ASSESSMENT OF AIR, WATER QUALITY AND HEALTH IMPACT ON THE ENVIRONMENT OF PETROL STATIONS IN ADO LOCAL GOVERNMENT AREA OF EKITI STATE, NIGERIA

BY

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DECLARATION

I, BOSEDE CHRISTIANAH, MAKANJUOLA, declare that this Dissertation is a product of research work carried out leading to an award of M.Sc. degree in Environmental Health Science. Information derived from other sources are duly acknowledged. I also declare that neither whole nor part of this dissertation has been presented for another degree programme nor has been submitted elsewhere for publication.

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ABSTRACT

Petroleum and its products are one of the main sources of energy world over, the utilization of which may have constituted public health problems to human and aquatic lives. Therefore, this study assess the level of air quality parameters compared with the recommended standard values and assess the health impacts of the petrol station on the petrol attendants in Ado Ekiti metropolis of Ekiti State, Nigeria. A combination of field survey and experimental research design was adopted in the study. The data collected include air samples, (Particulate matters, i.e. $PM_{2.5}$ and PM_{10}) using air quality monitor, and petrol attendants. A purposive sampling technique was used to sample two hundred and twenty-five (225) petrol attendants selected from the sixty (60) functional petrol stations. Data gathered were analyzed using descriptive statistics, MS Excel and SPSS 21. Findings shown that 11 Petrol Filling Stations (PFS) out of 60 have their $PM_{2.5}$ values above the recommended WHO standard at 20m distance, 10 PFS at 40m and 17 filling stations at 50m in the study area. For $P.M_{10}$, 12 out of 60 have their values above WHO value at 20m distance, 13 and 15 PFS have their values above WHO value at 40m and 50m respectively. PM_{10}. The distribution of the symptoms among petrol station attendants was as follows: 40.0% had nose irritation, 5.3% had palpitation of heart, 10.2% had shortness of breath/breathing difficulty, 73.8% had body weakness, 49.3% had regular sweating, 40.0% had skin irritation and 13.3% had abdominal discomfort. There should be an increased effort on awareness of the harmful effects of air pollutants to the petrol attendants and communities surrounding the various filling stations including children, pregnant women and the elderly who are vulnerable group. Relevant agencies should ensure adherence to DPR guidelines and ensure alternative water sources for the affected people.

KEYWORD: PAHs, Filling station, Air quality, water quality Particulate matters ($P.M_{10}$, $PM_{2.5}$)

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LIST OF ABBREVIATION

SDGs: Sustainable Development Goals

PM: Particulate Matter

PAHs: Polycyclic Aromatic Hydrocarbons

MTBE: Methyl Tert-Butyl Ether

BTEX: Benzene, Toluene, Ethylene and Xylene

IQ: Intelligent Quotient

CHARGE: Childhood Autism Risks from Genetics and the Environment

FMEV: Federal Ministry of Environment

BaP: Benzo (a) Pyrene

MCL: Maximum Contamination Level

VOCs: Volatile Organic Compounds

DPRs: Department of Petroleum Resources

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Petroleum is one of the main sources of energy and its products occur as complex mixtures of chemicals, primarily hydrocarbon (James, 2019). Hydrocarbons are organic compounds composed of carbon and hydrogen atoms arranged in varying structural configurations. At a simple level, they may be divided into two families including aliphatic and aromatics (Siberberg and Martins, 2004). Technological advancement improves the initiative of man towards the development of automobile and the discovery of petroleum products which in turn activates the construction of fuel/petrol filling stations (PFSs) at strategic locations to meet the demand of vehicle owners. It is this rapid growth in urbanization that produced greater demand of vehicles and gasoline especially in the United States of America because of people's reliance on cars (National Academies of Sciences, 2019).

In Nigeria, the role that petroleum products play in the economy is significant and cannot be underestimated. For instance, the products play a face-saving and palliative roles for her citizens experiencing epileptic power supply and need alternative power source. Chinambu (2011) affirmed that, petroleum products are a key driver of industrial activities in some nations. It is noteworthy that, business and the transportation sector is the major consumer of fuel to facilitate people's movement around the world (Garcia-Olivares, 2015).

However, as important as these products seem to be, the indiscriminate siting of petrol filling stations in residential areas is gradually posing a threat to the lives and property of citizens, considering the high risk and dangers associated with petroleum product as a highly inflammable product, its exploration, transportation, offloading, storing and sale points should not be taken for granted like other products. The World Health organization (2015), classifies air pollution among one of the leading cause of environmental risks and possible deaths. It is estimated that, about 3million deaths occur annually as a result of exposure to ambient air pollution (Ede, Obunwa, & Nlerumchi, 2010). Much recently a study identified that, about 11.6% of deaths globally is associated with air pollution; and about 94% of these deaths occurred in the developing countries (Ukemenam, 2014). This means that the dangers associated with ambient air pollution are grave. Therefore, high amounts of gases and particulate matters such as O_3; NO_2; SO_2, H_2S, CO_2, $PM_{2.5}$, and PM_{10} pollutes the atmosphere, cause harmful effects to environment & human health; and renders the environment un-safe for habitation (Tawari & Abowei, 2012).

Though, individual countries through their environmental protection institutions, agencies, urban and regional planning establishments have evolved their own planning standards and principles as guidelines, the observed trend in recent times from this development as documented by Isabel, et al. (2010) is the risk associated with petrol filling stations including risks involving the release of petrol vapour into the air during the filling of the storage tanks by tanker delivery personnel and when customers refuel their vehicles; tank breathing which occurs due to temperature and pressure changes, spillage during vehicle refueling, emissions from loosely closed tanks and mishandling of the petroleum products leading to spillage into the air and the potential for releasing polluting agents into soil and water. (Nieminen, 2005). Isabel, et al. (2010) also confirmed that there is emission of combustion products from vehicle engines present in the station. Because of this dark side of petroleum products on the eco-system, its service location points must be strategically and consciously done to minimize damages to human beings, plants, other animals and their immediate environment because the environmental impacts of petroleum are mainly negative. This is due to the toxicity of petroleum which contributes to air pollution, acid rain, and various illnesses in humans.

The location of filling stations in various cities is largely influenced by a number of factors such as marketability, accessibility and approval by local authorities. In many countries, there is heavy presence of petrol stations due to urban growth. As a result, the health of people living close to these areas is endangered due to constant traffic and vapour emission. These fuels which include, liquefied natural gas (LNG), diesel, kerosene and especially petrol contain volatile organic compounds like benzene which are flammable and can give off vapour even at low temperatures (Menkes and Fawcett, 1997). In Nigeria, especially in Ado Ekiti, Ekiti State, it has been discovered that, petrol filling stations are located close to residential areas and in some cases close to commercial and industrial activities (Mshelia, et al., 2015). However, there has not been any significant study that has been intensively and extensively carried out to determine the pragmatic factor and environmental impacts of these petrol stations on the environment.

1.2 Statement of the Problem

Pollution is a major problem and it poses continuing risks to health. It remains an increasing environmental problem causing high mortality rates globally because 92 percent of the world’s population still lives without clean air (WHO, 2016). This problem affects large numbers of people greatly in the developing countries like Nigeria where pollution sources such as industrial emissions, poor sanitation, inadequate waste management, contaminated water supplies and exposures to indoor air pollution from biomass fuels is the order of the day. In Nigeria, there have been proliferations of petrol stations in residential areas as against the Department of Petroleum

Resources (DPR) regulations. This is exposing human and ecosystem to dangers due to the toxicity of petroleum related products that threaten human health. Many compounds found in oil are highly toxic and carcinogenic as well as causing other diseases (Don, 2013).

Oil pollution can have a devastating effect on the water and air environment as it spreads over the surface in a thin layer that stops oxygen from getting to the plants and animals that live in the water and human using the water for drinking and other domestic purposes. Also, inhalation of the fumes from dispensing petroleum products can have devastating effects on the neighbourhood and most importantly the petrol attendants who usually stay at close proximity while selling these products to customers for a longer period of time (Ogunneye, et al., 2014). It is therefore against this background that the study examined the air, water quality and health impact on the environment of petrol stations in Ado Ekiti, Ekiti State, Nigeria.

1.3 Justification of the Study

Studies related to petrol stations and its effects on air, water and, health impacts are very scanty. Though, studies have been carried out to ascertain the location of petrol filling stations but not on pragmatic approach of taken environmental samples for laboratory analysis.

Therefore, the survey might expose the risks and dangers of indiscriminate siting of petroleum stations on the environment. Secondly, owners of filling stations will find the review useful as the research will expose proactive steps that could be taken to minimize the hazardous effects of petrol stations on the environment. It might also help the policymakers and stakeholders in the petroleum industry to make new policies that will make the environment safer from petroleum products' pollutions. Similarly, the study will serve as a guide for individuals, developers, the government and other stakeholders in the urban planning, downstream petroleum industry, and other areas for further research and decision making. Finally, the students and researchers will find this study useful as it will serve as a resource for future study and hence contribute significantly to the body of knowledge.

1.4 Aim and Objectives of the Study

1.4.1 Aim

To investigate the quality of air, water and health impacts of petrol stations on the environment of petrol stations in Ado- Ekiti.

1.4.2 Objectives

The Specific Objectives are to:

i. Determine the Level of air quality parameters in the study area compared with the recommended standard values
ii. Determine the water quality in the study area and compared with national and international standards for drinking water.
iii. Assess the health impacts of petrol station on the petrol attendants
iv. Evaluate the adherence of petrol station owner to Department of Petroleum Resources (DPR) guidelines

1.5 Scope of the Study

The study investigates the air quality, water quality and health impact on the environment of petrol stations in Ado Local Government Area of Ekiti State, Nigeria. All primary data for the study were collected in Ado Ekiti Local Government Area of Ekiti State, Nigeria.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter contains the conceptual review, empirical review and theoretical literature on the environmental implications of petroleum stations and the effects on air, water quality and health of people. This chapter is organized into three main sections, the first section presents the conceptual review which has to do with the conceptual definitions of some facts, and the second section presents the empirical review on various research works on the study concerned, and thirdly the theoretical framework for the study.

2.2 Conceptual Review

2.2.1 Concept of Petrol Station

A petrol station or filling station is a facility that sells fuel and engine lubricants for motor vehicles. The most common fuels sold are gasoline, kerosene and diesel fuel. In petrol stations, Fuel dispensers are used to pump petrol/gasoline, diesel, compressed natural gas, kerosene, alcohol fuel (like methanol, ethanol, butanol, propanol), biofuels (like straight vegetable oil, biodiesel), or other types of fuel into the tanks within vehicles and calculate the financial cost of the fuel transferred to the vehicle. Also, many filling stations incorporate a convenience store. The convenience stores found in filling stations typically sell candy, soft drinks, snacks and, in some cases, a small selection of grocery items, such as milk (Mark, 2005).

Most filling stations are built in a similar manner, with most of the fueling installation underground, pump machines in the forecourt and a point of service inside a building. Single or multiple fuel tanks are usually deployed underground. Local regulations and environmental concerns may require a different method, with some stations storing their fuel in container tanks, entrenched surface tanks or unprotected fuel tanks deployed on the surface. Fuel is usually offloaded from a tanker truck into the tanks through a separate valve, located on the filling station's perimeter. Fuel from the tanks travels to the dispenser pumps through underground pipes. For every fuel tank, direct access must be available at all times. Most tanks can be accessed through a service canal directly from the forecourt.

In Nigeria, filling stations operations started prior to independence; the production and distribution of petroleum products which did not gain much popularity until independence in 1960 as a result of the fact that the mileage of motorable roads rarely increased and are few vehicles plying these roads. However, with the independence in1960, construction of more roads, schools, and factories started and consumption of petroleum products increased. Demands for all grades of petroleum products started to overtake the supply and this became more manifested after the civil war leading to opening of many filling stations across the country (Udoh, 2013).

Filling Station (otherwise known as Petrol station, Gas Station, Refuelling Station, or Service Station) across the world is a facility which sells fuel and lubricants for motor vehicles, generators and other machine. The most common fuel products sold is Premium Motor Spirit (PMS) known as petrol, Automotive Gas Oil (AGO) and Dual Purpose Kerosene (DPK) known as kerosene. Filling stations should be located where there are less congestion and danger to the community as much as possible and should conform to the guidelines of the regulating bodies. (Samuel, 2011).

2.2.2 Concept of the Environment

The environment includes the surroundings, conditions or influences that affect an organism. The World Health Organization (2006) defines environment, as it relates to health, as “all the physical, chemical, and biological factors external to a person, and all the related behaviors.” Environmental health consists of preventing or controlling disease, injury, and disability related to the interactions between people and their environment. It is all that which is external to the human host that can be divided into physical, biological, social, cultural, etc., any or all of which can influence health status of populations". According to this definition, the environment would include anything that is not genetic, although it could be argued that even genes are influenced by the environment in the short or long-term.

For the purpose of environmental health, however, a more practical definition of the environment is needed, because environmental health action generally tries to change only the natural and physical environments and related behaviours (e.g. hand washing). Such interventions can rarely modify the social and cultural aspects of a community, which are usually independent of the environment (e.g. cultural pressures on lifestyle, unemployment).

WHO,2015 reiterated that the environment is all the physical, chemical and biological factors external to the human host, and all related behaviours, but excluding those natural environments that cannot reasonably be modified. This definition excludes behaviour not related to environment, as well as behaviour related to the social and cultural environment, genetics, and parts of the natural environment. This definition thus aims to cover those parts of the environment that can be modified by environmental management. In the case of petroleum products, for example, the definition of environment would include only that part of the environment that had been affected by man-made interventions (in this case, filling stations), and which could be modified by further intervention.

Estimates of the environmental health impact would not include disease caused by vectors living in natural environments such as rivers, if those vectors could not be controlled by reasonable environmental interventions. Similarly, deaths and injuries of soldiers during war is not included here, even though they could be considered occupational, because no intervention could possibly provide a safe working environment. Our definition of "environment" is thus not all-inclusive in terms of the natural environment, and includes only those aspects that are modifiable (not necessarily immediately, but with solutions that are already available) (WHO, 2015).

Some of the environmental factors include:

i. Pollution of air, water, or soil with chemical or biological agents;
ii. Ultra violet and ionizing radiation;
iii. Noise, electromagnetic fields;
iv. Occupational risks;
v. Built environments, including housing, land use patterns, roads;
vi. Agricultural methods, irrigation schemes;
vii. Man-made climate change, ecosystem change;
viii. Behaviour related to the availability of safe water and sanitation facilities, such as washing hands, and contaminating food with unsafe water or unclean hands.

Human health is directly threatened by serious environmental problems that arise in and around people's homes. According to McGranahan, (2012), inadequate sanitation, insufficient or contaminated water, smoky cooking fuels as well as insect infestation are all correlated with urban poverty and a lack of environmental services. Within this scenario, children, the elderly and women are particularly vulnerable to health hazards emanating from the home environment because these groups spend longer time in or around the homes. Thus respiratory infections and diarrheal diseases are the two biggest childhood killers being largely the consequence of inadequate home and neighbourhood environments.

The quality of community environment is therefore essential for health of both adults and children. This explains why concerted effort has been directed towards the improvement of environment as a sustainable strategy for the improvement of overall health of the people. This is hinged on the belief that specific diseases and injuries are impacted by environmental risks. It is important to note that the influence of the environment on human health is also mediated by socioeconomic as well as neighbourhood conditions of urban residents. In other words, the magnitude of the impact of various environmental conditions on human health is determined by, among other factors, the household economy, family hygiene, water quality and availability as well as the presence of environmental services at the household and community level (Raheem et al., 2009).

2.2.3 The Concept of Pollution

Pollution is the process of making land, water, air or other parts of the environment dirty and not safe or suitable to use. This can be done through the introduction of a contaminant into a natural environment, but the contaminant does not need to be tangible. Things as simple as light, sound and temperature can be considered pollutants when introduced artificially into an environment. Toxic pollution affects more than 200 million people worldwide, according to Pure Earth, a non-profit environmental organization (Beil, 2017). In some of the world's worst polluted places, babies are born with birth defects, children have lost 30 to 40 IQ points, and life expectancy may be as low as 45 years because of cancers and other diseases. A pollutant is a waste material that pollutes air, water, or soil. Three factors that determine the severity of a pollutant include; its chemical nature, the concentration and the persistence (Beil, 2017).

(a) Forms of pollution

According to (Wilson, Shen, Pope & Schemelling, 2001), the major forms of pollution are listed below along with the particular contaminant relevant to each of them:

i. Air Pollution: The release of chemicals and particulates into the atmosphere. Common gaseous pollutants include carbon monoxide, sulphurdioxide, chlorofluorocarbons (CFCs), and nitrogen oxides produced by industry and motor vehicles. Photochemical ozone and smog are created as nitrogen oxides and hydrocarbon react to sunlight. Particulate matter, or fine dust is characterized by their micrometre size PM_{10} to $PM_{2.5}$.

ii. Electomagnetic Pollution: overanbundance of electromagnetic radiation in their non-ionizing form, like radio waves that people are constantly exposed especially in large cities. It is still unknown whether or not those types of radiation have effects on human health though.

iii. Light pollution: This indicates light trespass, over illumination and astronomical interference.

iv. Littering: The criminal throwing of inappropriate man-made objects, unremoved, onto public and private properties.

v. Noise pollution: This encompasses road way noise, aircraft noise. Industrial noise as well as high-intensity sonar.

vi. Plastic pollution: It involves the accumulation of plastic products and microplastics in the environment that adversely affects wildlife, wildlife habitat, or humans.

vii. Soil contamination occurs when chemicals are released by spill or underground leakage. Among the most significant soil contaminations are hydrocarbons, heavy metals, MTBE, herbicides, pesticides and chlorinated hydrocarbons.

viii. Radioactive contamination, resulting from 20th century activities in atomic physics, such as nuclear power generation and nuclear weapons research, manufacture and deployment.

ix. Thermal pollution, is a temperature change in natural water bodies caused by human influence, such as use of water as coolant in a power plant.

x. Visual pollution, which can refer to the presence of overhead power lines, motorway billboards, scarred landforms (as from strip mining), open storage of trash, municipal solid waste or space debris.

xi. Water pollution: The discharge of waste water from commercial and industrial waste (intentionally or through spills) into surface waters; discharges of untreated domestic sewage, and chemical contaminants, such as chlorine, from treated sewage; release of waste and contaminants into surface runoff flowing to surface waters (including urban runoff and agricultural runoff, which may contain chemical fertilizer and pesticides; also including human faeces from open defaecation is still a major problem in many developing country); groundwater pollution from waste disposal and leaching into the ground, including from pit latrines and septic tanks; eutrophication and littering.

(b) Cost of pollution

Pollution has a cost. Manufacturing activities that cause air pollution impose health and clean-up costs on the whole of society, whereas the neighbours of an individual who chooses to fire-proof his home may benefit from a reduced risk of a fire spreading to their own homes (Harvey et al., 2017; Jawad, Alabbasy, Salih, & Aljamali, 2013). A manufacturing activity that causes air pollution is an example of a negative externality in production. A negative externality in production occurs "when a firm's production reduces the well-being of others who are not compensated by the firm. For example, if a laundry firm exists near a polluting steel manufacturing firm, there will be increased costs for the laundry firm because of the dirt and smoke produced by the steel manufacturing firm (Kolstad, 2011).

If external costs exist, such as those created by pollution, the manufacturer will choose to produce more of the product than would be produced if the manufacturer were required to pay all associated environmental costs. Because responsibility or consequence for self-directed action lies partly outside the self, an element of externalization is involved. If there are external benefits, such as in public safety, less of the good may be produced than would be the case if the producer were to receive payment for the external benefits to others. However, goods and services that involve negative externalities in production, such as those that produce pollution, tend to be over-produced and underpriced since the externality is not being priced into the market (Kolstad, 2011).

Pollution can also create costs for the firms producing the pollution. Sometimes firms choose, or are forced by regulation, to reduce the amount of pollution that they are producing. The associated costs of doing this are called abatement costs, or marginal abatement costs if measured by each additional unit (McLaughlin, 2016). In 2005 pollution abatement capital expenditures and operating costs in the US amounted to nearly $27 billion (Akey and Appel, 2018).

2.2.4 The Concept of Environmental Pollution

Urbanization has expanded rapidly over the past two centuries globally and it has resulted in high pollution levels. Numerous fuel dispensing stations are built to serve the ever-increasing demand of consumers and are busy at all times, emitting volatile organic compounds (VOCs) that may affect the residents and workers in the environment. (Alenezi and Aldaihan, 2019).

Petroleum substances together with heavy metals are the most common soil environment pollutants (Panagiotakis and Dermatas, 2018). In the case of heavy metals, the occurrence of various metals in environment is analysed, depending on the possibility of their occurrence in the area. Literature data mainly concern the content of Cu (copper), Cr (chromium), Pb (lead), Zn (zinc), Cd (cadmium), Ni (nickel), but also Fe (iron), As (arsenic), Mn (manganese), or Ti (titanium) in soil. They are analysed both in industrial and urban areas (Caporale et al., 2018; Harvey et al., 2017). In the case of petroleum pollutants, soil is most often analysed regarding the presence of polycyclic aromatic hydrocarbons (PAHs) or in general considering the amount of total petroleum hydrocarbon (TPH) (in this case, depending on the used methodology, the range of compounds being tested is different) (Bielińska et al., 2018; Sushkova et al., 2019).

Crude oil and its derivatives appear in the environment mainly during its storage and transport. Events such as spills oil are particularly dangerous for the environment because the contaminant fills the soil pores changing its parameters, and then it can reach the groundwater level and pollute it too (Mena, et al., 2016). In addition, petroleum pollutants limit or completely block the free flow of water and air in the soil. The situation when the content of petroleum hydrocarbons in the soil is high is particularly unfavourable for the soil. Then the bacteria and fungi present in the soil consume all available nitrogen, phosphorus and oxygen (Badowska and Bandzierz, 2019).

Soil contamination is associated with its impact on the ecosystem, in the case of plants it may be associated with their growth, in the case of animals it affects t he development of diseases caused by being in a polluted environment (dos Santos and Maranho, 2018). The analyses of petroleum hydrocarbons content in soil are made mainly in places located in the vicinity of objects that affect or may have a negative impact on the soil environment. Exemplary research concerns soil from industrial areas, petrol stations, but also from farmland located near petrol activity.

