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Landuse Characteristics and Environmental Health Impact of Petrol Filling Stations in Students' Residential Areas of LAUTECH, Nigeria

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Abstract: This study, against the background of informing policy direction, evaluates the landuse characteristics and environmental health impact of Petrol Filling Station (PFSs) in the students' residential areas of Ladoke Akintola University of Technology (LAUTECH), Ogbomoso. Nigeria. 14 PFSs are identified in the five students' residential areas, out of which 7 (50%) were randomly sampled. Further a ring of 30 meters radius was delineated around the selected PFSs for landuse inventory, while 210 questionnaires were randomly administered to an adult representative in the delineated rings. The concentration level of air pollutants from the PFSs were determined at pump, 30 meters and 60 meters for the determination of distance decay – if any. Environmental Health Impact Index was developed to appraise the impact of the PFSs. 80.3% of the areas around PFSs in the study area are residential landuses – occupied by students, while none of the PFSs adhere to Urban Planning guidelines in the observation of setback. The concentration level of air pollutants from PFSs is low, and a distance decay is observed. There is

currently a low environmental health impact of PFSs, and the prevalent impacts, among others, are Eye irritation (39.29%) and Nausea (14.73%) etc. The study recommends buffering of PFSs and an inclusively-driven development control.

Keywords*:* Landuse, Environmental Health, Air pollution, Ogbomoso, Petrol Filling Stations

1.0 Introduction

Petroleum-derived contaminants constitute one of the most prevalent causes of global environmental health challenge. Exposure to petrol vapor affects human health status (Moolla, Curtis and Knight, 2015). It contributes to neurological, inhalation, and teratogenic disorders (Tunsaringkarn, Siriwon, Rungsiyothin, and Nopparatbundit, 2012). More than 100 diseases and injuries including stroke, heart disease, lung, cancer and chronic respiratory diseases are caused by petroleum related pollutants, while an estimated yearly death of 4.2 million can be attributed to its exposure (World Health Organisation, 2021). The sources of these contaminations are in the process of extraction, refining, storage, transporting and consumerism. Petrol Filling Stations (PFSs) not only plays an important role in ensuring the availability of petroleum products to consumers, they are also potential sources of petroleum derived contaminants (Morales *et.al*, 2010). The extensive use of petroleum, its related dumping process and accidental spills contributes to its continuous pollution (Manish, Anamika, Anjali and Varun, 2019).

In Nigeria, PFSs are cardinal to the entire petroleum process. However, the literature is replete with the account of various environmental and hazardous impact of PFSs, particularly in local communities where they are sited (Olanrewaju, Wakeel , & A, 2020). As activities takes place in these PFSs, different types of volatile pollutants are diffused into the atmosphere, which are transported through wind mechanisms, to various homes (Horton, 2014). Residents are therefore exposed to these pollutants thereby causing different types of environmental health challenges.

Locating PFSs, like other land uses, is a concern of land use planning and critical to environmental management decisions. First, that PFSs is a category of landuse with its associated locational challenges in Nigeria (Olanrewaju, Abazu, & Fakayode , 2020). Also pollutants from the operation of this category of landuse is not

only evaporative and inflammatory, it is hazardous (World Health Organisation, 2005). The level of VOCs and related pollutants emitted from PFSs depend on different factors such as volume of fuel sales, type of fuel, number of pumps, location of petrol stations and meteorological conditions. Also the diversity of VOCs depends on the composition of the petroleum. Generally, about 95% of the vapor emissions from petrol are 80% paraffinic, 15% olefin; while the remaining 5% are from aromatic compounds (Brugnone, Perbellini, Romeo, Cerpelloni, Cecco, Leopard, Moro, and Ferracin,1997). Aromatic compounds have proven to be the most important and concerning because of their carcinogenic effect and higher percentage levels in unleaded fuels (World Health Organisation, 2005). Exposure to this has several health implications, which include cough, sore throat, eye irritation, even death. (Zhang, Gao, Luo, Leung, Zhang, Wang and Fan, 2018; Manish, Anamika, Anjali and Varun, 2019).

Student residential areas, like other residential enclaves, are places where students utilize about 40% of their daily time. The peculiarities of these areas are its youthful characteristics and the poor health cognizance of students. There is an increasing incidence of PFSs in the five students' residential areas of Ladoke Akintola University of Technology (LAUTECH) Ogbomoso, Nigeria. These PFSs, because of their prime location, not only serve as sales point for petroleum products, they are areas where students cluster to enjoy night life and associated glamour. With this, students have direct exposure to pollutants emanating from the PFSs. To avert public health crisis, there is a need to investigate into the landuse characteristics and environmental health impact of these PFSs - hence this study. It examined the landuse characteristics of the PFS, the quality of air around PFSs, and the perceived environmental health impact of PFSs.

