UNIVERSITY OF GHANA

THE EFFECTS OF AIR POLUTION ON WORKERS: A CASE STUDY OF NORTH INDUSTRIAL AREA

BY

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DECLARATION

I do hereby declare that this thesis is a result of my own research and has not been presented by anyone for any academic award in this or any other University. All references used in the text have been duly acknowledged.

I am responsible for any shortcomings.

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CERTIFICATION

I hereby certify that this thesis was supervised in accordance with procedures laid down by the University of Ghana.

…… ……

DR ALBERT AHENKAN **DATE**
(SUPERVISOR)

DEDICATION

This piece of work is dedicated to my Lord, Almighty God who saw me through from the MPA programme till the end. Secondly, to my family and very good colleagues whose encouragement and support brought me this far.

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LIST OF ABBREVIATIONS

SDG	Sustainable Development Goals
WHO	World Health Organization
UN	United Nation
PM	Particulate Matter
NIA	North Industrial Area
MIC	Methyl Isocyanate
USA	United States of America
UNEP	United Nation Environmental Protection
UNICEF	United Nations International Children's Emergency Fund
VOC	Volatile Organic Compound
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Products
LPG	Liquefied Petroleum Gas
CO	Carbon Monoxide
SO	Sulphur Dioxide
NO	Nitrogen Dioxide
O	Ozone
IQ	Intelligence Quotient

Mn	Manganese
IHME	Institute for Health Metric and Evaluation
EPPL	Expandable Polystyrene Products Limited
EPA	Environmental Protection Agency

ABSTRACT

The purpose of this study was to investigate the causes and effect of air pollution on the health of workers and explore the plans put in place by companies to reduce pollution. The mixed methods was employed for this study and this involve both qualitative and quantitative which utilized a total of 60 participants from the North Industrial Area. Stratified random sampling techniques was also used in order to choose the respondents from the North Industrial Area.In order to gain a first-hand information on peoples reaction during pollution, respondents were observed. Analysis showed the information gathered, perception of respondents and understanding of air pollution, relationship between air quality and health. Dissemination of information play a vital role for people becoming aware of the health hazards of air pollution. Education also play a significant role in the perception of how certain sicknesses affect the public.

Paying attention to air pollution will help to reduce diseases which are caused by air pollution and also increase the life span of people.

CHAPTER ONE

INTRODUCTION

1.1 Background Study

Countries all over the world are increasingly worried at the rate at which the environment is being degraded through pollution whiles the world population depend on the environment for their economic resource and basic needs. According to the Sustainable Development Goals (SDG 2015), over 3 billion people depend on marine and coastal for their livelihood whiles the marine absorb over 30% of carbon dioxide yet water bodies are littered with over 13,000 plastics per a square meter.

Countries in the world are concerned with the high rate of pollution especially in the urban areas. According to World Health Organization (WHO 2016) monitored air pollution of urban areas show that at least more than 80% exceed the limit of air quality approved by WHO.

Due to lack of jobs among rural folks, in the less developed countries especially in the Sub-Saharan Africa, people move from different rural areas with the aim of finding jobs in the urban centres thereby choking the already overcrowded cities. A current data statement by WHO said all cities of the world are affected with populations however the mostly affected cities are in the low-income areas because the population in the cities keep on rising. Dr Maria Neira, WHO Director of the Department of Public Health, Environmental and Social Determinants of Health said "Urban air pollution continues to rise at an alarming rate, wreaking havoc on human health."

These people with no little or no skills try to find jobs in the urban areas and are employed as factory hands in the cities. In 2013, it was estimated by the United Nation (UN 2015) that manufacturing provides at least more than half a billion employment.

Industries are the main source from which goods are produced. All countries engage in this and

with the increase of industries, there is also an increase in job opportunity for people however, in developing countries these increased industrial activity leads rural urban migration and this rise the population in the urban area thereby stressing the environment. (Pandey 2005). This is a major concern to all countries because this affect the natural and artificial environment by destroying and also depletes the ozone layer and hence the effect of the greenhouse contribute to climate change. According to San *et al* (2017) degrading of the ecosystem is mainly from developing socially where people crave for industrial goods which increase the growth of the economy and directly affecting the environment.

Air pollution also further threatens human health causing respiratory tract infections which include lung cancer, tuberculosis, chronic coughs and asthma. It is alleged that as air quality decline, it increases the risk of stroke, cancer and other terminal diseases hence air pollution as the main cause of death in the cities. According to Indian Heart Journal (2015), air pollution has adverse effects on health, particularly Cardiovascular. It can precipitate heart failure, arrhythmia and even cardiac arrest.

Air pollution is the releasing of airborne particles into the air. These are harmful materials appear in an ultrafine, fine or coarse texture. These element come in different kinds including vapour, dirt, and particle visible in nature to be seen with the naked eyes. The air circulating in most cities in the world are compromised and no fresher. A recent study of 350 districts in China only 24 of them passed the WHO Interim Target 1 Particle matter (WHO 2015).

1.2 Problem Statement

In the past, the work of keeping the environment clean was the responsibility of Environmental Protection Officers attach to local municipal assemblies who go from house to house office to office to ensure that people keep their surroundings and environment neat. It was the duty of these officers to ensure people keep their houses neat, offices and surroundings are kept clean as well as their localities. If vicinity is found not clean then people are summoned to the local

municipal office and charged for keeping unsafe surrounding.

However, as population increase, there issue of rural urban migration became prevalent hence the increased of slum areas. More industries started springing up, it became difficult for the environmental protection officers to go round to ensure the environment is kept clean thereby the environment deteriorating.

It is therefore the duty of mankind to keep the environment clean because it supports and sustain human livelihood and provides basic needs like air, water, food and shelter for mankind. Human beings needs to be concern and responsive of the environment and control the activities that affect the environment like releasing of excess toxic waste in to the which affect the health of people. Out of the over 26 million population in Ghana 6,500 people die each year due to air pollution as reported by WHO (2015).

It is the dream of every developing country to be able to develop sustainable to meet the basic needs of life hence developing countries governments are working in order to have sustainable development and this is development that meet its present generation needs without compromising the ability of the future generations to meet their own needs (UCEP 1987). The environment needs to be protected and maintained so that after the current generation is gone it will still be intact for the future generations as well.

Employees are needed to be healthy to enable them work whiles employers need healthy workers and would not like to spend so much of the company's money on hospital bills

1.3 General Objectives

The general objective of this study is to investigate the effect of air pollution on employees using North Industrial Area (N.I.A) as a case study.

1.4 Specific Objectives

The specific objectives of the study are as follows;

1. To know the main causes of air pollution in the N.I.A.
2. To investigate the effects of air pollution on workers' health.
3. To identify plan put in place to reduce air pollution

1.5 Research Questions

The following questions will be answered during the study:

1. What are the main causes of air pollution in the N.I.A?
2. What is the effect of air pollution on workers' health in N.I.A?
3. What are the plans put in place to reduce air pollution by companies in the N.I.A?

1.6 Significance of the study

In comparing research on air pollution, it was realized that research is skewed towards indoor air pollution against outdoor air pollution as most of the research portray and more so it is evidently seen as there is a reduction in indoor air pollution. (Qingling Zhang *et all* 2015) hence this study is to know the key measures that causes outdoor sources of air pollutants, and implementing policies to educate people about the effect of air pollution.

Extensive research on pollution is normally done on emission from vehicle because it is basically seen every day as people are transported from work, school, church and various activities back and forward sometimes they stay in long hours in traffic thereby inhaling these toxic waste hence lot of research has been carried out on such topics and this research is to bridge the gap between vehicular and industrial pollution. Shadow Bright (2016) did an extensive work on ambient air pollution of vehicles in Accra.

In order to protect the environment since human life also depends on plants (SDG 2015) because plant gives mankind oxygen and takes out the polluted air carbon dioxide to keep the circulating of air fresh because the last trees death will lead to the extinction of mankind it is therefore necessary to have series of these studies on all aspect of the problems to prove

empirically the effects of air pollution

This study is to add up to existing available research on air pollution.

This study will also help to focus extensively on the causes of air pollution and its effect on human health and to generate the real concern among policy planners.

The outcome at the end of the study will be helpful for policymakers and public official to make informed decisions on industrial air pollution

1.7 Chapter Organization

Chapter one introduces the main work of the study and it entails the background of the study, problem statement, general and specific objectives as well as the research questions and significance of the study, cause and effect of air pollution.

The Chapter two study have then 10 sub topics giving empirical evidence and reviewing of what has been done by other researchers on the topic of study. The sub topics deals extensively with the conceptual definition of air pollution, indoor and outdoor pollution, ways to sense air pollution as well as the sources and causes of air pollution. Conceptual framework of the study is given in this chapter and mechanism through which air pollution is formed is discussed under this chapter diseases related to air pollution is also discussed and this will help to understand the study and make informed decisions.

Chapter Three discusses the research approach and methods used for the study and this helps to explain and justify the research study. The scope of the study, settings and population of the study are all explained here. In this chapter sampling technique used to collect data, sources of data and instruments used for collection of the data are clarified since there other methods to choose from. Data management and ethical consideration is also explained. Research demands a systematic and scientific approach and in order to follow this, the methodology employed should be appropriate.

Chapter Four, presents the data from respondents, findings from the study and also discusses the discussions. This chapter stress on the connections between the research questions, reviwed literature, the study objectives and respondents responses.

