Digital Innovations & Contemporary Research in SCIENCE, ENGINEERING & TECHNOLOGY
Vol. 9. No. 1, 2021

Article Citation Format
Ajayeoba, A.O., Fajobi, M.O., Raheem, W.A., Adebiyi, K.A. Olayinka, M.D. & Farinu, T.P (2021):
Risk Factor Assessments and Development of Predictive Model for Volatile Organic Compounds Emission in Petrol Stations in Nigeria. Journal of Digital Innovations & Contemp Res. In Science., Engineering & Technology. Vol. 9, No. 1. Pp 57-74
DOI: dx.doi.org/10.22624/AIMS/DIGITAL/V9N1P5

Article Progress Time Stamps

Article Type: Research Article
Manuscript Received: 20th March, 2021
Review Type: Blind
Final Acceptance: 22nd May, 2021

Risk Factor Assessments and Development of Predictive Model for Volatile Organic Compounds Emission in Petrol Stations in Nigeria

[1]Ajayeoba, A.O., [2,3*]Fajobi, M.O., [4*]Raheem, W.A., [1]Adebiyi, K.A. [1]Olayinka, M.D. & [1]Farinu, T.P
[1]Department of Mechanical Engineering, Ladoke Akintola University Technology of Ogbomoso, Nigeria
[2]Ladoke [2]Akintola University Technology, Open and Distance Learning Center, Ogbomoso, Nigeria
[3]Department of Mechanical Engineering, University of Ilorin, Ilorin, Nigeria
[4]Department of Systems Engineering, University of Lagos, Lagos, Nigeria
[*]**Corresponding Authors E-mail**: mofajobi54@lautech.edu.ng, wraheem@unilag.edu.ng
***Phone:** +2348035226126, 08038623569

ABSTRACT

Importance of energy as a developmental driving force of any economy cannot be overemphasized. In this connection, upsurge of Petrol Stations (PTs) in Nigeria has now attained a magnitude of an inconceivable nightmare with perceived repercussions on both human health and the environment. This study therefore assessed the risk factors associated with location and operations of PTs paying cognizance to occupational hazards, health and safety implications on the attendants, customers and the occupants in close proximity. Concentrations of Volatile Organic Compounds, VOCs of sampled PTs were obtained using a gas analyzer, and their effects on the respondents were evaluated. Interactive effects of temperature, relative humidity and VOC were investigated using the response surface methodology. A VOC predictive model was then developed. Assessments revealed that, majority of the sampled PTs did not properly conform to stipulated regulation standards of Department Of Petroleum Resources, DPR, on-site location and acceptable working conditions. Risk potentials of the sampled PTs are fire outbreak, fuel spillage, vehicle accident, robbery, noise/vibration, stress, hazardous fumes, use of mobile phones, traffic congestion and VOCs amongst others. These coupled with ergonomic deficit resulted to adverse health challenges of dizziness (64.2%), headache (55.3%), low back pain (44.7%), eye irritation (36.2%), loss of coordination (36.2%), nausea (12.8%), and cough (10.6%). However, too much exposure to higher concentrations of VOCs resulted in loss of consciousness, respiratory failure, cardiac sensitization, coma and sometimes eventual death. Therefore, this study has proposed a mathematical model to predict the level of VOC to reduce the risk of exposure. The resulting model exhibited cubic property to model the real-life scenarios with the coefficient of determination (R2) of 0.8404, thus, PTs, as well as other allied, would find in this model reliable, economical, effective, and efficient prediction tool.

Keywords: Petrol station; volatile organic compounds (VOC); risk; prediction; energy.

1. INTRODUCTION

Energy is a developmental driving force of any economy as it is significantly instrumentalto efficiency and growth, both domestically and industrially. Energies in forms of fossil fuels likediesel, liquefied natural oil, kerosene, Dual Purpose Kerosene, (DPK), aviation turbine kerosene and Premium Motor Spirit (PMS), have found a wide range of applications especially in the operations of internal combustion engines used for powering automobiles.

It has also found usefulness in in electric power generation [1]. Specifically, of all these fuels, PMS is most popular in this part of the world because operations of different types of mechanical devices commonly found in Nigeria, such as electricalgenerating sets, motorcycles, tricycles, vehicles and others depend on PMS [2-3]. PMS is referredto as petrol or gasoline used in powering internal combustion engines. It is majorly characterized by some organic compounds and additives that enhance the engine performance [4].

The study area is one of the prominent cities in southwestern, Nigeria, characterized by enormous commercial activities that require energy. These coupled with the shortfall in the supply of electricity from the national grid have skyrocketed the demand for petroleum products. Consequently, commercialization of fuel is now lucrative business, which prompted the mass location of petrol stations in almost all the strategic areas of Nigeria with some of them sited out of conformity with the department of petroleum resources, guidelines and principles [5-6]. Besides, Ahmed, *et al.,* [7] asserted that the proliferation and upsurge of petrol stations in Nigeriahave now reached a level of an unimaginable nightmare with perceived consequences on both human health and the environment.

According to Mshelia *et al.,* [1], petrol station is any petroleum facility, service station, public garage, highway filling station, petro part, or fuel depot that sells fuel and lubricants for motoristsand other users. In this modern day, petrol stations are necessary, but explosions from such facilities frequently trigger loss of life and property within the surrounding or communities, thus posing great concern to the government and people [8]. Generally, siting of a petrol station, notwithstanding, its significance to the economy, has to be guided by principles of environmental and safety rules, such as; ergonomic principles, the size of the proposed land site, ensuring the sitedoes not lie within pipeline or electrical-power high tension cable Right of Way, and the distancefrom the edge of the road to the nearest bump which must not be less than 15 meters [5].

Also, thetotal number of petrol stations within 2km stretch of the site on both sides of the road must not bemore than four including the one under consideration, the distance between an existing station andthe proposed one must not be less than 400 meters, and drainage from the site must not go into a stream or river, etc. [5]. Strict adherence will enhance the demands of population increase, economic development, nature conservation as well as urban renewal [4].

Despite that owners of these petrol stations are government and independent petroleum marketers, yet most owners still play nonchalance to safe locations without complying with standard requirements [7]. Fajobi, *et al.*, [9] reported that an ergonomic design of the workplace environment should eliminate static orawkward posture, repetitive motion of the worker, poor access or inadequate clearance and excessive reach to work areas. This is achieved when an organization successfully matches the work processes with the individual who performs the tasks. The repercussion of not keying into these principles is not limited to the petrol station structures and equipment alone but also posed a serious threat to the health of the workers and masses residing in proximity to the petrol stations [10]. Environmental planning especially land use planning plays a vital role in ensuring public safety as there are risks associated with the environment [11]. Implementation of this technical approach will minimize potential hazards and consequently reduces risks associated with the location of dangerous facilities and enhances safety practice [12-13].

Consequences of noncompliance were reported to amount to the loss of resources both materials and humans. According to the world health organization (WHO) in 2004 reiterated by Mshelia *et al.,* [1], annually, more than 2.3 million lives and properties worth more than 4.5 billion are lost to fire outbreaks associated with petroleum products mishandling. The health risks associated with petrolare numerous such as; on contact with the skin of the handlers, it could cause dermatitis, due to the presence of hydrocarbon [7]. Furthermore, hematological disorders could be attributed to the exposure of a person to benzene which is more prevalent in less developed Countries [6-7].

