EFFECTS OF COVID-19 POLICY ON AIR QUALITY IN LAGOS STATE, NIGERIA

BY

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UNIVERSITY OF BENIN.

DECEMBER, 2022.

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AN UNDERGRADUATE PROJECT SUBMITTED TO THE DEPARTMENT OF ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY, FACULTY OF LIFE SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, EDO STATE, NIGERIA; IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR AWARD OF BACHELOR OF SCIENCE (B.Sc.) DEGREE IN ENVIRONMENTAL MANAGEMENT AND TOXICOLOGY

DECEMBER, 2022.

CERTIFICATION

This is to certify that this research titled "**EFFECTS OF COVID-19 POLICY ON AIR QUALITY IN LAGOS STATE, NIGERIA"** was carried out by **AMADI, Stephanie Ugochinyere (MISS)** with Matriculation Number **LSC1605234** and presented to the Department of Environmental Management and Toxicology, Faculty of Life Sciences, University of Benin, Benin City, Edo State in partial fulfilment of the requirements for the award of Bachelor of Science (B. Sc.) in Environmental Management and Toxicology. It was conducted under suitable conditions, was carefully supervised, and subsequently approved as having met the requirements for the award of Bachelor of Science degree in Environmental Management and Toxicology.

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DR. C. F. AMAECHI **DATE**

PROJECT SUPERVISOR

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PROF. A. A. ENUNEKU **DATE**

HEAD OF DEPARTMENT

DECLARATION

I, **AMADI,** Stephanie Ugochinyere (**MISS)** declares that **EFFECTS OF COVID-19 POLICY ON AIR QUALITY IN LAGOS STATE, NIGERIA** is my own work and that all sources that I have used or quoted have been acknowledged by means of complete references and that this work has not been submitted before for any other degree at any other University.

AMADI STEPHANIE UGOCHINYERE (MISS)

DEDICATION

This Project is dedicated to God Almighty whose grace has brought me thus far and my parents Mr and Mrs Alphonsus Amadi whose love and unending support has been the greatest encouragement all through this programme.

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My eternal gratitude goes to God Almighty for his mercy and love which never comes to an end nor ceases.

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ABSTRACT

Decrease in air quality has been a major concern in the world for decades and it has continued to worsen with dangerously toxic pollutant gases accumulating at a rapid rate every second. The atmosphere has majorly been polluted as a result of human day to day activities and these activities reduced a great deal during the covid-19 pandemic when a lockdown policy was established. The study area which is Lagos state, Nigeria is the state with the highest population count making it most prone to the spread of the covid virus and as such had the strictest policy regulation. This study was carried out to assess the effect of the covid-19 lockdown policy on air quality in Lagos state. The study adopted geographic information systems (GIS) using the Sentinel-5P data to obtain information on the concentration of Nitrogen dioxide (NO_2), Particulate matter ($PM_{2.5}$), Carbon monoxide (CO) and Sulphur dioxide (SO_2) as parameters for air pollution for the year before the lockdown (2019), the year of the lockdown (2020) and the year after the lockdown (2021) which were compared and the results were analysed statistically to determine a significant difference in the concentrations per year. The data showed the year 2020 had less concentrations of $PM_{2.5}$ and NO_2 which increased in 2021 when human and vehicular activities were back to normal, while SO_2 and CO concentrations were higher in 2020 than in 2021 as a result of the increase in the use of indoor air pollution sources.

CHAPTER ONE

INTRODUCTION

1.1. BACKGROUND TO THE STUDY

Air pollution is one of the greatest scourges of our time, not only because of its effects on climate change but also because of its effects on public and individual health due to rising morbidity and mortality (Manisalidis *et al*., 2020).

In the modern world, air pollution is a significant problem that contributes to problems with the environment and human health. The threat to both human health and the environment is expanding. The term "air pollution" refers to the contamination of the atmosphere by gaseous, liquid, or solid wastes or by-products that may be harmful to materials, the environment, or human health as well as the welfare of plants and animals. It may also cause unpleasant aromas or reduce visibility. Both inside and outside of buildings, air pollution is an issue.

Any substance that could endanger both people and the environment is considered an air pollution. Pollutants might be solid particles, liquid droplets, or gaseous particles. They might also be the result of human or natural creation. You can tell whether a pollutant is primary or secondary. Examples of primary pollutants that are typically produced directly from a process are volcanic ash, carbon monoxide gas from automotive exhaust, and Sulphur dioxide released from factories. There are no secondary pollutants that are directly emitted.

Instead, they arise from the interactions or reactions of the major airborne pollutants. Ground level ozone is a significant example of the numerous secondary pollutants that contribute to photochemical smog. Any substance that could endanger both people and the environment is considered an air pollutant. Pollutants might be solid particles, liquid droplets, or gaseous particles. They might also be the result of human or natural creation. You can tell whether a pollutant is pimary or secondary. Examples of primary pollutants that are typically produced directly from a process are volcanic ash, carbon monoxide gas from automotive exhaust, and Sulphur dioxide released from factories. There are no secondary pollutants that are directly emitted.

Instead, they arise from the interactions or reactions of the major airborne pollutants. Ground level ozone is a significant example of the numerous secondary pollutants that contribute to photochemical smog.

Some pollutants may be both primary and secondary: that is, they are both emitted directly and formed from other primary pollutants.

FACTORS RESPONSIBLE FOR AIR POLLUTION.

Air pollution can result from both human and natural actions. Natural events that pollute the air includes forest fires, volcanic eruptions, wind erosion, pollen dispersal, evaporation of organic compounds and natural radioactivity. Most causes result from man-made sources mostly related to burning different kinds of fuel.

COVID-19

A virus that was first identified in Wuhan, China, in late 2019 spread over the world in 2 Air pollution is one of the worst problems of our time because of its effects on climate change, as well as the impact it has on public and individual health due to rising morbidity and mortality. In the modern world, air pollution is a major problem that contributes to problems with the environment and human health. Health of people and the environment are under increasing threat. A common definition of air pollution is the contamination of the atmosphere by wastes or byproducts that are gaseous, liquid, or solid and that can harm materials, threaten the health of people and animals, or produce offensive odors or reduce visibility. Both inside and outside are affected by the air pollution issue. The name of this virus was coronavirus (covid-19). Many individuals caught it, and it slowly spread around the world. The entire world was placed under lockdown to reduce casualties because of the covid virus' infectious nature and high mortality rate.

A respiratory ailment that ranges from mild to moderately severe manifested its symptoms. The world is in a state of emergency to reduce the contact rate and, consequently, the death rate due to the severity of this illness and the lack of a remedy at the first stage.

The lockdown rule that accompanied this state of emergency in many nations had minor differences, but they all amounted to people staying in the same location as they had been at the time the lockdown policy was put into place.

The covid 19 pandemic was a global pandemic which started in December 2019 to most of the year 2020 worldwide and started in Nigeria with Lagos state having the highest number of cases in March 2020 which mandated the need for a lockdown policy in the state.

1.2. STATEMENT OF PROBLEM

Air pollution is a significant risk factor for multiple health conditions including respiratory infections, heart disease, and lung cancer. According to the (WHO), Air pollution affects kids more than adults due to higher concentrations of polluted air in their systems per body size and in large cities, over 80% of fatal pollutants that cause lung damage come from cars, buses, motorcycles, and other vehicles on the road.

The health effects caused by air pollution may include difficulty in breathing, wheezing, coughing, asthma, and aggravation of existing respiratory and cardiac conditions. These effects can result in increased medication use, increased doctor or emergency room visits, more hospital admissions and premature death. The human health effects of poor air quality are far reaching, but principally affect the body's respiratory system and the cardiovascular system. Individual reactions to air pollutants depend on the type of pollutant a person is exposed to, the degree of exposure, the individual's health status and genetics.

1.3. JUSTIFICATION

Air pollution has proven to be a major environmental issue presenting a lot of concern regarding its effect on the environment as well as human health. Therefore, this study seeks to show if the covid 19 policy brought about tremendous positive effect on air quality in relation to the decrease in anthropogenic activities which lead to reduced air quality.

1.4. AIM AND OBJECTIVES

AIM

The aim of this study is to assess the effect of the covid-19 lockdown policy on air quality in Lagos state.

OBJECTIVES

The objectives of this study are to:

1. Assess the air quality parameters for the years 2019, 2020 and 2021.
2. Determine Carbon monoxide, Nitrogen oxide, Sulphur dioxide and Particulate matter ($PM_{2.5}$) emissions for the years under review.
3. Determine if there is statistical difference in air quality between years under review.

CHAPTER 2

LITERATURE REVIEW

2.1. AIR POLLUTION

Air pollution is the contamination of the air brought on by the presence of compounds in the atmosphere that are detrimental to the health of people and other living things, or that impair the climate or materials. One of the most significant environmental problems facing both developed and developing nations worldwide is air pollution. Road traffic and fossil fuel-based energy generation are two major variables contributing to substantial public health issues on a local, regional, and national scale.

The World Health Organization (WHO) estimates that 91% of the world's population lives in polluted areas and breathes air with high levels of pollutants, and that exposure to ambient air pollution and fuel smoke causes 7 million deaths annually. (Virghileanu *et al.*,2020)

There are seven (7) major air pollutant gases which are carbon monoxide, lead, nitrogen oxides, ground-level ozone, particulate matter ($P.M_{2.5}$ and $P.M_{10}$), methane and Sulphur oxides. (NCEH, 2021)

These pollutants are produced by both natural and man-made processes, such as burning fossil fuels like fuel oil, gasoline, and natural gas in power plants, gas flaring, automobiles, and other combustion sources, as well as complicated chemical reactions between nitrogen dioxide and a number of volatile organic compounds (e.g., gasoline vapors). (Nathanson, 2022)

Due to their severely detrimental effects on human health, "particulates" in the air, such as soot, dust, smokes, fumes, and mists, are classified as major air pollutants when they have a diameter of fewer than 10 micrometres (µm; millionths of a metre). Different industrial operations, coal- or oil-burning power plants, home heating systems, and autos all emit them.