The final chapter summarizes, recommend and conclude the study. The necessary recommendations made will inform policy makers and public officials to ensure regulations on pollution is applied.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

Air forms part of the atmosphere on the earth and it is an important essential resources. One things that sustain life of all humans, animals and plants is air and it should be quality air for sound growth of life. However this is not so because the air around the word has been contaminated due to mostly human activities and has led to many complicated diseases and even death among human making quality air elusive. This makes it imperative to protect the environment against such pollutant.

The need to protect the environment from air pollution was realized during the era of western civilization and social changes where there was industrial proliferation and extensive use of coal as a source of energy. This generated a lot of pollution and the effect impacted on the health of the people leading to a stringent control measures of emission in many countries. According to Holgate *et al* (1999), the excessive use of coal to choke the atmosphere in London led to the passing of law in the British Parliament to forbid burning of coal.

In 1984 a gas disaster in Bhopal claimed close to 20,000 lives when 40 tons of Methyl

Isocyanate (MIC) gas was released into the air (theatlantic.com)

In a study observed from space over China by Ritcher *et al* (2005), pollution is concentrated in the industrialised areas with emission from biomass, soil and lightening signatures.

Ghana, the capital city Accra's has it's suburb Agbogbloshie named in two consecutive years thus 2013 and 2014 as one of ten worst polluted places in the world due to the turning toxic pollution (Pure Earth).

2.1 The Conceptual Definition of Air Pollution

Air pollution is the presence of toxic chemical or compound gas particles in the air mainly due to the activities of humans or naturally activated affecting the air quality. This air is harmful and poisonous to living organism including human, animals, food crops whiles damaging the environment. This is term air pollution.

According to Indian Standards Institute (1966), "air pollution is the presence of ambient atmosphere of substances, generally resulting from the activity of man, insufficient concentration, present for sufficient time and under circumstances which interfere significantly with the comfort health or welfare of persons or with the full use of enjoyment of property." The substances dispersed into the air due to human activities over time causes the same human health related diseases which makes it impossible to enjoy life.

Various activities by man through industrial operations either internal or external combustions like reactions from fuel and diesel engines and smoke, dust or sulphur oxides disperse pollutants into the air to prevent sustainable life. According to Engineer Joint Council of United States of America (USA) "air pollution is present in the outdoor atmosphere are of one or more contaminants such as dust, fumes, gas, mist, odour, smoke or vapour in quantities, with characteristics and of durations such to be in furious to human, plant or animal life or to property or which unreasonably interfere with the comfortable enjoyment of life and property."

With increased volume of these harmful biological toxics into the atmosphere, the incoming sunlight scatters thus increasing the carbon dioxide in the atmosphere hence increasing global temperature leading to an effect on the greenhouse.

Human activities through rapid industrialization is seen as to have an effect on the air creating pollution hence air pollution is referred as "as price of industrialization" (Pandey 1999) and air pollutant emitting from vehicles as "disease of wealth" (Miller, 2002).

Air pollution is viewed as one of the important environmental problems confronting this second millennium civilization of oil production, mining, construction. Industrial work, smelting and transportation contributing to the global pollution of air each and every single day. To Kumar (1999), "the atmosphere is used as a natural sink for gaseous" pollutant and this is known to be very serious and is seen as one of the ten top environmental issues reported by UNEP.

2.2 Indoor and Outdoor Air Pollution

Pollution of air can be either indoor or outdoor which are equally harmful to humans. Indoor pollution poses serious health issues for the over 3 billion of people who prepare food and warm their homes with fuel and coal thereby inhaling smoke according to WHO (2016). Paints contain toxic chemicals as well as other household cleaning goods thereby emitting toxic when used indoor.

Outdoor air pollution also known as Ambient. WHO reports of over 3 million people every year who reside in both urban and rural are affected with ambient outdoor pollution causing untimely deaths around the world. People who are exposed to small particles of 10 microns or less are susceptible to diseases including cardiovascular, cancer and respiratory as it projected by UNICEF (2015) that by the year 2050 air pollution occurring outdoor will a leading deaths among children.

Yet people are less concern with pollution and it mean different to people depending on how it happened. For people in the house it may be expressed as an irritation of the eye and stained cloth, whiles a farmer see it as destroyed crops, a pilot as a decline in sight and the industries as difficulties in processing.

2.3 Methods of Sensing Air Pollution

According to Rao and Rao (1998) there are 3 methods of identifying air pollution and the ways are widely known although they have their advantages and disadvantages. They include:

1. Sensual Visibility
2. Standard measure of pollution
3. Impacts seen plants and structures

Sensual visibility is usually air pollution first awareness which have effects on the individual they are also high subjective phenomena and vary from person to person.

These are

- pungent odours
- reduced visibility
- itchy eye
- acidic taste felt in the throat
- Strange feeling under foot.

Physical measurement of pollution. Rao further postulates that whiles sensory gives the initial signal of the existence of a contaminants in the atmosphere, however the quantity of toxic substance cannot be measured hence physical measurement is required by using laid down standard methodology to analyses

The third method according to Rao is the impacts on vegetation, animal and structures. Air pollution can be detected through the growth of the plant and wellbeing of the animal in a polluted area because certain plants and buildings react to certain atmospheric impurities.

2.4 Sources of Air Pollution

Air pollutants are generated by two main sources of pollution which are classified as natural and anthropogenic or man-made however but some sources can be both natural and man-made for certain kind of air pollution. "Sources of air pollution can be categorized as natural sources (volcanic eruption, forest fire, tornado, sea salts, natural radio-activity, ozone and natural hazes) and anthropogenic or man-made sources (the thermo-power plant, the nuclear power plant, industry, refrigerator, sewage treatment plant, household combustion, and all sort of transportation means)" (Kumar, 1999).

2.4.1 Natural Pollutants

Gases and particles are sometimes naturally dispersed into the atmosphere. For example the release of biogenic VOC from trees and vegetation. The main pollutants are dust and soils blown which contains a high level of PM (Chueinta *et al*, 2000).

Dispersion of pollen grains in the air by plants through wind pollination results in irritating some individuals. This makes some people suffer from asthma, eye irritation, dermatitis and hay fever. The particle size is between 10 to 50µ (micron) although small may be small as 5µ or larger as 100µ in diameter.

Volcanic eruption is as a result natural emission from a biological process on land and oceans.

Natural fog is the dispersion of liquids like water or ice into the atmosphere reducing visibility. Natural pollutant can hardly be controlled and its contribution is minute as compared to artificial pollution.

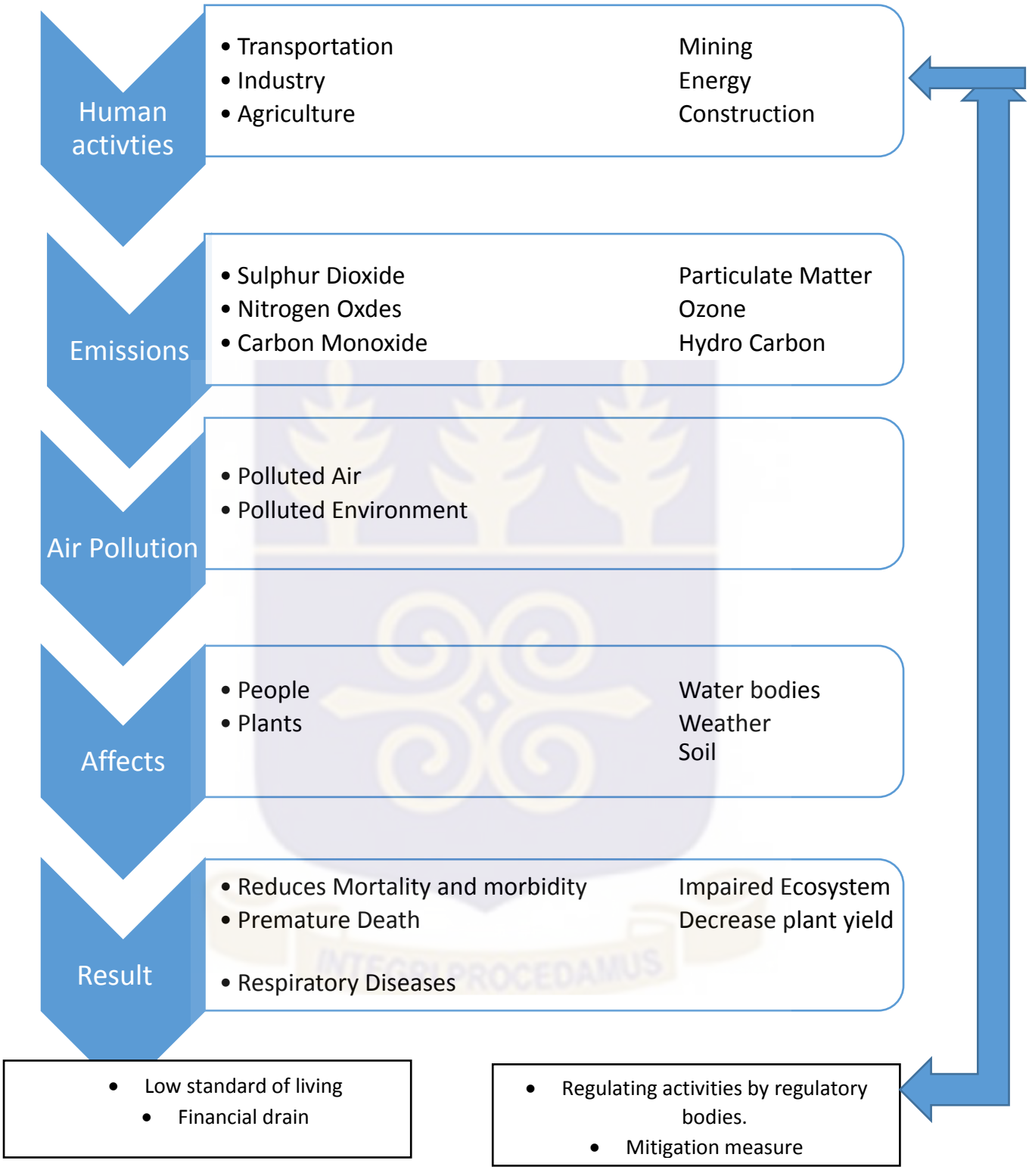
2.4.2 Artificial Pollutants

These are pollutant generated from activities of human. They are basically emitted due to the action of man and include combusting of fossil fuels and particles. Examples are:

Dust don't normally diffuse through breaking and crushing of materials from chimney, construction and cement into the air and settles mostly on things under the power of gravity.

