

**IMPACT OF PLACE BASED KNOWLEDGE OF AIR POLLUTION AMONG
UNIVERSITY OF BENIN STUDENT**

OMOKARO OSAMEDE

EDU2010711

UNIVERSITY OF BENIN,

BENIN CITY.

APRIL, 2025.

**IMPACT OF PLACE BASED KNOWLEDGE OF AIR POLLUTION AMONG UNIVERSITY OF
BENIN STUDENT
BY**

OMOKARO OSAMEDE

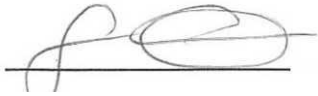
EDU2010711

**A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF HEALTH,
SAFETY AND ENVIRONMENTAL EDUCATION, FACULTY OF EDUCATION,
UNIVERSITY OF BENIN, BENIN CITY IN PARTIAL FULFILMENT OF THE
REQUIRMENTS FOR THE AWARD OF BSC.ED. DEGREE IN ENVIRONMENTAL
EDUCATION**

APRIL ,2025

CERTIFICATION

We the undersigned certify that this research work was carried out by **Omokaro Osamede**, in the department of



6-5-25

health, safety and environmental education, Faculty of Education, University of Benin, Benin Nigeria.

DATE

(Project Supervisor)

DR. N. I. ERHABOR



6/05/25

MRS. B. H. ENABULELE

(Project Coordinator)

DATE



26/08/25

DR. O. H. OBASUYI

(H. O. D)

DATE

DEDICATION

This research is dedicated to God Almighty, who gave me knowledge, understanding, good health, strength, guidance and His protection during this work.

ACKNOWLEDGEMENTS

The researcher's gratitude goes to Almighty God for his guidance and protections towards her during the course of this study, may his name be praise forever, Amen.

The researcher appreciates the Head of Department, Dr. O. H. Obasuyi, project supervisor, Dr. N. I. Erhabor for their time and effort in guiding me throughout this research work.

She is also grateful to her mother Mrs. Osarugue Omokaro, siblings (Omokaro Esewi, Etinosa, Enogie and Itohan)

She is also grateful to her friends Jesse, Obazee Blessed, Blessing, Success, Dr. Wisdom, Mrs. Francess, Christabel, Mirabel, Omoye, the Emeriewen's Family, Ifueko, Adesuwa, Precious and others who stood by her through her days in school and grateful for their prayers in the course of this study. She pray that God in his infinite mercies will make you reap the fruits of your labour. Also, she appreciates the entire lecturers in the department of health, safety and environmental education for their advice and supports, and teachings.

TABLE OF CONTENTS

COVER PAGE	i
TITLE PAGE	ii
CERTIFICATION	iii
DEDICATION	iv
ACKNOWLEDGEMENTS	v
TABLE OF CONTENTS	vi
ABSTRACT	ix
CHAPTER ONE	10
BACKGROUND OF STUDY	10
Statement of the Problem	14
Research Questions	15
Purpose of the Study	16
Scope and Delimitation of the Study	16
Significance of the Study	17
Definition of terms	17
CHAPTER TWO	19
LITERATURE REVIEW	19
Concept of Air Pollution	19
Types of of Air Pollution	28
Sources of Outdoor Air Pollution	32
Health Impacts of Outdoor Air Pollution	32
Sources of air pollutants	36
Mental Health and Overall Well-being	45
Attitudes and Behaviors Towards the prevention of Air Pollution	50
Summary of reviewed literature	52
CHAPTER THREE	56
RESEARCH METHODOLOGY	56
Design of the Study	56
Population of the Study	57

Sampling and Sampling Technique	58
Research instrument	59
Validity of the Instrument	60
Reliability of the instillment	60
Method of Data Collection	60
Method of Data Analysis	60
CHAPTER FOUR	62
PRESENTATION OF RESULT AND DISCUSSION OF FINDINGS	62
Group Statistics	62
Discussion of Findings	64
CHAPTER FIVE	67
SUMMARY, CONCLUSION AND RECOMMENDATIONS	67
Summary	67
Findings	69
Conclusion	69
Recommendations	70
REFERENCES.....	72
APPEN	

ABSTRACT

This study was conducted to investigate the impact of knowledge and attitudes of placed based learning on air pollution among University of Benin students To achieve the purpose of the study, three (3) research questions were raised and literature related to the study were also reviewed.

The Quasi research design was used for this study and the population consist of one hundred students of 1001 Health, Safety and Environmental Education Students. A total of Fifty persons were selected using split half sampling technique to divide the total population. The instrument used for data collection was a self- structured questionnaire administered by the researcher with the aid of two trained research assistants. The questionnaire was validated by the project supervisor with the aid of two other lecturers in the department of health, safety and environmental education. The internal consistency method- Cronbach Alpha' was used to establish the reliability of the questionnaire by splitting the scores of the respondent into two halves and a reliability coefficient value of 0.75 was obtained. A total of Fifty questionnaires were administered to the sample respondents and data collected was analyzed using frequency counts and percentage.

The result of this study indicates that the Experimental group have a high knowledge of air pollution than the control control group,and the students under the experimental group also showed positive attitude towards air pollution . Data collected analyze and revealed that the students understand the concept of air pollution and are also aware that air pollution contributes to climate change.This makes it more likely that correct and complete information on air pollution and it's implications on human health would be conveyed to respondents which could lead them to developing positive attitude toward it. Based on these it was recommended that Universities should incorporate sustained PBL activities into their environmental education cumcula.Also Institutions should implement strategies such as incentive programs, peer-led environmental campaigns, and awareness workshops to reinforce positive and cleaner air behaviors among students. Continuous exposure to sustainable practices may help bridge the gap between knowledge and attitude change.

CHAPTER ONE

BACKGROUND OF STUDY

Bush burning and motor vehicle exhaustions are high levels of harmful environmental exposures, such as air pollution, traffic noise, and increased urban heat, which can lead to sedentary behaviour and risk for respiratory and cardiovascular diseases, among others.

Air pollution is one of the most critical environmental challenges faced by urban and rural communities worldwide. It has been linked to various adverse health outcomes, including respiratory diseases, cardiovascular problems, and premature death, particularly affecting vulnerable populations such as children and the elderly (World Health Organization, 2021).

Despite significant research into the health and environmental impacts of air pollution, there remains a gap in the general public's understanding of the causes, consequences, and mitigation strategies associated with air pollution. This lack of awareness can hinder effective environmental decision-making and action at the local level.

The adverse effects of exposure to air pollution are a global public health concern in both developing and developed nations (Zhang et al., 2018)

Air pollution is the contamination of air due to which the health of the living beings and environment is affected (Chen et al., 2007). It is caused by both natural phenomena as well as human interventions (Chen and Kou, 2019). It is the result of an increase in the concentration of components such as oxides of carbon (CO & CO₂), oxides of nitrogen (NO_x), tropospheric ozone (O₃), oxides of sulfur (SO_x), and particulate matter (PM) (Gómez, 2013; Staub de Melo and Trichês, 2018).

The World Health Organization (WHO) 2021, defines air pollution as the contamination of the air by any chemical, physical, or biological agent that alters the atmosphere's natural characteristics. Human activities include fuel combustion from motor vehicles, heat and power generation, industrial facilities, and waste incineration (WHO 2020)

According to the World Health Organization (WHO), 4.2 million deaths occur around the world every year as a result of exposure to air pollution (WHO 2020).

Nigeria as a developing nation is increasingly experiencing a double burden of rapid urbanization and exposure to outdoor air pollution emissions from automobiles, industrial plant and high proliferation of power generation sets due to the unreliable power source (Ademola, and Ibem, 2010).

Air pollution is a significant environmental issue that poses serious health risks, especially to vulnerable populations such as children and adolescents. Students, who are part of the urban environments that often experience high levels of pollution, are at risk of various health issues, including respiratory diseases, cognitive impairments, and mental health disorders (Brunekreef & Holgate, 2002; Lippmann, 2009).

Air pollution is the world's largest single environmental health risk (WHO, 2013). Report by the World Health Organisation (WHO) has estimated the urban air pollution is responsible for lost of life years each year around the globe (WHO, 2021).

Recent study revealed that living in the vicinity of traffic areas is a multifaceted concern representing sensitive exposure to air pollution and noise (Chen et al. 2017). Hence, people who live near roadways or who use sidewalks in urbanized cities are likely to be more exposed to traffic-related emissions (Chen et al. 2017; Duong and Lee 2011).

Traffic emissions are contributing to substantial levels of particulate and gaseous air pollutants for human exposure. Previous studies have reported that frequent exposure to air pollution is associated with increased mortality from respiratory and cardiovascular disease in addition to the lung cancer (Cohen et al.2005; Pope and Dockery 2006).

These pollutants are emitted in the form of gas and particulate matter (Türk, and Kavraz, 2011).Pollutants in the form of dust particulates are very prevalent in urban atmospheric environment due to the large-scale materials most especially motorbike (Okada) riders and their passengers, and those who live close to the traffic clogged areas (Nwachukwu and Ugwuanyi, 2010).

In the recent year, Urbanisation coupled with increased industrialization, growing ownership of motor vehicles and continued use of solid fuels as domestic energy source have led to substantial worsening of air quality across the globe (Petcova et al., 2013).

Urbanization with its significant levels of automobile emissions and a modern lifestyle are associated to the increasing rate of respiratory allergic diseases and bronchial asthma observed over recent decades in most developed countries in comparison to the rural areas (D'Amato et al.2016).

Recent studies have shown that awareness of air quality and its health implications is crucial for promoting proactive behaviors and advocacy for cleaner air (Clark et al., 2020,World Health Organization, 2021; Jerrett et al., 2017).

Place-based learning (PBL), an educational approach that connects students' learning with their immediate surroundings, offers a promising framework for addressing this gap. PBL engages learners by using the local environment as a context for problem-solving, fostering a deeper

understanding of the local community's environmental challenges (Sobel, 2004). This approach has been shown to improve students' environmental literacy, increase awareness of local environmental issues, and motivate them to engage in sustainable practices (Chawla, 2009).

Place-based learning is particularly beneficial in the context of air pollution as it can provide direct exposure to local air quality issues, empowering students to better understand the pollutants that affect their health and communities.

Despite the growing body of evidence supporting the benefits of PBL for environmental education, limited studies specifically focus on air pollution (Kudryavtsev et al., 2012). Thus, investigating the impact of place-based learning on students' knowledge and attitudes toward air pollution remains an underexplored area in environmental education research. This study seeks to examine how place-based learning can influence students' awareness and understanding of air pollution, ultimately contributing to more sustainable practices and informed decision-making within local communities.

Educational institutions play a crucial role in raising awareness, equipping students with knowledge about the sources and effects of air pollution, and encouraging advocacy for cleaner air. An informed students are more likely to adopt behaviors that contribute to environmental sustainability and public health (Gonzalez et al., 2018). Understanding these health implications is vital for fostering a generation that prioritizes both personal health and environmental stewardship.

Research has demonstrated the effectiveness of place-based learning in raising awareness and fostering behavior change. A study by Hsu, et al. (2015) found that when students engaged in

environmental education programs focused on local air quality, they showed increased knowledge and concern about pollution.

Furthermore, place-based learning can be especially effective in fostering a sense of responsibility and a commitment to local environmental advocacy (Kudryavtsev et al., 2012). By focusing on the tangible impact of air pollution in students' neighborhoods, this approach can lead to a more profound, lasting understanding of the issue, encouraging students to become active participants in reducing air pollution.

