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Environmental Impacts of Commercial Haulage Operations on Air Quality in Nigeria

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Abstract

The operation of large haulage vehicle parks in Nigeria significantly contributes to ambient air pollution, posing serious environmental and health risks. This study investigates the adverse environmental consequences of air pollutants released by haulage vehicles in a major highway park connecting Osun state to other parts of Nigeria. Focusing on Oke Ese, Ilesha, Nigeria, the research identifies primary pollutants, measures concentrations, and analyzes air quality impacts. Total Suspended Particulates (TSP) and X-ray Fluorescence (XRF) analyses were conducted across various sample sites, including the truck park and surrounding residential areas. Findings reveal that Total Suspended Particulate (TSP) concentrations range from 83.14 μg/m^3 to 720.59 μg/m^3, exceeding Nigerian air quality standards and posing health risks to nearby residents. Average ambient sampling values were 404.86 μg/m^3, significantly higher than the FEPA standard of 250 μg/m^3. Source Sampling and residential sampling averages were 990.2μg/m^3 and 235.29 μg/m^3, respectively. XRF analysis detected high levels of magnesium in truck exhaust, with a maximum value of 189.25106 ×106 (μg/m^3), far exceeding the US National Ambient Air Quality Standard (NAAQS) of 100 μg/m^3. The study concludes that stricter emission regulations and alternative energy solutions are necessary to mitigate environmental and public health impacts. Achieving recommended air quality guidelines could save millions of lives globally, emphasizing the importance of addressing air pollution. The research underscores the need for urgent action to protect the health and well-being of communities surrounding haulage vehicle parks in Nigeria.

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1. Introduction

Nigeria's economic growth relies heavily on the transportation sector, with haulage trucks playing a crucial role in transporting materials and commodities nationwide. As the primary mode of transportation, heavy-duty haulage trucks connect various regions across the country. Following the decline of rail transportation, Nigeria has increasingly relied on these vehicles to transport goods [1, 2]. However, their operations have been linked to elevated ambient air pollutants, posing significant risks to human health and the environment. Large haulage vehicle parks, where vehicles are parked, loaded, unloaded, and maintained, are identified as major air pollution sources in urban areas. This study investigates the impact of haulage vehicle activities on ambient air pollutants at a prominent haulage vehicle park in Oke Ese, Ilesha, Nigeria. The operations of haulage vehicles within and surrounding the park have raised concerns due to their detrimental environmental and health impacts, exacerbated by the coexistence of commercial trading activities and residential apartments in the area [3]. This highlights the importance of residential sampling in assessing air quality. Globally, the issue of air pollution from haulage truck operations has gained significant attention due to research underscoring its adverse effects on ambient air quality. Moreover, air pollution poses broader ecological risks, threatening buildings, vegetation, and agricultural productivity [4, 5].

Despite the potential impact of haulage vehicle activities on ambient air quality, there is a lack of comprehensive data on the subject in Nigeria. Most studies on air pollution in Nigeria have focused on vehicular emissions in general, with limited attention given to differentiate haulage vehicle activities impacts on the ambient air and the residential houses around those places in particular. This study seeks to fill this gap by assessing the impact of haulage vehicle activities on ambient air pollutants at haulage vehicle parks, analyzing from source sampling, ambient sampling and residential sampling using a large haulage park at Oke Ese, Ilesha, Osun State Nigeria as a case study. This park appears to have the largest concentrations of heavy-duty trucks in the state. Activities of the haulage vehicles within and around this park have been reported to have serious impacts on environment health. Worried by the presence of commercial activities of trading as well as residential apartment in the area [6-8]. The study intends to examine the relationship between the concentration of pollutants and haulage vehicle activities such as loading, offloading, and maintenance. The findings of this study will be relevant to policymakers, environmental agencies, and other stakeholders in the transportation industry, as it will provide insight into the impact of haulage vehicle activities on ambient air pollutants and suggest measures to reduce emissions and improve air quality [9-11].

Research has extensively explored the effects of haulage truck operations on ambient air pollution. A notable study by Choi, et al. [9] investigated the toxic potential and spatial distribution of air pollutants around a haulage truck stop. The researchers monitored pollutant concentrations during dry and rainy seasons using ToxiRAE II Gas Monitors at five sampling locations, including a control point 55 kilometers away from the truck stop's influence. This study shed light on the cytotoxic effects and geographical distribution of gaseous criterion air pollutants, contributing to our understanding of haulage truck operations' impact on air quality. Environmental humidity influences thermal and photochemical reactions, prompting researchers to conduct seasonal sampling of key air pollutants at a haulage vehicle park [12-14]. The study revealed that average carbon monoxide (CO) levels during both dry and wet seasons remained below Nigeria's 10 ppm national air quality standard, as set by the Federal Ministry of Environment (FEPA). However, the findings indicate that haulage truck activities significantly elevate ambient air pollutant levels [15].