Some of the analyses of soil quality in industrial areas are studies carried out in Italy in three different locations. The content of petroleum pollutants determined as THC was up to 179.33 mg/kg, however, most of the samples were below the acceptable value in Italy (50 mg/kg) (Riccardi et al., 2013). On the other hand, in areas considerably contaminated, the content of TPH in the soil can be significantly higher and equal more than 80000 mg/kg (Smith et al., 2015). The research on the total petroleum hydrocarbon content was also carried out in the Macabarie Island subantarctic area, selecting sites exposed to oil and gas (fuel farm and powerhouse). For samples from the depth of 0.5 m, the hydrocarbon content was in the range from below the level of determination to about 740 mg/kg (Errington et al., 2018). In other studies, in soil samples from the area of fuel terminal, the hydrocarbon content in the range above C12 was the 32147.85 mg/kg at 0.3 m depth, while at a depth of 2.0 m was 3938.2 mg/kg.

In the studies of soil contamination with petroleum hydrocarbons carried out in the area of petrol stations located in various places, the maximum values of total petroleum hydrocarbon in the range from 79.9 mg/kg to 956.9 mg/kg were determined. For individual locations, the maximum values were determined from various depths. In another case, soil samples originating from the areas of two fuel stations, contained 9367 mg/kg and 8075 mg/kg of petroleum hydrocarbons respectively. The research of soil samples from farmland located no more than 100 m from oil wells showed that the pollution with petroleum compounds (as a sum of n-alkanes) was below 40 mg/kg, much higher values were determined for wasteland located within a radius of 20 m from the source of pollution (even 460.79 mg/kg) (Alharbi, et al,, 2018).

The analysis of the ground environment assessment is also made in case of designation changes of the area, due to a change its development. Such tests were carried out, for instance, for the area of the railway yard designated for parking, where the petroleum hydrocarbon content was 110 mg/kg (ibid). The assessment of soil quality resulting from the occurrence of adverse events is equally important. According to the research in Louisiana, the content of petroleum pollutants in soils, in places of earlier oil spills, was for some individual locations 42.6 mg/kg, or 85 mg/kg expressed as maximum average (Badowska and Bandzierz, 2019).

In contaminated soils, the content of petroleum hydrocarbons is often analysed depending on the depth. The amount of contaminants can diverse at individual levels. In one soil sample, depending on the layer, the values can be determined in the range from 36000 mg/kg up to 140000 mg/kg (Lassalle et al., 2018).

2.2.5 The Concept of Air Pollution

Researchers and policy makers have equally argue that one of the major challenges that plague cities especially in the developing world is pollution and environmental sanitation (Adoki, 2012; Akinfolarin, Obunwo, & Boisa, 2018). As a result, the scholars have always attended to it as a major issue (Bada, Olatunde, & Oluwajana, 2013). The reason for this generated attention includes but not restricted to; the health impacts. it can cause, environmental deterioration, risk of loss of life via accidents, breeding ground for mosquitoes and rodents which in turn have severe consequence for human health (Ewona, Osang, Obi, Udoimuk, & Ushie, 2013).

On the other hand, the World Health organization (WHO), classifies air pollution among one of the leading cause of environmental risks and possible deaths. It is estimated that, about 3million deaths occur annually as a result of exposure to ambient air pollution (Ede, Obunwa, & Nlerumchi, 2010). Much recently a study identified that, about 11.6% of deaths globally is associated with air pollution; and about 94% of these deaths occurred in the developing countries (Ukemenam, 2014). This means that the dangers associated with ambient air pollution are grave. Therefore, high amounts of gases and particulate matters such as O3; NO2; SO2, H2S, CO2, PM2.5, and PM10 pollutes the atmosphere, cause harmful effects to environment & human health; and renders the environment un-safe for habitation (Tawari & Abowei, 2012).

An awareness of the dangers associated with these pollutants, results in developed countries designing environmental and social frameworks with which to cater for pollution and the citizenry (Ibe, et al, 2016). This has resulted in setting up of agencies, legal frameworks, and health schemes to cater for citizens who may be exposed to anthropogenic pollution et al., 2012). Similarly, summits, conferences, colloquy, and interactive sections are held regularly, for to inform, and sensitize the people, what the dangers of their actions would mean for the larger society (Obisesan and Weli, 2019).

Nevertheless, a large contrast is experienced in Nigeria in particular and Africa in general; where pollution is treated with lightness. Nothing serious is happening, although a lot of propaganda is being made at various media, the lack of will to-do on the part of government and populace, has left Africa an endangered zone, where large number of people are subjected to health risks resulting from anthropogenic pollution daily (Okunola, et al,, 2012). Worst still, there are very few data sources available to get information regarding pollution and deaths associated with pollution. This has left large number of the citizenry on the fence regarding the dangers of anthropogenic air pollution.

Also, the politics of air pollution is rampant; where people are treated differently due to their social, political, religious and ethnic affinities, when it comes to application of pollution laws and sanctions (Weli and Ayoade, 2014). Also land-use are not planned for or structured; in which case people are allowed to site their residential buildings around industrial ones or vice-versa. Some of these industries are not built with the health of the environment in mind. The implication of these is that, ambient air pollution problems have continued to mount unabated (Obisesan and Weli, 2019).

To improve urban air quality, policy makers express widespread interest in controlling major airborne pollutants such as PM_{10}, NO_X, NO_2, NH_3, SO_2, H_2S, O_3, CO, THC and NMHC. Oil refineries are complex process plants, which convert crude oil into variety of products. Refining operation is associated with the emission of various volatile organic compounds (VOCs) into the atmosphere, mainly originating from production processes, storage tanks, distribution terminals and wastewater treatment areas (Harrison & Hester, 2007). The transportation, distribution and marketing of refined products involve many distinct operations, each of which represents a potential source of evaporation, loss and occupational exposure problem for the workers.

The fugitive emissions from oil refineries add millions of pounds of harmful pollutants to the atmosphere each year, including over 80 million pounds of volatile organic compounds (VOCs) and over 15 million pounds of toxic pollutants (Kalabokas, Papayannis, Tsaknakis, & Ziomas, 2012). But there is a lack of data on exposure to these fugitive emissions. The atmospheric behavior of VOCs is governed to a large extent by their life time. In the process of long-range transport, BTEX are among other VOCs that react with other pollutants such as NOx and produce secondary pollutants with different reaction rates (Sushkova et al., 2019).

The wide range of VOCs released at petroleum refineries may have significant impacts on health of the workers depending on the levels of exposure. Assessment of human exposure to a complex array of such volatile compounds is a key factor in quantifying the relationship between environmental factors and human diseases. Deleterious effects on human health (Brunekreef and Holgate, 2002), injury to plants (Saitanis, Karandinos, Riga-Karadinos, Lornenzini, & Vlassi, 2003) and reduction of crop yield are known to be caused by increased levels of these pollutants.

Besides, elevated levels of VOCs and ground level O3, measured across regional air sheds are known to affect human health. In many countries across Asia, North America and Europe, the air quality has been improved over the last two decades. Air pollution continues to receive a great deal of interest worldwide due to its negative impacts on human health and welfare. Several studies reported significant correlations between air pollution and certain diseases including shortness of breath, sore throat, chest pain, nausea, asthma, bronchitis and lung cancer (Al-Salem, Al-Fadhleeb, & Khan, 2009)

2.2.6 Effect of Air Pollution by Hydrocarbon

An often-overlooked but graver danger is that posed by the fumes emitted during every opening of vehicle tanks and dispensing of fuel, and also discharging of fuel into filling station tanks (volatile organic compounds). The volatile organic compounds in petroleum motor spirit pollutes the air with attendant health effects on the environment. In areas where fuel stations are situated very close to rivers, these vapours are potential threats to aquatic life (Ogunkoya, 2016). In a study on the impact of petrol filling stations on surrounding residential buildings in Murcia, Spain, Terres et al. (2010) observed that volatile organic compounds, particularly the carcinogenic benzene, have ambient air concentrations (37.3 3 µg/m) near filling station pumps and tanks far in 3 excess of background levels (1.16 µg/m) at 100m away from the filling stati ons. Concentrations however depend on the number of petrol pumps, the frequency and volume of sales, the structure of the surroundings (whether there are tall buildings surrounding the filling station and the area closed up as to restrict pollutant dispersion), and weather conditions.

Terres et al. (2010) also noted that though Spanish petrol stations were traditionally located in largely uninhabited areas, the continuous urban growth recently experienced in the country resulted in many urban area petrol stations being surrounded by buildings. This situation has led to controversy between citizens whose houses are close to petrol filling stations and the authorities responsible for land management. The situation in Murcia, Spain where urban planning regulations subsist may pale into insignificance when compared to that at busy petrol stations along major road sections heavily populated with stations, in Nigeria.

Exposure of attendants to Premium Motor Spirit fume has been limited in the USA by the use of rubber hood over the delivery pump and use of “self-service” at stations. Although a very small percentage admitted going into the underground storage to measure the volume of Premium Motor Spirit the practice itself is extremely dangerous. The extreme heat generated in the underground facility produces more Premium Motor Spirit fumes which have little escape route. It is therefore very hazardous to enter into such enclosure. Also, In Nigeria Premium Motor Spirit at fuel stations is still largely dispensed by attendants who are exposed to the gasoline fumes for more than a typical 40- hour work week (Udonwa et al., 2010).

Epidemiological research has shown that poor air quality is a significant contributing factor to mortality and a range of cardiovascular and respiratory diseases (Heft-Neal et al., 2018). It is estimated that 3–4 million people worldwide die each year due to exposure to PM2.5 and in 2016, 95% of people worldwide lived in areas where particulates exceeded the WHO's recommended levels (Quarmby, Santos, and Mathias, 2019a) . This places poor air quality as a leading contributor to deaths worldwide, ahead of factors such as lack of exercise, poor sanitation and a low birth rate. New research also suggests that the societal harm caused by poor air quality may be subtler and pervasive than traditionally thought. Economic implications include decreased productivity, and exposure to poor air quality during early-life has been associated with decreased cognitive abilities later in life (Zivin and Neidell, 2018).

Extreme effects of air pollution include high blood pressure and Cardiovascular problems (Urch et al., 2005). Correlations between air pollution and increased morbidity and mortality rates were reported. The World Health Organization states that Ambient (outdoor air pollution) in both cities and rural areas was estimated to cause 3.7 million premature deaths worldwide in 2012 (World Health Organization, 2016). Epidemiological studies have shown a strong correlation between pneumonia related deaths and air pollution from motor vehicles in UK (Knox et al., 2013). In addition to its negative health impacts, air pollution is known to cause injuries to animals, forests and vegetation, and aquatic ecosystems. Its impacts on metals, structures, leather, rubber, and fabrics include cracks, soiling, deterioration, and erosion (Daly and Zannetti, 2007).

At present, the database for Ambient Air Quality in and around an oil refinery regarding exposures of the workers and the village inhabitants is rather sparse in the international literature. In general, a main problem in linking the environmental pollution to health effects is the current lack of data about the actual exposure to hazardous pollutants (Espejo et al., 2019).

Many attempts have been made by scientists to monitor and control such gaseous pollutants. Khan and Al-Salem (2007) have studied airborne pollutants in an urban area in Kuwait in order to assess the ambient air quality and its suitability for urban living development. With data collected for three years it was discovered that hydrogen sulfide (H_2S) was the pollutant with the major annual increase due to the abundant sources surrounding the area under investigation. Major violations against the KEPA were recorded in that study. A strict strategy was proposed to monitor urban area air quality in Kuwait, with constant monitoring tools and methods.

Khan and Al-Salem (2007) have selected three pollutants (methane (n-CH_4), benzene (C_6H_6) and NO_x) to be seasonally monitored and studied for a period of three years in an urban estate in Kuwait. The elevated temperatures and strong winds of the summer seasons over the study period affected methane levels drastically due to the increase of dust levels in the summer periods in Kuwait. Dust adsorption effect and break down of methane particles all resulted in low levels of methane gas in the summer seasons.

(a) Autism Spectrum Disorders

Austism Spectrum Disorders are a group of developmental disorders commonly characterized by problems in communication, social interaction, and repetitive behaviors or restricted interests. Although the severity of impairment for the autism spectrum disorders varies across the spectrum (full syndrome autism being the most severe), the incidence rate of all autism spectrum disorders is now reported to be as high as 1 in 110 children (Daniels and Mandell, 2014). Emerging evidence suggests that environment plays a role in autism, yet at this stage, only limited information is available as to what exposures are relevant, their mechanisms of action, the stages of development in which they act, and the development of effective preventive measures (Volk, et al., 2013).

Recently, air pollution has been examined as a potential risk factor for autism Using the Environmental Protection Agency's dispersion model estimates of ambient concentrations of hazardous air pollutants, Windham and colleagues identified an increased risk of autism based on exposure to diesel exhaust particles, metals (mercury, cadmium, and nickel), and chlorinated solvents in Northern California census tracts. Additional research using dispersion-model estimates of hazardous air pollutants also reported associations between autism and air toxics at the birth residences of children from North Carolina and West Virginia(Kalkbrenner et al., 2010)

These epidemiologic findings on autism are supported by additional research describing other physical and developmental effects of air pollution due to prenatal and early life exposure. For example, high levels of air pollutants have been associated with poor birth outcomes, immunologic changes, and decreased cognitive abilities (Currie, Neidell, & Schmieder, 2009).

Recently, an association between the risk of autism and an early life residence within 309m of a freeway in the Childhood Autism Risks from Genetics and the Environment (CHARGE) study was reported. The near-source traffic related air pollutant mixture has a large spatial variation, returning to near-background daytime levels beyond this distance. Herein, we report associations of autism with estimates of exposure to the mixture of traffic related air pollution and with regional measures of nitrogen dioxide, particulate matter less than 2.5_min aerodynamic diameter ($PM_{2.5}$), and particulate matter less than 10 _min aerodynamic diameter (PM_{10}) in the CHARGE sample (Volk et al., 2013).

2.2.7 Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic Aromatic Hydrocarbons (PAHs) are a class of chemicals that occur naturally in coal, crude oil, and gasoline. They also are produced when coal, oil, gas, wood, garbage, and tobacco are burned. PAHs generated from these sources can bind to or form small particles in the air. High-temperature cooking will form PAHs in meat and in other foods. Naphthalene is a PAH that is produced commercially in the United States to make other chemicals and mothballs. Cigarette smoke contains many PAHs. (CDC,2009). Hussein et al (2015) also explained that PAHs are ubiquitous environmental pollutants generated primarily during the incomplete combustion of organic materials (e.g. coal, oil, petrol, and wood). They are basically classified into two: low molecular weight PAHs (LPAHs) and high molecular weight PAHs (HPAHs). LPAHs (e.g. naphthalene, acenaphthene, acenaphthylene, fluorene, anthracene, phenanthrene) tend to have a core structure of two to three benzenoid rings (six-sided aromatic rings of carbon) while HPAHs have molecular structures of four or more benzenoid rings e.g. fluoranthene, pyrene, benzo[a]pyrene, and benzofluoranthenes. (Aleksandra, 2011).

Table 1: Physicochemical Properties of the 16 priority PAHs

PAHs	Chemical formula

Figure 2.1: Structure of 16 Priority PAHs (ibid)

(a) Human exposure to Polycyclic Aromatic Hydrocarbons (PAHs)

The major route of exposure to PAHs in the general population according to (Aleksandra, 2011), include breathing ambient indoor air, eating food containing PAHs, smoking cigarettes, or breathing smoke from open fireplaces, from the fossil fuels that we use to drive our cars, cook our food warm our home, and fuel our industry. Occupational exposure of workers to PAHs, e.g., during coke production, roofing using bituminous products, oil refining, and coal gasification. Occupational exposure to PAHs may also occur from workers breathing exhaust fumes such as mechanics, street vendors, or motor vehicle and those involved in mining, metal working. For smokers the contribution from smoking can be great.

Food can be contaminated from environmental sources (natural and mostly anthropogenic), from industrial food processing, and from some domestic cooking practices. PAHs can enter the food chain by deposition from air, or by deposition and transfer from soil and water (Harvey et al., 2017). He further explained that; human exposure to PAHs also occurs through inhalation of cigarette smoke, exposure to industrial emissions, automobile exhausts, hazardous waste sites, jet fuel, and burn pits, and consumption of barbecued food.

Based on the findings of Raimi et al., 2019, human beings are exposed to PAHs via air, water and contaminated food they ingest. PAHs are frequently measured in the atmosphere for air quality assessment, in biological tissues for health-effects monitoring, in sediments and molluscs for environmental monitoring, and in foodstuffs for safety reasons. Exclusive sources for Benzol(a)pyrene (BaP) contamination of the environment and exposure to humans include industrial and automobile emissions, hazardous waste sites, cigarette smoke, biomass burning, waste burning, municipal incinerators, volcanic eruptions, home heating and consumption of charcoal broiled and smoked food. Other exposure comes from tobacco smoke, Vehicular traffic,

e-waste and medical waste, etc. PAHs are widespread environmental pollutants, so widespread that it is impossible for anyone to avoid exposure to them.

Routes of exposure include ingestion, inhalation, and dermal contact in both occupational and non-occupational settings. Some exposures may simultaneously involve multiple routes such as dermal and inhalation exposures from contaminated air, affecting the total dose of absorption. (Mahgoub, 2014). More than 80% of the total PAH contribution to environmental and health concerns could be attributed to the 16 EPA priority PAHs as described by Adenji et al.,(2017)

b. Effect of PAHs Exposure

PAHs are important class of environmental contaminants because of their potential adverse health effects. They are known to have carcinogenic, mutagenic and teratogenic properties. Exposures from various occupations and high levels of pollutant mixtures containing PAHs are known to result in symptoms such as eye irritation, nausea, vomiting and diarrhoea. Mixtures of PAHs are also known to cause skin irritation and inflammation. Anthracene, Benzo(a)Pyrene, and naphthalene are direct skin irritants while anthracene and Benzo(a)Pyrene are reported to be skin sensitizers, i.e. as cause of an allergic skin response in animals and humans (Mahgoub, 2014).

A series of health problems (an increased risk of skin, lung, bladder, and gastrointestinal cancers) for workers exposed to mixtures of PAHs and other work place exposure of PAH chemicals have been reported. Also, Health effects from chronic or long-term exposure to PAHs may include decreased immune function, cataracts, kidney and liver damage (e.g. jaundice), breathing problems, asthma-like symptoms, and lung function abnormalities, and repeated contact with skin may induce redness and skin inflammation (Aleksandra, 2011; Park, 2007). PAH eg BaP and Pyrene has also been identified as the cause of cancer in laboratory animals. Repeated skin contact to the PAH naphthalene can result in redness and inflammation of the skin. DNA damage induced by PAH exposure has been demonstrated by numerous authors. Long term exposure to PAHs is suspected to raise the risks of cell damage via gene mutation and cardiopulmonary mortality (Park, 2007).

FIG. 2: Flow chart showing short and long term health effects of exposure to PAHs (Kim, Jahan, Kabir and Brown 2013).

c. Sources of PAHs

PAHs have natural as well as anthropogenic sources. Adeniji et.al reiterated that there are two major sources of PAHs which are explained below;

i. Natural sources: These include natural petroleum seeps, forest fires, prairie fires, agricultural burning and post-depositional transformation of biogenic precursors. The actual amount of PAHs and particulates emitted from these sources varies with the type of organic material burned, type of fire, nature of the blaze and intensity of the fire. PAHs from fires tend to sorb to suspended particulates and eventually enter the terrestrial and aquatic environments as atmospheric fallout. Treated wood has also been recognized as a source of PAHs in water and sediments. Other natural sources include volcanoes, chlorophyllous plants, fungi and bacteria.

ii.Anthropogenic sources: Anthropogenic sources are basically grouped as pyrolytic and petrogenic. Pyrolytic sources include combustion processes (e.g. fossil fuel combustion, electric power generation, refuse incineration, home heating and industrial emissions), while the petrogenic input is closely related to releases from petroleum products (e.g. oil spills, road construction materials such as production of coke, carbon black, coal tar, and asphalt). Anthropogenic and natural sources of PAHs in combination with global transport phenomena contributed to their worldwide distribution.

They are formed mainly as result of the burning of fossil fuels during heating processes, waste incinerators and from automobile exhausts. They are widely distributed environmental contaminants that have detrimental biological effects, toxicity, mutagenicity and carcinogenicity. PAH concentrations in the environment vary widely, depending on the proximity of the contaminated site to the production source, the level of industrial development, and the mode(s) of PAH transport. PAHs are present in high concentrations in products of fossil fuel, vehicular traffic émission and refining (Tang et al., 2015, Singh and Gupta 2016), biomass burning, charcoals, tobacco and garbage, Petroleum refining, and transport activities, are major contributors to localised loadings of PAHs into the environment. Loadings may occur through discharge of industrial effluents and through accidental release of raw and refined products.

2.2.8 Environmental pollution with petroleum and petrochemical products BTEX (benzene, toluene, ethylbenzene, and xylenes)

Environmental pollution with petroleum and petrochemical products has been recognized as a significant and serious problem (Smith and Guentzel, 2010). Contamination of aquatic ecosystems by BTEX (benzene, toluene, ethylbenzene, and xylenes) has been observed in sediment, water and aquatic flora and fauna worldwide (Smith and Guentzel, 2010). BTEX is the collective name for benzene, toluene, ethyl benzene, and xylenes, the volatile aromatic compounds often found in industrial discharges, petroleum oils and products (Anderson et al., 2007). Benzene is used in the production of synthetic materials and consumer products, such as synthetic rubber, plastics, nylon, insecticides and paints. Toluene is used as a solvent for paints, coatings, gums, oils, and resins. Ethylbenzene is a gasoline and aviation fuel additive. They are also used extensively in manufacturing processes (Baker et al., 2001).