Plate 2.1: Industrial Air Pollution.

Photo credit: Claire Cosby (2015).

Lead fumes, which are airborne particles with a size of smaller than 0.5μm and are a significant pollutant in many diesel fuels, are highly dangerous.

Criterion pollutants, with the exception of lead, are discharged into the atmosphere at incredibly high rates in developed countries, typically measured in millions of tons annually. Except for ozone, all of them are directly emitted into the atmosphere from a variety of sources. The establishment of ambient air quality standards, which are the maximum allowable concentrations of each criteria pollutant in the atmosphere, irrespective of its source, is their main method of regulation. (Nathanson, 2022)

2.2 AIR POLLUTION IN NIGERIA

Nigeria ranks fourth globally in terms of air pollution, but it has the highest number of air pollution-related deaths in Africa. According to statistics, this environmental hazard resulted in 150 fatalities per 100,000 persons in 2016. Nigeria's air quality is among the deadliest in the world, according to the Health Effects Institute's (HEI) State of the Global Air Report. Air pollution is brought on by atmospheric dangers such generator fumes, car emissions, and crop burning. (Dolpheide, 2019)

Nigeria's air pollution levels remain dangerously high, with little sign of relief in sight but with clear signs of improvement. This is in contrast to many low- and middle-income countries that are strengthening pollution restrictions to decrease public exposure to the deadly air hanging over their cities.

Lagos, Abuja, Port Harcourt, Kano, and particularly Onitsha are among the Nigerian cities with the highest air pollution levels.

With an annual mean concentration of 594 micrograms per cubic meter (μg/m3), Onitsha recorded the worst levels of PM10 (particles smaller than 10 micrometers) air pollution in the world in 2016. This was more than 40 times the World Health Organization's (WHO) annual PM10.1 limit of 15μg/m3.

The emissions from automobiles and trucks' tailpipes, smoke from the open burning of household trash, diesel generators, road dust, industry, and soot from the use of biomass cookstoves indoors are the main causes of air pollution in Nigeria. (Chasant, 2018)

Air pollution is caused by generator fumes, which emit the lethal gas carbon monoxide. Automobiles with older engines are also more likely to emit harmful fumes into the atmosphere. Kerosene stoves in homes produce flames, which contribute to poor air ventilation. The country generates over 3 million tons of waste per year, and most Nigerians burn it in their neighborhoods rather than discarding it, adding to the pollution in the atmosphere. The use of firewood and coal to cook is another factor contributing to Nigeria's air pollution crisis.

Furthermore, indoor air pollution is a major issue in Nigeria, with fine particulate matter levels in many households exceeding air quality guidelines by 20 times. According to the WHO, nearly 7 million people died in Lagos, Nigeria, in 2012, as a result of indoor and outdoor air pollution. (Dolpheide, 2019)

Every year, over 700,000 people are killed by air pollution on the African continent; air pollution kills more people than unsanitary hygiene practices and malnutrition.

In Nigeria, casualties as a result of the air pollution crisis have increased by nearly 40% in the last 30 years. Nigeria has some of the worst air pollution levels on the African continent. Overall, Nigerian cities have the worst air quality, with ten urban areas ranking among the top 30 cities in Africa for poor air quality.

Human activity is a major contributor to air pollution. Refuse heaps are a common sight throughout the country. This waste dumpsite makes the air around it unbreathable, affecting commuters and business owners.

Lagos, Nigeria's economic capital, has a high rate of air pollution. The incineration of solid waste at dumpsites throughout Lagos is a major source of air pollution in the state.

For more than a decade, these landfills have had poor solid waste management and a bad reputation for consistently polluting the air for several kilometers. (Amaechi,2022)

This emits CO_2, a greenhouse gas linked to climate change, as well as methane, another greenhouse gas linked to climate change. This is released into the environment and because of the mixture of different gases that affect the soil, these landfills emit even more CO_2 than the vehicles we drive, which is very bad for the environment.

There should be environmentally friendly methods of managing this waste, one of which would be to generate less waste, recycle it, and upcycle it. Residents would have to consider wearing a nose mask to protect themselves from polluted air. (Amaechi,2022)

2.3 AIR POLLUTION IN LAGOS STATE, NIGERIA.

Air pollution is the third leading cause of death worldwide, and fine particulate matter ($PM_{2.5}$) levels in most major cities exceed WHO health guidelines. (Mulhern, 2021)

Lagos state is currently the most populated state in Nigeria with the population at about 17.5 million people and the population keeps rising. The population in Lagos results in a high rate of pollution from anthropogenic activities. The presence of industries and the use of fossil fuel consumption causes a high level of air pollution in Lagos. Lagos state is popular for the traffic congestion that occurs on a daily basis, this is a chief source of carbon monoxide pollution.

Lagos is Nigeria's commercial and economic center. It is also one of the world's fastest growing megacities, with plans to make it the largest by 210010. (Hoornweg and Pope 2016). In 2015, it contributed 25% of the country's Gross Domestic Product (GDP) and 70% of the country's industrial and commercial activities. (Owoade *et al*., 2013; PwC 2015). Rapid urbanization and industrialization have exposed the majority of the population to high levels of air pollution, which has had a negative impact on human lives (Olowoporoku *et al*., 2012) as well as changing climatic conditions (Komolafe *et al*., 2014).

In Lagos, there are currently no operational air quality monitoring stations. The available data on air quality are largely based on short-term and irregular measurements taken with air samplers. Only a few studies tracked $PM_{2.5}$ levels in a few representative city areas for longer periods of time (e.g., one year) (Croitoru *et al*., 2020). It is difficult for officials to take informed and decisive action in the absence of official measurement stations and standardized methods. Nonetheless, a few independent operations have provided indicative values for organizations to work with, and a few studies have monitored $PM_{2.5}$ over year-long periods in a few representative locations in Lagos. (Mulhern, 2021)

Road transport, industrial emissions, and power generation all contribute significantly to Lagos' air pollution. (Croitoru *et al*., 2020) and are the major sources of $PM_{2.5}$ in Lagos. all of which can be addressed with the right actions. (World bank, 2020)

The primary source of $PM_{2.5}$ is road transport. With few alternatives for transportation, the number of vehicles in Lagos has nearly quadrupled in the last decade. The average commute in Lagos is four hours per day, the longest in the world. Every km of road is clogged by 227 vehicles every day. Most vehicles are over 15 years old and use outdated emission technologies and fuel with high Sulphur levels: 200 times higher than US diesel standards.

The second major source of $PM_{2.5}$ is industrial emissions. Previous research revealed that industrial and commercial zones such as Apapa, Idumota, Ikeja, and Odogunyan, where cement, chemicals, furniture, refinery, steel industries, and markets are concentrated, have high levels of pollution. In the Odogunyan site, known for its iron smelting factories, a $PM_{2.5}$ concentration of 1 770 g/m3 was measured in 24 hours - 70 times higher than the WHO guideline. More data is needed to identify major industry and power emission sources (World bank, 2020).

Nigeria's thriving economy, large population, and unreliable power supply have resulted in a heavy reliance on backup generators. Generators, the third source of $PM_{2.5}$, meet roughly half of the city's total energy demand in Lagos alone. Large diesel generators are used in institutional, commercial, and residential settings, while small generators have spread to homes and small businesses. Because generators are used near people, the poor combustion of gasoline and lubricating oil pollutes the air and causes significant health damage.

Two other factors contribute to pollution: insufficient waste infrastructure and pollution from the two ports. In the absence of a proper waste management system, people resort to open waste burning and illegal dumping, resulting in toxic pollutant emissions. In 2017, 33 million metric tons of cargo passed through Nigeria's two major ports of Apapa and Tin Can, according to port statistics. Every day, approximately 5,000 highly polluting diesel trucks seek port access or park for months, picking up or waiting for their loads, causing significant congestion and pollution. (World bank, 2020)

Plate 2.2: Source of air pollution in Lagos state.

Photo credit: Ihekire (2020)

Plate 2.3: Air Pollution in Lagos state.

Photo credit: Ihekire (2020)

Plate 2.4: Air pollution source in Lagos state.

Photo credit: Ihekire, (2020).

2.4. HEALTH IMPACTS

According to World Health Organization (WHO, 2019), High levels of air pollution can have a few negative health consequences. It raises the risk of respiratory infections, heart disease, and lung cancer. Short-term and long-term exposure to air pollutants has been linked to health effects. People who are already sick are more severely affected. Children, the elderly, and the poor are especially vulnerable. Fine $PM_{2.5}$ particles that penetrate deep into lung passageways are the most health-harmful pollutants, closely associated with excessive premature mortality.

Air pollution has a variety of health consequences. Even on days with low air pollution, the health of vulnerable and sensitive individuals can be harmed. Short-term air pollution exposure is linked to COPD (Chronic Obstructive Pulmonary Disease), cough, shortness of breath, wheezing, asthma, respiratory disease, and high hospitalization rates (a measurement of morbidity) (Manisalidis *et al.*, 2020).

Chronic asthma, pulmonary insufficiency, cardiovascular diseases, and cardiovascular mortality are all long-term effects of air pollution. Diabetes appears to be induced by long-term air pollution exposure, according to a Swedish cohort study. (Eze *et al*., 2014). Furthermore, air pollution appears to have a variety of negative health effects in early human life, including respiratory, cardiovascular, mental, and perinatal disorders (USGCRP, 2009), resulting in infant mortality or adult chronic disease (Kelishadi and Poursafa, 2010).