Studies have exposed the alarming air quality issues around metropolitan areas such as Lagos, Nigeria, where there is presence of heavy haulage truck park along the major highway. Many researchers have revealed that toxic airborne particles, with cytotoxic levels ranging from 0.58 to 6.00, far exceeding the 0.11 to 0.33 levels at a control site. This indicates haulage vehicles significantly degrade air quality, endangering commuters. To combat this, stringent regulations and effective controls are vital for protecting public health and preserving cleaner air. Implementing measures to mitigate air pollution will safeguard human well-being, vegetation, and wildlife, ultimately fostering a healthier environment and minimizing haulage vehicle operations' adverse impacts [16-18].

This research study seeks to uncover the relationship between pollutant levels and the activities of haulage vehicles, encompassing loading, unloading, and maintenance operations. The primary goal is to understand how these activities contribute to air pollution, ultimately informing policymakers, environmental organizations, and industry professionals on effective strategies to mitigate these impacts. Nigeria faces significant environmental and health challenges due to air pollution, particularly in the transportation sector. The life expectancy at birth in Nigeria was 54.5 years in 2016, with 6.8 years of compromised health. Haulage vehicles are major contributors to this issue, but there's a lack of comprehensive research on their specific impact [19-21]. This study brings a fresh perspective by exploring the connection between haulage vehicle operations and air pollution. By shedding light on the effects of haulage trucks on air quality, this research will inform policies to reduce emissions and promote a healthier environment in Nigeria. The findings will also contribute to the country's long-term low-emission development strategy, aiming to reduce emissions by 47% by 2030 [2]. Ultimately, this study will expand our understanding of air pollution's impacts on the environment and public health in Nigeria, particularly in the

Int. Journal of Integrated Engineering Vol. 17 No. 9 (2025) p. 220-232

transportation sector. The research will provide valuable insights for policymakers to create targeted solutions, such as (a) Identifying ways to minimize emissions from haulage vehicles, like alternative fuels or optimized maintenance schedules (b) Developing effective methods for tracking pollutant levels in areas with high haulage vehicle activity (c) Collaborating with stakeholders to create policies addressing the environmental and health impacts of haulage vehicle operations.

2. Materials and Methods

2.1 Sample Area Description

The study area is a standard tipper truck park in Oke Ese, Ilesha, Osun State, southwest Nigeria, situated along kilometer 56 of the Lagos-Ibadan dual carriageway. The high vehicle density in the area led to the selection of these places. Geographically, the park is located at 7.624274, 4.739087. The park is around 500 m^2 in size and serves as the community's main truck hub, housing between 50 and 80 vehicles. Along the main road that connects Akure lies the Association of Tipper and Quarry Truck Park. Trucks and tippers use it as a main park.

To get accurate samples, we chose specific spots to measure pollution early in the morning. We considered things like which way the wind was blowing, how many trucks were parked, and how far apart the trucks were. Fig. 1 (a) and (b) presents the exact places we took the samples on a Google Map and the set-up used for the investigation, respectively.

