Article

Characterization of atmospheric particulate matter from urban traffic sources in Ilorin

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Abstract
Air quality has become a pressing issue in both developed and developing countries. This is due to the various health issues which are associated with Atmospheric Particulate Matter (APM). Many countries have as a result introduced Environmental Protection Agencies to monitor the amount of Particulate Matter (PM) in the atmosphere. Ilorin, the capital of Kwara State, is a city which should also not be left out. This is because Ilorin as a city is susceptible to PM. pollution. There is little or no research known to have been carried out on the quality of air inhaled in the city of Ilorin. This study aims at investigating the chemical signatures of APM in an Urban-Traffic corridor using a nuclear analytical technique. Total suspended particulate-phase aerosols that were monitored for 30 days at a traffic corridor located in the north-central (Ilorin) geopolitical zone, were collected using a low volume total suspended particulate sampler and were characterized using an Energy Dispersive X-ray Fluorescence (ED-XRF) spectrometer. Gravimetric analysis was carried out to determine the mass concentration of each sample. From the 30 days measured, the highest mass concentration was recorded on the 1st of March 2019 with a value of 7974.8 μg/m^3 and lowest on the 14th of March 2019 which had a mass concentration of 11.61 μg/m^3. For the reported days, the 24 hours average chemical concentrations of V, Cr, Zn, Cu, Pb, Cd, Mn and Fe from samples collected at tipper garage, Ilorin, were found to be 5007.8 ng/m^3, 2562.6 ng/m^3, 535.7 ng/m^3, 1432.1 ng/m^3, 604.2 ng/m^3, 1.1 ng/m^3, 3550.8 ng/m^3, 3191.6 ng/m^3 respectively. The study concludes that mass and chemical concentrations were excessively high and could impact significantly on human health.

Keywords Energy Dispersive X-ray Fluorescence; environment; gravimetric analysis; particulate matter; total suspended particulate-phase aerosols.

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1 Introduction

There is said to be a growing concern about Particulate Matter (PM) emissions globally which is due to its potential impact on human health and environment. In urban and rural settings, PM is also considered to be one of the air pollutants to be the most concerned (Maffia et al., 2020). Particulate pollution is the pollution of an environment that consists of particles suspended in some medium. There are three forms of pollutants namely Atmospheric Particulate Matter (APM), marine debris and space debris (Cinza, 2010). Marine debris is defined as the particulates suspended in liquid usually water on the earth's surface. Notably, some of the same kind of particles can be suspended in both air and water. The major example of marine debris includes pure sea salts (Fuzzi et al., 2015). Space debris is defined as particulates in vacuum or outer space, specifically particles originating from human activities that remain in the geocentric orbit around the Earth. Space debris is classified by size and operational purpose and divided into four main subsets namely; inactive payloads, operational debris, fragmentation debris, and micro particulate matter. Examples include old satellite, spent rocket stages and fragments from their disintegration and collision (Shane, 2010).

PM or aerosol particle is defined as condensed (solid or liquid) materials suspended in the atmosphere. These include; crystal materials, soot, combustion particles, nucleating clusters and biological materials such as spores. Non-conventional examples include; raindrops, hail, and other hydrometeors (Bloss, 2015; SOGA, 2018). PM is said to be composed of a wide variety of chemical species, both organic and inorganic. A more effective approach would be to consider the APM as a mixture of mass contribution by various sources (Manousakas et al., 2017). A major component in urban air pollution is PM which can be classified into two, namely coarse, and fine particles. A coarse particle (PM_{10}) is one with an aerodynamic diameter ranging from 2.5-10 μm, while a fine particle ($PM_{2.5}$) is one with an aerodynamic diameter of less than 2.5μm. Coarse particles mostly contain materials from the earth's crust, dust from vehicles and industrial plants, while fine particles contain the secondary formed aerosols, combustion particle, re-condensed organic and metallic vapor (Tahri et al., 2013). PM is generated from two classes of source namely natural source which include dust-storm popularly known as sand-storm, soil re-suspension, sea sprays, volcanic eruption, etc., and anthropogenic (artificial or man-made) source which includes fuel combustion from vehicles, bush burning, to mention but a few. Aerosols introduced directly into the air by the natural or anthropogenic source is known as a primary aerosol, while secondary aerosol is the result of processes that induce new particle formation such as coagulation, nucleation, etc (Khare and Baruah, 2010). PM is considered to be a common proxy indicator for air pollution. It affects more people than any other pollutant. The major components of PM are sulfate, nitrates, ammonia, sodium chloride, black carbon, mineral dust, and water etc (WHO, 2018). PM is an extremely complex matrix, containing a wide range of chemical species including inorganic acids and salts, metals, water, and a complex mixture of low volatility organic compound all in highly variable concentration (Walgraeve et al., 2009).

