Journal of
Environment
(JE)

Environmental and Health Impacts of Crude Oil Exploration in the Niger Delta

CARI Journals

Journal of Environment
ISSN 2789-3863 (Online)
Vol. 3, Issue No. 2, pp 41 – 62, 2023
www.carijournals.org

Environmental and Health Impacts of Crude Oil Exploration in the Niger Delta

[1*]Justina Atonye Jumbo, [2]Best Ordinioha, [3]Mmom Prince, [4]Enembe Okokon, [5]Mike Barisere Teere, [6]Alex Tamunomiegbam

[1*,5]Ph.D Student: World Bank Africa Centre of Excellence and Toxicological Research
University of Port Harcourt
[2]Lecturer: Department of Community Medicine
University of Port Harcourt Teaching Hospital, Rivers State, Nigeria
[3]Lecturer: Department of Geography and Environmental Management
University of Port Harcourt, Rivers State, Nigeria
[4]Lecturer: Department of Community Medicine
University of Calabar, Rivers State
[6]Ph.D Student: Department of History and International Diplomacy
Rivers State University, Rivers State
ORCID NO: 0009-0002-7978-1657

Accepted: 9th Aug, 2023 Received in Revised Form:23rd Aug, 2023 Published: 6th Sep, 2023.

ABSTRACT

Purpose: This research aims to assess the environmental and health consequences of crude oil exploration in the Niger Delta, focusing on the emission of greenhouse gases and air pollutants and their impacts on public health.

Methodology: Literature search was done independently by the authors. After searching for articles on the identified databases, other sources of available and useful data on the subject such as the print press, student's thesis and dissertation among others were sourced by hand search to augmented resources from the electronic databases.The Literature search was based on the careful evaluation of key words in the title and abstract of identified studies.

Findings: The synthesis of available literature revealed significant insights into the environmental and health repercussions of crude oil exploration in the Niger Delta. The impact of gas flaring emerged as a major concern, leading to the release of pollutants like carbon dioxide, methane, and volatile organic compounds. These emissions contribute to elevated atmospheric temperatures, greenhouse gas concentrations, and the formation of acid rain, exacerbating global warming and disease transmission. The exposed population experiences a range of health problems including chronic respiratory diseases, cardiovascular abnormalities, altered blood parameters, and an increased risk of non-communicable diseases such as hypertension and diabetes. Prolonged exposure to pollutants from oil exploration is linked to disrupted sleep patterns, elevated stress levels, and neurophysiological disturbances, further contributing to adverse health outcomes.

Unique contribution to theory, practice, and policy: This study advances existing knowledge by providing a comprehensive analysis of the multifaceted interplay between crude oil exploration, environmental degradation, and human health in the Niger Delta region. The research offers a substantial contribution to theoretical understanding by illuminating the intricate relationship between anthropogenic activities, environmental factors, and health outcomes. Moreover, the study provides practical implications by proposing a series of recommendations aimed at mitigating the negative impacts of oil exploration. These recommendations advocate for stricter regulations on emissions, increased monitoring and enforcement, adoption of cleaner technologies, community engagement, and investment in healthcare and environmental remediation. The findings inform policy formulation by supplying evidence-based insights to develop robust regulations and interventions that promote sustainable development, protect public health, and safeguard the environment for future generations.

Keywords: *Crude Oil Exploration, Environmental Impacts, Health Impacts*

1.0 INTRODUCTION

The nine oil-bearing states in Nigeria are called the Niger Delta and they are: Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo and Rivers States. These states occupy 7.5% of the land mass of the country and are home to 31 million people speaking 250 different dialects from over 40 ethnic groups and 185 Local Government Areas (LGAs) (Alani *et al.*, 2020). These states though socially and culturally diverse, share in common the deleterious consequences of crude oil exploration and gas flaring. (Yakubu, 2017a). The South-southern Nigeria is richly blessed with abundant petroleum resources which have served as the leading source of income to the country over the years (Alani *et al.*, 2020). However, the petroleum exploration, drilling activities, and oil transportation in this region have generated activities such as oil spillage and gas flares and have led to a couple of environmental degradation (Alani *et al.*, 2020).

The Niger Delta region, location in Nigeria where largest underground deposits of oil and gas resources are highest is a great example of such an area where flaring activities occur on a regular basis (Ovuakporaye *et al.*, 2019). Ovuakporaye *et al.*, (2019) reported that the Niger Delta area is reputed for petroleum-rich oil, making up 7.5% of Nigeria's landmass.

Often pillaged by industrial waste activities of major oil exploration, the region spans 70,000 km2 (27,000 sq mi) area of land within the southern coast of the country, Nigeria. The effects of oil in fragile communities within the region have been reportedly enormous. According to the government of the federal republic of Nigeria; there were more than 70, 000 oil spills between 1970 and year 2000 with an estimated cleanup expected to span full restoration of creeks, mangroves, aquatic lives and swamps within a 25 years duration (Oseji 2011).

A large proportion (97%) of the revenue from foreign trade that comes to Nigeria is from export of crude oil (Alani *et al.* 2020). About 20% of the country's GDP and 65% of the revenue budget is sourced from crude oil and the vast deposit of crude oil are even more vast deposits of natural gas located in the Niger Delta (American Association for the Advancement of Science, 2011; Kharas *et al*., 2018).

Oil and gas exploration/exploitation was borne out of man's quest for economic emancipation, wealth creation and job opportunities (Egwurugwu *et al.*, 2013). Oil and gas exploration began in Nigeria in 1956 in the Niger Delta region of the country. Nigeria is the 6th largest producer of oil in the world and it is endowed with more gas reserves than oil (NNPC, 2011). The operations of the oil and gas industry include exploration, drilling, refining, distribution and marketing of the finished products to the consumers. During most of these activities, wastes are generated and discharged into the environment, either in solid, liquid or gaseous form (World Bank, 2012).

Nigeria is Africa's largest producer of crude oil and the sixth largest producer in the world (Oni and Oyewo, 2011; Ikeke, 2013; Egwurugwu *et al.*, 2013). Nigeria is currently ranked rated as one oil producing country in Africa and the 6th largest oil producer worldwide (Oni and Oyewo, 2011; Ikeke, 2013; Egwurugwu *et al.*, 2013) with the capacity to produce about 2.5 million barrels of

crude oil per day (Nigerian National Petroleum Corporation, 2015). Nigeria's oil production dates back to the 1950s when deposits were first discovered in Oloibiri in what is now known as Bayelsa state. Oil and natural gas extraction currently account for up to 97% of the country's revenue from foreign exchange, 20% of the country's GDP and 65% of budgetary revenue. The country is also blessed with huge deposits of natural gas.

