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EFFECT OF FUEL SUBSIDY REMOVAL ON AIR QUALITY IN LAGOS STATE, SOUTH WESTERN, NIGERIA

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Abstract

Examining the impact of the fuel (Premium Motor Spirit) subsidy removal policy on air quality enhances our understanding of the relationship between economic policies and the environment. This study aims to investigate the effect of the subsidy removal policy on air quality in Lagos State, Nigeria, by adopting Sentinel 5p techniques. Two months (April-May, 2023) before and two months (June-July, 2023) after the policy was implemented were chosen as the scope of the study. The result revealed a maximum and minimum carbon monoxide (CO) concentration of 0.0484 mol/m^2 and 0.0415 mol/m^2 before subsidy removal, and after the policy was passed, the concentration was between 0.0442 mol/m^2 and 0.0378 mol/m^2. Maximum and minimum concentration values for aerosols before subsidy removal were between 0.392 and -0.277, and after the policy was implemented, the concentrations were between -0.277 and -0.832. The maximum and minimum concentration values for nitrogen dioxide (NO_2) before subsidy removal were between 0.000126 mol/m^2 and 0.0000502 mol/m^2, and after the policy was passed, the concentration was between 0.0000892 mol/m^2 and 0.0000481 mol/m^2. The study reported that there was a statistically significant ($p<0.05$) decrease in the emissions of CO and aerosols (with p-values of 0.04 and 0.022, respectively) in the two months following the pronouncement of the end of the fuel subsidy regime. Furthermore, the study revealed that though NO_2 emissions decreased, this decline was not statistically significant (p-value 0.464). Findings from this study suggest that the fuel subsidy removal policy led to improved air quality in Lagos State.

Key Words: *Sentinel 5p, Subsidy, Air quality, Lagos, Nigeria*

Introduction

Since the 1970s, there has been an interest in understanding the origins and implications of oil price shocks (Amaiquema and Amaiquema, 2017; Jo *et al*., 2017; Obi *et al*., 2016; Lorussoa and Pieronib, 2018; Fueki *et al*., 2018). These oil price shocks necessitated the need for fuel subsidies in the mid-1980s as a response to cushion the suffering experienced by individuals, households, and businesses as a result of high fuel pump prices. Successive Nigerian governments, despite receiving significant income from oil exports, failed to provide the social amenities required to reduce and/or eradicate poverty (Agu *et al*., 2018).

The Nigerian government has continuously subsidized fuel pumps for decades, to the detriment of its economy and environment. The impact of subsidizing fuel pump prices has taken a toll on the economy of the West African nation, especially with exponential population growth and an utter lack of accountability and leadership (Kadiri and Lawal, 2016).

In what may be described as an impromptu pronouncement, the newly inaugurated president of the Federal Republic of Nigeria had on May 29, 2023, announced the removal of subsidy on fuel, bringing to an end the fuel subsidy regime (Damilola, 2023). The elimination of subsidy on fuel could lead to better air quality and public health outcomes by lowering fuel consumption and promoting the use of cleaner alternative modes of transportation (IEA, 2021). The Nigerian government has continuously subsidized fuel pump prices for decades, to the detriment of its economy (Majekodunmi, 2013) and environment (Arzaghi and Squalli, 2023). One common viewpoint is that fuel subsidy policies encourage the wasteful use of fossil fuels, which worsens environmental damage (Overland, 2010). According to Parry *et al*. (2021), removing fuel subsidies can lead to a substantial decrease in greenhouse gas emissions (Parry *et al*., 2021). Previous studies (Lin and Jiang, 2011; Li *et al*., 201; Gelan, 2018; and Sarrakh *et al*., 2020) have looked at the environmental effects of ending fuel subsidy. These studies used computable general equilibrium (CGE) models and made strict assumptions (Arzaghi and Squalli, 2023). Nevertheless, no research has yet utilize Sentinel 5P in estimating the effect on air quality resulting from subsidy removal.