The increased risk of morbidity and mortality has been mentioned in national reports. (WHO,2019). These studies, conducted in a variety of locations around the world, show a link between daily PM concentration ranges and daily mortality. Global warming and climate change (USGCRP, 2009) could aggravate the situation. Furthermore, increased hospitalization (a morbidity indicator) has been observed among the elderly and vulnerable individuals for specific reasons. Fine and ultrafine particulate matter appear to be linked to more severe illnesses

(Kelishadi and Poursafa, 2010), because it can penetrate the deepest parts of the airways and enter the bloodstream more easily.

2.5. ENVIRONMENTAL IMPACTS OF AIR POLLUTION

Air pollution harms not only human health but also the environment (Ashfaq and Sharma, 2012) in which we reside. The following are the most significant environmental effects:

ACID RAIN: This is a type of precipitation that can be wet (rain, fog, snow) or dry (particulates and gas) and contains toxic levels of nitric and sulfuric acids. They can acidify the water and soil environments, causing damage to trees and plantations, and even causing damage to buildings and outdoor sculptures, constructions, and statues. (Manisalidis *et al.,* 2020)

HAZE: When fine particles disperse in the air, they reduce the transparency of the atmosphere. It is caused by airborne gas emissions from industrial facilities, power plants, automobiles, and trucks.

Ozone occurs at both ground and upper levels of the Earth's atmosphere (stratosphere). The Sun's harmful ultraviolet (UV) rays are shielded by stratospheric ozone. Ground-level ozone, on the other hand, is harmful to human health and a pollutant. Unfortunately, ozone-depleting substances slowly deplete stratospheric ozone (i.e., chemicals, pesticides, and aerosols). If the protective stratospheric ozone layer thins, UV radiation will reach our planet, causing harm to human life (skin cancer) (Madronich and de Gruijl, 1993) and crops (Teramura, 2006). Ozone enters plants through the stomata, causing them to close, preventing CO2 transfer and reducing photosynthesis. (Singh *et al*., 2009).

GLOBAL CLIMATE CHANGE: This is a significant issue which affects all of humanity. The "greenhouse effect," as it is known, keeps the Earth's temperature stable. Unfortunately, anthropogenic activities have destroyed this temperature-regulating effect by emitting large amounts of greenhouse gases, and global warming is worsening, threatening human health, animals, forests, wildlife, agriculture, and the water environment. According to one report, global warming is increasing the health risks for poor people. (Manderson, 2019). People living in poorly constructed buildings in warm-climate countries are at high risk for heat-related health problems as temperatures mount (Manderson, 2019).

WILDLIFE: Toxic pollutants from the air, soil, or water ecosystems burden the ecosystem, and animals can develop health problems when exposed to high levels of pollutants. There have been reports of reproductive failure and birth complications. (Manisalidis, 2020)

There is, without a doubt, a critical concentration of air pollution that an ecosystem can tolerate without being destroyed, which is related to the ecosystem's ability to neutralize acidity. This load was set at 20 kg/ha/year by the Canada Acid Rain Program. (Canadian Ministers, 1999).

As a result, air pollution has a negative impact on both soil and water. (Zuhara and Isaifan, 2018). Concerning particulate matter (PM) as an air pollutant, it has been reported that it has an impact on crop yield and food productivity. Its impact on bodies of water is linked to the survival of living organisms and fish, as well as their productivity potential. (Zuhara and Isaifan, 2018)

Plants exposed to the effects of ozone show a reduction in photosynthetic rhythm and metabolism. (Zuhara and Isaifan, 2018). Acid rain is caused by Sulphur and nitrogen oxides, which are toxic to plants and marine organisms. Finally, the toxicity of lead and other metals is the most serious threat to our ecosystems (air, water, and soil) and living creatures. (Zuhara and Isaifan, 2018)

2.6. COVID 19 POLICY IN NIGERIA

The COVID-19 pandemic was a globally unprecedented threat. However, the contexts, issues, and consequences vary by country and region. There is a lack of a coordinated and comprehensive strategy in developing countries such as Nigeria to deal with economic consequences, food needs, health emergency needs, livelihood support, and safety nets to prepare the ground for economic recovery. Following global responses to the pandemic, the Nigerian government implemented lockdown and containment measures - a stay-at-home order. Many argued, however, that the westernized approach was ineffective in low-income and developing countries such as Nigeria, where extreme poverty is prevalent, and the majority of the population is dependent on the informal economy based on daily wages. According to the African Development Bank, nine out of ten rural and urban workers rely on the informal sector, with the majority being women and youths.

On January 28, 2020, the Federal Government of Nigeria assured Nigerians that it was ready to strengthen surveillance at the country's five international airports in order to prevent the spread of coronavirus. The airports have been named Enugu, Lagos, Rivers, Kano, and the Federal Capital Territory (FCT). On the same day, the Nigeria Centre for Disease Control announced that it had already established a coronavirus group and was ready to activate its incident system if any cases were discovered in Nigeria.

Following the outbreak of the COVID-19 pandemic in mainland China and other countries around the world, Nigeria's federal government established a Coronavirus Preparedness Group on January 31 to mitigate the virus's impact if it spreads to the country. The World Health Organization identified Nigeria as one of 13 African countries at high risk of virus spread on the same day. Following the outbreak of the COVID-19 pandemic in mainland China and other countries around the world, Nigeria's federal government established a Coronavirus Preparedness Group on January 31 to mitigate the virus's impact if it spreads to the country. The World Health Organization identified Nigeria as one of 13 African countries at risk on the same day.

After this, the Nigerian government declared a lockdown policy in populated states in the country such as Lagos state and made sure the stay-at-home policy was enforced.

2.7. GEOGRAPHIC INFORMATION SYSTEMS(GIS) AND REMOTE SENSING (RS)

GIS is a set of computer-based tools for organizing information from various data sources to map and analyze changes on Earth It is intended for the capture, storage, management, analysis, and visualization of all types of geographical data. GIS enables the integration and analysis of geospatial data from various sources, such as satellite imagery, GPS recordings, and textual attributes associated with a specific space. GIS is used in nearly every field where spatial patterns and relationships between different datasets must be understood, from land-use planning to emergency response to resource management (NASA 2022).

Remote sensing is detecting and monitoring an area's physical characteristics from a distance by measuring reflected and emitted radiation (typically from satellite or aircraft). Special cameras collect remotely sensed images, allowing researchers to "sense" things about the Earth (USGS, 2022). Some examples of RS are collection of satellite imagery and weather data obtained by remote sensing radars, allowing us to see far more than we could from the ground, sonar systems on ships can be used to generate images of the ocean floor without having to travel to the bottom and satellite cameras can be used to capture images of temperature changes in the oceans.

Some specific applications of remotely sensed Earth images include:

Large forest fires can be mapped from space, giving rangers a much larger view than they would have from the ground.

Tracking clouds to help predict weather, watching erupting volcanoes, and keeping an eye out for dust storms

Following the development of a city as well as changes in farmland or forests over several years or decades. (NASA, 2022)

Satellite remote sensing provides data on air quality. Ground monitoring resource spatial gaps are unavoidable, and satellite data can fill in air quality information in areas without a ground monitor.

The discovery and mapping of the ocean floor's rugged topography (e.g., huge mountain ranges, deep canyons, and "magnetic striping" on the ocean floor). (NASA, 2022)

2.8. IMPLEMENTATION OF GOOGLE EARTH ENGINE IN AIR QUALITY MONITORING.

The Google Earth Engine (GEE) portal expands the possibilities for conducting earth observation studies. It is a web portal that provides global time-series satellite imagery and vector data, as well as access to software and algorithms for processing such data. (Kumar and Mutanga, 2018).

The Google Earth Engine provides maps and air quality information channeled from the Sentinel 5p satellite. It provides detailed information on the spread of air pollutant gases and their emission rates.

2.9. APPLICATION OF GIS AND REMOTE SENSING IN AIR QUALITY MONITORING USING SENTINEL-5P.

Sentinel-5P is a single satellite mission for monitoring atmospheric quality as part of the Global Monitoring for Environment and Security (GMES) program, which is now known as the European Copernicus program (Virghileanu *et al*.,2020). The mission is comprised of a single satellite carrying the Tropospheric Monitoring Instrument (TROPOMI). ESA and the Netherlands co-founded the TROPOMI instrument. (ESA, 2022). The basic aim of this mission is the regulatory detection and monitoring of trace gas concentration like Sulphur dioxide, nitrogen dioxide, carbon monoxide, ozone, formaldehyde, particulate matter (2.5 and 10) methane and aerosols.

The Copernicus Sentinel-5P mission's goal is to take high-resolution atmospheric measurements for air quality, ozone and UV radiation, and climate monitoring and forecasting (ESA, 2022).

CHAPTER 3

RESEARCH METHODOLOGY.