Therefore, considering the high risk and hazards associated with the product as a highly inflammable product, its exploration, transportation, offloading, storing, sale points and facilities should not be taken for granted like other products [14]. This paper, therefore, analyzed the risk factors in petrol stations within the study area. It also assessed the existing safety conditions at the petrol stations which included the work-related hazards and their health effects; existing fire safety measures; critical examination of schedules for petrol attendants; training patterns and access to welfare facilities. Lastly, this study developed a predictive model for volatile organic compounds which can be used to determine the concentration of VOCs in the ambient air.

2. MATERIALS AND METHODS

2.1 Description of the study area

The study was carried out in Ogbomoso (located on latitude and longitude of 8.1227° N and 4.2436° E respectively) metropolitan city of southwestern Nigeria. After Ibadan, Ogbomoso is the second most populous city in Oyo state with a population of 576,557 and a projected average growth rate of 4.2% yearly till 2032 [15].

2.2 Data collection for ergonomic risk assessments

A participatory intervention approach incorporated with a random sampling technique was used to select 94 petrol attendants across 94 petrol stations located across the five local government areas in the study area. The approach allows pertinent stakeholders in fuel commercialization to be involved in this study. A well-structured questionnaire sectioned into two was administered to obtain demographic information of the respondents and to evaluate the health implications due to activities involved, including occupational risks data that the respondents are exposed to at their workplaces. The Area Health and Safety Risk Assessment Form, AHSRAF was employed to collect data on prevailing hazardous activities, awkward posture, repetitive motion, noise and vibration, fire, vehicle accident, fuel spillage, robbery, hazardous fumes, lighting levels and lifting of nozzles.

2.3 Experimentation of Volatile organic compounds, VOCs and predictive model development

Concentrations of volatile organic compounds, VOCs of sampled petrol stations were obtained using a gas analyzer (Aeroqual Series 500 – Portable VOC monitor) (shown in Plate 1), and their effects on the respondents were evaluated. Interactive effects of temperature, relative humidity and VOC were investigated using the response surface methodology which is an in-built tool in Design-Expert software version 13.0, from where a predictive model was developed to project the quantity of VOC relative to atmospheric conditions. Data obtained were processed in Microsoft Excel Spreadsheet version 2016 and then exported into the SPSS (Statistical Package for Social Sciences) software version 21.0, for further analysis. Analysis of variance, ANOVA was also conducted on the set of VOC data collected during the morning, afternoon and evening sessions for 7 days, and the p-values were obtained for the evaluation of any significant differences. The VOC sensor integrated software automatically analyzed the VOC data obtained for all the petrol stations and was then exported into a personal computer, PC for discussion. The effectiveness and efficiency of the developed model were premised upon the value of the coefficient of determination, R-squared value obtained.

Plate 1: Aeroqual gas analyzer being used for experimentation (VOCs measurement)

3. RESULTS AND DISCUSSION

3.1 Descriptive demographic profile of the respondents

All the instruments administered were retrieved and analyzed. Table 1 shows the demography and details of forms of training undertaken by the petrol attendants. Demographic information of the respondents revealed that the majority (85%) of them were within the age bracket of 18 and 30 years with an average of 24. It was also established that about three-quarters,68%, of the respondents were male while slightly above one-quarter, 32% of them were female. This implies that the population of male attendants is above double of that of the female. This might be due to the nature and types of activities involved in serving as a petrol attendant, such as turning generators on/off, opening of station's gates, opening of vehicles taps for fueling, which often stiff, running up and down to attend to customers, even at the kerosene, diesel and cooking gas points, etc., these seem strenuous and energy demanding. The result matches the study conducted earlier [16]. About 64% of the respondents attained secondary school level, which is not enough to justify the requisite knowledge of safety culture and its effects. Perhaps, this is done due to remunerations since the business is strict to maximize profit, thus the owners prefer lower cadre to those with higher degrees, as average wages for a higher degree holder satisfy about 3 to 5 secondary school holders.

The analysis further revealed that 57% of the petrol attendants have less than two years of work experience and 43% of them have been working for over two years; while 83, 66 and 15% of the petrol attendants are trained through demonstration, oral and other training respectively (Table 1). Training and years of experience in any job description are very important because the synergy between the two describes the expertise of an employee at work. Despite that 77% of the attendants are trained fortnightly, it was observed that training is given to the petrol station attendants only takes care of a few safety precautions involved in the activities of petrol stations (see Table 1). However, the associated experience of health challenges such as dizziness (64.2%), headache (55.3%), low back pain (44.7%), eye irritation (36.2%), loss of coordination (36.2%), nausea (12.8%) and cough (10.6%) which resulted basically from inhalation of petrol fumes, were inevitable. (see Table 2). It is reported that too much exposure to higher concentrations of the fumes could result in acute health challenges such as loss of consciousness, cardiac sensitization, and coma which are cost engulfing and sometimes eventual death resulting from respiratory failure Table 2.

Table 1: Demography of petrol attendants and details of training undertaken

Variables	Characteristics	Frequency (N = 94)	Percentage (%)
Age of respondents	18-24	42	44.7
	25-30	38	40.4
	above 31	14	14.9
Sex of respondents	Male	64	68.1
	Female	30	31.9
Educational attainment	Primary	02	2.1
	Secondary	58	61.7
	Tertiary	34	36.2
Years of Work Experience	Less than 2 years	54	57.4
	above 2 years	40	42.6
Forms of training and duration of training of petrol attendants			
Oral	Yes	62	66
	No	32	34
Demonstration	Yes	78	83
	No	16	17
Other	Yes	14	14.9
	No	80	85.1
Duration of Training	Less than 2 weeks	72	76.6
	Two weeks and above	22	23.4

Table 2: Frequent experience of health challenges by the petrol attendants

Parameter	Response Options	Frequency (N=94)	Percentage (%)
Headache	Yes	42	55.3
	No	52	44.7
Low back pain	Yes	42	44.7
	No	52	55.3
Eye irritation	Yes	34	36.2
	No	60	63.8
Nausea	Yes	12	12.8
	No	82	87.2
Dizziness	Yes	42	64.2
	No	52	35.8
Cough	Yes	10	10.6
	No	84	89.4
Loss of coordination	Yes	34	36.2
	No	60	63.8

3.2 Prevalence of occupational hazard related to activities in the petrol stations

Analysis of data collected using the Area Health and Safety Risk Assessment Form, AHSRAFgave 63.8% for awkward posture, noise, and vibration, 95.7%, fire outbreak, 25.5% and vehicle accident 34%. While fuel spillage, robbery and hazardous fumes had 76.6, 23.4 and 68.1% respectively (Figure 1). Noise and vibration are most prevalent of all the assessed occupational hazards existing in the sampled petrol stations. This may be due to the location and closeness of the petrol stations to the major roads [17]. The next prevalent occupational hazard was observed to be fuel spillage with a percentage magnitude of 76.6, followed by hazardous fumes with 68.1%,then by awkward posture, vehicle accident, and fire outbreak having 63.8, 34.0 and 25.5% respectively. While robbery, 23.4% was the least occupational hazard observed in all the sampled petrol stations. It may be as a result of security measures put in place and the technological advancement in monetary transactions.