Air pollutants such as CO, aerosols, and NO_2 are produced during the combustion of fuel and from vehicular emissions (Bhandarkar, 2013, Bisht *et al*., 2022; Kumar *et al*., 2023). As the number of motor vehicles rises, pollution from car emissions continues to worsen environmental degradation and human health issues (Ji *et al*., 2018; Mishra *et al*., 2019; Xiaonian *et al*., 2019; Nathaniel and Xiaoli, 2020). Epidemiological studies have demonstrated that exposure to CO, aerosol, and NO_2 can result in serious health issues, which include headaches, dizziness, irritation of the nose, eyes, and throat, shortness of breath, upper respiratory infections, lung cancer, damage to the liver and kidneys, heart disease, lung cancer, and brain damage (Robert *et al*., 2017; Javeria *et al*., 2018; Ernyasih *et al*., 2023; Mebrahtu *et al*., 2023; Van der Weijden, 2023).

A study conducted by Croitoru et al. in 2020 suggests that road transport, industrial emissions, and power generation are the largest contributors to pollution in Lagos State. Due to variables like industrialization (Bauer *et al*., 2019), vehicle emissions (Lang *et al*., 2021) and high population density (Chen *et al*., 2020), sustaining adequate air quality standards in rapidly urbanizing areas like Lagos State is extremely difficult. As a result, examining the effect of the subsidy removal policy on air quality contributes to greater knowledge of how economic policies affect the environment. This study evaluates the effect of the fuel subsidy removal policy on air quality in Lagos State. Lagos State is a particular urban setting with a high population density and rapid urbanization, making it suitable for this study. The findings of this study will contribute to the development of evidence-based decision-making.

Materials and Method

Study Area

Lagos State is located on the Gulf of Guinea coast in southwestern Nigeria with longitude 3°21′24″E and latitude 6°35′8″N. The climate of the state is tropical and hot all year, with a dry season from November to March and a rainy season from April to October. All year, but especially during the rainy season, the humidity level is high with high rainfall amounts, especially from May through July. Temperatures are at their peak during the dry season. As of 2016, the population was at 12,550,598 (National Population Commission, 2007), which increased to 15,946,000 in 2023 (Macrotrends, 2023) and a wide area of 1,171.28 square kilometres (452.23 square miles). It is also the most populated metropolis in Nigeria and on the entire African continent (Auwalu *et al*., 2023). It consists of 20 local government areas (LGA), which include 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, Epe, and Ikeja, which is the state capital. Lagos State is a particular urban setting with a high population density and rapid urbanization (Auwalu et al., 2023), making it suitable for this study. High vehicle density (227 vehicles/km/day), old cars (over 15 years old) are the primary contributors of air pollution in Lagos State (Croitoru, et al., 2020). The abundance of outdated vehicles in Lagos, along with the city's limited transportation alternatives and traffic congestion, has resulted in a decline in air quality that poses a significant threat to public health (Croitoru *et al*., 2020; Ogunlade, 2023).