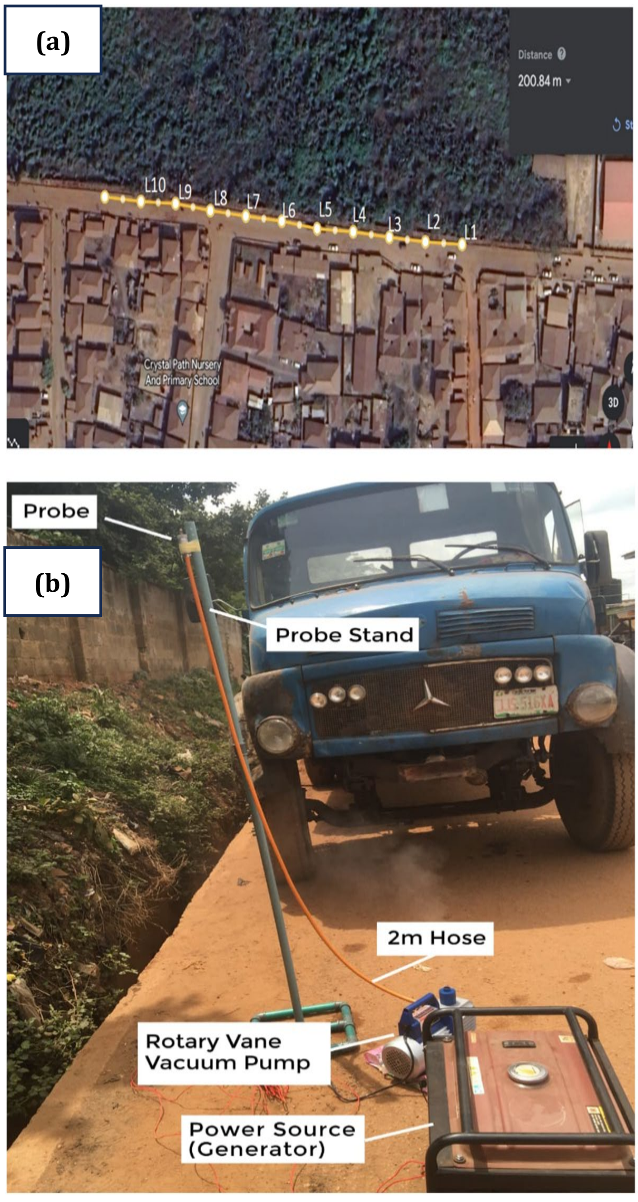

Fig. 1 *(a) Google Map of sampling locations of the haulage park; (b) Sampling set-up*

For this research, we used a range of equipment, including 30 Whatman cellulose filters (25.4 mm diameter), a rotary vane vacuum pump, a specialized mechanical probe, a high-precision weight balance (Mettler Toledo, Columbus, OH, USA), a Varian 3800/4000 gas chromatograph-mass spectrometer, and an Elepaq gasoline generator (model 8KVA-sv22000E2). The generator ensured a reliable power supply for our equipment. Figure 2 shows the assembly of all equipment used in air sample collection while figure 3 shows the probe used in capturing.

2.2 Sampling Technique

An average truck park with space for up to 40 vehicles served as the sampling location. The Global Positioning System (GPS) geographic coordinates of the region were used to record the coordinates of the sample sites. The 10 sample sites extend from the park's entrance to the the shed where the truck drivers congregate before they leave. Each of these places of sampling are shown in Table 1.

The sampling was done during the rainy season, when the average temperature was between 22 and 32°C during the day and between 22 and 27°C at night. During the sampling activity, the morning humidity was measured at 60–62%, the midday humidity at 54-57%, and the night-time humidity at 75-88%. A mobile phone app for weather monitoring was used to get these numbers. Before being transported to the sampling locations, the sample filters have been weighed, placed in hermetically sealed edicts, and tagged. The sample was conducted from around 6 a.m. to 7 a.m. till 5 p.m. to 6 p.m. The wind direction, the number of parked vehicles, and the separations between each truck were taken into consideration while selecting strategic sample locations.

A rotary vane vacuum pump (1 hp, 12 m^3/min) was used to collect air samples from the haulage vehicle park. The Rotary vane vacuum pumps for collecting air samples have a pumping speed of 10-100 l/min, ultimate vacuum of 10^-3 to 10^-2 mbar, and accuracy of ±1% to ±5% of the setpoint pressure. The pump sucked air through a Whatman cellulose filter paper in a custom-made probe (25.4 mm diameter). The probe had an inlet and an outlet, connected by a 10 mm hose to the pump. A stand held the probe during sampling. The park was divided into 10 sampling points and recorded GPS coordinates, wind speed, temperature, and humidity. The filter was placed on paper in the probe, sealed with Teflon tape, and connected the pump to a generator. The pump created a vacuum, drawing air through the probe and onto the filter paper. The sampling occurs for 10 minutes, with the probe facing the atmosphere. After 10 minutes, the filter paper was replaced and repeated three times at each sampling point. Furthermore, the samples were collected from three different sources: truck exhaust pipes (source sampling), ambient sampling (150 m away), and residential areas (600 m away).

Int. Journal of Integrated Engineering Vol. 17 No. 9 (2025) p. 220-232

Table 1 *GPS and verbal description of activities in different locations*

Locations	GPS			
Source	Latitude	Longitude	Distance Coordinates (20m apart)	Verbal Description
L1	7.624209	4.739082	First Coordinates	This sampling point was chosen based on the fact that it is located at the entrance of the street park.
L2	7.624220	4.73898	20m west from the first Coordinates	Going in and out of the trucks
L3	7.624235	4.738717	40m west from the first Coordinates	Points around where the trucks are parked to start their vehicles.
L4	7.624245	4.738536	60m west from the first Coordinates	There were no significant pollution activities, only buying and selling around the sampling point.
L5	7.624263	4.738356	80m west from the first Coordinates	A few trucks were parked nearby with their engines off.
L6	7.624285	4.738173	100m west from the first Coordinates	More Residential buildings around the area.
L7	7.624310	4.737997	120m west from the first Coordinates	A few trucks were parked nearby with their engines off
L8	7.624332	4.737816	140m west from the first Coordinates	Kiosks and shops, powered by generators, were constantly emitting smoke into the atmosphere, contributing to air pollution. This factor, combined with the presence of a few trucks in the area, exacerbated the issue.
L9	7.624344	4.737632	160m west from the first Coordinates	Near this location, there is a workshop where generators and other types of engines are repaired.
L10	7.624352	4.737446	180m west from the first Coordinates	A few trucks were parked nearby with their engines turned off. There was minimal human activity, with only passers-by walking around.