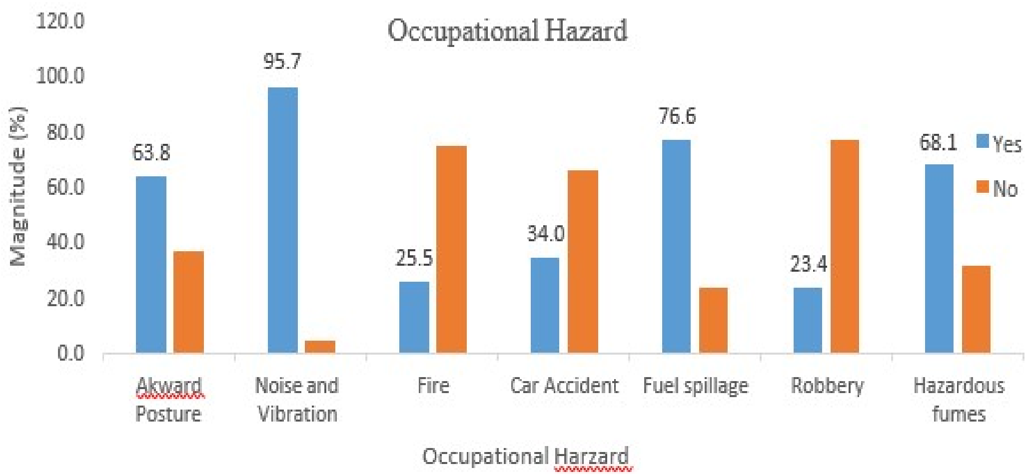


Figure 1 Distribution of occupation hazard in the petrol stations

Table 3: Occupational hazards in petrol stations

Response	Frequency (N=94)	Percentage	Response	Frequency (N=94)	Percentage
Fire Outbreak					
How often is the experience?			What is the level of impact?		
Rare	44	46.8	Insignificant	52	55.3
Unlikely	30	31.9	Minor	22	23.4
Possibly	16	17	Moderate	14	14.9
Likely	04	4.3	Major	06	6.4
Almost Certain	00	0.0	Catastrophic	00	0.0
Fuel Spillage					
How often is the experience?			What is the level of impact?		
Rare	06	6.4	Insignificant	16	17.0
Unlikely	18	19.1	Minor	40	42.6
Possibly	40	42.6	Moderate	26	27.7
Likely	20	21.3	Major	12	12.8
Almost Certain	10	10.6	Catastrophic	00	0.0
Vehicle Accident					

Unlikely	34	36.2	Minor	28	29.8
Possibly	14	14.9	Moderate	06	6.4
Likely	10	10.6	Major	06	6.4
Almost Certain	00	0.0	Catastrophic	00	0.0
Robbery					
How often is the experience?			What is the level of impact?		
Rare	34	36.2	Insignificant	62	66.0
Unlikely	44	46.8	Minor	20	21.3
Possibly	08	8.5	Moderate	10	10.6
Likely	06	6.4	Major	02	2.1
Almost Certain	02	2.1	Catastrophic	00	0.0
Fuel Leakage					
How often is the experience?			What is the level of impact?		
Rare	24	25.5	Insignificant	20	21.28
Unlikely	16	17.0	Minor	40	42.55
Possibly	36	38.3	Moderate	28	29.79
Likely	18	19.2	Major	06	6.38
Almost Certain	00	0.0	Catastrophic	00	0.0

3.3 Assessments of occupational hazards in petrol stations

The occupational hazards involved in petrol stations include; fire outbreaks, fuel spillage, vehicleaccidents, robbery, fuel leakage, noise, stress, hazardous fumes, fumes inhalation, use of mobile phones, traffic congestion and VOCs.

3.3.1 Fire outbreak

Results obtained for this study showed that, for the past years, a higher percentage of the sampledpetrol stations rarely experienced fire outbreaks which may be as a result of strict adherence to thebasic safety precautions of fire accident prevention. This is corroborated by the percentage fire outbreak of 47%, while 17 and 4% believed that such outbreak was possible and likely to have occurred respectively. Though, it was generally accepted by 55% of the respondents that at one point or the other, they experienced fire outbreaks, but, the effects were not significant. Such caseswere observed to be minor 23% and moderate 15%, meanwhile, 6% impact was recorded but no case of catastrophic effect was recorded. (see Table 3).

3.3.2 Fuel spillage and leakage

The prime risks identified were fuel dripping and leaking. Critical observation and inference of theanalyses revealed that most attendants did not count fuel spillage as something that could lead to a great loss as shown in Table 3. Also, 10.6% of the respondents affirmed that the experience of fuel spillage is almost certain, it then becomes imperative to instill appropriate safety culture. Another risk that poses a great threat to petrol stations is fuel leak either from the nozzle, or the hose pipe or leakage from the underground tank which serves as a reservoir for the stations. The assessment showed that 26% of the respondents believed that experience of fuel leakage is rare, while those who believed that experience of fuel leakage occurred by chance were 19 and 38% likelihood and possibility respectively. However, the negative perception as to the occurrence of the incident was 17% unlikelihood of the experience as affirmed by the respondents. There were insignificant, 22%, minor, 43%, and moderate, 30% impacts by the few leakages recorded while a6% major impact was experienced although not catastrophic, Table 3. These results could be attributed to technological advancement in material science, thereby giving rise to improved materials used in the design of the various components that constitute the petrol station especiallythe reservoir/storage tank, transferring pipes, dispensing hoses and nozzles. Meanwhile, proactiveactions are required to contain further occurrences of fuel leakage in the petrol stations.

3.3.3 Vehicle accident and Robbery

Vehicle accidents around petrol stations may lead to inferno and about 40 % of the respondents consented to unlikelihood, while 25.5% believed otherwise (see Table 3). Over 38.3% of those vehicle accidents were not fatal but the 6% major impact should be a concern to the management. Robbery is the act of forcibly or violently taking something valuable from another person. This is one of the major challenges facing the nation in all facets and various forms, and the case of petrol stations are not exempted [10,18]. However, the result presented in Table 3 showed that the rate of robbery has reduced in petrol stations as 38% of the respondents agreed that it is a limiting factor, leaving a 2% impact, but cumulatively, about 61% of respondents agreed that robbery is possible to occur. This act, therefore, entices the stakeholders to go digital, making commercialization of fuels and indeed other goods and services easier as transactions could be made online, either through bank transfer or point of sale service, POS gadget, thus, reducing the risk of manual handling of the huge amount of money which can attract robbery, pose threat to lives and properties. In the same vein, 38% of the respondents believed robbery of petrol stations is rare but miscreants may leverage on the porous security situation in the country, which does not guarantee the safety of lives and properties.

Table 4: Occupational hazards in petrol stations cont'd…

Noise					
How often is the experience?			What is the level of impact?		
Rare	02	2.1	Insignificant	04	4.3
Unlikely	14	14.9	Minor	32	34.0
Possibly	30	31.9	Moderate	26	27.7
Likely	36	38.3	Major	24	25.5
Almost Certain	12	12.8	Catastrophic	08	8.5
Stress					
How often is the experience?			What is the level of impact?		
Rare	02	2.1	Insignificant	04	4.3
Unlikely	14	14.9	Minor	14	14.9
Possibly	36	38.3	Moderate	60	63.8
Likely	28	29.8	Major	16	17.0
Almost Certain	14	14.9	Catastrophic	00	0.0
Hazardous Fumes					
How often is the experience?			What is the level of impact?		
Rare	08	8.5	Insignificant	00	0.0
Unlikely	18	19.1	Minor	30	31.9
Possibly	34	36.2	Moderate	58	61.7
Likely	28	29.8	Major	06	6.4
Almost Certain	06	6.4	Catastrophic	00	0.0
Fumes Inhalation					
How often is the experience?			What is the level of impact?		
Rare	10	10.6	Insignificant	04	4.3
Unlikely	20	21.3	Minor	24	25.5
Possibly	32	34.0	Moderate	52	55.3
Likely	28	29.8	Major	10	10.6
Almost Certain	04	4.3	Catastrophic	04	4.3