3.1 STUDY AREA

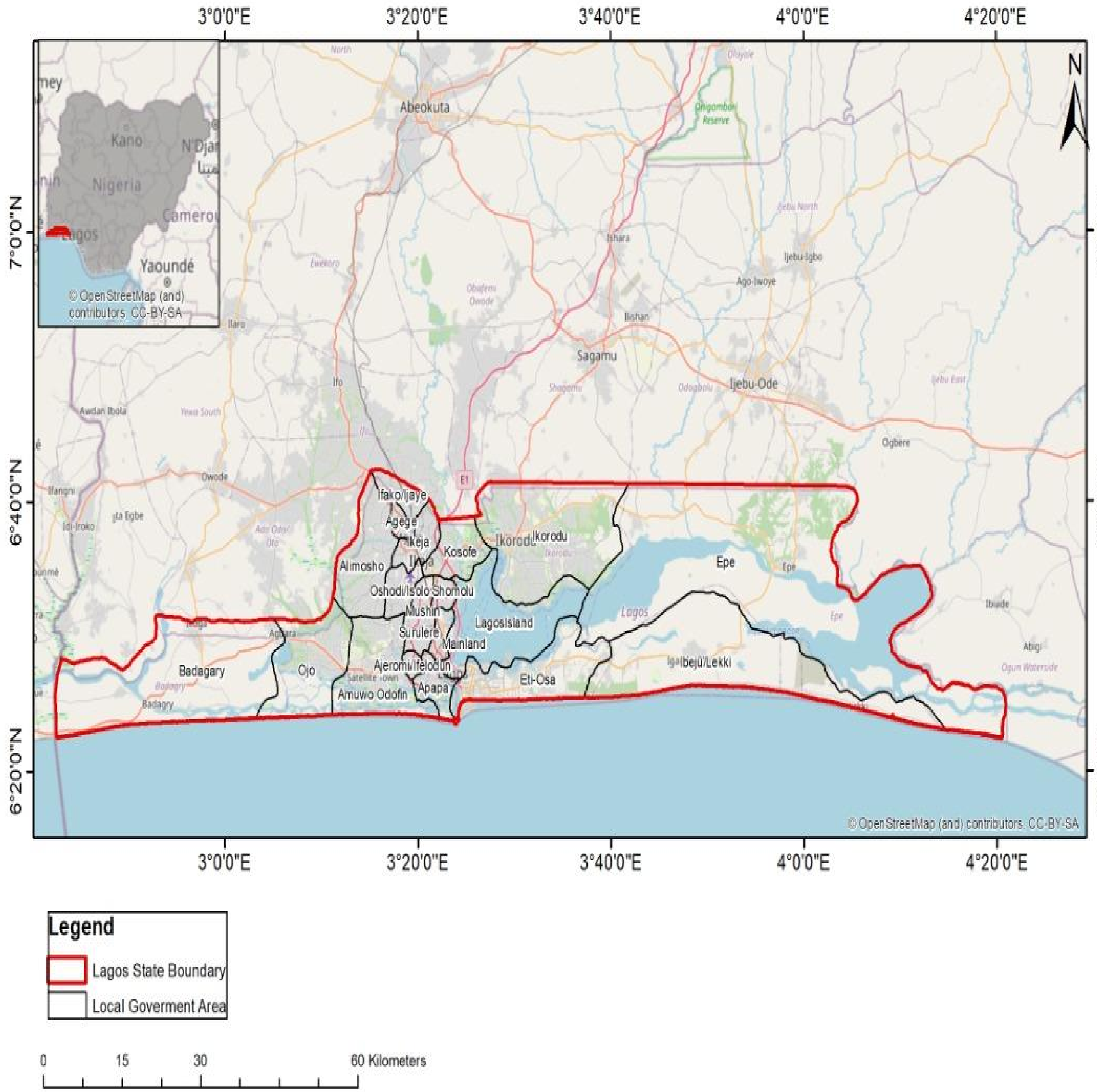

Figure 3.1: Map of Lagos state.

Source: Google Earth Engine.

Lagos state, Nigeria, is the study area of this research. The city is in southwestern Nigeria, on the Gulf of Guinea coast. Because it is the most populated and busy state in the country, it is an excellent example for comparing air quality before, during, and after the Covid-19 lockdown policy. The research area is located at latitude 6.465422E and longitude 3.406448N. The state has a tropical climate that is hot all year, with a dry season from November to March and a rainy season from April to October. The humidity level is high all year, but especially during the rainy season. Rainfall is abundant, particularly from May to July. The dry season sees the highest temperatures. Lagos is the country's financial centre; it is also the most populous city in Nigeria and the African continent, with a current population of about 17 million people, and it covers a vast area of 1,171.28 square kilometers (452.23 square miles).

Lagos state comprises of 20 Local government areas (LGA) which includes: Agege, Alimosho, Apapa, Ifako-Ijaye, Ikeja, Kosofe, Mushin, Oshodi-Isolo, Somolu, Eti-Osa, Lagos Island, Lagos Mainland, Surulere, Ojo, Ajeromi-Ifelodun, Amuwo-Odofin, Badagry, Ikorodu, Ibeju-Lekki and Epe. The LGAs include Ikeja which is the capital of the state.

3.2. RESEARCH DESIGN

Year of Study/Review 2019, 2020 and 2021

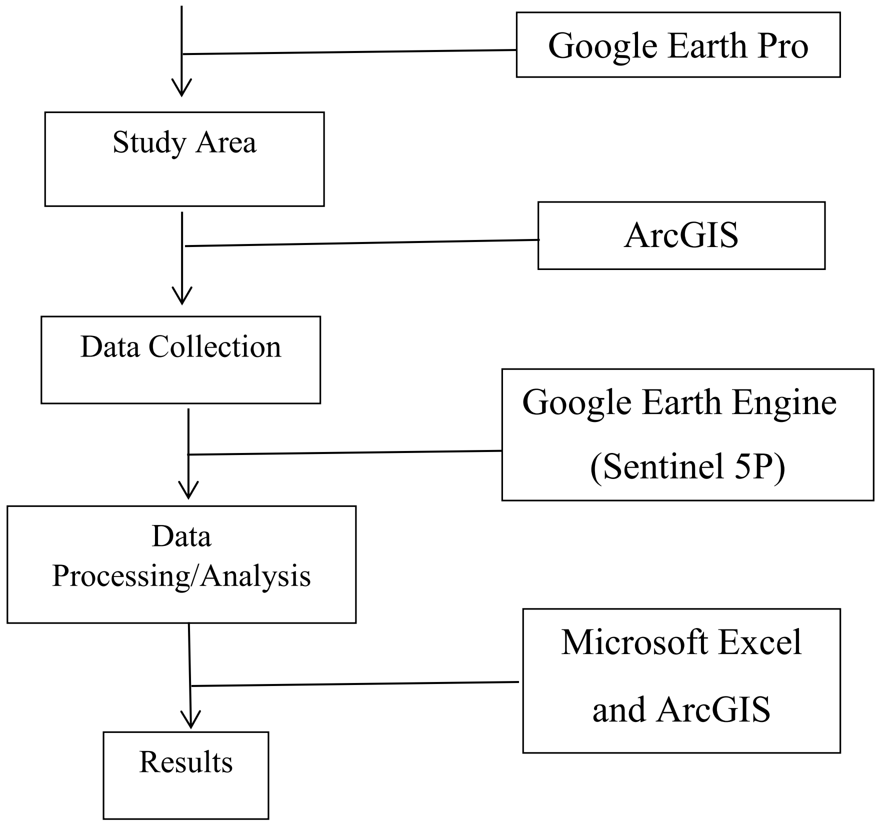

Figure 3.2: Schematic illustration of research design.

3.3. DATA TYPE AND DATA SOURCE

This study relied primarily on secondary data analysis derived from the application of air quality technology, with the use of Sentinel 5P. The data type used for the research was secondary data. Secondary data are readily available compared to that of primary data. Secondary data collection has proven to be more accessible, less expensive, and less time consuming than primary data collection. Secondary data sources include tax records and social security data, census data, health records, books, journals, textbooks, and newspapers etc. Secondary data analysis process can be carried out quantitatively or qualitatively depending on the kind of data the researcher is dealing with. The quantitative method of secondary data analysis is used on numerical data and is analyzed mathematically, while the qualitative method uses words to provide in-depth information about data (Johnston, 2017).

The secondary data was obtained from Sentinel-5 Precursor, a mission instrument that collects useful data for assessing air quality (Sentinel-5P). The Sentinel-5P satellite mission is part of the Global Monitoring for Environmental and Security (GMES/Copernicus) program. (Virghileanu *et al*., 2020). Copernicus Sentinel-5 P is the first Copernicus mission dedicated to monitoring the Earth's atmosphere. The mission is made up of one satellite that carries the Tropospheric Monitoring Instrument (TROPOMI) (ESA, 2022). The TROPOMI instrument is a multispectral sensor with a spatial resolution of 0.01 arc degrees that records reflectance of wavelengths important for measuring atmospheric concentrations of ozone, methane, formaldehyde, aerosol, carbon monoxide, nitrogen oxide, and Sulphur dioxide, as well as cloud characteristics. The TROPOMI is a passive sun backscatter imaging spectrometer that can acquire 8-band imagery in multiple spectral domains ranging from UV to visible to near-infrared (NIR) and shortwave infrared (SWIR) (Lorente *et al*., 2019). It has a higher spatial resolution than its predecessors, measuring 7 x 3.5 km^2 (along and across track), Sentinel-5P offers a new potential for air quality research, making it suitable for polluting emission sources monitoring (Manisalidis *et al*., 2020).

Recent research carried out by Manisalidis *et al.* (2020) have found strong correlation between data obtained from Sentinel 5P and ground base data giving validation to the data obtained.

3.4. METHOD OF DATA COLLECTION

The information on the study area was obtained through the Google Earth Engine. Sample points were generated along the local government areas (LGAs) of the state. The points were saved into a shape file from ArcGIS and imported into google earth engine to be processed in order to generate results through sentinel-5P on google earth engine for the three years (2019 - 2021) under review for air quality analysis in all sample points.