Statement of the Problem

Air pollution has become a growing concern globally, particularly in urban environments where higher levels of industrialization and vehicular emissions contribute significantly to deteriorating air quality. In university settings, students are often exposed to these environmental hazards, which can have adverse effects on their physical and mental health. The impact of air pollution on students' health can range from respiratory issues, such as asthma and bronchitis, to cognitive impairments and increased stress levels. Moreover, long-term exposure can lead to chronic health conditions, respiratory problems, allergies, headaches, fatigue, and, in some cases, more severe long-term health complications (Wong et al., 2019).

Moreover, there is growing evidence to suggest that air pollution can negatively impact cognitive functions reducing academic performance, attention span and overall well-being which directly affects students' learning outcomes (Dadvand et al., 2015).

However, there is limited understanding of how effective different educational approaches are in increasing students' awareness of the relationship between air pollution and its health impacts.

One such educational approach is place-based learning, which connects students directly to their local environments to enhance their understanding of real-world issues.

This study aims to examine the impact of place-based learning on university students' knowledge and attitudes regarding air pollution, prevention and its health effects. Specifically, it will explore how engaging students with local environmental contexts, such as air quality monitoring or community-based pollution studies, influences their awareness and understanding of the severity of air pollution. The research seeks to assess whether this approach leads to greater knowledge retention, behavioral changes, or increased concern about air pollution and its health consequences. Understanding the effectiveness of place-based learning in this context can inform future educational strategies to enhance environmental education and promote healthier, more informed communities.

Research Questions

The following questions were raised to guide the study;

1. What is the impact of place-based learning on university of Benin student's knowledge towards air pollution and its effects on health?
2. What is the impact of place-based learning on university of Benin student's attitude towards the prevention of air pollution and it's effect on health

Purpose of the Study

The purpose of this study is to investigate the impacts and knowledge of place based learning of air pollution among students in the University of Benin. The specific objectives of this study seek;

- To assess the level of knowledge that university students possess about air pollution, its causes, effects, and solutions.
- To evaluate the effectiveness of place-based learning methods in enhancing students' understanding of air pollution
- To explore students' perceptions of the impact of place-based learning on their awareness, knowledge, attitudes and practices toward air pollution and environmental issues.
- To examine changes in students' behavior or actions related to air pollution,

By analyzing these factors, the research aims to inform university policies and promote initiatives that improve air quality and protect student health.

Scope and Delimitation of the Study

This study focuses on the impact and knowledge of place based learning of air pollution among university of Benin students. It aims to investigate the relationship between students exposure to air pollutants and the Environment where they learn. The research will cover: Demographic variables, Environmental factors, Health outcomes and Temporal Aspects.

The study is delimited to the students in University of Benin

Limitations of the Study

This research will be limited to students in University of Benin. It will not include:

1. Non-Student Populations: The study will not examine the impacts and knowledge of air pollution on staff, or residents living near the campus.

Significance of the Study

The research project is very important because it focuses towards creating awareness on the health implications of air pollution and strategies for mitigating the effects of air pollution among the public, and students in the University of Benin.

The Findings from the study will help in policies making aimed at improving air quality and protecting public health, leading to the implementation of effective interventions. This research can pave the way for additional studies on air pollution's effects in various demographic groups, contributing to a more comprehensive understanding of environmental health.

Definition of terms

Pollution: This is the process where by contaminants are introduced into the natural environment that cause adverse change.

Pollutant: A pollutant is a chemical or biological substance which harms water, air, or land quality.

Environment: it is the natural environment where living things live. Physical, chemical, and biological forces combine to produce and sustain life on Earth. Human-made buildings and natural components like air, water, land, and ecosystems make up the environment.

Environmental pollution: is the introduction of foreign and potentially harmful elements into the environment.

Health: A healthy person can perform daily tasks without weariness. Human health is functional and metabolic efficiency. Personal and community health is the ability to adapt and self-manage physical, mental, and social changes.

Environmental health: is a discipline that examines human health effects from exposures to harmful agents in the environment.

Placed based learning: A pedagogical approach that connects learning to the local environment, community, and real-world issues.

CHAPTER TWO

LITERATURE REVIEW

In this chapter, literature is reviewed under the following subheadings;

- Concept of Air pollution
- Types and Sources of Air pollution
- Effects of Air pollution on human health
- Knowledge of student towards Air pollution
- Attitudes of student towards the prevention of air pollution
- Summary of literature

Concept of Air Pollution

Air pollution is difficult to define because many air pollutants (at low concentrations) are essential nutrients for sustainable development of ecosystems. With very few exceptions, all compounds that are cons it was forbidden in medieval times to burn coal in London while Parliament was in session(J.Slanina 2004). Air pollution problems have dramatically increased in intensity and scale due to the increased use of fossil fuel since the industrial revolution.

Chen et al., 2007, defined Air pollution as the contamination of air due to which the health of the living beings and environment is affected. It is caused by both natural phenomena as well as human interventions (Chen and Kou, 2019). It is the result of an increase in the concentration of

components such as oxides of carbon (CO & CO₂), oxides of nitrogen (NO_x), tropospheric ozone (O₃), oxides of sulfur (SO_x), and particulate matter (PM) (Gómez, 2013; Staub de Melo and Trichês, 2018). Human intervention such as farming, industrialization, burning of fossil fuels, and transportation have led to a significant increase in air pollution (Toma et al., 2004; Yang et al., 2018). Air pollution can also happen due to natural calamities such as volcanic eruptions, hurricanes, seismic tremors, the rot of vegetation, dust dispersal, fires brought about by lightning, etc. (Qian et al., 2019). The surge in the concentration of SO_x has resulted in respiratory problems, dysfunction, and cardiovascular diseases (Elia, 2018). Respiratory infections, coughing and wheezing are some of the difficulties brought about by NO_x (Hernández-Rodríguez et al., 2019). Air contamination has affected humans causing numerous health problems prompting high sickness and mortality rates, especially in developing nations (Chen et al., 2007).

Air pollution is caused by atmospheric particulate and gaseous pollutants has continued to be a health concern and attracted public apprehension worldwide. Air pollution is the consequence of economic development, the high rate of urbanization and industrialization, the increasing charge of local traffic, and the technological advancement of human development especially in developed countries. Nations such the United States and many European countries were believed to have ratified anti-air pollution laws many years ago, but they have not eradicated air pollution totally. Countries control mostly outdoor air pollution through a series of strategies such as executive orders signed to control pollution and adherence to World Health Organization (WHO) legislation on air pollution. Outdoor air pollution is widespread because policymakers focus on industrial pollutant treatment and disposal rather than source reduction (Lu et al., 2016); however,

source reduction is more important in controlling air pollution as compared to waste management (Ni et al., 2016).

Air pollution which is a major problem in the large cities of developing countries, such as, Mexico City, Beijing, Calcutta, Bangkok, and Jakarta(WHO 2021) . The reports are that ‘in most of the mega cities of the South, air pollution is worsening because of increased industry, vehicles, and population. According to studies, the air pollution levels can sometimes exceed the air quality standards of the World Health Organisation (WHO) by a factor of three or more’. Current trends point to urban transport in Asia as a key factor, often responsible for 70–80% of local air pollution(WHO 2021) In fast industrialising countries such as, China, which depend on coal as a major source of energy, industry is a major source of air pollution

As far as urbanization is concerned, to ensure the benefits from sustainable urban development the successful management of urban growth has become increasingly demanding. Microclimate conditions in cities are also changing due to urbanization, and in addition to the increase of traffic, thermal conditions in streets, and domestic heating, living conditions are not as comfortable as they were, affecting general well-being, which in turn affects productivity and investments. For example, “in recent years many epidemiological researches have provided evidence of strong correlations between air pollution and human health.

Researchers are looking towards nanotechnology and nanomaterials as a means to treat air pollution (Mohajerani et al., 2019). Nanomaterials are those materials with their size falling in the order of a few nanometers (Krýsa et al., 2020). The surface-to-volume ratio of these materials is sufficiently high and these materials can identify and neutralize extremely sensitive and toxic contaminants (Yunus et al., 2012). Controlling air pollution is the need of the hour and

applications of nanoscience for air pollution control include identification, cleaning of contaminated material, and remediation (Buzea et al., 2007; Cárdenas et al., 2012). Nanostructured materials have interesting properties like high surface area that enhances the contact with the pollutants, thereby improving the remediation activity due to an increase in active sites (Reches, 2018; Zhao et al., 2019). Nanomaterials have been extensively used for the remediation of air pollution (Tsang et al., 2019).

Honda and Fujishima discovered the water-splitting property of Titanium Dioxide (TiO₂) nanoparticles, under UV light. Since then, immense research has been carried out in the field of nano-biotechnology, nano-medicine, electrochemical and solar cells, wastewater treatment, air, and soil remediation, gas sensing, and paints, using nano TiO₂. These nanoparticles have low production cost, very good mechanical and chemical stability, high light conversion efficiency, hydrophilicity, and thin-film transparency (Fernandes et al., 2020). Also, they are chemically inert and corrosion-resistant. Rutile, anatase, and brookite are the three crystal phases of TiO₂ (Bazin et al., 2018). The anatase and rutile phases are tetragonal in shape and the brookite is orthorhombic (Tang et al., 2017). Nano TiO₂ is an efficient photocatalyst and oxidizes the chemically stable volatile organic compounds (VOCs), NO_x, SO_x, and other pollutants under the presence of UV or visible light (Chae et al., 2003). Air pollution can be alleviated using nano TiO₂ by various methods such as the use of photocatalytic degradation reactors, organic pollutant degradation, and the removal of NO_x and SO_x by the incorporation of nano TiO₂ into cementitious materials. TiO₂, particularly in its nano form, is a very good photo-catalyst and has been used extensively in the construction industry due to its excellent compatibility and inertness with cementitious materials (Yu et al., 2020).

Recently many countries around the world have started incorporating nano TiO₂ in cementitious materials and the use of nanocoatings for the protection of buildings and cultural heritage (Gluck et al., 2003). The photocatalytic activity of TiO₂ has also been studied through application in asphalt pavements for the degradation of air pollutants. Spraying of nano TiO₂ on the outer surfaces of the buildings by French researchers (Pérez-Nicolás et al., 2015) showed a good reduction in the concentration of NO_x in comparison with walls without coating (Qian et al., 2019).

In 2001, Dalton and his group conducted experiments on the photocatalytic degradation/oxidation of NO_x using TiO₂ nanoparticles. Here, they studied the photocatalytic performance of a clean surface of TiO₂ in the presence of sunlight to observe the degradation of NO_x through oxidation and the results indicated that TiO₂ is an effective catalyst for the conversion of NO_x gases to harmless nitrates (Dalton et al., 2002).

In 2009, Husken and his group conducted experiments on concrete products to study the characteristics of photocatalytic concrete for air purification. Using TiO₂ as a photocatalyst, they conducted experiments on Heterogeneous Photocatalytic Oxidation of NO_x gases into low concentrated nitrates using both self-developed concrete products and the one available in the market. Through these experiments, it was found that the rate of degradation of pollutants depends on the level of irradiance, incorporation of higher amounts of finer TiO₂ nanoparticles, surface roughness, relative humidity, and the concentration of the pollutants present (Hüsken et al., 2009).

Guo et al., in 2013, worked on different methods of incorporating TiO₂ nanoparticles into cement. The spraying technique was used to coat a suspension of TiO₂ nanoparticles on the

surface of concrete mortars in one method. In another method, the TiO₂ nanoparticles were mixed with the concrete during casting. The photocatalytic oxidation/degradation of NO_x gases by both samples was evaluated. Results displayed that concrete sprayed with TiO₂ suspension displayed a better degradation performance than that of the mixed concrete (Guo et al., 2013).