Smoke is predominantly made up of carbon particles and combustible materials including coal and oil.

Figure 1: Conceptual Framework



2.6 Causes of Air pollution

Pollution can be cause by noise, thermal, light and other various forms but for the purpose of this study air pollution is the focus.

2.6.1 Burning of Fuel

A key cause of air pollution in most industries is the combusting of fossil fuels which contain Sulphur dioxide such as coal and petroleum. Emission of pollution from various automobiles including SUVs, buses, vans, railway carriage, wagon, lorries and aircraft cause serious level of pollution. There is daily reliance on these transport to carry us through in and out of our daily activities however, they poses danger to both human and the environment due to the bad toxic they emit. Due to the improper or incomplete burning of fuel and diesel, vehicles emit poisonous gas. For nitrogen oxides gases are produced from natural and artificial emissions. In developing countries, fuel and diesel with high level of Sulphur content is continuously used unabated (cited Burris *et al* 2011).

2.6.2 Agricultural Activities

Agriculture is the backbone of the Ghanaian economy according to FAO Agriculture in Ghana is very important due its contribution to the Gross Domestic Product (GDP) of 41% notwithstanding chemicals are used in order to increase yield or prevent rodents from attacking agriculture produce is of concern and insecticides, pesticides, weedicides and fertilizers usage in agricultural activities has increased. Pesticides induced by sunlight reactions causes a chemical change in the organic products which emits harmful chemicals into the air and water during rainfall causing pollution. According to Fianko et al (2011) the modern type of agriculture cannot be successful without the use of these pesticides it is an integral part however most of these are poisonous and be very dangerous when not used in the right quantity. Reports of death during the use of pesticides have happened around the world especially in the developing countries. (Tariq et al 2007).

Chimney of manufacturing industries**:** Large volumes of chemicals such as hydrocarbons, carbon monoxides and other organic compounds are released into the atmosphere thereby reducing the air quality. Petroleum Stations and manufacturing industries especially in the developing countries can be found in even in the residential areas thereby releasing hydrocarbons and other chemicals that contaminant the air

Mining operations**:** Extraction of natural resources from beneath the earth using large equipment is known as mining. In the process of doing this sand and other chemical particles are released into the air causing air pollution this is inhale by workers and residents living closely to such sites deteriorating their health. According to Akpalu and Parks (2007) extraction and processing of gold have an effect on the natural environment which includes rivers, plants soil texture and the quality of air.

Cleaning products such as paint contain chemicals that are toxic and when used in households, reduce the air quality causing air pollution items. Organic solvents from paints and adhesives contain VOC and the smell created is pungent hence makes it difficult for breathing when inhaled.

2.7 Primary and Secondary Air Pollution

These pollutants can be described as primary and secondary based on the level and mixture of which the pollutants are made up of:

Primary air pollutants are those type of pollutants which are released straight into the atmosphere and adoes not combined with any other chemicals. Sources are chimney of a factory, suspended aerosol in the form of dust or dirt and this can easily be measured with the required instrument however the difficulty is that it is easily carried away by the wind thereby diffusing it. These sources of emission make up primary sources and adds up to the reduction

of air quality. The primary source of emissions produce the following gases nitrogen dioxide, carbon monoxides, Sulphur dioxides, particulates, volatile organic compounds and lead.

Secondary pollutant is produced when chemical reacts with a primary pollutant and intermingle with other primary pollutants and are exposed to sunlight. Smog and ozone are examples of secondary pollutants. This is further explained by Miller (2002) that they are made in the troposphere and it is as a result of a reaction by a chemical to primary source of pollution probably a component that is natural like water and oxygen. One of the common example of secondary pollutant is ozone which is almost totally produced through chemical reaction in the atmosphere. Due to the way secondary pollutants are formed, they are not readily included in emission because it take some time to form and certain components must come together before formation. (Seinfeld 1998).

2.8 Mechanism for formation of Air pollutants

The increase in urbanization and effluents lifestyle form of modern industrialization has increased energy consumption rapidly in industrials as well as the edge to owe and use different kinds of automobiles and gadgets thus increasing indoor and outdoor air pollution enormously. Wide variety of chemicals and other contaminants, generated by these industries are harmful to human.

Ghana, gaseous pollutants are produced and emitted by industries like Ghana Latex Foam Manufacturing limited, liquid petroleum gas (LPG) filling depots, extraction of gold, burning of unused fossil fuel during refinery operations to manufacturing goods all these processes involve combustion of fossil and fuels. According to Miller (2002)

"Around the world, five major types of materials are released directly into the atmosphere in their unmodified forms and in sufficient quantities to pose a health risk. They are carbon monoxide, hydro-carbons, particulates, sulfur dioxide and nitrogen compounds. This group of

pollutants is known as primary air pollutants. These materials may interact with one another in the presence of an energy source to form secondary air pollutants such as Ozone and other very reactive materials. Secondary air pollutants also form from reactions with natural chemicals in the atmosphere."

According to WHO Air Quality guidelines (2005) there is the need to follow the laid down expert standard methodology indicated and outlined worldwide for the four air pollutants which include sulphur dioxide, nitrogen compounds, particulate matter and carbon monoxides. However for the purpose of this study, six air pollutants will be discussed in order to give better understanding of common forms of air pollutants.

Carbon monoxide (CO)

Is describe as a poisonous, colourless, odourless gas which is generated through natural and anthropogenic sources like forest fires, volcanic activities and combusting respectively. The main source is attributed to automobiles and any machinery that is combustible to fossil fuels. It is outdoor pollutants and in various home it emits from gas heater gas stoves, kerosene and leaking pipes. It is emitted from the vehicle exhaust due to incorrect mixture of air and fuel mixture which result in an incomplete combustion. Activities of human contribute to an estimate of 35 billion metrics tons of CO release into the air every year due from energy usage according to IEA. However whiles natural generate 1 p.p.m (per particulate matter) of CO, anthropogenic generate several p.p.m of CO and it is toxic to both human and plants

It is generated through combusting of fossil fuel including coal, petroleum and natural gases. Jones J.C. (2008) mentioned CO as a high toxic main source of pollutant occurs in vehicle exhaust and that during road worthiness test for cars, it is required that monoxide level are checked and this varies from country to country. He also sees United States of America as the largest pollutant of CO. in Mahendra SP, Krishnamurthy (2004) report on CO gave an ambient

air concentration at Sheshadri road in Bangalore due to the morning peak traffic and revealed that high concentrated CO is closely related to heavy traffic.

According to US Environment Protection Agency, CO obstructs the carriage of oxygen to certain parts of the body like the heart, brain and other relevant nerves. This pollutant also poses as great danger to unborn and newly born babies as it gives them heart diseases but for people with good health expose to CO, experience pains in the head, body weakness and reduce responses. High concentration in the body can be able to cause dizziness, unstable mind, unconsciousness and even life lose.

Hydro-carbon

Hydrocarbons is part of the volatile organic compounds (VOC) and are chemicals which contain both hydrogen and carbon as well as possibly other elements that evaporate easily. They contribute substantially to the increase of the formation of ozone through the increasing the amount of nitric dioxide in the air which combines with oxygen molecules hence producing ozone (US Environmental Protection Agency). Most prominent source of VOC is through leakages from pressurized systems example is natural gas and methane .Benzene is a liquid fuel which easily evaporates and is part of VOCs. It is used for the industrial production of other chemicals. It is necessary in the productive items like paint and products, such as rubber, sealants, solvents, spray paints lacquers, and more. In motor vehicle facilities, products produced with benzene are used to clean brakes, hydraulic systems, and fuel system components. Benzene is also used in the creation of rubber tires and is a component of asphalt and crude oil, as well as all lubricants made from crude oil. In USA about 238,000 of people are expose to benzene due to their occupation. According to U.S. Department of Health and Human Services (1997), benzene is seen as a chemical substance promote the formation of cancer (Verma, Y., and S.V.S. Rana 2001).

Particulate Matter (PM)

It is aerosol that suspends in the air is made up of solids and watery elements of microscopic sizes in animate and inanimate shapes. PM origins is from various man made sources of air pollution like man diesel trucks, power equipment, quarries activities, wood carvings and industrial production are formed through burning and produce smog which temporary blinds people. The main chemicals produce by PM include black carbon, sulfate, sodium chloride, nitrates, ammonia, water and mineral dust. PMs can be said to be the constituent of air pollution, which are developed through various man-made activities of industries and automobile through combusting of coal and oil fuel. According to Huang *et all* (2015) these elements are generated from different sources comprising fumes from wielding, diesel soot burning carbon and coal. The exposure of PM to human keeps on increasing and it is estimated that up to 80% of diesel exhaust is expose to human being. Their diameter range from 0.01 to 100 micron although some may be less than that. It is believe that PM affects more human than any of the other pollutants and contributes to many health diseases caused by air pollution especially those below 10 microns or lesser which are able to travel deep into the lungs. (WHO air quality guidelines 2005).