2.3 Determination of Total Suspended Particulate

One technique for determining the concentration of solid particles in the air is TSP analysis. Dust, smoke, pollen, mold spores, and other airborne pollutants are examples of these particles. TSP analysis may be used to evaluate possible health hazards related to particulate matter exposure and offers valuable information about air quality. The weight difference of the suspended particles divided by the volume of air sampled yields the TSP concentration. Typically, TSP (μg/m^3) is calculated using Equation 1 and 2 [22].

$$TSP = \frac{W_2 - W_1}{V} \quad (1)$$

$$V = Q \times T \quad (2)$$

where,

- W1 = Starting Weight
- W2 = Final Weight
- V = Air Sample Volume
- Q = cfm (pump flow rate)
- T is the sampling time in minutes.
- The pump flow rate (Q) is 12cfm^{-1} (cubic feet per minute). In S.I units, 0.34m^3/minutes. Sampling time is 10minutes.

2.4 Determination of X-Ray Fluorescence Analysis

One non-destructive analytical method for figuring out a material's elemental makeup is X-Ray Fluorescence (XRF) analysis. It operates by employing high-energy X-rays to excite the atoms in a sample, which results in the emission of secondary (fluorescent) X-rays at distinct energies that are unique to each element found in the sample. The samples were taken to an analysis laboratory at NASENI, Akure where 5 samples were analysed and the results were obtained. The XRF breakdown was further calculated and converted to the standard unit of measurement is micrograms per cubic meter (μg/m^3). The XRF result can be gotten in these steps in Equation 3 and 4 [27]:

$$\text{Source Content} \times 10{,}000(\text{ppm}) = X_1 \quad (3)$$

$$X_1 \times 1{,}000(\mu g/m^3) = X_2 \quad (4)$$

Where;
X_1=Result from conversion of source content to parts per million (ppm)
X_2= Results from conversion of X_1 to (μg/m^3).
M= Molecular Weight (g/mol)
All values for the XRF are gotten in this format.

3. Results and Discussion

3.1 Total Suspended Particulates

TSP analysis was conducted using three sources that server as a reference for comparison: (i) the sample collected from the tip of the exhaust (source sample); (ii) ambient sample (environment) and (iii) residential area. Three replications were conducted for the source sample, that is, K1, K2 and K3. Furthermore, 10 sample were conducted for ambient source (A to J) while three samples were reiterated for residential source (L1, L2 and L3). In each case, average means was calculated with their standard deviation for comparison.

3.1.1 TSP Analysis for Source Sampling

Three samples were taken directly from the tip of the exhaust, namely K1, K2 and K3, respectively. These samples are called the source samples because they were taken directly from the source of the exhaust. From the results of these samples, the mean TSP and Standard deviation were calculated as shown in Table 2.

Three distinct vehicles' idle concentration readings are displayed in Table 2, with an average value of 990.2 (μg/m^3). The degree of service, the age of the cars, or the state of the engine might all be contributing factors to the reading variance. The concentration will undoubtedly affect the concentration of ambient air because it is being released into the atmosphere. A high concentration of suspended particles in the air is indicated by a TSP result of 990.2 μg/m^3. The high TSP value shows that the exhaust emissions from the truck contain a significant amount of particulate matter. These particles can include a range of substances such as soot, dust, metals, and other combustion byproducts. This is not uncommon, as idling engines tend to produce more particulate matter compared to when the vehicle is in motion. Factors such as incomplete combustion, low engine efficiency, and inadequate emission control systems can contribute to higher particulate emissions during idling [8, 22, 23].

Table 2 TSP analysis result source samples (μg/m^3)

Sample No	Sample Type	TSP	Mean (μg/m^3)	Standard Dev. (μg/m^3)
Sample K1	Source	1464.72		
Sample K2	Source	823.53	990.2	340.39
Sample K3	Source	682.35		

3.1.2 TSP Analysis for Ambient Sampling

A variety of total suspended particle concentrations was found by ambient monitoring at 10 distinct locations. As slated in Table 3, the lowest value ever recorded was 83.14 μg/m^3, and the highest value was 720.59 μg/m^3. These values are significantly higher than the World Health Organization's (WHO) guideline value of 20 μg/m^3 for TSP