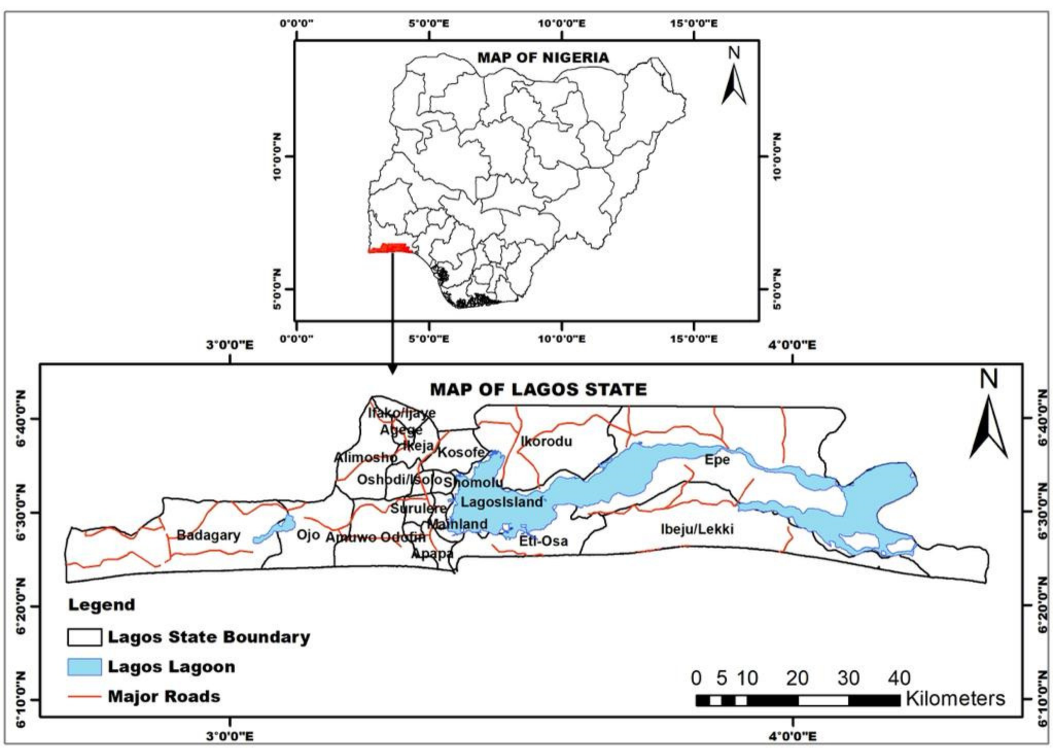

Fig. 1: Map of Lagos State, Nigeria

Data Type and Data Source

The present investigation utilized air quality data of criteria pollutants of interest (CO, Aerosols, and NO_2,) from two months before and after the subsidy removal policy was announced (April-May; June-July, 2023). The data was obtained through the implementation of air quality technology, specifically the utilization of Sentinel 5P. The Sentinel-5P satellite mission is part of the Global Monitoring for Environmental and Security (GMES/Copernicus) program (Vîrghileanu *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) (Psomouli *et al*., 2023).

The TROPOMI instrument is a multispectral sensor that captures reflectance of wavelengths crucial for quantifying atmospheric concentrations of ozone, methane, formaldehyde, aerosol, carbon monoxide, nitrogen oxide, and sulfur dioxide, in addition to cloud characteristics (Muthu, 2021). 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) (Yadav *et al*., 2022). It has a higher spatial resolution than its predecessors, measuring 7 x 3.5 km^2 (along and across track), and Sentinel-5P offers a new potential for air quality research, making it suitable for polluting emission source monitoring (Manisalidis *et al*., 2020). Recent research carried out by Manisalidis *et al*. (2020) has found a strong correlation between data obtained from Sentinel-5P and ground-based data, giving validation to the data obtained for this study.

Method of Data Collection and Analysis

Data on the study area was obtained through the Google Earth Engine. The shapefile of Nigeria was downloaded from the DIVA-GIS website. Lagos State, which is the region of interest, was exported as a shape file using ArcMap and imported into Google Earth Engine to be processed to generate results through Sentinel-5P on Google Earth Engine for the various months. Sentinel 5p houses the TROPOMI sensor, which observes pollutants and gives results for their concentration in mol/m^2. The result was assessed using Google Earth Engine by scripts of codes run on the editor. The results were exported as a tiff file and a CSV file. The tiff file was imported into ArcMap for visualization, while the CSV file was exported to Excel for graph making, and SPSS 20.0 was used to determine the statistically significant differences between the results of each month. Figure 2 shows the research methodology flowchart. The dataset for the analysis of atmospheric pollutants using Google Earth Engine is shown in Table 1.