Ethylbenzene may be present in consumer products such as paints, inks, plastics, and pesticides. Xylenes are used as a solvent in printing, rubber, and leather industries. The behavior of the four compounds is somewhat similar when released to the environment and thus they are usually considered as a group. The main source of BTEX contamination is the leakage of gasoline from faulty and poorly maintained underground storage tanks. Other sources of BTEX contamination are releases from large bulk facilities, surface spills, and pipeline leaks. Exposure to BTEX can occur by ingestion, inhalation, and absorption through the skin. Toxicity testing for BTEX compounds has also been conducted on aquatic organisms. Typically water concentrations in excess of 1 mg/L are required to produce acute toxic effects in organisms such as algae, daphnids and fish (Ameh et al., 2013). Of the four BTEX compounds, benzene is the most toxic. Benzene increases the risk of cancer and other illnesses (Dougherty et al., 2008).

Toluene is readily absorbed from the gastrointestinal tract after ingestion, and is distributed preferentially in adipose tissue, then the kidneys, liver and brain. The main effect of toluene is on the brain and nervous system, with fatigue and drowsiness being the most obvious symptoms (Ameh et al., 2011). The EPA considers that there is inadequate information to assess the carcinogenic potential of toluene (US EPA 2005). Toluene, Ethyl benzene and xylene have harmful effects on the nervous system (USGS 2006).

A considerable amount of gasoline enters the environment as result of leak age from underground storage tanks, accidental spills, or improper waste disposal practices (Bowlen and Kasson, 1995). When gasoline is in contact with water, benzene, toluene, ethylbenzene and the xylene isomers (BTEX) account for as much as 90% of the gasoline components that are found in the water-soluble fraction (Saeed and Al-Mutairi, 1999). Consequently, these chemicals are some of the most common contaminants found in drinking water. BTEX are toxic to humans and their removal from polluted environments is of special interest (Mehlman, 1992). BTEX is not one chemical, but are a group of the following chemical compounds: Benzene, Toluene, Ethylbenzene and Xylenes. BTEX are made up of naturally-occurring chemicals that are found mainly in petroleum products such as gasoline. Besides gasoline, BTEX can be found in many of the common household products we use every day. BTEX are in a class of chemicals known as Volatile Organic Compounds (VOCs).

b. Impact of Exposure of Petrol Station Attendants to Petrol fumes

(Alam et al., 2014 explained that 'Petroleum Filling Station (PFSs) as a sensitive facility which contains flammable substance may lead to disastrous consequence to its site and surroundings. Ground water and surface water contamination; open fire and explosion; VOC (Volatile Organic Compound) emission; and traffic obstruction are potential hazards which may occur on site and give impact to surroundings due to accident or carelessness'

No alternative to petrol (premium motor spirit, PMS) has been introduced into the Nigerian automobile industry. Therefore, millions of automobiles on Nigerian roads run on Premium Motor Spirit or diesel fuel. Premium Motor Spirit contains volatile organic compound (VOC) such as benzene which is limited by regulation to 6–8% of the content of Premium Motor Spirit in Nigeria (Rowat, 1998) and between 1% (v/v) to 5% in the USA and Europe (Wallace, 1996). Nitrobenzene is largely used in the manufacture of aniline and for the production of lubricating oils used in automobiles and machineries among other uses. Few studies have reported haematological disorders associated with the exposure to benzene in the environment in less developed countries.

Gupta and Dogra (2002) made it known that some of the group of people that have a greater risk of exposure to gasoline vapors are the filling station workers, the service station attendants, drivers of gasoline trucks, and refinery workers. The volatile nature of petrol products makes them readily available in the atmosphere any time it is dispensed, especially at petrol filling stations and depots. Rekhadevi et al. (2010) also affirmed that. filling station attendants are exposed to a mixture of hydrocarbons in fuel vapours when they are dispensing fuel and to the gases from vehicular exhaust.

However, there is evidence about health effects linked with low dose exposures to volatile organics including benzene in Premium Motor Spirit. It is acutely toxic by inhalation, causing mucous membrane irritation, neurological and other symptoms due to respiratory failure. Chronic exposure has been reported to result in bone marrow depression, aplasia and leukaemia, cardiac abnormalities, heart attack, and other cancers of the lung, brain and stomach. Following inhalation, benzene vapour is rapidly absorbed into the blood and distributed throughout the body (Romieu, Ramirez and Menses (1999).

One of the effects of benzene in the body is the production of methaemoglobin (MetHb) which differs from haemoglobin. Haemoglobin accepts and transports oxygen only when the iron atom is in its ferrous form. When haemoglobin becomes oxidized, iron is converted to the ferric state (Fe^{3+}) or MetHb. MetHb lacks the electron that is needed to form a bond with oxygen and, thus, is incapable of oxygen transport. Since red blood cells are continuously exposed to various oxidant stresses, blood normally contains MetHb levels of between 1 and 3%. Considering that MetHb has little affinity for oxygen, transport of the later to cells is hindered resulting in functional anaemia. As the level of MetHb increases, symptoms like shortness of breath, palpitation, fatigue, loss of consciousness, anxiety and confusion occur. Humans are commonly exposed to benzene and other VOCs through the pulmonary and dermal pathways. (Alana., 2017).

Exposure assessment studies have indicated that important microenvironments for benzene exposure are those associated with petrol use: driving, working at or visiting a service station, having an attachment to an automobile mechanic (AM) workshop, and living close to waste sites of petroleum refinery or chemical manufacturing plants. Benzene uptake and distribution have been investigated relying on unmetabolised benzene in exhaled air (breath), blood, and urine, as well as benzene metabolites in urine among occupationally exposed workers (Sherwood and Carter, 1970).

The other way is to use blood MetHb concentration to assess exposure and for risk assessment in order to provide information on the internal dose received by individuals. In turn, this dose can be related to health outcomes. In studying the acute toxicological effects of diesel and crude oil, that also contain benzene, in experimental animals an increase in dose of the fuel administered into the animals caused a dose dependent decrease in haemoglobin (Hb) and packed cell volume (PCV). The observed linear reductions in haematological parameters demonstrated and suggested an anaemic condition in the animals (Ovuru and Ekweozor, 2004).

Automobile Mechanics (AM) and Petrol Station Attendants (PSA) is commonly found in Nigeria. The AM does routine maintenance and repair of motor vehicles while the PSA dispenses Premium Motor Spirit and other petrochemical products at automobile re-fueling stations. In Nigeria Automobile Mechanics are commonly exposed to Premium Motor Spirit by sucking with their mouth through a tube in an attempt to siphon Premium Motor Spirit from the vehicle tank.

They also often wash vehicle parts with Premium Motor Spirit without any gloves. Petrol Station Attendants practice dispensing the fuel into vehicles without using any protective device to minimize their exposure. In the process the AM and the Petrol Station Attendants inhale the Premium Motor Spirit fume. Therefore, automobile re-fueling and repairs are reasonable sources of benzene exposure among Petrol Station Attendants and Automobile Mechanics in Nigeria. This raises serious public health concern. These classes of workers are seldom subjected to pre-employment medical examination or provided with regular medical checkups to detect potential serious risk the exposure may have.

2.2.9 The concept of water pollution

Many areas in the world are facing water shortages due to the scarcity of water resources in addition to the increase in the population (Gleick, 1993). Rivers are very important freshwater ecosystems with essential importance for life maintenance. They provide numerous benefits for the people, some of which are irreplaceable, such as: water supply for households, industry and agricultural purposes, hydropower, navigation, recreation and spiritual fulfillment (Ramirez et al., 2012). Due to the fact that water quality and human health are tightly interconnected, the analysis of water before its usage has primary importance. There are some physical, chemical and microbiological parameters, which are used as standards for determination of the quality of water.

Rapid urbanization in coastal zones can result in increased emissions of nutrients, such as phosphorus (P) and nitrogen (N), into the surrounding environment. Pollutants (mainly N and P) in urban areas can be washed away by storm runoff, flow into natural water bodies and, ultimately, cause the eutrophication of lakes, rivers, and coastal waters, and meanwhile they are a threat to ecosystem security. Urban storm runoff is the main driving force for the migration and conversion of nutrients in urban areas. Nutrients, especially those containing N and P, exist widely in the natural environment (Brack et al., 2017).

Moreover, industrial and agricultural activities also emit a large amount of nutrient salts into the surrounding environment (in which the nutrient salts released into the atmosphere play an important role in the formation of aerosols) and cause pollution. The nutrient salts accumulate in soil and water bodies and on the rough earth surface via pollutant emission and atmospheric dry deposition, etc., during non-rainy days. During rainfall events, aerosol particles get into cloud droplets through working as cloud nuclei, then the falling rain droplet particles collide with aerosol particles through Brownian diffusion, interception, impaction, and turbulent diffusion. Finally, the nutrient salts are discharged into the surrounding coastal environment by leaching and wash off via surface flow and sewage system. (Seinfeld and Pandis, 2016).

In urban areas, the surface runoff is generated and polluted on the ground and then flows into the municipal drainage system during rainfall events, and is finally discharged into natural waterbodies. Many studies have focused on the investigation of the formation and characteristics of nutrient loads on various surfaces, such as roofs and roads, in urban areas (Chislock, et al. 2010).

Studies on the re-mobilization of sediments in stream and river channels have indicated that the initial scouring effect plays an important role in the formation of polluted surface runoff. To quantify the impact of polluted urban surface runoff on waterbodies, many empirical or conceptual process models (e.g., SWMM (Storm Water Management Model) and HSPF (Hydrological Simulation Program-Fortran)) have been developed to simulate the wash-off process of accumulated pollutants, and the transport and conversion processes of the polluted runoff in municipal sewage systems and in river channels (Bertrand-Krajewski, et al., 2000).

The suitability of integrating deterministic models to estimate the relative contributions of atmospheric dry and wet deposition onto an urban surface was investigated and the subsequent volumes removed by stormwater runoff (Burian and Pomeroy, 2010). Bergman,et al., 1986 modeled pollutant loads during storm events in the South Prong watershed, USA, using HSPF and found that the prediction error of TSS (total suspended solids) and TP (total phosphorus) was 3% and 24%, respectively. (Zafra, et al., 2011) studied pollution fluxes during rainy weather in a combined sewer system catchment in Santander, Spain, using SWMM, and indicated that the accuracy of the total simulated loads of SS (suspended solids), COD (chemical oxygen demand) and TKN (total Kjeldahl nitrogen) at the end of the rainfall events were 93%, 95%, and 78%, respectively.

Moreover, the loads emitted during the first-flush events were determined to account for 65%, 57%, and 54% of the total polluting loads of COD, SS, and TKN, respectively. In coastal cities, pollutants in storm runoff will eventually be transported into the natural waterbodies such as sea, rivers, and lakes, and will result in the deterioration of water quality (Josefson and Rasmussen, 2000)

Storm runoff contains many kinds of pollutants (e.g., N, P, heavy metals, petroleum hydrocarbons, etc.). The increase of nutrient concentrations (mainly N and P) which are caused by the polluted surface runoff can easily lead to a red tide breakout under appropriate weather and environmental conditions. It should be noted that storm runoff not only conveys nutrient salts to the coastal waters, but also contains toxic pollutants (e.g., heavy metals, organo-chlorine pesticide, polycyclic aromatic hydrocarbons, etc.) that can inhibit algal growth but are low in concentrations. After the dilution by coastal waters, the toxic pollutants in urban storm runoff pose an even more subtle influence on inhibiting algal growth (Villarino et al., 2015).

the annual loads of C, N, P, silicate, TSS and their yields in six watersheds of the Mississippi River Basin, USA, using water quality and water discharge records from 1973 to 1994 were studied. They found that the increase of inorganic nitrogen and bio-available phosphate resulted in algae blooms in the northern Gulf of Mexico. The results suggested a strong relationship between land use and land cover on turbidity, along with higher concentrations of N and fecal coliforms. This demonstrated that storm runoff during the rainy season conveyed more organic material into the sea and led to the deterioration of seawater quality (Rabalais, et al., 2009).

The impact of intense rains and flooding on the input of mercury into the coastal zone of the southern Baltic region was investigated and found that the decreased retention of mercury during intense rainfalls demonstrated mercury elution from the catchment. Meanwhile, floods, melting snow, and development of urban infrastructure and farmlands increases also have a tremendous impact on the outflow of mercury from the catchment. Also, coastal and offshore areas were vulnerable to freshwater-transported nutrients, consistent with terrestrial hydro morphology and sea surface-water circulation. (Saniewska et al., 2014)

In recent decades, many marine ecological dynamic models have been developed to simulate, predict, and manage the coastal zone environment. For example, USEPA (United States Environmental Protection Agency) recommends the use of WASP (Water Quality Analysis Simulation Program) and MIKE (developed by DHI (Dansk Hydraulisk Institut)) to model the variation of water quality in coastal zones. The models have been successfully applied to simulate the eutrophication of estuary water bodies in many areas, such as Chesapeake Bay and the river mouth of the Neuse River (Zhao et al., 2013). With the help of these prediction models, many studies have indicated that storm runoff contributed 55% of the total pollutant loads in coastal zones in the USA and investigations in Europe have also provided similar conclusions.

Based on the foregoing studies, it is evident that many investigations took into account storm runoff pollution in coastal urban areas using various methods. The formation mechanisms of storm runoff pollution and their characteristics have been studied extensively. Meanwhile, many computer models based on hydrological, physical, and chemical processes are being developed to analyze the spatial-temporal variation of pollutant outputs at basin scale (Zhao et al., 2013).

Furthermore, studies on eutrophication in coastal zones have mainly focused on the variation of the flux of nutrients, their transport and conversion mechanisms, and the relationship between algal growth and environmental factors. However, the effect of nutrients (mainly N and P) carried by the storm-generated surface runoff on the variation of eutrophication (reflected by the concentration of chlorophyll-A) in coastal zones has not yet been the subject of much research attention, and the spatial and temporal variation of algae proliferation after a single storm event in offshore areas remains unclear (Zhao et al., 2013).

(a) Effect of Polluted Water on Human Health

Petroleum products are a complex mixture of hydrocarbons, consisting of both aromatic and long- and short-chain aliphatic hydrocarbons. Components of crude and refined petroleum, namely volatile organic compounds (VOCs), such as benzene, toluene and xylenes, and polycyclic aromatic hydrocarbons (PAHs), have independently been associated with adverse human health effects. Acute exposures to high concentrations of VOCs cause central nervous system toxicity, resulting in symptoms such as headaches, fatigue and dizziness (Kponee, et al.,2015).

Chronic exposure to VOCs can impair the immune system via oxidative stress and decreases in white blood cell count (Bahadar, et al. 2014). Benzene in particular is strongly associated with disorders of the hematopoietic system such as aplastic anemia. Benzene is also classified as a known human carcinogen based on occupational studies in humans. Polycyclic Aromatic Hydrocarbons cause symptoms such as nausea, vomiting and skin and eye irritation following acute, high-level exposures (Kim, et al., 2013).

Exposures to PAHs during pregnancy have been linked to decreased birth weight and impaired development in offspring (ibid). Chronic occupational exposures are associated with dose-dependent increased risks of certain types of cancers, including lung, skin and bladder cancer (Sudakin, et al., 2011). Naphthalene, can adversely affect the hematopoietic system, damaging and killing red blood cells, causing symptoms such as shortness of breath and fatigue. Alkylated PAHs comprise the majority of PAHs detected in petroleum products and are particularly persistent. Although the health effects of alkylated PAHs have not been well studied, limited evidence suggests that they may be more toxic and carcinogenic than their parent PAH compounds (ibid).

Prior research has primarily focused on high-dose, short-term occupational exposures to crude oil, in particular those occurring during remediation of oil spills. Workers exposed to petroleum hydrocarbons have reported adverse health symptoms such as headaches, eye and skin irritation and respiratory difficulties (Kponee, et al., 2015).

A recent cross-sectional study found that blood samples of oil spill workers showed alterations consistent with impairment of the hepatic and hematopoietic systems. Research on the Prestige oil spill has provided preliminary evidence of exposure-dependent DNA damage in cleanup volunteers. Few studies have examined adverse effects associated with chronic exposure to elevated concentrations of refined oil products in the general population. Increases in depression and stress, stemming from perceived health risks and financial concerns, have been observed in communities subjected to chronic oil spill exposures (ibid).

One study found increases in cancer incidence and mortality in communities near the Amazon basin oil fields in Ecuador. A thorough search of the scientific literature revealed only one health study conducted in the Niger Delta region, which reported higher rates of respiratory and skin disorders in Eleme compared to a less-industrialized Nigerian community. However, this study does not include a description of the sampling design and locations, among other study weaknesses, and is therefore not suitable for reaching conclusions regarding any association between petroleum exposure and adverse health outcomes. Further research on chronic, high-magnitude exposures in individuals living in proximity to oil sites is needed to improve understanding of how oil spills might affect human health (Kponee, et al., 2015).

2.2.10 Environmental and Health Impact of Petroleum Products

Petroleum is a complex mixture of many components. These components include straight chained, branched, cyclic, monocyclic aromatic and polycyclic aromatic hydrocarbons. The toxicity of oils can be understood using the toxic potential or the toxicity of each individual component of oil at the water solubility of that component (Di Toro et al., 2007). There are many methods that can be used to measure the toxicity of crude oil and other petroleum related products. Certain studies analyzing levels of toxicity can use the target lipid model or colorimetric analysis using colored-dyes in order to assess toxicity and biodegradability. Different oils and petroleum-related products have different levels of toxicity. Levels of toxicity are influenced by many factors such as weathering, solubility, as well as chemical properties such as persistence. Increased weathering tends to decrease levels of toxicity as more soluble and lower molecular weight substances are removed. Highly soluble substances tend to have higher levels of toxicity than substances that are not very soluble in water (Montagnolli et al., 2015). Generally, oils that have longer carbon chains and with more benzene rings have higher levels of toxicity. Benzene is the petroleum-related product with the highest level of toxicity. Other substances other than benzene which are highly toxic are toluene, methylbenzene and xylenes (BTEX). Substances with the lowest toxicity are crude oil and motor oil (Montagnolli et al., 2015).

Despite varying levels of toxicity amongst different variants of oil, all petroleum -derived products have adverse impacts on human health and the ecosystem. Examples of adverse effects are oil emulsions in digestive systems in certain mammals might result in decreased ability to digest nutrients that might lead to death of certain mammals. Further symptoms include capillary ruptures and hemorrhages. Ecosystem food chains can be affected due to a decrease in algae productivity therefore threatening certain species. Oil is "acutely lethal" to fish - that is, it kills fish quickly, at a concentration of 4000 parts per million (ppm) (0.4%). The toxicity of petroleum related products threaten human health. Many compounds found in oil are highly toxic and can cause cancer (carcinogenic) as well as other diseases. Studies in Taiwan link proximity to oil refineries to premature births. Crude oil and petroleum distillates cause birth defects (Lin et al., 2001).

Benzene is present in both crude oil and gasoline and is known to cause leukaemia in humans. The compound is also known to lower the white blood cell count in humans, which would leave people exposed to it more susceptible to infections. Studies have linked benzene exposure in the mere parts per billion (ppb) range to terminal leukemia, Hodgkin's lymphoma, and other blood and immune system diseases within 5-15 years of exposure (Kirkeleit et al., 2015). Emissions from the petroleum industry occur in every chain of the oil-producing process from the extraction to the consumption phase. In the extraction phase there are emissions of not only carbon dioxide but various other pollutants like nitrous oxides and aerosols. Certain by-products include carbon monoxide and methanol. When oil or petroleum distillates are combusted, usually the combustion is not complete and the chemical reaction leaves by-products which are not water or carbon dioxide. However, despite the large amounts of pollutants, there is uncertainty about the amount and concentration of certain pollutants (Tuccella et al., 2017).

In the refinement stages, petroleum also contributes to large amounts of pollution in urban areas. This increase in pollution has adverse effects on human health due to the toxicity of oil. A study investigating the effects of oil refineries in Taiwan. The study found an increased occurrence of premature births in mothers that lived in close proximity to oil refineries than mothers who lived away from oil refineries. There were also differences observed in sex ratios and the birth weight of the children. Also, fine particulates of soot blacken humans' and other animals' lungs and cause heart problems or death. Soot is cancer causing (carcinogenic) (Di Toro et al., 2007). The combustion process of petroleum, coal, and wood is responsible for increased occurrence of acid rain. Combustion causes an increased amount of nitrous oxide s, along with sulfur dioxide from the sulfur in the oil. These by-products combine with water in the atmosphere to create acid rain. The increased concentrations of nitrates and other acidic substances have significant effects on the pH levels of rainfall. Data samples analyzed from the United States and Europe from the past 100 years and showed an increase in nitrous oxide emissions from combustion. The emissions were large enough to acidify the rainfall.

The acid rain has adverse impacts on the larger ecosystem. For example, acid rain can kill trees, acidified lakes and kill fish. Coral reefs are also destroyed from the acidified rainfall of acid rain. Acid rain also leads to the corrosion of machinery and structures (large amounts of capital) and to the slow destruction of archeological structures like the marble ruins of Rome and Greece (Brimblecombe and Stedman, 1982). The combustion of petroleum causes an increased amount of carbon dioxide emissions as well as other greenhouse gases. The first study on the effects of carbon dioxide was studied by Swedish Nobel chemist Svante Arrhenius (Ramanathan and Feng, 2009). His mathematical model showed that an increase of carbon dioxide results in an increase in surface temperatures, therefore both factors are correlated. The combustion of petroleum for transport, industrial and domestic use is one of the major forms of air pollution. The ultimate by-product of oil combustion is carbon dioxide, however, there are other by-products such as carbon monoxide and nitrates. These by-products react with the atmosphere to produce ozone and other greenhouse gases. The increased pollution has consequences on global temperature. The atmosphere reflects 30% of the incoming longwave radiation back and keeps 70% of it for warmth. However, an increased carbon dioxide concentration in the atmosphere acts as a "blanket" to increased heat. Therefore, more longwave radiation is trapped in the atmosphere when there is a higher concentration of carbon dioxide and this trapping results in increased surface temperatures (Ramanathan and Feng, 2009). Waste oil is oil containing not only breakdown products but also impurities from use. Some examples of waste oil are used oils such as hydraulic oil, transmission oil, brake fluids, motor oil, crankcase oil, gear box oil and synthetic oil. Many of the same problems associated with natural petroleum exist with waste oil. When waste oil from vehicles drips out engines over streets and roads, the oil travels into the water table bringing with it such toxins as benzene. This poisons both soil and drinking water. Runoff from storms carries waste oil into rivers and oceans, poisoning them as well.

