

International Journal of Engineering and Environmental Sciences | ISSN 1694-4372 Published by AIR JOURNALS | https://airjournal.org/ijees 16/18 Avenue des Longaniers, Quatre Bornes, Mauritius airjournals@gmail.com; enquiry@airjournal.org



ABSTRACT

An Assessment of the Contributions of Road Transport to Environmental Pollution in Enugu Metropolis, Enugu State, Nigeria

Agwu, Jacob Parkins

Department of Geography, Alex Ekwueme Federal University, Ndufu Alike Ikwo (AEFUNAI), Nigeria

Citations - APA

Agwu, J. P. (2025). An Assessment of the Contributions of Road Transport to Environmental Pollution in Enugu Metropolis, Enugu State, Nigeria. *International Journal of Engineering and Environmental Sciences*, 8(1), 1-18. DOI: <u>https://doi.org/10.5281/zenodo.15532926</u>

This study assessed the contributions of road transport to environmental pollution in Enugu Metropolis, Enugu State, Nigeria with a view to proffering adequate measures in tackling these problems in the study area. Specific objectives of the study included to identify the various types and sources of environmental pollution arising from road transport and its prevalence in Enugu Metropolis; analyze the factors that contribute to the continued environmental pollution arising from road transport in the study location; analyze the consequences of environmental pollution emanating from road transport within the metropolis; and make adequate recommendations to curb the menace of environmental pollution arising from road transport in the study area. The study adopted the survey research design which facilitated reach to all respondents. Stratified, purposive and simple random sampling techniques was adopted and a total number of 399 respondents were selected for the study. Well-structured questionnaires, interview and personal observation facilitated in the gathering of information. Collected data were presented and analyzed using tables, percentages, means and the hypothesis was tested using Chi-Square test. The study revealed that air pollution was more prevalent in the study area followed by noise pollution; land/soil pollution; waste pollution and water pollution. The study also revealed that the sources of air pollution as occasioned by road transport include emission of gases from combustion engines; burning of damaged motor parts among others, for noise pollution: loud horning sound from vehicles; vibration of vehicles; noise from road construction equipment and among others; water pollution: waste oil from crankcases at mechanic workshops; dumping of damaged motor parts in water bodies and among other; for land pollution: illegal littering of refuse from commuters on the ground; illegal dumping of damaged motor parts on the ground and waste oil from crankcases at mechanic workshop while waste pollution sources included waste from commuters and waste from damaged motor parts. The study also found that ageing and ill maintained Tokunbo cars; lower fuel quality; growing need to move people and goods; high use of private vehicles; use of high emission engine vehicles; absence of appropriate road traffic among others contributed to the continued environmental pollution arising from road transport in Enugu Metropolis. From the study, it was revealed that health concerns (breathing problems, swollen eyes, frustration and anxiety and skin diseases); loss of aesthetic value of the urban environment and indiscriminate littering of refuse on the urban environment among others constituted the consequences of road transport induced pollution in Enugu Metropolis. The study through thorough analysis revealed that designating and expanding green spaces in urban areas; promote electric, hybrid and natural gas vehicles; implement and improve air quality legal frameworks; reinforce traffic policies and restrictions and good transportation management system among others were viable measures in tackling road transport induced pollution. Result from the hypothesis show that the consequences of environmental pollution arising from road transport are statistically significant in Enugu Metropolis as the p value was (.001) was less than the significance level (α) of 0.05. The major recommendation of this study highlights that the outright banning of the use of high carbon emitting vehicles will go a long in curbing environmental pollution. This will lead to attitudinal change on the negative actions that result to pollution thereby making Enugu Urban liveable, enjoyable to live, work and recreate.

Keywords: Road Transport; Environment; Air Pollution; Water Pollution; Land/Soil Pollution; Noise Pollution; Waste Pollution; Enugu Metropolis

Copyright: ©2025 The Author. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Introduction

The increasing number of cars on major roads due to high travel requirements which often overwhelm transport systems during peak periods is an emerging problem in most cities of the world (Schrank and Lomax, 2022; Kai and Stuart, 2021). Rapid urbanization in most cities has given rise to urban centers with poor physical planning, deteriorating environment and increasing mobile congestion especially in developing countries due to unrestrained population growth and lack of proper planning (Etim, 2023). This is potentially dangerous given that urban centers are predicted to constitute 80% of urban humanity by 2030 (United Nations Population Fund, 2021).

Interestingly, urban centres pose both a challenge and an opportunity for environmental problems; a challenge because cities are a major focus of pollution as cities consume 75% of the world's energy (Whiteman, 2022) and are responsible for more than 80% of worldwide Greenhouse gas emissions (Martos, 2021). In the United States, gross national product (GNP) grew by a factor of nine with a consequent doubling of the fossil fuel use since 1950 (DoE, 2021). Still in the United States, fossil fuel consumption gave rise to air pollution (Conservation Foundation, 2022). Studies by Freeman (2021) and Leighton (2023) estimated that the annual gross benefits (not benefits net of pollution control expenditures) to the United States population in 1981 from air pollution control was between 20 billion dollars.

Environmental pollution in Europe centres basically on the high emission of harmful gases into the atmosphere which results in air pollution. In 1952, a large cloud of sulphur aerosol covered London for just 2 days, yet killed about 12, 000 people (Wang et al., 2021). Air Quality (2020) reported that air pollution reduces the average life expectancy in Europe by nearly a year (a total of 7 million life years are lost annually).

Urban centers in developing regions are always characterized by high population density with its associated traffic congestions and the concomitant production of disproportionate amount of road traffic emissions compared to their geographic size (UNFPA, 2021). Traffic emissions are often the main source of gaseous pollutants such as NO2, CO and volatile organic compounds in deteriorating urban area (Hellen, et al., 2021; Pirjola, et al., 2021) and consequently degrades ambient air quality and can result in morbidity and mortality for drivers, commuters and individuals living or working near major roadways (Kai and Stuart, 2021). Environmental Pollution by vehicular emissions is worsened by inefficient vehicles, bad road networks, traffic congestion, and fuel adulteration (Hopkins, et al., 2021; Assamoi, et al., 2024).

In Brazil, water and air pollution accounts as the most pressing environmental problem being faced in the country (Findley, 2021). Air pollution comes mainly from industry and from thousands of motor vehicles choking metropolitan areas (Findley, 2021). With an evolving political and legislative system, much is yet to be achieved in the control of environmental problems especially pollution in the third world countries.

Another case of environmental pollution in a developing nation is the case of Malaysia. In Malaysia, the biggest source of pollutant is waste arising from human, transportation and industrial activities. This results in water, air and land pollutions (Hadi, 2020). The ineffectiveness of waste management technique has exposed the urban environment to harmful substances which disturbs the health of the residents and the environment at large (Zamri, Kamaruddin, Samah, Saudi, Wahab, Saad & Bati, 2023).