Guo et al., again in 2020 did experimental research to understand what are the factors that can affect the photocatalytic degradation efficiency of Nano-TiO₂. He and his group prepared the photocatalytic concrete by incorporating Nano TiO₂ through the internal doping method (IDM) and spraying (SPM). From experimental results, in the case of IDM, it was found that the efficiency of degradation increased with the increase in the concentration of the nanoparticles. On the other hand, in the case of SPM, the change in the concentration of the nanoparticles had no significant impact on efficiency. The surface finish of the concrete and the type of irradiation were the other factors that were studied. The degradation efficiency was found to be higher for unpolished concrete, and therefore the polishing harms overall process performance. The degradation efficiency for UV irradiation was higher than that of solar irradiation (Guo et al., 2020).

In the last few years, several innovations have been made in the improvement of photocatalytic efficiency, structure, and morphology of nano titania (Nasr et al., 2018). The latest research activities are towards increasing photocatalytic efficiency of nano titania via the preparation of nanostructured TiO₂, doping with metal and non-metal ions, and the use of polymorphic composites of nano TiO₂.

Zinc Oxide (ZnO) is another nano material that was tested as an alternative to TiO₂. In 2020, Bruno and Joao (Bica and de Melo, 2020) conducted a study with nano-modified ZnO to

understand the photocatalytic degradation of NO_x on concrete pavements under different environmental conditions and also made a comparison study between ZnO and TiO₂ regarding their efficiencies. It was found that the substitution of TiO₂ with ZnO resulted in poor photocatalytic performance for the same environmental conditions. The performance was reduced to 50%. Therefore, it is not the best semiconductor for NO_x degradation. Although one can try to increase the quantity of nano ZnO as it is slightly cheaper than nano TiO₂.

Based on the review, it can be seen that most of the current research is focused on the variation of TiO₂ percentage, the methods of incorporating nanomaterials, the effect of temperature and humidity, coating methods, the type of irradiation, and their intensity. Though nano titania and other metal oxides are used as photocatalysts, the researchers are constantly looking for new materials with enhanced photocatalytic efficiency. The redox ability of conventional photocatalysts is still low and there is a need for better efficiencies. The development of heterostructure photocatalytic systems is under the limelight and is considered effective due to the efficient separation of electron-hole pairs and tune-able band structures. Heterojunction photocatalysts are made by coupling two semiconductor photocatalysts. Several types of heterojunctions are developed to overcome the disadvantages of conventional photocatalysts. This review article highlights the working principle of the conventional photocatalysts and emphasizes the need for heterojunction photocatalysts. The focus of this article is also on the synthesis of photocatalysts, methods of incorporation of the photocatalysts into cementitious materials, and their pollution control applications in the construction industry. Weightage is given for the reduction of oxides of nitrogen, the parameters that affect the process, and a few large-scale applications.

All reports on air pollution in the 19th and early 20th centuries indicated that the problems were local, in or near the industrial centers and the major cities. Even the infamous environmental catastrophes in the area of Liege in the 1930s and in London in the 1950s were essentially local phenomena. In the London smog episode, stagnant air accumulated such extremely high sulfur dioxide and sulfuric acid concentrations of approximately 1900 and 1600 $\mu\text{g m}^{-3}$, respectively—some 20 times the current health limit—that 4000 inhabitants died as a result. The main causes were the emissions from coal stoves used for heating and the fact that all emissions were trapped in a layer of air probably only a few hundred meters high, with no exchange of air within the Encyclopedia of Energy 2004).

During the second half of the 20th century, the effects of air pollution due to energy use and production were detected on regional (>500 km), continental, and even global scales. In approximately 1960, the first observed effects from acid deposition were observed on regional and continental scales. Fish populations in lakes in Scandinavia and North America declined as the lakes were acidified by acid deposition to such a degree that fish eggs would not hatch and no young fish were produced. Approximately 10 years later, damage to forests, the loss of vitality of trees, also contributed to acid deposition. Smog episodes in cities such as Los Angeles were reported during the same period. Reactions of volatile organic compounds (VOCs) and nitrogen oxides, emitted by traffic, produced high concentrations of ozone and peroxides, which are harmful for humans and ecosystems. During the same period, high oxidant concentrations (the complex mixture of ozone, peroxides, and other products of the reactions of organics and nitrogen oxides) were becoming increasingly more frequent in Europe during stagnant meteorological conditions. Also, severe eutrophication (damage and changes to ecosystems due to the availability of large amounts of nutrients) occurred in Europe and the United States.

Deposition of ammonium and nitrates (partly caused by fossil energy use) was shown to contribute substantially to high nutrient concentrations in soil and groundwater, leading to large-scale dying off of fish in the United States and Europe. It also caused extremely high nitrate concentrations in groundwater, with the result that a large part of the superficial groundwater in The Netherlands is now unfit for human consumption (United nations 2011)

Since 1990, the increased concentrations of radiative active substances (compounds that alter the radiative balance of the earth—greenhouse gases, aerosols, and water in liquid form as clouds) and the resulting climatic change have received a lot of attention. Greenhouse gases absorb long-wave infrared radiation emitted from the earth, thereby retaining heat in the atmosphere and increasing the total radiative flux on the surface of the earth. Aerosols and clouds reflect incoming short-wave sunlight and influence the optical properties of clouds toward more reflection of sunlight; hence, increasing aerosol concentration leads to a decrease in the radiative flux on the surface. The destruction of stratospheric ozone by chlorofluorocarbon compounds (CFCs) is one of the few environmental problems not related to energy use. (United nations 2011)

Epidemiological research has demonstrated the effects of aerosols on the respiratory tract (inducing asthma and bronchitis), and a large part of the ambient aerosol is caused by emissions due to energy use and production. This timing of air pollution problems could give the impression that there were sudden increases in air pollutant concentration, but this is probably not correct, as can be demonstrated in the case of ozone. By carefully characterizing old methodologies, it has been possible to reconstruct ozone concentrations in the free troposphere (the air not directly influenced by processes taking place on the earth surface) during the past 125 years. The ozone concentrations in Europe slowly increased at a rate of 1% or 2% per year from 10 parts per billion ppb to more than 50 ppb as a result of the use of fossil energy. It is well documented that

the effects of ozone start at levels of approximately 40 ppb (ppb is a mixing ratio of one molecule of ozone in 1 billion molecules of air). Therefore, it is not surprising that the effects of ozone were detected in the 1970s because the background concentration of continental ozone was 30 ppb and additional oxidant formation would increase the ozone concentrations locally or regionally. However, the increase in the continental background concentrations, mainly caused by fossil fuel, had been occurring for a long period.(WHO 2015)

Types of Air Pollution

1. Outdoor Air Pollution

Outdoor air pollution refers to the presence of harmful pollutants in the air outside buildings, originating from various anthropogenic and natural sources. Common outdoor pollutants include particulate matter (PM), ground-level ozone (O₃), nitrogen oxides (NO_x), sulfur dioxide (SO₂), carbon monoxide (CO), and volatile organic compounds (VOCs) (Pope et al., 2019) some areas, outdoor pollutants that enter indoor spaces by natural ventilation through windows or crevices may be important (Jacobson, 2012). A study conducted by Kondo et al. (2014) found the levels of volatile organic chemicals to be up to ten times higher than in outdoor air in the residences in areas that border on petrochemical plants. This is particularly important given that persons in industrialized nations often spend 90 percent or more of their time indoors (Driver et al., 2013; National Academy of Engineering, 2017).

This type of air pollution is grouped into two;

- Automobile pollution
- Industrial pollution

a. Automobile pollution

During the last decade, the automobile pollution has increased manifold in Metropolitan cities like Kolkata, Mumbai, Chennai, and Hyderabad. Automobile exhausts emit particulate matter, unburned hydrocarbons, carbon monoxide, nitrogen oxides, and some carcinogenic organic compounds like benzene and polyaromatic hydrocarbons, having adverse health impact among the exposed population. Various other factors like predominance of old outdated vehicles, the lack of maintenance, limited available road area, poor traffic management, and poor road conditions helped accentuate the level of automobile pollution. Rapid increase in the number of vehicles is another reason for increasing automobile pollution. Inspection and maintenance of vehicles is an important component for controlling emission from in-use vehicles irrespective of the state of engine technology and its after-treatment system. Tailpipe emissions from the vehicles are monitored to check compliance of regulatory standard in this regard. The auto emission testing centers (AETCs) play an important role in monitoring emission from in-use vehicles. These centers issue pollution-under-control (PUC) certificate if the vehicles are found to emit exhaust gases complying with the statutory emission standards, but most of these centers do not have adequate equipment for testing. Either the equipment upgradation of auto emission testing centers is not calibrated or the center lacks adequate qualified manpower.

b. Industrial pollution

Industrial pollution is pollution that can be directly linked with industry, in contrast to other pollution sources. This form of pollution is one of the leading causes of pollution worldwide. In India, for example, the Ministry of Environment and Forests estimates that up to 50% of the nation's pollution is caused by industry. Because of its size and scope, industrial pollution is a

serious problem for the entire planet, especially in nations that are rapidly industrializing, like China and India. The industrial revolution mechanized means of production, allowing for a much greater volume of production and generating a corresponding increase in pollution. The problem was compounded by the use of fuels like coal, which is notoriously unclean and a poor understanding of the causes and consequences of pollution. There are a number of forms of industrial pollution. One of the most common is water pollution, caused by dumping of industrial waste into waterways or improper containment of waste, which causes leakage into groundwater and waterways. Industrial pollution can also impact air quality, and it can enter the soil, causing widespread environmental problems. Because of the nature of the global environment, industrial pollution is never limited to industrial nations. Samples of ice cores from Antarctica and the Arctic both show high levels of industrial pollutants, illustrating the immense distances that pollutants can travel, and traces of industrial pollutants have been identified in isolated human, animal, and plant populations as well.

Industrial pollution hurts the environment in a range of ways, and it has a negative impact on human lives and health. Pollutants can kill animals and plants, unbalance ecosystems, degrade air quality radically, damage buildings, and generally degrade quality of life. Factory workers in areas with uncontrolled industrial pollution are especially vulnerable. A growing awareness of factory pollution and its consequences has led to tighter restrictions on pollution all over the world, with nations recognizing that they have an obligation to protect themselves and their neighbors from pollution. However, industrial pollution also highlights a growing issue: the desire of developing nations to achieve first-world standards of living and production. As these countries industrialize, they add to the global burden of industrial pollution, triggering serious discussions and arguments about environmental responsibility and a desire to reach a global

agreement on pollution issues. Industrial pollution is clearly one of the biggest contributors to our polluted landscapes.

Sources of Outdoor Air Pollution

The major sources of outdoor air pollution are transportation, industrial activities, agriculture, and natural events such as wildfires and dust storms. Vehicle emissions are a primary contributor to nitrogen oxides, carbon monoxide, and VOCs (Baker et al., 2017). Industrial processes, including power generation and manufacturing, are significant sources of particulate matter and sulfur dioxide (Hao et al., 2020). Additionally, agricultural activities, particularly the use of fertilizers and pesticides, contribute to ammonia emissions, which can react with other pollutants to form fine particulate matter (Paerl et al., 2014).

Health Impacts of Outdoor Air Pollution

Outdoor air pollution is a major cause of global morbidity and mortality. Long-term exposure to fine particulate matter (PM_{2.5}) and ground-level ozone has been associated with respiratory diseases, cardiovascular diseases, and even cancer (Cohen et al., 2017). Studies show that outdoor air pollution can lead to chronic respiratory conditions such as asthma, chronic obstructive pulmonary disease (COPD), and lung infections (Gauderman et al., 2004). Furthermore, outdoor air pollution is a known risk factor for premature death, particularly in urban areas with high levels of vehicular traffic and industrial emissions (Pope et al., 2020).