The impact of hydrocarbons on human health depends somewhat on whether exposure was from ingestion, inhalation, or dermal (skin) contact and on whether the exposure was acute (short-term) or chronic (long-term). The acute effects of ingestion may include irritation to the mouth, throat, and stomach, and digestive disorders and/or damage. Small amounts of hydrocarbon can be drawn into the lungs, either from swallowing or vomiting, and may cause respiratory impact. The chronic effects of ingestion may include kidney, liver, or gastrointestinal tract damage, or abnormal heart rhythms. Prolonged and/or repeated exposure to aromatics like benzene may cause damage to the blood-producing system and serious blood disorders, including leukaemia (Robert, 1993). A number of PAHs have been linked to cancer of the skin, lung, and other sites on the body. Most human exposure to PAHs comes from nonpetroleum sources, including cigarette smoke, fossil fuel combustion products, and food. The acute symptoms of HC exposure by inhalation may include irritation of the nose, throat, and lungs, headaches and dizziness, anaesthetic effects, and other central nervous system depression effects. Chronic effects of inhalation exposure to HCs containing high concentrations of aromatic compounds, including gasoline, can be weight loss from loss of appetite, muscular weakness and cramps, and possible liver and renal damage. Exposure of eyes and skin to HCs may result in irritation, mechanical or chemical damage to eye tissue, or dermatitis. Exposure to petrochemicals, particularly polycyclic aromatic HCs, increases susceptibility to skin infections, including skin cancer when there is simultaneous exposure to sunlight. One potential source of HC exposure to humans is ingestion of HC-contaminated food, particularly seafood. Studies have shown that most organisms cleanse themselves of HCs within a matter of weeks after being removed from the source of contamination. This cleansing time, however, depends upon the contaminated organism (Pathak and Mandalia, 2012).

2.2.11 Environmental Legislation and International Environmental Law on petroleum issues in Nigeria

Advances in the development of petroleum resources has contributed enormously to the global energy demand and economic development over the past decades, however, it has left profound negative impacts on the natural environment as well as adverse human health effects in most oil–producing host communities around the world. Over the past fifty–five years, the oil–producing host communities in the Nigeria's Niger Delta region has experienced a wide range of environmental pollution, degradation, human health risks and socio–economic problems as a result of activities associated with petroleum exploration, development and production (Ite and Ibok, 2013). In addition, the inability of the political elite to effectively manage petroleum–derived revenue, loss of petroleum resource revenues to corruption and ineffective government's petroleum development policies has equally contributed to degradation of the Niger Delta environment over the years. According to Ite et al. (2013), discharges of petroleum hydrocarbon and chemical–derived waste streams associated with petroleum exploration and production have caused environmental pollution, adverse environmental and/or human health effects, negative impacts on the terrestrial ecosystems, detrimental impacts on regional economy, socio–economic problems and degradation of oil–producing host communities in the Niger Delta region. Apart from other anthropogenic sources of petroleum pollutants, some of the major environmental consequences associated with petroleum exploration and production operations include:

(i) atmospheric pollution associated with natural gas flaring and venting which may contribute to global climate change,

(ii) pollution of marine ecosystem which often result in adverse impacts on wildlife and negative impact on tourism, fishing and other related businesses, and

(iii)) controlled water (surface and ground water) sources and soil pollution (Ogri, 2001).

The inadvertent release of petroleum hydrocarbons into the environment, whether accidentally or through anthropogenic activities, is a major cause of environmental pollution that poses threats to human health, safety and often result in several socio–economic consequences in the impacted areas. According to Ite and Semple (2012), polycyclic aromatic hydrocarbons (PAHs) containing from two to five fused aromatic rings are of serious concern because they persist in nature due to their lipophilic character and electrochemical stability. PAHs are relatively recalcitrant in soils and some PAHs have been identified as carcinogens, mutagens, or teratogens. Acute and chronic toxicity of PAHs demonstrates the potential deleterious effects and negative impacts of petroleum derived chemical wastes on the temperate and tropical marine environment. Evidence from the Prestige oil spill suggests that human population exposed to volatile organic compounds (VOCs), toxic air emissions and persistent organic pollutants associated with oil spillage may experience long term respiratory problems, chromosomal damage and various health problems (Holdway, 2002). Although oil spills in the Niger Delta region of Nigeria may be regional in scale, soils and sediments have become the ultimate sink for most petroleum contaminants around the world due anthropogenic activities as well as few contributions associated with natural sources. Petroleum contamination of the environment is a global concern because of the toxicity of the hydrocarbons and refractory character of the aromatic components in the absence of oxygen (Ite and Semple, 2012). Although PAHs are a widespread class of environmental chemical contaminants which make up about 5% by volume, aliphatic hydrocarbons that constitute the bulk of crude oil and aromatic hydrocarbons are significant petroleum contaminants in the Nigeria’s Niger Delta region (Block et al., 1991).

Consequently, the Niger Delta region is often characterized by widespread problem of petroleum hydrocarbon pollution and noncompliance with best practices to support sustainable development goals by the multinational oil companies and/or oil and gas service companies in Nigeria. For example, the Chevron North Apoi Gas Rig (located in Southern Ijaw in Bayelsa State) blowout occurred on 16th January 2012 and the explosion resulted in huge gas fire as well as accidental spillage which lasted for 46 days, causing severe damage to the environment. From the estimates, over 2,567,966 barrels of crude oil have been spilled in 5733 incidents in the Niger Delta from 1976–2000 and about 549,060 barrels were recovered while 1,820,411 barrels were lost to the environment. Over the years, the Niger Delta has experienced a number of petroleum–related incidents or disasters which often influence the nature of the relationship between oil–producing host communities, multinational oil companies and the Nigerian government. Petroleum–related matters fall strictly under the control of the Federal Government and it has been observed that both the Nigerian government and multinational oil companies operating in the Niger Delta region have done too little to redress unsustainable practices and petroleum contamination of the environment (Ogri, 2001). The ineffective and/or unsustainable environmental management practices by the petroleum industries and the failure of Nigeria's environmental regulations have contributed to the environmental pollution with direct consequences on the ecosystem, human health, the regional populations' socio–cultural and socio–economic wellbeing. It is known that petroleum–related environmental pollution, adverse human health risks and socio–economic problems associated with activities of petroleum industries around the world depend on the geological and geographical setting of the oil–rich host communities, stages of exploration, development and production processing, demography and socio–economic activities of the regional population, cultural heritage, corporate governance systems and political economy (Ite et al., 2016).

However, some of the multinational oil companies operating in the Niger Delta region have failed to adopt best practices for sustainable development, risks mitigation and compliance with environmental regulations. For the past fifty–five years, successive governments have not been able to properly addressed and effectively manage the environmental pollution, socio–economic problems and devastating effects on wild life and its habitats associated with both onshore and offshore petroleum exploration and production operations in the Niger Delta region (Aghalino and Eyinla, 2016; Ebeku, 2003). A general survey of national and international laws/legal framework reveals that there were few provisions governing best practices for sustainable development of petroleum resources in Nigeria's Niger Delta. The legislative and institutional framework regulating Nigeria petroleum industry run the gamut of laws applicable in the federation and these include the Constitution of the Federal Republic of Nigeria, all the international and regional treaties in force in the country, all the laws made by the government of the federating states, the local governments, as well as the common laws and case laws.

(a) The Nigerian Constitution

The Constitution of the Federal Republic of Nigeria (CFRN) contains the fundamental principles that comprehensively describe the organizational framework of the state (supreme law), the limitations on the exercise of state authority and it also defines the relationship among different kinds of laws that have binding force on the authorities and persons throughout the country. Over the past decades, Nigeria has had nine constitutions viz the Clifford Constitution of 1922, the Richards Constitution of 1946, the Macpherson Constitution of 1951, the Lyttelton Constitution of 1954, the Independence Constitution of 1960, the Republican Constitution of 1963, the 1979 Constitution, the 1989 Constitution, and the extant 1999 Constitution. The Nigerian environmental objectives are enshrined in Chapter 2 of the 1999 operative Constitution of the Federal Republic of Nigeria and section 20 implicates the 'right' to a healthy environment. Pursuant to Section 20 of Chapter 2 of the 1999 Constitution of the Federal Republic of Nigeria, the State has obligation to protect and improve the environment and safeguard the water, air and land, forest and wildlife of Nigeria (Federal Republic of Nigeria, 1999; Premoboere and Raimi, 2018).

However, this afore–stated provision has one serious defect with regards to the very broad wording of the section and the relevant provision falls under Chapter 2 of the 1999 Nigerian Constitution, which is non-justiciable and as such, the provision lacks judicial enforcement in Nigeria. According to Fagbohun (2002), the provision under the Nigerian environmental objectives attempts to justify a possible agreement between two extreme positions formulated by a system that is not ready to initiate any serious environmental change the thrust of which may affect its economic direction and long–term development goals. Although Section 20 of Chapter 2 of the 1999 Nigerian Constitution has resulted in a legal mirage, the Federal Government of Nigeria has promulgated various laws and regulations to protect the Nigerian environment. In accordance with Section 4(5) of the 1999 Nigerian Constitution, the State components are permitted to enact laws under the concurrent and residual legislative lists, subject to Federal Government Law made by the National Assembly. The 1999 Constitution of the Federal Republic of Nigeria lacked a specific provision on the environmental protection and Nigeria operates a dualist system wherein other regional or international environmental laws cannot be enforced (Federal Republic of Nigeria, 1999; Premoboere and Raimi, 2018). Unless incorporated into through domestic legislation or ratification by the National Assembly. In line with Agenda 21 of the United Nations, Nigeria in its National Policy on the Environment has identified establishment, strengthened legal, institutional and regulatory framework as part of its holistic strategy for implementation of sustainable development (United Nations, 1993).

(b) Environmental Regulation of Petroleum Exploration and Production in Nigeria

There are several approaches, statutory and legal instruments directed at protecting the environment and ensuring environmental objectives within the petroleum industry at the national level. However, early legislations were not environmental–oriented and the Federal Government of Nigeria did not have any legislations or legal instruments, either general or specific, on the petroleum sector for much of the first half of the century. According to Ogbodo (2009), the Federal Government of Nigeria responded to most environmental problems on an ad hoc basis following the discovery of toxic waste dumped in Koko, at remote part of southern Nigeria, in June 1988. The Nigerian government reacted to the sustained media attention and public outcry to handle the situation and subsequently, many approaches have been developed for the protection and management of the environmental impacts and human health risks associated with oil and natural gas exploration and production operations in the Niger Delta. Over the past years, the Federal Government of Nigeria has promulgated laws and regulations so that petroleum resources exploration and production, on both onshore and offshore oilfields, could be controlled by systems of legislations which aim at minimizing the associated environmental impacts and human health risks. According to Ite et al. (2013) and Premoboere and Raimi, (2018), some of the most important and essential petroleum related environmental laws and principal regulations governing the oil and gas sector in Nigeria include the following:

i. **Mineral Oils (Safety) Regulations, 1963;**
ii. **Oil Pipelines Act 1956 (amended in 1965);**
iii. **Oil in Navigable Waters Acts, 1968;**
iv. **Petroleum (Drilling and Production) Regulations, 1969;**
v. **Petroleum Decree (Acts), 1969;**
vi. **Petroleum (Drilling & Production Amendment) Regulations, 1973;**

vii. Petroleum Refining Regulation, 1974;

viii. Associated Gas Re–injection Act, 1979;

ix. The Federal Environmental Protection Agency (FEPA) Act, 1988;

x. The National Policy on the Environment, 1989 (revised in 1999);

xi. National Environmental Protection (Effluent Limitations) Regulations, 1991;

xii. Environmental Protection (Pollution Abatement in Industries Generating Wastes) Regulations, 1991;

xiii. Environmental Impact Assessment (EIA) Act, 1992, and

xiv. Department of Petroleum Resources (DPR) Environmental Guidelines and Standard for the Petroleum Industry in Nigeria (EGASPIN), 2002.

The provisions of these legal instruments has given the relevant government authorities and/or government agencies obligations to provide subsidiary instruments in order to ensure that the relevant environmental objectives become operational and binding in the course of petroleum exploration and production in the Nigeria's Niger Delta region. Currently, the Environmental Impact Assessment (EIA) is a framework that provides prior assessment of potential impact of development activity on the environment and the Section 2 of the 1992 EIA Act obliged the public or private sector of the economy to not undertake or embark on authorized projects or activities without prior consideration of the effect of such projects on the environment (Ite et al., 2016).

The emergence of EIA Decree was a fundamental legal development in terms of enhancing environmental protection efforts and the goal of sustainable development is embedded in the EIA Act. Although the EIA procedures have some jurisdictional flaws, its full implementation is aimed at improving the physical, biological and socio–economic conditions for all citizens living in Niger delta region of Nigeria. Therefore, these environmental and petroleum–related legal instruments and/or policies give specific authority and/or relevant governmental agencies power needed to ensure protection of the environment with regards to sustainable petroleum exploration and production in the Niger Delta region. The Department of Petroleum Resources (DPR) administers oil and gas laws in Nigeria as well as legislative instruments that are meant to ensure that oil and gas companies carry out petroleum resources exploration and production in line with best practices for sustainable development. Although most of the statutory laws and regulations provide the legal framework for petroleum exploration and exploitation, only some of them give guidelines on issues of environmental pollution.

However, numerous environmental agencies in Nigeria have regulations that affect the exploration, development and production processes in the oil and gas industry. Despite the putative environmental policy framework, successive Nigerian governments have fail to effectively implement either the National Policy on Environment (NPE) that ensures sustainable development or any of the related environmental policies and/or legislative instruments aimed at reducing negative impacts of energy production and use on the environment (Ite et al., 2016).

2.2.12 Planning Criteria for Location of Petroleum Filling Stations (PFS) in Nigeria

The Department of Petroleum resources (DPR, 2010) stated that PFSs should be located within a growth centre or an urban area except in circumstances where it can be shown through appropriate studies that the need exists or otherwise. The criteria for the locations of Petroleum Filling Stations by DPR among others include;

i. Stations should be located at a minimum of 100 m from any public institution such as schools, churches, public libraries, auditoriums, hospitals, public playgrounds, etc.

ii. Distance between one petrol station and another should not be less than 1000m

iii. Filling Stations will not be allowed in any area where the traffic situation is such that it will cause obstructions in entering or leaving a station or on tight curves where visibility is not adequate.

iv. Buildings are to be located a minimum of 12m from road property boundaries to provide adequate area for maneuvering of vehicles in the service area.

v. Petrol pumps shall be located a minimum 100m from any residential building.

vi. Where the site adjoins the side or rear boundary of a residential lot, a solid wall 3 m in height should be constructed and maintained along that lot boundary.

vii. Signs should be in accordance with the Advertisement Regulations and should be located so as not to reflect the sun into the face of motorists and should be large enough so that they can be seen from a reasonable distance at a reasonable speed.

viii. The Investor should approach the Infrastructure Advertisement Department for both the regulations and approval of the location of the signage.

ix. Stations are to be equipped with fire-fighting and fire protection equipment installed in accordance with the National Police (NPF), Federal Environmental Protection Agency and the Ministry in charge of disaster management.

x. All volatile flammable liquid storage tanks shall be installed below ground in compliance with the requirements of the Ministry of Trade and Industry.

xi. Proper facilities for storage and disposal of used and waste oil and gas must be provided.

xii. Waste water from the washing of motor vehicles and sewage disposal should be to the satisfaction of the federal Environmental Protection Agency (FEPA).

xiii. No access to or from a filling station shall be closer than 45m to any road intersection or 75 m from the intersection of two main roads.

2.2.13 International Air Quality Strategies and Technologies

Policy decisions are at the core of issues of air quality, given that government actions spanning from pollution standards, to allocation of health resources and behaviour change approaches are key to influencing the level of harmful emissions in the air. There is evidence from developing countries that government spending on air quality initiatives may not be proportional to their effectiveness, and that there is often an overemphasis on new technologies to the detriment of more mundane policy options, such as provisions for active travel (Heft-Neal et al., 2018).

The air quality measures within the policymaking context by combining insights from the policy studies literature with the body of existing scientific knowledge on air quality. Given that local and national-level governments have the potential to play a significant role in helping reduce air pollution levels across the globe, air quality strategies and technologies that are most likely to have widespread impact are the ones that can be operationalised within respective policy contexts (Hare, 2017).

Air quality initiatives cannot be introduced in isolation from the policy context of which they are part. In addition, a greater understanding of the interface between science and policy will more effectively mobilise scientific knowledge for real-world impact (Wesselink, et al. , 2013; Young et al., 2014). Air quality measures are also unlikely to be effective in isolation given the complex and interacting factors that contribute to air pollution. There is a disjuncture between the tendency in the scientific literature to study individual air quality interventions and the fact that social change is most often predicated on a combination of mutually reinforcing policy measures (Nilsson, et al., 2016).

It also includes an evaluation of initiatives that feature in the grey literature but do not yet feature in the academic literature, thus indicating promising avenues for further academic research. Furthermore, it contributes to addressing the tendency in the scientific literature to focus overly on large, or “mega” cities, as in, whilst understudying smaller cities. Given that 31.9% of the world population live in cities of fewer than one million inhabitants (compared with 6.9% of the population which live in megacities of more than ten million inhabitants), the policy measures enacted in these smaller cities will reach a significant proportion of the world’s population, and therefore have the potential for high impact. Air quality is understood as the levels of pollutants in the air and how these compare with permissible levels. The key air pollutants are: particulate matters (PM2.5 and PM10), nitrogen oxides (NOX), Sulphur dioxide (SO2), carbon monoxide (CO), and volatile organic compounds (VOCs) (Kuklinska, et al., 2015).

The main source of ambient air pollution is emissions from fossil fuel vehicles, and air pollution is generally worse in cities. There is substantial research linking air pollution from traffic to negative health outcomes. For these reasons, we focus on strategies and technologies relating to road transport in urban areas (Slovic & Ribeiro, 2018). The air quality impact of industrial and domestic pollutant sources tends to remain consistent or be improving over time, whilst traffic pollution problems are worsening across the world; policies regarding industry and manufacturing are therefore not included in this study. We divide air quality initiatives into strategies and technologies. Strategies encompass the policy levers available to governments, including legislation, “soft power”, and taxation and funding. Technologies are subdivided into those which prevent emissions, and those which seek to retrospectively remove emissions from the air (Quarmby et al., 2019a).

To assess the evidence-base for interventions, (Quarmby et al., 2019a) use the following framework: evidence of effects(i.e., this has been shown to work), evidence of no effects (this has been shown to not work), and lack of evidence (there is insufficient evidence to determine whether this works or not).

(a) Improving Air Quality: Individual Strategies and Technologies

In this section, we review individual policy measures which aim to improve air quality, and indicate what evidence is available about their effectiveness.

i. Individual Strategies

The majority of air quality strategies for which evidence exists focus on discouraging private car use. This is predominantly done via regulations and legislation, as well as investing in infrastructure which promotes alternative transport. Here we discuss some key air quality strategies and other illustrative examples where they have been put into practice.

ii. Low Emission Zones

Low emission zones (LEZ) are areas in which vehicle use is restricted in order to limit tailpipe emissions. They are a popular localized air quality measure in European cities, with approximately 200 in existence across twelve European countries including, for example, England, Italy, Sweden, and Holland. Restrictions typically apply to heavy duty vehicles, which usually run on diesel, but some LEZs also include other types of vehicles, such as very old, polluting cars. The zones are often created to ensure that cities comply with European emission standards, which have become more stringent over time, and so the types of vehicles which are allowed entry vary according to each location's needs (Holman, Harrison, & Querol, 2015).

London’s low emission zone, which applies to most of the area within the M25 ring road and targets heavy duty diesel vehicles, is a prominent example and one of a number of area-specific air quality measures currently in place in the city. From April 2019 an Ultra Low Emission Zone will be introduced in the Congestion Charging area. This Ultra Low Emission Zone will include cars, motorcycles and vans, which will need to meet tighter emissions standards. In October 2021 the Ultra-Low Emission Zone will be expanded to the inner London area, bounded by the North and South Circular roads (Quarmby et al., 2019a).

There is some evidence that low emission zones can have a positive effect on air quality, although their efficacy varies dependent on the location’s characteristics, as well as how stringent the zone’s requirements are. For example, a study conducted in five Dutch cities found that low emission zones directed solely at heavy goods vehicles have no significant impact on air quality, suggesting that more wide-ranging restrictions achieve better air quality results. A variation on low emission zones are zero emission zones, in which only cars that produce no tailpipe emissions, such as electric vehicles, are permitted. Oxford City Council recently set out plans to gradually move towards a zero-emission zone, starting in 2020 (Bigazzi & Rouleau, 2017).

Congestion charging zones are an example of an associated initiative which is not primarily focused on air quality but may have effects thereupon. The cost of driving is increased via a congestion charge within a designated area or on certain roads, which acts as a deterrent for drivers. There is evidence that congestion charging assists a behavioural change shift from private car use to public transport, which may in turn improve air quality. An issue with low emission zones and congestion charging zones, like all measures focused on a particular area, is that emissions may be displaced rather than reduced overall and can result in poorer air quality outside the zone (Hawkes, 2015).

iii. Private Vehicle Behavioural Change

Urban air quality policy combinations often ally methods for discouraging private car use with measures to make less polluting forms of transport, such as cycling and public transport, more appealing. Investments in cycling and public transport infrastructure, such as a network of cycle lanes, are costly in the short term but may assist in facilitating long term behavioural change away from polluting transport. To ensure it is a viable option, public transport needs to be frequent, reliable, relatively quick and potentially, subsidised. Several countries are also considering ways to help people connect easily between different forms of transport. Singapore plans to create more integrated transport hubs, enabling easier transition between different modes of transport, for example, from bus to tram (McGranahan, 2012).