In the article approach to counselling patients: *the air quality health index*, Abelsohn and Stieb (2011) emphasis on the need to classified PM in sizes. The size is important because the smaller the diameter that is less than 2.5 micron of particle, the deeper it is able to travel through to the lungs to affect the alveoli. Regular exposure to the particles leads to developing of cardiovascular and respiratory diseases. Studies have shown that PM less tha 2.5 micron coupled with other air pollutants can cause serious health issues and even death.

Sulphur Dioxide (SO_2)

Is from a group of gases called sulphur oxides and the others gases are less common in the atmosphere. It has a pungent odour and has no colour and a major causes of air pollution. The main source of SO_2 is both natural and anthropogenic. The man-made or natural includes volcanoes and the anthropogenic sources the burning of fossil fuels including coal, petroleum, smelting of mineral ores that contain sulphur and other factory combustibles activities. Domestically SO_2 is found in fossil fuels that is used in heating and generating power.

Combusting of fuel by equipment like plants in and other industrial activities are the principal source of SO_2 in the air by power plants and other industrial facilities. According to Guarnieri and Balmes (2014) in the developing countries, Sulphur is as the main source of chemical release during industrial process and production of energy and reacts in the troposphere with other compounds to form smaller molecules. These reactive molecules contribute immensely to PM that enters deep into the lungs and cause severe damage to health.

Exposure to SO_2 can affect the respiratory system causing the well-functioning the lungs and making breathing difficult. According to Johns and Linns (2011) SO_2 cause more prominent bronchoconstriction especially in asthmatic individual making breathing difficult when these air pollutant are in circulation.

Nitrogen Dioxide (NO_2)

Forms part of the Nitrogen Oxides group of gases and are dangerous to both health of mankind and the environment which is of great concern to humanity. Other forms nitrogen oxides are the chemical nitric and nitrous acid. The nitrogen oxide group in totality is indicated as NO_2. The major sources of NO_2 is anthropogenic emissions and are form through the burning of fuels through thus smelting, reheating generating of power and running of vehicular and ship engines. NO_2 is produced and gets into the air when fuels are burnt at excessive temperature

and also the major source of nitrate aerosol since it is an integral part of the formation of PM less than 2.5 micron pollutant in the air. NO_2 absorbs into the air exceeding 200 micron is toxic and causes infections through the airwaves.

The predominant cause of NO_2 is road traffic and combusting of electrification generation hence individuals who resides besides areas where serious burning of coals and power plants or heavy motor vehicle traffic are exposed and susceptible inhaling of higher level of nitrogen oxides. According to Rietbergen-McCracken & Abaza, (2013), low level of nitrogen oxides in the air is even harmful because it causes eyes irritation, nose running and throat itch which results in cough, shortness of breath, dizziness and nausea.

Acid rain is harmful to the ecologies such as rivers, lakes and vegetation and NO_2 combine with oxygen and water as well as other chemicals form acid rain other NO_x interact with water, oxygen and other chemicals in the atmosphere to form acid rain which causes water pollution.

Secondary pollutants

Ozone

Ozone can be describe as good or bad depending on its source and where it is found. The natural source of ozone is known as stratospheric because it is located in the upper part of the atmosphere is term good because it forms a protective that shield human from the ultraviolet sun rays which are destroyed by man-made activities.

The bad ozone is known as Tropospheric or ground level ozone. Its main source is anthropogenic and the major constituents of this ozone is photochemical smog at ground level and comprises of three particles of Oxygen however its emission is not directly into the atmosphere but in the lower part of the atmosphere due to its reaction of the presence of sunlight coupled with chemical pollutants which include NOx from industrial and vehicular emissions formed by VOCs as well as emission from oxygen solvent during warm weather. This reaction

is cyclical and when ozone is formed it quickly breaks down into oxygen and NO_2 however with presence of hydrocarbons and VOCs in the atmosphere it prevents ozone from the breakdown thereby increasing ozone concentration in the sky. The maximum concentration of ozone in the air causing pollution is normally in the sunny weather and are easily transported to longer distances by wind.

Ozone have effects on vegetation as well sensitive during growing seasons in particular and the ecological system of an area.

Health wise ozone reduces lung working ability and reacts to lung tissues .Expose to ozone cause airborne infections, hypertension and decrease lung functions and asthma among adults. Ozone exposure results in airway inflammation, airway hyper-responsiveness, and decrements in lung function in healthy and asthmatic adults (Seltzer J. *et al* 1986)

2.9 Diseases Related to Air pollution

Various studies have found that ambient air pollutants are associated with adverse effects on human health. These pollutants initiate or trigger the occurrence of diseases and has become the outcome of several health conditions. Health conditions or outcomes associated with higher exposures to air pollutants include hypertension, stroke, respiratory diseases and mortality (Allen et al., 2009; Khanna, 2011). Newly born babies and under one year babies are all under the risk of breathing polluted air risking the development of their brain whiles suffering from neurological problem with reduced Intelligence Quotient (IQ), anxiety and symptoms of depression are caused by hydrocarbon (Vishnevetsky *et al* 2015). UN children agency warns of about seventeen million worldwide risk breathing toxic air putting their brain development at risk. Children are playful and most of their plays are in a group which most of time take place outside the room and as their lungs are not fully developed makes them susceptible to air pollutant they are exposed to a higher burden of pollutants because of their greater ventilatory

rate and propensity to spend more time outdoors, engaging in physical activity. They are also exposed at a vulnerable stage, when the immune and metabolic systems are less mature and the lungs are rapidly developing (Chen et al 2015). People in developing countries are more susceptible to health risk like cancer and respiratory and other related pollution diseases because among these countries regulation is low. Industrial pollution poses a health risk to more than 200 million people around the world, often through elevated levels of cancer, respiratory disease and other illnesses which Ghana is no different. The Deputy Director of Environmental Protection Agency of Ghana (EPA), Mr Emmanuel Appoh linked the increase cases of Acute respiratory to air pollution as it has moved to being the second top killer after malaria and he blamed it on emissions from rickety vehicles, open burning of refuse and plastic/electronic waste, bush burning, industrial pollution among others (Graphic online, May 26, 2017).

People exposed to fumes risk contracting various respiratory diseases. In Sweden welding is a common job to find and it is estimated that about 25, 000 are employed permanently as welders and a further more 250,000 jobs related to welding (Taube 2013). Welding fumes are from metal fumes like e.g., manganese (Mn) and gases, e.g., ozone, particles in the respirable dust with different size range. Exposure to welding fume could cause short- and long-term respiratory effects. The prevalence of work-related symptoms among mild steel welders was studied, and the occupational exposure to welding fumes was quantified by repeated measurements of respiratory dust, respirable Mn, and ozone.A study of 108 Swedish mild steel welders exposed to respirable dust (RD), manganese (Mn), and O3 showed that the welders frequently demonstrated job-related symptoms including nasal obstruction (33%), ocular symptoms (28%) and hacking cough (24%) Kedmer *et al* (2014).

Fungal reproduction bacteria and pollen grains from weeds and plants to individuals who are sensitive and allergic to these pollutants can cause asthma over the long inhaling of such

pollutants. PM frequently contains various immunogenic substances, such as fungal spores and pollen, which have been independently associated with exacerbation of asthma symptoms (Delfino R J., *et al*. 1997) According to Mann *et al* a temporary exposure to ambient PM between 2.5 and 10 micron in diameter causes cohorts of asthma in children and in adults show asthma symptoms. People are experience similar symptoms when expose to NO2. A five years studies by Perez *et al* (2009) on asthmatic children and adults have identified associations between nitrogen dioxide and symptoms of asthma, reduced response to bronchodilators, (Hernandez-Cadena et all 2012) decrements in lung function, (Liu et al, 2009) 30 and exacerbation of asthma (Iskandar et al 2012).

PM increase the illnesses and death on daily and in a span of time. In 2004, the first American Heart Association technically stated on "Air Pollution and Cardiovascular Disease" and concluded that exposure to particulate matter (PM) air pollution is a major contributor to cardiovascular morbidity and mortality. In the interim, numerous studies also expanded our understanding of this association and further elucidated that the physiological and molecular mechanisms of the heart is also involve. (American Heart Association.2010).

The Nitrogen compounds reacts with other chemicals to essentially form ozone which are harmful when inhale and are a health problem themselves

Inflammation of the respiratory tract causes coughing, mucus secretion, aggravation of asthma and chronic bronchitis makes people more prone to infections of the respiratory tract. Hospital admissions for cardiac disease and mortality increase on days with higher SO_2 levels. According to Naveen Kishore and Surinder Deswal (2017) who carried out a health survey in India city of Gwalior which can boost of industries comparatively alluded that SO_2 concentration was high and the people around the area showed symptoms and developes sore throat, shortness of breath, skin irritation, wheezing, sneezing, chest tightness, nausea etc. .

Epidemiological studies have shown that symptoms of bronchitis in asthmatic children increase in association with long-term exposure to NO_2 and reduced lung function growth is also linked to NO_2 at concentrations currently measured (or observed) in cities of Europe and North America. Excessive ozone in the air can have a marked effect on human health. Ozone can worsen bronchitis, emphysema, and asthma increase medical care and also causes mortality rise In Europe it is currently one of the air pollutants of most concern. Several European studies have reported that the daily mortality rises by 0.3% and that for heart diseases by 0.4%, per 10 $\mu g/m^3$ increase in ozone exposure.