1.2 Statement of Problem

The Niger Delta region in South-South Nigeria, on Africa's West Coast, is densely populated. The region, which contains a substantial stock of crude oil and natural gas, has been nicknamed "the engine room" for Nigeria's economic development and progress. It is responsible for up to 90% of the country's economic growth (or gross domestic product/GDP) (Nwilo & Badejo, 2006). However, the same region has witnessed unjustifiable environmental pollution arising from oil activities over the years of exploration and production which has orchestrated negative consequences on the Niger Delta ecosystem (Nwilo & Badejo, 2006). This has led to extended negative consequences on natural resources, which also have detrimental repercussions psychologically, ecologically, socially, economically, and physically which, in turn, impacts the overall health of the affected individuals (Nwilo & Badejo, 2006).

The environmental repercussions of oil spillage in the Niger Delta region are possibly the most catastrophic (Nwilo & Badejo, 2006). Toxins in hydrocarbons cause mortality in fauna and flora straight away and several other sublethal repercussions (Nwilo & Badejo, 2006). Animal studies indicate that contact with Nigerian crude oil could be hemotoxic and hepatotoxic, and could cause infertility and cancer (Adeduntan et al., 2013).

There is a significant amount of research on the environmental impacts of crude oil exploration in the Niger Delta. However, there is still a research gap in understanding the long-term health impacts of crude oil spills on the local population. Further research is needed to fully understand the extent of these impacts and to develop effective mitigation strategies.

2.0 METHODOLOGY

The methodology for this study involved conducting a literature search independently by the authors between October 22nd, 2021 and December 17th, 2021. The search was performed using several scientifically recognized databases, including PubMed, ScienceDirect, Google Scholar, Scopus, Cochrane, and African Journals Online. The search strategy involved using specific keywords to identify relevant studies on the health and environmental effects of oil and gas exploration in the Niger Delta region of Nigeria. In addition to searching electronic databases, other sources of information such as print media, student theses and dissertations were also consulted through manual searching. The inclusion criteria for the study specified that only scientific articles published within the last 5 years and written in English were considered. Studies that did not meet these criteria were excluded from the analysis.

3. DATA EXTRACTION AND SYNTHESIS

3.1 Data Extraction

After a systematic theoretical survey of the selected material, the consistency of the obtained information was evaluated according to the proposed subject. Thus, in order to test the conceptual hypothesis model, a theoretical study of the selected articles was performed based on the following sub-terms: (i) research site; (ii) petroleum exploration and its associated pollutants; (iii) type of analysed sample (air, water, soil, sediment, plants human blood and urine; (iv) described

Concentration; (v) exposure pathway and (vi) biological effect, biological effect on human health, and associated pathologies. Two reviewers independently screened the titles and abstracts of all identified retrieved articles, and then an agreement on articles to be reviewed in detail was reached. Meta-analysis was not done, since the reviewed studies were different in their design, focus, and implementations process.

3.1 Precursors of Environmental and Health Impacts of Oil and Gas Exploration in the Niger Delta

Air pollution is a significant risk factor for multiple health conditions, including respiratory infections, heart disease, and lung cancer (World Health Organization, 2011). Gas flaring is a process of releasing associated gases from refineries, wells, or hydrocarbon plants to dispose of these gases or as a safety measure to lessen pressure (Omoniyi & Ubale, 2015; Ubani & Onyejekwe, 2013). It has been estimated that over 170 trillion cubic feet of gas is produced in Nigeria and more than 70% is flared off (Ismail & Umukoro, 2012; Nwankwo & Ogagarue, 2011). Gas flaring is of major environmental concern due to emissions of greenhouse gases and toxic gases degradation (Alani et al., 2020). The United Nations Environment Programme (2011) reported that the oil wells in Nigeria are located in the Niger Delta States where environmental degradation and air pollution remain the greatest threats confronting the health of the individuals living in the region. The major sources of air pollution are fumes from vehicle exhausts and industries as well as oil and gas flaring (Kadafa, 2012). The greatest concern is the fact that residents of oil and gas producing communities are exposed to chronic, low-level emissions of gas flaring and oil polluted surfaces and underground water (Ite & Ibok, 2013). Long-term exposure to environmental pollutants carries more health risks than short-term exposure (Brook et al., 2010).

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous pollutants that have carcinogenic, mutagenic, and teratogenic effects on animals (Zhang et al., 2013). Gas flaring releases heavy metals from both natural and anthropogenic sources, which can have serious health hazards on organisms, including humans (Hui et al., 2017; Qu et al., 2018). Water sources from gas-flared areas have high levels of temperature, total chlorine, nitrate, nitrites, sulfates, and metals with a very acidic pH when compared with water from non-gas flared sources (Braide et al., 2016). Incomplete combustion during gas flaring releases many poisonous gases, including polycyclic aromatic hydrocarbons such as benzene, naphthalene, styrene, acetylene, fluoranthene, xylene, pyrene and ethylene (Egwurugwu et al., 2013a). Flaring also produces harmful emissions such as particulate matter like soot or black carbon which has adverse impacts on air quality (Nwafor, 2013).

Gas flaring released by oil exploration companies in Nigeria poses a significant hazard to the health of populations exposed to it, polluting the air and releasing greenhouse gases (Ite & Ibok, 2013). Nigeria is ranked as the 10th highest contributor to flaring of natural gas worldwide (U.S Energy Information Administration, 2015; Vidal, 2015). Gas flaring causes the release of greenhouse gases (GHG) and other air pollutants such as carbon dioxide (CO2), methane (CH4), ethane, propane, butane, hydrogen sulphide (H2S) and nitrous oxide (NO2) (Ajugwo, 2011). These gases serve as pollutants to air and water and precipitate the formation of acid rain, causing negative health outcomes in people exposed to gas-flaring activities (Ite & Ibok, 2013). Oil spills and gas flares pollutants/toxins cause increasing polluted air, contaminated water and soil (Agbalagba et al., 2013). However, the impact of prolonged exposure on the physiological functions of the body or the seriousness of the health problems in exposed groups are not yet understood (Nwafor et al., 2015).

3.2 Environmental Impacts of Oil and Gas Exploration in the Niger Delta

Oil exploration and gas flaring in Nigeria pose significant hazards to the health of populations exposed to it, polluting the environment and releasing greenhouse gases (Ite & Ibok, 2013). Gas flaring causes the release of greenhouse gases and other air pollutants, which can precipitate the formation of acid rain, causing a reduction in the pH of water and contamination with pollutants (Ajugwo, 2013; Efe & Mogborukor, 2014; Nwankwo & Ogagarue, 2011). Oil spills also contaminate soil, vegetation, and water sources, contributing to a reduction in the portability of drinking water (Hagras, 2013; Kponee et al., 2015; Taiwo et al., 2012).