2.0 Materials and Methods

The study utilized both primary and secondary data. Primary data utilized include landuse characteristics, and the concentration level of VOCs, and other pollutants such as Hydrogen Sulphide (H_2S), Carbon monoxide (CO), Carbon dioxide (CO_2), and Methane (CH_4). Also obtained are the perceived health impact of PFSs on students. To sample PFSs, an inventory of the PFSs in the student residential areas of LAUTECH was done. There are five student residential areas in LAUTECH (Under G,

Yuaco/Oke Afin, Stadium/Aduin, General/Oke Aanu and Aroje/Aba) where 14 PFSs were identified. Thereafter, random sampling was utilized to select 50% (i.e 7 PFSs) from the list. The sampled PFSs are G-71(Under-g), Rubbie (Stadium Road), Salaudeen (Isale general), Rubbie (Yoaco area), AlariAkata (Under-g), Musalat (Stadium) and Alade (General).

To evaluate the landuse characteristics of PFSs, a ring of 300 meters radius was delineated around each selected PFS, while the landuse characteristics of this delineated area was inventorised and analysis made. To appraise the air quality of PFSs, a Crocrown air sampler was used. This instrument was used to determine the concentration levels of H_2S, CO, CO_2, CH_4 and VOC at the pump, 30 meters and 60 meters from the PFSs. Readings were made at different location for the determination of distance decay effect. Readings were done on Wednesday (Weekday) and Saturday (Weekend), to assess weekday-weekend differences in the concentration of pollutants emanating from PFSs. Questionnaire was administered to one representative from each of the building within the delineated area. In all 210 questionnaires were administered to appraise the perceive health impact of PFSs among the students.

Obtained data were subjected to both descriptive and inferential statistics. Descriptive statistics utilized are measure of averages, and percentages. Inferential statistics such as two sample T-test were used to evaluate differences in the incidence of pollutants in both weekdays and weekends. Analysis of variance was used to test the distance decay in the concentration levels of pollutants. An index, Students Health Index, was developed to evaluate the health impact of PFSs on students in the residences within the delineated area.

3.0 The Study Area

Ogbomoso, one of the major towns in Oyo State, is located in the southwestern part of Nigeria. It lies within latitude 8º07'N and longitude 4º14'E. The town has a population of about 1 million and, it plays a host to many higher institutions such as Best legacy college of Education, Bowen University Teaching Hospital, Baptist School of Nursing, Nigeria Baptist Theological Seminary and Ladoke Akintola University of Technology. The urbanizing and economic characteristics of Ogbomoso has seen to the continual springing up of PFSs, especially along road networks in residential areas at proximity to the higher institutions.

Ladoke Akintola University of Technology was established, as a non- residential institution, in the year 1992. The institution, due to its peculiarity, has been housing its students in residences that are at proximity to it – these areas are referred to as students' residential areas of LAUTECH. They are areas that, although also occupied by non-students and indigenes, are predominately resided by students. These areas are Under g, Oke-afin, Yuaco, Adenike, Stadium, Aduin, Amama, General, Aroje and Abaa. Meanwhile to ease security and achieve coordination in these areas, a five-way classification for these areas was adopted by the Students Affairs Division of the institution in the year 2013 – hence areas within the same axis are clustered and categorized as an entity. Eventually, the students' areas were classified as Under G, Yuaco/Oke Afin, Stadium/Aduin, General/Oke Aanu and Aroje/Aba. These Students' residential areas because of their linear configuration along road networks have witnessed massive intrusion of PFSs that are weaved within the residential clusters – hence the need for an assessment of impacts.

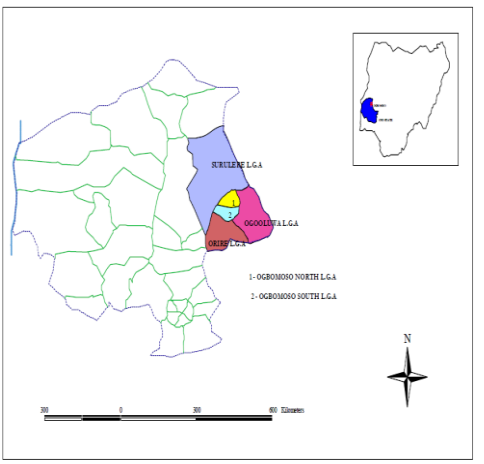

Figure 1: Map of Ogbomoso
Source: Adapted from GIS laboratory, LAUTECH, Ogbomoso, Oyo, State (2019)

4.0 Discussion of Findings

This section discussed the findings that were made in the study area. It is tailored to capture the objectives of the study. Hence there are three sections in all: viz - landuse characteristics of the PFSs; air

quality of areas around the PFSs; the environmental health impacts of the PFSs on students.