Mobile Phones					
How often is the experience?			What is the level of impact?		
Rare	30	31.9	Insignificant	50	53.2
Unlikely	48	51.1	Minor	28	29.8
Possibly	16	17.0	Moderate	12	12.8
Likely	00	0.0	Major	00	0.0
Almost Certain	00	0.0	Catastrophic	00	0.0
Traffic Congestion					
How often is the experience?			What is the level of impact?		
Rare	10	10.6	Insignificant	04	4.3
Unlikely	12	12.8	Minor	18	19.1
Possibly	40	42.6	Moderate	52	55.3
Likely	32	34.0	Major	18	19.1
Almost Certain	00	0.0	Catastrophic	02	2.1

3.3.4 Noise

Noise is an unwanted sound considered unpleasant, extremely louder than the threshold limit, or highly disruptive to hearing [19]. Experience and impact of noise were assessed and results are shown in Table 4, from where it was revealed that (2, 15, 32, 38 and13) % of the respondents gavetheir consent on the experience of noise at the petrol stations for rare, unlikely, possibly, likely andalmost certain respectively. Percentage insignificant, minor, moderate, major and catastrophic were 4, 34, 28, 26 and 9% respectively. It is when noise becomes unusually loud and uncontrolledthat it diminishes the quality of air and adversely affects the environment, public health, and welfare [20]. Noise from various sources such as automobiles, workshops around, power plant (generator), petrol dispensing pump and other activities being performed around are suggested tocontribute to the level of noise in the petrol station. Apart from the fact that this noise could hinderthe concentration of the fuel attendant, it also serves as a distraction when duty is being carried out, thus probably leading to fuel spillage.

Moreover, such noise when propagated does not only affect the petrol station alone but also serves as environmental pollution. World Health Organization [21] stressed that noise pollution has associated risk factors due to exposure to its high levels for which the effect may be too severe to bear, such that, they could lead to speech interference, reduction in productivity, high blood pressure [22], hearing defects, health disorders,sleep interference, cardiovascular effects, loss of concentration and absenteeism [23], tinnitus, temporary/permanent threshold shifts, sleep/reading disturbance, uncoordinated thinking as well as fatigue, sometimes permanent loss of memory or psychiatric disorder [19].

3.3.5 Stress and poor design of attendant's workplace

The ergonomics application to the design of goods, products, processes and workstations that have strong agreements with ergonomic characteristics demand of the users' anthropometry is to enhance natural working postures, to avert any form of musculoskeletal disorder [24]. Analysis revealed 2 and 15% rareness and almost certain that the attendants experienced stress in their bodies due to their respective tasks, while others were 55% cumulatively, Table 4. The impact associated with this amounts to 17% while other perceptions were 83%, nevertheless, no catastrophic impact was recorded (see Table 4). The reason for the highlighted degrees of impact was established through pertinent inspection of the petrol stations and personal interaction with the attendants where it was noted that in the majority of the sampled petrol stations, automatic dispensing pumps are being used. Integrated to the pumps are (HMI) Human Machine Interface (monitor) units where the price to purchase are displayed before dispensing, however, it was observed that ergonomic application principles were most inappropriately applied, because, the way most dispensing pumps are installed necessitate awkward positioning and repetitive motion of the attendants, thus subject the users to musculoskeletal disorders.

Another hazard prone to is the inappropriate workplace design/layout, however, effects of this can be overridden when adequate consideration is given to anthropometry characteristics of the attendants in the configuration of workstation [25], therefore, dispensing pumps should be installed appropriately. It was also noted that most attendants continuously work for longer hours that contradict the minimum of 8 hours a day recommended by the International Labour Organization, ILO [26], therefore, duty shift is suggested to keep the body free of stress.

3.3.6 Experience of hazardous fumes and Use of mobile phones

Furthermore, the nature of PMS due to its constituents may generate hazardous fumes that when inhaled could have an adverse effect. Therefore, this study has revealed hazardous fumes in the petrol stations and their possible inhalation by the attendants, results presented in Table 4. It was revealed that over 15% of the respondents agreed that hazardous fumes were experienced while 85% felt otherwise. The formal believed it was inhaled during fuel dispensation by the attendants,customers or others close to the source. Personal interview on the possible health challenges resulting from inhaling hazardous fumes showed eye, nose, and throat irritation, headaches, dizziness, nausea, vomiting, confusion, and breathlessness while sometimes can result in coma, loss of muscle control, as well as protracted heart and lungs difficulties. Also, too much exposureto petrol fumes can cause skin damages or burns. These results align with those obtained from theliteratures, where occupational hazards, health problems and safety practices of petrol attendants were assessed.

The effect of use of mobile phones within the petrol station has been a major controversialissue, as many believed it could lead to inferno while some disagreed. Owing to these diverse opinions, this study assessed the use of mobile phones in petrol stations sampled and the results are presented in Table 4. 32% of the respondents affirmed that mobile phones are being used within the petrol stations by either the attendants or their customers while 68% of the respondentsreported that use of mobile phones occurred by chance. The danger associated with the use of mobile phones at petrol stations is a topmost widespread myth because of the perceived risk of explosion. It is imperative to switch off mobile phones when at the petrol station, although many do forget. This is similar to the same general traffic regulation that prohibits keeping the engine running, as well as electrical systems such as the radio or devices that emit electromagnetic radiation turned on. The power rating of these devices is low-power radio-frequency transmitters (between 450 and 2700 MHz), with a peak power value that ranges between 0.1 and 2 watts, therefore, the question of whether these could cause an explosion is technically not certain, because these devices emit very little energy (less than 1 W/cm^2).

However, the only way that a mobile phone could generate a spark at a petrol station would be due to a defective battery, which is unlikely and could occur in the case of the vehicle's battery. The possibility of explosion via mobile phone is remote, but there is a low risk that an explosion could occur from the gases that are emitted by the dispensing hose. Furthermore, the use of mobile phones may be dangerous as asource of distraction than as a possible source of an explosion. According to a report from the Federal Communications Commission (FCC) in Washington [27], technically, research evidence has not yet proven the hypothesis that mobile phones can cause serious accidents in the petrol station because testing did not find a dangerous link between wireless and fuel fumes. Nevertheless, asides causing a distraction on the part of the petrol attendant, it is important to notethat the use of the mobile phone at petrol stations can make the driver lose concentration which can cause spillage and chaos, etc., based on that, use of the phone at petrol stations is not recommended.

3.3.7 Traffic congestion

This study evaluated the rate at which traffic congestion is being experienced in the sampled petrolstations and the results are presented in Table 4. It usually relates to an excess of vehicles in a particular location at a time, resulting in a much lower speed of movement [6]. In this connection,11% agreed that they rarely experience traffic congestion in their petrol stations. 13 and 43% of the respondents said it was 'unlikely' and 'possible' while 34% said traffic congestion was often experienced by chance.

However, this was accompanied by 19 and 2% catastrophic impacts withrespective 4, 55 and 19% for insignificant, minor and moderate impacts on the attendants and the environments. The 11% rarely occurrence of traffic congestion is assumed to be due to fuel scarcity, thereby contributing immensely to the already existing air and noise pollutions in the environment. This is so because the independent petroleum marketers have an association, where upon hearing the government proposal to increase the pump price of PMS, they proscribe the activities of some of their members by way of sharing formula which ensues rotation of sales, thus,this singular event could lead to more vehicles concentrating on the only available petrol station that is selling.