An integrated hub linking bus, train and cycling facilities opened in Port Talbot,Wales in 2017 and a number of stations in London serve as underground, train and bus stations, and Sustainability provide cycle racks, often inside the building. Examples include Paddington, Euston and King's Cross, to name a few. Cycling is one of the least polluting transport modes, falling under the active travel category, along with walking. Despite this, there is a lack of evidence quantifying the air quality impacts of cycling, since tra_c related air quality research tends to focus on pollutant emissions produced. A recent study attempting to estimate air quality impacts from a number of walking and cycling schemes run by Sustrans, an active travel charity, in towns and cities in the UK, provides estimates of the air quality benefits for local populations due to reduced emissions from car journeys, and the impacts on an individual due to change in pollution exposure from shifting to active travel (Quarmby et al., 2019a) .

Although there was an improvement for local populations in some areas, the schemes did not have uniformly positive impacts and in some cases, such as Leeds, there was a negative effect. This is because the impacts of the schemes depend on the number of participants, the extent to which walkers and cyclists are exposed to air pollution, and the population density of the surrounding area, amongst others (Quarmby et al., 2019a).

Furthermore, in areas where the majority of cycle routes are not separated from vehicle traffic, such as Cardiand Plymouth, the schemes had a detrimental effect on people who use active travel. Other studies, for example, estimate that a 40% reduction in car trips in Barcelona City would yield a reduction of PM2.5 concentrations of only 0.64%, and 10.03 air pollution related deaths avoided per year (Quarmby et al., 2019a). They also find that the benefit for the general population due to reduce air pollution is much smaller than the benefit of the physical activity that cycling yields, a result also reported in (Quarmby et al., 2019a). Cycling initiatives, therefore, are a promising but not unproblematic air quality improvement strategy but must balance the potential negative side effects of cycling, such as the exposure of cyclists to vehicle emissions.

iv. Speed Management

Lower speed limits may be a cost-effective way of quickly making an impact on air quality near roads and are included in several European countries’ air quality plans. For example, the Welsh Government has recently introduced 50 mph speed limits on five main roads and 20 mph speed limits will be introduced on all TFL managed roads (approximately 5%) in central London by 2020, although the measure is primarily aimed at improving road safety conditions (D’Elia et al., 2018).

The effect on emissions from lower speed limits is generally due to mitigating the stop-start nature of tra c, thus preventing unnecessary acceleration and deceleration, rather than the actual speed of the vehicles. This includes pollution produced through brake and tyre wear, given that stopping from 20 mph emits approximately half the amount of particulate matter from the brakes as stopping from 30 mph. The effects of speed management measures are dependent on local weather conditions and the physical infrastructure surrounding the road. For example, in Amsterdam, a speed limit reduction from approximately 62 mph to 50 mph resulted in decreased PM concentrations, but had no effect on NOx. Speed management has in places been complemented by “eco-driving” campaigns, which educate the public on fuel-efficient forms of driving. An eco-driving programme carried out in the Netherlands between 1994 and 2004 is thought to have reduced fuel consumption by between 0.3 and 0.8% (Quarmby et al., 2019a).

(b) Outreach Strategies

Outreach and marketing activities have been shown to increase public awareness and compliance when used in conjunction with other air quality initiatives. For example, Singapore’s air quality strategy emphasizes creating community ownership of air quality issues and holds annual ‘community and youth for the environment’ days. The Royal Borough of Kensington and Chelsea enlists ‘green champions’ to educate members of the community on energy efficiency and ways of reducing pollution (Hesketh et al., 2017).

Involving stakeholders from industry, academia and NGOs in designing and implementing interventions also leads to improved compliance, and can be facilitated through awards schemes, such as the City of London Corporation’s awards for business which use sustainable technology (Hesketh et al., 2017).

On the other hand, the impetus for environmental ownership may arise from communities themselves, rather than local or national authorities. In 2017, residents of the Kings Heath suburb of Birmingham collaborated with the consultancy firm Earthsense to monitor local pollution levels, as well as organising a "Clean Air Day" where residents were encouraged to commute by active travel rather than private car. The European Union also funded the CITI-SENSE project, in which approximately 400 volunteers were involved in establishing and monitoring an air quality sensor network of 324 individual units across Europe (Harmsen, van den Hoed, & Harmelink, 2007).

None of these community-led initiatives is likely to result in long-term impact by themselves. Whilst leaving the car at home may be feasible for everybody supporting the action one day, it may not be practical for all the other days of the year. Similarly, whilst neighbours may volunteer to help with air quality measurements for one day, it is unlikely that they would agree to do so to that extent on a regular basis. However, these community-led initiatives show that people in areas of high air pollution are aware of, and concerned by, the situation and may therefore be more likely to support policies introduced by the government.

(c) Technologies

i. Removing Pollutants from the Air

Technologies designed to remove pollution from the air often gain media attention due to their unusual designs. For example, China has recently constructed a 100-m-tall air purifying tower in Xi'an, which is shaped like a chimney and uses greenhouses to move air through a filtration system. There is however little evidence to substantiate the initial success claims made for the tower (Quarmby et al., 2019a).

Separately, using substances which react with NO2 to absorb it from the air, have been trialled in several countries, including the Netherlands, Japan and England. These can be applied to surfaces as paint or be integrated within materials themselves such as paving slabs and roofing felt. The results of these initiatives are as yet inconclusive, and every day wear and tear can limit their effectiveness. Delhi has also recently trailed water cannons to wash pollution out of the air, with no measurable effect (ibid).

Evidence is beginning to emerge that planting vegetation on surfaces of urban areas, for example, green walls and green roofs, has a small and highly localised positive impact on air quality. The key problem with such initiatives is that only a small fraction of air ever comes into contact with any given technology, meaning that the overall impact on air quality is often negligible. Lewis urges caution regarding such initiatives and argues that "it is far, far easier to come up with technologies and schemes that stop harmful emissions at source, rather than try to capture the resulting pollution once it's free and in the air" (Jayasooriya, Ng, Muthukumaran, & Perera, 2017).

ii. Switching to Less Polluting Cars

A number of technologies exist to make diesel and petrol cars less polluting. Catalytic convertors, devices which make tailpipe emissions less harmful, have been a legal requirement for new vehicles in the UK and most other countries worldwide for several decades. The oil company Shell has developed a synthetic "drop in" alternative to diesel, i.e., one that requires no modification to the engine. This may have positive effects on NOx and PM emissions, but is yet to be rigorously evaluated (Quarmby et al., 2019a).

Alternatively, San Paulo has focused on "flex" vehicles, which can run on di_erent forms of fuel, usually a combination of petrol and ethanol. Flex vehicles are different to hybrid vehicles, which are usually powered by both electric and fuel-burning engines. There is some evidence that ethanol-based flex vehicles may produce less NOx than petrol or diesel fuelled cars, but the specific context in Brazil, including their investment in ethanol production infrastructure, may mean that flex vehicles are a less viable initiative elsewhere (ibid).

Another common strategy is to encourage the population to substitute older, more polluting vehicles for newer, cleaner versions, which is most often achieved through a variety of taxation, subsidies and funding. Electric vehicles are the most high-profile cleaner car, and the proportion of the vehicle fleet made up by electric cars worldwide is increasing. Electric vehicle uptake spans the strategies and technologies distinction, since this new technology can only make a positive impact on air quality if the population changes their buying behaviour and begins to use them. The majority of EU member states other tax incentives or grants for buying and running electric vehicles (Bunsen et al., 2018). On a smaller scale, San Paulo does not tax electric or hydrogen vehicle imports, and Southampton City Council used an Air Quality Grant from the UK Department for Environment, Food and Rural Affairs to fund cash-back for taxi drivers to replace polluting vehicles.

By contrast, cities around the world, including Mexico City, Athens, Paris and Madrid, plan to employ a legislative approach by banning diesel vehicles from city centres by 2025; and many countries have pledged to stop new petrol and diesel car sales by a set year, for example France and England by 2040. The International Energy Agency predicts that under the policies and measures that governments around the world have already put in place, the global stock of electric vehicles will reach 13 million by 2020 (up from 3.7 million in 2017) and nearly 130 million by 2030. Electric vehicles produce no tailpipe emissions whilst being driven, but consideration must be paid to how the electricity that powers them is generated, as well as whether they are charged in the daytime or at night (Quarmby et al., 2019a).

Electric vehicles also still produce particulate matter resulting from tyre and brake wear and road abrasion. In the UK in 2015, the latest year for which statistics are available, 31% of PM10 emissions from road transport were from tailpipes, 45% were from tyre and brake wear, and 24% were from road abrasion. In the longer term, there is a movement towards electric vehicles becoming autonomous, i.e., not requiring a human to drive them. Autonomous vehicles may have a positive impact on air quality by mitigating the human tendency for stop-start driving, as well as braking, and via vehicle platooning, where a number of vehicles travel closely together to improve aerodynamics. A drawback of the increasing proportion of electric vehicles is that if numbers continue to grow as predicted, there may be the knock-on effect of reduced income from fuel duties for governments.

iii. Roadside Barriers

Roadside noise reduction barriers, like congestion charging zones, have effects on air quality without this being their original purpose. Artificial barriers tend to lead to decreased pollution behind the barrier and are therefore regarded as a promising air quality measure. Barriers comprised of a mixture of vegetation and artificial material seem to have the most positive impact on air quality, although barriers made solely of vegetation with thick foliage are also regarded as promising (Tong,et al., 2016).

iv. Trees and Vegetation

Perhaps counterintuitively, for the same reason that vegetation barriers can be effective in preventing the movement of pollution, trees can lead to reduced air quality within built-up urban environments. If they are planted along major roads, their canopies can act as a roof, preventing pollution from dissipating (Quarmby et al., 2019a). However, they can still be an effective way of improving air quality in less built-up environments and their leaves are capable of filtering out certain pollutants, such as NO2, from the air. Guides regarding where to plant trees for optimal air quality benefit have been created, such as Morani et al.'s "planting priority index" map which ranks areas according to localised pollution levels, population density and existing tree cover (Morani, et al., 2011).

There has also been research into the most effective tree species for improving air quality; conifers have been found to capture more pollution than broad leaved trees. Initiatives focused on planting trees, such as New York's "Million Tree Initiative," therefore, may be beneficial, but should not be seen as the panacea for air quality issues. There is some evidence that "urban greening" initiatives, such as green walls and vertical gardens can have a positive effect on air quality due to their capacity for trappingNO2 and particulate matter. Sydney, Singapore and Mexico City are amongst the many cities worldwide to experiment in urban greening (Quarmby, et al., 2019b). More research is needed to determine the effects of urban greening, but evidence suggests that urban form plays an important role in their effectiveness, for example, green walls may be most beneficial in "urban canyons", streets with high buildings along each side.

v. Air Quality Monitoring

Choosing the most effective air quality initiatives is predicated on knowing both the overall air pollution levels and the chemical composition of the pollution. Most countries, however, do not have a systematic approach to air quality monitoring. This results in a lack of air quality data, which undermines attempts to evaluate the effectiveness of air quality initiatives. The need to expand and improve monitoring networks is consistently referenced in the literature as a fundamental prerequisite for improving air quality. Examples include (Craig et al., 2008). As well as the EU funded CITI-sense network, and citizen-led monitoring mentioned above, attempts being made to address this include the Chinese government's creation of a nationwide network monitoring PM2.5 levels, the data from which is publicly available and can be checked in real time by anyone with a smartphone, much like the "London Air" app in England . The potential for monitoring to improve air quality links to the broader interest in smart cities, a term used to denote the many and combined ways that technology can be incorporated into daily urban life to improve it (Quarmby et al., 2019b)

2.2.14 Preventing Groundwater Contamination at Gas Stations

As the environmental risks associated with petrol stations, particularly the risk of gasoline leaked from underground storage tank (UST) systems have become increasingly clear, vast improvements have been made in the design, construction, and operation of UST systems. Unfortunately, federal and state regulators and underground storage tank system designers and installers have not succeeded in engineering all of the groundwater contamination risk out of these systems (Ayotte et al., 2005).

The main sources of concern with respect to double-walled underground storage tanks and groundwater contamination are vapor releases from underground storage tank facilities and small spills of fuel that routinely occur when fuel is being dispensed to vehicles. In addition to vapor releases and chronic small spills, larger spills sometimes take place during the process of fueling vehicles and portable containers. Well-designed and operated petrol stations incorporate a number of measures to minimize the groundwater contamination risk from routine and accidental spills. Outlined below are some of the techniques to prevent underground water contamination by petrol stations:

Siting Restrictions: Given the likelihood that underground storage tank systems will release petroleum constituents (most commonly in the form of vapour leaks from underground piping systems or overfills of the underground storage tank , vehicle tank, or portable container) and the possibility that spilled fuel will be carried off the fueling area by storm water, environmental officials interested in providing the highest possible level of protection for groundwater used for drinking water should consider restricting the siting of petrol stations as they would any other land use that is likely to contaminate groundwater.

Storm water Management: The guiding principle of storm water management at petrol stations is to keep clean water clean. Relatively clean storm water, such as from roofs and areas other than the fueling area, may not be allowed to run onto the fuel dispensing area.

Existing Gas Stations: The most important non-regulatory role for water suppliers and municipal officials with respect to existing petrol stations is to ensure compliance with state requirements with respect to storm water management, spill containment, and periodic inspection of release prevention and detection systems.

2.3 Empirical Review

Literature on locations of filling stations and their impact on the environment are scanty. Public's perception on the location of filling stations can be viewed with regard to the knowledge that the public has on standards and guidelines on filling stations locations. Filling stations were traditionally located in largely uninhabited areas (Isabel et al., 2010). The situation obtaining on the ground proves to be different since many filling stations are being built within urban areas surrounded by residential and public buildings. This trend has been observed regardless of the dangers associated with filling stations. Filling stations come up in newly developed areas only when development reaches a point at which business potential of the areas can be assessed. A delayed demand for Service Site is then created and will culminate in request for permits to use sites which are detrimental to sound development of the area. Preferences for locations on heavily travelled streets so as to obtain the maximum patronage from local area as well as the passing traffic results in serious traffic hazards and traffic congestion (Gopalaswamy, 1977). Filling stations are a source of volatile organic compound emission which raised concerns and discussions about groundwater contamination in the USA and Europe due to recently detected evidence of fuel spills and leaks that have actually been happening for several decades (EFOA, 2002). Volatile Organic Compounds including benzene and toluene along with toxic gases such as carbon monoxide and traces of soot can have deleterious effect on general health particularly on the respiratory system (Alam et al., 2014).

According to the Australian Transport Safety Bureau (ATSB) (2005), between 1993 and 2004, there were 243 reported incidents of fires breaking out at petrol stations. The continuous urban growth experienced by Spain in recent years has also resulted in many petrol stations being built within urban areas surrounded by buildings. This situation has led to controversy between the citizens whose houses are close to the petrol stations and the authorities responsible for land management (Isabel et al., 2010). There are quite a number of case studies that have been carried out on filling stations location around the globe. The studies have been carried out to ascertain the dangers associated with filling stations locations and public's perceptions. One interesting discussion in the literature is the case of City of Singapore. Chan et al., 2004 proposed a structural model to explain both the geographic locations of gasoline retailers in Singapore, as well as the nature of price competition between the retailers and their geographic locations. Interestingly, the premise underlying the development of the model was that, the Singapore government determines where to locate gasoline stations in the city. This was found very unique as compared to most capitalist market driven economies. The authors reiterated that, the government of Singapore is a social welfare planner and thus her approach to streamline the distribution of gasoline stations across the city is to minimize aggregate travel cost incurred by consumers in their efforts to buy gasoline in Singapore.

Another study by Hamid et al., (2009) discussed site potentiality for petrol station business based on traffic volume counts using a regression and Geographic Information System (GIS) based spatial system. The authors stressed that, site potentiality is an important factor that influences business success of a petrol station which relies on customer visits. On this note, Kearny (1998) disclosed that, it was empirically found in the United States of America that, site location was the primary factor for drivers to choose a petrol station. In a similar vein, another study conducted in Ipoh, Perak, and Malaysia attention was focused on analyzing the viable land parcels for installing new petrol filling stations. The geospatial data was collected from Mapping and Surveying Department of Ipoh (Khahro et al., 2013). The standards used in practice for the site selection for petrol filling station were collected from City Planning Department, Ipoh. A set of questionnaire was also designed to get the stakeholders opinion regarding the site selection of the petrol filling stations. Analytic Hierarchy Process (AHP) was used as a Multi-Criteria Decision Making (MCDM) technique. Expert Choice (EC) was used to analyze the qualitative results. At the end, to achieve the main objective of the research, the spatial data was used to identify the suitable land parcels for installing new petrol filling stations using GIS. The responses from the public were analyzed to generate the land suitability map for petrol filling stations location and to validate the final land suitability map for petrol filling station, the overlay technique was adopted. The data layer of existing petrol filling stations was generated by using the coordinates. The coordinates were collected from the online available source provided by the Malaysian Geospatial Data Infrastructure. The coordinates were validated by using the hand Global Positioning System (GPS).

Similar to the two GIS based Analysis of the location of Petrol Filling Stations, Mohammed et al., (2014) conducted a study in Kano Metropolitan Area in northern Nigeria to establish the compliance of Petrol filling station entrepreneurs to the Physical Planning Standards set by the Department of Petroleum Resources (DPR) (2007). The results produced some unique and significant revelation on the non-compliance of some of the petrol filling stations to the standards. For instance, it was revealed that, only eight (8) stations (4%) out of 192 stations did not meet the criteria of 15 meters minimum distance from road. Njoku and Alagbe (2015) also highlighted on some of the illegal location of Petrol filling stations in Oyo State using GIS to assess suitability of petrol filling stations. From another study carried out in Maiduguri and Jere, Borno State, Nigeria, the workers in the petrol stations and the residents living nearby the petrol stations have in one time or the other suffer various health effects as a result of working in petrol stations or being in their close proximity, (Mshelia et al., 2015). The results from Mshelia et al showed that, respiratory problems (diseases) had the highest percent of 38.05%. This by implication means, it was the most prevalent health problems affecting both the workers and some of the residents as a result of the inhalation of fuel contaminated air. However, skin and sight problems alongside other health complications were also issues of concern. If the situations continue thereafter, such could lead to narcotics effects with symptoms including headache, nausea, dizziness and mental confusion (Mshelia, et al., 2015). From the result obtained, only 26% were located in conformity with the standards and guidelines. The study also revealed that some of the petrol stations were separated by a wall or narrow path. One significant revelation from the study was that, some of the petrol stations were located much earlier before environmental guidelines and regulations were formulated. Similarly, some of the residential houses were developed close to petrol filling stations. In other words, urban planners also fail to implement physical development control measures to restrain potential landlords to build in close juxtaposition to petrol filling stations.

The issue of location preferences of entrepreneurs also features within the literature (Njoku and Alagbe, 2015; Mohammed et al., 2014). Njoku and Alagbe stated that, in as much as petrol filling stations should be located where they can be easily accessible, the concern had been that there has been over-provision within one geographical area as well as indiscriminate locations within Oyo town and Nigeria at large. The observed trend within the literature is that, some owners prefer to select the optimum location to locate their petrol filling station on the profit maximization principle. Nkoju and Alagbe (2015), disclosed that, the Commissioner of Physical Planning and Urban Development stated that, "the Government of the Republic of Nigeria had sometime before the year 2015, imposed a three-year ban on major marketers of petroleum products in the State of Oyo due to their nonchalant attitude and failure to comply with national government's call to desist from erecting illegal petrol filling stations". The review of the literature brought to light the efforts governments throughout the world are making to ensure that the risks associated with petrol filling stations locations are either avoided or minimized. One of the risks experienced in recent times in connection with filling stations is fire explosions. This brings to the fore the importance of all stakeholders adhering and ensuring that planning guidelines and environmental standards are complied with in the sitting of filling stations.

However, in view of some lapses in the application of the planning guidelines and standards in some of the countries in the developing world there has been serious fire explosions related to filling stations in Accra, Ghana and Lagos, Abuja, Kano in Nigeria and Umvoti and Cato Ridge in KwaZulu Natal in South Africa (enca.com South Africa). In Accra Ghana, one of the worst fire explosions engulfed the Goil Filling Station on 3rd June 2015 at the Kwame Nkrumah Circle which killed nearly 200 people during a rainstorm. In Nigeria, fire explosions at filling stations have been a common feature which has destroyed properties within the vicinities of the filling stations. The filling stations that were engulfed by fire explosions include ASCON on the Admiralty Way Likki Phase 1 Lagos, MRS Filling Station in Surulere in Lagos (dailypost.ng) and Canoil Filling Station Opposite the Nigerian National Petroleum Corporation (NNPC) in Abuja.

2.4 Theoretical Framework

The theories adopted for this study are the obnoxious facility location and the central place theory. The discussion on the theoretical expositions begins with the obnoxious facility location model; Obnoxious facilities location model categorized facilities into two, i.e., desired facilities and undesired facilities. Desired facilities are those which are desired by inhabitants to be placed in closer areas. Undesired facilities are those which are never desired to be placed in nearby areas by the inhabitants and they are termed under what is known as obnoxious facilities (Rana and Garg, 2014). In the literature review, it was discovered that petrol filling stations pose a risk to the environment and are a source of concern in case of fire explosion (Muzenda, 2015). Hence, they can be categorized under obnoxious facilities. The location of petrol filling stations is a very significant issue and needs to consider impact of various relevant parameters such as distance, population and access time on a location (Rana and Garg, 2014).

Obnoxious facility location problem deals with the proper placement of such materials which are preferred to be placed far from the populated area to prevent the inhabitants from health related issues as caused by such facilities. If petrol filling stations are located closer to populated areas, it may be dangerous to the lives of mankind and keeping in view all adverse effects of the petrol filling stations over the environment and population, it is crucial to locate obnoxious facilities away from the populated area (Rana and Garg, 2014). The exposition by Rana and Garg was affirmed by the studies by Mshelia et al., 2015 and Afolabi et al., 2011) who highlighted on respiratory and other health problems affecting both workers and residents living within close proximity of the filling stations. The location of a filling station is supposed to be in consonance with the Department of Petroleum Regulations standards and guidelines for sitting of petrol filling stations. Unfortunately, petrol filling station operators always assume that quality of site location is associated with the type and volume of traffic flows passing the site, proximity to a major travel route, visibility from the road, time taken by drivers to slow down to enter the petrol station, general ability to attract customers, road direction or movement, artery types, and distance of catchment areas from residential neighbourhoods (Iman et al., 2009). This means that filling station operators always have a location preference with the hope of maximizing sales and profits. Hence, they will choose to locate their business at a central place where they feel it will attract a lot of motorists for refueling and as a result, maximize on their income.