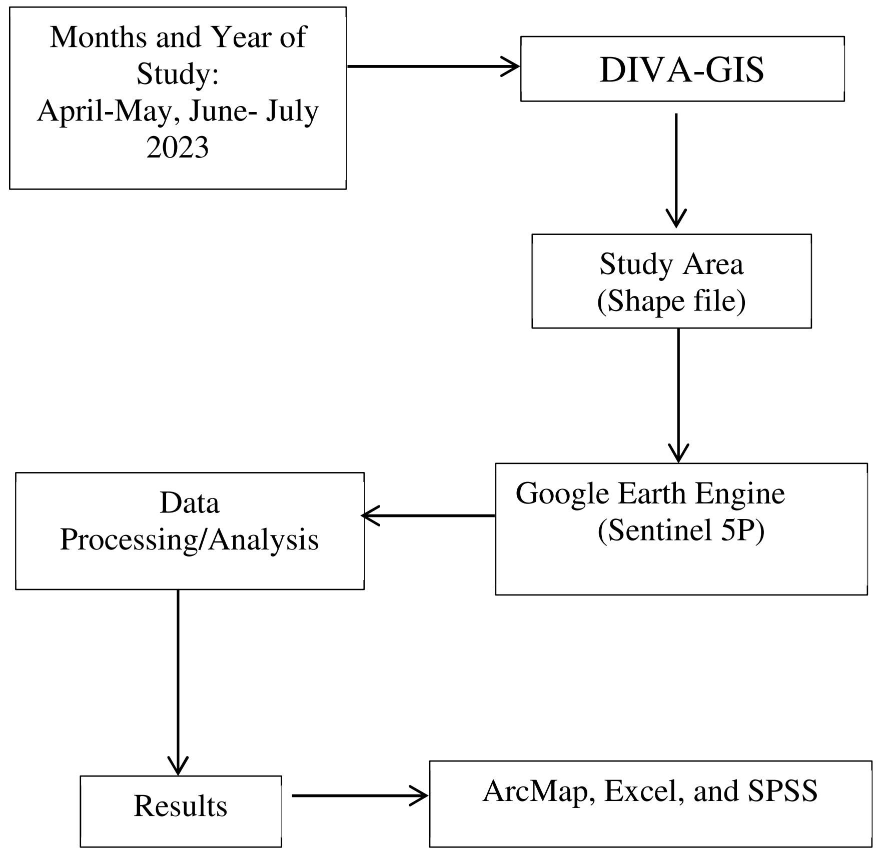

Fig. 2: Research Methodology Flowchart

Table 1: Dataset for analysis of CO, Aerosols and NO_2

Parameter Analyzed	Image Collection	Band Used	Unit
Carbon monoxide (CO)	COPERNICUS/S5P/NRTI/L3_CO	CO column number density	mol/m²
Aerosols	COPERNICUS/S5P/OFFL/L3_AER_AI	Absorbing aerosol index	--
Nitrogen dioxide (NO_2)	COPERNICUS/S5P/NRTI/L3_NO2	NO_2 column number density	mol/m²

Results and Discussion

Table 2 reveals the values of CO, aerosols, and NO_2 concentrations in Lagos State before and after the removal of fuel subsidy in the months of April-May and June-July 2023. The range of minimum and maximum values recorded before subsidy removal were between 0.0412-0.0484 mol/m^2 for CO; -0.277 - 0.392 for aerosols, and 0.0000502 - 0.000126 mol/m^2 for NO_2, and the range of minimum and maximum values recorded after subsidy removal were between 0.0378 - 0.0442 mol/m^2 for CO; -0.832 - (-0.203) for aerosols, and 0.0000481-0.0000892 mol/m^2 for NO_2. The average mean values obtained before the removal of fuel subsidy were 0.0449 mol/m^2 for CO; 0.0575 for aerosols, and 0.0000881 mol/m^2 for NO_2. The average mean values obtained after the removal of fuel subsidy were 0.0410 mol/m^2 for CO; -0.518 for aerosols, and 0.0000687 mol/m^2 for NO_2. There was a statistically significant difference ($p \leq 0.05$) for CO and aerosols; however, the concentration of NO_2 was observed to be not significant ($p > 0.05$).

Table 2: Comparison of the mean values for each month before and after subsidy removal

Pollutants	**Mean value before subsidy Removal (April-May)**		**Mean value after subsidy Removal (June-July)**		
	$\overline{x}$±SD	Min-Max	$\overline{x}$±SD	Min-Max	pvalue
CO	0.0449±0.0049	0.0415-0.0484	0.0410±0.0046	0.0378-0.0442	0.04
Aerosol	0.0575 ±0.473	-0.277-0.392	-0.518 ±0.445	-0.832 - 0.203	0.022
NO_2	0.0000881±0.0000536	0.0000502-0.000126	0.0000687±0.0000290	0.0000481-0.0000892	0.464

x ± SD = average mean generated from values across the months ± standard deviation; min–max = minimum and maximum values, ($p \leq 0.05$) are significantly different while values with ($p > 0.05$) are not significantly different.

Figure 3a shows the trend of CO concentration before and after fuel subsidy removal. The values of CO during the sampling months ranged from 0.0415-0.0484 mol/m^2 and 0.0378-0.0442 mol/m^2 before and after fuel subsidy removal. Using the paired sample t test, there was a significant difference in mean values of CO before and after the fuel subsidy removal. Figure 3b spatially revealed that the north region of Ikorodu, Mushin, Agege, Kosofe, Sululere, and Ikeja had the highest concentrations before subsidy removal was announced. These regions were reduced in concentration, as depicted in the post-subsidy removal map in Figure 3b.