3.3.7.1 Data analysis and modelling of VOCs data using response surface methodology Volatile organic compounds, VOCs are gases emanating from different activities being carried out in petrol stations such as fuel storage and dispensation, automobile emissions and smoking amongothers. VOCs is one of serious occupational risks posed before petrol attendants and any other individuals around. VOCs may pose varieties of health hazards which could have short or long- term adverse effects. There were experiences of VOCs in all the sampled petrol stations as all(100%) attendants consented to that. This necessitated the need to investigate the effects and relationship among VOCs, temperature and relative humidity by collecting data on the three listed variables at different times (morning, afternoon, and evening) of the day for 7 days. Considering the cost of procurement and the technicalities involved in the use of Aeroqual gas analyzer fortaking readings of VOCs, Response Surface Methodology (RSM) was adopted in the design ofexperimental combinations of factors which consequently lead to the development of a predictive model for difficult-to-measure (VOCs) from the easy-to-measure variables (temperature andrelative humidity), details presented thus;

Table 5: ANOVA for Response Surface Cubic Model (Temperature)

Source	Sum of square	Df	Mean square	F value	p-value (Prob >F)	
Model	1.425E+006	9	1.583E+005	99.48	< 0.0001	Significant
A	20853.45	1	20853.45	13.10	0.0004	
B	6.534E+005	1	6.534E+005	410.54	< 0.0001	
AB	2.699E+005	1	2.699E+005	169.58	< 0.0001	
A^2	5242.49	1	5242.49	3.29	0.0713	
B^2	2211.30	1	2211.30	1.39	0.2401	
A^2B	104.39	1	104.39	0.066	0.7982	
AB^2	1.579E+005	1	1.579E+005	99.22	< 0.0001	
A^3	22753.81	1	22753.81	14.30	0.0002	
B^3	3.698E+005	1	3.698E+005	232.39	< 0.0001	
Residual	2.705E+005	170	1591.47			
Cor total	1.695E+006	179				

3.3.8 Response: Volatile organic compounds, VOCs

To describe the variation of this response, VOCs with the factors (temperature and relative humidity) and to test for its adequacy, the design programme suggested a cubic model. The model F-value of 99.48 implies the model is significant (see Table 5). There is only a 0.01% chance that"Model F-Value" of this large could occur due to noise [26]. Analysis of variance, ANOVA principles says that p-value less than 0.0500 indicate model terms are significant. Therefore, in this case B, AB, AB^2 and B^3 are significant model terms (Table 5). Notwithstanding, the non- appearance of "Lack of Fit F-value" implies that the model perfectly (100%) fit relative to the pureerror [26].

Table 6 shows the results for model estimation, from where it was observed that "Predicted R-Squared" value of 0.8059 is in reasonable agreement with the "Adj R-Squared" valueof 0.8320. "Adeq Precision" measures the signal-to-noise ratio. It is reported that a ratio greater than 4 is desirable [28]. Therefore, the value of "Adeq Precision" that is 49.297 indicates an adequate signal, which implies that the model developed can be used to navigate the design space.This further suggests that once the values for temperature and pressure are known, the model canbe used to predict any VOC values that are within the scope of the raw data even if such was not experimented. The R-Squared value of 0.8404 was obtained for the model developed. R-Squareddepicts an indication that the model was able to efficiently predict not less than 84.0% of the response (VOCs) values, which is statistically acceptable. Model equation for predicting occupational health hazard, VOCs in Nigerian petrol stations Equation 1 is the developed model for predicting VOC occupational health hazards in petrolstations.

$$VOC = 64895.27 - 23029.73(A) + 7039.14(B) - 176.11(AB) + 1004.84(A^2) - 67.54(B^2) - 0.34(A^2B) + 1.41(AB^2) - 11.28(A^3) + 0.14(B^3) \quad (1)$$

The model equation is given in terms of coded factors where,
VOC = Volatile organic compound (ppm),A = Temperature (°C) and,
B = Relative humidity (%).

Table 6: Result of model estimation

Std. Dev.	39.89	R-Squared	0.8404
Mean	109.13	Adj R-Squared	0.8320
C.V. %	36.56	Pred R-Squared	0.8059
PRESS	3.29E+05	Adeq Precision	49.297

3.3.9 Diagnostic Tests

Diagnostic tests were conducted such that predicted vs actual plot and normal plots of residuals showed how precisely the response was modelled and how reliable the model is. Since all the points line up nicely and the deviation of points of the response from normality is insignificant, then the model is a very good one [26]. For instance, VOC as seen in Figures 2a & 2b, the earlierstated conditions were met and these confirms the models developed are reliable and adequate. Figure 2a has the plot of predicted VOC against the actual VOC and Figure 2b shows the normal plot of residuals for VOC. The alignment of the data points observed in the two plots to the line offit is also an indication of the suitability of the developed model.

3.3.10 Analyses of response surface plots for VOCs in the selected petrol stations

This is aimed at having a clearer visualization of the variations between the response and the variable factors. For this purpose, interactive graphs and three dimensional, 3D response surface were drawn from the Design Expert software version 12.1. According to Abhilasha *et al.,* [29], the3D response surface plot is a graphical representation of the regression equations. This was plottedto show the interactions among the variables. Response surface plotted for VOC was generated with the combination of the two factors (temperature and relative humidity) and the convex response surface obtained suggested that there are well-defined optimal variables. (see Figure 3). If the surface is rather symmetrical and flat near the optimum, the optimized values may not varywidely from the single variable conditions [30]. Figure 3 shows the representation of the response surface plot and the interactive effects of combining the two factors (temperature/relative humidity) for predicting the VOC.

3.3.11 Interactive effects of temperature and relative humidity on VOC

It was observed from Figure 3 that the relationship between temperature and VOC is concerted. For instance, for the minimum temperature value recorded, i.e., 25 °C, VOC value was 515ppm. As the temperature increased from 25 °C to 27.75 °C, the VOC decreased from 515ppm to 197ppm. This suggested an inversely proportional relationship, where the increase in temperature resulted in a decrease in the corresponding value of VOC. Also, temperature increases from 27.75 °C to 30.50 °C as the VOC increases from 197ppm to 315ppm. This implies that the two variables simultaneously changed in the same direction i.e., direct-proportional relationship, which shows that as temperature increases, the VOC value also increased. While temperature increased from 30.50 °C to maximum temperature value of 31.70 °C, the VOC decreased from 315g/kg to 182ppm. This is an indication of an inversely proportional relationship. The effect of relative humidity, RH, on VOC was also observed in Figure 3. For the minimum RH value recorded, 45%, the VOC value was 0ppm. When RH increased from 45 to 57.5%, VOC increased from zero to 437ppm.