(a) Central Place Theory

The Central place theory is a geographical theory that seeks to explain the number, size and location of human settlements in a residential system. The theory was created by the German geographer Walter Christaller, who asserted that settlements simply functioned as 'central places' providing services to surrounding areas (Goodall, 1987). Central place theory essentially concerns places that provide a convenient point of focus for consumers for the purchase of goods and services, and centrality is the essence of the point of focus (Gbakeji, 2014). Centrality refers to a state of high accessibility, the quality of being at the center of the transportation system (Inyang and Ogbonna, 2001). Thus, it follows that the term central place is a relative one. It describes the relationship between a point and other points in the surrounding region, and the central place is that point which can be most 'easily' reached from other locations in the region. Hence, this is the desire of filling station operators to locate their businesses at a central place where they can attract motorists. The primary concern of filling stations' operators is a central place which would minimize the travel costs of the consumers in gaining access to the services they require and at the same time, give them a great exposure to consumers. Centrality implies that consumers generally use service centers that will enable them satisfy their wants with the minimum effort (Gbakeji, 2014). Even though filling stations' operators have locational preferences, it should be understood that, the location of filling stations generally despite its importance to the economy, is expected to be guided by a defined standard (Mshelia, et al., 2015). Bolen (1988) stated that, every location on the earth has its analyzable advantages and disadvantages and according to Mshelia et al.,2015, before the planning permission is granted to construct a petrol filling station, it is a requirement to conduct an Environmental Impact Assessment (EIA). Lawrence (1997) defined EIA as an aid to decision-making; providing a systematic examination of the environmental implications of a proposed action and alternatives before a decision is taken. Lösch (1954) argued that, a firm seeking to maximize profit (a basic assumption of all economic theory) may choose a certain location to gain a competitive advantage over other firms and locate in a market area that provides the greatest profit. Locating the market area of greatest profit depended on assumptions of equal costs of transportation and population distribution. He argued that, the more competitive the market, the more firms will be inclined to seek and adjust to the maximum profit location. The location selected will depend in part upon such demand factors as:

i. Elasticity of product demand.
ii. Location of competitors.
iii. Importance of proximity to customers.
iv. Importance of direct contact with customers.
v. Extent of market area (regional, national, international).
vi. Relative competitiveness of the industry.

Iman, et a1., (2009) stated that, location of petrol filling stations is usually associated with the type and volume of traffic flows passing the site, proximity to a major travel route, visibility from the road, time taken by drivers to slow down to enter the petrol station, general ability to attract customers, road direction or movement, artery types, and distance of catchment areas from residential neighbourhoods. Such physical factors in a site location can make the difference between excellence, mediocrity, or failure in use for service station purposes. With respect to the distance of catchment areas from residential neighbourhoods, site proximity to the surrounding residential neighbourhoods can be expected to exert significant influence on a petrol station business. This explains the locational preference of petrol filling stations owners which is based on profit maximization (O'Sullivan, 2005).

CHAPTER THREE

3 MATERIALS AND METHODS

This chapter describes the method and procedures that were adopted in this study including the research design, area of study, population for the study, sample and sampling techniques, other procedures and method of data analysis.

3.1 Study Design

This study adopted a combination of survey and experimental research design which allow for data collection from respondents through interviews, air sample collection and analysis of water samples collected from the study area.

3.2 Study Area and Population

Ado Ekiti is a city in southwest Nigeria, the state capital and headquarters of Ekiti State. Ado-Ekiti is geographically located within latitude 7°37′16″north of the equator and longitude 5°13′17″east of the Greenwich meridian (Figure 3.1). It covers a land area of 293 km^2, with a population of 308,621, according to the 2006 population census. The total projected population for Ekiti State for the year 2018 is 3, 550, 350. The people of Ado Ekiti are mainly of the Ekiti sub-ethnic group of the Yoruba and the inhabitants of the area are mainly civil servants and those that engage in trading businesses.

The geology of Ado Ekiti belongs to the basement complex (igneous rock) rock of South Western Nigeria. Ado-Ekiti falls within the tropical savannah climate, characterized by heavy rainfall and high sunshine and nutritious soil that supports the growth of yam, plantain and fruits like mangoes, banana to mention a few.

The city is the trade centre for a farming region where yams, cassava, grain, and tobacco are grown. Cotton is also grown for weaving. There is a large population of youths and adolescents due to the tertiary institutions located in the city. Ado-Ekiti is bordered by Irepodun/ Ifelodun Local Government in north, Aiyekire local government (Gbonyin L.G.) in the west, Ikere and Ise/Orun Local Government in the south. It comprised of petrol attendants, petrol station owners and selected house owners/residents who live within 100m to the petrol stations.

Figure 3.1: Map Showing the sample site and the location of Ado Ekiti (Field Survey,2019).

3.3 Sample and Sampling Techniques

A purposive sampling technique was used to sample two hundred and twenty-five (225) petrol attendants selected from the sixty functional petrol stations in Ado-Ekiti for the study. Sixty (60) petrol station owners and 30 residents who live within 100 m to the petrol stations where water samples were taken.

3.4 Instrument for Data Collection

The instrument for data collection was the structured questionnaire on assessment of air, water quality and perceived health impacts on the environment of petrol stations in Ado Ekiti, Ekiti State. The questionnaire was divided into three sections; Section A consist of items on the socio-demographic information of the respondents. Section B comprised of questions on Health Impacts of Petrol Station on Petrol Attendants, Section C questions was on Adherence of Petrol Station Owner to Department of Petroleum Resources (DPR) Guidelines.

Other instrument used are;

i. GPS device (Garmin 72H) for taken coordinates of the study area
ii. Measuring Tape for distance measurement
iii. Bramc 4-in-1 Air Quality Monitor for air quality assessment
iv. Smart Sensor Multi-gas monitor to assess the level of air pollutants
v. Sterilized sample bottles for taken water samples

3.5 Validity of the Research Instrument

In order to ensure the validity of the instrument, face and content validity were ensured and approved by experts in Environmental Health field who scrutinized it. Only items found relevant for the study were used while items found to be irrelevant were discarded.

3.6 Reliability of the instrument

Reliability is basically the ability of the questionnaire to produce the same results under the same conditions. The reliability of the instrument was established through test-retest procedure. The instrument was administered to the petrol attendants and owners in Ijero Ekiti (having the same characteristic of the study area) and re-administered after 2-week interval. A reliability coefficient of 0.78 was obtained

3.7 Method of Data Collection

The research assistants were trained on how to elicit the information from the respondents using the research instrument while the sampling meter (to obtain concentration of Volatile Organic Compounds, Particulate matter ($PM_{2.5}$ and PM_{10}), and Formaldehyde (HCHO) were taken. Water samples were also taken for quantitative data using standard methods.

3.7.1. Procedure for Analyzing PAHs in Water Samples

Samples of water collected from Ado Ekiti were analyzed of PAHs using Dispersive liquid-liquid micro-extraction (DLLME) combined with gas chromatography–mass spectrometry GC–MS) (Adeniji, 2017) The procedure is described as follows:

i. In this procedure, the suitable combination of extraction solvent (500 µL chloroform) and disperser solvent (1000 µL acetone) were quickly injected into the water sample (10.00 mL) by Hamilton syringe.
ii. After centrifugation, 500 µL of the lower organic phase was dried under a gentle stream of nitrogen, re-dissolved in chloroform and injected into GC-MS.
iii. Chloroform and acetone were found to be the best extraction and disperser solvent, respectively.
iv. Validation of the method was performed using spiked calibration curves.
v. The enrichment factor ranged from 93 to 129 and the recovery ranged from 71 to 90%.
vi. The linear ranges for all the PAHs were 0.10-2.80 $ngmL^{-1}$.
vii. The relative standard deviations (RSDs) of PAHs in water by using anthracene-d_{10} as internal standard, were in the range of 4-11% for most of the analytes. Limit of detection (LOD) for different PAHs were between 0.03 and 0.1 $ngmL^{-1}$.

3.8 Data Management

Mean, standard deviation and coefficient of variation were computed for each of the parameter (VOC, $PM_{2.5}$, PM_{10}, and formaldehyde). Pearson correlation was used to establish relationship among the parameters. Also, relationship between these parameters and distance was explored using Pearson correlation while difference in the water samples collected were subjected to the PAHs analysis for testing water polluted by hydrocarbons were compared using independent-t test. Furthermore, data obtained was also analysed using multiple linear regression. Statistical significance was established at 5% and 1% level of significance. All data analysis and computations of result was done using the Statistical Package for Social Sciences (SPSS version 22.0).

3.9 Ethical Consideration

Permission to conduct this research work was obtained from the petrol station owners in Ado-Ekiti. Also, the purpose of the research was explained to the petrol attendants to allay any fear of insecurity. Prior consent of the house owners/residents where water samples taken were collected was sought before the samples collected.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Results

Table 4.1: Demographic Characteristics of the Petrol Attendants

Demographics Characteristics

Male

Out of the 225 petrol station attendants sampled, 179 (79.6%) were single, 45 (20.0%) were married and 1 (0.4%) was widowed. One hundred and thirty-eight respondents representing 61.3% had less than 1 year's experience as petrol station attendants while 22.2%, 7.6%, 4.9% and 4.0% of the respondents had been working as petrol station attendants for 1-2 years, 2-5 years, 5-10 years and more than 10 years respectively. The distribution of time they work per day were as follows: 12.4% worked for less than 8 hours, 10.7% worked for 8 hours, 17.3% worked for 9-10 hours while 59.6% worked for more than 10 hours per day.

Table 4.2: Demographics characteristics of the Petrol Stations Owners

Demographics
Characteristics

31-40

0
2 0 m
P F S s W ITH P M 2 . 5
P F S s W ITH P M 2 . 5

Result from Figure 4.1 shows the Air Quality Parameters ($PM_{2.5}$) in the sixty (60) functional petrol filling stations (PFSs) compared with WHO Value. It shows that 11 filling stations out of 60 have their $PM_{2.5}$ values above the recommended WHO standard value at a distance of 20m from the filling stations; at 40m 10 petrol filling stations have their values above WHO recommended standard and at 50m in the study area, 17 filling stations have their values above WHO recommended standards. This is in line with the study of Quarmby, et.al, 2019, that many people lived in areas where particulates exceeded the WHO recommended levels (Quarmby, et.al, 2019). The WHO standard value is between 1-25.

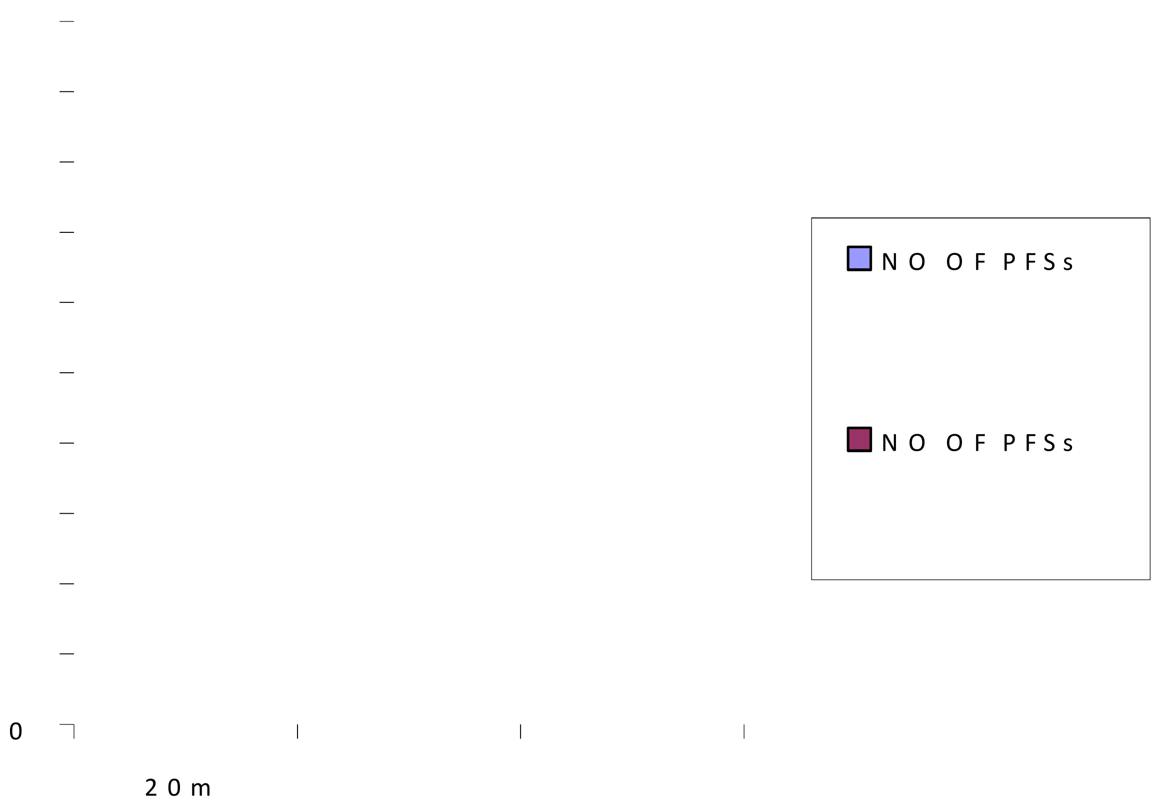

Figure 4.2: CHART SHOWING PM_{10} AT VARYING DISTANCES

Figure 4.2 shows results for PM_{10} in the sixty (60) functional petrol filling stations compared with WHO Value. 12 out of 60 have their values above WHO value at 20 m, 13 and 15 filling stations have their value above recommended value at 40 m and 50 m respectively. These are dangerous to human health as recorded by Kenneth et.al., 2001 that PM_{10} can result in respiratory and cardiovascular diseases such as coughing and wheezing, asthma attack, high blood pressure, stroke among others

Table 4.4: Level of air quality parameters in the study area compared with the recommended standard values

by the Federal Ministry of Environment (FMEV) and World Health Organisation (WHO). Result obtained for VOCS reveals that the level of VOCS obtained in the study area was slightly above the recommended standard but the difference was not significant (p =0.835, p>0.05). the Air Quality Index in the Study Area based on FMEV standard, $PM_{2.5}$ was classified as good; PM_{10} and HCHO were classified as very good while VOCs was very poor. Also, based on WHO standards, $PM_{2.5}$, PM_{10} and HCHO were very good while VOCs was very poor.

Table 4.5: Descriptive statistics for Polycyclic Aromatic Hydrocarbons (PAHs) parameters in the study area

PAHs

Table 4.6. Hydrocarbons (PAHs) compared with recommended standards

Benzo

(k)fluoranthene

Regular sweating

Table 4.8: Adherence of Petrol Station Owner to Department of Petroleum Resources (DPR) Guidelines

Others (specify)

Results presented in Table 4.8 and 4.8.1 show that all the petrol station owners were aware of the Department of Petroleum Resources (DPR) criteria for setting up a petrol station with 98.3% have licensed to operate filling station with 98.1% claimed that they provide Personal Protective Equipment for their employees. Of the 59 petrol station owners that claimed that they have PPE, 40.7% said they provided Goggle, 23.7% said they provided footwear/ boots while 23.7%, 18.6%, 6.8%, 1.7%, 1.7%, 1.7% and 5.1% claimed that they provided overall, nose masks, apron, hand gloves, air filter/ purifiers and other PPE facilities. All of them claimed that they normally organize pre-placement training on safety at work before worker start his/her work with majority of the petrol station owners (98.3%) indicating that they trained their petrol attendants trained on how to dress in safety wears with the majority of them (98.3%) claimed that environmental impact assessment conducted in your petrol filling station and this was conducted by the majority of the owners before construction (93.2%). Result also reveals that 98.3% of the respondents claimed that they have functional fire fighter equipment and that there are filing stations are insured in case of emergency (100%). Fifty-nine (59) petrol station owners (98.3%) claimed that they have functional fire fighter equipment while 98.3% of the owners of petrol station indicated that there is provision for worker's compensation in case of sustaining any injury when carrying out their duties while 96.7% indicated that they have first aid facility in place in their filling stations.

Table 4.9: Distance of Filling Stations from Residential Areas

Distance from residential building (in metres)

40-50

organic compounds (VOCs) shows insignificant relationship ($p>0.05$). The result of bivariate relationship also reveals that significantly negative correlation between VOCs concentration and $PM_{2.5}$ and PM_{10} concentration ($p<0.01$). Implying that as VOCs increases significantly, $PM_{2.5}$ and PM_{10} decreases significantly. This may be attributed to the toxic nature of these pollutants particularly VOC which is high at the various petrol filling stations. The interrelationship could be dependent on environmental conditions, particularly the nature of the elements (Davies et al., 2005).

4.2.2 Comparison of Air Quality with the International and National Standards

The analysis of $PM_{2.5}$, PM_{10} and HCHO obtained in the study area was significantly less than that of FMEV standard and WHO standard as shown in table 4.4. The result also shows that the level of VOC was significantly above that of FMEV standard and that of WHO standard. This could be because of a wide range of finely divided solids that may be dispersed into air from combustion process, industrial activities or natural sources This could also be attributed to urban sources as well as planned burns and it could be referenced against known events (Raimi, 2008). These VOCs react with primary anthropogenic pollutants specifically, NOx, SO_2 and anthropogenic organic carbon compounds-to produce haze of secondary pollutants (Janice, 2002; Raimi et al., 2018). The mean concentration of VOC in the air is 0.56±2.10. This could be attributed to soot and smoke from vehicular movement from the filling stations and therefore poses a problem to the health of the people and petrol attendant in the filling stations and nearby area and also to environmental sustainability. This finding agrees with highly significant values recorded by Raimi et al., (2018); Tawari and Abowei (2012) in their studies. The actual health damage caused by fumes during fuel dispensing and other dust particles depends upon its nature and composition (Raimi et al., 2018). The mean concentrations of $PM_{2.5}$ and PM_{10} in the studied samples were 20.83±9.91 and 19.39±12.67 respectively. $PM_{2.5}$ and PM_{10} were both significantly lower than their respective

FMEV and WHO standards, thus the air has met the "low health category" and posing no threat to the health of the petrol attendants and environment. This means that the levels of $PM_{2.5}$ and PM_{10} particles in the air can be considered healthy for the resident of the communities and everyone. Although it should be closely monitored because the present concentration could be due to anthropogenic activities of the filling stations in the study area. The concentration of $PM_{2.5}$ and PM_{10} measured may seem insignificant, cumulative effect might be harmful to health, particularly to the fuel attendant. Interestingly, sources of particulate matter can be manmade or natural. Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation and sea spray.

Human activities, such as fuel dispensing, the burning of fossil fuels in vehicles, power plants and various industrial processes also generate significant amounts of aerosols. Averaged over the globe, anthropogenic aerosole made by human activities currently account for about 10% of the total amount of aerosols in our atmosphere. Increased levels of fine particles in the air are linked to health hazards such as heart disease (Molles, 2005) altered lung function and lung cancer. Persistent free radicals connected to airborne fine particles could cause cardiopulmonary disease (Bronwen, 1999).

Further, with respect to the health effect due to ambient air pollution in the area, it was noticed that, the air quality such as $PM_{2.5}$, PM_{10}, HCHO and VOC at petrol stations and its surroundings is comparatively more than and affected than the control, which is least affected. The particulate and gaseous pollutants may affect petrol attendant and the people livings in the study area especially those suffering from asthma, chronic obstructive pulmonary diseases (COPD) and cystic fibrosis. Asthma has been observed in many petrol attendant and sensitive group like children and the elderly. In addition, the control station could represent the baseline pollution concentration in the study area before the advent of petrol filling stations.

Exposure is the key factor in potential health impacts. High concentration does not harm people if they are never present and even low levels become relevant when many people are present all the time. Thus, the most important factor in assessing the risk of adverse health effect is the population exposure. Therefore, the health effects caused by some air pollutants such as VOCs, $PM_{2.5}$, PM_{10} etc. are related to the total cumulative exposure during the petrol attendant's lifetime or over a long period.

4.2.3 Air Quality Index (AQI)

The Air Quality Index (AQI) was calculated for all sampling locations using the daily average concentration of the measured parameters as shown in table 4.3. Local air quality affects how we live and breathe. Like the weather, it can change from day to day or even hour to hour. The AQI is an index for reporting daily air quality. It tells us how clean or polluted the air is, and corresponding health effects. Our results show the Air Quality Index (AQI) in the study area. Based on Federal Ministry of Environment standard, the level of $PM_{2.5}$, PM_{10} and Formaldehyde (HCHO) were good and do not pose any health risk. However, VOC in the study area is very poor and can be described as unhealthy and hazardous for sensitive group such as children, women and elderly and people with respiratory diseases such as asthma. This implies high value of the index represents a highest value of environmental pollution, and, of course a highest health risk. It was observed that VOC may have posed serious health risks to petrol attendant and individuals who spent long hours at these locations. Sensitive groups such as asthmatics, children and the elderly, people with heart or lung diseases were at highest risk. For WHO classification, VOC levels were very poor and unhealthy. Sensitive people should consider limiting their stay within the petrol filling stations especially during dispensing of petroleum products at the filling stations. VOCs are important outdoor air pollutants are often divided into separate categories of methane (CH_4) and no methane (NMVOCs). Methane is an extremely efficient greenhouse gas which contributes to enhance global warming. Other hydrocarbon VOCs are also significant greenhouse gases via their role in creating ozone and in prolonging the life of methane in the atmosphere, although the effect varies depending on local air quality. Within the NMVOCs, the aromatic compounds benzene, toluene and xylene are suspected carcinogens and may lead to leukaemia through prolonged exposure. 1, 3-butadiene is another dangerous compound which is often associated with petroleum products.

4.2.4 Mean concentrations of PAHs at various locations

A summary of analytical results of the PAHs in water samples from Ado- Ekiti Nigeria is presented in Table 4.5. The maximum concentration limits for PAHs set by the European Community and United States Environmental Protection Agency is presented in Table 4.6. The 2 and 3 member rings PAHs comprising: naphthalene, phenanthrene, acenaphthylene, acenaphthene and fluorene constitute larger concentrations of the total PAHs in the thirty different water samples.