[11]. Several studies have reported similar findings, highlighting the impact of commercial haulage operations on air quality. For example, a study by Fazakas, et al. [20] found that the TSP concentration in a busy commercial area in developing nations was significantly higher than the WHO guideline value. Another study by Oyelami, et al. [11] reported that the particulate matter concentration in a major highway in Nigeria was higher than the WHO guideline value. The high TSP concentrations recorded in this study can be attributed to the large number of commercial vehicles plying the roads, which emit significant amounts of particulate matter and other pollutants [23]. The study's findings are consistent with other studies that have reported a positive correlation between traffic volume and air pollution levels [11]. The environmental implications of these findings are significant. Exposure to high levels of TSP has been linked to various health problems, including respiratory diseases, cardiovascular disease, and lung cancer [11, 24]. Furthermore, the high TSP concentrations recorded in this study can also have negative impacts on the environment, including reduced visibility, damage to crops and buildings, and increased greenhouse gas emissions [22].

Table 3 TSP analysis results for ambient samples (μg/m^3)

Sample No	Sample Type	Mean TSP (μg/m^3)	Standard Deviation TSP (μg/m^3)	Averag Mean, TSP (μg/m^3)	Average Standard deviation, TSP (μg/m^3)
Sample A	Ambient	389.21	11.89	416.98	198.58
Sample B	Ambient	471.56	59.43		
Sample C	Ambient	720.59	149.25		
Sample D	Ambient	225.49	44.93		
Sample E	Ambient	694.12	30.57		
Sample F	Ambient	83.14	256.97		
Sample G	Ambient	215.68	145.09		
Sample H	Ambient	470.58	264.58		
Sample I	Ambient	325.5	89.84		
Sample J	Ambient	574.51	44.93		

3.1.3 TSP Analysis for Residential Sampling

Monitoring for the residential samples were taken at three locations for the TSP. The initial sampling site is situated in a residential apartment along the roadside, followed by another residential building located approximately 30 meters away from the first site. The final sampling location is positioned around 80 meters from the first site and corresponds to a water treatment plant. The close proximity of the truck park to residential areas means that the emitted pollutants have a shorter distance to disperse. This resulted in higher localized TSP levels in the residential environment during sampling.

Among the three locations, the TSP level recorded in the vicinity of the first residential area is measured at 323.52 μg/m^3. This measurement exceeds the 250μg/m3 FEPA air quality limits [24]. The result of this specific sampling point was affected by the surrounding activities. Adjacent to the residence, there existed a small kiosk vending miscellaneous items, which also provided charging services powered by a generator during the observation period. A thorough investigation of the vicinity revealed poor epileptic power supply, thus rendering the use of a generator for the shop inevitable.

Additionally, in close proximity to the residence, there were labour workers engaging in smoking activities. All of these factors collectively contributed to the elevated TSP levels at this sampling point. The sampling location was selected for its proximity to residential areas and its direct exposure to the park. A TSP level of 323.52μg/m^3 is very high and is a serious health hazard. When High TSP levels can cause a variety of detrimental health outcomes, such as cancer, heart disease, respiratory issues, and early mortality. Apart from the potential health hazards [8], TSP may also have adverse environmental effects. Residents in this area are more likely to have health issues because to the high TSP levels. Particularly at risk are children, the elderly, and those suffering from respiratory conditions. Exposure to TSP can have either short-term or long-term health impacts. Chest discomfort, wheezing, coughing, and shortness of breath are possible immediate side effects. Premature mortality, cancer, heart disease, and asthma are examples of long-term consequences [6, 7, 9]. The TSP level study findings for the other two residential air regions show that the air quality in the vicinity of the park is still deemed safe for human habitation. Table 4 presents the TSP analysis results for residential samples

Table 4 TSP analysis results for residential samples

Sample No	Sample Type	Tsp (μg/m^3)	Mean	Standard Deviation
Sample L1	Residential	323.52		
Sample L2	Residential	235.29	235.29	72.03
Sample L3	Residential	147.05		

The average value of 416.98 ± 198.55 μg/m^3 for the ambient sampling is much higher than the FEPA limit of 250μg/m^3, with the lowest TSP level surrounding the sample location being 83.14μg/m^3 and the maximum being 720.59μg/m^3. Similarly, an average value of 990.2 ± 340.39 μg/m^3 derived from the Source Sampling was above the FEPA limit. However, the average residential sampling of 235.29 ± 72.03 μg/m^3 was within the limit recommended by FEPA. It should be noted that with the prolong exposure, there is high potential that the safety limit witness around the residential area will increase above the threshold limit. Fig. 2. present the overall average TSP for source, ambient and residential sampling.