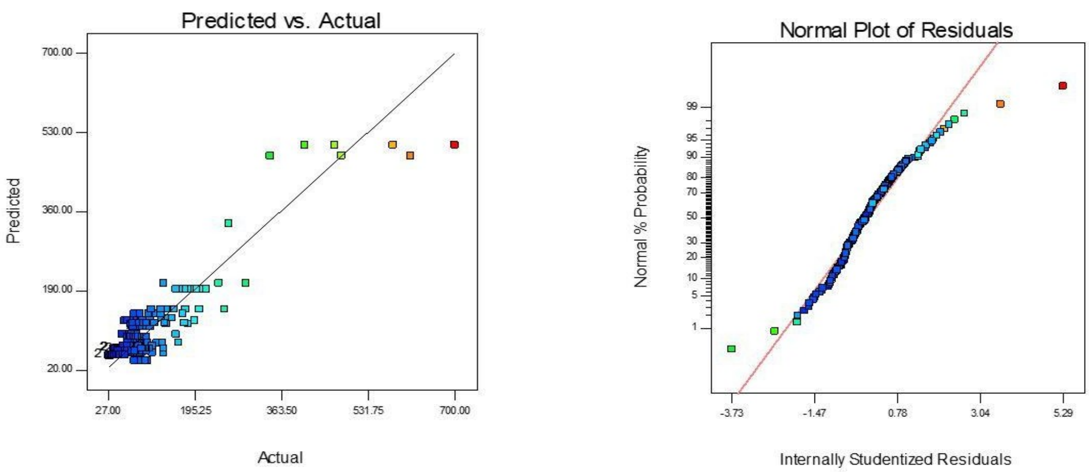
This proposes a directly proportional relationship, which shows that as RH increases, theVOC value also increased. Furthermore, when the RH value increased from 57.5 to 73.5%, the VOC decreased from 437ppm to 35ppm. This suggested an inversely proportional relationship, where the increase in RH resulted in a decrease in the corresponding value of VOC. Also, when the RH increased from 73.5% to a maximum RH value of 83.0%, then the VOC increased from 35ppm to 527ppm. This implies that RH and VOC simultaneously changed in the same direction i.e., directly proportional relationship, which shows that as RH increases, the VOC value also increased. It could be deduced from the discussion that, the interactive effects and relationship thatexisted between VOCs and the factors (temperature and relative humidity values) are interwoven, comprising of inverse and direct proportional relationships.

Since, the researchers did not have control over the atmospheric condition of the petrol stations where the experimental VOC, temperature and relative humidity data were collected, thus, the haphazard nature of the plots (Figures 3, 4, 5 and 6) and relationship are justified. Also, this deduction is justified in the fact that, there were three tranches of data collected at different times of the day, i.e., morning, afternoon, and evening sessions (Table 7), and were modeled together, thus establishing the effects of the factors on the response. The statistical analysis of variance, ANOVA conducted on the set of experimental data collected for 7 days each in the morning, afternoon and evening gave p-valuesof 0.641, 0.328, and 0.726 respectively. This implies that at $p \leq 0.05$ significance level, there was no significant difference across the data collected for 7 days in the morning, afternoon and evening sessions because none of the p-values was less than or equal to 0.05. Typical behaviors of VOC data collected in the morning, afternoon and evening are shown in Figure 4, Figure 5, and Figure 6 respectively.

Therefore, the model developed can be used to predict the VOCs values of any time of the day. Apart from the weather condition, temperature and relative humidity which wereestablished in this study to affect the concentration of VOCs, other important factors that contributed to the concentration of VOCs in petrol stations were the rate of service and customer channels as well as insufficient room for ventilation. It was observed during data collection that, where there was enough ventilation, the concentration of VOCs was low compare to when there was no enough ventilation due to traffic congestion, buildings and structures around the petrol stations. This study proposes avoidance of automobile emissions, smoking, and provision of maximum ventilation as means to reduce the risk of exposure to VOCs. Also, considering the environmental impacts of VOCs and other pollutants emanating from petrol stations, minimum of 80m safe distance away from residential areas is recommended by Okonkwo, *et al.,* [18], because after this distance, the higher atmosphere would have absorbed all the emitted VOCs through evaporation thereby eradicating the possibility of harm to occupants of the residential areas, but for the attendants and customers patronizing petrol station, use of nose mask is recommended.

Table 7: Analysis of variance on the raw VOC dataset

Time	p-values	Inference
Morning (Including all the 7 days)	0.641	Insignificant
Afternoon (Including all the 7 days)	0.328	Insignificant
Evening (Including all the 7 days)	0.726	Insignificant



(a) (b)

Figure 2 (a) Predicted VOC vs actual VOC plot (b) Normal plot of residual for VOC