There are strong evidence that specific diseases including asthma, chronic obstructive pulmonary diseases, cancer, type 2 diabetics neurogenerative diseases, obesity (Xu et al 2006) and numerous study has it that exposure to air pollution causes morbidity and mortality as well as respiratory and cardiovascular diseases (Doanldson K and Seatn A., 2012).

2.10 Air quality Guidelines

With issues of Pollution, world's attention has always been drawn to emission by vehicle exhaust and climate but according to Walsh Bryan (Science Time) industrial pollution in poor cities and towns where industries, power plants and chemical facilities are prone to little or no regulation, the environmental risk to human health is very high. Air pollution is prevalent in every country and societies worldwide and it is estimated that only one person among 10 resides in cities that comply with WHO air quality guidelines (WHO 2016). Children of over 300 million currently resides in areas which pollution outdoor exceeds ta least six folds (WHO 2014).

Table1: The WHO quality guidelines value

Air Pollutant	Annual	Hour	minutes
Particulate Matter $PM_{2.5}$ PM_{10}	10 µg/m^3 annual mean 20 µg/m^3 annual mean	25 µg/m^3 24-hour mean 50 µg/m^3 24-hour mean	
Ozone		100 µg/m^3 8-hour mean	
Nitrogen dioxide (NO_2)	40 µg/m^3 annual mean	200 µg/m^3 1-hour mean	
Sulfur dioxide (SO_2)		20 µg/m^3 24-hour mean	500 µg/m^3 10-minute mean

Source: ***World Health Organization: Ambient (Outdoor) Air Quality and Health Fact Sheet No. 313*** **(updated 2016).**

The above guideline shows the minimum level of the various pollutant that are suppose to be measured by countries yearly, hourly and pre minutes in order to control air pollution to the barest minimum. These guideline limits aim is to reduce air pollution levels in countries of the world and in effect reduce burdens of diseases caused by these pollutants. WHO air quality model confirms that 92% of the world's population lives in places where air quality levels exceed "WHO's Ambient Air quality guidelines" for annual mean of particulate matter with a diameter of less than 2.5 micrometres ($PM_{2.5}$). WHO guideline limits for annual mean of $PM_{2.5}$ are 10 µg/m^3 annual mean.

To measure primary air pollutants emission inventories are often combined with dispersion models as a powerful tool for predicting air quality. They can, for example, be used to model local, regional and global conditions and observe spatial and temporal trends in emissions. Receptor modelling is an alternative method that is use in the measurements of air quality, frequently in combination with simultaneously measured meteorological data, to recognize and quantify the contributions of specific characteristic source types to air pollutant concentrations.

For secondary air pollutants, the mode of their formation makes it difficult to readily include them in emissions inventories or receptor modelling. Nevertheless, it is possible to estimate formation rates of secondary pollutants per unit volume of atmosphere per unit time. Air quality measurements are typically reported in terms of daily or annual mean concentrations of PM_{10} particles per cubic meter of air volume (m^3). Routine air quality measurements typically describe such PM concentrations in terms of micrograms per cubic meter ($\mu g/m^3$). When sufficiently sensitive measurement tools are available, concentrations of fine particles ($PM_{2.5}$ or smaller), are also reported.

In a quiet number of developing countries, observing, evaluating and regulating pollution caused by industries is is a waste of, costly, and take resources (Ayayo *et al*, 2001,Oketola and Osibanjo 2007). In Ghana, the deputy director of EPA complained of inadequate supply of air monitors hence the adoption of the use of USEPA portable air monitors with filters mounted at various prone polluted areas in Accra to reduce it. With introduction of the Akoben by EPA it intends to enforced compliance of guidelines of air pollution in companies. The AKOBEN is a traditional way of environmental rating methodology system used in Ghana to punish companies who do not comply with laid regulations; compliance monitoring of industries by EPA and this is a clarified ways for monitoring points, data source, data analysis methodology, dispute resolution and rating disclosure. Here colours are used to describe the performance of a company in the issue of pollution.

Table 2: Rating Level Performance General Description

Colour	Performance	General Description
Red	Poor\Failed	to follow environmental law (LI 1652), shows pattern of chronic exceedances, and creates risks from toxics and hazardous wastes mismanagement and discharges
orange	Unsatisfactory	Exceedance of regulatory standards for non-toxics, weak environmental monitoring, and incomplete fulfillment of reclamation bond criteria
Blue	Good	Adequate compliance with environmental standards and reclamation bond criteria
Green	Very Good	Blue +adopts voluntary initiatives and is responsive to public complaints
Gold	Excellent	Green + mine site follows its corporate social responsibility policies

Source: https://www.slideshare.net/ *(accessed on 01 March 2018)*

2.11 Ways to reduce Air Pollution

Research on harmful effects on human respiratory health shows ozone, nitrogen dioxide, PM and carbon monoxide are main cause. Studies have also shown how China and other countries with high absorptions of air pollution in both indoor and outdoor pollutions suffer respiratory diseases which leads sometimes to death. Zhang et al (2015) opined the following for the elimination of indoor pollution.

1. There should be governmental policies to reduce overall air pollutant levels and this can lead to greater improvement in outdoor and indoor air quality.
2. Efficacious preventive measures and treatments must be adequately address the health effects of environmental air pollution in China.

With a lot of studies done of air pollution, there are information which countries refuse to disseminate and integrate into their system to manage air pollution hence Gould et al (2015) opined that countries should be ceased the feasibilities studies done by expert groups citing policies and initiatives that have been effective. There should also be transition from dirty fossil fuels use to clean energy and this must be done equitably and inclusive of all communities, especially those that are disadvantaged to benefit the health and future well-being of children worldwide.

To help solve the issue of air pollution especially in Africa, Petkova et al (2013) identified that local journal on the issue is not well indexed and also difficult to accessed. Data on monitoring are hardly published online by government and other institutions. To them, a publicly available information system will help in the assessing the health impacts of outdoor air pollution in Africa.

WHO description of policies on transportation, urban planning, and power generation by industrial are known to be effective in reducing emissions of fossil fuel. In USA fuels do not contain sulphur it is remove at the production level to mitigate the burning of sulphur during the use of coal and fuel oils.

For effective control of Air pollution WHO made available:

- Adopted a resolution and a road map for an enhanced global response to the adverse health effects of air pollution.
- Recommends the exposure limits of key air pollutants in the Air quality guidelines.
- Provision of detailed health-related assessments of different types of air pollutants, including particulates and black carbon particles, ozone.

- WHO's work on "Measuring health gains from sustainable development" has proposed air pollution indicators as a marker of progress for development goals related to sustainable development in cities and the energy sector.
- WHO assists Member States in sharing information on successful approaches, on methods of exposure assessment and monitoring of health impacts of pollution.

2.12 Empirical Evidence

Many studies have shown that those who stay in highly polluted places suffer from related cardio vascular diseases including stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma. A few study have shown that some of these cardiovascular diseases are hereditary or genetic (Sekar Kathiresan and Deepak Srivastav, 2012) but many more research studies documented show that cardiovascular and other related diseases are caused by air pollution through human activities.

A research in four localities thus Nima. James Town, Asylumn Down and East Legon in Accra by Zhou et all (2013) analyzed that PM chemical composition and various source of particle pollution in the capital city of Ghana are from the abundant of earth crust during harmattan period thus between December and late January when dust is carried from the Sahara desert, and after harmattan from biomass combustion associated with high black carbon, potassium and sulphur. These particles account for 42% of PM10 during Harmattan. They named other sources of air pollution were from vehicle emissions, tire and brake wear, road dust and solid waste burning. This contribute to decline of air quality in urban area leading to the risk of stroke, heart diseases, lung cancer, acute respiratory diseases for people living in those poor areas. According to the WHO Assistant Director General for family, Women and Children's Health air pollution is the major cause of disease and death whiles PM10 and PM2.5 include pollutants such as sulfate, nitrates and black carbon, which penetrate the lungs and into the cardiovascular system, posing the greatest risks to human health (Ghanabusinessnews).

According to UNEP (2015) the important industries in Ghana are; mining, lumbering, light manufacturing, aluminium smelting, food processing, cement, small commercial ship building, petroleum and others and they contributed USD 45.5B in 2013 to the country's GDP. These Industries share of 29% Electricity sources which a quarter of electricity generated in Ghana is derived from fossil fuels, thus power generation is also an important source of air pollutants, 40.6% of the installed electricity generating capacity (1.985 million KW in 2010) is generated from fossil fuel, the rest 59.4% is generated from hydropower. PM SO2, and NOx are some of the most important air pollutant from industrial sources in the country. Fossil fuel causes impairment of cognitive and behavioural development, respiratory illness, and other chronic diseases. WHO estimates that in 2012, some 72% of outdoor air pollution-related premature deaths were due to ischemic heart disease and strokes, while 14% of deaths were due to chronic obstructive pulmonary disease or acute lower respiratory infections and 14% of deaths were due to lung cancer (WHO 2016).

In Ghana alone it is reported that 17,524 people die of air polluted related diseases according to Code for Action (peaceonline 2016). This is due to low quality fuel sold on the African countries which is hazardous to the health of humans. When these fuel burns, sulphur is released into the atmosphere as sulphur dioxide including other compounds which are major contributors to respiratory diseases such as bronchitis and asthma. According to a new report from the World Bank and the Institute for Health Metrics and Evaluation (IHME), air pollution can lead to lung cancer, stroke, and heart disease – cost the global economy roughly $225 billion in 2013. Air pollution, per the Global Burden of Disease Study 2013, was the fourth-leading risk factor for premature death in 2013. (Institute for Health Metrics and Evaluation)

In Ghana Accra is said to be the only municipality reporting to WHO on air pollution and it has one of the highest outdoor air pollution which contains a mixture of chemical, particulate and biological matter which react to each other to produce small dangerous elements. This

leads to breathing problem, protracted diseases, continuous hospilization and premature death. Most common pollutants affect people in the short and long run. Short term symptoms include itchy eyes, nose and throat, wheezing, coughing, shortness of breath, chest pain, headaches, nausea, and upper respiratory infections like bronchitis and pneumonia. Long term effects include lung cancer, cardiovascular disease, chronic respiratory illness, and developing allergies. Air pollution is also associated with heart attacks and strokes. (iamat, 2016).