In Nigeria, environmental issues did not gain official prominence until the 1988 koko toxic waste dumping saga. This brought to the fore the exigent need to establish the Nigeria Federal Environmental Protection Agency (FEPA), Federal Ministry of Environment and other relevant agencies, ostensibly to tackle environmentally related issues in the country. Environmental pollution, sanitation, depletion of the ozone layer formed the major environmental issues to be addressed. Taking Lagos for example, the lack of proper adherence to physical planning regulations, jammed traffic coupled with the rapid population and urbanization occurring in the city, menacing environmental problems of which pollution (water, atmospheric and noise) takes huge prominence (Olayiwola, 2021). This poses great challenge on the health and environmental quality of the residents and the area respectively.

In Enugu State and Enugu metropolis in particular, transportation related emissions pollute the environment (Emodi, 2020). Pollution from transportation in Enugu metropolis affects water, air and land. Air pollution arises as a result of fossil fuel combustion and congested traffic. Water pollution arises from the contamination of water bodies with waste oils and gasoline while land pollution arises from indiscriminate waste disposal by commuters in vehicles among others. This results in urban decay, distortion of the aesthetic beauty and poses great environmental, physical and health risk for the urban populace. This study however assessed the contributions of road transport to environmental pollution in Enugu metropolis, Enugu State, Nigeria.

Statement of the Research Problem

The environmental crisis plaguing most cities of the world is due to environmental and ecological changes resulting from developmental process of the economic and technological man. In fact, if the present century is marked by socio-economic, scientific and technological advancement on the one hand, it is plagued by serious environmental problems caused majorly by pollution on the other hand. Reports and studies had agreed that environmental pollution is one of the major causes of deaths worldwide (World Health Organization, 2021; Prusselstun, 2020). Environmental pollution affects the atmosphere (air), water and land/soil. Authors had also agreed that increased population, high rate of urbanization, high dependence on the use of vehicles and increased dependence on technology had exacerbated the problem of pollution in today's urban areas (Goel, 2021; Ocheri, 2021). This had resulted in serious environmental concerns ranging from acute and chronic health related conditions like birth defects, reproductive failures, heart problems, severe breathing, defacing of the aesthetic beauty of the environment, reduced air quality, loss of vegetation, severe food shortage, global warming among others.

Similarly, in Enugu metropolis, which is one of the fastest growing urban cities in Southeastern Nigeria and Nigeria at large, has been experiencing high population increase which necessitates increased transportation and burning of fossil fuel. The continued and increased use of automobiles for transportation emits harmful gases into the atmosphere coupled with high noise levels is also a great concern. This has resulted in daunting health, environmental and socio-economic challenges both for city authorities and the residents at large. Therefore, this study was undertaken in order to assess the contributions of road transport to environmental pollution in Enugu Metropolis, Enugu State, Nigeria. Specific objectives pursued in the study included to identify the various types and sources of environmental pollution arising from road transport and its prevalence in Enugu Metropolis; analyze the factors that contribute to the continued environmental pollution arising from road transport within the metropolis; and yace the consequences of environmental pollution emanating from road transport within the metropolis; and make adequate recommendations to curb the menace of environmental pollution arising from road transport in the study area.

Research Hypothesis

In order to arrive at veritable findings and conclusion, the under listed hypothesis was formulated:

Ho1: The consequences of environmental pollution arising from road transport are not statistically significant in Enugu Metropolis.

Literature Review

Theoretical Review

An Ecological Perspective of Change and Development

The perspective is associated with the works of Wilkinson and Boulding (1973). The theory is concerned with issues of change and development in contemporary societies, especially as they relate to environmental changes and/or ecologically related trends of population growth and the need to devise and sort out techniques of tackling development problems. The theory states that, as the population of a society increases in size, individual members of the society exert more pressure on scarce available resources such as land and other natural endowments for

survival. They directly or indirectly carryout socio-economic activities that pollute the environment/society, and further cause harm (degradation) to the environment/society. The socio-economic activities, according to these theorists include subsistence agricultural activities of people in agrarian societies of Africa, Latin America etc and the commercial and industrial activities of people in Urban-industrialized societies of the western-Europe and North America.

The perspective further argued that development is needed when a society out grow its resource base and productive system. The perspective therefore posits that as the established economic system of a given environment/society is proved inadequate and productive system becomes more problematic, societies are therefore driven to change their methods. For instance, as the population of a society outgrows the available resources, especially in agrarian societies, people are forced to migrate to urban centres/cities in search of job opportunities. Some sell their labour, whereas some engage in several other commercial and agricultural investments such as livestock; some still carry out some technical and entrepreneurial businesses, all for survival. The urban and city dwellers establish and carryout industrial activities that equally pollute the society. Wilkinson and Boulding (1973) concluded that these activities directly and/or indirectly pollute the environment with its attendant consequences on biodiversity. From the above theory, it is therefore evident that residents of Enugu Urban engage in activities that pollute the environment.

Transport Innovation Theories

The transport innovation theories focused on how ideas on transport are formulated, its realization and implementation (Planing, 2021). These ideas entail how transportation can be improved, its level of improvement, challenges encountered and ways forward. A notable aspect of the innovation theories discussed in this section is the political economy of transport innovations.

The political economy of transport innovations was propounded by Feitelson and Salomon in 2004. The major idea of the theory explains why certain transport ideas or innovations put forward on political agendas are sometimes implemented or not. As put by Feitelson and Salomon (2004), the theory stemmed from the activities of policy entrepreneurs aimed at certain policies that better mobility such as road pricing, new projects on public transport etc.

Commenting further on the theory, Annema (2022) opined that a transport innovation will be implemented only when they meet the criteria of been feasible (technical, social, economic and political). Technical feasibility focuses on the benefits as well as the cost of such innovations. Five qualities of effectiveness, distribution, problem perception, interest groups and sanctions characterize the social feasibility of transport innovations. Economic feasibility ensures that such innovation must be viable while politically, an innovation must be adoptable or meeting the needs of the ruling class.

In adopting the theory for the study, ideas and policies on transportation have been enacted or formulated to curb these negativities in the study area. These ideas have been formulated to ensure better transport and environment in the city. However, its adoption and implementation lie on the ruling class of the society. It is to be noted that the implementation of any viable transportation idea will improve the opinions and acceptability of the public towards the transport sector which is the major focus of the current study.

The Soft Transportation Policy

The soft transport policy is not a theory per se but to a great extent explain how transport innovations help to reduce the use of private cars (Richter et al., 2021). The soft transport policy came to being as hard transport measures (like improved infrastructure for transport, higher rates for private car use etc) had been met with huge disapproval from the public, infeasibility from the political arena and largely insufficient in meeting the transport needs. Cairns et al. (2020) listed some soft transport policy measures to include sustainable workplace and school travel, personalized sustainable travel, effective travel awareness, car clubs, car sharing schemes, teleworking, teleconferencing among others. The adoption of the above policy for the study stems from the fact that the study may likely proffer soft transport measures as viable solutions to the environmental impacts as emanating from public transportation. This is to note that adopting soft transport measures have little or no negative consequence to the environment. Rather, it ensures that sustainable mobility measures are adopted, less or no emission of gases, efficient recycling of wastes from these measures and above all improved health, wellbeing of the residents and the physical environment.