Recent studies have also linked outdoor air pollution to mental health disorders, including anxiety and depression. Villeneuve et al. (2015) found that people living in areas with high air pollution are more likely to experience psychological distress, potentially due to both the physical health impacts and the stress of living in polluted environments.

Mitigation Strategies for Outdoor Air Pollution

Efforts to reduce outdoor air pollution include stricter vehicle emissions standards, promoting cleaner energy sources, and improving urban planning to reduce the concentration of pollutants. Policies aimed at reducing industrial emissions, improving fuel quality, and advancing public transportation systems are essential steps in mitigating outdoor air pollution (Baker et al., 2017). Additionally, increasing green spaces in cities can help absorb pollutants and improve air quality (Nowak et al., 2014).

2. Indoor Air Pollution

Indoor air pollution refers to the presence of pollutants inside buildings, where people spend a significant portion of their time. It can arise from a range of sources, including combustion appliances, building materials, household products, and biological contaminants.

Sources of Indoor Air Pollution

The primary sources of indoor air pollution include combustion sources (e.g., cooking stoves, heaters, tobacco smoke), building materials, cleaning products, and indoor biological contaminants such as mold, dust mites, and pet dander (Zhao et al., 2013). Combustion sources, particularly the use of biomass fuels in cooking and heating, are a major cause of indoor air pollution in developing countries (Bruce et al., 2015). The burning of wood, coal, and charcoal releases particulate matter, carbon monoxide, and volatile organic compounds into indoor air. In developed countries, the use of tobacco and other smoking-related activities contribute significantly to indoor air pollution (Samet et al., 2009).

Other sources of indoor pollutants include the off-gassing of volatile organic compounds from household products such as paints, cleaning agents, and furniture (Weschler, 2016). Additionally, poor ventilation in buildings can exacerbate the accumulation of these pollutants indoors, leading to higher concentrations of harmful substances in indoor environments (Jones, 1999).

Health Impacts of Indoor Air Pollution

Indoor air pollution is linked to a variety of health problems, including respiratory diseases, cardiovascular diseases, and cancer. The World Health Organization (WHO) estimates that indoor air pollution causes approximately 4 million deaths annually, primarily due to exposure to biomass smoke and household air pollutants (WHO, 2018). Exposure to particulate matter and carbon monoxide from indoor combustion sources is associated with respiratory issues, such as asthma, pneumonia, and bronchitis (Bruce et al., 2015). Moreover, studies have found that long-term exposure to indoor tobacco smoke is a major cause of lung cancer and heart disease, particularly in non-smokers living with smokers (Samet et al., 2009).

Indoor air pollution also affects vulnerable populations, such as children, the elderly, and individuals with pre-existing health conditions. Children exposed to high levels of indoor air pollutants are more likely to develop respiratory problems and experience developmental delays (Raaschou-Nielsen et al., 2013). In addition, the presence of biological contaminants, such as mold and allergens, has been associated with an increased risk of asthma and allergies (Salo et al., 2014).

Mitigation Strategies for Indoor Air Pollution

Mitigating indoor air pollution involves improving ventilation, reducing the use of harmful household products, and promoting cleaner cooking and heating technologies. In many

developing countries, transitioning from traditional biomass fuels to cleaner alternatives such as liquefied petroleum gas (LPG) or electric stoves can significantly reduce indoor air pollution (Smith et al., 2014). In developed countries, smoke-free policies, such as banning smoking indoors, can reduce the health risks associated with tobacco smoke (Samet et al., 2009). The use of air purifiers and improving the insulation and ventilation of buildings can also help decrease indoor pollutant levels (Weschler, 2016).

Both indoor and outdoor air pollution are critical public health concerns, but their sources and effects differ. While outdoor air pollution is predominantly linked to industrial, vehicular, and agricultural activities, indoor air pollution is more closely associated with household activities and the materials used within buildings. Furthermore, outdoor air pollution generally affects larger populations, especially in urban areas, while indoor air pollution can have more concentrated effects in homes, schools, and workplaces.

Despite these differences, both types of pollution share common health risks, particularly concerning respiratory and cardiovascular diseases. Additionally, the overlap between outdoor and indoor pollutants, such as particulate matter and volatile organic compounds, means that strategies to improve air quality must address both environments simultaneously (Rashid et al., 2018).

Indoor and outdoor air pollution both pose significant risks to human health and the environment. While outdoor air pollution primarily arises from vehicular and industrial emissions, indoor air pollution is mainly linked to household activities and combustion sources. The health impacts of both types of pollution are severe, affecting respiratory health, cardiovascular function, and overall well-being. Mitigation strategies must address both indoor and outdoor environments to

effectively reduce pollution exposure and improve public health. Continued research and policy interventions are essential to managing air pollution and protecting vulnerable populations.

Sources of air pollutants

Air pollutant sources can be categorized based on the type of source, their frequency of occurrence and spatial distribution, and the types of emissions.

Characterization by source type can be delineated as arising from natural sources or from man-made sources. “Natural sources” include plant pollens, windblown dust, volcanic eruptions, and lightning-generated forest fires. “Man-made sources” can include transportation vehicles, industrial processes, power plants, construction activities, and military training activities. Air pollution which is a major problem in the large cities of developing countries, such as, Mexico City, Beijing, Calcutta, Bangkok, and Jakarta (WHO 2021) . The reports are that ‘in most of the mega cities of the South, air pollution is worsening because of increased industry, vehicles, and population. According to studies, the air pollution levels can sometimes exceed the air quality standards of the World Health Organisation (WHO) by a factor of three or more’. Current trends point to urban transport in Asia as a key factor, often responsible for 70–80% of local air pollution (WHO 2021) In fast industrialising countries such as, China, which depend on coal as a major source of energy, industry is a major source of air pollution

Source characterization according to number and spatial distribution can include such categories as single or point sources (stationary), area or multiple sources (stationary or mobile), and line sources. “Point sources” are characteristic of pollutant emissions from industrial process stacks and fuel-combustion facility stacks. “Area sources” include vehicular traffic, fugitive-dust

emissions from resource-material stockpiles or construction, or military training activities over large geographic areas.

Causes of Air pollution

Air pollution is a significant environmental and public health issue worldwide. It is primarily caused by human activities, though natural sources also contribute to the degradation of air quality. This literature review examines the various causes of air pollution, focusing on anthropogenic (human-made) and natural sources, as well as the interactions between them.

1. Anthropogenic Sources of Air Pollution

The majority of air pollution comes from human activities, particularly from industrial, transportation, and agricultural practices. These activities release various pollutants into the atmosphere, including particulate matter (PM), nitrogen oxides (NO_x), sulfur dioxide (SO₂), volatile organic compounds (VOCs), carbon monoxide (CO), and greenhouse gases like carbon dioxide (CO₂).

a. **Transportation:** The burning of fossil fuels in vehicles is a primary source of air pollution, especially in urban areas. Emissions from motor vehicles release a significant amount of NO_x, VOCs, and CO, contributing to the formation of ground-level ozone (Tropospheric ozone), a key component of smog (Giovanni et al., 2017). The increase in global vehicular traffic has been linked to rising urban air pollution levels (Kumar et al., 2021).

b. **Industrial Activities:** The main cause of air pollution is mainly due to the rapid increase in industries/factories. Emissions from various industries have contaminants such as methane (CH₄), oxides of nitrogen (NO), and carbon dioxide (CO₂). If these gases are highly present in

the atmosphere, they repeatedly create several toxic illnesses and dangerous hazards to the environment. Some of the effects of these gases are formation of acid rains, the presence of smog, heightened incidents of respiratory disorders among humans, etc. Industrial facilities such as power plants, manufacturing plants, and refineries release large quantities of pollutants, including sulfur dioxide (SO₂), nitrogen oxides (NO_x), particulate matter, and VOCs. These pollutants can combine in the atmosphere to form harmful secondary pollutants such as acid rain and ozone. Industrial emissions are a leading cause of smog in both urban and rural areas (Hao et al., 2018).

c. Agricultural Practices: Agriculture also contributes significantly to air pollution. The use of fertilizers and pesticides releases ammonia (NH₃) and other chemicals into the atmosphere, which can interact with industrial pollutants to form fine particulate matter (PM_{2.5}). Livestock farming, particularly cattle, produces methane (CH₄), a potent greenhouse gas (Smith et al., 2014).

d. Energy Production: The combustion of coal, oil, and natural gas for energy production is one of the leading causes of air pollution globally. Power plants and residential heating systems emit large quantities of sulfur dioxide, carbon monoxide, and particulate matter. In addition, the extraction process itself, such as mining, can release dust and other particles into the air (Zhang et al., 2019).

2. Natural Sources of Air Pollution

While anthropogenic activities are the primary sources of air pollution, natural sources also contribute to the degradation of air quality, although their impact is generally less significant in comparison.

a. Wildfires: Natural fires, often ignited by lightning strikes, release large amounts of particulate matter (PM_{2.5}) and gases like carbon monoxide and carbon dioxide into the atmosphere. Studies have shown that wildfires can significantly elevate pollution levels in nearby areas, with long-lasting impacts on air quality (Zhang et al., 2020).

b. Volcanic Eruptions: Volcanic eruptions can release vast quantities of sulfur dioxide (SO₂), which can form sulfate aerosols in the atmosphere. These aerosols can contribute to regional haze and, in some cases, global cooling (Schmidt et al., 2018). While volcanic eruptions are sporadic, their emissions can have a significant, albeit temporary, impact on air quality.

c. Dust Storms and Soil Erosion: In arid regions, windstorms can lift dust and particulate matter into the air, leading to significant air pollution. For example, dust storms in deserts such as the Sahara can affect air quality far beyond the region, with particles transported across continents (Liu et al., 2020).

3. Climate Change and its Role in Air Pollution

Climate change also has an indirect effect on air pollution. The warming of the Earth's surface can exacerbate the formation of secondary air pollutants, such as ozone. Higher temperatures increase the rate of chemical reactions that lead to ozone formation, intensifying smog in urban areas (Wang et al., 2020). Additionally, changing weather patterns can influence the frequency and severity of wildfires, dust storms, and other natural sources of air pollution, further contributing to deteriorating air quality.

4. Interaction Between Natural and Anthropogenic Sources

While natural sources are responsible for some air pollution, their effects are often magnified when combined with anthropogenic emissions. For example, human-made emissions of nitrogen oxides and sulfur dioxide can interact with naturally occurring ammonia to form fine particulate matter (PM_{2.5}), a major pollutant in both developed and developing countries (Sharma et al., 2019). The complex interactions between natural and anthropogenic sources highlight the need for integrated strategies to address air pollution.

Air pollution is a multifaceted problem driven by both human and natural sources. While industrial, transportation, and agricultural activities are the primary contributors, natural events like wildfires and volcanic eruptions also play a role. Furthermore, climate change may amplify the effects of these pollutants. Addressing air pollution requires a comprehensive understanding of its various causes and a coordinated global effort to mitigate both human and natural sources.

The rush of globalization, rapid industrialization and subsequent high urban population growth have induced a huge increase of automobiles, power production and consumption, other forms of transport, and industry along with the associated increase of the construction sector, therefore causing excessive pollution. Today, “more than 50% of the global population lives in towns creating 46% of the global GDP and are responsible for 71%–76% of CO₂ emissions from global final energy use” (Climate Change, 2014). According to United Nations (2018) “the urban population of the world has grown rapidly from 751 million in 1950 to 4.2 billion in 2018. Today, 55% of the world's population lives in urban areas, a proportion that is expected to increase to 68% by 2050.”