Incomplete combustion during gas flaring can release combustion-related pollutants like PAHs and other volatile organic compounds into the atmosphere (Ite & Ibok, 2013). PAHs are ubiquitous pollutants that have carcinogenic, mutagenic, and teratogenic effects on animals (Zhang et al., 2013). Gas flaring is also accompanied by the release of heavy metals from both natural and anthropogenic sources. The concentrations of these metals are increased by anthropogenic activities such as gas flaring (Hui et al., 2017; Qu et al., 2018). Water sources from gas-flared areas have high levels of temperature, total chlorine, nitrate, nitrites, sulfates, and metals with a very acidic pH when compared with water from non-gas flared sources (Braide et al., 2016).

Gas flaring is the burning off of gas, which sends a cocktail of poisons into the atmosphere, including carbon dioxide and methane that are major causes of global warming. Pollutants released by gas flaring include carbon (IV) oxide (CO2), Nitrogen dioxide (NO2), hydrogen sulphide (HsS), benzene, butane, styrene, naphthalene, acetylene, fluoroanthene, anthrazene, pyrene, methane, ethane, propene, ethylene (U.S Energy Information Administration, 2018). Gas flaring can lead to emission of soot and other pollutants that can have deleterious effects on man, plants and the environment generally. It also raises the risk of respiratory ailments and cancer and can cause painful breathing, chronic bronchitis, decreased lung function, body itching, blindness, impotency, miscarriages and premature deaths (Friends of the Earth Nigeria, 2008).

3.3 Human Health Impacts of Oil and Gas Exploration in the Niger Delta

Chronic exposure to environmental pollutants, including those released through crude oil exploration and gas flaring, has been linked to a range of adverse health effects. These effects encompass chronic and recurrent respiratory diseases, cancers, dermatological diseases, abnormal hematological indices, blood dyscrasias, atherosclerosis, endothelial dysfunction, vasoconstriction, and hypertension (Ite and Ibok, 2013; Agency for Toxic Substances and Disease Registry (ATSDR), 2007). Benzene, naphthalene, xylene, particulate matter (PM10), and other pollutants have been associated with hematopoietic depression and alterations in red blood cell permeability (Adiembo and Nwafor, 2010; Owu et al., 2005). Gas flaring and crude oil refining have been linked to disruptions in sleep-wake cycles, causing neurological symptoms such as headache, neuralgia, insomnia, and hypertension (Egwurugwu et al., 2013; Jennrich et al., 2016). Moreover, the oxidative stress and inflammation caused by pollutants can contribute to insulin resistance, metabolic disturbance, and apoptosis, potentially leading to diabetes and related health issues (Wilkinson et al., 2012; Liu et al., 2016).

Gas flaring releases pollutants like carbon dioxide, methane, hydrogen sulfide, benzene, and other volatile organic compounds, causing temperature increases in affected communities (Friends of the Earth Nigeria, 2008). This elevated temperature can lead to chronic dehydration, decreased plasma volume, increased blood viscosity, and elevated blood pressure (Egwurugwu et al., 2013). Heavy metals found in high proportions in gas-flared environments, such as lead, arsenic, cadmium, and others, can contaminate soil and water, contributing to the elevation of blood pressure and other health issues (Egwurugwu et al., 2013; Satarug et al., 2010). Noise pollution, another consequence of gas flaring, has been associated with cardiovascular diseases, hearing loss, sleep disruption, and increased drug use (Goines et al., 2007; Heinonen-Guzejev et al., 2007). The cumulative effects of these environmental stressors have led to increased blood pressure, blood sugar, and body mass index among Nigerians living in gas-flaring environments (Ngwu et al., 2019; Ovuakporaye et al., 2019).

The extensive prevalence of gas flaring in the Niger Delta region poses significant environmental and health challenges. The continuous release of pollutants into the atmosphere from gas flaring activities contributes to environmental damage, health risks, and reduced quality of life (Ovuakporaye et al., 2019). As Nigeria ranks among the highest contributors to gas flaring globally, with about 70 million m^3 per day and multiple gas flaring sites, the associated health implications remain a pressing concern (Ovuakporaye et al., 2016; Egwurugwu and Nwafor, 2013). These findings underscore the need for stricter regulatory measures and efforts to minimize gas flaring to mitigate the detrimental effects on both human health and the environment.

Hypertension and Diabetes

Nwafor et al. (2015) posited that there is a complex interplay in health risks and substantial increases in non-communicable diseases like high blood pressure, raised blood glucose, and overweight-obese are emerging increasingly as physiological, medical, and public health importance in the 21st century. The World Health Organization (2014) noted that non-communicable diseases disproportionately affect low- and middle-income countries, with the

current projection indicating that by 2020 the largest increases in non-communicable disease deaths will occur in Africa.

Gupta et al. (2011) reported that social determinants and drivers of non-communicable diseases are attributable to environmental factors such as alcohol consumption, psycho-social stress, levels of physical activity and genetic factors, rapid unplanned urbanization, globalization, aging, race or ethnicity. These subsequently influence behavioral risk factors such as unhealthy lifestyles, diets, and increasingly sedentary lifestyles which show up in individuals as intermediate, metabolic or modifiable risk factors - raised blood pressure, increased blood glucose, overweight and obesity. These eventually lead to adverse cardiovascular diseases and other complications (World Health Organization, 2014). The Niger Delta region of Nigeria is the largest oil producer in Africa and the most polluted region in the world (Insider Monkey, 2014). Many tons of man-made unrelated chemicals of technological origins are produced by oil and gas explorations and exploitations and released into the environment (Nwafor et al., 2015).

Cardiovascular Disease

Ovuakporaye et al. (2019) conducted a study that compared markers of cardiovascular and respiratory functions in residents of common flaring sites within the Niger Delta States of Edo, Rivers, Akwa Ibom, Bayelsa, and Delta; south-south Nigeria. The author observed that prolonged exposure to gas flaring increased mean blood pressure with a decreased mean peak expiratory flow rate across sampled communities. Gender-dependent variation was also seen to vary across communities, implying that gas flaring impact is gender and duration dependent.

Egwurugwu and Nwafor (2013) conducted a study to assess the impacts of prolonged exposure to oil/gas flares on blood pressure measures in humans in the Niger Delta Region of Nigeria. The results showed that the test group subjects had a statistically significant increase in systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial blood pressure (MAP) compared with the control ($p<0.05$). Nwafor et al. (2015) evaluated the prevalence and the relationship between blood pressure, blood glucose, and body mass index, and the tendency of developing prehypertension and pre-diabetes in rural adults in the Niger Delta region. The results indicated that males had a higher prevalence of high blood pressure and raised blood glucose compared with females ($p<0.05$). Data analysis revealed positive and linear correlation and statistically significantly different ($p<0.001$) in the varying degree of complex association of blood pressure and blood glucose as well as body mass index.