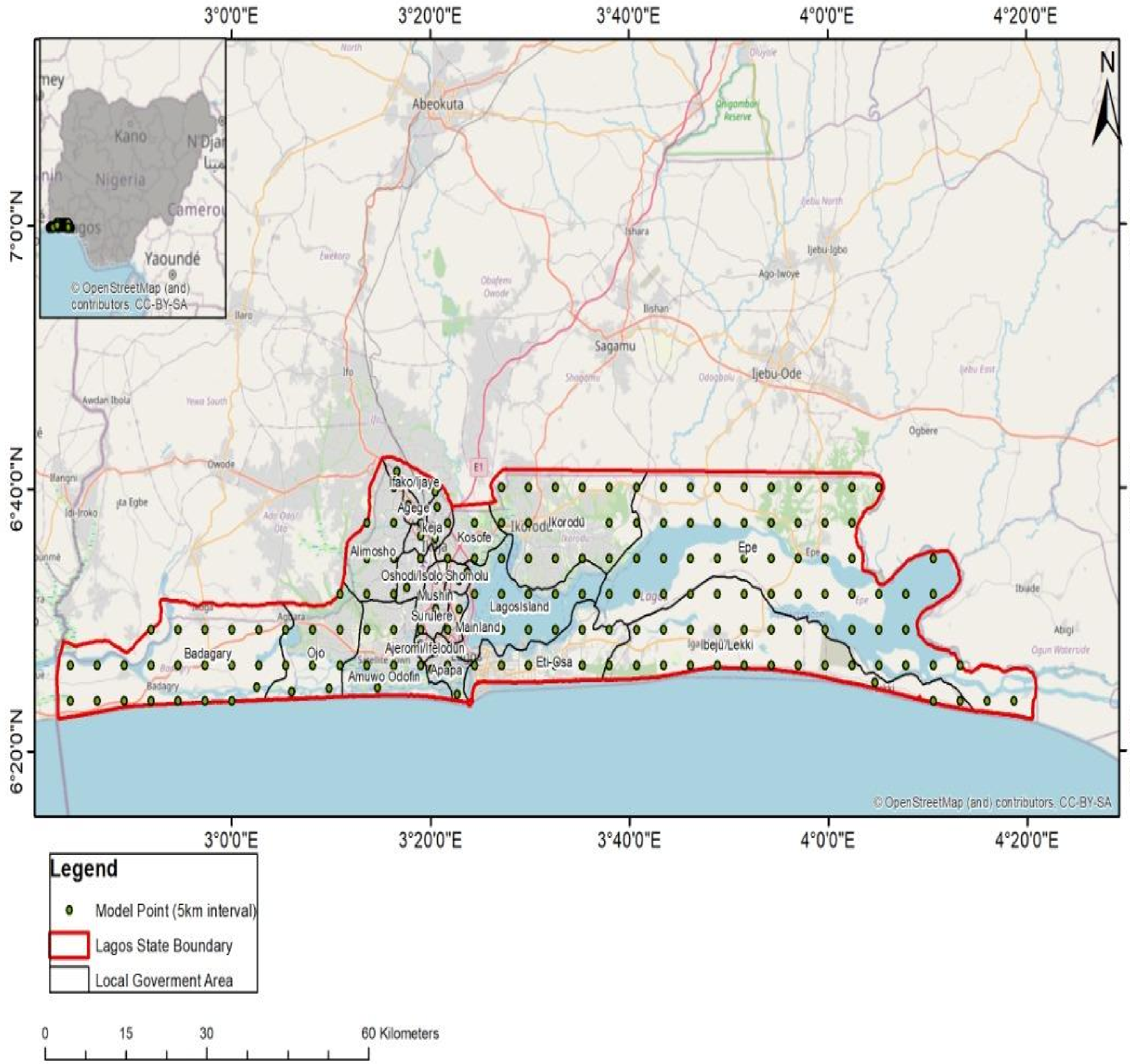

Figure 3.3: Map of study area showing sample points.

Source: Google Earth Engine (2022).

3.5 METHOD OF ANALYSIS

This process involves arranging and organizing the data for analysis. ArcGIS 10.5 and Google earth engine (GEE) were used for data processing and analysis. Google earth engine provides a database of petabytes of satellite imagery taken at near real time (NRTI). Sentinel 5p houses the TROPOMI sensor which observes pollutants and gives results for their concentration in mol/m^2. The result can then be assessed using Google earth engine by scripts of codes run on the editor. The dataset for analysis of the atmospheric pollutants using Google earth engine is shown below:

Parameter Analyzed	Image Collection	Minimum	Maximum	Band Used	Unit
Nitrogen dioxide (NO_2)	COPERNICUS/S5P/NRTI/L3_NO2	0.0000552	0.000101	NO^2 column number density	mol/m^2
Sulphur dioxide (SO)	COPERNICUS/S5P/NRTI/L3_SO2	0.540	1.0606	SO^2 column number density	mol/m^2
Carbon monoxide (CO)	COPERNICUS/S5P/NRTI/L3_CO	0.039	0.07706	CO column number density	mol/m^2
Particulate matter 2.5 (PM 2.5)	COPERNICUS/S5P/OFFL/L3_AER_AI	-1.219	0.20007	Absorbing aerosol index	mol/m^2

Table 3.1: Dataset for analysis of NO_2, SO_2, CO and PM 2.5.

Source: Sentinel (2022).

CHAPTER 4

RESULTS

4.1. RESULT PRESENTATION

Table 4.1: Concentration of CO for sampling years.

	2019	2020	2021
Sample months	CO	CO	CO
March	0.05761	0.075959	0.063594
April	0.051372	0.050011	0.071866
May	0.04362	0.044078	0.041461
June	0.04228	0.08038	0.042464
July	0.046138	0.043429	0.043295
August	0.044766	0.048293	0.014273
September	0.039966	0.042843	0.041132
Average mean	0.004546	0.01324	0.012737

Table 4.1 above shows the average concentration of carbon monoxide (CO) taken from all sampling points for each of the sample points and the calculated average concentration for years 2019 to 2021.

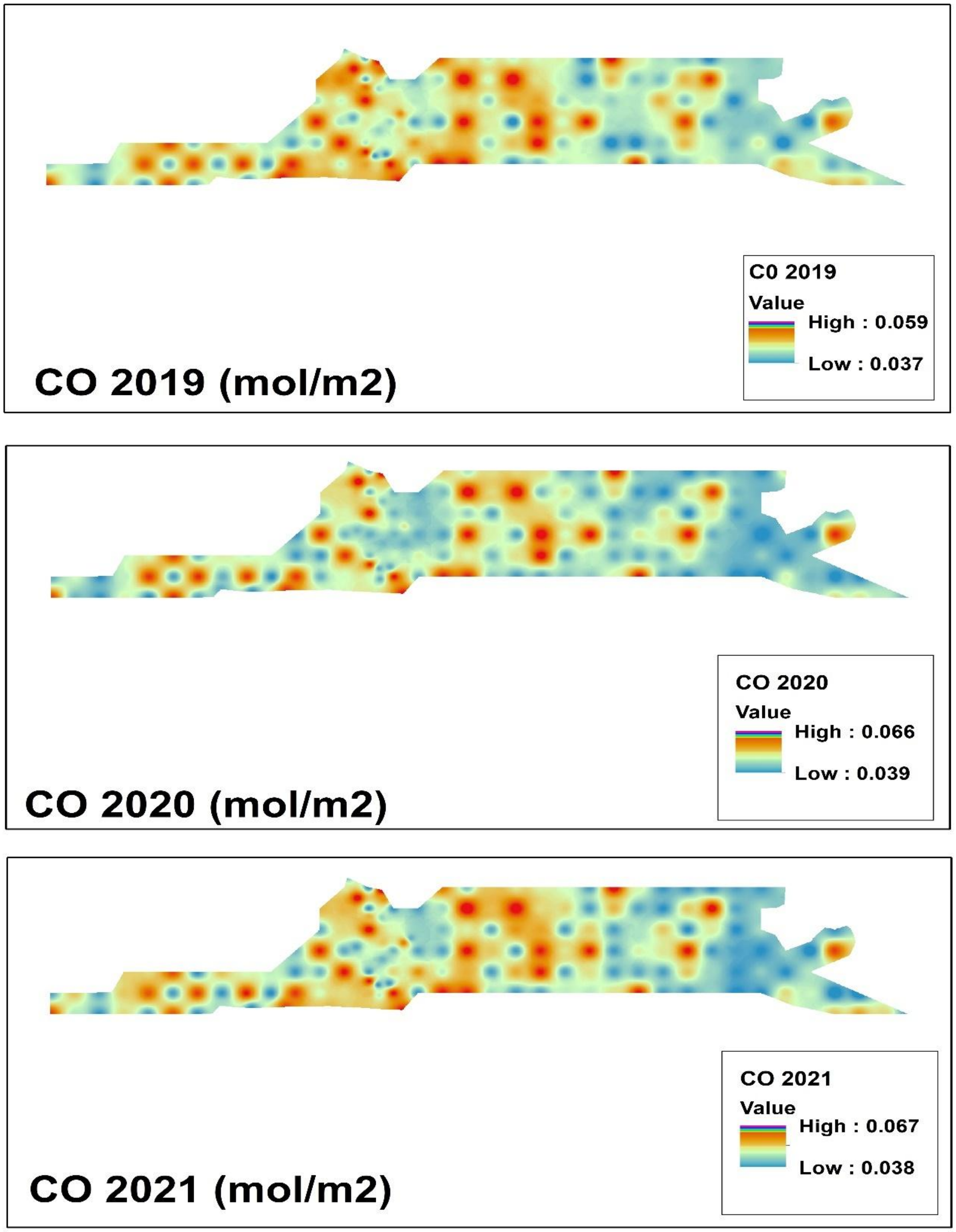

Figure 4.1:CO air pollution maps for sample years.