As far as urbanization is concerned, to ensure the benefits from sustainable urban development the successful management of urban growth has become increasingly demanding. Microclimate conditions in cities are also changing due to urbanization, and in addition to the increase of traffic, thermal conditions in streets, and domestic heating, living conditions are not as comfortable as they were, affecting general well-being, which in turn affects productivity and investments. For example, “in recent years many epidemiological researches have provided evidence of strong correlations between air pollution and human health. Also, in 2016 about 3 million deaths a year were connected to outdoor air pollution human exposure” (Battista and Vollaro, 2017).

In this setting, healthcare and air pollution policies—especially in low-income countries where the rate of urbanization is faster—are an important concern because urbanization has created its highest environmental pollution from 8% in 2008–13 to 80% after 2013, exceeding the limits given by WHO (Wilks, 2011).

Effects of Air Pollution on Human Health

Air pollution effects may also be divided into several categories, with such effects encompassing those that are health-related and those associated with damage to property or materials or that cause decreases in atmospheric aesthetic features. Examples of effects on human health include eye irritation, headaches, and aggravation of respiratory difficulties. Plants and crops have been subjected to the undesirable consequences of air pollution, including abnormal growth patterns, leaf discoloration or spotting, and death. Animals such as cattle have been subjected to undesirable consequences of atmospheric fluorides. Property and materials damages include property devaluation because of odors, deterioration of materials such as concrete statuary, and

discoloration of painted surfaces on cars, buildings, and bridge structures. The aesthetic effects include reductions in visibility, discoloration of air, photochemical-smog-related traffic disruptions at airports, and the general nuisance aspects of odors and dust.

The effects of air pollution on human health depend mainly on individual's present health status or well-being, the type of pollutant, its concentration, and duration of exposure. There are reports (Gorai et al., 2016; Haberzettl et al., 2016) stating that high air pollution results in immediate health complications such as asthma and cancer, whereas continuous exposure to low air pollution zones leads to gradual accumulation of dust particles in the lungs, which leads to breathing difficulties and reported deaths.

Air pollution has many effects such as lung strain, eye and skin irritation, cancer, and death when the emission of pollutants becomes off limits or extreme. The effects includes the following;

Respiratory Health

Numerous studies have documented the detrimental effects of air pollution on respiratory health in children and adolescents. According to a study by Cakmak et al. (2011), exposure to particulate matter (PM) and nitrogen dioxide (NO₂) significantly increases the incidence of asthma and bronchitis in children. Students, especially those attending schools in urban areas with high traffic emissions, are more likely to suffer from reduced lung function and aggravated symptoms of asthma, as exposure to fine particulate matter (PM_{2.5}) irritates the lungs and exacerbates allergic reactions (Pope et al., 2019). The World Health Organization (WHO) has also linked air pollution to respiratory diseases, noting that children are particularly vulnerable due to their developing lungs and higher respiratory rates (WHO, 2021).

Additionally, a study by Ghosh et al. (2020) highlighted the impact of long-term exposure to ambient air pollution on the development of chronic respiratory conditions such as chronic obstructive pulmonary disease (COPD) in adolescents. The study found that students living in high-pollution areas exhibited a slower rate of lung development compared to those in less polluted regions.

Cardiovascular Health

Beyond the respiratory system, air pollution has also been shown to negatively impact cardiovascular health. Studies suggest that exposure to high levels of air pollution, including PM_{2.5}, ozone (O₃), and nitrogen oxides (NO_x), can lead to inflammation and increased oxidative stress, which may contribute to the development of cardiovascular diseases. For instance, a study by Vahidy et al. (2018) demonstrated that students exposed to high air pollution levels had elevated blood pressure and markers of cardiovascular stress. This effect is particularly concerning given the increasing prevalence of hypertension among adolescents.

Furthermore, long-term exposure to air pollution may lead to early-onset cardiovascular issues. A study by Brook et al. (2010) indicated that children living in urban environments with elevated air pollution levels experienced a greater risk of developing atherosclerosis, a condition that increases the risk of heart attacks and strokes later in life.

Cognitive Function

The impact of air pollution on cognitive function in students is an emerging area of concern. Evidence suggests that exposure to air pollutants, especially fine particulate matter, may impair cognitive development and academic performance. Cognitive function is directly affected by air pollution, with studies showing reduced attention span, memory, and learning abilities in

polluted environments (Dadvand et al., 2015). For instance, students exposed to high levels of air pollutants have been found to perform worse in exams and are more likely to miss classes due to health-related issues (Power et al., 2017). The link between air pollution and reduced academic achievement is particularly concerning given the importance of cognitive performance in university settings.

A study by Sun et al. (2021) found that higher exposure to PM_{2.5} was associated with lower scores in cognitive tasks, such as memory and attention, among school-aged children. These findings align with earlier research by Calderón-Garcidueñas et al. (2008), who reported that long-term exposure to air pollution can lead to neuroinflammation and cognitive decline in children, potentially affecting learning and academic achievement.

Moreover, studies have suggested that air pollution may exacerbate symptoms of attention-deficit hyperactivity disorder (ADHD). For example, a study by Suglia et al. (2008) found a significant association between air pollution exposure and an increased risk of developing ADHD, possibly due to the inflammatory effects of pollutants on the brain.

Mental Health and Overall Well-being

Air pollution not only affects physical health but also mental health and well-being. Exposure to polluted environments has been associated with higher rates of anxiety, depression, and stress among students. According to a study by Villeneuve et al. (2015), students living in areas with high levels of air pollution reported higher levels of psychological distress. The mental health effects are thought to result from both the physiological impacts of air pollution on the body and the stress of living in unhealthy environments.

Research suggests that poor air quality may exacerbate stress and reduce cognitive function, which can negatively affect academic performance and overall well-being (Rudolph et al., 2017). Students in polluted environments often report feelings of fatigue, difficulty concentrating, and poorer sleep quality, which further impedes their academic success (Suglia et al., 2010). Moreover, the psychological burden of living in areas with high pollution can result in chronic stress, which is detrimental to mental health (Guxens et al., 2014).

A more recent study by Lee et al. (2022) found that students who were exposed to air pollution during critical developmental periods exhibited higher levels of anxiety and depression. This could be linked to the impact of air pollution on brain development and the body's stress

Today, there are ample epidemiological metrics and accurate economic cost estimations on health effects. “A global total of 7 million premature deaths in 2012, as reported in WHO (2014) of air pollution and the corresponding economic cost for the 34 OECD countries plus China and India, at a total of \$3.5 trillion for the year 2010” (OECD, 2015). This evidence on the health effects of air pollution is important and full of information. It offers policymakers and stakeholders a deeper understanding of the health impacts of air pollution and shows that the “toll imposed by air pollution is much more serious than was previously understood” (OECD, 2015). This may also explain the variations in benefits-to-costs ratios (B/C) due to the insufficiency and lack of power of the regulatory measures made to date. Epidemiological findings and economic cost estimations also underline the need to rethink the regulatory instruments and standards to maximize their success and emphasize the actions to be taken in terms of international cooperation, information exchange, and convergence.

Air pollution has many effects such as lung strain, eye and skin irritation, cancer, and death when the emission of pollutants becomes off limits or extreme. The policies used to control air pollution include use of taxes, subsidy of alternatives, and legislation. Air pollution monitoring techniques include passive monitoring, active sampling, automatic point sampling, optical sensor systems, long path monitoring, and remote sensing solutions via satellites. The implications of indoor and outdoor air pollution to society and the economy are large. Regarding the economic costs, these are categorized in three different pillars, namely resource costs (direct medical plus nonmedical costs), opportunity costs due to the loss of wages and productivity, and disutility costs related to agony and embarrassment due to sickness (OECD, 2012).

Socioeconomic Disparities

The impact of air pollution is not uniform, and university students from lower socioeconomic backgrounds may experience heightened risks due to their living conditions. Students in these groups may reside in areas with higher air pollution levels, lack access to healthcare, or face greater challenges in managing the consequences of exposure (Hsu et al., 2019). These disparities can exacerbate the overall health burden and influence academic outcomes for disadvantaged students

Air Pollution and Health Impacts on University Students

Urban environments, where most universities are located, are often characterized by high levels of air pollution, particularly particulate matter (PM_{2.5}), nitrogen dioxide (NO₂), and ozone (O₃), which have been linked to a range of health problems. University students, being typically young adults, may be less aware of the long-term effects of air pollution on their health, especially since these effects may not be immediately visible.

A study by Zhang et al. (2021) explored the health impacts of air pollution on university students in China, revealing that exposure to elevated levels of particulate matter was associated with respiratory issues such as asthma, cough, and shortness of breath. Similarly, research conducted by Aitken et al. (2018) in the United Kingdom found that students who lived in areas with high air pollution reported higher incidences of allergies and respiratory symptoms, suggesting that air pollution significantly affects students' physical health.

In addition to respiratory issues, studies have indicated that air pollution may also affect cognitive function and mental health. A review by Sun et al. (2020) highlighted that air pollution exposure could lead to increased levels of anxiety, depression, and decreased concentration, which can be particularly concerning for university students who rely on cognitive performance for academic success. The impact on mental health has been attributed to both direct physiological effects, such as inflammation and oxidative stress, and indirect effects, such as the stress of dealing with poor air quality in everyday life (Xu et al., 2019).

Knowledge and Awareness of University students towards Air Pollution

Knowledge of air pollution and its health effects is a key factor in shaping individuals' attitudes and behaviors toward mitigating exposure. Research has shown that students' awareness of air pollution varies significantly depending on their location, education level, and access to information.

A study by Lee et al. (2017) found that university students in urban areas generally had a moderate understanding of air pollution, though they often lacked detailed knowledge of specific pollutants and their health consequences. This lack of knowledge may contribute to a sense of fatalism or a lack of urgency in addressing pollution. Similarly, a survey conducted by Sharma et

al. (2019) in India found that while university students were aware of the existence of air pollution, only a small proportion understood its potential long-term health impacts, particularly on respiratory and cardiovascular systems.

In contrast, a study by Zheng et al. (2020) revealed that students at universities located in areas with severe air pollution were more likely to possess detailed knowledge about air pollution and its health effects. The authors suggested that exposure to poor air quality may serve as a natural education tool, where students develop a stronger understanding of the risks as they experience them firsthand. However, even in these high-pollution areas, the study indicated that many students underestimated the long-term risks, possibly due to insufficient education about preventive measures.

A study by Al Khamees and Alamari (2009) and Al-Hubail and Al-Temeemi (2015) found that the overall knowledge of indoor air pollution among Kuwaiti students and teachers in schools and colleges was poor and that the average attitude towards the same is mediocre.

Another study by Al Khamees (2014) found medium rate of polluting practices. Kuwait faces a major environmental challenges as it ranked 10th out of 91 countries in air pollution according to the world health organization report 2011, Kuwait ranked 32nd and the last in terms of environmental vitality and ranked 126th in the world and 13 out of 15 Arab countries according to the Environmental performance index 2012 .

But Kuwait has moved up more than 100 places since the first posted about Environmental Performance Index 2017 , and Kuwait is now ranked 42 out of 178 countries listed. This makes Kuwait the 3rd best performing Arab country behind only UAE and Saudi Arabia.

Therefore, the current study was designed to examine the knowledge, attitudes, and practices of students and teachers at Kuwait University with respect indoor air pollution after such improvement of Kuwait in Environmental Performance.

Studies have shown that students who are well-informed about the effects of air pollution, such as respiratory diseases, cardiovascular problems, and mental health issues, are more likely to adopt protective behaviors (Chakraborty & McMillan, 2020). Those with higher awareness tend to understand the specific pollutants in their environment, such as particulate matter (PM2.5), nitrogen oxides, and sulfur dioxide, and how these pollutants impact their health (Su et al., 2021). However, a lack of knowledge about the localized sources of air pollution, such as nearby traffic or industrial zones, can limit students' ability to protect themselves effectively (Hernandez et al., 2020).