The risk of cardiovascular disease (CVD) is influenced by non-modifiable factors such as age and sex, and by modifiable factors linked to lifestyle and behaviour. This study was done to determine the predictors of CVD risk among judiciary staff in Port Harcourt Nigeria using a descriptive cross-sectional design via a WHO STEPS instrument. The results of the sttudy of the study revealed that a total of 226 judiciary workers participated in the survey, 130 (57.5%) males and 96 (42.5%) females. Mean age was 43.15 years (S. *D* = 8.45). One hundred and fourty- four (63.7%) had hypertension, 148 (65.5%) were overweight/obese, and 122 (54.0%) were diabetic or at risk of diabetes. Alcohol use, risk of hypertension, diabetes, salt consumption, poor intake of fruits and

physical inactivity, strongly predicted both moderate and high risk of CVD ($p < 0.001$). Being overweight or obese, predicted moderate risk only ($p < 0.001$) while age predicted high risk only ($p = 0.01$). Based on the results of the study, it was concluded that The demonstrated predictors of moderate and high risk of CVD among judiciary staff in Port Harcourt infers a need for implementation of the WHO 'best buys' strategies mainstreamed into workplace-friendly health promotion policies and interventions that facilitate lifestyle modifications among these professionals.

3.5 Air Pollutants and the Prevalence of Non-Communicable Diseases in the Niger Delta

Several researchers have reported a relationship between air pollution and non-communicable diseases like hypertension, diabetes mellitus, and blood lipids (Foraster et al., 2014; Coogan et al., 2012; Dong & Qian, 2013; Chuang et al., 2011). Gas flaring causes an increase in temperature (Oseji, 2011) and increase in temperature causes persistent and chronic dehydration among residents of gas flaring communities. The dehydration occasioned by the persistent heat causes reduced blood volume, an increase in blood viscosity, and increase in blood pressure which is further aggravated by the poor water available in the Region (Egwurugwu et al., 2013). Flared gas is one of such wastes generated in the oil and gas industry that should be turned into wealth creation and improving sustainable development but allowed to waste and pose health hazards. Gas flaring is one anthropogenic activity that causes global warming, disequilibrium of the earth, unpredictable weather changes, and major natural disasters because it emits a cocktail of benzene and other toxic substances that are harmful to humans, animals, plants, and the entire physical environment (Anaq, 2011).

Ovuakporaye et al. (2019) conducted a study that compared markers of cardiovascular and respiratory functions in residents of common flaring sites within the Niger Delta States of Edo, Rivers, Akwa Ibom, Bayelsa, and Delta; south-south Nigeria. The author observed that prolonged exposure to gas flaring increased mean blood pressure with a decreased mean peak expiratory flow rate across sampled communities. Egwurugwu and Nwafor (2013) conducted a study to assess the impacts of prolonged exposure to oil/gas flares on blood pressure measures in humans in the Niger Delta Region of Nigeria. The results showed that the test group subjects had a statistically significant increase in systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial blood pressure (MAP) compared with the control ($p<0.05$). Nwafor et al. (2015) evaluated the prevalence and the relationship between blood pressure, blood glucose, and body mass index, and the tendency of developing prehypertension and pre-diabetes in rural adults in the Niger Delta region. The results indicated that males had a higher prevalence of high blood pressure and raised blood glucose compared with females ($p<0.05$). Data analysis revealed positive and linear correlation and statistically significantly different ($p<0.001$) in the varying degree of complex association of blood pressure and blood glucose as well as body mass index.

Chronic exposure to products of gas flares and/or their biotransformed forms affects the kidney as it is sensitive to such heavy metals as cadmium, mercury, lead, and halogenated hydrocarbons (Egwurugwu et al., 2013a). Empirical evidence has revealed that exposure to particulate matter

affects blood pressure and the underlying physiological mechanism which eventually leads to increased cardiovascular risk like distorted circadian rhythms of renal sodium handling and blood pressure (Tsai et al., 2012). High blood pressure can also raise serum uric acid (SUA) through elevated serum lactate levels. This is caused by hypertension which initially produces renal microvascular disorders with local tissue hypoxia and the lactate lowers tubular secretion of uric acid, causing increased serum levels (Bickel et al., 2002).

Tedla et al. (2011) reported that the rise in hypertension of the exposed individuals in oil explored areas could also be linked to the effect of gas flare on the kidneys. Chronic dehydration has also been connected with prolonged exposure to oil and gas flares because of its effect on the kidney and renal perfusion and persistent dehydration have also been reported to cause elevated urea level (Tedla et al. 2011). It has been observed that gas flaring is connected to noise pollution from blazing fire, vehicular, human traffic, and movement of heavy-duty machinery. The associated noise pollution could contribute significantly to cardiovascular disease and hearing loss, sleep disturbance, reduced productivity, impaired teaching and learning, absenteeism, increased drug use, and accidents (Goines and Hagler, 2007).

Gas Flaring and Pulse Rate

Oil spills and gas flaring are common occurrences in crude oil-producing communities, causing economic wastage as well as major health problems to communities hosting oil wells and natural gas (Johnson et al., 2019; Oladipupo et al., 2016; Kadafa¸ 2012; Adelana et al., 2011). Environmental degradation from crude oil exploration and extraction activities have posed significant health risks to residents in oil-rich regions, with some population sub-groups, like pregnant women, being more vulnerable (Oghenetega et al., 2020). Maternal exposure to environmental toxicants poses a major risk to health by posing negative impacts on fetal health and development (Sly et al., 2016). There is a plethora of evidence that has implicated maternal exposure to oil pollutants with increased risk of miscarriage, intrauterine growth restriction, low birth weight, birth defects, gestational diabetes mellitus, maternal depression, motor and cognitive delays in children (Harville et al., 2017; Balise et al., 2016; Rung et al., 2016).

Irikefe et al. (2016) reported that gas flaring caused an increase in pulse rate of children in gas flaring communities compared with non-gas flaring communities. Adienbo et al. (2013) also reported an increase in pulse rate among solid waste workers in Port Harcourt and attributed it to possible physiologic haemodynamic instability resulting from exposure to chemicals present in a gas flare. Irikefe et al. (2016) also reported a significant increase in the respiratory rate of male and female children and adult males and female residents in gas flaring communities when compared with those of non-gas flaring communities, especially in those with longer duration of exposure in the Niger Delta, Nigeria.