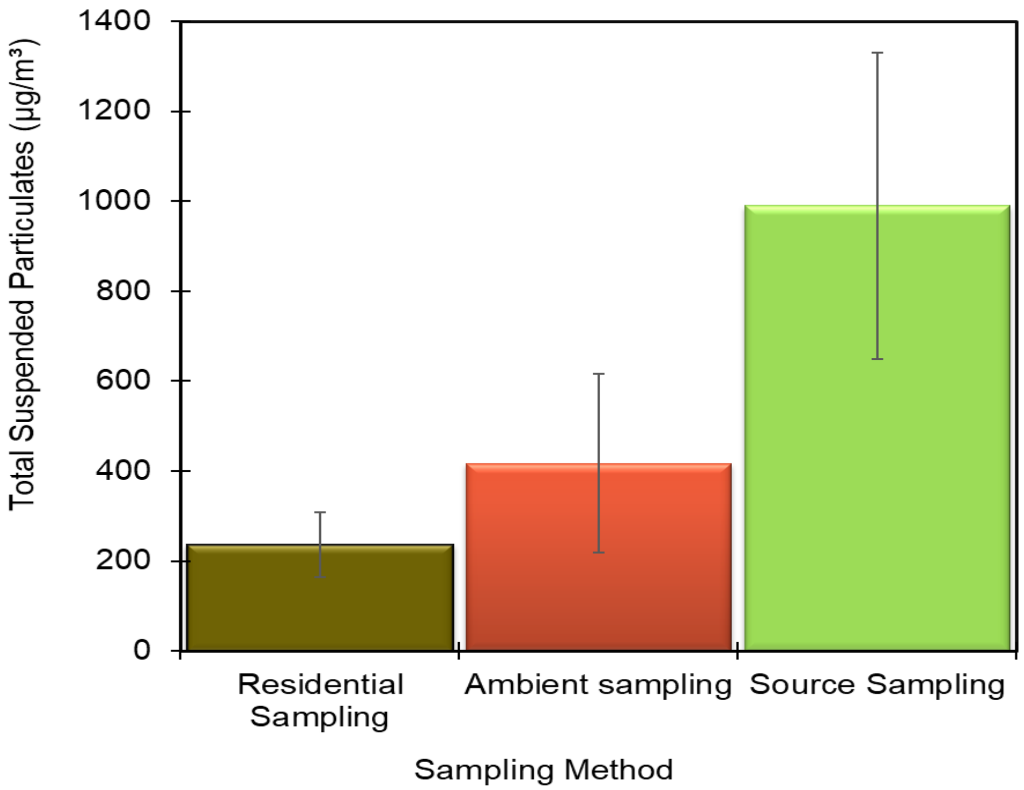

Fig. 2 *Overall average TSP for source, ambient and residential sampling*

3.2 X-ray Fluorescence Analysis

3.2.1 X-ray Fluorescence Analysis for Source Contents

For the source content, the element magnesium has the maximum value of 189.25106 106 (μg/m^3) while titanium, vanadium, chromium, cobalt and manganese have a minimum value of 0.000(μg/m^3). The X-ray fluorescence analysis (XRF) sample result of magnesium having a value of 189.25106 106 (μg/m^3) indicates that the exhaust of the truck contains a high level of magnesium.

In the US, the yearly average of magnesium's National Ambient Air Quality Standard (NAAQS) is 100 μg/m^3. Accordingly, the average annual concentration of magnesium in the air shouldn't be more than 100 μg/m^3. Compared to the NAAQS, the XRF sample value of 189.25106(μg/m^3) is noticeably higher. This suggests that the truck's exhaust is above the NAAQS for magnesium. For magnesium, the Environmental Protection Agency (EPA) has not established a short-term (24-hour) criterion. For particulate matter (PM), a similar pollutant, the Agency has established a short-term criterion. A 24-hour average of 35 μg/m^3 is the PM standard. Accordingly, the 24-hour average PM content in the air shouldn't be more than 35 μg/m^3.

Some factors, according to Ali [25], Wang, et al. [26] could influence this result including factors such as:

- The type of fuel used in the truck. Diesel fuel contains more magnesium than gasoline, so trucks that use diesel fuel will typically have higher levels of magnesium in their exhaust.
- The age of the truck. Older trucks tend to have higher levels of magnesium in their exhaust because the engine components are more worn and therefore emit more magnesium.
- The driving conditions, trucks that operate in dusty or dirty conditions will typically have higher levels of magnesium in their exhaust because the dust and dirt will collect on the engine components and then be emitted into the air [20].

The XRF sample result of 189.25106 (μg/m^3) is also significantly higher than the PM standard. This indicates that the exhaust of the truck is likely violating the PM standard. The high level of magnesium in the exhaust of the truck could be a potential health hazard for people who live or work in the area. The EPA has identified magnesium as a hazardous air pollutant (HAP), which means that it can cause or contribute to serious health problems, such as respiratory problems and heart problems.