Conceptual Review

Concept of Road Transportation

Footage from the past shows that walking was the initial mode of transportation. After the invention of the wheel, numerous types of vehicles were built (Amin and Vyas, 2024). The English word transportation really comes from the Latin words trans ("across") and portare ("to carry"). The sources are the ancient French word "transporter" and the Latin term "transportare" [www.businessdictionary.com]. In American English and British English, transportation refers to the act of transferring people and objects from one place to another. The following two definitions of transport are more commonly used:

- a. any device used to move commodities or objects from one location to another. Common means of transportation include cars, trains, airplanes, and other two-wheeled vehicles like motorcycles and bikes.
- b. the process of moving goods or an item from point A to point B.

People may now move quickly between locations, safely cross oceans and seas, visit celestial planets, and transfer large loads of freight thanks to a variety of travel options. People commute for a variety of purposes, including employment, recreation, education, health, and other social obligations. They travel to both nearby and distant locations. Most individuals don't know how much time they spend traveling. Traveling on a regular day could be going to see friends, shopping, or traveling to work or school. There are essentially two methods to get around: using a private or personal automobile or public transit. It is possible to move people and cargo by land, sea, or air.

Concept of Pollution

The term pollution is a derivation of the word pollutes- which means, to make something dirty or no longer pure, especially by adding harmful or unpleasant substances to it. In another development; the committee on pollution of the United States National Research Council (2023) defined pollution as; an undesirable change in physical, chemical or biological characteristics of air, land and water that may or will harmfully affect human life or that of other desirable species, industrial processes, living conditions cultural assets that may or will waste or deteriorate existing raw material resources. Pollution according to the above definition is a disorder within an environment and is a by-product of energy conversion and the use of resources. Ekuri and Eze (2021) accordingly, defined pollution as a contamination, a defilement, mischief, perturbation and reduction in the value of an object or thing. Relatedly, Jande (2021) describes the term Pollution to mean to make something dirty or no longer pure, especially by adding harmful or unpleasant substances to it. In this study therefore, the concept, Pollution is used to refer to a situation where waste-materials and/or harmful substances which can deplete, wear/tear away and affect the entire environment and cause disorderliness to all living organisms. Furthermore, environmentally minded persons are of the opinion that human activities as well as natural disasters on the environment can pollute the environment leads to environmental regression and/or diminution (Anijah-Obi, 2020; Gbehe, 2021; Ocheri, 2021).

The Relationship: Transport and the Environment

Underlying actions, results, and outcomes of transportation systems are the primary environmental interconnections of transportation (Kesharwani, 2022). It's challenging to establish relationships between these various dimensions. For example, how much variations in land use influence carbon monoxide emissions? Two further observations further complicate the links between transportation and the surroundings:

First, transportation-related activities directly, indirectly, and cumulatively contribute to environmental hazards, in addition to artificial and natural factors. They might have a significant impact in some situations while playing a little part in others. Second, transportation-related activities are responsible for a variety of regional, national, and continental issues, including pollutants such as acid rain and smog, as well as local issues like CO emissions and noise pollution and global issues like climate change.

Therefore, the degree of input and the geographic scope must be considered when developing and implementing green initiatives for mobility; otherwise, certain policies may simply transfer issues elsewhere and have unexpected effects. One prominent example are local and regional regulations that have pushed the building of taller chimneys for coal-burning units (power plants) and contributed to the atmospheric dispersal of acid rain. The geographic scope of pollution diffusion (especially that of air pollutants) therefore clearly extends beyond designated jurisdictions, even in the case that an administrative division (city, county, state/province) has sufficient environmental enforcement measures. The network, traffic, and modes' effects on the environment must be taken into account in addition to the industrial and economic processes that support the transportation system. These include the manufacturing of fuels, automobiles, and building supplies, certain of which require a lot of energy to produce (like aluminum), as well as the disposing of automobiles, components, as well as infrastructure. Every one of them has a life cycle that includes phases for manufacturing, use, and disposal. Therefore, the assessment of the relationship between transportation and the environment without taking into account phases within the natural world and in the life of the product is likely to provide a narrow depiction of what is happening and could even result in inaccurate policy and judgment.

Empirical Review and Gap

Appannagari (2022) in his study highlighted that population growth with its accompanied increase in transportation, increased general affluence and economic growth, nature of modern technology, urbanization, unplanned urbanization, coal burnt thermal power plants and poverty were among the major causes of pollution across cities of the world. The study further revealed that consequences of pollution include environmental degradation, increased pressure on available resources and ecosystem, generation of more and more waste, and underlining health conditions.

Ityavyar & Thomas (2021) investigated environmental pollution in Nigeria with a need to create awareness for sustainable development. The study revealed that the major causes of pollution in Nigeria include transportation, industrial activities, noise, housing, and conflicts and wars. The study also highlights the consequences of these activities to include loss of vegetation, land degradation through erosion and severe grazing, loss of aquatic life and water pollution, health conditions like typhoid, dysentery, epidemics, anxiety, damage to the tymphanic membrane, increase waste generation, deaths, among others. The study therefore recommends that awareness and creation and change in attitudes for effective environmental and resources management strategies as a way forward.

Onokala and Olajide (2024) discussed the current problems and challenges facing the four major modes of transportation in Nigeria. Data used were obtained from in-depth literature search in books, journals and relevant government publications as well as oral interviews and field observations. They averred that the movement of people and all types of goods all over the country is handled by road transport. The study found that the consequences of the predominant use of road transportation over all the other modes are environmental problems of road transportation and high frequency of road traffic accidents on Nigerian roads. Some of these problems include landslides from severe erosion, destruction of land and forest resources, problems of road maintenance, air, noise and environmental pollution as well as traffic congestion and their contribution to climate change. The study therefore recommended that sustainable ways of handling these problems and challenges so that other modes of transportation can continue their contribution to the economic development of Nigeria in the 21st Century.

Eze, Ugwoke and Ugwoke (2021) in their study assessed road traffic congestion and vehicular emissions in Enugu Urban, Nigeria with a view of identifying factors that influence them and evolve suitable mitigation measures. The study revealed that the concentration of vehicular emissions as obtained in the experimental routes is significantly different (P<0.05) from the control routes and also differs significantly (P<0.05) from WHO permissible limits for Air quality. The study also recorded significant relationships between traffic congestion and the incidence of vehicular emissions in the study area. The finding of this study suggests that major roads within the Enugu metropolis may not be safe from traffic related pollution threats. There is an urgent need to focus on air quality management in urban areas to safeguard the environment and public health. The study recommended the provision of required road facilities, enforcement of traffic control laws by relevant authorities and good transportation management system in the study area.

Abdulhafiz, et al. (2020) analyzed the spatial and temporal concentrations of road transport in Kaduna metropolis, Kaduna State, Nigeria. The study result showed that carbon monoxide is above the 20ppm stipulated by FEPA (Federal Environmental Protection Agency) base line while the remaining gases (NH3 .889ppm, SO2 .0836ppm, VOCs 1.628ppm, NO2 .203ppm) has not gone beyond the local and international safe limits. The study concluded that it is pertinent to emphasize that, continuous exposure of urban residents to these emissions could have cumulative negative impacts on the health of urban residents and calls for concerted effort to be put in place to ensure that carbon monoxides from various road transport modes are within acceptable safe limit. Similar study by Ndoke and Akpan (2021) investigated the contribution of vehicular traffic to carbon dioxide emission in Kaduna and Abuja. Despite the fact that the study discovered a strong influence of traffic congestion on carbon dioxide emission; the focus on only carbon dioxide is a limitation of the study.