2.13 Summary

In summary air pollution is mainly due to the action of human activities though our activities of industrialization. Turning the wheels of industrialization, increases the emission of the pollutants which form in the air and affects human health. These pollutants affect depending on the exposure and type of pollutants inhaled. Air pollution also affect finances of individuals, countries and the world at large.

The further gave the solution of which will help reduce air pollution in Africa as African cities to have policies related to energy, transportation and urban planning with explicit strategy for poor communities.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter discusses the method adopted in collecting data for the study. It involves the details of which this study was done. It involves the research paradigm which discusses the approaches that were used to address the research questions and these include the research design, target population, the sampling technique, study area and instruments used for data collection.

3.1 Research Approach Method and Design

The mixed-method research approach thus both quantitative and qualitative were used for this study**.** This method approach helped to categorize responses and ensure more flexibility in questioning of research population. According to Teddlie & Tashakkori, 2009 mixed methods promoted clearer and explicit understanding on the social issue in relation to education, pollution, health, culture, and lifestyle.

The mixed method approach explored and confirmed analysis about a phenomenon and this supported or disapproved the aspects of the phenomenon as indicated by Creswell (2007) that exploratory research enable a researcher to gain familiarity with a phenomenon and acquire new insight into it in order to formulate a more precise problem or develop analysis.

The mixed research method seek to use rigors different kinds of methods for its data collection and analysis in a study through structured or semi-structured method to ensure decisions on effects of air pollutions in the area of study as according to De Vaus (2001) that is this research benefitted from rigors designing, collecting and analyzing data.

Qualitative method research was used to describe and explain individual experiences and relationship of the population in the life's situation as they went about the normal working

duties and enabled the researcher to draw general conclusion of the evident of the effect of pollution as according to Crowe *et a*l., (2011), the leverage in using the case study design is that it enables the researcher to closely examine data within its real-life, natural context in order to obtain detailed understanding of the issues under study.

3.2 Scope of the Study

The study was defined within the scope of accessing the effect of pollution on employees and within the north industrial area in Accra, discussed the causes of air pollution and plans or measures put in place by the companies to ensure that air pollution is reduced in the N.I.A.

3.3 Study Population

The study was purposefully centered on employees who work in the N.I.A which is one of the three industrial areas located in the Greater Accra region of Ghana. The N.I.A. is the first republic designated area as an industrial enclave in Ghana. It boast of many industrial and commercial activities. It is located in the northern part of Accra and bounded to the west by North Kaneshie, east by Kokomlemle\Circle, South by Tesano and North by Awudome. It employs over 10, 000 workers and harbours about 100 companies, sole proprietorship and public institutions. The manufacturing companies produce furniture, PVC pipes, mattresses, plastics, and poly products and also beverages, non-alcoholic and alcoholic. There are warehouses, distribution, marketing a trading centres who trade in all sorts of items from motorbikes to home appliances and multi shopping centres. There are also over 10 banks and hotels located in the industrial area. Churches and public institutions can be found in the industrial area as well as petty traders who sells food, books and some in different types of activities.

3.3.1 Study Settings

The study setting included workers in the industrial area, EPPL and Ghana Carton Boxes Manufacturing Company limited. These two companies were chosen based on their location

and the number people and other companies surrounding them which makes them prone to the inhaling of bad air. EPPL is a company who uses expandable polystyrene manufacture wide range of packaging, construction and insulation products. It is situated on Plot 36 Robertson Kotei Street in the North Industrial Area is a suburb of Accra. The area is noted for its industrial and commercial activities. EPPL shares boundary both with World Vision Ghana and Imexco Ghana Limited and located rightly opposite Forewin Ghana Limited. Adjacent to EPPL is Lighthouse Chapel.

Ghana Carton Boxes Manufacturing Company Limited is located off the Dadeban Road produces carton and boxes for packaging of various types and sizes. Ghana Cartons Boxes Manufacturing employs about 65 workers both permanent and casual. The company is surrounded by petty traders and 500 metres on the same lane is located two banks, Melcom and trading centres. It is a densely populated area.

3.3.2 Sampling

This process selected the population with aim of obtaining data to address research problem. The study employed convenience and stratified purposeful sampling techniques. With the questionnaire, convenience sampling was employed to engage people who are conveniently available and since this sampling method has a disadvantage of being ineffective and unrepresentative sometimes, stratified purposeful sampling was used also to select sub groups in the industrial area for the interviews. Stratified purposeful sampling was used because certain questions can only be answered by certain category of workers and this ensured these groups were well represented. According to Babie (2004), stratified sampling helps researchers to strategically avoid biases in the selection of study of people. Both companies has four department which include finance, administration, production and transport with the bulk of the workers in the production line whiles the environmental protection officer is under administration Employees around were randomly selected for the interview and questionnaires administered based on your department. This prevented selection of more respondents from the

same department. The research selected 60 people, ten for interview and the other 50 to answer questionnaire however, the questionnaires were administered in and out of the selected two companies.

Concurrent mixed method used merged both qualitative and quantitative data to ensure data collection at the same time and provide one comprehensive analysis of the research. This ensured integration of data into a smaller form.

3.3.3 Data Collection Instruments

The quantitative approach employed a highly structured method in the form of questionnaire. It employed the form of close ended questions and this helped the respondent to choose from a selected response. Here the researcher has no control over the chosen response. The questionnaire was deemed less tedious as it provided relevant and straight questions to address air pollution and sought to provide easy and constructive answer to the questions. According to Kerlinger (1973) questionnaire gives the relevance and s widely used for collecting data in research because it is developed to answer questions, it is effective instrument for securing factual information about practices and decisions of subjects. The questionnaire were divided into four main sections. Section one was on demographic background of respondents, section two tested the knowledge of the respondent air pollution, three delved into the sicknesses caused by air pollution and four how to minimise air pollution. The questions werebasically centred on the study.

The qualitative method used in-depth interview and participant observation which were constructed based on the research question. The in-depth interviews allowed the researcher sought answers to the research questions posed for the study and gathered needed information. Participant were observed for a period of one week to know people's behaviour during emission into the air. These instruments were chosen for the following reasons. The qualitative data collection instruments described people's experience and expression of phenomenon as well as their cultural characteristics and scenes of the group under observation. The selected

instruments were useful tools in conducting explanatory and descriptive studies. These tools allowed the researcher to extract the perspectives, thoughts and feelings of respondents in order to meet the objectives of the study.

3.3.4 Sources of Data

The sources of data were from both primary and secondary**.**

The primary sources of data were from the questionnaire and in depth in-depth interview administered to the employees of EPPL and Ghana Carton Boxes Manufacturing Company Limited and also around area of study based on the causes and effects of air pollution. The questionnaire was structured based on the research question which reflected the objectives of the study and the interview guide also provided data from the sampled workers. The study also employed observation too.

Secondary data will be obtained from desk based research, published books and articles, journals on air pollution. According to Yin (2003) various sources and types of evidence abound and could be used for study.

3.3.5 Data Management and Analysis

The Statistical Product and Service Solutions (SPSS) and Microsoft Excel 2013 were used in analyzing the quantitative data to draw significant relationship between air pollution and health of workers. Qualitative data analyzed treating each case as unique captured data in details and specific to discover each case important patterns and themes. This helped to explore the phenomenon under the study and place functions of the study with historical context to made meaning of the study.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.0 Introduction

This chapter gives a highlight of responses received from respondents as a result of questionnaires administered, interviews conducted to solicit information and observation made about the effect of air pollution on health of workers in the industrial area and measures put in place to reduce pollution. These responses were analysed through the use of tables, to depict the demographic characteristics, air pollution causes, as well as the views and opinions of respondents on air quality, effects on health and measures put in place to reduce air pollution in N.I.A. In all a total of 60 respondents participated in this research however at the end four questionnaires were rejected hence 56 questionnaires were used in the analysis.

Table 3: Age of respondents

Variable	Frequency	Percentage
10-19yrs	5	8.9
21-30yrs	22	39.2
31-40yrs	17	30.4
41-50yrs	9	16.1
51-60yrs	3	5.4
Total	56	100

Source: **Field data, 2018**

From the total of 56 respondents in the table above, the age range between 10-19 was 5(8.9%), 21-30 22(39.2%), 31-40 as 17(30.4%), 41-50 age range represented 9(16.1 %) and 51-60 represented 3(5.4%)

Table 4: Gender of respondents

Variable	Frequency	Percentage
Male	36	64.3
Female	20	35.7
Total	56	100

Source: **Field data, 2018**

From the table 4, 36 (64.3%) were males whiles females were 20(35.7%).

Table 5: Educational background of respondents

Variable	Frequency	Percentage
Primary\Junior High School	17	30.3
Secondary Education	22	39.3
Degree	16	28.6
Post Graduate	1	1.8
Total	56	100

Source: **Field data, 2018**

From the above, the various educational background was exploited and out of the 56 respondent were, Junior high school and lower 17(30.3%), Secondary 22(39.3%), Degree 16(28.6%) and 1(1.8) postgraduate.