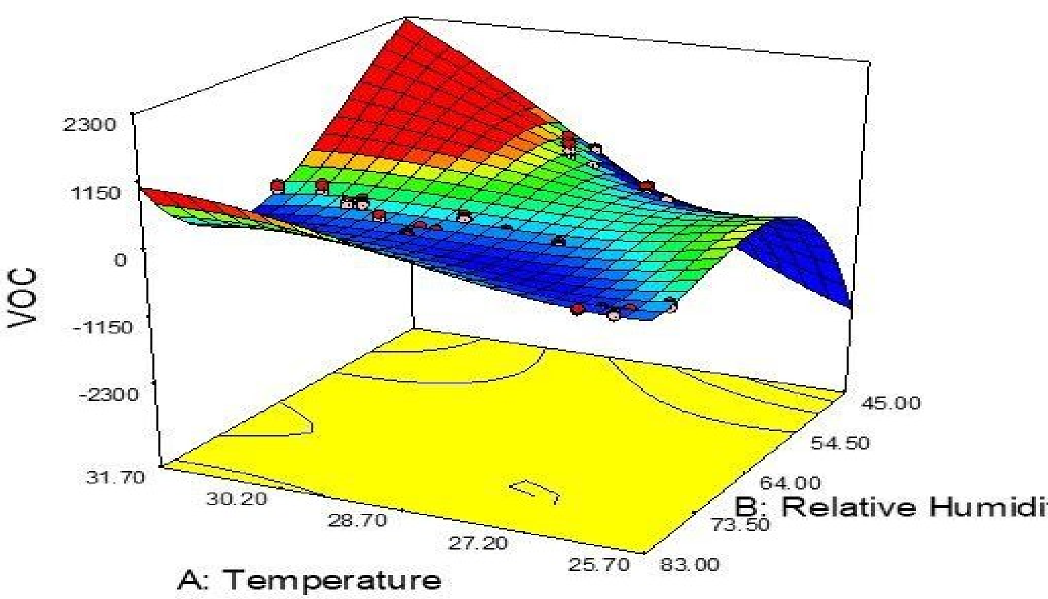


Figure 3: Interactive effect of temperature and relative humidity on VOC

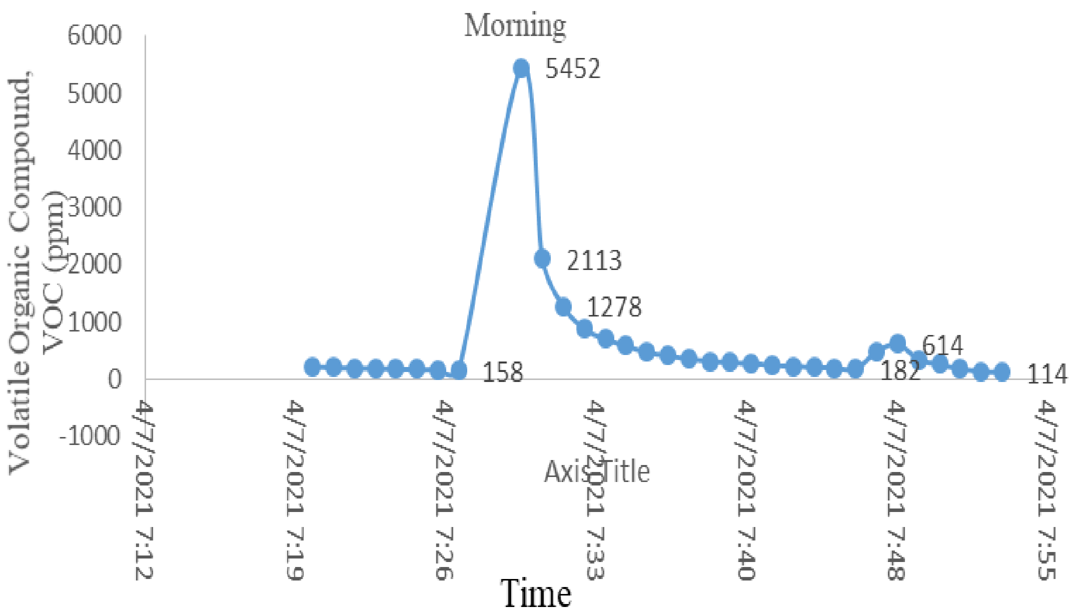


Figure 4 Typical plot of VOC against time in the morning

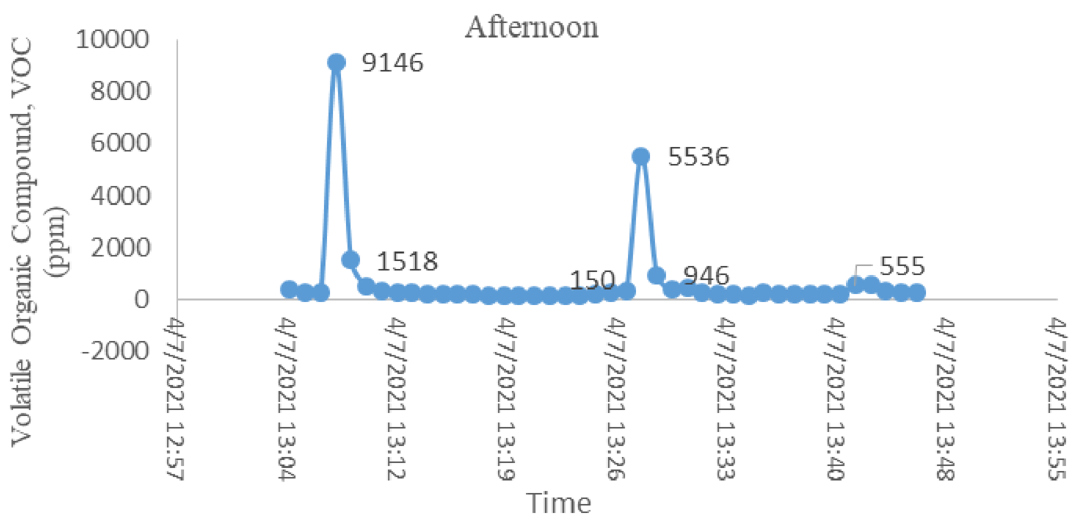


Figure 5 Typical plot of VOC against time in the afternoon

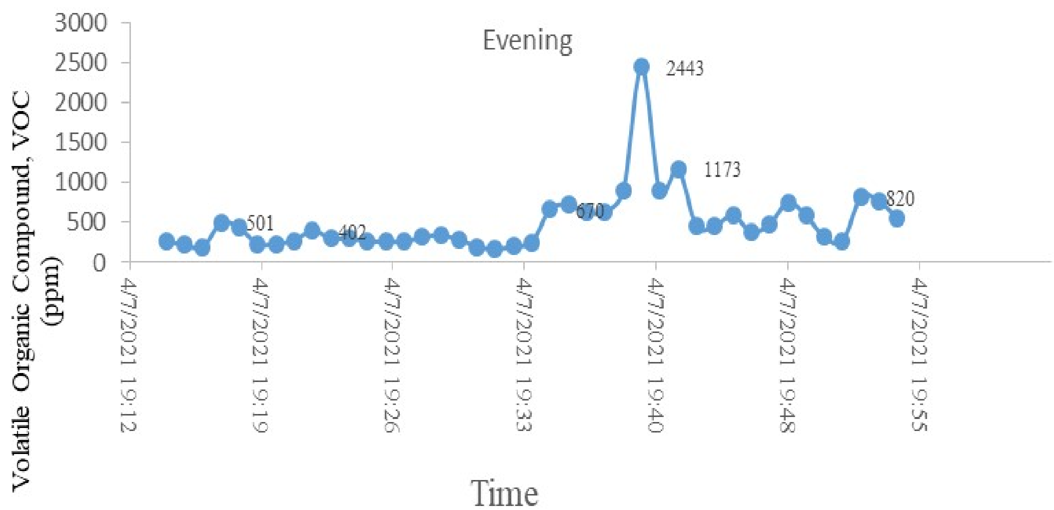


Figure 6 Typical plot of VOC against time in the evening

4. CONCLUSIONS AND RECOMMENDATIONS

Globally, integration of ergonomic principles and extenuation of occupational risks in petrol station are premised on compliance to site location/regulatory standards and effective management because they synergistically heighten; the comfort of petrol attendants in the discharge of their duties, profit maximization, socio-economic growth of humans' life and properties in the hosting areas. This study assessed and concluded the prevailing ergonomic and occupational risk potentials of petrol stations situated in the studied area to be; fire outbreak, fuel spillage, vehicle accident, robbery, fuel leakage, noise/vibration, stress, hazardous fumes, fumes inhalation, use of mobile phones, traffic congestion and VOCs amongst others. The respondents' experience of ergonomic deficit and occupational risks resulted to adverse health challenges of dizziness (64.2%), headache (55.3%), low back pain (44.7%), eye irritation (36.2%), loss of coordination (36.2%), nausea (12.8%), and cough (10.6%). However, too much exposure to higher concentrations of VOCs resulted in loss of consciousness, respiratory failure, cardiac sensitization, coma and sometimes eventual death.

Therefore, this study has proposed a mathematical model to predict the level of VOC to reduce the risk of exposure. The resulting model exhibited cubic property to model the real-life scenarios with the coefficient of determination (R2) of 0.8404, thus, petrol stations, as well as other allied, would find in this model reliable, economical, effective, and efficient prediction tool. It was concluded that the majority of the sampled petrol stations did not properly conform to stipulated regulation standards of DPR on-site location and acceptable working conditions. It was also established that the air quality in the studied area was negatively affected due to emissions of pollutants such as fumes, vehicle emissions, and VOCs from petrol stations into the ambient air. Therefore, urgent actions should be taken by the appropriate bodies to arrest this ugly trend. It is recommended that most of the sampled petrol stations should be equipped with modern anti-fire preventive control and first-aid boxes. Asides that, personal protective equipment such as nose masks and reflective safety vests should as well be provided and measures should be put in place to enforce their usage by the attendants. Lastly, mandatory standardized training on health and safety standards for all attendants to conscientize them on the hazards associated with their work is recommended.