Nwadiogbu, et al. (2021) analyzed the contributions of vehicular traffic to carbon monoxide emissions in Enugu Metropolis, Nigeria. The results obtained revealed that the concentrations of CO in high traffic (HT) area is higher than that of low traffic (LT) and is unacceptable compared with the Federal Environmental Protection agency (FEPA) Nigeria set limit. The dispersion pattern of the pollutant showed that the extent of spreading depends on the traffic population of the area. This strongly suggests that vehicular emission contributes to the levels of carbon monoxide in the environment.

Wu and Zhang (2020) discussed on how to reduce air pollution in China. They averred that the use of electric vehicles, non-motorized transport and increased awareness of environmental problems of road transportation is needed. Kuirt (2022) was of the opinion that emission control on new vehicles could be achieved by engine modifications and that substantial reduction in carbon monoxide and other air pollutants result from consideration of design and operating factor.

Emodi (2020) investigated the environmental quality of Enugu, Nigeria as impacted by the primary air pollutants from transport emissions in the area. Classifying the metropolis in different neighbourhoods and the stratifying into low, medium and high-density areas, samples were collected randomly from the neighbourhoods. Result from the study indicates that 91.7% variations in the residential environmental quality could be predicted from air pollution. Results also revealed that health challenges like reduced oxygen carrying capacity of blood, chronic bronchitis and worsening respiratory illness were identified as some of the effects. Findings also showed that acidification of soils, staining of fabrics accounts as environmental problems. The study further recommends that making petroleum products like kerosene available and affordable will serve as a mitigating measure.

Okeke, et al. (2020) investigated the outdoor air pollution levels in vehicular traffic junctions in the major cities of Nsukka, Enugu and semi-urban area of Awgu all in Enugu State, Nigeria using standard analytical procedures. The study revealed that the mean hourly traffic density in the vehicular traffic junctions in Nsukka metropolis, Enugu metropolis and Awgu were 2015, 2873 and 587 respectively. The mean range of values of PM_{2.5}, NO2, SO2, O3 and CO in vehicular traffic junctions within the investigated environments were $1.67 - 12.16 \mu g/m3$, $3.72 - 23.83 \mu g/m3$, $2.96 - 30.09 \mu g/m3$, $5.45 - 66.54 \mu g/m3$ and 1.18 - 15.17 ppm respectively. The mean levels of the determined air pollutants in the air around vehicular traffic junctions in Nsukka metropolis, Enugu metropolis and Awgu semi-urban area differed significantly. The mean levels of PM_{2.5}, and CO in the air around vehicular traffic junctions in Nsukka metropolis were above the recommended permissible limits. Traffic density was therefore seen as the single most important factor contributing to the varying air pollution levels observed in the investigated environments. The study recommended that the government of Nigeria at all levels should look critically into the physical and mechanical states of vehicles plying on the roads in major Nigerian cities, quality of fuel dispensed to motorists and impose strict penalties on those who drive old, rickety and poorly

maintained vehicles and those that subvert traffic rules, in order to drastically stem the levels of emission of toxic air pollutants on the environment through vehicular activities.

Owaduge (2021) studied the contributions of road transport to environmental pollution in Owo, Ondo State, Nigeria. The study found that road transportation resulted in air, noise, water, land and waste pollution. The study found that emissions from exhaust pipes of vehicles, oil spillage, noise from construction equipment and loud horning sound from vehicles were major sources of pollution arising from road transport. The study also revealed that the consequences of environmental pollution as occasioned by road transportation included increased urban heat levels, acidic rain which causes damage to vegetation, poor water quality, loss of aesthetic value of the urban environment among others. The study suggested that a number of mutually reinforcing policies need to be used in urban areas in general, and the city of Owo in particular, to try and reduce the growing energy demand and emissions from the transport sector.

Going further, Zamri et al. (2023) examined environmental pollution and solid waste management in Malaysia. From the study, it was observed that pollution from waste include water and air pollution coupled with extreme human health challenges. The study therefore highlights that the effective implementation of the 3R (Reduce, Reuse and Recycle) as well as the privatization of waste management can help improve finance and promote awareness by the public.

Umeakuka & Mba (2022) observed that blockage of storm water drainage paths in Onitsha with solid wastes which in turn induced flooding cannot enhance the quality of the area. Nwafor, (2020) examined the causes of urban solid waste management problems and the attendant economic, social and health costs, as well as environmental and aesthetic costs. He identified the inertia factor, the demographic factor, institutional factor as well as absence public participation as being responsible. According to him the force of inertia operates from three angles; difficulty in enrolling public involvement for change, the perceptional aspect and the response aspect. Considering the demographic factor, rapid urban population, increase the accelerated rate of urbanization, while lack of intersectoral communication and coordination to manage the environment are the major institutional constraints. Consequently, solid waste management problems have resulted in critical environmental, economic, social and human health crises in the metropolis, impairing seriously the environmental quality of the area. There seems to be a dearth of literature that focused on the contributions of road transport to environment pollution with emphasis on Enugu Metropolis, Enugu State Nigeria. It is therefore essential that a study of the detailed contributions of the most widely used form of transportation in the city is timely. This will aid in the identification of the types, nature, causes and possible evaluation of the effects of environmental pollution in the study area. This will help in achieving a livable urban environment while also achieving a sustainable environment.

Materials and Methods

The Study Area

Enugu Metropolis is geographically located at the centre of Enugu State, lying approximately between latitudes 6°23'N and 7°03'N of the equator and longitudes 7°03'E and 7°19'E of the Greenwich Meridian. Its administrative boundaries include the city centre and surrounding districts that occupy an area of about 72 square kilometers (lyi, 2020).

Enugu's hills at the extreme may reach an elevation of 1,000 metres (3,300 ft). Highlands surrounding Enugu for the most part are underlain by sandstone, while lowlands are underlain by <u>shale</u>. Much of the escarpment stretching from Enugu to <u>Orlu</u> has been ravaged by soil and gully erosion (Egboka, 2020).

Soil is composed of organic matter (decomposing biomas), inorganic (mineral) particles, air and water. Enugu has relatively low organic matter content ranging from 1% to 10%, the soil is known as mineral soil. Enugu metropolis falls within the equatorial climatic zone. The annual rainfall ranges between 1250mm and 2030mm. the annual mean temperature ranges between 22°C and 30°C (Weather Spark, 2020). The relative humidity fluctuates between 40% and 80%. Of the six vegetation belts in Nigeria, Enugu falls within Guinea savannah belt. The Guinea savannah belt

International Journal of Engineering and Environmental Sciences | IJEES Vol. 8, No. 1 | 2025 | DOI: https://doi.org/10.5281/zenodo.15532926

is the broadest belt in Nigeria. It spans between Zaria in the North and Enugu in the South, encompassing the entire middle belt. The natural vegetation in this belt is mainly composed of tall grasses and short to medium sized trees. Most of the trees are deciduous in order to minimize loss of moisture through transpiration. Common tree species in the region are locust bean, shear butter, oil bean and isoberlina tree which are normally less than 6m in height. The metropolis comprises three local government areas (Figure 1); namely, Enugu North, Enugu South and Enugu East. The population of the three (3) local government areas that make up the city is estimated at 722,665 persons with 348,902 males and 373763 females.