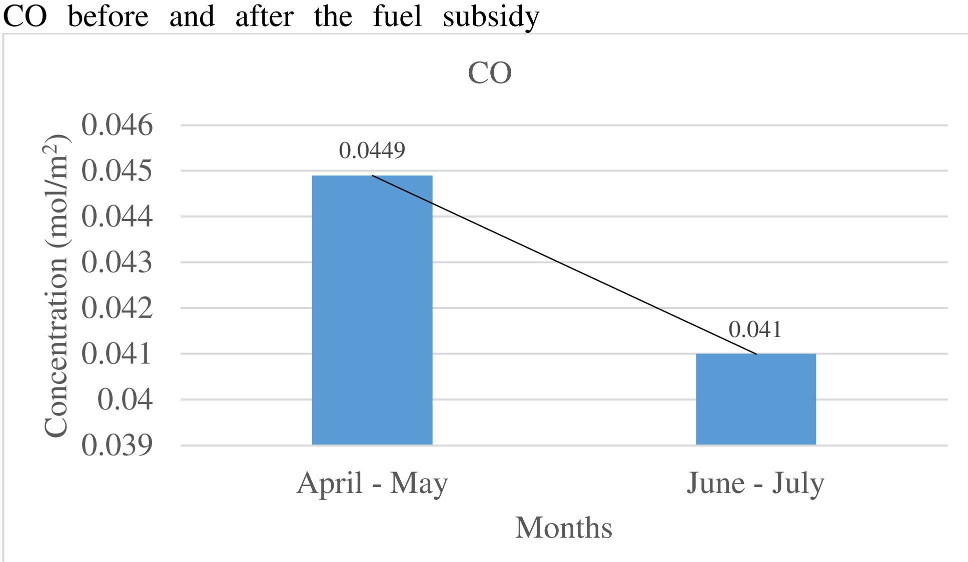

Fig. 3a: Bar chart showing trend of carbon monoxide concentration from April-May, June-July 2023

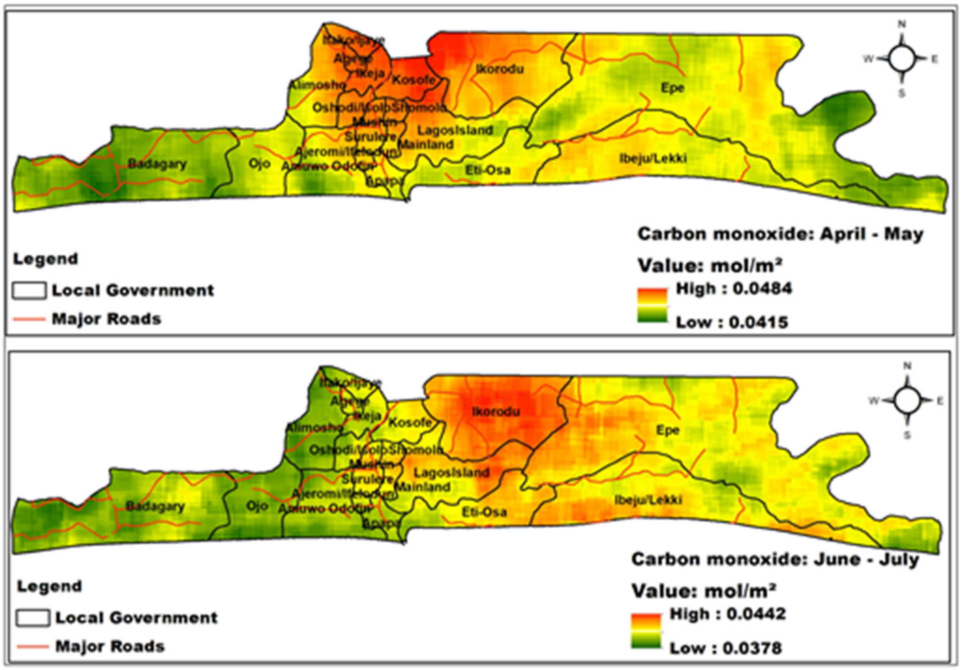

Fig. 3b: Map showing mean spatial variation of carbon monoxide concentration from April-May, June-July 2023

Figure 4a reveals the trend of aerosol concentration before and after fuel subsidy removal. The figure depicts a decreasing trend in the values of aerosol emissions throughout the study period. This shows a general reduction in the consumption of fuel in the study area that contributes to the formation of atmospheric aerosols. The values of aerosols during the sampling months ranged from -0.277 to 0.392 and -0.832 to -0.203 before and after fuel subsidy removal respectively. Using the paired sample t test, there was statistically significant difference before and after the fuel subsidy removal.