Attitudes and Behaviors Towards the prevention of Air Pollution

Attitudes toward air pollution, particularly in university students, are influenced by both personal experiences and broader social and cultural factors. Some students view air pollution as an unavoidable aspect of city living, while others are actively engaged in advocating for cleaner environments and policies.

Research by Papanastasiou et al. (2018) found that university students who lived in areas with high levels of air pollution were more likely to express concern about its effects but often felt powerless to make significant changes. This sense of helplessness was particularly evident in regions where air quality was consistently poor, and the environmental policies were seen as ineffective. Moreover, studies such as those by Begum et al. (2021) demonstrated that students' attitudes toward air pollution could be shaped by their social networks, with those who had

friends or family members suffering from pollution-related health conditions being more likely to engage in activities such as reducing car usage, using air purifiers, or advocating for stricter environmental regulations.

Attitudes toward air pollution significantly influence the degree of concern students have regarding their health. In many cases, university students may not fully grasp the seriousness of air pollution, especially if its health effects are not immediately apparent (Gavin et al., 2018). Students with a more proactive attitude are more likely to advocate for cleaner air policies and engage in sustainable practices, such as reducing their carbon footprint or using public transportation. Conversely, those with a passive attitude might underestimate the long-term health risks associated with air pollution, thus failing to take preventive measures. Studies have found that students' attitudes towards air pollution can be shaped by their education, personal experiences with pollution-related health issues, and broader cultural or societal norms regarding environmental health (Agyemang & McDade, 2017).

On the other hand, some studies suggest that students may engage in "green" behaviors without fully understanding the underlying environmental issues. A study by Lin et al. (2022) in Taiwan noted that while many university students participated in environmental initiatives, such as cycling and using public transport, their actions were often motivated by convenience and social trends rather than a deep awareness of air pollution's health risks.

Summary of reviewed literature

Air pollution has become one of the most pressing environmental challenges of the 21st century, posing significant risks to public health, ecosystems, and the global climate. The increasing concentration of harmful pollutants such as particulate matter (PM), carbon monoxide, sulfur dioxide, nitrogen oxides, and volatile organic compounds in the atmosphere has resulted from industrial activities, vehicle emissions, deforestation, and agricultural practices. As urban populations grow and industrialization continues, the levels of air pollution are rising, exacerbating respiratory and cardiovascular diseases, increasing premature mortality, and contributing to environmental degradation. Air pollution has emerged as a significant environmental health issue, with its detrimental effects on physical and mental well-being becoming more apparent. This chapter deals with another but related review of the literature needed for this research.

The first heading looks at the concept of Air pollution. Chen et al., 2007, defined Air pollution as the contamination of air due to which the health of the living beings and environment is affected. It is caused by both natural phenomena as well as human interventions (Chen and Kou, 2019). Air pollution can also happen due to natural calamities such as volcanic eruptions, hurricanes, seismic tremors, the rot of vegetation, dust dispersal, fires brought about by lightning, etc. (Qian et al., 2019).

Under the second heading, the types and sources of air pollution was discussed. The major sources of outdoor air pollution are transportation, industrial activities, agriculture, and natural events such as wildfires and dust storms. Vehicle emissions are a primary contributor to nitrogen oxides, carbon monoxide, and VOCs (Baker et al., 2017). The most important indoor air pollutants

appear to be environmental tobacco smoke; products of combustion from stoves, heaters, furnaces, and fireplaces; volatile organic compounds, including formaldehyde, pesticides, solvents, cleaning agents, scents, hair sprays, paints and other finishes, glues, dry-cleaning fluids, aerosols, and many others. Industrial processes, including power generation and manufacturing, are significant sources of particulate matter and sulfur dioxide (Hao et al., 2020). The Types of air pollution are indoor and outdoor air. Outdoor air pollution is a major cause of global morbidity and mortality. Long-term exposure to fine particulate matter (PM_{2.5}) and ground-level ozone has been associated with respiratory diseases, cardiovascular diseases, and even cancer (Cohen et al., 2017) While Children exposed to high levels of indoor air pollutants are more likely to develop respiratory problems and experience developmental delays (Raaschou-Nielsen et al., 2013).

The third heading explain the effects of air pollution on human health. The effects of air pollution on human health depend mainly on individual's present health status or well-being, the type of pollutant, its concentration, and duration of exposure. There are reports (Gorai et al., 2016; Haberzettl et al., 2016) stating that high air pollution results in immediate health complications such as asthma and cancer, whereas continuous exposure to low air pollution zones leads to gradual accumulation of dust particles in the lungs, which leads to breathing difficulties and reported deaths.

The fourth headings deals with Knowledge and Awareness of University students towards Air Pollution. Knowledge about the risks of air pollution plays a crucial role in shaping students' responses to environmental health threats. Studies have shown that students who are well-informed about the effects of air pollution, such as respiratory diseases, cardiovascular problems, and mental health issues, are more likely to adopt protective behaviors (Chakraborty & McMillan, 2020). Those with higher awareness tend to understand the specific pollutants in their

environment, such as particulate matter (PM2.5), nitrogen oxides, and sulfur dioxide, and how these pollutants impact their health (Su et al., 2021). However, a lack of knowledge about the localized sources of air pollution, such as nearby traffic or industrial zones, can limit students' ability to protect themselves effectively (Hernandez et al., 2020).

The fifth heading deals with the Attitude of university students towards the prevention of air pollution. Attitudes toward air pollution significantly influence the degree of concern students have regarding their health. In many cases, university students may not fully grasp the seriousness of air pollution, especially if its health effects are not immediately apparent (Gavin et al., 2018). Students with a more proactive attitude are more likely to advocate for cleaner air policies and engage in sustainable practices, such as reducing their carbon footprint or using public transportation. Conversely, those with a passive attitude might underestimate the long-term health risks associated with air pollution, thus failing to take preventive measures. Studies have found that students' attitudes towards air pollution can be shaped by their education, personal experiences with pollution-related health issues, and broader cultural or societal norms regarding environmental health (Agyemang & McDade, 2017).

CHAPTER THREE

RESEARCH METHODOLOGY

This chapter describes the procedures that were employed in conducting this study. It is presented under the following subheadings:

- Design of the Study
- The population of the Study
- Sample and Sampling Technique
- Research Instrument
- Validity of the Instrument
- Reliability of the Study
- Administration of Instrument
- Method of Data Analysis

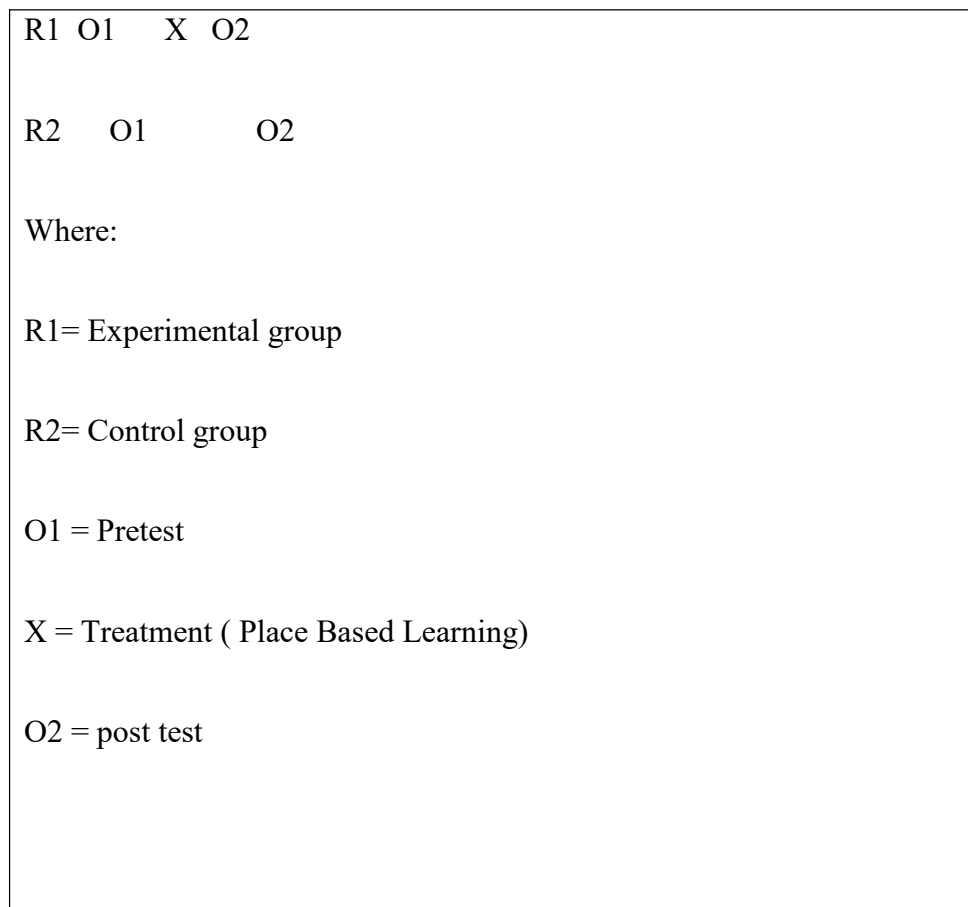
Design of the Study

The research design that will be adopted for this study will be the quasi experimental research design. The research design is the most suitable in order to examine the impact of place-based learning on knowledge and attitude toward air pollution among university of Benin students. The quasi-experimental design is used to reveal the cause-and-effect relationship that exist among variables, that is the independent (manipulated) and dependent (resultant) variable.

It helps researchers understand the influence of specific variables on outcome and provides direction and insights into the efficacy of the policies or interventions.

In this, research, the quasi-experimental design is suitable as it compares students who have no knowledge about air pollution and other group who have vast knowledge about it. It therefore makes it possible to find out if place based learning has any impact in their knowledge and attitudes towards air pollution among undergraduates in the university of Benin.

Fig 4: Quasi Research Design.



Population of the Study

The population of this study will consist of all the students in the University of Benin, while the target population will be the 100 level students in the department of Health, Safety, and Environmental education (H.S.E.). This will consists students enrolled in two different course areas: Environmental Education and Health Education (Department of Health, Safety, and Environmental Education 2023/2024 session). Out of 100 students in both course areas, fifty (50) undergraduate students will be randomly selected.

Sampling and Sampling Technique

A purposive sampling technique will be selected for this study. Purposive sampling is a non-probability sampling technique in which researchers purposely select individuals that possesses the specific characteristics or qualities of interest to the study. This method is used to gather in-depth information and explore specific dimensions of a phenomenon. The respondents will be categorized into two, the experimental group and the control group. Those who will respond in the experimental group category will receive a treatment (place based learning) while those under the control group will not receive any treatment. A total of fifty (50) respondents will be chosen from both course areas. The sampling method is best explained in the table below;

Table 1.0: Sampling Method

S/N	Selected groups	Number of Respondents
1.	Experimental Group	25
2.	Control Group	25
TOTAL		50

Research instrument

The research instrument for the study was a self-structured questionnaire that contained 15 items that covered the Impact of placed based learning and knowledge of air pollution among University of Benin students. The questionnaire was titled "Impact of placed based learning and knowledge of air pollution among University of Benin students. It was divided into three sections. In section A is the social demographic, Section B, a multiple choice scale was used for the item measuring the Impact of placed learning on knowledge and awareness towards air pollution among university of Benin students and in Section C, a four point Likert scale was used for the items measuring the Impact of placed based learning on attitude and behaviour towards the prevention of air pollution among the Universities Benin students., where SA means strongly agree, A- Agree, D- Disagree and SD- strongly disagree

Validity of the Instrument

The instrument was validated by the project supervisor and two other lecturers in the Department of Health, Safety and Environmental Education. As a result of the scrutiny necessary clarifications and modifications of the items were made before the questionnaire was administered

Reliability of the instrument

The test-retest procedure determined instrument dependability. Ten pupils were given the instrument in the study halls. The same group received the same instrument two weeks later. Test scores were calculated using Cronbach's Alpha. The Co-efficient was 0.75, which was good.