Figure 1: Map of Enugu Metropolis Source: Enugu State Geology and Survey, 2025

Methods

The study employed the survey research design. For this study, the chosen design assisted the researcher in elucidating vital information from residents of the selected areas, various transportation management agencies in the areas, transport Company Unions, Town planners and other professionals in the built environment as domiciled in Enugu Metropolis notably Independence Layout, New Haven, Achara Layout, Trans Ekulu, Abakpa and Awkunanaw in Enugu metropolis. Questionnaire, interviews and personal observation facilitated the gathering of information. The utilized questionnaire was well-structured, open-ended and worded in simple English language for easy

understanding by the respondents. The respondents were to choose from a list of options their desired answers while in some cases, they were meant to indicate multiple answers. The questionnaire instrument focused on acquiring information on the types and sources of road transport induced pollution as experienced in the study area. The instrument also helped in eliciting required data on the factors and consequences of road transport induced environmental pollution in the study area. Stratified, purposive and simple random sampling techniques were employed for the study. Stratified sampling entails that the metropolis was stratified according to densities, that is, low, medium and high-density areas. For the study, high density areas include: Abakpa, Iva valley, Asata, Camp, Ogbete, Ogui New layout Achara layout, Ogui, Uwani. Medium densities include the following areas: Awkunanaw, Idaw River, New era, New Haven, Trans-Ekulu, secretariat quarter and Udi Siding. The Low-density areas include: Aria, City Layout, G.R.A, Independence Layout, Republic, Maryland, River side, and Thinkers Corner. From these density areas, six (6) samples were selected randomly thereby given no room for bias. A total of three (3) high, two (2) medium and one (1) low density areas were chosen for the study. They include Independence Layout for the low, Trans Ekulu and New Haven for medium while Abakpa Nike, Achara Layout and Awkunanaw formed the high-density sample areas for the study. On this wise, 399 questionnaire were administered in the study area. Collected data were presented and analyzed using frequencies, percentages, means and the hypothesis was tested using Chi-Square test.

Findings

Analyzing Objective One

Various types and sources of environmental pollution arising from road transport and its prevalence in Enugu Metropolis

Table 1 revealed that majority of the respondents indicated that all the identified forms of environmental pollution arising from road transport were prevalent in the study area. From the result in table 1, majority of the respondents indicated that air pollution was more prevalent (98%) in the study area. This was followed by noise pollution (90%); land/soil pollution (78%); waste pollution (73%) and water pollution (66%). This therefore implies that environmental pollution occasioned by road transport is actually a challenge facing the residents of Enugu Metropolis and drastic measures must be taken to tackle it. This result is in unison with that of Appannagari (2022) and Owuduge (2021) who averred that air, water, soil/land, waste and noise pollution were the major forms of pollution facing cities of the 21st century.

Option	Frequency	Percentage
Air pollution	343	98
Water pollution	231	66
Land/soil pollution	273	78
Noise pollution	315	90
Waste pollution	256	73
Source: Becearcher's Fieldwork 202		

Table 1: Response on Type of Pollution Prevalent in Enugu Metropolis	Table 1: Res	ponse on Type	of Pollution P	Prevalent in Enu	gu Metropolis
--	--------------	---------------	----------------	------------------	---------------

Source: Researcher's Fieldwork, 2025

Table 2 revealed the sources of environmental pollution from road transport in Enugu Metropolis. From the result of the analysis, all the identified sources of pollution from road transport were accepted as they recorded mean scores above 1.49. For air pollution, sources included emission of gases from combustion engines (m= 2.48); burning of damaged motor parts (m= 2.30); smoke from burning vehicles during overheating and accidents (m= 2.08) and dust raised on untarred road surfaces (m= 2.06).

For noise pollution, sources include noise from cars (m= 2.46); noise from fire fighting vehicles (m= 2.40); loud horning sound from vehicles (m= 2.26); vibration of vehicles (m= 2.14); noise from road construction equipment (m= 2.14) and noise from cars with burst exhaust pipes (m= 2.04).

For water pollution, sources of pollution include waste oil from crankcases at mechanic workshops (m= 2.36); dumping of damaged motor parts in water bodies (m= 2.34) and dumping of waste from commuters in water bodies (m= 2.22).

For land pollution, sources included illegal littering of refuse from commuters on the ground (m= 2.60); illegal dumping of damaged motor parts on the ground (m= 2.34) and waste oil from crankcases at mechanic workshop (m= 2.28). Lastly, for waste pollution, sources included waste from commuters (m= 2.36) and waste from damaged motor parts (m= 2.10). This finding is in tandem with that of Owaduge (2021) who opined that emissions from exhaust pipes of vehicles, oil spillage, noise from construction equipment and loud horning sound from vehicles were major sources of pollution arising from road transport. Empirical evidence from Okeke et al (2020) revealed that the mean levels of $PM_{2.5}$, and CO in the air around vehicular traffic junctions in Enugu metropolis were above the recommended permissible limits.

Pollution Type	Sources of pollution from road transport	Significant 3	Moderate Significant 2	Not significant 1	Mean	Rmk
Air pollution	Emission of gases from combustion engines	24	26	-	2.48	Accepted
	Smoke from burning vehicles during overheating or accidents	14	26	10	2.08	Accepted
	Burning of damaged motor parts	22	21	7	2.30	Accepted
	Dust raised on untarred road surfaces	12	29	9	2.06	Accepted
Noise	Vibrations of vehicles	16	25	9	2.14	Accepted
pollution	Loud horning sound from vehicles	33	7	-	2.26	Accepted
	Noise from cars	27	19	4	2.46	Accepted
	Noise from fire fighting vehicles	29	12	9	2.40	Accepted
	Noise from cars with burst exhaust pipes	16	20	14	2.04	Accepted
	Noise from road construction equipment	16	25	9	2.14	Accepted
Water pollution	Waste oil from crankcases at mechanic workshops	26	16	8	2.36	Accepted
	Dumping of damages motor parts in water bodies	24	19	7	2.34	Accepted
	Dumping of waste from commuters in water bodies	22	20	8	2.28	Accepted
Land pollution	Waste oil from crankcases at mechanic workshops	18	25	7	2.22	Accepted
	Illegal dumping of damaged motor parts on the ground	25	17	8	2.34	Accepted
	Illegal littering of refuse from commuters on the ground	32	16	2	2.60	Accepted
Waste	Waste from commuters	22	24	4	2.36	Accepted
pollution	Waste from damaged motor parts	15	25	10	2.10	Accepted
Source: Rese	archer's Fieldwork, 2025					•

Table 2: Response on sources of pollution from road transport in Enugu Metropolis (N= 50)

Analyzing Objective Two

Factors that contribute to the continued environmental pollution arising from road transport in the study location

Table 3 indicated the factors that contribute to road transport induced environmental pollution in the study area. From the results in the table below, all the identified 10 factors were accepted as they recorded mean scores above 1.49. These factors included ageing and ill maintained Tokunbo cars (m= 2.80); lower fuel quality (m= 2.66); growing need to move people and goods (m= 2.64); high use of private vehicles (m= 2.52); use of high emission engine vehicles (m= 2.50); absence of appropriate road traffic reduction strategy (m= 2.48); lack of adequate green/open spaces in the urban area (m= 2.44); absence of an efficient public transport system (m= 2.36); increased population and urbanization (m= 2.20) and poor waste management techniques (m= 1.76). This result corroborates that of Pathak and Mandalia (2020), Abdulhafiz et al (2020), Eze et al (2021), Ityavyar and Thomas (2021) and Owaduge (2021) who averred that ageing and ill maintained Tokunbo cars, poor fuel quality and the use of high emission engine vehicles among others contributed to road transport induced pollution.