Figure 4b shows that Ifako/Ijaye, Agege, Ikeja, Mushin, Oshodi-Isolo, and Surulere and the Western region of Ikorodu and the Northern regions of Somolu and Lagos Island Ifako/Ijaye, Agege, Ikeja, Mushin, the Western region of Oshodi-Isolo, and Surulere recorded the highest values of aerosol concentration, while the Western part of Epe recorded the lowest readings.

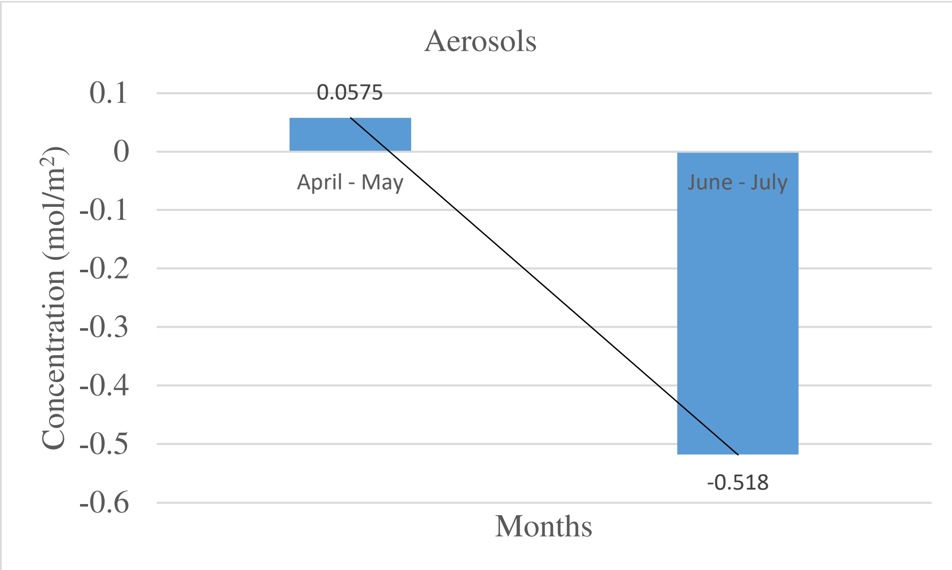

Fig. 4a: Bar chart showing the trend of aerosols concentration from April-May, June- July 2023