The increase in the amount of vehicles in use on the road, is directly associated with changes in societal lifestyles, economic development and fuel consumption, which subsequently leads to constant traffic congestions at and around intra-urban road intersections, and are a very common source of PM emissions in Urban areas (Adeniran et al., 2017). The rapid urbanization and industrialization in recent years, has caused air pollution to become a primary environmental problem faced by many cities (Yao et al., 2019). Urbanization has affected air quality and ecosystems at the local and regional levels, this is mainly due to motor traffic (Flores et al., 2019). Road traffic in urban areas is a major source of both particle sizes and certain heavy metals. The emission of these heavy metals necessitates numerous source factors such as diesel-engine and petroleum product combustion, wearing of vulcanized tyres, pavement material, brake linings, corrosion material, and road maintenance activities (Limo et al., 2018). The free movement of vehicles on the road causes the resuspension of road dust, while the slow movement of vehicles at Traffic Intersections (TIs) causes incomplete combustion of fuel, leading to the release of harmful pollutants into the atmosphere (Adeniran et al., 2017). In many urban areas around the world, road traffic emissions are often considered the main source of

Volatile Organic Compounds (VOC) and PM_1, especially in intensive traffic sites (Adeniran et al., 2017). Metal-rich sources in urban areas are said to be attributed to local traffic emissions, and their contributions can be spatially inhomogeneous. These metal-rich sources may disproportionately contribute to PM2.5 toxicity due to the high oxidative potential of some transition metals. Thus, the spatial variability of traffic-related metals is of great interest as these may disproportionately mediate health outcomes arising from $PM_{2.5}$ exposures across metropolitan areas (Jeong et al., 2019). In Madrid, road traffic is acknowledged as the major source of air pollutants. In quantitative terms, NOx and CO emissions were said to be related to traffic in more than 80% in the city, 48% of PM_{10} mass was proven to be contributed by emissions from Vehicles, and 65% of tropospheric O_3 (Ozone) formation is on account of traffic-related precursors. This close relationship between traffic and pollution comes along with severe health implications: indeed, worldwide epidemiological, and toxicological studies have linked these traffic related pollutants to respiratory issues, cardiovascular health effects and lung cancer risk (Ibai et al., 2016).

Particulate matter is described as a major contributor to premature mortality and a short life expectancy (Li et al., 2019). The high concentration of airborne trace elements may seriously affect air quality, posing direct influences on human health (Gao et al., 2002). Atmospheric PM is recognized as a causal agent of both short, and long-term adverse effects such as chronic respiratory disease, heart disease, lung cancer, etc (Niu et al., 2010). As pollution derived elements are often concentrated on fine particles, they could remain suspended in air with relatively long residence times and could efficiently penetrate human lungs. Thus, trace metals associated with fine aerosol particles may contribute to particulate toxicity (Gao et al., 2002). Environmental pollution has a lot of un-favorable effects on the ecosystem and human health such as visibility reduction (NASA, 2010), and cardiovascular diseases respectively. The methods of determining and reducing these pollutants have received special attention in recent time (Lamela et al., 2017). For example, India developed the National Clean Air Program (NCAP) which is to provide a tangible amount of reduction of surface $PM_{2.5}$ by the year 2024. They also developed the Graded Response Action Plan (GRAP) which was designed for the National Capital Region (NCR) which allows authorities responsible for pollution control reduce the enormity of air pollution for various Air Quality Indices (AQI) (Chinmay et al., 2020). Growing evidence has shown that living in an area with heavy motor vehicle traffic is associated with an increase in the risk of being infected by cardiovascular and pulmonary diseases. Numerous epidemiological studies suggest that exposure to Traffic-Related Air Pollutants (TRAP) may play a causal role in these increased health risks. Linking TRAP contribution to health outcomes requires an understanding of how concentrations of TRAP vary within communities with multiple sources of TRAP, because TRAP concentrations can significantly differ in both space and time near roadways (Yu et al., 2016). According to the World Health Organization, outdoor air pollution is a major environmental health problem affecting people in low, middle, and high-income countries such as Somalia, Nigeria, and the United Kingdom (WHO, 2018). Air pollution has been confirmed to be the world's largest environmental health risk according to the WHO, with seven million premature deaths due to exposure to indoor and outdoor air pollutants (Flores et al., 2019). Air pollution has become one of the most potent environmental concerns in urban areas especially in view of the adverse health effects associated with ambient atmospheric particulate (Mkoma, 2010).