This group of PAHs could be treated with water via exposure to sunlight, biodegradation using microorganisms. Benzo (k) fluoranthene, benzo (b) anthracene, dibenzo (a, h) anthracene and indeno (1, 2, 3 – cd) pyrene were below detection limits in all the samples analyzed. -combustion PAHs sources (e.g. Oil seeps and petroleum spills) contain predominantly two- and three- ring compounds whereas combustion sources (e.g. Automobiles, domestic heating with coal, forest fires, etc.) result in predominantly four to six rings species. The two and three ring compounds detected in all the samples were at higher concentrations. The mean concentration of the higher molecular weight (HMW) aromatic hydrocarbon, benzo (a) pyrene (BaP) (0.01±0.00 ng/µl) resulting from samples 1 to 30 is much higher than the USEPA and EC maximum allowable limits (0.00001 ng/µL). BaP is amongst the most toxic PAH compounds, causing deleterious effects on human health. Reports have shown that benzo (a) pyrene is the most widely. investigated among the PAHs, as it poses a relatively stronger carcinogenic effect to laboratory animals and man. This is very dangerous because of the possible bioaccumulation in humans over long period, which could lead to cancer. Further studies have shown that benzo (a) pyrene (BaP) do accumulate to potentially hazardous levels in fish and invertebrates. The various forms of BaP intermediates such as diol and phenol epoxides were reported to concentrate mutagenesis and carcinogenesis of mammals. PAHs concentrations previously reported in literature on different water samples were compared to the present data. The levels of PAHs in this study were higher than the values reported in studies around the world. This result is a re-affirmation of other studies in Nigeria that showed occurrence of PAHs in most potable water sources. Therefore. regular checks and control measures should be intensified to remediate the overwhelming effects for future generations to come. The higher values of PAHs obtained in this study compared to previous publications could be due to the following factors apart from the proximity or remoteness to the gasoline filling stations.

4.2.5 Water Quality Index (WQI)

The WQI method assigns a rating or weightage (Wi) for each chosen parameter and select the pollution parameter on which the index is to be based. It can be defined as inversely proportional to the recommended standard (Si) for each parameter (Mohan et al., 1996). In this study, the concentration limits (i.e., the highest permissible value for drinking water (Si) and maximum desirable value (MAC) (Ii) for each parameter) were taken from the EU and USEPA standard. The uppermost permissive value for drinking water (Si) refers to the maximum allowable concentration in drinking water in the absence of any alternate water source. The desirable maximum value (Ii) indicates the standard limits for the same parameters in drinking water.

The WQI indicate that fluranthen, benzo(b)fluoranthene and benzo(a)pyrene are very poor when compared with the European Union (EU) standards while fluorine, phenanthrene, anthracene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene and benzo(a)pyrene etc are very poor when compared with USEPA standard. The WQI represents the composite influence of PAHs on the overall quality of water (Kumar et al. 2012; Prasanna et al., 2012). The rating is based on the relative importance of individual quality considerations and defined as inversely proportional to the recommended standard for each PAHs (Mohan et al., 1996). This suggest the effect of petrol stations activities on groundwater quality within the petrol stations vicinity.

However, in this study, most of the frequently used drinking water sources in the study area were found to be unsuitable for human consumption, because of the high and very poor WQI value (Yisa and Jimoh, 2010; Khanna et al., 2013).

Thus, a large percentage of the population depends on unsuitable drinking water sources, and scarcity of safe drinking water sources is reflected in the study area. Dependent populations of unsuitable drinking water sources are facing high adverse risk to their health due to exposure to highly toxic elements and pathogens, causing them to suffer from various waterborne diseases (Flanagan et al., 2012). The exposure pathways of contaminants may vary from region to region, depending on factors such as human activity, geological composition of the aquifer and more. Also, various climatic and geomorphic conditions such as rainfall, runoff, infiltration rate, groundwater level and fluctuation, groundwater flow pattern, distribution pattern of toxic elements, and many more, can influence exposure pathways (Bhattacharya et al., 2002, 2011; Shrivastava et al., 2014).

Alternative safe water management plan is highly essential to protect public health, especially in the study area. In a recent study conducted in the Tala Upazila of Satkhira district, Saha et al.

(2018) identified safe installation sites based on calculating the WQI for drinking water sources, and GIS-based, geo-statistical, and spatial analysis. By using these techniques, before installation, it will be easy to explore suitable sites with the depth necessary for discovering high quality drinking water. To improve this situation, certain steps need to be taken to ensure safe drinking water. These steps include installation of safe water treatment plants; near water bodies need to be protected from water pollution; keeping safe distance (>20m) between water sources and contamination sources (petrol stations); periodical and long term monitoring periods of drinking water sources need to be implemented; hygiene behavior needs to be taught and practiced, as well as practicing using safe drinking water sources; and a sufficient water treatment plan needs to be established, etc. (Rahman et al., 2000; Bhattacharya et al., 2011; Cronin et al., 2017; Dey et al., 2017b).

However, in terms of the Water Safety Planning (e.g., WHO, 2009) approach, appropriate strategies, and effective and socially accepted frameworks for water resources management, are also necessary for communities to reduce the risk of contamination of water (Flanagan et al., 2012; Cronin et al., 2017; Bhattacharjee et al., 2019). Thus, ensuring the availability and sustainability of water sources are highly essential for public health and meeting target of Sustainable Development Goals (SDGs).

4.2.6 Spatial variation of Polycyclic Aromatic Hydrocarbons (PAHs) Groundwater Quality Parameters

According to the drinking water quality standards, PAHs should not be present in groundwater used for drinking purpose (BIS, 2003). Table 4.6 shows that traces of hydrocarbons are persistent in groundwater in the study area. There is no evidence that PAHs contamination from petrol filling stations leaked into groundwater during the time of the study. However, PAHs contamination of the groundwater could also be due to leakage of the current practices of oil storage in tanks in the various filling stations. During field investigation, it is understood from the residents that the groundwater quality was poor within the petrol filling station, it has been reported that oil leakages from the activities of the petrol filling stations has impacted the surrounding groundwater. However, many factors can influence the potential for contamination of groundwater by chemicals, such as the properties of the soils and the physicochemical properties of the chemical.

The properties of the chemicals, however, will mainly affect their distributional behaviour and fate in the environment for the same soil type and characteristics. PAHs are generally retained in soils for many years due to adsorption or absorption by soil organic carbon and may even enter the aquatic environment, inducing further hydrospheric pollution because of their hydrophobicity, so that soil can be a secondary emission source or the final sink of PAHs. This result suggested that precipitation might introduce PAHs to drinking water sources, or the higher levels of dissolved organic carbon were present in water in the study area. This distribution of PAHs in water was consistent with another study that reported much higher PAHs (Okoro, 2007).

The levels of the PAHs in the current study are generally believed to be of petrogenic origin and closely related, due to their molecular weights (Okoro, 2007). The high concentrations detected in the samples could therefore be traced to petroleum contamination of the groundwater aquifer from the poorly sitting of petrol filling stations in the neighbourhood. The petrol filling stations operators could have been discharging oil-contaminated wastewaters into the surrounding water bodies the small mainland for over a decade now. The possibility of constituent pollutants seeping, and subsequently contaminating groundwater aquifer proximally has also been identified by other authors such as Ogbonna et al. (2006; 2008), Narayanan (2007) and Kaufmann and Claveland, (2008). The high water table and porous soils of the area could aid contamination of groundwater aquifers. Anyakora et al., (2004) had already identified components of the PAHs in ground waters of some other region of Nigeria; wherein he detected high concentrations of benzo(a)pyrene, especially in water sources of some oil producing communities.

The maximum permissible limit for total PAHs in drinking water by the World Health Organization (WHO, 1993) is 0.0002mg/l. Values from this study far exceed this standard for total PAHs. Undoubtedly, these results create a great cause for public health concerns, especially as certain PAHs have been confirmed to be carcinogenic (ATSDR, 1995), and are not only ingested by inhabitants through drinking contaminated waters, but also when the water is used to prepare their foods. This thus increases the risk of elevated concentrations in adipose tissues of man and other animals. Inevitably man suffers the greatest risk of bioaccumulation due to his position as tertiary consumer in the trophic chain, in addition to his predisposition to other route of entry into his body. Furthermore, carcinogenicity is transgenic, as oncogenes (cancer prone genes) could be inherited by filial generations (Evans, 1977; Cerna, 1996).

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

Water and air pollution is a global issue with major challenge that humanity is facing in the twenty-first century and world community is facing worst results of polluted environmental media. The PAHs analysis of the study reveals that the groundwater of the study is contaminated with fluorine, phenanthrene, anthracene, fluranthen, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene and benzo(a)pyrene. The groundwater is also contaminated with nitrate concentration which exceeds the permissible limits of EU and USEPA. The mean concentrations of $PM_{2.5}$, PM_{10} and other assessed parameters such as Formaldehyde etc. are generally lower and within acceptable range of National and International regulatory standards for air quality indices. There are however, few exceptions such as mean concentrations of volatile organic compounds respectively high compared to National and International standards. Air around the petrol stations in Ado Local Government area of Ekiti State, Nigeria were found to be relatively polluted.

5.2 Recommendations

Generally, this research could serve as a vital tool to assist in monitoring concentration of pollutants viz a viz environmental pollution. To improve on the current air and water quality monitoring and assessment programmes in petrol stations in Ado Local Government area of Ekiti State, there is need to embark on the following:

i. Town planners should ensure that the allocation of plots for construction of Petrol Stations are far from residential arears

ii. State and local government officials such as Environmental Health Officers should actively disseminate health warning so that communities can better protect themselves from air related pollution.

iii. Environmental Health Officers (EHOs) should raise awareness of the harmful effects of pollutants to the petrol attendants and communities surrounding the various filling stations.

iv. They should ensure that there is Limit of exposure of vulnerable people, particularly children, pregnant women the elderly and petrol attendants to air pollution when levels are high around the filling stations and community at large

v. EHOs should ensure provision and using of PPEs by those working in Petrol Stations

vi. Department of Petrol Resources (DPRs) should develop monitoring mechanisms, regulations and enforcement measures for their members to prevent them from unlawful acts that can jeopardize the health of workers and community at large.

vii. Planning policies to minimize pollution that may be caused by future development.

viii. Government agencies such as the Ministry of Environment should collaborate with other multinationals and stakeholders in air pollution management to come up with a comprehensive Air Quality Monitoring scheme for the region.

ix. Environmental Impact Assessment (EIA) should be ensured before commencing operation of petrol station to minimize or prevent likely heath and environmental related diseases and conditions

x. There should be regular medical check up for workers such as pre-employment, pre-placement and periodic check up to minimize the effects of work on their health.

REFERENCES

Abdulraheem A. F, Olalekan R. M, Abasiekong E. M (2018) Mother and father adolescent relationships and substance use in the Niger delta: a case study of twenty-five (25) communities in Yenagoa local government of Bayelsa state, Nigeria. Sociol Int J. 2018;2(6):541–548. DOI: 10.15406/sij.2018.02.00097

Adeniji A.O., Okoh O.O. and Okoh A.I. (2017). Analytical Methods for Polycyclic Aromatic Hydrocarbons and their Global Trend of Distribution in Water and Sediment

Adoki, A. (2012). Air quality survey of some locations in the Niger Delta Area. Journal of Applied Sciences and Environmental Management, 16(1), 125–134

Akey, P., & Appel, I. (2018). The limits of limited liability: Evidence from industrial pollution.

13th Annual Mid-Atlantic Research Conference in Finance (MARC) Paper.

Akinfolarin, O. M., Obunwo, C. C., & Boisa, N. (2018). Air quality characteristics of emerging industrial areas in Port Harcourt, Nigeria. Journal of Chemical Society of Nigeria, 43(1).

Alam, R., Zafar, A., Ghafoor, A., Naseem, A., Ali, Q., and Imtiaz, F. (2014), Lung Function Abnormalities Among Fuel Filling Workers In Karachi, Pakistan. Pinnacle Environmental and Earth Sciences, vol. 1, No. 1, pp. 183-187

Alana Biggers. (2017). What is Methemoglobinemia.

Alenezi, R., & Aldaihan, N. (2019). Impact of fuel dispensing stations in the vicinity residential homes on the indoor and outdoor air quality. International Journal of Environmental Science and Technology, 16(6), 2783-2796.

Aleksandra Buha (2011). Polycyclic Aromatic Hydrocarbons

Alharbi, B. H., Pasha, M. J., Alhudhodi, A. H., & Alduwais, A. K. (2018). Assessment of soil contamination caused by underground fuel leakage from selected gas stations in Riyadh, Saudi Arabia. Soil and Sediment Contamination: An International Journal, 27(8), 674–691

Al-Salem, S. M., Al-Fadhleeb, A. A., & Khan, A. R. (2009). Ambient air quality assessment of Al-Mansoriah residential area in the state of Kuwait. The Journal of Engineering Research [TJER], 6(2), 52–63.

Bada, B. S., Olatunde, K. A., & Oluwajana, A. (2013). Air quality assessment in the vicinity of Cement Company. International Research Journal of Natural Sciences, 1(2), 34–42.

Badowska, E., & Bandzierz, D. (2019). The analysis of petroleum hydrocarbons in soils deriving from areas of various development. E3S Web of Conferences, 100, 00002. EDP Sciences.

Bahadar, H., Mostafalou, S., & Abdollahi, M. (2014). Current understandings and perspectives on non-cancer health effects of benzene: A global concern. Toxicology and Applied Pharmacology, 276(2), 83–94.

Beil, L. (2017). Pollution killed 9 million people in 2015. Sciencenews. Org. Retrieved, 1. Bergman, H. L., Kimerle, R. A., & Maki, A. W. (1986). Environmental hazard assessment of effluents. Pergamon Books Inc., Elmsford, NY.

Bertrand-Krajewski, J.-L., Barraud, S., & Chocat, B. (2000). Need for improved methodologies and measurements for sustainable management of urban water systems. Environmental Impact Assessment Review, 20(3), 323–331.

Bielińska, E. J., Futa, B., Ukalska-Jaruga, A., Weber, J., Chmielewski, S., Wesołowska, S., … Mielnik, L. (2018). Mutual relations between PAHs derived from atmospheric deposition, enzymatic activity, and humic substances in soils of differently urbanized areas. Journal of Soils and Sediments, 18(8), 2682–2691.

Bigazzi, A. Y., & Rouleau, M. (2017). Can traffic management strategies improve urban air quality? A review of the evidence. Journal of Transport & Health, 7, 111–124.

Bhattacharjee, S., Saha, B., Saha, B.o., Uddin, M. S., Panna, C. H., Bhattacharya, P., et al. (2019). Groundwater governance in Bangladesh: established practices and recent trends. Groundwater Sustain. Dev. 8, 69–81. doi: 10.1016/j.gsd.2018.02.006

Bhattacharya, P., Chatterjee, D., and Jacks, G. (1997). Occurrence of arsenic contaminated groundwater in alluvial aquifers from DeltaPlains, Eastern India: options for safe drinking water supply. Int. J. Water Resources Dev. 13, 79–92. doi: 10.1080/07900629749944

Bhattacharya, P., Hossain, M., Rahman, S. N., Robinson, C., Nath, B., Rahman, M., et al. (2011). Temporal and seasonal variability of arsenic in drinking water wells in Matlab, southeastern Bangladesh: a preliminary evaluation on the basis of a 4 year study. J. Environ. Sci. Health Part A 46, 1177–1184. doi: 10.1080/10934529.2011.598768

Bhattacharya, P., Jacks, G., Ahmed, K. M., Routh, J., and Khan, A. A. (2002). Arsenic in groundwater of the bengal delta plain aquifers in Bangladesh. Bull. Environ. Contamination Toxicol. 69, 538–545. doi: 10.1007/s00128-002-0095-5

Brack, W., Dulio, V., Ågerstrand, M., Allan, I., Altenburger, R., Brinkmann, M., … Escher, B. I. (2017). Towards the review of the European Union Water Framework Directive: Recommendations for more efficient assessment and management of chemical contamination in European surface water resources. Science of the Total Environment, 576, 720–737.

Bronwen, M., (1999). The Price of Oil and Human Rights Watch. Perception and Reality: Assessing Priorities for Sustainable Development in the Niger River Delta Retrieved October 3, 2011.

Bunsen, T., Cazzola, P., Gorner, M., Paoli, L., Scheffer, S., Schuitmaker, R., … Teter, J. (2018). Global EV Outlook 2018: Towards cross-modal electrification.

Burian, S. J., & Pomeroy, C. A. (2010). Urban impacts on the water cycle and potential green infrastructure implications. Urban Ecosystem Ecology, (urbanecosysteme), 277–296.

Cancer Index. Nigeria Cancer Statistics. 2015. [Accessed on 6th January, 2016 [online]]. on http://www.cancerindex.org/Nigeria n

Caporale, A. G., Adamo, P., Capozzi, F., Langella, G., Terribile, F., & Vingiani, S. (2018). Monitoring metal pollution in soils using portable-XRF and conventional laboratory-based techniques: Evaluation of the performance and limitations according to metal properties and sources. Science of the Total Environment, 643, 516–526.

Centers for Disease Control and Prevention (CDC). (2009). Polycyclic Aromatic Hydrocarbons

Chinambu, C. (2011). A Study on market structure and competition: The Petroleum Industry in Zambia.

Chislock, M. F., Doster, E., Zitomer, R. A., & Wilson, A. E. (2013). Eutrophication: Causes, consequences, and controls in aquatic ecosystems. Nature Education Knowledge, 4(4), 10.

Craig, L., Krewski, D., Samet, J., Shortreed, J., van Bree, L., & Krupnick, A. J. (2008). International Perspectives on Air Quality: Risk Management Principles for Policy Development–Conference Statement. Journal of Toxicology and Environmental Health, Part A, 71(1), 4–8.

Cronin, A. A., Odagiri, M., Arsyad, B., Nuryetty, M. T., Amannullah, G., Santoso, H., et al. (2017). Piloting water quality testing coupled with a national socioeconomic survey in Yogyakarta province, Indonesia, towards tracking of Sustainable Development Goal 6. Int. J. Hyg. Environ. Health 220, 1141–1151. doi: 10.1016/j.ijheh.2017.07.001.

Currie, J., Neidell, M., & Schmieder, J. F. (2009). Air pollution and infant health: Lessons from New Jersey. Journal of Health Economics, 28(3), 688–703

Daly, A., & Zannetti, P. (2007). Air pollution modeling–An overview. Ambient Air Pollution, 15–28.

Daniels, A. M., & Mandell, D. S. (2014). Explaining differences in age at autism spectrum disorder diagnosis: A critical review. Autism, 18(5), 583–597.

David Brigg. (2003). Environmental Pollution and Global Burden of Disease

Davies, B., Valente, M. B., and Hall, A. (2005). The Zambezi Rivers in Mozambique: the physicochemical status of the middle and lower Zambezi prior to the closure of the Cobora Bassa Dam freshwater. Biology 7, 187–189. doi: 10.1111/j.1365-2427.1977.tb01668.x.

D'Elia, I., Piersanti, A., Briganti, G., Cappelletti, A., Ciancarella, L., & Peschi, E. (2018). Evaluation of mitigation measures for air quality in Italy in 2020 and 2030. Atmospheric Pollution Research, 9(6), 977–988.

Dey, N. C., Parvez, M., Dey, D., Saha, R., Ghose, L., Barua, M. K., et al. (2017b). Microbial contamination of drinking water from risky tubewells situated in different hydrological regions of Bangladesh. Int. J. Hyg. Environ. Health 220, 621–636. doi: 10.1016/j.ijheh.2016.12.007

Don Lieber.(2013): Ten Most Toxic Ingredients Used in Coal, Oil and Gas Production

dos Santos, J. J., & Maranho, L. T. (2018). Rhizospheric microorganisms as a solution for the recovery of soils contaminated by petroleum: A review. Journal of Environmental Management, 210, 104–113.

Ede, P. N., Obunwa, C. C., & Nlerumchi, S. C. (2010). Air quality studies around some local palm oil mill plant at the Northern fringes of the Niger Delta Area, Nigeria. Journal of Chemical Society of Nigeria, 35, 6–10.

El-Mahdy N.M, Kharoub H.S, El-Halawany F.(2015) Chromosomal anomaly among petrol station workers occupationally exposed to benzene.

Errington, I., King, C. K., Houlahan, S., George, S. C., Michie, A., & Hose, G. C. (2018). The influence of vegetation and soil properties on springtail communities in a diesel-contaminated soil. Science of the Total Environment, 619, 1098–1104.

Espejo Garriazo, G., & Zavaleta Velásquez, S. (2019). Factores que influyen en el clima organizacional en las empresas Latinoamericanas. Revisiones sistemáticas los últimos 10 años (Trabajo de Investigación Parcial).

Ewona, I. O., Osang, I. E., Obi, E. O., Udoimuk, A. B., & Ushie, P. O. (2013). Air quality and Environmental Health in Calabar, Cross River State, Nigeria. IQSR Journal of Environmental Science, Toxicology and Food Technology, 6 (6): 55, 65.

Flanagan, S. V., Johnston, R. B., and Zheng, Y. (2012). Arsenic in tube well water in Bangladesh: health and economic impacts and implications for arsenic mitigation. Bull. World Health Org. 90, 839–846. doi: 10.2471/BLT.11.101253.

Funmilayo A. A, Robert O. T, Olalekan R. M, Okoyen E, Tuebi M (2019). A study of the context of adolescent substance use and patterns of use in yenagoa local government, Bayelsa State, Nigeria. MOJ Addiction Medicine and Therapy. 2019;6(1):25–32. DOI: 10.15406/mojamt.2019.06.00142

Genovese, P. (2004). Full-Service Gas Stations." In Lurie Maxine N; Mappen Marc. Encyclopedia of New Jersey. Piscataway. New Jersey: Rutgers University Press.

Gleick, P. H. (1993). Water in crisis. Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute, Oxford Univ. Press. 473p, 9.