Table 3: Response on situation	ons that contribute	e to road	transport	induced	environmental	pollution i	i <mark>n Enugu</mark>
Metropolis (N= 50)							

S/N	Situations that contribute to road transport induced environmental	Significant	Moderate Significant	Not significant	Mean	Rmk
	pollution	3	2	1		
1	Growing need to move people and goods	33	16	1	2.64	Accepted
2	Absence of appropriate road traffic reduction strategy	29	16	5	2.48	Accepted
3	Ageing and ill maintained 'tokunbo' cars	40	10	-	2.80	Accepted
4	Absence of an efficient public transport system	26	16	8	2.36	Accepted
5	Lower fuel quality	34	15	1	2.66	Accepted
6	Use of high emission engine vehicles	27	21	2	2.50	Accepted
7	High use of private vehicles	31	14	5	2.52	Accepted
8	Increased population and urbanization	19	22	9	2.20	Accepted
9	Poor waste management techniques	15	18	7	1.76	Accepted
10	Lack of adequate green/open spaces in the urban area	24	24	2	2.44	Accepted

Source: Researcher's Fieldwork, 2025

Analyzing Objective Three

Consequences of Environmental Pollution emanating from Road Transport within the Metropolis

Table 4 revealed the consequences of environmental pollution arising from road transport in Enugu Metropolis. From the result, all the 13 identified consequences were accepted as they scored means above the benchmark of 1.49. These consequences included health concerns (breathing problems, swollen eyes, frustration and anxiety, skin diseases etc) (m= 2.66); loss of aesthetic value of the urban environment (m= 2.52); indiscriminate littering of refuse on the urban environment (m= 2.48); damage and loss of vegetation (m= 2.44); urban flooding (m= 2.42); poor water quality (m= 2.42); increased urban heat levels (m= 2.40); visible particles in the atmosphere/poor visibility (m= 2.38); acidic rain (m= 2.36); polluted air/foul smell (m= 2.32); decreased crop yield (m= 2.28); imbalance in the ecosystem (m= 2.08) and emigration of people from noisy areas (m= 2.04). This result is in line with that of Ityavyar & Thomas (2021) and Owuduge (2021) who opined that increased urban heat levels, acidic rain which causes damage to

vegetation, poor water quality, loss of aesthetic value of the urban environment among others constituted major consequences of pollution from road transport.

Table 4: Response or	n Consequences of environr	nental pollution aris	sing from road transpo	rt in Enugu Metropolis
(N= 50)				

S/N	Situations	Significant	Moderate Sianificant	Not sianificant	Mean	Rmk
		3	2	1	x	
1	Emigration of people from noisy areas	36	10	4	2.04	Accepted
2	Increased urban heat levels	24	22	4	2.40	Accepted
3	Visible particles in the atmosphere/poor visibility	22	25	3	2.38	Accepted
4	Acidic rain	25	18	7	2.36	Accepted
5	Decreased crop yield	24	16	10	2.28	Accepted
6	Damage and loss of vegetation	25	22	3	2.44	Accepted
7	Imbalance in the ecosystem	17	20	13	2.08	Accepted
8	Polluted air/foul smell	22	22	6	2.32	Accepted
9	Poor water quality	26	19	5	2.42	Accepted
10	Loss of aesthetic value of the urban environment	28	20	2	2.52	Accepted
11	Urban flooding	22	27	1	2.42	Accepted
12	Indiscriminate littering of refuse on the urban environment	28	18	4	2.48	Accepted
13	Health concerns (breathing problems, swollen eyes, frustration and anxiety, skin diseases etc)	33	17	-	2.66	Accepted

Source: Researcher's Fieldwork, 2025

Analyzing Objective Four

Measures to tackle Environmental Pollution from Road Transport in Enugu Metropolis

Table 5 showed the measures that can be employed to tackle environmental pollution from road transport in Enugu Metropolis. The table below indicated that the identified measures were accepted as viable in tackling road transport induced pollution in the study area. Among these measures include designate and expand green spaces in urban areas (m= 2.72); promote electric, hybrid and natural gas vehicles (m= 2.58); implement and improve air quality legal frameworks (m= 2.44); reinforce traffic policies and restrictions (m= 2.32); good transportation management system (m= 2.32); provision of required road facilities (m= 2.28); ban the uncontrolled dumping and burning of damaged motor parts (m= 2.24); provide good quality access to public transport and non-motorized transport infrastructure (m= 2.20) and provision of adequate waste collection and management strategies (in vehicles and on ground) (m= 2.08). This result corroborates that of Okeke et al (2020), Wu and Zhang (2020) and Kuirt (2022) who recommended the use of electric vehicles, non-motorized transport and increased awareness of environmental problems of road transportation, a critical look into the physical and mechanical states of vehicles plying on the roads, quality of fuel dispensed to motorists and impose strict penalties on those who drive old, rickety and poorly maintained vehicles and those that subvert traffic rules, in order to drastically stem the levels of emission of toxic pollutants on the environment through vehicular activities.

S/N	Situations	Significant 3	Moderate Significant 2	Not significant 1	Mean X	Rmk
1	Implement and improve air quality legal frameworks	26	20	4	2.44	Accepted
2	Promote electric, hybrid and natural gas vehicles	25	23	2	2.58	Accepted
3	Provide good quality access to public transport and non- motorized transport infrastructure	18	24	8	2.20	Accepted
4	Ban the uncontrolled dumping and burning of damaged motor parts	20	22	8	2.24	Accepted
5	Provision of required road facilities	17	30	3	2.28	Accepted
6	Good transportation management system	23	20	7	2.32	Accepted
7	Reinforce traffic policies and restrictions	26	16	8	2.36	Accepted
9	Designate and expand green spaces in urban areas	36	14	-	2.72	Accepted
10	Provision of adequate waste collection and management strategies (in vehicles and on ground)	17	20	13	2.08	Accepted
Courses	December's Fieldwork 2025					

Table 5: Measures to tackle environmental pollution	from road transport in Enugu Metropolis
(N= 50)	

Source: Researcher's Fieldwork, 2025

Testing of Hypothesis

Ho1: The consequences of environmental pollution arising from road transport are not statistically significant in Enugu Metropolis.

Ho₂: The consequences of environmental pollution arising from road transport are statistically significant in Enugu Metropolis.