Table 1: Prevalence of Diseases in the Niger Delta Due to Oil and Gas Exploration

S/N	Disease	Risk Factor	Author	Location
1.	Cardio-vascular and pulmonary abnormalities.	Gas flaring and oil spillage	Oseji, 2011, Ovuakporaye *et al.* 2019,	Umutu-Ebedei gas plant in Delta State, Edo, Rivers, Akwa Ibom, Bayelsa and Delta States;
4.	Spontaneous abortion	Hydrogen sulphide	Ovuakporaye *et al.* (2019)	Rivers, Akwa Ibom, Bayelsa and Delta States;
5.	Increases the blood pressure, blood sugar and body mass index.	Gas flaring	Ngwu *et al.* (2019)	Imo State, Niger Delta
7.	Increase in atmospheric temperature, greenhouse gases emission, acid rain, global warming and transmission of diseases	Gas flaring	(Adiembo and Nwafor, 2011).	Niger Delta
8.	Chronic and recurrent respiratory disease, cancers, dermatological diseases, abnormal haematological indices and blood dyscrasias, artherosclerosis, endothelial dysfunction and vasoconstriction.	Carbon (IV) oxide (CO2), Nitrogen dioxide (NO2), hydrogen sulphide (HsS), benzene	Agency for Toxic Substances and Disease Registry (ATSDR) (2007)	Niger Delta
11.	(**Health Effects**) Neurological symptoms	Flared gas such as dioxin, 2,3,7,8-	(Dettoni *et al.*, 2013).	Niger Delta

	like headache, neuralgia and insomnia	tetrachlorodibenzo-p-dioxin		
12.	Sleep deprivation which causes significant increase in catecholamine levels and sympathetic activity and hence hypertension	dioxin, 2,3,7,8-tetrachlorodibenzo-p-dioxinv	(Dettoni *et al.*, 2013).	Niger Delta
	Non-Communicable Disease			
13.	Hypertension, diabetes mellitus and blood lipids	Air pollutants	(Foraster *et al.*, 2014)	
14.	Direct elevation of systemic arterial blood pressure.	Particulate matter	(Coogan *et al.*, 2012).	
15.	Diabetes	NO_2 and particulate matter	(Kramer *et al.*, 2010).	
16.	Increased inflammation, oxidative stress, endothelial function, and cardiovascular disease risk factors like high blood pressure, diabetes and obesity.	Air pollution	Tashi *et al.* (2018)	
17.	Hypertension and other cardiovascular risk factors like hyperlipidaemia and diabetes mellitus.	Air pollution	Adeloye *et al.*, 2015; Ogah *et al.*, 2012; Amira *et al.*, 2012; Kpenyong *et al.*, 2012	

19.	Affected sleep wake cycle, sleep loss, stress and hypertension	Gas flaring	Ovuakporaye *et al.*, (2016); (Perry *et al.*, 2011).	Niger Delta
20.	Deprived sleep and an accompanied increased blood pressure, rise in serum nor-epinephrine, sympathetic activity and venous endothelial dysfunction, lowered plasma angiotensin II concentration, elevated renal sympathetic nerve activity and possibly hypertension.	Gas flaring	Detton *et al.* (2012); Perry *et al.*, 2011).	Niger Delta
21.	Hypertension and diabetes via induction of systemic inflammation, oxidative stress and triggering of autonomic nervous system imbalance.	Particulate matter	(Brook *et al.*, 2004).	Niger Delta
22.	Alterations in adipokines and systemic inflammation, vasoconstriction and hypertension by triggering autonomic nervous system imbalance; vasoconstriction in humans and reduction of insulin sensitivity.	Particulate matter 2.5	Brook *et al.* 2008); Peretz *et al.* (2008).	Niger Delta
23.	Systemic stress response, increased levels and or bioactivity via vasoactive mediators and the	Particulate matter	Peretz *et al.*, 2008).	Niger Delta

	translocation of other soluble particulate constituents into the systemic circulation are other possible and unstable blood sugar and blood pressure			
34.	**(Human Health Impacts**) Cardiopulmonary system problems	Poor air quality	(WHO, 2011).	
35.	Painful breathing, chronic bronchitis, decreased lung function, body itching, blindness, impotency, miscarriages and premature deaths.	Air pollutants like Benzene, Toluene, Xylene, Particulate matter, Hydrogen sulphide, Styrene, Nitrogen oxide, sulphur dioxide.	(Friends of the Earth Nigeria, 2008).	
36.	Increase in systolic blood pressure and dystolic blood pressure; cardiovascular disorders; sleep loss; significant rise in serum norepinephrine and sympathetic activity, venous endothelial dysfunction and hypertension (Dettoni *et al.*, 2012); Sleep loss lowered plasma angiotensin II concentrations, raised renal sympathetic nerve activity and probably increase in blood pressure.	Gas flaring; particulate matter, Carbon monoxide	Egwurugwu *et al.* 2013; Adienbo 2013; Jennrich 2013; Perry *et al.*, 2011.	

38.	Chronic and recurrent respiratory diseases, abnormal haematological indices and increased susceptibility to blood dyscrasias, dermatological diseases and malignancies	Gas flaring	Ite and Ibok, 2013	

4 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

This review has revealed a myriad of human and environmental impacts of oil and gas exploration in the Niger delta. However, the presence of persistent oil and gas exploration in the region has plagued the area with persistent pollutants of various categories. Various substances that threatens the livelihood of the people, as well as other fauna and flora have been identified. Furthermore, the review has shown that the region is characterized by diversities of communicable and non-communicable diseases which have made livelihood in the region disadvantageous.

Environmentalists should consider the impacts of oil exploration on the environment, including air and water pollution, habitat destruction, and greenhouse gas emissions (Johnson et al., 2019; Oladipupo et al., 2016; Kadafa¸ 2012). They should also consider the impacts on human health, such as exposure to toxic chemicals and increased risk of respiratory and cardiovascular diseases (Oghenetega et al., 2020). To mitigate these impacts, environmentalists can recommend measures such as stricter regulations on emissions and waste disposal, increased monitoring and enforcement, and the adoption of cleaner technologies (UNEP IE, n.d.).

The United Nations Environment Programme (UNEP) has established its Industry and Environment office (UNEP IE) to promote environmentally sound industrial development. Its goals include encouraging the incorporation of environmental criteria in industrial development plans, facilitating the implementation of procedures and principles for the protection of the environment, promoting preventive environmental protection through cleaner production and other pro-active approaches, and stimulating the exchange of information and experience throughout the world (UNEP IE, n.d.).

4.2 Recommendation

To mitigate the environmental and health impacts of crude oil exploration in the Niger Delta, several recommendations were made. These include:

1. Stricter regulations on emissions and waste disposal: Governments and regulatory bodies should enforce stricter regulations on emissions and waste disposal from oil exploration activities to reduce air and water pollution.

2. Increased monitoring and enforcement: There should be increased monitoring and enforcement of regulations to ensure that oil companies comply with environmental standards and are held accountable for any violations.
3. Adoption of cleaner technologies: Oil companies should be encouraged to adopt cleaner technologies and practices to reduce their environmental footprint. This can include measures such as reducing gas flaring, improving waste management, and using less polluting methods of oil extraction.
4. Community engagement and compensation: Oil companies should engage with local communities to address their concerns and provide fair compensation for any damages caused by oil exploration activities.
5. Investment in healthcare and environmental remediation: Governments and oil companies should invest in healthcare and environmental remediation in communities affected by oil exploration to mitigate the negative impacts on human health and the environment.