A. Landuse Characteristics of PFSs in Students Residential Areas of LAUTECH

PFSs are economic activities, however one can hardly pass through the residential enclaves of urban centers in Nigeria without identifying one or more PFSs (Olanrewaju *et. al.,* 2020). In the student residential areas of LAUTECH, similar pattern is observed, as 80.3% of delineated area around the PFSs are occupied by residential landuse - predominated by students (Table 1). Student residential areas are vulnerable as these areas, despite their dense population, are characterized with poor infrastructure and sanitation. The environmental conditions of these areas coupled with exposure of these students to pollutants from PFSs tends to make them to be more susceptible to different sicknesses which may affect their productivity. The health impact of exposure of students to PFSs may not be so immediate, as the pollutants are accumulative in the body system and its effects is long term.

In the student residential areas of LAUTECH, PFSs are garnished between different micro-landuses observing physical planning standards differently. Generally, PFSs in the student areas of Ogbomoso have similar landuse configuration. They are directly adjoined by transportation landuse/ circulation to the front, and residential landuses to the rear, left and right sides (Table 2). This on the one hand justify that PFSs, particularly in Nigeria, are usually located along road networks for ease of access and patronage (Olanrewaju et al, 2020). It also indicates that PFSs like other commercial activities, due to their ability to afford the increasing cost of land in urban areas, are displacing residential landuses in urban centres. This is a case for effective landuse management and control. The argument here is not really the location of PFSs within residential areas, as these landuses are complimentary to a lot of domestic activities as well as small and medium scale enterprises that are carried out within these residential areas. Locating PFSs at an insurmountable range from these domestic activities may encourage illegal sale of petroleum products at close informal outlets. However, locating PFSs requires effective development control – with respect to setback and density of adjoining landuses.

Unfortunately, PFSs in these student residential areas appear not to be regulated as all the physical planning standards of Oyo State Ministry of Physical

Planning with respect to setback are floated. As summarized in Table 2, an average setback of 2.51 is maintained between PFSs and their adjoining road. This is against setback of 12 meters prescribed for the lowest category of road by the guide. Similarly, the average setback of PFSs to adjoining residential developments on the rear, left and right sides are 0.75 meters, 0.98 meters and 0.62 meters respectively (Table 2). This is against the minimum setback of 9 meters prescribed by the guide. With this situation, except for PFSs with side fences, it is hard to differentiate between PFSs and adjoining residential developments. Absence of setback subject adjoining residents to direct impact of PFSs, such as exposure to air – related pollutants emanating from the filling stations. This is worrisome as these residents utilize a considerable period, particularly at weekends, implying that residents have long duration of exposure to these pollutants. Also that pollutants have more density at night, there is a possibility of the occurrence asphyxiation among residents. Domestic activities, like cooking and open burning, at adjoining residential areas may also put the entire neighborhood at the risk of fire outbreak.

Table 1: Landuse Characteristics of Area around PFS

Landuse type	Area Covered	
	Kilometer	%
Residential	227.08	80.3
Others	26.09	9.3
Commercial	25.68	9.1
Industrial	2.34	0.8
Recreational	1.53	0.5
Total	***282.74***	***100***

Table 2: Type and Setback of Adjoining Landuses to PFS

Petrol Filling Station	**Front**		**Rear**		**Left**		**Right**	
	Landuse Type	**Setback distance (meters)**	**Landuse Type**	**Setback distance (meters)**	**Landuse Type**	**Setback distance (meters)**	**Landuse Type**	**Setback distance (meters)**
G-71	Circulation	2.5	Residential	0.3	Residential	0.5	Residential	0.4

Rubbie (Stadium)	Circulation	3.1	Residential	0.5	Residential	0.7	Residential	0.3
Salaudeen	Circulation	2.7	Residential	1.2	Residential	0.5	Residential	0.7
Rubbie (Yuaco)	Circulation	3.0	Residential	0.6	Residential	0.8	Residential	0.5
Alari-Akata	Circulation	3.6	Residential	1.6	Residential	0.4	Residential	1.6
Musalat	Circulation	2.5	Residential	0.6	Residential	1.3	Residential	0.5
Alade	Circulation	2.9	Residential	0.5	Residential	2.7	Residential	0.4
Average		***2.51***		***0.75***		***0.98***		***0.62***