In order to test the above hypothesis, question 13 was posited in the questionnaire which states thus: How would you rate the occurrence of these situations on the physical environment?

The values from tables 4 on 'Response on Consequences of environmental pollution arising from road transport in Enugu Metropolis' was inputted into the computer with the software (Statistical Package for Social Sciences) and the Chi-Square results below and Appendix I were obtained.

Chi-Square Value	=	54.946
p Value	=	.001
Level of significance (α)	=	0.05 (See Appendix I)

Decision Rule:

Reject Ho, if p value is less than level of significance and do not reject Ho if otherwise.

p value = .001; Level of significance = 0.05

Therefore, Ho is rejected because p value (.001) is < (less than) level of significance which is 0.05. Also, a Pearson's R^2 and Spearman correlation value of 1 and .754 respectively shows strong correlation between the variables.

Implication:

The implication of this result is that the null hypothesis (Ho) was not accepted, which states that the consequences of environmental pollution arising from road transport are not statistically significant in Enugu Metropolis and H_1 is accepted which states that the consequences of environmental pollution arising from road transport are statistically significant in Enugu Metropolis.

Therefore, it is concluded that the consequences of environmental pollution arising from road transport are statistically significant in Enugu Metropolis.

Conclusion

Pollution needs to be dramatically reduced because it is destroying the environment we live in, contaminating our food and water, causing diseases and cancers in humans and wildlife, and destroying the air we breathe and the atmosphere that protects us from harmful ultra-violet radiation. It is the responsibility of every living person to protect the environment, and with the increase in car ownership and the need to transport person and goods, pollution problems are only going to get worse unless we do something about it. Protecting the environment is a long and daunting task, requiring continuous planning, governmental policies, and public and industrial participation.

However, the result of ignoring the problem will be catastrophic and life as we know it will begin to end. By designating and expanding green spaces in urban areas; promote electric, hybrid and natural gas vehicles; implement and improve air quality legal frameworks; reinforce traffic policies and restrictions; good transportation management system; provision of required road facilities; ban the uncontrolled dumping and burning of damaged motor parts; provide good quality access to public transport and non-motorized transport infrastructure as postulated by the study, this would significantly reduce the amount of pollution going into the environment annually from road transport and increase the beauty of the environment and the quality of life of the residents of Enugu Metropolis, Enugu State and Nigeria at large.

Recommendations

With reference to the above findings of the study, the following physical planning proposals are made:

- 1. Adequate awareness and sensitization programmes should be embarked on by physical planners and other stakeholders in the built environment on the dangers of pollution to the human health and environment. This will lead to attitudinal change on the negative actions that result to pollution as it regards to road transport.
- 2. Physical planners and government agencies like ESWAMA and Ministry of Environment should collaborate on the best practice concerning waste (solid, liquid and gas) disposal in the urban area.
- 3. The outright banning of the use of high carbon emitting vehicles will go a long in curbing environmental pollution.
- 4. Adequate laws and policies concerning pollution should be implemented and enacted to the later to curb this urban menace. Also, institutional, technical, legal and administrative frameworks concerning pollution should be strengthened to tackle pollution in the urban area.
- 5. The federal, state and local government should implement programmes that enhance the living conditions and standard of living of the people residing in the country, state and local government areas. This will entrench the use of electric and non-motorized transport in no short time in Enugu Metropolis and Nigeria in general.

References

- Abdulhafiz, G., Auwal, F., Abdussalam, H., Muazu, F. and Tadama, H. (2020). Analysis of Spatio-Temporal Emissions from Road Transport in Kaduna Metropolis, Kaduna State, Nigeria. *Science World Journal 15(4).* 66-71.
- Air Quality in Europe (2020). Report can be found under <u>https://www.eea.europa.eu/publications/air-quality-in-</u> <u>europe-2020</u>.
- Amin, S. and Vyas, S. (2024). Effects of Transportation on Environment. *International Journal of Advanced Research* (IJAR), 4(11), 212-225.
- Anija-Obi, F.N. (2020). Environmental Protection and Management: Planning, Process and strategies for sustainable development, University of Calabar Press.
- Appannagari, R.R. (2022). Environmental Pollution Causes and Consequences: A Study. North Asian International Research Journal of Social Science & Humanities. 3(8), 23-34.
- Assamoi, E. M. and Liousse, C. (2024). A new inventory for two-wheel vehicle emissions in West Africa for 2002. Atmosphere and Environment, 44: 3985-3996.
- Wilkinson, R.G and Boulding, K.E. (1973). Introduction: Poverty and Progress: an ecological perspective on economic development: Preager publishers, New York –Washington.

Conservation Foundation (2022). State of the Environment: A view Toward the Nineties

- Department of Energy (D.O.E.) (2021). Annual Review of Energy 2021
- Egboka, B. C, E. (2020). <u>Water Resources Problems in the Enuqu Area of Anambra State, Nigeria"</u>. Water Resources and Environmental Pollution Unit (WREPU), Department of Geological Anambra State University of Technology: 95, 97. Geology and Survey, Enugu
- Ekuri, P. & Eze, E.B. (2021). Teaching Environmental Pollution in Primary/secondary schools. Workshop paper, on the orientation workshop for teachers on the implementation of the National environmental education curricula at Ogoja, in October, 2014.
- Emodi, E.E. (2020). Environmental Quality of Enugu, Nigeria as Impacted by the Primary Air Pollutants in the Area. International Journal of Environment and Pollution Research 8(4) ECRTD-UK.
- Etim, E. U. (2023). Air pollution emission inventory along a major traffic route within Ibadan Metropolis, southwestern Nigeria. *African Journal of Environment and Science Technology*, 4(5), 432-438.
- Eze, C. T., Ugwoke, J. L and Ugwoke, J. J. (2021). Road traffic congestion and vehicular emissions in Enugu Urban, Nigeria. *Poll Research*, 38(1): 1-8.
- Findley, R.W. (2021). Pollution Control in Brazil. *Ecology Law Quarterly* 15(1)
- Freeman, M. (2021). The Benefits of Air and Water Pollution Control: A Review and Synthesis of Recent Estimates. Council on Environmental Quality, Government Printing Office.
- Gbehe, N.T. (2021). Land Development in Nigeria: An Examination of Environmental Degradation Associated with land use Types. Conference Paper at the Department of Geography Benue State University (B.S.U.) Makurdi. January 2021.
- Goel, P.K (2021). Water pollution: causes, effects and control. New Age International, New Delhi
- Hadi, A. S. (2020). Perubahan Persekitaran Dan Kemudahan Terancam Lembangan Langat. Bangi, Selangor: Penerbit Universiti Kebangsaan Malaysia.
- Hellen, H., Hakola, H., Pirjola, L., Laurila, T. and Pystynen, K.H. (2021). Ambient air concentrations, source profiles, and source apportionment of 71 different C2 and C10 volatile organic compounds in urban and residential areas of Finland. *Journal of Environmental Science Technology*, 40: 103-108.
- Ityavyar, E.M., & Thomas, T.T., (2021). Environmental pollution in Nigeria: the need for awareness Creation for sustainable development. *Journal of Research in Forestry, Wildlife and Environment* 4(2), 23-33.
- Iyi, E. A. (2020). A Review of Enugu (Enugu State, Nigeria) Urban Growth and Development. *Journal of Research in Environmental and Earth Sciences* 1(3), 29-34.
- Jande, G.G. (2021). Legal Mechanisms for the control of Pollution on the high seas. *African Journal of Environmental Law and Development Studies*, 1(1), 1–13.
- Kai, Z. and Stuart, B. (2021). Air pollution and health risk due to vehicle traffic. Journal of Science and Total Environment, 450: 307-316.
- Kersharwani, S. (2022). Impact of Transportation System on Environment. Available Online: <u>https://www.slideshare.net/slideshow/impact-of-transportation-system-on-environent/252931831</u> [Accessed 23/04/2025]

Kuirt, D. V. (2022). How carbon dioxide become a pollutant. *Wall Street Journal* (9) 48-59.