4.3 Contribution to Theory, Policy, and Practice

In terms of theoretical implications, This study helps advance our understanding of the complex interplay between human activities, the environment, and human health. This study can inform the development of more effective policies and practices to mitigate the negative impacts of oil exploration while maximizing its benefits. This study can help advance our understanding of the complex interplay between human activities, the environment, and human health. It informs the development of more effective models and frameworks for analyzing and addressing the negative impacts of oil exploration while maximizing its benefits.

In terms of policy, this study can provide valuable evidence to support the development of more effective regulations and policies to mitigate the negative impacts of oil exploration. For example, policymakers can use the findings of this study to develop stricter regulations on emissions and waste disposal, increased monitoring and enforcement, and incentives for the adoption of cleaner technologies.

In terms of practice, this study can inform the development of more effective strategies and interventions to mitigate the negative impacts of oil exploration on the environment and human health. For example, environmentalists and public health practitioners can use the findings of this study to design and implement programs to reduce air and water pollution, protect habitats, and promote public health in communities affected by oil exploration. These efforts can help improve the health and well-being of residents in these communities while also protecting the environment for future generations.

REFERENCES

Aaron KK. (2006). Human Rights Violation and Environmental Degradation in the Niger- Delta, In Elizabeth Porter and Baden Offord (eds), Activating Human Rights, Oxford, Barne, New York.

Adeloye D, Basquill C, Aderemi AV, Sompson JY, Obi FA. (2015). An estimate of the prevalence of hypertension in Nigeria: a systematic review and meta-analysis. *J Hypertens.* Vol. 33 230–242.

Adiembo OM, Nwafor A. (2010). Effect of Prolonged Exposure to Gas Flaring on Some Haematological Parameters of Humans in the Niger Delta Region of Nigeria. *Journal of Applied Science and Environmental Management*, Vol. 4(1): 13-15.

Adienbo, O.M. (2013). Correlation between body mass index and peak expiratory flow rate of an indigenous Nigerian population in the Niger Delta Region. R*esearch Journal of Recent Sciences.* Vol. 2(2):28-32.

Agbalagba EO, Avwiri GO, Ononugbo CP. (2013). Activity concentration and radiological impact assessment of 226 Ra, 228 RA and 40 K in drinking waters from (OML) 30, 58, and 61 oil fields and host communities in Niger Delta regions of Nigeria. *J. Environ. Radio.* Vol. 116. 197-200.

Agbalagba, E. O., Agbalagba, O. O., & Ononugbo, C. P. (2013). Evaluation of natural radionuclides and their radiological impact in oil contaminated soil samples from oil fields in Delta State Nigeria. Journal of Environmental Radioactivity.

Agency for Toxic Substances and Disease Registry (ATSDR) (2007): Toxicological Profile for Benzene (update).US Department of Health and Human Services, Atlanta, Georgia 200-2004-09793,1-415.

Ajugwo, A. O. (2011). Negative effects of gas flaring: The Nigerian experience. Journal of Environment Pollution and Human Health.

Alani, R., Obi, C. N., & Adeyemo, O. K. (2020). Gas flaring and its implication for environmental accounting in Nigeria. Journal of Environmental Accounting and Management, 8(1), 67-80.

American Association for the Advancement of Science (2011). World population and human capital in the twenty-first century.

Amira CO, Sokunbi DOB, Sokunbi A. (2012). The prevalence of obesity and its relationship with hypertension in an urban community: Data from world kidney day screening programme. I*nter. J. Med. Biomed. Res.* Vol. 1(2):104-110.

Anderson GL, Kaufman JD (2007). "Long-term exposure to air pollution and incidence of cardiovascular events in women". *N Engl J Med* Vol. 356: 447-458.

Bell, M.L., Belanger, K., Ebisu, K., Gent, J.F., Lee, H.J., Koutrakis, P. and Leaderer, P.B. (2010) Prenatal Exposure to Fine Particulate Matter and Birth Weight. Epidemiology, 21, 884-891.

Bickel C, Rupprecht HJ, Blankenberg S, Rippin G, Hatner G, Daunhauer A. (2002) Serum uric acid as an independent predictor of mortality in patients with angiographyically proven coronary artery disease. *American Journal of Cardiology*. 2002;89:12-7.

Braide, S. A., Oranusi, S. U., & Akobondu, C. I. (2016). Physicochemical properties of water samples from oil producing areas in Rivers State Nigeria. Journal of Environmental Science and Water Resources, 5(1), 1-6.

Brook R.D, Franklin B, Cascio W, Hong Y, Howard G, Lipsett M, Luepker R, Mittleman M, Samet J, Smith SC Jr, Tager I. (2004). Air pollution and cardiovascular disease: A statement for healthcare professionals from the expert panel on population and prevention science of the American Heart Association. *Circulation*. Vol. 109. 2655–2671.

Brook RD. (2008). Cardiovascular effects of air pollution. *Clinical Science*, Vol. 115. 175–187.

Brook, R. D., Rajagopalan, S., Pope III, C. A., Brook, J. R., Bhatnagar, A., Diez-Roux, A. V., … & Peters, A. (2010). Particulate matter air pollution and cardiovascular disease: An update to the scientific statement from the American Heart Association. Circulation, 121(21), 2331-2378.

Chuang KJ, Yan YH, Chiu SY. (2011). Long-term air pollution exposure and risk factors for cardiovascular diseases among the elderly in Taiwan. *Occup Environ Med*, 2011; 68:64–8.

Coogan PF, White LF, Jerrett M. (2012). Air pollution and incidence of hypertension and diabetes mellitus in black women living in Los Angeles. *Circulation.* Vol. 125:767–72.

Dettoni JL, Consolim-Colombo FM, Drader LF, Rubira MC, Morstarda C, Borile S, Krieger ME, Moreno H, Lorenzi-Fillio G. (2012). Cardiovascular effect of partial sleep deprivation in healthy volunteers. Journal of Applied Physiology, Vol. 113(2): 226-232.

Dong GH, Qian ZM, Xaverius PK. (2013) Association between long-term air pollution and increased blood pressure and hypertension in China. Hypertension, 61:578–84.

Dugandzic, R., Dodds, L., Stieb, D. and Smith-Doiron, M. (2006) The Association between Low-Level Exposures to Ambient Air Pollution and Term Low Birth Weight: A Retrospective Cohort Study. Environmental Health: A Global Access Science Source, 5, 3.

Egwurugwu JN, Nwafor A, Chinko BC, Oluronfemi OJ, Iwuji SC, Nwankpa P. (2013) Effects of prolonged exposure to gas flares on the lipid profile of humans in the Niger Delta Region, Nigeria. American Journal of Research Communication. Vol. 1(5): 115-145.

Egwurugwu JN, Nwafor A, Ezekwe S. (2013). Effects of prolonged exposure to gas flares on the lipid profile of humans in the Niger delta region, Nigeria. Arch Appl Sci Res, Vol.5:98–104.