B. Quality of Air in Student Areas of LAUTECH

This section attempts to evaluate the concentration of pollutants emanating from PFSs. Readings were made at pump, 30 meters and 60 meters to evaluate the concentration of pollutants, and its distance decay. This study understands that PFSs cannot be isolated as the sole cause of these pollutants within a wide area, as several other activities and biogenic interactions may also be taking place consecutively– hence the purpose of delineating a micro extent of 60 meters. Attempt was made to evaluate weekday and weekend differences in the occurrence of pollutants in the residential areas – to cater for the weekday-weekend difference in activities and patronage at the PFSs.

As at the time of this study there is no trace of H_2S and CH_4 both at all observation points. Also there is a considerably low concentrations of other pollutants - the average concentration of CO, CO_2 and VOC are 6.91ppm, 0.20ppm, and 30.82ppm respectively. These observed values are extremely lower than the international standards (Olson *et.al*, 2009). Meanwhile quantum of activities in the PFSs influences the concentration level of pollutants, thus a weekday-weekend difference. As evidenced in Table 3, the average weekend concentration of CO is 8.91ppm, while that of weekend is 4.92ppm. Similarly, the weekend concentration of CO_2 is 0.220ppm against 0.195ppm recorded for weekdays. In the same trend, the average weekend concentration of VOC is 34.41ppm while that of average

weekday concentration is 27.23ppm.

Evaluating these differences with the aid of t-test further confirms that these differences are statistically significant. For instance, the t-value for weekend –weekday differences in the concentration of CO is 34.22; $p=0.02<0.05$, and with $t=16.71$; $p=0.008<0.005$ as well as $t=27.27$; $p=0.005<0.05$, the earlier reported weekend-weekday differences in the concentration of CO_2 and H_2S is statistically significant. Reasons for this, among others, include increase sales at filling station at weekends. Unfortunately, there is usually a higher exposure to these pollutants at weekends as students either stay indoor during this time, while some of them even relaxes at these PFSs for nocturnal social activities.

As evidenced in Table 3, the F value of 230.55; p=0.00, and F value of 158.00; p=00 as well as F value of 194.20; p=0.00 respectively for the differences in the concentration of CO, CH_4 and VOC at different intervals informs a decay in the concentration of pollutants with distance from the PFSs. This statistic also indicates that beyond 60 meters, there is a likelihood of no occurrence of the pollutant hence the need for setbacks and buffer zone between PFSs and adjoining residences.

Table 3: Concentration of Air pollutants around filling Stations

	Day of Sample Collection	N	Pump	30 meters	60 meters	DISTANCE DECAY		Average Weekly Value	Average Value	Weekday-Weekend Differences	
						F-value	p-value			t-value	p-value
CO	During the week	56	12.51	4.03	10.2	230.55	0.00	8.91	6.91	34.22	0.002
	Weekend	56	10.25	3.10	1.40			4.92			
H2S	During the week	56	.000	.000	.000	N/A	N/A	N/A	N/A	N/A	N/A
	Weekend	56	.000	.000	.000			N/A			
CH4	During the week	56	.000	.000	.000	N/A	N/A	N/A	N/A	N/A	N/A
	Weekend	56	.000	.000	.000			N/A			
CO_2	During the week	56	0.310	0.200	0.170	158.00	0.00	.220	0.20	16.71	0.008
	Weekend	56	0.300	0.165	0.120			.195			
VOC	During the week	56	63.05	30.18	10.02	194.20	0.00	34.416	30.82	27.25	0.005
	Weekend	56	45.00	27.26	9.45			27.23			

Except where otherwise stated, all measurements are made in part per million (ppm)

C. Perceived Environmental Health Impact of PFSs in the Students Residential Areas of LAUTECH

To assess the environmental health impact of PFSs on students in the study area, an index, Student's Health Index was used - further, disease prevalence was calculated. As evidenced in Table 4, students reported low occurrence of PFSs heath related challenges, as none of these challenges meet the 50% prevalence line. Does this imply that the PFSs do not have health impact on the Students? This may currently be true; as low concentration of pollutants is recorded in the study area. It may also not be, but points to the poor health cognizance of students. Also the transitory nature of student may influence this response – as students tends to move in different houses during their stay in school hence may be relatively new in the area. It may also not be disconnected from the accumulative nature of the pollutants and their long term effects – to which students' duration of stay may likely not be sufficient enough to cause symptomatic effects. This notwithstanding, some health challenges were reported by the students.