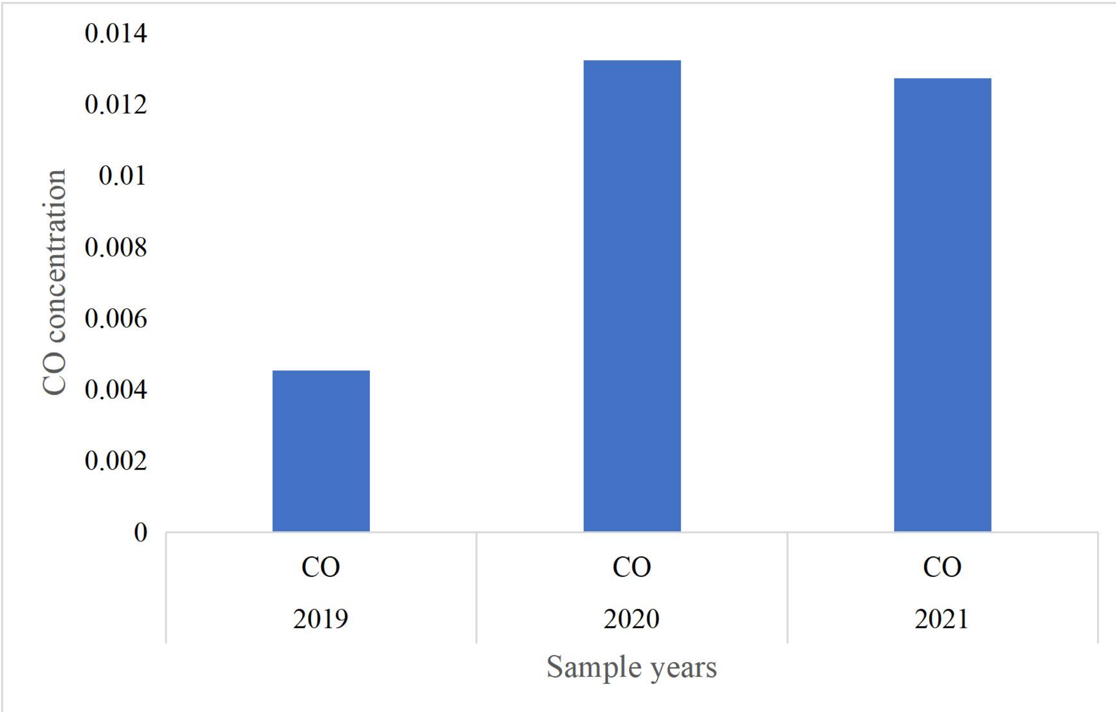

Figure 4.2: Graph showing the concentration level of CO for sample years. (2019 – 2021)

Table 4.2: Concentration of SO_2 for sampling years.

	2019	2020	2021
Sample months	SO_2	SO_2	SO_2
March	0.706945	0.64175	0.67941
April	0.660605	0.663859	0.647331
May	0.574061	0.489058	0.699359
June	0.736237	0.658117	0.686589
July	0.758125	0.707382	0.735666
August	0.765165	0.679998	0.747275
September	0.724396	0.892511	0.850516
Average mean	0.049323	0.071886	0.048807

Table 4.2 above shows the average concentration of sulphur dioxide (SO_2) taken from all sampling points for each of the sample points and the calculated average concentration for years 2019 to 2021.

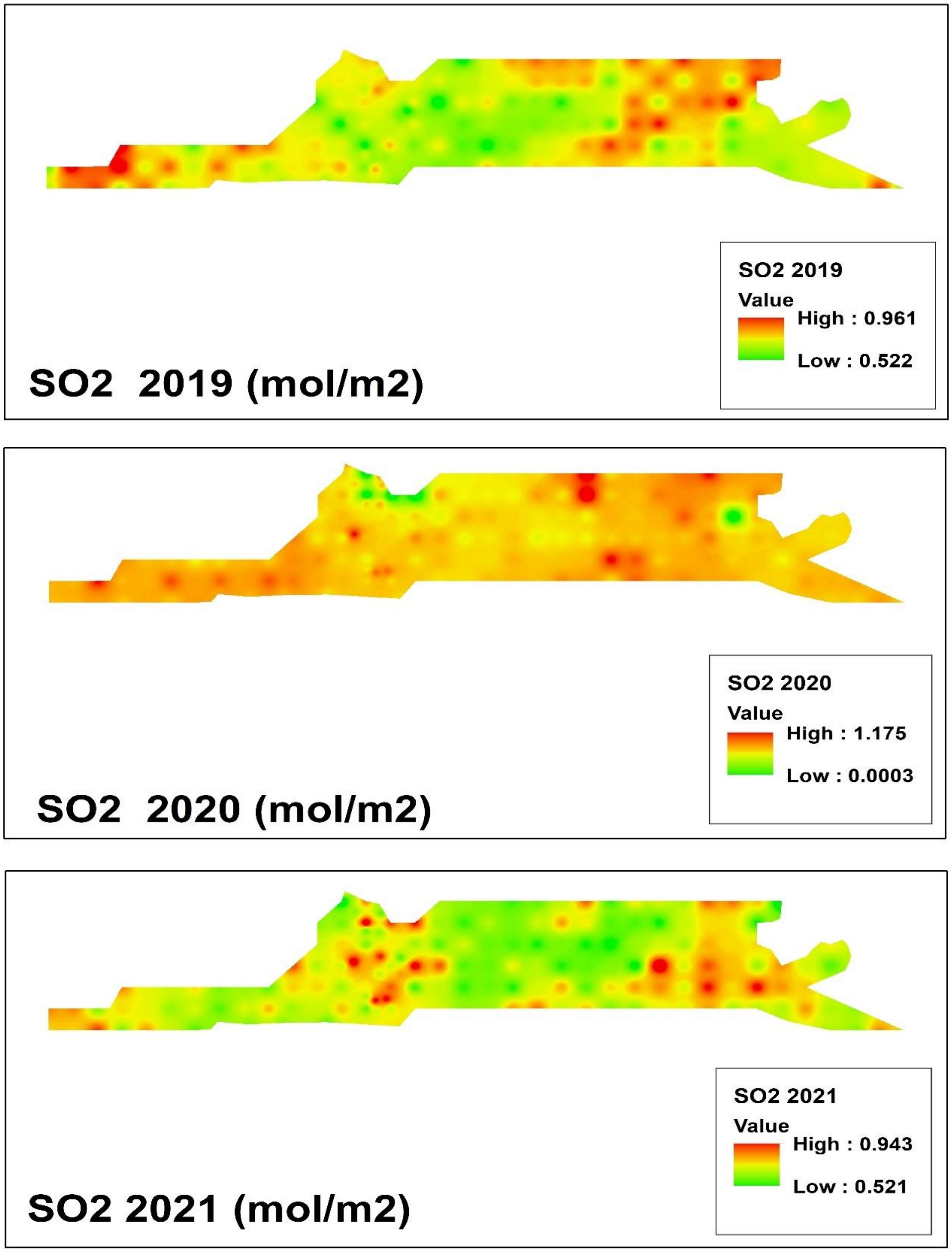

Figure 4.3: SO_2 air pollution maps for sample years.

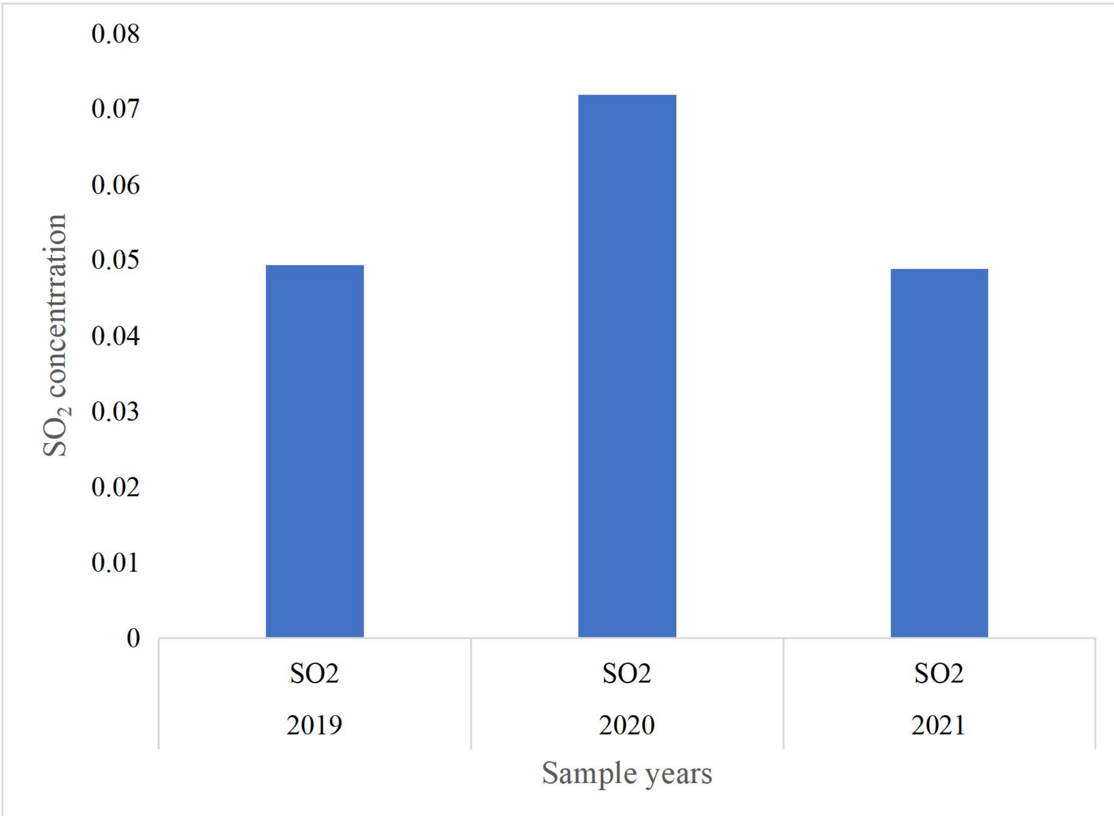

Figure 4.4: Graph showing the concentration level of SO_2 for sample years. (2019 – 2021)

Table 4.3: Concentration of $PM_{2.5}$ for sampling years.