Table 6: Occupation of respondents

Variable	Frequency	Percentage
Factory hand	19	33.4
Public Servant	5	8.9
Banker	3	5.3
Self-employed	16	28.6
Manufacturing (office workers)	8	14.3
Others	5	8.9
Total	56	100

Source: **Field data**

From the table, the number of respondents who are factory hands were 19(33.4), Public Servant 5(8.9%), bankers 3(5.3%), self-employed 16(28.6%), manufacturing office employees 8(14.3%) and others 5(8.9%).

Table 7: Hours spend in the N.I. A by respondents

Variable	Frequency	Percentage
0-2 hrs	1	1.8
3-5 hrs	6	10.7
6-8 hrs	27	48.2
9-11hrs	15	26.8
Over 12 hrs	7	12.5
Total	56	100

Source: **Field data, 2018**

In table 7, the number of respondents who spend 2hours and below was 1(1.8%), between 3-5 hours 6(10.7%), 6-8 hours 27(48.2%), 9-11 hours 15(26.8%) and over 12 hours 7 (12.5%).

Table 8: Air quality in the industrial

Variable	Frequency	Percentage
Particle in the air at regular times.	10	17.8
Fumes in the air from chimneys.	15	26.8
Scent of chemicals breathe	4	7.1
Fumes from big tractors.	6	10.7
All the above	21	37.5
Total	56	100

Source: **Field data, 2018**

From the above table the respondents were ask what they makes the air bad in the North Industrial Area and 10(17.8%) believe particles in the air, 15(26.8%) fumes from chimneys, 4(7.1%) scent of chemical, fumes from big tractors were 6(10.7%) and 21(37.5%) all the above.

Table 9: General Causes of Pollution

Variable	Frequency	Percentage
Construction of building\roads	5	8.9
Motor vehicles	8	14.3
Bush burning	1	1.8
Fumes from industries	20	35.7
Natural disaster	3	5.4
All of the above	18	32.1
Total	56	100

Source: **Field data, 2018**

From the above table 5(8.9%) respondents believe pollution is caused by construction of buildings and roads, 8(14.3%) by motor vehicles, only 1(1.8%) by burning bush, 20(35.7%) by fumes from industries, natural disaster 3(5.4%) and all of the above is 18(32.1%).

Table 10: Major causes of pollution in N.I.A

Variable	Frequency	Percentage
Construction of buildings/roads	10	17.8
Motor vehicles	8	14.3
Bush burning	2	3.6
Fumes from industries	21	37.5
Chemical release into the air.	15	27.8
Total	56	100

Source: **Field data, 2018**

Major causes of air pollution in the N.I.A shows construction of buildings\roads as 10(17.8%), motor vehicles 8(14.3%), whiles bush burning, fumes from industries and chemical release into the air constitutes 2(3.6%), 21(37.5%) and 15(27.8%) respectively.

Table 11: Importance of Health

Variable	Frequency	Percentage
Not important	3	5.3
Not very important	6	10.7
Fairly important	11	19.6
Very important	24	42.8
Don't know	12	21.4
Total	56	100

Source: **Field data, 2018**

In the above table 3(5.3%) respondents does not see importance of quality air, 6(10.7%) not very important, 11(19.6%) fairly important, 24(42.8%) very important and 12(21.4%) don't know.

Table 12: Relation of Air to Health

Variable	Frequency	Percentage
Not important	2	3.6
Not very important	5	8.9
Fairly important	13	19.6
Very important	26	57.1
Don't know	10	17.8
Total	56	100

Source: **Field data, 2018**

According to respondents 2(3.6%) think quality of air is not important to health, to 5(8.9%) it is not very important, 13(19.6%), for the majority of 26(57.1%) think it is very important and 10(3.5%) don't know.

Table 13: Sicknesses that are cause by air pollution

Sickness	Frequency	Percentage
Asthma	8	14.3
Bronchitis	5	8.9
Heart Problems	17	30.3
Cough	10	17.8
Cancer	7	12.5
Skin problems\Ezcema	2	3.5
Others ……..	7	12.5
Total	56	100

Source: **Field data, 2018**

Some 8(14.3%) respondent think air pollution causes asthma, 5 (8.9%) believe it causes bronchitis, 17(30.3%) heart problems, cough by 10(17.8%) respondents whiles 2(3.5%) and 7(12.5%) skin problems and others respectively.

Table 14: Experience of diseases

Sickness	Frequency	Percentage
Cough	13	23.2
Dry throat	6	10.7
Sneezing	8	14.2
Stuffy nose	12	21.4
Runny nose	11	19.6
Chronic respiratory disease	4	7.1
Hay fever	2	3.6
Total	56	100

Source: **Field data, 2018**

Respondents asked the sicknesses they experience 13(23.2%) said cough, 6(10.7%) dry throat, sneezing 8(14.2%), stuffy nose 12(21.4%) whiles 11(19.6%), 4(7.1%) and 2(3.6%) experience runny nose, chronic respiratory disease and hay fever respectively.

Table 15: Experience of the Above

Times	Frequency	Percentage
Every week	7	12.5
Once a month	10	17.8
Once in 3 months	14	25
Once in six months	19	33.9
Don't know	6	10.7
Total	56	100

Source: **Field data, 2018**

Some 7(12.5%) responded they experience any of the above sickness every week, 10(17.8%) once a month, 14(25%) once in three months, 19(33.9%) once in six months and 6(10.7%) respondents don't know.

Table 16: Experience of the above illness for the past three months

Sickness	Frequency	Percentage
Never	1	1.8
Rarely	3	5.3
Sometimes	21	37.5
Fairly often	11	19.6
Often	20	35.7
Total	56	100

Source: **Field data, 2018**

The following were the responses to if respondents have suffered any of the above illness for the past three months only 1(1.8%) never, 3(5.3%) rarely, 21(37.5%) sometimes, 11(19.6%) and 20(35.7%) often.

Table 17: Sicknesses for the above 12 months

Sickness	Frequency	Percentage
Wheezing without cold	14	25
Chest tightness	12	21.4
Shortness of breath	4	7.1
Attack of cough	26	46.5
Total	56	100

Source: **Field data, 2018**

From the above table, 14(25%) have suffered wheezing without cold for the past 12 months, chest tightness 12(21.4%), shortness of breath 4(7.1%), and attack of cough 26(46.5%).

Table 18: Chronic diseases from the following

Sickness	Frequency	Percentage
Wheezing without cold	13	23.2
Chest tightness	12	21.4
Shortness of breath	4	7.1
Attack of cough	17	30.3
Don't know	10	17.8
Total	56	100

Source: **Field data, 2018**

From the above 13(23.2%) respondents ever had chronic disease from wheezing without cold, 12(21.4%) chest tightness, shortness of breath 4(7.1%), attack of cough 17(30.3%) and 10(17.8%) don't know.

Table 19: Air pollution as the world's largest single environment health problem

Variable	Frequency	Percentage
Strongly disagree	5	8.9
Disagree	8	14.3
Neutral	11	19.6
Agree	17	30.3
Strongly agree	15	26.8
Total	56	100

Source: **Field data, 2018**

The above shows the response of respondent on seeing air pollution as the world's largest environmental health problem. 5(8.9%) strongly disagree, 8(14.3%) disagree, 11(19.6%) are neutral, 17(30.3%) agree and 15(26.8%) strongly agree.

Table 20: Effect of outdoor pollution on children and adults

For both children and adult outdoor pollution can be dangerous

Variable	Frequency	Percentage
Strongly disagree	4	7.1
Disagree	5	8.9
Neutral	10	17.8
Agree	23	41.1
Strongly agree	14	25
Total	56	100

Source: **Field data, 2018**

For some 4(7.1%) respondent strongly disagree outdoor pollution can be dangerous to both children and adult whiles 5(8.9%) disagree, 10(17.8%) are neutral, 23(41.1%) agree and 14(25%) strongly agree with the statement.

Table 21: Air quality should be a priority of the government

Variable	Frequency	Percentage
Strongly disagree	2	3.6
Disagree	3	5.3
Neutral	19	33.9
Agree	10	17.8
Strongly agree	22	39.3
Total	56	100

Source: **Field data, 2018**

Respondents show the extent to which they expect quality air to be a priority of government for 2(3.6%) strongly disagree, 3(5.3%) disagree, 19(33.9%) are neutral, 10(.17.8%) agree and 22(39.3%) strongly agree.

Table 21: Polluting companies should be fined even if it puts some jobs at risk

Variable	Frequency	Percentage
Strongly disagree	10	17.8
Disagree	14	25
Neutral	16	28.6
Agree	11	19.6
Strongly agree	8	14.2
Total	56	100

Source: **Field data, 2018**

From the table above 10(17.8%) strongly disagree that polluting companies should be fine even if it risk some jobs whiles 14(25%) disagree, 16(28.6%) were neutral, 11(19.6%) agree and 8(14.2%) strongly agree.

Table 22: Factories should switch to cleaner process of fuel

Variable	Frequency	Percentage
Strongly disagree	0	0
Disagree	1	1.8
Neutral	9	16.1
Agree	18	32.1
Strongly agree	28	50
Total	56	100

Source: **Field data, 2018**

The table 22 shows the extent to which respondents believe that factories should switch to cleaner process of fuel. Only 1(1.8%) disagree, 9(16.1%) are neutral, 18(32.1%) agree and 28(50%) strongly agree.