The most prevalent health challenges in the study area, as evidenced in Table 4, is Eye Irritation (39.29%). Other health challenges are Nausea (14.73), Asthma (14.33%), Cough (12.13%) and Skin Irritation (10.93%). Though reportedly low, there are incidences of Catarrh (3.53%), Memory loss (2.33%) and Fatigue (1.19%). These reported challenges indicated that, although still low, there are evidences of the health impact of PFSs in the students' areas of LAUTECH. It therefore calls for intervention to prevent the emergence of public health crisis in this areas.

Table 4: Perceived Environmental Health Impacts of PFSs

Environmental Health Impact	**SA**		**A**		**I**		**D**		**SD**		∑	∑	χ	χ- x	$(\chi- x)^2$	%
	F	W	F	W	F	W	F	W	F	W	F	W				
Eye irritation	15	75	10	40	53	159	40	80	92	92	210	446	2.12	-0.67	0.45	39.29
Nausea	55	275	40	160	39	117	46	92	30	30	210	674	3.21	0.41	0.17	14.73
Asthma	30	150	21	84	30	90	49	98	80	80	210	502	2.39	-0.41	0.17	14.33
Cough	75	375	15	60	40	120	31	62	49	49	210	666	3.17	0.37	0.14	12.13
Skin Irritation	48	240	25	100	60	180	65	130	12	12	210	662	3.15	0.36	0.13	10.93
Catarrh	60	300	10	40	27	81	11	22	102	102	210	545	2.60	-0.20	0.04	3.53
Memory loss	56	280	18	72	15	45	35	70	86	86	210	553	2.63	-0.16	0.03	2.33
Fatigue	42	210	30	120	42	126	60	120	36	36	210	612	2.91	0.12	0.01	1.19
Dizziness	35	175	18	72	75	225	53	106	29	29	210	607	2.89	0.09	0.01	0.75
Headache	50	250	35	140	25	75	40	80	60	60	210	605	2.88	0.08	0.01	0.61
Conjuctivitis	35	175	26	104	66	198	35	70	48	48	210	595	2.83	0.04	0.00	0.11
Nose and throat Discomfort	25	125	44	176	45	135	50	100	46	46	210	582	2.77	-0.03	0.00	0.06
Total													33.57		1.15	
Average (x)													2.80			

S.A =Strongly Agree A = Agree I=Indifference
D =Disagree SD = Strongly Agree

5.0 Recommendations and Conclusion

Having established the landuse challenges of PFSs in the Students' areas of LAUTECH and its environmental health impact, the following recommendations are proffered:

- ***Buffering of PFSs***: PFSs in the study area should be delineated and a buffer of a minimum of 10 meters be established between PFSs and their adjoining residences. This buffered area should be landscaped and dedicated for the growth of flowers and trees to refresh the air as well as absorb the pollutants emanating from the PFSs.
- ***Cooperate Social Responsibility***: The operators of PFSs in the students' residential areas should be committed by Oyo State Ministry of Physical Planning and Urban Development to engage in timely health awareness and evaluation of residents' health – as a Cooperate Social Responsibility. This will assist in monitoring the health of the residents as well as prevent a public health crisis. Also PFSs should be encouraged to provide sanitary facilities – water and other social infrastructures within their host community to boost the environmental quality of the areas, thus reducing the likely effects of the pollutants.
- ***Inclusively – Driven Development Control***: To utilize development control in the management of PFSs in the study area, three approaches are advanced – awareness, involvement and enforcement. Operators of PFSs as well as landlords of students' residences should be reached by the staff of Oyo State Ministry of Physical Planning and Urban Development – Ogbomoso North Office, for enlightenment on the locational requirements of PFSs, and the impact of poor location on residents. An inclusive task force team comprising operators of PFSs, landlords of students' residences, Students representatives and Staff of the ministry should be set up to assess existing PFSs in the students' area, while enforcement as well as adjustments be done to cater for buffer and setback needs in the study area. Location of PFSs in dense residential areas should be discouraged by denying approval to such developments when proposed.

This study understands the importance of landuse interactions in Urban fabric as well as the social cum economic implications of demolition of PFSs – especially when they have trace effects as seen in the study area. Hence demolition is not recommended for the management of the current situation. The afore–discussed recommendations will no doubt go a long way in ensuring a sustainable pro-health landuse developments in the student's areas of LAUTECH and other residential areas with similar characteristics.

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