	2019	2020	2021
Sample months	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$
March	0.015021	-0.3375	-0.38511
April	-0.19399	-0.59577	-0.82904
May	-0.80021	-0.91236	-1.4133
June	-0.81002	-0.86665	-1.37496
July	-0.87608	-0.91225	-0.02791
August	-0.67903	-0.83679	-0.54274
September	-0.99655	-1.11167	-0.60896
Average mean	0.303221	0.188288	0.398984

Table 4.3 above shows the average concentration of particulate matter ($PM_{2.5}$) taken from all sampling points for each of the sample points and the calculated average concentration for years 2019 to 2021.

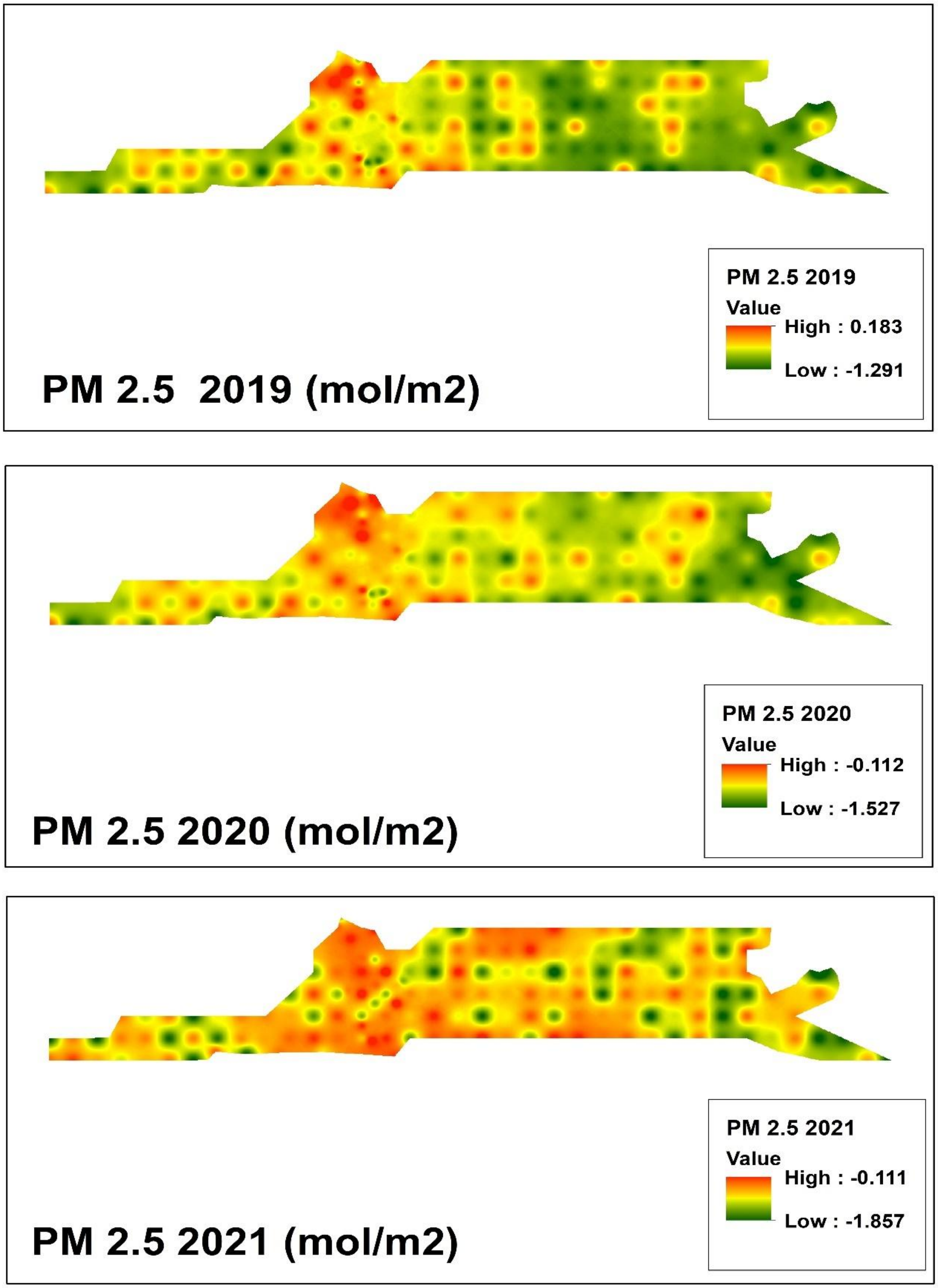

Figure 4.5: $PM_{2.5}$ air pollution maps for sample years.

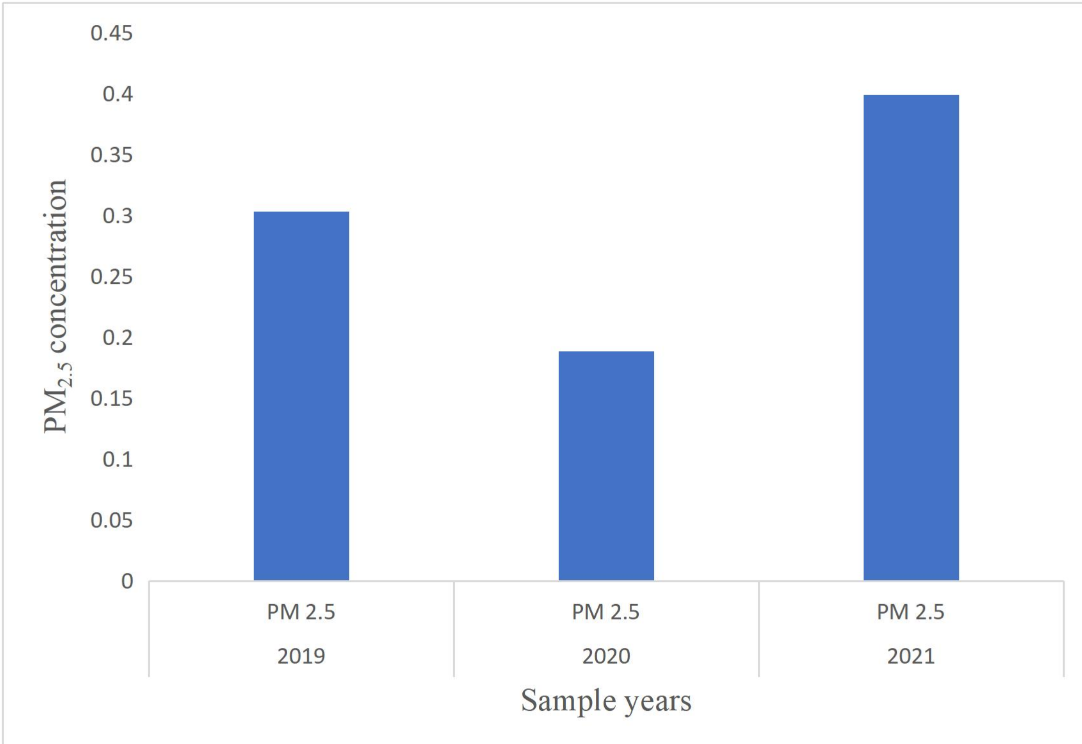

Figure 4.6: Graph showing the concentration level of $PM_{2.5}$ for sample years. (2019 – 2021)

Table 4.4: Concentration of NO_2 for sampling years.

	2019	2020	2021
Sample months	NO_2	NO_2	NO_2
March	9.08E-05	7.75E-05	0.000101
April	7.84E-05	6.77E-05	9.15E-05
May	7.38E-05	0.000074	8.21E-05
June	6.33E-05	7.71E-05	9.93E-05
July	5.79E-05	5.78E-05	6.68E-05
August	5.52E-05	0.000065	6.47E-05
September	6.93E-05	6.49E-05	7.54E-05
Average Mean	9.59E-06	6.05E-06	1.23E-05

Table 4.4 above shows the average concentration of nitrogen dioxide (NO_2) taken from all sampling points for each of the sample points and the calculated average concentration for years 2019 to 2021.