For the level of titanium, cadmium, has values of 0.000 (μg/m^3) indicates that the exhaust of the truck contains a very low level of these elements This could be due to the type of fuel used in the truck. Taking titanium as an example diesel fuel contains more titanium than gasoline, so trucks that use gasoline will typically have lower levels of titanium in their exhaust. Older trucks tend to have higher levels of titanium in their exhaust because the engine components are more worn and therefore emit more titanium [18]. However, if the truck is very old, it may have deteriorated to the point where it no longer emits any titanium. The condition of the engine. A poorly maintained engine will emit more pollutants than a well-maintained engine. However, if the engine is well-maintained, it may not emit any titanium at all [17].

3.2.2 X-ray Fluorescence Analysis for Residential Contents

The X-Ray Fluorescence analysis of household dust revealed a magnesium concentration of 161.76 μg/m^3, exceeding the recommended annual inhalation limit of 100 μg/m^3 set by the World Health Organization and the United States Environmental Protection Agency. This surpasses the guidelines for particulate matter inhalation, specifically PM2.5, posing significant health risks. Prolonged magnesium inhalation above recommended thresholds is linked to respiratory issues, cardiovascular problems, and neurological effects, including inflammation, irritation, damage to lung tissue, increased blood pressure, cardiac arrhythmias, headaches, nausea, fatigue, and neurodegenerative diseases. Magnesium's toxicological effects are attributed to oxidative stress, disruption of cellular homeostasis, and activation of pro-inflammatory cytokines, with toxicity comparable to metals like aluminum and copper. Therefore, measures should be taken to reduce magnesium emissions and concentrations to mitigate adverse health effects [6, 17].

3.2.3 X-ray Fluorescence Analysis for Ambient Contents

For the ambient content, the element magnesium has the maximum value of 371.355106 (μg/m^3) while titanium, vanadium, chromium, cobalt and manganese have a minimum value of 0.000(μg/m^3). Magnesium's X-ray fluorescence analysis (XRF) sample result of 371.355106 (μg/m^3) shows that there is a very high concentration of magnesium in the ambient air. A yearly average of 100 μg/m^3 is the national air limit for magnesium set by the US Environmental Protection Agency (EPA). Nigerian standards have not yet been established. Accordingly, the average annual concentration of magnesium in the air shouldn't be more than 100 μg/m^3. Magnesium levels of 371.355106 μg/m^3 in the XRF sample are far higher than the national air requirement. This suggests that the ambient air in the region where the sample was collected could not be magnesium-rich enough to fulfill national air standards.

The EPA has not set a short-term (24-hour) standard for magnesium. However, the Agency has set a short-term standard for a related substance, particulate matter (PM). The PM standard is 35 μg/m^3 for a 24-hour average. Additionally, the magnesium XRF sample value of 371.355106μg/m^3 is far greater than the PM norm. This suggests that the PM standard is not being met by the ambient air in the sample location. People who live or work in the region may be at risk for health problems due to the high concentration of magnesium in the surrounding air. Magnesium is not considered to be a carcinogen, but it can cause respiratory problems, such as asthma and bronchitis. It can also irritate the eyes and skin.

The factors that influenced this result include:

- The location of the sampling point: The level of magnesium in the air varies depending number of idling trucks in that point at that particular time. The more the trucks, the more the concentration of magnesium in the air around that region.
- The time of year: Because of the dry season, the amount of magnesium in the air can also change. For example, regions that have more dust storms during certain seasons may have greater amounts of magnesium in the air [14, 27].

The high level of magnesium in the ambient air could be a potential health hazard for people who live or work in the area. Magnesium is not considered to be a carcinogen, but it can cause respiratory problems, such as asthma and bronchitis. It can also irritate the eyes and skin. For safety precautions, humans avoid living or working near those sites. If one must live or work near these areas, one must keep windows closed and use an air purifier to help remove pollutants from the air. It is important to note that the XRF result of magnesium in the ambient air is just one indicator of the overall quality of the air [28]. There are other factors that can also affect the level of magnesium in the air, such as the location, the time of year, and the weather conditions. Table 5 presents result for X-ray Fluorescence Analysis for the source, ambient and residential content.