Vol. 8, No. 1 | 2025 | DOI: https://doi.org/10.5281/zenodo.15532926

Leighton, J. (2023). The Aggregate Benefits of Air Pollution Control. Environmental Protection Agency

- Martos, A, Pacheco-Torres, R, Ordóñez, J, Jadraque-Gago, E (2016). Towards successful environmental performance of sustainable cities: intervening sectors. A review. Renew Sustainable Energy Rev 57
- Nwadiogbu, J. O., Eze, K. A., Ezidinma, T. A. and Echegi, U. S. C. (2021). Contributions of vehicular traffic to carbon monoxide emissions in Enugu Metropolis, Nigeria. Archives of Applied Science Research, 5 (6):189-192.
- Ocheri, M. I. (2021). Environmental Health Hazards and national Survival and Stability: A need for Education. *Benue State University Journal of Education (BSUJE)*, 4 (2)
- Olayiwola, L.M (2021). Techniques for Achieving Sustainable Development for Towns and Cities in Osun State, Paper presented at Workshop on Urban Planning and Sustainable Development in Osun State
- Onokala, P. C. and Olajide, C. J. (2024). Problems and Challenges Facing the Nigerian Transportation System which affect their Contribution to the Economic Development of the Country in the 21st Century. *Transportation Research Procedia* 48, 2945–2962.
- Owaduge, S. B. (2021). The Contributions of Road Transport to Environmental Pollution in Owo, Ondo State, Nigeria. Nordic Road and Transport Research, 1, 8 - 11.
- Pathak, C. and Mandalia, H.C. (2020). Impact of Environmental Pollution on Human Future. *World Journal of Environmental Pollution* 1(2), 67-88.
- Pirjola, J., Lähde, T., Niemi, J.V., Kousa, A., Rönkkö, T., Karjalainen, P., Keskinen, J., Frey, A. and Hillamo, R. (2021). Spatial and temporal characterization of traffic emissions in urban microenvironments with a mobile laboratory. *Journal of Atmosphere and Environment*, 63: 156-167.
- Prüsselstun, A. (2020). Preventing Disease through Healthy Environments: A Global Assessment of the Burden of Disease from Environmental Risks. World Health Organization. http://apps.who.int/iris/bitstream/10665/204585/1/9789241565196 eng.pdf?ua=1
- Schrank, D. and Lomax, T. (2022). The 2007 urban mobility report. http://financecommission. dot.gov/Documents/Background%20Documents/mobility_report_2007_wappx.pdf. (Accessed August 22, 2023).
- Umeakuka, I. J.M and H.C Mba, (2022). Waste Management Practices, A case study of Anambra State. *Journal of the Nigerian institute of Town planners*, 7
- United Nations Population Fund (UNFPA), (2021). State of World Population 2007 Unleashing the Potential of Urban Growth. United Nations Population Fund, New York, USA.
- United States National Research Council (2023). Committee on Pollution of the United States (U.S) National Research Council 2015
- Whiteman, G. (2022). Business strategies and the transition to low-carbon cities. Business Strategic Environment 20(4)
- World Health Organization (2021). Ambient (outdoor) air quality and health. http://www.who.int/mediacentre/factsheets/fs313/en/. [Assessed April 23, 2025]
- Wu, G. F. and Zhang, N. (2022). A time series study of Ambient Air pollution and daily mortality in shanghai, China. Research on Respiratory Health Effective Institute: 154:17-78.
- Zamri, N. S., Kamarudin, M. K. A., Samah, M. A. A., Saudi, A. S. M., Wahab, N. A., Saad, M. H. M., & Bati, S. N.A. M. (2023). The Environmental Pollution and Solid Waste Management in Malaysia. *International Journal of Academic Research in Business and Social Sciences*, 9(12)

APPENDIX I

Chi-square test Result

Case Processing Summary

	Cases						
	Valid		Missing		Total		
	N	Percent	Ν	Percent	Ν	Percent	
CONSEQUENCES_OF_ ROAD_INDUCED_POLL UTION * SIGNIFICANCE	650	100.0%	0	0.0%	650	100.0%	

CONSEQUENCES_OF_ROAD_INDUCED_POLLUTION * SIGNIFICANCE Crosstabulation

				SIGNIFICANCE		
			NOT SIGNIFICANT	MODERATE SIGNIFICANT	SIGNIFICANT	Total
CONSEQUENCES_OF_	Emigration of people	Count	4	10	36	50
ROAD_INDUCED_POLL	from noisy areas	Expected Count	4.8	19.7	25.5	50.0
OTION	Increased urban heat	Count	4	22	24	50
	levels	Expected Count	4.8	19.7	25.5	50.0
	Visible particles in the	Count	3	25	22	50
	atmosphere/poor visibility	Expected Count	4.8	19.7	25.5	50.0
	Acidic rain	Count	7	18	25	50
		Expected Count	4.8	19.7	25.5	50.0
	Decreased crop yield	Count	10	16	24	50
		Expected Count	4.8	19.7	25.5	50.0
	Damage and loss of	Count	3	22	25	50
	vegetation	Expected Count	4.8	19.7	25.5	50.0
	Imbalance in the	Count	13	20	17	50
	ecosystem	Expected Count	4.8	19.7	25.5	50.0
	Polluted air/foul smell	Count	6	22	22	50
		Expected Count	4.8	19.7	25.5	50.0
	Poor water quality	Count	5	19	26	50
		Expected Count	4.8	19.7	25.5	50.0
	Loss of aesthetic value of	Count	2	20	28	50
	the urban environment	Expected Count	4.8	19.7	25.5	50.0
	Urban flooding	Count	1	27	22	50
		Expected Count	4.8	19.7	25.5	50.0
	Indiscriminate littering of	Count	4	18	28	50
	environment	Expected Count	4.8	19.7	25.5	50.0
	Health concerns (breathing problems, swollen eves, frustration	Count	0	17	33	50
	and anxiety, skin diseases etc)	Expected Count	4.8	19.7	25.5	50.0
Total		Count	62	256	332	650
		Expected Count	62.0	256.0	332.0	650.0

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	54.946 ^a	24	.000
Likelihood Ratio	56.167	24	.000
Linear-by-Linear Association	1.102	1	.294
N of Valid Cases	650		

a. 13 cells (33.3%) have expected count less than 5. The minimum expected count is 4.77.