4.1 Discussion and Findings

- The demographic composition of the respondents' sex show more males than female because men pursue work more often than women. More people work as factory hand (33.4%) and work in the factories or industrial work is tedious hence more men.
- There is a high proportion (69.6%) of respondents between the ages of 21-40 because that age bracket have the energetic workforce.
- The number of respondent who have secondary background are more than any other educational background though the gap between them and degree as well Primary junior is less than 9% and 10.7% respectively. This shows respondents with basic

education thus from primary to secondary education as stipulated in the Constitution of Ghana (Article 25 Clause 1a) dominated the educational level accounting for 69.9% of the respondents because majority of the work in the industrial area does not need specialization and it is easily trainable task.

- From the industrial area, a high proportion don't know much about air pollution this may be attributed to lack of information dissemination in the country from the print media such as newspapers, journal as well as television and radio stations.
- From the observation as the emission of fumes from chimneys in the industrial causes severe air pollution however, it was also observed that people around such industries continue their work as schedule less concern, only a few about 40% covered their nose not to inhale such fumes.
- Respondent see the main contributor of air pollution in N.I.A. as fumes from industries (37.5%) and chemical release (27.8%), followed by construction of roads and buildings (21%) and motor vehicles (14.3%) . this is in agreement with result achieved by Wang *et al* (2016) in a similar survey found these three as a major causes of air pollution thus industrial emission, more construction in the industrial area and heavy trucks conveying raw materials and processed goods to and from the industrial area.
- Different opinion were expressed by respondent on importance of air pollution in relation to human health. 12.6% don't know the effect of air pollution on health this my due to the belief that some of this sickness may be due to hereditary or o lifestyle because according to the respondent for the past three months about 92.8% have once suffered sicknesses the following sicknesses cough, dry throat, sneezing, stuffy nose, runny nose, chronic respiratory disease and hay fever.

CHAPTER FIVE

SUMMARY, RECOMMENDATIONS AND CONCLUSIONS

5.0 Introduction

This chapter completes the research process. It is organized into three main sections. The first section summarizes the study key findings; the second includes the recommendations that presents some inferences and implications for management and leadership as well as suggestions for new research avenues. The chapter ends with the conclusion that gives insight for policy implications and institutional directions.

5.1 Summary

The study investigates the effect of air pollution on human health a case study of the N.I.A. The research adopted the mixed method approach of research and the purposive and stratified random sampling techniques to include 56 participants for the study. The study adopted the data collection method of using questionnaire, interview guide and observation. To ensure reliance, validity and understanding of the primary data, it was analysed and displayed in a table form.

5.2 Recommendations

This study is to finds innovative ways to which people will be made aware of air pollution and its effect on their health. Information dissemination to the public through all forms of social media. According to Jiang et al (2016) government of all levels, Non-Governmental Organisation, universities and communities should be encouraged to participate in the dissemination on air pollution. As the general public gain information, they able to insist on their rights and report any industries that do not comply with the lay down procedure of air pollution. Through this the effect of air pollution on their health will be known and they will take care of themselves to prevent these sicknesses.

5.3 Conclusions

Through the analysis it was found that individually the level of education play a vital role on how people understand the effect of air pollution.

In addition the perception of air pollution is important where people think government should do more about air pollution since individuals believe air pollution affects human health and government should ensure that policies pertaining to air pollution is thoroughly followed. A few respondents think punitive measures establish by governments is not enough and continuously the air quality is deteriorating.

The findings may help the policy makers to have clear understanding if he public perception of air quality and assist in the dissemination to the general public and establish a proper regulations of industries and manufacturing companies.

5.4 Limitations and indications for new research avenues

A number of limitations in this research may be useful for exploration in future. In the study, only two companies and its surrounding were selected in the population of N.I.A.

There was also lack of data from the Environmental Protection Agency (EPA) on current measurement of air pollution for the industrial area and acesss were partially granted.

Survey did not follow up to the hospital to ascertain the record of people from diseases caused by air pollution.

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APPENDICES

UNIVERSITY OF GHANA

QUESTIONNAIRE

BIO DATA

1. What is your age range?

a 20-30 [ ] b. 31-40 [ ] c. 41-50 [ ] d. 51-60 [ ] e. others pls state …….

2. Sex .

a. Male [ ] b. Female [ ]

3. What is your educational background?

a.Primary [ ] b. J.H.S. [ ] c. Secondary [ ] d. Degree[ ] f. No Education

3. What do you do here?

a. work [ ] b. live [ ] c. visit [ ]

4. If work as what

a. Factory Hand [ ] b. Private Enterprise [ ] d. Public Servant[ ] e trader [ ]

f. others. ……

5. How many hours do you spend here?

a. 0-2 [ ] b. 2-4 [ ] c. 4-6 [ ] d. 6 -8 [ ] e. above 8 [ ].

Standardization of air quality

6. Do you think the air you breathe around here is of good quality?

a. Yes [ ] b. No[ ]

7. What makes you think the air is not good?

a. because of the particle seen in the air at regular times.'

b. because of fumes seen in the air through chimneys.

c. scent of chemicals breathe

d. fumes from big tractors.

e. all the above

8. Below is a list of things that sometimes causes air pollution?

a. Construction of building\roads
b. Motor vehicles
c. Bush burning
d. Fumes from industries
e. All of the above

9. In this area what do you think is the major cause of air pollution?

a .Construction of buildings/roads

b .Motor vehicles

c .Bush burning

d. Fumes from industries

e .chemical release into air.

10. Is air quality important to you?

a. Yes [ ] b. No [ ]

11. How important do you think quality air is important to people's health?

a. Not important [ ] b. not very important [ ] c .fairly important [ ]

d. very important [ ] e. don't know[ ]

12. Do you think air quality is important to your health?

a. Not important [ ] b. not very important [ ] c .fairly important [ ]

d. very important [ ] e. don't know[ ]

Air quality in relation to health

Please tick the one which you think is the correct response to the question.

Below is a list of health problems that some people suggest might be connected with air pollution. I would like to know if you think air pollution is caused by any of these illness?

13. Sickness	can cause it	can't cause it	don't know
Asthma	[ ]	[ ]	[ ]
Bronchitis	[ ]	[ ]	[ ]
Heart Problems	[ ]	[ ]	[ ]
Cough	[ ]	[ ]	[ ]

Cancer	[ ]	[ ]	[ ]
Skin problems\Ezcema	[ ]	[ ]	[ ]
Others ……..	[ ]	[ ]	[ ]

14. Have you suffered from any illness or health problem that you think is caused by air pollution?

a. Yes [ ] b. No [ ] c. Don't know [ ]

15. Which of the following do you experience?

a. cough [ ] b. dry throat [ ] c. sneezing d. stuffy nose [ ]

e. Runny nose f. Chronic respiratory disease [ ] g. hay fever [ ]

h. others ……..

16.How often do you experience the above?

a. every week b. once a month [ ] c. once in 3months [ ]

d. once in six months [ ] e. don't know [ ] .

17. Have you experience the above illness for the past three months?

a Never[ ] b. Rarely [ ] c. Sometimes [ ] d. fairly often e. often [ ]

18. During the last 12 months have you suffered any of these?

a Wheezing without cold b.chest tightness

c shortness of breath d. attack of coughing

19. Have you ever had chronic diseases from the following?

a Wheezing without cold b. chest tightness

c shortness of breath d. attack of coughing

The following questions should be answered with how much you agree with the statement

Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
20. Air pollution is now the world's largest single environment health				
[ ]	[ ]	[ ]	[ ]	[ ]

21. For both children and adult outdoor pollution can be dangerous

[ ] [ ] [ ] [ ] [ ]

22. Air quality should be a priority of the government

[ ] [ ] [ ] [ ] [ ]

23. Polluting companies should be fined even if it puts some jobs at risk

[ ] [ ] [ ] [ ] [ ]

24. Factories should switch to cleaner process of fuel

[ ] [ ] [ ] [ ] [ ]

Thank you for taking the time to complete this survey and for your ongoing commitment to improving air pollution

UNIVERSITY OF GHANA
Interview Guide

This Interview Guide is from a student pursuing Masters in Public Administration from University of Ghana Business School (UGBS). It is meant to collect data to conduct a study on the topic: ***the effect air pollution on health; a case study of Expandable Products Polystyrene Limited***

Kindly assist by responding to these questions. All information provided will strictly be used for research purposes only. Thank you.

Bio data

1. What is your current position?
2. What is your responsibility?
3. How long have you been performing this responsibilities?
4. What do you know about air pollution? Please explain
5. What do you think is the biggest cause of air pollution in the industrial area and the community?
6. What is the main constituent of air pollution?
7. What are some ways you have become more aware of air pollution and its effects?
8. What type of fuel d you use to power the machines? Is it natural gas, electricity, diesel, petrol. Please explain?
9. Air pollution and Health
10. To you what harmful impact does air pollution have?
11. Explain the risk involve with air pollution
12. How much health risk do you think does air pollution cause?
13. How often does the staff absent themselves from duty due to illness?

14. Do you have any medical hospital which the staff of EPPL attend?

15. What illness are often reported by the staff or hospitals

16. Is there any staff being treated for any medical problem currently?

17. Has any staff member died for the past five years?

18. If yes what was the cause of death if known?

19. What steps do you think the government could take to rectify or control air pollution?

20. What steps do you think you as an individual can take to rectify or control air pollution?
21. Are any changes foreseen in the implementation of air quality legislation?

22. Has anything changed in the legislature since the inception?

23. Is there a way to find out the air quality in this area?

24. How often is it measured? Please explain

25. How often does EPA visit your premises?

26. Has there been a visit from the beginning of this year?

27. Do you think the air pollution need a stricter control from the government?

28. What are the measures put in place to ensure that air pollution is reduce in this area? Please explain?