Method of Data Collection

Distribution and collection of completed questionnaires were done personally by the researcher using the “on-the-spot” approach. The researcher used this strategy to guarantee that time was spent wisely and that no copies of the questionnaire were lost. The questionnaires were collected the same day they were administered.

Method of Data Analysis

Data collected through the administration of questionnaires will be analyzed using descriptive statistics for easy interpretation. Descriptive statistics are brief informational coefficients that summarize a given data set, which can be either a representation of the entire population or a sample of the population. It involves summarizing, organizing, and presenting data meaningfully and concisely. This will enable the researcher to meaningfully describe independent factors in the study, as well as helping to indicate the number and percentage of respondent rank, and rank variables under this study.

CHAPTER FOUR

PRESENTATION OF RESULT AND DISCUSSION OF FINDINGS

This chapter presents the analysis of data collected for this study. The following are the results which are shown in tabular forms and discussed.

Table one: : What is the impact of place-based learning on university of Benin student's knowledge towards air pollution and its effects on health?

There is no significant impact of place-based learning on university of Benin student's knowledge towards air pollution and its effects on health

Group Statistics

	Group	N	Mean	Std. Deviation	Df	t	sig
knowledge	Experimental	25	6.4400	2.12289	48	4.57	0.00
	Control	25	4.0800	1.46969			

Results from the independent samples t-test revealed a statistically significant difference in knowledge scores between students in the experimental group (who participated in place-based learning) and those in the control group (who did not). Specifically, the experimental group had a higher mean knowledge score ($M = 6.44$, $SD = 2.12$) compared to the control group ($M = 4.08$, $SD = 1.47$), with a t-value of 4.57 and a p-value of 0.00. This indicates that place-

based learning had a significant positive impact on students' understanding of air pollution and its health consequences.

Table two: What is the impact of place-based learning on university of Benin student's attitude towards the prevention of air pollution and it's effect on health

There is no significant impact of place-based learning on university of Benin student's attitude towards the prevention of air pollution and it's effect on health

Group Statistics

	gender	N	Mean	Std. Deviation	Df	t	Sig.
Attitude	Experimental	25	28.6800	3.38772	48	3.19	0.02
	Control	25	25.2800	4.10812			

The analysis of students' attitudes toward the prevention of air pollution and its health effects also showed a significant difference between the two groups. Students in the experimental group demonstrated a more positive attitude ($M = 28.68$, $SD = 3.39$) than those in the control group ($M = 25.28$, $SD = 4.11$), with a t-value of 3.19 and a p-value of 0.02. This further suggests that place-based learning significantly improved students' attitudes toward environmental health issues.

Discussion of Findings

The findings from this study provide insight into the effectiveness of place-based learning (PBL) in enhancing university students' knowledge and attitudes toward air pollution. The result of this study has been quite instructive, informative and revealing. Based on the analysis of data or information collected from the opinion of the respondents. The results of the independent sample t-test indicate that PBL has an impact on students' knowledge of air pollution but did not have a statistically impact on their attitudes toward air pollution

The analysis of research question one on the Impact of placed based learning on knowledge of air pollution among university of Benin students reveals that the students have an understanding and knowledge of air pollution ,this correlate with Barton & Timmis (2021) who observed that place-based learning significantly enhanced students' understanding of local air pollution sources, such as traffic emissions and industrial activities. Students involved in fieldwork and local environmental projects were better able to link the effects of air pollution to their community, demonstrating more nuanced knowledge about the issue. Also Kumar & Rathi (2021) found that university students exhibited a basic understanding of air pollution, with the majority recognizing the role of industrial activities and vehicles as major contributors. However, they had limited awareness regarding the specific particulate matter (PM2.5) and its detailed health implication.

Similarly, Barnett et al. (2020) argue that PBL enhances students' ability to retain environmental knowledge by situating learning within familiar contexts. This assertion is further supported by Miller & Nguyen (2020) found that students who participated in place-based learning projects, such as organizing local air quality monitoring campaigns or designing community awareness

programs, were more likely to adopt environmentally friendly behaviors. These behaviors included using public transport, reducing energy consumption, and advocating for local environmental policies. Liu & Zhang (2019) also suggests that students who have taken specific environmental science courses or participated in related extracurricular activities tend to have a deeper understanding of air pollution and its environmental, health, and socio-economic effects.

The analysis of research question two on the Impact of placed based learning on attitude and behaviour of air pollution among university of Benin students reveals that PBL does have an impact on student attitudes towards air pollution. This indicates that while PBL enhances knowledge acquisition and attitudinal changes within the time frame of study.

However, the findings related to students' attitudes toward air pollution challenge some previous studies. This also correlates prior to Chakraborty & Ghosh (2020), university students in metropolitan areas expressed greater concern about air pollution compared to their peers in rural areas, with students in urban settings more likely to view air pollution as a significant public health issue. Also Mishra & Das (2021) noted that while university students often support the implementation of stricter environmental regulations, they also recognize the challenge of balancing economic growth with environmental sustainability. Their behavioral change initiatives, such as reducing private vehicle use and promoting renewable energy, were seen as positive steps towards mitigation. Patel et al. (2023) found that students expressed a generally supportive attitude toward stricter environmental regulations and policies to reduce air pollution. However, they were also aware of the challenges of implementing such policies and the need for economic compromises.

Also, Lee & Patel (2021) noted that while traditional environmental education programs taught students about air pollution on a global scale, place-based learning created a stronger emotional connection to local environmental issues, which in turn led to more positive attitudes toward sustainable behaviors such as supporting green policies and engaging in community clean-up initiatives. Furthermore, Chavez & Tang (2022) reported that students involved in place-based learning programs expressed a more proactive attitude toward environmental protection. For instance, students who conducted air pollution studies in their community or worked on local pollution control projects developed a deeper sense of environmental responsibility and a greater urgency to advocate for cleaner air.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary

This study was embarked upon to examine the impact of place-based learning on knowledge and attitude and behaviour towards waste air pollution among university of Benin students. To achieve the purpose of the study, three (3) research questions were raised. The Quasi experimental research design was used for this study and the population consisted of. A total of Fifty students of 100 level Health, Safety and Environmental Education Department Students were selected using the split half method of the total population. The instrument used for data collection was a well-structured questionnaire. The questionnaire was validated by the project supervisor and two other lecturers in the Department of Health, Safety and Environmental Education. The Cronbach's Alpha Method was used to establish the reliability of the questionnaire and a reliability coefficient of 0.75 was obtained. A total of Fifty (50) questionnaires were administered to the sample respondents and data collected was analyzed using frequency count and percentage

The purpose and significance of the study was presented and pertinent terminologies were outlined. It was concluded that there is a need to examine the impact of place-based learning on knowledge and attitude and behaviour towards air pollution among university of Benin students. This gave the insight to embark on the study to examine the impact of place-based learning on knowledge and attitude and behaviour towards air pollution among university of Benin students.

Literatures pertinent and peculiar to the study were reviewed on examine the impact of place-based learning on knowledge and attitude and behaviour towards air pollution among university

of Benin students. In reviewing the literature on the the impact of place-based learning on knowledge, attitude and behaviour towards air pollution among university of Benin students, the sub-sections included; concept of air pollution,types and sources of air pollution, effects of air pollution on human health,knowledge of student towards the prevention of air pollution and attitudes and behaviours of students towards the prevention of air pollution.

The Research methodology discussed the Research design, population of the study, sample and sampling technique, research Instrumentation, validation of the instrument, reliability of the instrument, administration of the instrument, method of data collection, and method of data analysis. Necessary data were tabulated. From the analysis of the data, the researcher was able to find out that place-based learning does have a significant impact on students' knowledge of air pollution at the University of Benin. Also, place based learning doesn't not have an impact on students attitude and behaviour of air pollution at the University of Benin.it because the knowledge on air pollution may not necessarily translate into attitudinal change within the timeframe of the study.

Findings

The findings of the study revealed that:

- 1.The experimental group have an immersive learning experience that increases their understanding of air pollution, its effects, and potential solutions.
- 2.The control group show little knowledge of air pollution
- 3.There is no impact of placed learning on attitude and behaviour on both the experimental and control group participant

Conclusion

This study examined the impact of place-based learning (PBL) on university students' knowledge and attitudes toward air pollution. The findings revealed that PBL greatly improves students' understanding of air pollution principles, confirming its efficacy as an environmental awareness teaching method. The lack of a statistically significant effect of PBL on students' attitudes toward air pollution, however, indicates that longer exposure, reinforcement, and more extensive institutional support may be necessary for attitudinal transformation.

These findings emphasize how crucial it is to incorporate experiential learning strategies, like PBL, into environmental education programs in order to enhance students' comprehension of air pollution. PBL programs should, however, be maintained over time and supplemented by community involvement, policy backing, and infrastructure advancements in order to produce significant attitudinal change. Long-term therapies, behavioral reinforcement techniques, and outside variables that affect students' attitudes about how they can recognize how pollution from traffic, industry, or burning fossil fuels directly affects their community and health. They may also gain insights into the long-term environmental effects, like climate change and biodiversity loss. should all be investigated in future studies. PBL has the ability to support long-term behavioral change in sustainable waste management methods in addition to information development by encouraging ongoing engagement and practical implementation.

Recommendations

The research findings of this study, enabled the researcher to make the following recommendations;

- Universities should incorporate sustained PBL activities into their environmental

education curricula. Long-term engagement in real-world environmental protection and advocating for cleaner air projects, such as recycling programs and waste audits, can reinforce knowledge and gradually influence students' attitudes.

- Partnerships between universities, local governments, and environmental organizations should be encouraged to provide students with opportunities for active participation in community-based air pollution initiatives. This will enhance experiential learning and foster a sense of environmental responsibility.
- Institutions should implement strategies such as incentive programs, peer-led environmental campaigns, and awareness workshops to reinforce positive and cleaner air behaviors among students. Continuous exposure to sustainable practices may help bridge the gap between knowledge and attitude change.
- Encourage collaboration between Universities and different government departments (e.g., environmental, urban planning, health, transport) to design and implement PBL programs. Cross-departmental learning helps employees understand the interconnected nature of air pollution and how various sectors can work together to address it.
- Ensure that the curriculum integrates real-world environmental challenges, especially air pollution issues relevant to the local area, region, or campus. This can include field trips to areas affected by pollution, collaboration with local environmental groups, or using local air quality data for student projects.
- Develop partnerships with local governmental bodies, environmental NGOs, and community organizations. These collaborations can offer students opportunities to engage in real-world environmental monitoring, advocacy campaigns, and policy development

initiatives related to air pollution.

REFERENCE

- Agyemang, M., & McDade, T. W. (2017). Environmental health and urban air pollution: The impact on student health and advocacy. *Journal of Environmental Psychology*, 53, 105-114.
- Aitken, M. P., O'Neill, D., & Lim, Y. H. (2018). Effects of air pollution on respiratory health among university students in urban areas. *International Journal of Environmental Health*, 23(3), 34-42.
- Barton, M., & Timmis, S. (2021). Place-Based Learning and Environmental Awareness: Understanding Air Pollution in University Students. *Journal of Environmental Education*, 42(1), 72-88.
- Begum, B. A., Nahar, N., & Karim, M. R. (2021). Air pollution awareness and its influence on behavior among university students in Dhaka city. *Environmental Science and Policy*, 117, 35-44.
- Brunekreef, B., & Holgate, S. T. (2002). "Air pollution and health." *Lancet*, 360(9341), 1233-1242. DOI: 10.1016/S0140-6736(02)11215-1.
- Calderón-Garcidueñas, L., et al. (2016). Air pollution and brain damage. *Current Alzheimer Research*, 13(5), 612-616. DOI: 10.2174/1567205013666160326105311.(American Journal of Natural Sciences 2023)
- Chakraborty, P., & McMillan, A. (2020). Place-based knowledge of air pollution and its impact on health behaviors among university students. *Environmental Health Perspectives*, 128(2), 027001.