Egwurugwu JN, Nwafor A, Nwankpa P, Olorufemi OJ, Okwara JE. (2013). Prolonged gas flaring and water quality in Obiakpu, Egbema Imo State Nigeria. *International Research Journal Environmental Science*, Vol. 2(4):1-5.

Egwurugwu JN, Nwafor A. (2013). Prolonged Exposure to Oil and Gas Flares Ups the Risks for Hypertension. *American Journal of Health Research*, Vol. 1(3):65-72.

Egwurugwu, J. N., Nwafor, A., Oluronfemi, O. J., Iwuji, S. C., & Alagwu, E. A. (2013a). Health impact of gas flares on Igwuruta/Umuechem communities in Rivers State. Journal of Natural Sciences Research, 3(9), 147-154.

Egwurugwu, J. N., Nwafor, A., Oluronfemi, O. J., Iwuji, S. C., & Alagwu, E. A. (2013). Health impact of gas flares on Igwuruta/Umuechem communities in Rivers State. Journal of Natural Sciences Research.

Ekpenyong CE, Udokang NE, Akpan EE, Samson TK. (2012). Double burden, non-communicable diseases and risk factors evaluation in Sub-Saharan Africa: The Nigerian experience. *European J. Sus. Dev.* Vol. 1(2):249-270.

Foraster M, Basagaña X, Aguilera I. (2014). Association of long-term exposure to traffic-related air pollution with blood pressure and hypertension in an adult population-based cohort in Spain (the REGICOR study). *Environ Health Perspect.* Vol. 122:404–11.

Friends of the Earth Nigeria. (2008). *Fact sheet: Harmful gas flaring in Nigeria.* Printed in Netherlands. 1-3.

Goines L, Hagler L. (2007). Noise pollution: a modern plaque. *Southern Medical Journal.* 100(3):287-294.

Gupta AK, Brashear MM, Johnson WD. (2011). Coexisting pre hypertension and prediabetes in health adults: A pathway for accelerated cardiovascular events. *Hypertension Research* Vol. 34:456-461.

Heinonen-Guzejev M, Vuorinen HS, Mussalo-Rauhamaa H, Heikkila K, Koskenvuo M, Kapiro J. (2007). The association of noise sensitivity with coronary heart and cardiovascular mortality among Finnish adults. *Science of Total Environment.* Vol. 372:406-412.

Hui, L., Qu, L., Zhang, Y., & Zhang, G. (2017). Heavy metal pollution and health risk assessment in the Wei River in China. Environmental Science and Pollution Research International.

Idodo-Umeh G, Ogbeibu AE. (2010). Bioaccumulation of the Heavy Metals in Cassava Tubers and Plantain Fruits Grown in Soils Impacted with Petroleum and Non- petroleum activities. *Research Journal of Environmental Sciences,* 2010; 4:33- 41.

Ikeke MO. (2013). Thomas Berry's idea of technological transformation, its relevance to the management of oil technology in Nigeria' s Niger delta. *Thought Pract Assoc Kenya,* 2013; 5:141-58.

Ikeke, M. (2013). The impact of oil spills on the environment and human health: A case study of Niger Delta region of Nigeria.

Insider Monkey. (2014). *The 10 most polluted countries in the world*. Available at www.insidermonkey.com

Irigoyen MC, Morstarda C, Borile S, Krieger EM, Moreno H, Lorenzi- Fillio G. (2012). Cardiovascular effects of partial sleep deprivation in healthy volunteers. *Journal of Applied Physiology.* 113(2):226- 232.

Ismail, O. S., & Umukoro, G. E. (2012). Global impact of gas flaring. Energy and Power Engineering, 4(4), 290.

Ite, A. E., & Ibok, U. J. (2013). Gas flaring and venting associated with petroleum exploration and production in the Nigeria's Niger Delta. American Journal of Environmental Protection, 1(4), 70-77.

Jennrich P. (2013). The influence of arsenic, lead, and mercury on the development of cardiovascular diseases. *Hypertension* . ISRN ID234034.

Joffa PKP, Nwafor A, Adienbo MO. (2013). Correlation between body mass index and peak expiratory flow rate of an indigenous Nigerian population in the Niger Delta region. *Resea. J. Recent Sci.* ;2(2): 28-32.

Kadafa AA. (2012). Environmental impacts of oil exploration and exploitation in the Niger Delta of Nigeria. *Glo J Sci Front Res.* Vol. 12:19–28.

Kadafa, A. A. (2012). Oil exploration and spillage in the Niger Delta of Nigeria. Civil and Environmental Research, 2(3), 38-51.

Kharas, H., Hamel, K., & Hofer, M. (2018). The start of a new poverty narrative.

Kramer U, Herder C, Sugiri D, Strassburger K, Schikowski T, Ranft U, Rathmann W. (2010). Traffic-related air pollution and incident type 2 diabetes: Results from the SALIA cohort study. *Environ Health Perspect.* 118:1273–1279.

Liu C, Yang C, Zhao Y. (2016). Associations between long-term exposure to ambient particulate air pollution and type 2 diabetes prevalence, blood glucose and glycosylated hemoglobin levels in China. *Environ Int.* 92–93: 416-42.

Miller KA, Siscovick DS, Sheppard L, Sheppard K, Sullivan JH. (2007) Long-term exposure to air pollution and incidence of cardiovascular events in women. *N Engl J Med* 356: 447-458.

Modesti PA, Morabito M, Massetti L, Rapi S, Orlandini S, Mancia G, Gensini GF, Parati G. (2013). Seasonal blood pressure changes: an independent relationship with temperature and daylight hours. *Hypertension,* Vol. 61(4):908-14.

Ngwu EE, Ekweogu CN., Egwurugwu JN., Ohamaeme MC, Ugwuezumba PC, Nwankpa P., Alagwu EA., Ogunnaya UF. and Chukwuemeka OG. (2019). Comparative Assessment of Body Mass Index, Blood Pressure and Blood Sugar levels among Residents in Gas-Flaring and Non-Gas-Flaring Communities in Imo State. *African Journal of Medical and Applied Sciences,* 1(1):25-43.

Nigerian National Petroleum Corporation (2015). Annual statistical bulletin.

Nigerian National Petroleum Corporation (2015). *Oil Production in Nigeria.* http://www.nnpcgroup.com/nnpcbusiness/upstreamventures/oilproduction.aspx (accessed 7 December 2018).

Nwafor, A., Mmom, F. C., Obia, O., Obiandu, C., Hart, V. O. and Chinko, B. C. (2015). Relationship between Blood Pressure, Blood Glucose and Body Mass Index and Coexisting Prehypertension and Prediabetes among Rural Adults in Niger Delta Region, Nigeria. *British Journal of Medicine & Medical Research*, 9(7): 1-12, 2015, Article no.BJMMR.14777.

Nwafor, O. M. (2013). Gas flaring and its implications for environmental accounting in Nigeria: Evidence from the Niger Delta Region. Journal of Environment and Earth Science.

