustrates

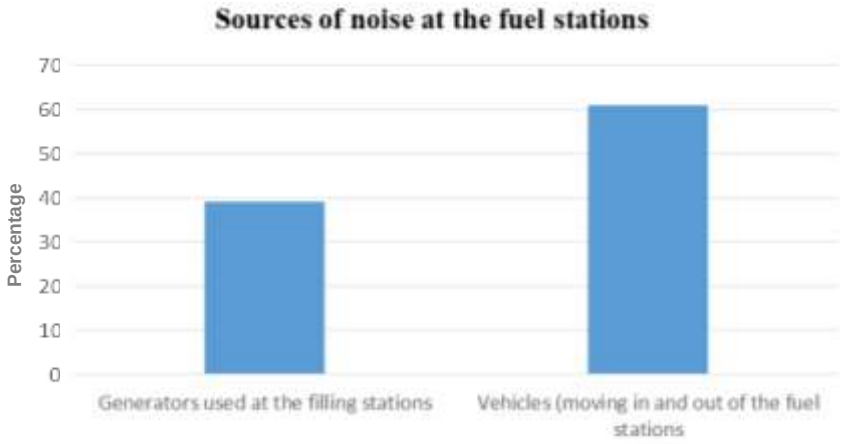

Figure 7. Respondents' perception of the sources of noise pollutions.

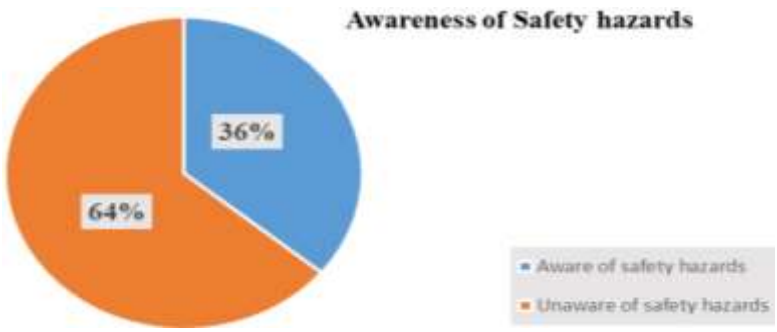

Figure 8. Respondents' awareness of safety hazards.

the lack of effective enforcement of institutional and policy framework for implementing sound and sustainable land use planning in the country in line with national development goals. This fact was consistent with findings obtained from a previous study conducted by Brueckner et al. (2001), which indicated that irregular and unsound urban development is the common problem of all urban settlements today; and that the increasing continuation of this problem is inevitable in this order, where the economy-ecology balance is not taken into consideration and economic concerns always win.

Distances between filling stations and between petrol stations and the residential houses/places of public assembly

The haphazard siting of fuel stations was consistent with the following statement made by the EPA Chief Executive Director: "there is currently no law in the books that regulate where LPG or Petrol filling stations should be sited in the country" (Global, 2017). The infringements of required distances between filling stations, the distances between the filling stations and the nearest houses/places of public assembly are clear indications of pressing concerns about the health and safety hazards these filling stations posed and the hazards residents were prone to (Nieminen, 2005). This fact is further proven by the finding by Olusegun et al. (2011) which stated that the siting of fuel stations in close proximities and within residents flout standards. This situation is quite alarming as government's regulatory institutions appear not to play effective roles in the siting of fuel stations. Several empirical studies have shown that, fuel stations provide suitable grounds for fire outbreaks and expose employees and residents to several physical, chemical and ergonomic hazards (Sakyi et al., 2012).

Besides, Gattas et al. (2001) as stated by Markus et al. (2015) indicated that exposure to diesel, petroleum fumes and fuel components such as benzene and formaldehyde contribute to cancers, acute myeloid leukemia and acute non-lymphocytic leukemia. The occurrence of fire

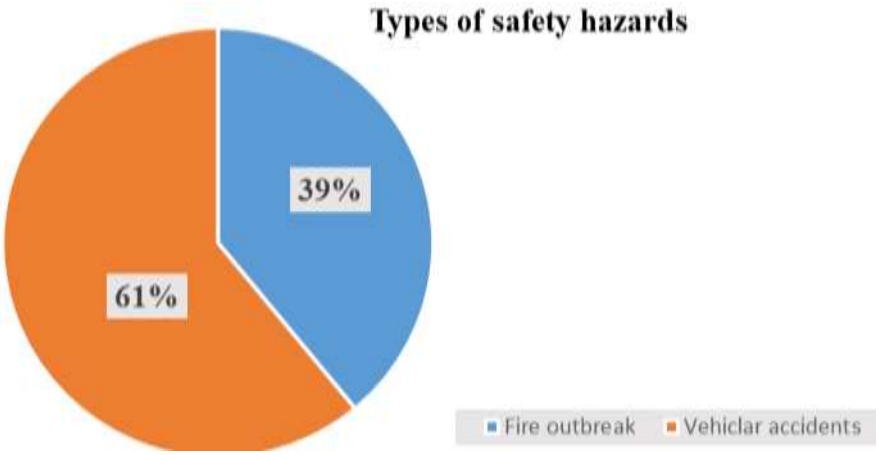

Figure 9. Respondents' perception of type of safety hazards they are exposed to.

outbreaks at filling stations are mostly as a result of the lack of effective law enforcement by regulatory authorities. This fact is highly deplorable as these incidents often result in loss of lives and properties as recorded in the fire and blast incident which occurred at a liquefied gas filling station and a nearby petrol station in the Kwame Nkrumah Circle which claimed 150 lives (BBC, 2015; Myjoyonline.com, 2017; GhanaWeb, 2018). These incidents vindicate findings of an earlier research by Baffour et al. (2014) which indicated that with the increase in these filling stations, much focus is geared toward the economic benefits other than the health and safety management practices. Hence, the occurrences of these incidents across the country should be a wakeup call for the regulatory agencies in charge of monitoring the siting and functioning of fuel stations. The present study therefore provides an additional compelling evidence that justifies the need for the NPA, TCPD, and EPA to as a matter of urgency carry out a joint audit to assess the extent to which the regulations are being flouted with impunity by filling station operators across the country.