Table 5 Result for X-ray Fluorescence Analysis

Element	Source Content (μg/m^3)	Ambient Contents (μg/m^3)	Residential content (μg/m^3).
Mg	189.25×10^6	371.355×10^6	363.436×10^6
Al	9.774×10^6	2.211×10^6	1.916×10^6
Si	13.267×10^6	2.394×10^6	0.874×10^6
P	0.746×10^6	1.287×10^6	0.874×10^6
Si	10.797×10^6	9.806×10^6	7.119×10^6
K	1.731×10^6	2.670×10^6	2.386×10^6
Ca	1.692×10^6	2.316×10^6	0.991×10^6
Ti	0.0000	0.0000	0.0000
V	0.0000	0.0000	0.0000
Cr	0.0000	0.0000	0.0000
Mn	0.0000	0.0000	0.0000
Co	0.0000	0.0000	0.0000
Fe	7.982×10^6	1.0672×10^6	3.653×10^6
Ni	1.525×10^6	2.034×10^6	0.934×10^6
Cu	3.900×10^6	2.813×10^6	2.791×10^6
As	2.172×10^6	2.670×10^6	1.828×10^6
Pb	0.0000	0.0000	0.0000
W	0.0000	0.0000	0.0000
Au	0.0000	0.912×10^6	1.147×10^6
Ag	0.0000	0.0000	0.0000
Rb	0.0000	0.082×10^6	0.0000

3.3 Future Direction

Future research should focus on developing and implementing sustainable solutions to mitigate the adverse environmental impacts of commercial haulage operations. One potential area of research is the development of alternative fuels and technologies that can reduce emissions from commercial vehicles. For example, studies can investigate the feasibility of using compressed natural gas (CNG), liquefied natural gas (LNG), or electric vehicles for commercial haulage operations in Nigeria. Additionally, research can explore the potential of implementing emission-reducing technologies, such as particulate filters and selective catalytic reduction systems, on commercial vehicles.

Another important area of research is the development of effective policies and regulations to manage the environmental impacts of commercial haulage operations. Studies can investigate the effectiveness of existing policies and regulations, such as the Nigerian National Environmental (Transportation and Storage of Petroleum Products) Regulations, in reducing emissions from commercial vehicles. Research can also explore the potential of implementing low-emission zones, congestion pricing, and other traffic management strategies to reduce emissions from commercial haulage operations. Furthermore, studies can investigate the role of public-private partnerships in promoting sustainable commercial haulage operations and reducing environmental impacts. By exploring these research directions, Nigeria can develop effective solutions to mitigate the environmental impacts of commercial haulage operations and promote sustainable development.

4. Conclusions

Haulage vehicles are essential for our daily lives, but their emissions pose serious environmental and health problems, such as air pollution, toxic fumes, and climate change. However, as people become more aware of the need to protect the environment and be sustainable, governments and organizations are working to reduce vehicle emissions and promote eco-friendly practices. We analyzed haulage trucks and commercial cars to measure the number of harmful pollutants released in various settings: exhaust pipes, the atmosphere, and residential areas. This research revealed that these pollutants are considerably present in large numbers in this location judging from the results obtained from the source, ambient and residential sampling. Idling habits, vehicle emissions, low engine efficiency, and poor fuel quality are the main causes of the air pollution near the haulage park. There is an urgent need to address the problem of TSP emissions from haulage vehicle operations at a haulage park. By incorporating XRF analysis and the recommended measures, stakeholders can work together to mitigate TSP emissions, creating a healthier environment for workers, residents, and the surrounding community. Through collaborative efforts and continuous monitoring, the impact of particulate matter on air quality can be minimized, fostering a sustainable future for all.

To curb air pollution from haulage vehicles, it is imperative to enforce strict emission standards, especially for particulate matter, should be a primary objective. Regulatory authorities must collaborate with haulage companies to establish specific limits for TSP emissions. Regular emission testing, including TSP measurement, using XRF analysis, can ensure compliance and encourage companies to adopt cleaner technologies and practices. For transport trucks, promoting the use of alternative fuels may greatly lower TSP emissions. Vehicles that run on electricity, natural gas, or hydrogen produce less particulate matter than diesel engines. Providing incentives and subsidies to companies that transition to cleaner fuels will foster a more sustainable and eco-friendlier environment at the haulage park. Mandatory maintenance and inspection of haulage vehicles should include TSP emission checks using XRF analysis. Regular maintenance can ensure optimal engine performance and reduce the release of particulate matter. XRF analysis can also assist in identifying trace elements in TSP, aiding in identifying potential sources and necessary corrective actions. Strategically planning green spaces and natural barriers around the haulage park can help mitigate TSP emissions. Vegetation can act as a filter, trapping particulate matter and improving air quality. XRF analysis can be utilized to assess the elemental composition of particulates trapped by vegetation, helping in monitoring improvements and the effectiveness of green space initiatives.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

*The authors confirm contribution to the paper as follows: **study conception and design:** S Oyelami, A. T. Oyewo, P.O. Ibiyemi; **data collection:** P. O. Ibiyemi; **analysis and interpretation of results:** P. O. Ibiyemi, B. O. Okedere, K. A. Adenike, S. Oyelami, A. T. Oyewo **draft manuscript preparation:** P. O. Ibiyemi, O. S. Ogunsesan, J.O. Adebola, S. A. Ajayi. All authors reviewed the results and approved the final version of the manuscript.*

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