REFERENCES

1. Mshelia A. M., John, A. and Emmanuel, D. D. Environmental Effects of Petrol Stations at Close Proximities to Residential Buildings in Maiduguri and Jere, Borno State, Nigeria. Journal of Humanities and Social Science (IOSR-JHSS) 2015, 20(4), 01 – 08.
2. Okemiri, H. A., Nweso, E. N. and Eze, M. O. Critical Review of Petrol Station Management System with Emphasis On The Advantages If Digitalized In Nigeria. Journal of Multidisciplinary Engineering Science and Technology (JMEST) 2016, 3(1), 3687 – 3693
3. Sangotola, T. M., Fasanmade, P. A., Ayanrinde, W. A., Olatinwo, I. O. and Olaniran H. F. On the effects of petrol stations in Nigeria. International Journal of Science, Engineering and Technology Research (IJSETR) 2015, 4(4):947 – 954.
4. Douti, E. E. Y., Abanyie, N. B., Ampofo, S. K., and Amuah, S. Spatial distribution and operations of petrol stations in the Kassena-Nankana district and associated health and safety hazards. Journal of Toxicology and Environmental Health Sciences, 2019, 11(5), 50 – 61.
5. DPR (Department of Petroleum Resources) 2018 Guidelines on Approval of Siting of Petrol Stations accessed on https://www.dpr.gov.ng/wp-content/uploads/2018/08/PETROL-
6. STATION-GUIDELINES.pdf Date: Thursday July 15, 2021, by 13:55 hours of the day. 5
7. Ogunyemi, O., Ajileye, S. A., Muibi, O. O., Alaga, K. H., Eguaroje, A. T., Samson, O. E., Ogunjobi, S. A., Adewoyin, G. A., Popoola, J. E., Oloko-Oba, O. S., and Omisore, M. O. Geo- Information and Distribution Pattern of Petrol Service Station in Sango – Ota Metropolis in Ado – Odo Ota Local Government Area, Ogun State, Nigeria. Asian Research Journal of Arts& Social Sciences, 2017, 2(1), 1 – 11.
8. Ahmed, S., AbdulRahman, A. S., Kovo, A.S., Ibrahim, S., Okoro, E. O. and Agbo, A. A. Health, Risk and Safety of Petrol Stations in Minna Town: An overview World Applied Sciences Journal 2014, 32 (4): 655 – 660
9. Batambock, S., Innocent, N. M. and Waffo, B. D. Auditing the Siting of Petrol Stations in the City of Douala, Cameroon: Do they Fulfil the Necessary Regulatory Requirements? Advances in Science, Technology and Engineering Systems Journal 2021, 6(1), 493 – 500.
10. Fajobi M. O., Awoyemi E. A. and Onawumi, A. S. Ergonomic Evaluation of Hospital Bed Design and Anthropometric Characterization of Adult Patients in Nigeria International Journal of Scientific & Engineering Research, 2016, 7(8).
11. Tah, D. S., (2017). GIS-based locational analysis of petrol stations in Kaduna Metropolis, Science World Journal. 2017, 12(2), 17 – 20.
12. Kehinde, A. G. Assessment of Fire Service Station Response to Petrol Stations Fire Outbreak and Vulnerable Healthcare Centers to Petrol Stations in Urban Settlement. International Journal of Research and Review 2020, 7(3), 10 – 30.
13. Isaac, M., John, B. D., Abigail, A., Asantewa, G. T. and Fred, O. Health and safety in high- risk work environments: A study of fuel service stations in Ghana. Journal of Environmental and Occupational Science 2015, 4(3), 132 – 140.
14. Mirza, M. A., Kutty, S. R. M, Mohd, F. K., Idris O. and Azmi, M. S. Hazard Contributing Factors Classification for Petrol Fuel Station. World Academy of Science, Engineering and Technology International Journal of Civil and Environmental Engineering 2012, 6(12), 1103- 1114.
15. Shabir, H. K., Abd Nassir, M., Imtiaz, A. C. and Mir Aftab, H. T. Land suitability analysis for installing new petrol stations using GIS. Elsevier Procedia Engineering 2014, 77, 28 – 36.
16. WPR, (World Population Review) (2021). accessed on https://worldpopulationreview.com/world-cities/ogbomosho-population Date: Thursday July 15, 2021, by 16:55 hours of the day.
17. Ulasi, J. O., Uwadiegwu, B. O. and Okoye, C. O. Assessment of the Level of Compliance of Petroleum Filling Stations to Development Control Standards on Land Space/Size and Setbacks in Anambra

State. Civil and Environmental Research 2020, 12(2), 77 – 87.
18. Orupabo, S. and Newton, Y. F. Assessment of Petrol Stations Locations in Port Harcourt, Rivers State, Nigeria Using Geospatial Techniques. International Journal of Scientific & Engineering Research Volume 2018, 9(6), 764 – 775.
19. Okonkwo U. C., Orji I. N. and Onwuamaeze I. Environmental Impact Assessment of Petrol and Gas Filling Stations On Air Quality in Umuahia, Nigeria. Global Journal of Engineering Research 2014, 13, 11-20
20. Ajayeoba, A. O., Olanipekun, A. A., Raheem W. A. Ojo, O. O. and Soji-Adekunle A. R (2021) Assessment of Noise Exposure of Sawmill Workers in Southwest, Nigeria. Sound andVibration. 55(1), 69-85
21. Goswami B Hassan Y., and Sarma A. J. D. The Effects of Noise on Students at School: A Review. International Journal of Latest Engineering and Management Research. 2018, 3 (1),43-45.
22. World Health Organization Burden of disease from environmental noise. European Environmental Agency. 2011, 14-127
23. Potgieter J. M, Myburgh H. C. and Smits C. The South African English smartphone digits-in noise hearing test: effect of age, hearing loss, and speaking competence. Ear Hear 2018, 839(4):656 – 663.
24. Oguntunde, P. E., Okagbue, H. I., Oguntunde, O. A. and Odetunmibi, O. O. Study of NoisePollution Measurements and Possible Effects on Public Health in Ota Metropolis, Nigeria, Macedonian Journal of Medical Sciences. 2019, 7(8):1391-1395.
25. Fajobi, M. O., Awoyemi, E. A., Odedele, D. T., Adesope, W. A. and Adio, T. A. Investigation of the Relationship between Stature and Popliteal Height Sitting of Nigerian Bus Drivers, Elixir International Journal; Elixir Mech. Engg. 2017, 111:48710-48713
26. Fajobi, M. O., Onawumi, A. S., Udoh, M. O. and Awoyemi E. A. Mismatch between Anthropometry Characteristics of Nigerian Occupational Bus Drivers and the In-Vehicle Measurement, International Conference on Engineering for a Sustainable World Held on July9 – 13, 2018 At Covenant University, Ota, Nigeria, published in 2019.
27. Onawumi A. S., Dunmade I. and Fajobi M. O. Anthropometry Survey of Nigerian Occupational Bus Drivers to Facilitate Sustainable Design of Driver's Workplace. World Journal of Engineering and Technology, 2016, 4, 176-182
28. FCC (Federal Communications Commission) (2021).
29. https://docs.fcc.gov/public/attachments/FCC-20-188A1.pdf Date: Wednesday July 21, 2021, by 17:47 hours of the day.
30. Aremu M. O., Oke E. O., Arinkoola A. O. and Salam K. K. 'Development of Optimum Operating Parameters for Bioelectricity Generation from Sugar Wastewater Using Response Surface Methodology' Journal of Scientific Research & Reports 2014 3(15): 2098-2109.
31. Abhilasha S, Mathuriya V and Sharma N. Bioelectricity production from various wastewaters through Microbial Fuel Cell technology. Journal of Biochemical Technology. 2009, 2(1):133-137.
32. Salam, K. K., Arinkoola, A. O., Oke, E. O., and Adeleye, J. O. Optimization of operating parameters using response surface methodology for paraffin-wax deposition in pipeline Petroleum & Coal.; 2014, 56(1):19-27.