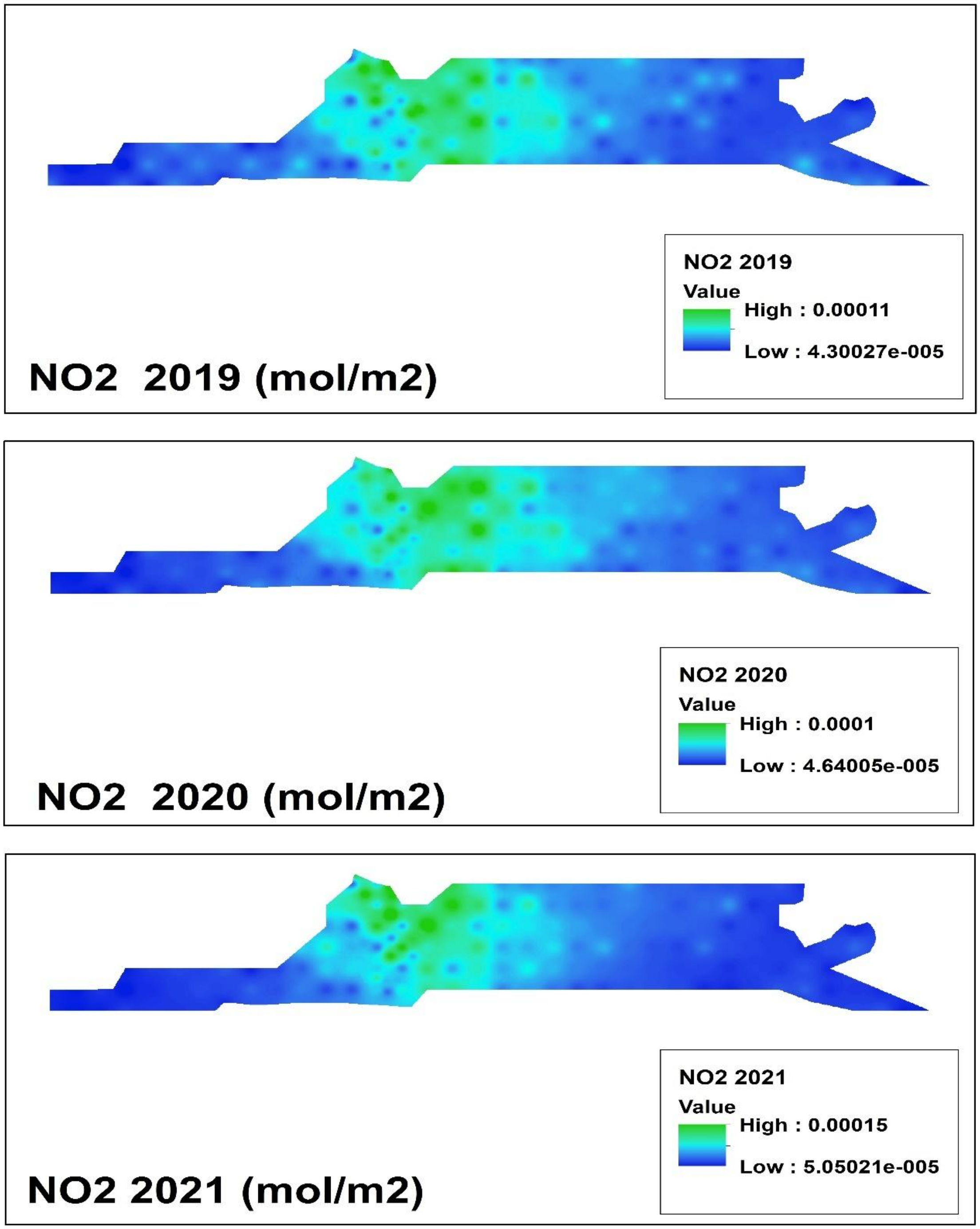

Figure 4.7: NO_2 air pollution maps for sample years.

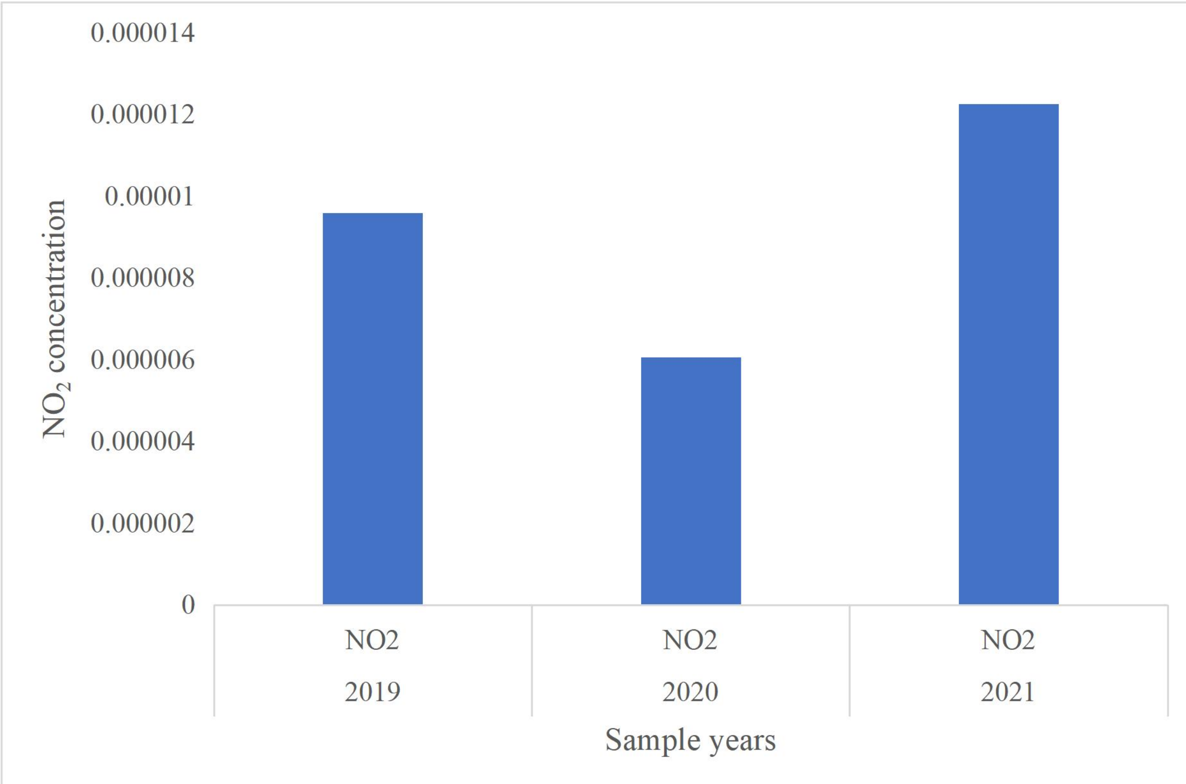

Figure 4.8: Graph showing the concentration level of NO_2 for sample years. (2019 – 2021)

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATION.

5.1 DISCUSSION

The concentration level of particulate matter ($PM_{2.5}$) and nitrogen dioxide (NO_2) showed to have dropped in 2020 during the covid-19 lockdown period and rose back to be much higher with significant difference in the year 2021 when activities went back to normal. While the policy did not reduce the concentration of carbon monoxide and sulphur dioxide. The NO_2 and $PM_{2.5}$ levels in the sampling year 2020 when the lockdown policy was enacted, proves the reduction in anthropogenic activities during this period positively reduced the concentration of air pollutant gases. Road traffic is the principal outdoor source of nitrogen dioxide (NO_2) (Glorennec *et al.,* 2008). The combustion of fossil fuels (coal, gas, and oil), particularly fuel used in automobiles, is the primary source of nitrogen dioxide produced by human activities. It is also produced during the production of nitric acid, welding and the use of explosives, petrol and metal refining, commercial manufacturing, and food manufacturing. This proves that during the pandemic year when these activities were reduced, the nitrogen dioxide concentration in the atmosphere reduced thereby improving air quality. $PM_{2.5}$ which occurs in the atmosphere as a result of human activities or naturally occurring dust, ash, and sea-spray. Human-made sources of $PM_{2.5}$ are more important than natural sources, which make only a small contribution to the total concentration. Particulate matter (including soot) is emitted during the combustion of solid and liquid fuels in applications such as power generation, domestic heating, and vehicle engines. The $PM_{2.5}$ air pollution maps in figure 4.5 shows the low concentration in most sample points for the year 2020 less than the year 2021, this means the lockdown policy established in the year 2020 during the covid-19 period improved the air quality by leading to reduced concentration of air pollutant gases in Lagos state. The air pollution graphs of CO and SO_2 in figure 4.2 and figure 4.4 respectively, shows that the concentrations of both parameters increased in the year 2020 and decreased back in 2021.

This is due to the indoor sources of CO such as gas space heaters, leaking chimneys, furnaces and unvented spaces. In other words, the reduction of fossil fuel combustions did not decrease the concentration of CO but increased it because of the use of gas cookers, furnaces and kerosene stoves to cook more since they are at home and as such the cooking is done several times in multiple homes during the lockdown. Meanwhile, after the lockdown in 2021, for a significant part of the day, these indoor activities were not being carried out as much as they were in 2020. The result for CO concentration were the lowest in 2019 because the population count of the study area was much lower than that of the years 2020 and 2021. As shown in figure 4.4, the SO_2 concentration was also higher in 2020 than it was in 2021 due to the indoor source of SO_2 such as electric utilities. Since people were at home all the time in the year 2020, more electricity was used in multiple homes leading to the increase in concentration of SO_2 during the course of the lockdown. Therefore, in 2021, the concentration reduced because the same electrical appliances were now used in the same place by multiple people. This study has established that there was significant improvement in air quality as a result of the decrease in concentration of $PM_{2.5}$ and NO_2 concentrations.

5.2 CONCLUSION

It was established that the covid-19 lockdown policy which brought about a decrease in anthropogenic activities that reduce the air quality was positively effective in reducing the emission of air pollutant gases which decrease the quality of air. It was proven that for most sample areas in the year 2020, the air quality clearly improved. Air pollutant gases such $PM_{2.5}$ and NO_2 which are unhealthy were decreased in concentrations in more than 75% of the study area. This means that the covid-19 lockdown policy brought about positive effects in relation to air quality and therefore provided healthier air for living things in the study area. Improvements in air quality during lockdown indicate the magnitude of effort required to bring air quality within the limits

5.3 RECOMMENDATION

The air quality during lockdown should possibly become the baseline air quality, and our models and targets should be re-calibrated.

More recommendations after this study include:

- Since it is impossible to be locked down at home all the time, whenever possible, walk, bike, skate, take the bus, or carpool instead of driving.
- Invest in fuel-efficient vehicles. Vehicles that do not release so much pollutant gases into the air should be used.

- Conserve energy both at home, at work and anywhere we find ourselves. This forms a conscious effort within us and would be effective if everyone makes it a point.
- Reduce your use and exposure to toxic chemicals. Toxic chemicals which we were not in use of during the lockdown has proven that we can do without them.
- Install solar energy at your residence or business. This reduces the use of petroleum generators which is constituted of high levels of these pollutant.

It is established that humans cannot be put permanently on lockdown to protect the environment but we can make extra efforts to live almost as we did during the lockdown by reducing the activities that contribute to a decrease in air quality or use air quality friendly alternatives.

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