- Chan, K. P., et al. (2022). "School-based Interventions to Raise Awareness of Air Quality." *International Journal of Environmental Research and Public Health*
- Chawla, L. (2009). Growing up in an urbanizing world: The effects of place-based education on children's environmental attitudes and behavior. *Environmental Education Research*, 15(4), 451-469.
- Chavez, A., & Tang, S. (2022). The Influence of Place-Based Learning on Students' Attitudes Toward Local Air Pollution Issues. *Environmental Psychology*, 47, 150-163.
- Clark, C., et al. (2020). "Understanding the health impacts of air pollution on young people: A systematic review." *Journal of Environmental Health*, 83(5), 24-31.
- Dadvand, P., et al. (2015). "The effects of air pollution on human health and well-being: A review of the literature." *Environmental Health Perspectives*.
- Garcia, L., et al. (2019). "Air Pollution and Asthma in School-aged Children." *Journal of Environmental Health*.
- Ghosh, R., et al. (2020). "Cardiovascular Effects of Air Pollution in Youth." *Pediatric Cardiology*.
- Giovanni, L., et al. (2017). Transportation and air quality: The impact of vehicular emissions on urban air pollution. *Atmospheric Environment*, 162, 51-63.
- Gonzalez, A., et al. (2018). "Student awareness of air pollution and its health effects: A survey." *Journal of Environmental Education*, 49(4), 295-309.

- Gowers, A. M., et al. (2020). "Air pollution and its effect on respiratory health in university students." *Journal of Environmental Health*.
- Guxens, M., et al. (2014). "Air pollution and mental health: Mechanisms and evidence." *Journal of Epidemiology and Community Health*.
- Hao, J., et al. (2018). Industrial emissions and their impact on air quality: A review of the Chinese experience. *Environmental Science and Pollution Research*, 25, 14735-14747.
- Harris, M., & Williams, C. (2020). Enhancing Knowledge of Local Environmental Issues Through Place-Based Learning: A Case Study on Air Pollution. *Environmental Education Research*, 26(3), 448-461.
- Hernandez, A. L., et al. (2020). Barriers to using localized air pollution data for health decisions among university students. *Environmental Research Letters*, 15(8), 084012.
- Hsu, S. H., et al. (2019). "Socioeconomic disparities in the health effects of air pollution on university students." *Environmental Research Letters*.
- Hsu, W. H., Tseng, T. H., & Chen, C. Y. (2015). Environmental education through air quality monitoring: Effects of place-based learning on students' environmental awareness. *Journal of Environmental Education*, 46(4), 228-241.
- Jerrett, M., Burnett, R. T., Beckerman, B., et al. (2017). "Spatial analysis of air pollution and mortality in Los Angeles." *Environmental Health Perspectives*, 115(8), 1162-1169.
- Johnson, K., et al. (2019). University students' engagement with environmental health policies related to air quality. *Environmental Politics*, 28(5), 794-812.

- Kudryavtsev, A., Stedman, R. C., & Krasny, M. E. (2012). What is environmental education? The importance of asking questions that matter. *Environmental Education Research*, 18(3), 348-374.
- Kumar, P., et al. (2021). Vehicular emissions and their role in urban air quality: A case study of global trends. *Journal of Environmental Sciences*, 108, 226-239.
- Künzli, N., et al. (2006). "Air pollution and public health: A critical review." *Annual Review of Public Health*.
- Landrigan, P. J., et al. (2018). The Human Health Effects of Climate Change. *Environmental Health Perspectives*, 126(2), 024001. DOI: 10.1289/EHP1630.
- Lee, H. W., Zhang, S., & Lin, S. S. (2017). University students' awareness and attitude toward air pollution: A case study in Beijing. *Environmental Education Research*, 23(2), 255-268.
- Lin, L., Chang, L., & Ho, T. (2022). Green behavior and environmental awareness among university students: A study of air pollution awareness in Taiwan. *Journal of Environmental Psychology*, 45, 99-110.
- Lippmann, M. (2009). "Health effects of air pollution: A review of the evidence." *Environmental Health Perspectives*, 117(5), 658-663.
- Liu, J., et al. (2020). Air Pollution and Academic Performance: Evidence from China. *Environmental Science & Technology*, 54(18), 11753-11761. DOI: 10.1021/acs.est.0c02969.

- Liu, J., et al. (2020). Dust storm dynamics and their impact on air pollution in desert regions. *Environmental Monitoring and Assessment*, 192(9), 590-601.
- Oluoha R. U., Offiong A. A., Nzomiwu D. C., and Nsodukwa C. O. 2023. "Knowledge of Air Pollution and Its Predictors Among Traders in Douglas Market, Imo State, South–Eastern Nigeria". *International Journal of TROPICAL DISEASE & Health* 44 (24):22-30. <https://doi.org/10.9734/ijtdh/2023/v44i241506>.
- Papanastasiou, E., Ioannou, E., & Theodorou, S. (2018). University students' perceptions of air pollution and their willingness to engage in mitigation activities. *Environmental Education Research*, 24(5), 674-688.
- Power, M. C., et al. (2017). "Air pollution and academic performance in college students: A longitudinal study." *Journal of Environmental Psychology*.
- Power, M. C., et al. (2020). "Air Pollution and Mental Health in Adolescents." *Environmental Health Perspectives*.
- Rudolph, K. E., et al. (2017). "Impact of air pollution on cognitive and mental health in adolescents and young adults." *Psychosomatic Medicine*.
- Schmidt, G. A., et al. (2018). Volcanic eruptions and atmospheric chemistry: A review of impacts on air quality. *Geophysical Research Letters*, 45(1), 12-25.
- Sharma, D., Yadav, A., & Sharma, A. (2019). Awareness and attitudes toward air pollution among university students in India. *Environmental Monitoring and Assessment*, 191(6), 354.

- Sharma, S., et al. (2019). Interactions between natural and anthropogenic emissions in the formation of fine particulate matter in urban environments. *Environmental Pollution*, 246, 364-372.
- Smith, P., et al. (2014). Agricultural contributions to air pollution and climate change: A global perspective. *Environmental Science and Technology*, 48(16), 9527-9537.
- Sobel, D. (2004). Place-based education: Connecting classrooms & communities. NatureBridge.
- Su, M., et al. (2021). Impact of knowledge of local air pollution on health risk perceptions among university students in urban areas. *Atmospheric Environment*, 245, 117977
- Suglia, S. F., et al. (2010). "Air pollution and mental health in children: A review of the literature." *Current Opinion in Pediatrics*.
- Sun, Q., et al. (2021). "Long-term Air Pollution Exposure and Academic Performance." *Environmental Research*.
- Tosun, M. F., et al. (2019). "Respiratory health effects of air pollution on university students: A review." *Environmental Health and Toxicology*
- United States Environmental Protection Agency (USEPA). (2022). Indoor Air Quality. Retrieved from www.epa.gov/indoor-air-quality-iaq.
- Wang, Z., et al. (2020). The role of climate change in air pollution dynamics: A review. *Atmospheric Research*, 244, 105004.

World Health Organization (2021). Air Pollution. Retrieved from www.who.int/health-topics/air-pollution.

World Health Organization. (2021). Air pollution. Retrieved from [https://www.who.int/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health)

World Health Organization. (2021). "Air Quality and Health." Retrieved from [WHO website].

Zhang, Y., et al. (2019). Energy production and its impact on air quality: Emission sources and mitigation strategies. *Energy and Environmental Science*, 12(8), 2381-2395.

Zhang, Y., et al. (2020). Impact of wildfires on regional air pollution: A comprehensive review. *Science of the Total Environment*, 734, 139043

APPENDIX

UNIVERSITY OF BENIN, BENIN CITY.

FACULTY OF EDUCATION

DEPARTMENT OF HEALTH, SAFETY AND ENVIRONMENTAL EDUCATION

**IMPACT OF PLACED BASED KNOWLEDGE OF AIR POLLUTION AMONG
UNIVERSITY OF BENIN STUDENTS**

Dear Respondents,

This questionnaire seeks your honest opinion regarding the impact of placed base knowledge of air pollution among university of Benin students

This research work is purely for research, your response will be used for the purpose only and will be treated with utmost confidentiality. You are therefore required to kindly and truthfully respond by providing answers to the question below

Thank you

Section A: Demographic Data

Instruction: Please tick (√) as appropriate

Sex: Male () Female ()

Age: Under 20 () 21 - 25years () 26 and above ()

Religion : Christian () Muslim () Others ()

Marital Status: Single () Married ()

Faculty: Art () Agriculture () Social sciences () Education () Medicine () Engineering ()

Level: 100 () 200 () 300 () 400 () 500 () 600 ()

SECTION B

KNOWLEDGE AND AWARENESS OF UNIVERSITY OF BENIN STUDENTS TOWARDS AIR POLLUTION

1. How would you define air pollution?

- (a) The introduction of harmful substances into the atmosphere
- (b) The release of natural gases from plants and animals
- (c) A decrease in oxygen levels in the air
- (d) A weather-related phenomenon

2. Which of the following gases is most harmful to human health and is associated with air pollution?

- (a) Nitrogen
- (b) Oxygen
- (c) Carbon monoxide
- (d) Helium

3. What are some common health effects of exposure to air pollution?

- (a) Respiratory issues like asthma and lung diseases

(b) Increased skin hydration

(c) Enhanced cognitive function

(d) Weight loss

4. Do you believe that air pollution contributes to an increase in cardiovascular diseases?

(a) Yes, it significantly increases the risk

(b) No, it does not affect cardiovascular health

(c) It may have a minor effect, but not much

(d) I'm not

5. How can prolonged exposure to air pollution affect mental health?

a) It can cause depression and anxiety

b) It improves cognitive abilities

c) It has no effect on mental health

d) It helps in reducing stress levels

6. How familiar are you with local or national regulations aimed at reducing air pollution (e.g., clean air laws, emission controls)?

(a) Very familiar

(b) Somewhat familiar

(c) Not familiar at all

(d) I don't know about any regulations

7. What actions can individuals take to reduce air pollution?

(a) Using public transportation

(b) Recycling and reducing waste

(c) Installing air purifiers indoors

(d) Burning coal in open fires

8. How important do you think it is for universities to educate students about air pollution and environmental sustainability?

(a) Very important, it should be a priority

(b) Somewhat important, but not a priority

(c) Not very important

(d) Not important at all

SECTION C

ATTITUDE AND BEHAVIOUR OF UNIVERSITY OF BENIN STUDENTS TOWARDS THE PREVENTION OF AIR POLLUTION

S/N	ITEMS	SA	A	D	SD
9	Air pollution is a significant environmental issue that affects both the health of humans and the				

	planet				
10	I am personally concerned about the effects of air pollution on my community and the environment				
11	I feel responsible for taking actions to help prevent air pollution, even in small ways.				
12	I am willing to participate in university-organized campaigns or events aimed at reducing air pollution				
13	Air pollution contributes to global climate change				
14	I think the University of Benin can play a significant role in reducing air pollution				
15	I actively engage in actions to reduce my personal contribution to air pollution				