Distances between fuel stations boundaries and the middle of the road (N10 Highway), and the distance between the filling stations underground tanks and the nearest houses/institutions

The study data also revealed that out of the twenty-four (24) petrol stations, eighteen (18) were less than 7 m away from the middle of the N10 highway. This situation did not conform with the recommended minimum distance of 7 m (IRC, 2009). This finding raises concerns to the dangers posed by fumes (volatile organic compounds) emitted through operational activities on people residing close or pedestrians (Ogunkoya, 2016). The study also showed that the underground fuel storage tanks of some of the recorded filling stations were located less than 5 m or between 5 and 20 m from the nearest houses or places of public assembly. This situation is highly alarming in view of the fire and environmental hazards the people inhabiting these houses or frequenting these places of public assembly are exposed to. Research has shown that petroleum contains aliphatic or aromatic hydrocarbons which have the propensity to contaminate soil and underground water which can be fatal or in volatile form can pose risk to public safety and health (Bruel and Hoag, 1984). Studies have further established that whenever petrol escapes from an underground storage tank or pipelines, it can travel significant distances. Thus, petrol vapour can find its way into basements of buildings and public drains with serious consequences should the vapour come into contact with an ignition source (Health and Safety Authority, 2017). This depicts that, people living farther are also prone to these harms. The study findings are therefore a clear indication that the residents of Paga who dwell in areas close to filling stations underground tanks are living in a highly risk prone area.

Perceptions of residents of the potential dangers associated with the proliferation of filling stations

The study revealed that many of the respondents were aware of the proliferation of filling stations in the area and the inadequate distances between some of the filling stations. The respondents noted that the distances between the filling stations and most of the houses were inadequate. 57% of the sample of respondents were aware of the safety, health, and other environmental hazards associated with the proliferation and siting of the filling stations in the area. This is an indication of the

existence of public awareness and knowledge of issues relating to the potential hazards associated with the siting and operations of filling stations in the study area and the proximities of some residential houses to these stations. Hence, the inaction of the government regulatory agencies vis-à-vis the haphazard construction of filling stations in Paga could prompt the citizenry to view these agencies as white elephants. This analysis is indeed buttressed by a statement on the gas explosion incident at the Atomic Junction in Accra, which states that "the country is wasting resources on EPA and NPA who have not lived up to expectations" (Pulse.com.gh, 2017). It also appeared that although an overwhelming majority of the residents of Paga had good knowledge and awareness of potential hazards associated with fuel stations, no action was taken by the locals to get their concerns addressed. This attitude is contrary researches in citizen participation in good governance that strongly recommend that citizens should be more involved in the affairs of their state, and remain vigilant to ensure consistent levels of accountability as well as responsiveness to their needs (Ile and Mapuva, 2010). Hence, the apparent indifference of locals regarding the improper siting of petrol stations and the associated health and safety hazards implies that the solution to this problem is within the exclusive purview of the local authorities, and that they should keep themselves aloof from it. Indeed, this fact coupled with the indifference or inaction of the district TCPD and EPA directorates, could be construed as a joint failure by the locals and these regulatory agencies to proactively address the problem relating to the haphazard construction of petrol stations against the backdrop of the spate of explosion and fire incidents that occurred at filling and gas stations across the country.

Conclusion

The present study reveals that the haphazard springing up of filling stations in Paga township is laden with serious health, safety and environmental hazards which are mostly blamed on the failure by the main governmental regulatory institutions to effectively enforce the laws and policies regarding the siting and operations of petrol stations across the country. Thus, this study indicates the need for these regulatory agencies to take immediate remedial actions in response to the present situation and the attendant health and safety hazards, and evolve new monitoring and regulatory mechanisms that would avert the recurrence of this problem in future. Instances of specific actions in this regard could be as follows:

(1) Carrying out a joint audit to assess the extent to which the guidelines governing the siting and functioning of filling stations are being flouted with impunity by filling station operators across the country, and applying sanctions to offenders.
(2) Prompting the national legislature to enact laws barring people from acquiring plots of land for building residential homes close to filling stations or near lands earmarked for putting up petrol stations, or vice versa.
(3) Requesting that the land owners be debarred by these laws from releasing plot of lands located within residential areas for construction of filling stations.
(4) Carrying out constantly joint public education and awareness raising campaigns on the benefits the citizenry stands to gain by strictly adhering to these laws, so as to help make their enforcement effective.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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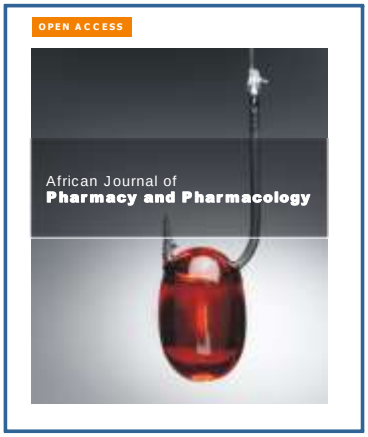

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