Gobo, A. E., Ideriah, T. J. K., Francis, T. E., & Stanley, H. O. (2012). Assessment of air quality and noise around Okrika communities, Rivers State, Nigeria. Journal of Applied Sciences and Environmental Management, 16(1), 75–83.

Gupta, S. and Dogra T.D. (2002): "Air pollution and human health hazards," Indian Journal of Occupational and Environmental Medicine, vol. 6, no. 2, pp. 89–93, 2002

Hanekom, P. (2001). Guidelines for the Construction and Upgrade of Filling Stations and Associated Tank Installations. Agricultural, Conservation, Environmental and Land Affairs, Diamond Corner Building, 68 Eloff and Market Street, Johannesburg. South Africa. Pp. 1 – 17.

Hare, T. (2017). Policy Transfer in International Development: Whose Security in Central America? Reconsidering Development, 5(1).

Harmsen, R., van den Hoed, R., & Harmelink, M. (2007). Improving the energy efficiency of road transport: The case of eco-driving in the Netherlands. Proceedings of the European Council for an Energy Efficient Economy Conference, La Colle Sur Loup, France.

Harrison, R. M., & Hester, R. E. (2007). Air pollution and health. Royal Society of Chemistry.

Harvey, P. J., Rouillon, M., Dong, C., Ettler, V., Handley, H. K., Taylor, M. P., … Trinh, R. (2017). Geochemical sources, forms and phases of soil contamination in an industrial city. Science of the Total Environment, 584, 505–514.

Hawkes, N. (2015). Air pollution in UK: the public health problem that won't go away. BMJ, 350, h2757.

Heft-Neal, S., Burney, J., Bendavid, E., & Burke, M. (2018). Robust relationship between air quality and infant mortality in Africa. Nature, 559(7713), 254.

Hesketh, R., Jones, L., Hinrichs-Krapels, S., Kirk, A., & Johnson, S. (2017). Air quality improvement initiatives in other cities.

Holman, C., Harrison, R., & Querol, X. (2015). Review of the efficacy of low emission zones to improve urban air quality in European cities. Atmospheric Environment, 111, 161–169.

Hussein I, Abdel-Shafy, Mona S.M. and Mansour. (2015). A review on polycyclic aromatic hydrocarbons: Source, environmental impact, effect on human health and remediation

Isabel, M., Minarro, M., Ferradas, E., Caracena, A, and Rico, J. (2010), Assessing the impact of petrol stations on their immediate surroundings: Journal of Environmental Management

Isabel, M.C., Graciela, A and Monica, R.C., 2010.Evaluating emission from gas stations. Journal of environmental management. 6.42-50.

James Chen. (2019). Petroleum

Jawad, A. M., Alabbasy, A. J., Salih, L. A. M., & Aljamali, N. M. (n.d.). International Journal f Green Chemistry.

Jayasooriya, V. M., Ng, A. W. M., Muthukumaran, S., & Perera, B. J. C. (2017). Green infrastructure practices for improvement of urban air quality. Urban Forestry & Urban Greening, 21, 34–47.

Josefson, A. B., & Rasmussen, B. (2000). Nutrient retention by benthic macrofaunal biomass of Danish estuaries: Importance of nutrient load and residence time. Estuarine, Coastal and Shelf Science, 50(2), 205–216.

Joseph, P and Riva, J. R., (2010). The history of the words petroleum industry.1.6-7. Newyork publisher.

Kalabokas, P. D., Papayannis, A. D., Tsaknakis, G., & Ziomas, I. (2012). A study on the atmospheric concentrations of primary and secondary air pollutants in the Athens basin performed by DOAS and DIAL measuring techniques. Science of the Total Environment, 414, 556–563.

Kalkbrenner, A. E., Daniels, J. L., Chen, J.-C., Poole, C., Emch, M., & Morrissey, J. (2010). Perinatal exposure to hazardous air pollutants and autism spectrum disorders at age 8. Epidemiology (Cambridge, Mass.), 21(5), 631.

Khanna, D. R., Bhutiani, R., Tyagi, B., Tyagi, P. K., and Ruhela, M. (2013). Determination of water quality index for the evaluation of surface water quality for drinking purpose. Int. J. Sci. Eng. 1, 9–14. Available online at: https://pdfs. semanticscholar.org/abcd/76cb3f6acb47e91ce939e2446472fb0572ac.pdf.

Kim, K.-H., Jahan, S. A., Kabir, E., & Brown, R. J. (2013). A review of airborne polycyclic aromatic hydrocarbons (PAHs) and their human health effects. Environment International, 60, 71–80.

Knox, A., Mykhaylova, N., Evans, G. J., Lee, C. J., Karney, B., & Brook, J. R. (2013). The expanding scope of air pollution monitoring can facilitate sustainable development. Science of the Total Environment, 448, 189–196.

Kolstad, C. (2011). Intermediate Environmental Economics: International Edition. OUP Catalogue.

Kponee, K. Z., Chiger, A., Kakulu, I. I., Vorhees, D., & Heiger-Bernays, W. (2015). Petroleum contaminated water and health symptoms: A cross-sectional pilot study in a rural Nigerian community. Environmental Health, 14(1), 86.

Kuklinska, K., Wolska, L., & Namiesnik, J. (2015). Air quality policy in the US and the EU–a review. Atmospheric Pollution Research, 6(1), 129–137.

Kumar PJS, Delson PD, Babu PT (2012) Appraisal of heavy metals in groundwater in Chennai city using a HPI model. Bull Environ Contam Toxicol: 1–6. doi:10.1007/s00128-012-0794-5

Lassalle, G., Credoz, A., Hédacq, R., Fabre, S., Dubucq, D., & Elger, A. (2018). Assessing soil contamination due to oil and gas production using vegetation hyperspectral reflectance. Environmental Science & Technology, 52(4), 1756–1764.

Last John, (2001). Definition of the environment

Mahgoub H.A.(2014). Extraction Techniques for Determination of Polycyclic Aromatic Hydrocarbons in Water Samples

Mark Gwynn (2005). "When people become words" (PDF). Ozwords. Australian National Dictionary Centre. Archived (PDF) from the original on 2009-03-20

McGranahan, G. (2012). Air pollution and health in rapidly developing countries. Earthscan.

McLaughlin, M. (2016). Ban, Fee, Take-Back/Recycle: Which Approach Wins Out in the End?

Mena, E., Villaseñor, J., Rodrigo, M. A., & Cañizares, P. (2016). Electrokinetic remediation of soil polluted with insoluble organics using biological permeable reactive barriers: Effect of periodic polarity reversal and voltage gradient. Chemical Engineering Journal, 299, 30–36.

Mohan SV, Nithila P, Reddy SJ (1996) Estimation of heavy metal in drinking water and development of heavy metal pollution index. J Environ Sci Health Asso 31(2):283–289.

Molles Jr, M.C., (2005). Ecology Concepts and Applications. 3rd Edn., McGraw-Hill Co. Inc, pp: 93-94.

Morani, A., Nowak, D. J., Hirabayashi, S., & Calfapietra, C. (2011). How to select the best tree planting locations to enhance air pollution removal in the MillionTreesNYC initiative. Environmental Pollution, 159(5), 1040–1047.

Mshelia, M., Abdullahi, J. and Dawha, E. (2015), Environmental Effects of Petrol Stations at Close Proximities to Residential Buildings in Maiduguri and Jere, Borno State, Nigeria, Vol. 20, No. 4, pp. 1-8.

National Academies of Sciences

Nieminen, P. M. (2005), Environmental Protection Standards at Petrol Stations: A Comparative Study of Technology Between Finland and Selected European Countries. Thesis for the Degree of Doctor of Technology, Tampere University, Finland

Nilsson, M., Griggs, D., & Visbeck, M. (2016). Policy: Map the interactions between Sustainable Development Goals. Nature News, 534(7607), 320.

Nwankwoala, H. O., Amadi, A. N., Oborie, E., and Ushie, F. A. (2014). Hydro chemical Factors and Correlation Analysis in Groundwater Quality in Yenagoa, Bayelsa State, Nigeria. Appl. Ecol. Environ. Sci. 2, 100–105. doi: 10.12691/aees-2-4-3.

Obisesan, A., & Weli, V. E. (2019). Assessment of Air Quality Characteristics across Various Land-Uses in Port-Harcourt Metropolis. J Environ Pollut Manage, 2, 106.

Ogunneye A.L,Omoboyowa D.A., Sonibare A.L, Adebusuyi A.J and Faniran T.P. (2014). Hepatoxic and Nephrotoxic Effects of Petroleum Fumes on Petrol Attendants in Ibadan, Nigeria.

Okonkwo, UC., Orji I.N. and Onwuamaeze, I. (2014). Environmental Impact Assessment Of Petrol And Gas Filling Stations On Air Quality In Umuahia, Nigeria. Global Journal of engineering research Vol 13, 2014: 11-20.

Okunola, O. J., Uzairu, A., Gimba, C. E., & Ndukwe, G. I. (2012). Assessment of gaseous pollutants along high traffic roads in Kano, Nigeria. International Journal of Environment and Sustainability, 1(1).

Palla, A., Gnecco, I., & Lanza, L. G. (2010). Hydrologic restoration in the urban environment using green roofs. Water, 2(2), 140–154.

Panagiotakis, I., & Dermatas, D. (2018). The Industrial Emission Directive Baseline Report as a tool for potentially contaminated site and industrial hazardous waste management: SAGE Publications Sage UK: London, England.

Petra S, Krisina P. and Dora N.(2017). The Growing Importance of Petro Stations asd Channels for Expanding the Retail Services.

Prasanna MV, Praveena SM, Chidambaram S, Nagarajan R, Elayaraja A (2012) Evaluation of water quality pollution indices for heavy metal contamination monitoring: a case study from Curtin Lake, Miri City, East Malaysia. Environ Earth Sci. doi:10.1007/ s12665-012-1639-61-15.

Premoboere Edna Ateboh and Raimi Morufu Olalekan (2018) Corporate Civil Liability and Compensation Regime for Environmental Pollution in the Niger Delta. International Journal of Recent Advances in Multidisciplinary Research Vol. 05, Issue 06, pp. 3870-3893, June, 2018

Quarmby, S., Santos, G., & Mathias, M. (2019a). Air quality strategies and technologies: A rapid review of the international evidence. Sustainability, 11(10), 2757.

Rabalais, N. N., Turner, R. E., Díaz, R. J., & Justić, D. (2009). Global change and eutrophication of coastal waters. ICES Journal of Marine Science, 66(7), 1528–1537

Ramírez, A., Engman, A., Rosas, K. G., Perez-Reyes, O., & Martinó-Cardona, D. M. (2012). Urban impacts on tropical island streams: Some key aspects influencing ecosystem response. Urban Ecosystems, 15(2), 315–325.

Rahman, M. M., Hassan, M. Q., Islam, M. S., and Shamsad, S. Z. K. M. (2000). Environmental impact assessment on water quality deterioration caused by the decreased Ganges outflow and saline water intrusion in south-western Bangladesh. Environ. Geol. 40, 31–40. doi: 10.1007/s002540000152.

Raimi M.O, Abdulraheem A F, Major I, Ebikapaye O, Bilewu O. O. (2019). Public Health Impact of Substance Use on Adolescent: A Snapshot of Yenagoa in Bayelsa State, Nigeria. American Journal of Biomedical Science & Research. 2019 - 4(3). AJBSR.MS.ID.000796. DOI: 10.34297/AJBSR.2019.04.000796. https://biomedgrid.com/current-issue.php

Raimi, M. O. (2008). The Effect of Vehicular Emission on Human Health. A Case Study of Yenagoa Motor Parks. Unpublished, A Seminar Paper Presented to the Department of Geography and Environmental Management, Niger Delta University, Wilberforce Island, Bayelsa State.

Rekhadevi P.V., Rahman M.F., Mahboob M, and Grover P. (2010): "Genotoxicity in filling station attendants exposed to petroleum hydrocarbons," Annals of Occupational Hygiene, vol. 54, no. 8, pp. 944–954.

Riccardi, C., Di Filippo, P., Pomata, D., Di Basilio, M., Spicaglia, S., & Buiarelli, F. (2013). Identification of hydrocarbon sources in contaminated soils of three industrial areas. Science of the Total Environment, 450, 13–21.

Saha, R., Dey, N. C., Rahman, S., Galagedara, L., and Bhattacharya, P. (2018). Exploring suitable sites for installing safe drinking water wells in coastal Bangladesh. Groundwater Sustain. Dev. 7, 91–100. doi: 10.1016/j.gsd.2018.03.002

Samuel, J. A. (2011) Spatial Location of Filling stations in Kaduna. Kaduna: Scribid Inc

Shrivastava, A., Barla, A., Yadav, H., and Bose, S. (2014). Arsenic contamination in shallow groundwater and agricultural soil of Chakdaha block, West Bengal, India. Front. Environ. Sci. 2:50. doi: 10.3389/fenvs.2014.00050.

Saniewska, D., Bełdowska, M., Bełdowski, J., Jędruch, A., Saniewski, M., & Falkowska, L. (2014). Mercury loads into the sea associated with extreme flood. Environmental Pollution, 191, 93–100.

Seinfeld, J. H., & Pandis, S. N. (2016). Atmospheric chemistry and physics: From air pollution to climate change. John Wiley & Sons.

Siberberg and Martins. (2004). Chemistry. The Molecular Nature of Matter and Change

Slovic, A. D., & Ribeiro, H. (2018). Policy instruments surrounding urban air quality: The cases of São Paulo, New York City and Paris. Environmental Science & Policy, 81, 1–9.

Smith, E., Thavamani, P., Ramadass, K., Naidu, R., Srivastava, P., & Megharaj, M. (2015). Remediation trials for hydrocarbon-contaminated soils in arid environments: Evaluation of bioslurry and biopiling techniques. International Biodeterioration & Biodegradation, 101, 56–65.

Spencer, K. (2004)."Mobile Phone as Fire Risks". (BBC News Online) http://newsbbc.co.uk/1/hi/programmes/clickonline/3986509.stm. Retrieved 2010-08-22.

Sudakin, D. L., Stone, D. L., & Power, L. (2011). Naphthalene mothballs: Emerging and recurring issues and their relevance to environmental health. Current Topics in Toxicology, 7, 13

Sunali Khanna and Amit S.G. (2017). Petroleum Carcinogenicity and Aero digestive Tract: In Context of Developing Nations

Sushkova, S., Minkina, T., Deryabkina, I., Rajput, V., Antonenko, E., Nazarenko, O., … Mohan, D. (2019). Environmental pollution of soil with PAHs in energy producing plants zone. Science of the Total Environment, 655, 232–241.

Tawari, C. C., & Abowei, J. F. N. (2012). Air pollution in the Niger Delta area of Nigeria. International Journal of Fisheries and Aquatic Sciences, 1(2), 94–117.

Tong, Z., Baldauf, R. W., Isakov, V., Deshmukh, P., & Zhang, K. M. (2016). Roadside vegetation barrier designs to mitigate near-road air pollution impacts. Science of the Total Environment, 541, 920–927.

Udoh N. (2013). Petroleum Marketing in Nigeria. BRANDIQ Pan-African Summit for Media and Communication, Nirobi Kenya

Ukemenam, O. S. (2014). Causes and consequences of air pollution in Nigeria. South African Journal of Public Health Volume, 2, Issue, 2.

Urch, B., Silverman, F., Corey, P., Brook, J. R., Lukic, K. Z., Rajagopalan, S., & Brook, R. D. (2005). Acute blood pressure responses in healthy adults during controlled air pollution exposures. Environmental Health Perspectives, 113(8), 1052–1055.

Villarino, C. B. J., Jayasena, V., Coorey, R., Chakrabarti-Bell, S., Foley, R., Fanning, K., & Johnson, S. K. (2015). The effects of lupin (Lupinus angustifolius) addition to wheat bread on its nutritional, phytochemical and bioactive composition and protein quality. Food Research International, 76, 58–65.

Volk, H. E., Lurmann, F., Penfold, B., Hertz-Picciotto, I., & McConnell, R. (2013). Traffic-related air pollution, particulate matter, and autism. JAMA Psychiatry, 70(1), 71–77.

Weli, V. E., & Ayoade, J. O. (2014). Seasonal analysis of atmospheric pollutants concentrations in urban and rural land use areas of Rivers State, Nigeria. International Journal of Environment and Pollution Research, 2(3), 1–16.

Wesselink, A., Buchanan, K. S., Georgiadou, Y., & Turnhout, E. (2013). Technical knowledge, discursive spaces and politics at the science–policy interface. Environmental Science & Policy, 30, 1–9.

Wilson, B. H., Shen, H., Pope, D., & Schmelling, S. (2001). Cost of MTBE remediation. Sixth International In Situ and On Site Bioremediation Symposium, 129–136.

World Health Organization. (1993) Guidelines for drinking water quality, vol 1, 2nd edn, recommendations, WHO, Geneva, p 13.

World Health Organization (2006). Preventing disease through healthy environments. Geneva, Switzerland.

World Health Organization, (2009). Water Safety Plan Manual: Step-by-step Risk Management for Drinking-water Suppliers. Available online at: http://www.who.int/water_ sanitation_health/publications/publication_9789241562638/en/ (accessed August 01, 2015).

World Health Organization, (2016). Ambient air pollution: A global assessment of exposure and burden of disease.

Yisa, J., and Jimoh, T. (2010). Analytical studies on water quality index of river Landzu. Am. J. Appl. Sci. 7, 453–458. doi: 10.3844/ajassp.2010.4 53.458

Young, J. C., Waylen, K. A., Sarkki, S., Albon, S., Bainbridge, I., Balian, E., … Margerison, C. (2014). Improving the science-policy dialogue to meet the challenges of biodiversity conservation: Having conversations rather than talking at one-another. Biodiversity and Conservation, 23(2), 387–404.

Zafra, C. A., Temprano, J., & Tejero, I. (2011). Distribution of the concentration of heavy metals associated with the sediment particles accumulated on road surfaces. Environmental Technology, 32(9), 997–1008.

Zhao, L., Li, Y., Zou, R., He, B., Zhu, X., Liu, Y., … Zhu, Y. (2013). A three-dimensional water quality modeling approach for exploring the eutrophication responses to load reduction scenarios in Lake Yilong (China). Environmental Pollution, 177, 13–21.

Zivin, J. G., & Neidell, M. (2018). Air pollution's hidden impacts. Science, 359(6371), 39–40.

APPENDIX

QUESTIONNAIRE

Kwara State University, Malete

Department of Environmental Health Science

Dear Respondent,

This instrument is part of my dissertation research effort focused on "Assessment of Air, Water Quality and Health Impact on the Environment of Petrol Stations in Ado Local Government Area of Ekiti State, Nigeria". I am an M.Sc. student in the above named Institution. Please answer the questions below as appropriate. The answers you provide will be used along with data gathered from the field as part of this investigation. Your response(s) is strictly confidential. Thank you very much for taking time to complete this survey. If you have any questions, please do not hesitate to contact me via telephone at (+234)8032239215 or via e-mail at makanjuolabc@gmail.com.

SECTION A (Socio Demographic Characteristics)

1. Sex: Male ( ) Female ( )
2. Age: 18- 30 ( ) 31 – 40 ( ) 41 – 50 ( ) 51 – 60 ( ) 60 and above ( ).
3. Level of education: Tertiary Education ( ) Secondary ( ) Primary ( ) None ( )
4. Marital status: Single ( ) Married ( ) Divorced( ) Widow/Widower ( )
5. Distance from residential building… … … … … … … … … … … ..
6. Filling Station where respondents were sampled: … … … … … … … … … … … … … … … …

FOR PETROLEUM ATTENDANTS ONLY

SECTION B: Health Impacts of Petrol Station on Petrol Attendants

1. **For how long have you been working here? a. Less than 1-year b. 1-2 years c. 2-5 years d. 5-10 years e. More than 10 years**
2. **How many hours do you work in a day? a. less than 8 hrs. b. 8hrs c. 9-10 hrs. d.above 10hrs**
3. **Did you undergo pre-employment medical examination before you were appointed? a. Yes b. No**
4. **Have you gone for medical checkup since you have started working in this filling station? a. Yes b. No**
5. **Like how many cars do you service per day? a. less than 20 b. 20-40 c. 41-60 d. above 60**
6. **Were you provided with personal protective equipment (PPE)? a. Yes b. No**
7. **If yes, do you wear these equipment? a Yes b. No**
8. **If no, what is/are the reason (s) for not wearing it? a. Not comfortable b. Too big (oversize) c. religious reason d. not provided e. other reasons (specify)………………**
9. **Which of the following PPE are provided for you at workplace? a. respiratory mask b. Apron c. safety boot d. face mask/goggle e. hand glove**
10. **How often do you shower after each day work? a. Every day b. Once in a while c. Shower only in the morning**
11. **Do you have health insurance in case of emergency? a. Yes b. No**
12. **Do you smoke? a. Yes b. No**
13. **Are you aware of the likely health effects of your work as a petrol attendant? a. Yes b. No**

Which of the following effects do you experienced often during work hours?

14 Nose irritation

A Goggle

12. Is there first aid facility in place in your petrol station? a. Yes b. No

RESEARCH PLATES

PLATE 1: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 1

PLATE 2: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 2

PLATE 3: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 3

PLATE 4: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 4

PLATE 5: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 5

PLATE 6: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 6

PLATE 7: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 7

PLATE 8: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 8

PLATE 9: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 9

PLATE 10: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 10

PLATE 11: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 11

PLATE 12: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 12

PLATE 13: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 13

PLATE 14: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 14

PLATE 15: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 15

PLATE 16: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 16

PLATE 17: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 17

PLATE 18: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 18

PLATE 19: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 19

PLATE 20: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 20

PLATE 21: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 21

PLATE 22: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 22

PLATE 23: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 23

PLATE 24: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 24

PLATE 25: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 25

PLATE 26: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 26

PLATE 27: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 27

PLATE 28: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 28

PLATE 29: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 29

PLATE 30: SPECTRA OF VOLATILE COMPOUND IN SAMPLE 30

PLATE 31: GPS device (Garmin 72H)

PLATE 32: Air Quality Monitor

PLATE 33: Smart Sensor Multi-Gas monitor

PLATE 34: Field Measuring Tape

PLATE 35: Water Sample Bottle