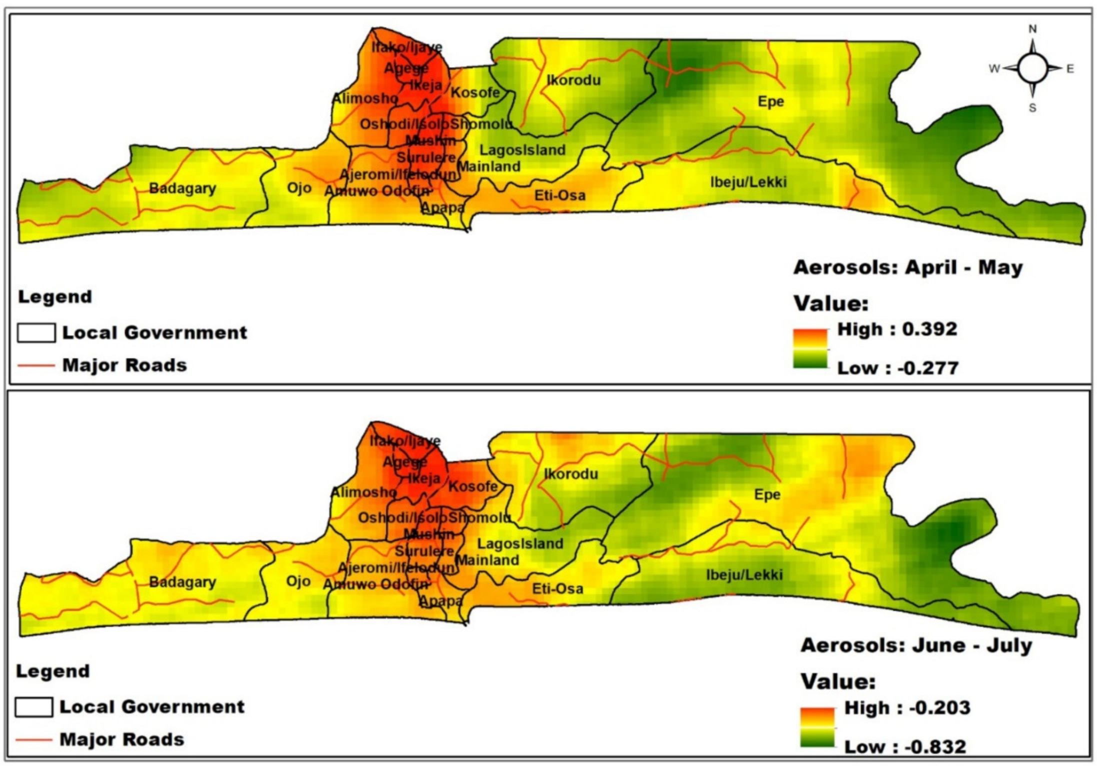

Fig. 4b: Map showing mean spatial variation of aerosols concentration from April-May, June-July 2023

Figure 5a shows the trend of NO_2 concentration before and after fuel subsidy removal. The values of NO_2 during the sampling months ranged from

0.0000502-0.000126 mol/m^2 and 0.0000481-0.0000892 mol/m^2 before and after fuel subsidy removal. Using the paired sample t test, there was no statistically significant difference before and after the fuel subsidy removal. Before the fuel subsidy removal policy was implemented, Kosofe, Ikeja, Agege, Somolu, the Western region of Oshodi-Isolo and Mushin, Lagos Island, the Eastern region of Ikorodu, and Surulere local government areas recorded high and slightly high, while Badagary, Ojo, Ibuju/Lekki and the Western region of Epe local government areas had lowest concentrations of NO_2. After the fuel subsidy removal policy was implemented, Kosofe, Somolu and western region of Oshodi-Isolo and eastern region of Ikorodu local government area recorded the highest concentration, while Badagary, Ojo and the western region of Epe and Southern region of Amuwo-Odofin had lowest concentrations of NO_2.

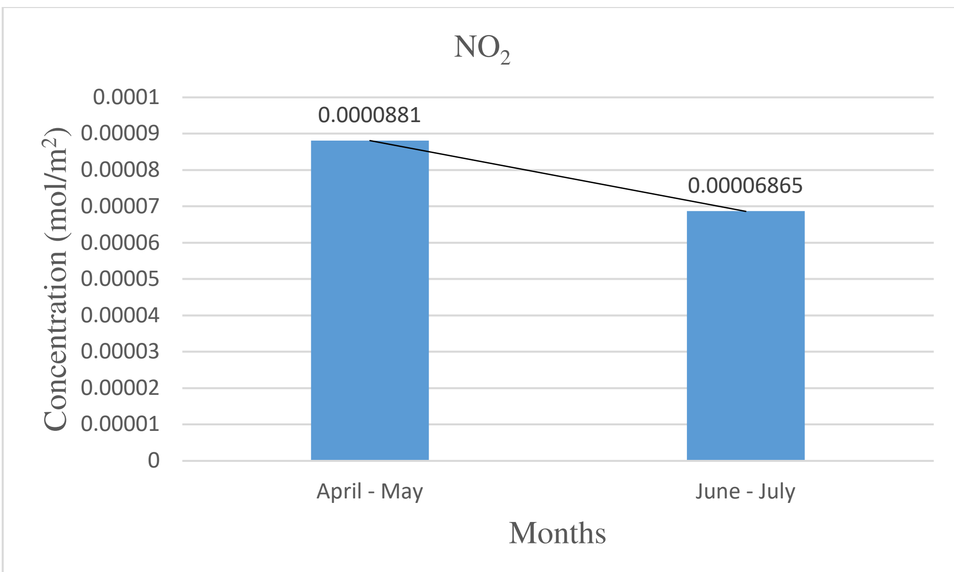

Fig. 5a: Bar chart showing trend of NO_2 concentration from April-July and June-July, 2023