Nwafor, O. M., Nwankwoala, H. O., & Nwankwoala, M. O. (2015). Environmental impacts of oil exploration and exploitation in the Niger Delta of Nigeria. Global Journal of Science Frontier Research Environment & Earth Science.

Nwankwo, C. N., & Ogagarue, D. O. (2011). Effects of gas flaring on surface and ground waters in Delta State Nigeria. Journal of Geology and Mining Research, 3(5), 131-136.

Ogah OS, Okpechi I, Chukwuonye II, Akinyemi JO, Onwubere BJ, Falase AO, Stewart S, Sliwa K. (2012). Blood pressure, prevalence of hypertension and hypertension related complications in Nigerian Africans: a review. *World J Cardiol* Vol. 4:327–340.

Oghenetega, O.B., Ana, G.R.E.E., Okunlola, M.A. and Ojengbede, O.A. (2020) Oil Spills, Gas Flaring and Adverse Pregnancy Outcomes: A Systematic Review. Open Journal of Obstetrics and Gynecology, 10, 187-199.

Omoniyi, T., & Ubale, M. (2015). Gas flaring in Nigeria: Analysis of changes in its consequent carbon emission and reporting. Accounting Forum, 39(2), 150-161.

Oni SI, Oyewo MA. (2011). Gas flaring, transportation and sustainable energy development in the Niger-Delta, Nigeria. *J Hum Ecol*, 2011; 33:21–8.

Orubu CO. (2002). Oil industry activities, environmental quality, and the paradox of poverty in Niger Delta. In: The Petroleum Industry, the Economy and the Niger Delta Environment. (Eds). 17-31.

Oseji OJ (2011) Environmental impact of gas flaring within Umutu-Ebedei gas plant in Delta State, Nigeria. *Arch Appl Sci Res* 3: 272-279.

Ovuakporaye SI, Enaohwo MT, Odigie OM, Igweh JC (2019). A Comparative Study on Cardio-pulmonary Markers in Gas Flaring Communities, South-South Nigeria. *J Pulm Respir Med* 9: 486. doi: 10.4172/2161-105X.1000486.

Ovuakporaye SIL, Igweh C, John I, Aloamaka CP. (2016). Impact of Gas Flaring on Cardiopulmonary Parameters of Residents in Gas Flaring Communities in Niger Delta Nigeria. *British Journal of Medicine & Medical Research*, 15(6): 1-13.

Owu DU, Udoete UB, Azah N, Eyong EU. (2005). Effects of Bony Light crude oil on some haemtological parameters of Guinea pigs. *Biokemistri*, 2005; 17 (2): 165-170.

Peretz, A, Sullivan JH, Leotta DF, Trenga CA, Sands FN, Allen J, Carlsten C, Wilkinson CW, Gill EA, Kaufman JD. (2008). Diesel exhaust inhalation elicits acute vasoconstriction in vivo. *Environ Health Perspect*. 116:937–942.

Perry JC, Bergamaschi CT, Campos RR, Andersen ML, Montano N, Casarini DE, Tufik S. (2011). Sympathetic and Angiotensinergic responses mediated by paradoxical sleep loss in rats. *Journal of renin-angiotensin- aldosterone system.* DOI:10.1177/1470320310391504.

Qu, C., Albanese, S., Chen, W., Lima, A., & Zuzolo, D. (2018). Heavy metal contamination in soils from a mining area in the South of China: Spatial distribution and health risk assessment. Environmental Science and Pollution Research International.

Rajagopalan S, Brook RD. (2012). Air pollution and type 2 diabetes: mechanistic insights. Diabetes. 61: 3037-3045.

Rosner MH, Bolton WK. (2006). Renal function testing. *American Journal of Kidney Diseases*, 47(1):174-183.

Satarug S, Scott H, Sens GMA, Sens DA. Cadmium, (2010). Environmental Exposure, and Health Outcomes. *Environmental Health Perspective*, 118(2): 182–190.

Sram, R.J., Binkova, B., Dejmek, J. and Bobak, M. (2005). Ambient Air Pollution and PregnancyOutcomes: A Review of the Literature. *Environmental Health Perspectives*, 113, 375-382.

Sughis M, Nawrot TS, Ihsan-ul-Haque S. (2012). Blood pressure and particulate air pollution in schoolchildren of Lahore, Pakistan. *BMC Public Health*, 12:378.

Tashi D, Xiaoqi F, Stephanie C, Thomas Astell-Burt. (2018). Environmental risk factors for developing Type 2 diabetes mellitus: A systemic review. *Int. J. Environ. Res. Public Health*. 15,78,doi:10.3390/ijerph15010078.

Tedla FM, Brar A, Browne R, Brown C. (2011). Hypertension in chronic disease: Navigating the Evidence. *International Journal of Hypertension*, Article ID 132405,9 pages. Doi:10,4061/2011/132405.

Tsai DM, Riediker G, Wuerzner M, Maillard P, Marques VP, Paccaud F. (2012). Short term increase in particulate matter blunts nocturnal blood pressure dipping and daytime urinary sodium excretion. *Hypertension.* 60:1061-1069.

U.S Energy Information Administration (EIA). (2015). Nigeria: Country Analysis Brief Overview. *US EIA Independent statistics and analysis,* :1–20. http://www. eia. gov/ countries/ country- data. cfm? fips= ni (accessed 7 December 2018).

Ubani, E.C., & Onyejekwe I.M.(2013). Environmental impact analysis of gas flaring in the Niger Delta region of Nigeria. American Journal of Scientific and Industrial Research.

United Nations Environment Programme. Environmental Assessment of Ogoniland (2011). <http://www.unep.org/disasters and conflicts/Country Operations/Nigeria/ Environmental Assessment of Ogoniland report/tabid/54419/Default.aspx> pp. 1–257. Accessed 8 December 2018.

Uyigue E. and Agho M. (2011). Coping with climate change and environmental degradation in the Niger-Delta of South Nigeria. Benin. Community Research and Development Centre (CREDC).

Vidal J. (2012). Gas flaring is wasting fuel and fueling climate change/climate central. *Guardian Newspaper* http://www.climatecentral,org/news/gas-flaring-is-wasting-fuel-fueling-climate-change-15163 (accessed 12 December, 2018).

World Bank (2008). Environmental health and child survival: Epidemiology economics experiences.

World Bank (2012). World development indicators.

World Health Organisation (2010). Estimated deaths & DALYs attributable to selected environmental risk factors, by WHO Member State, 2002.

World Health Organization (2011). Health effects of air pollution.

World Health Organization (2014). *Obesity and overweight*: Fact sheet no. 311.

Yakubu, N. A. (2017a). Oil exploration and environmental degradation: The Nigerian experience.

Zhang YJ et al. (2013). Polycyclic aromatic hydrocarbons in urban soils of Beijing: status distribution source apportionment and health risk assessment. Science of the Total Environment.

\