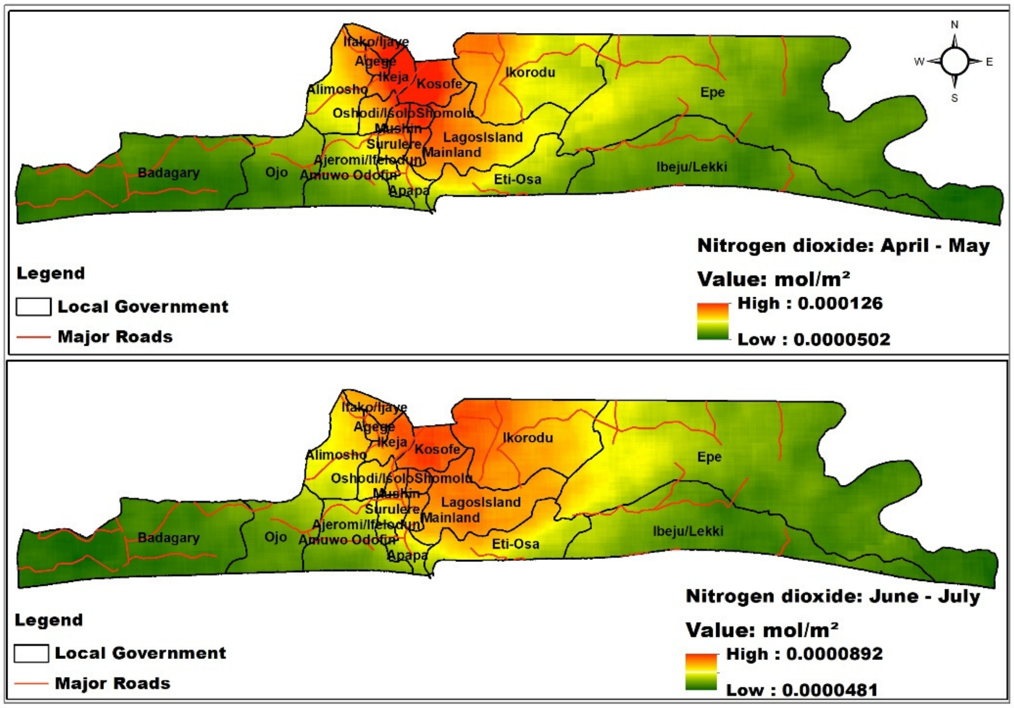

Fig. 5b: Map showing mean spatial variation of NO_2 concentration from April-May, June-July 2023

The study revealed that while there was a decrease in the amount of NO_2 emissions after the removal of fuel subsidy, it was not statistically significant. However, the study showed that CO and Aerosols emissions decrease significantly after the elimination of subsidy on fuel. Furthermore, NO_2 was reported to have a p-value of (0.464) while CO and Aerosols had a p- value of (0.04) and (0.022) respectively. The reduction in the concentration of CO, aerosols, and NO_2 showed that the reduction in petroleum product consumption due to the increase in price after the subsidy policy removal positively improved air quality. The combustion of fossil fuels such as coal, gas, and crude oil, particularly fuels used in automobiles, is one of the primary sources of CO and NO_2 produced by human activities (Glorennec *et al*., 2008). A common anthropogenic source of aerosols is the incomplete combustion of diesel, gasoline, coal, and biomass (Wu *et al*., 2022). Gao *et al*. (2021) stressed the significance of developing policies that permit a decrease in traffic emissions. Mehmood *et al*. (2021) study also aimed to look into connections between the COVID-19 lockdown and air pollution. Studies have revealed human exposures to aerosols to be associated with multiple respiratory diseases including chronic obstructive pulmonary disease, asthma and lung cancer (Lee *et al*., 2020; Harari, *et al*., 2020). This study has shown that there has been a significant reduction in the concentration of CO and aerosols and a gradual, not significant decrease in NO_2 concentration levels, which has led to an improvement in the air quality in Lagos State, Nigeria, since the policy became effective in May 2023.

Conclusion

This study suggests that fuel subsidy removal significantly improved air quality in Lagos State. The reduction of the concentrations of CO, Aerosols, and NO_2 shows that the policy of removing fuel subsidies has led to improved air quality. It is highly recommended that solar energy, efficient mass transit systems, and other eco-friendly energy sources be adopted as a means to reduce reliance on fossil fuels. Where possible, subsidies or grants should be made available by government to encourage the acquisition of vehicles with improved technology such as electric or hybrid cars to replace older, more polluting ones. These findings emphasize the importance of evidence-based policy decisions to address air pollution in Lagos State, Nigeria. Furthermore, researchers of this study recommends that a more extended study be carried out in other to buttress the findings of this study.

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