High level of PM on the earth surface can lead to significant deterioration of visibility. The impact of aerosols upon the climate of the earth has received intense attention because of the uncertain roleaerosols play in present-day anthropogenic radiative forcing of climate (Jing et al., 2014). The radiative forcing by aerosols arises both through the direct scattering and absorption of solar radiation by aerosol particles, as well as the modification of clouds by aerosols, which can impact the transmission of solar and infrared radiation through the cloud layer (Wilcox, 2010). Aerosols can alter climate via clouds. Most clouds owe their existence to the presence of aerosols in the atmosphere which serve as tiny seeds called Cloud Condensation Nuclei (CCN) (NASA, 2010). Aerosol particles are known to have negative health effects on human causing cardiovascular and respiratory disease (Schleicher et al., 2011) The harmful effects of PM depends on their sizes and chemical composition. PM_{10} can penetratethe lungs, $PM_{2.5}$ can reach the alveoli region while the Ultrafine Particles (UFPs) can pass into the bloodstream thereby causing systemic effects (Sysoltseva et al., 2018). Western Pacific and Southeast Asia are classified among the most affected regions globally, having mortality rates which are attributed to air pollution of 80.7 and 48.9 deaths per 100 000 in the year 2010, respectively (Li et al., 2019).

Tipper garage is an area which is characterized by a lot of human activities which contributes to the increase in APM of the area. This study is aimed at investigating the chemical signatures of APM in an Urban-Traffic corridor using a nuclear analytical technique. This study will help us in various ways such as; knowing the quality of the air we breathe in, characterization of the APM present in the air around us, boost our knowledge on the health risk involved in living in this environment (Tipper Garage, Ilorin), boost the knowledge of the source of most of the atmospheric particulate matter in the air around us, also help in developing air quality guidelines for Nigeria in the future.

2 Materials and Methods

2.1 Site description

Ilorin is the state capital of Kwara State and it is located between longitudes $4^{\circ}20'$ and $4^{\circ}35'$E, and latitude $8^{\circ}30'$N. The city of Ilorin occupies an area of about 468 km^2 and it is situated in the transitional zone within the forest and guinea savannah regions of Nigeria. The climate of Ilorin is tropical under the influence of the two trade winds in Nigeria, namely North-East trade wind and South-West trade wind. Ilorin metropolis experiences two seasons namely rainy and dry season. The rainy season occurs between March and November and varies from 1000 mm to 1500 mm, with a peak in September. It has a generally high mean monthly temperature (Personal investigation).

Tipper garage is situated at Tanke, Ilorin, Kwara State, Nigeria. Its name was derived from the regular Park where Tippers which are used to convey a large amount of sand are parked. It is centralized as there are four major roads leading to it. These include one major road from Gaa-Akanbi area of Ilorin, one major road from Post Office area of Ilorin, one major road from Fate-Tanke area of Ilorin and one major road from the University of Ilorin. Tipper Garage has two main traffic peak period, one in the morning when people are leaving for work, in the evening when people are returning from work. It is one of the busiest areas in Tanke, Ilorin. This is because a lot of human activities go on there, such as buying and selling, smoking, loading of passengers by commercial vehicles heading to different destinations, etc. These are the major reasons we decided to use Tipper garage for the study (Personal investigation).

2.2 Field sampling

Thirty samples were collected over a period of two months, from the 13^{th} of February 2019 to 18^{th} of April 2019. The MCE (Mixed Cellulose Ester) filter papers were changed once the Total Suspended Particulate (TSP) sampler measured to a volume of between 10 ft^3 and 25 ft^3. This was achieved in approximately 10-15 hrs of the day for each filter paper. As a result of unstable power supply, it took two days to achieve this volume, some took 3 days to achieve this volume depending on the availability of power supply. The filter paper used was MCE filter paper, it has a diameter of 47 mm, a pore size of 0.45 µm, the thickness of 125 µm with an airflow rate of 4 L/min×cm^2 and a high retention rate. TSP low volume air sampler was placed in a Salon at Tipper Garage, Tanke, Ilorin, Kwara State. A hose was let out to allow for suction of air from outside the Salon, thereby allowing for the intake of air from the traffic corridor.

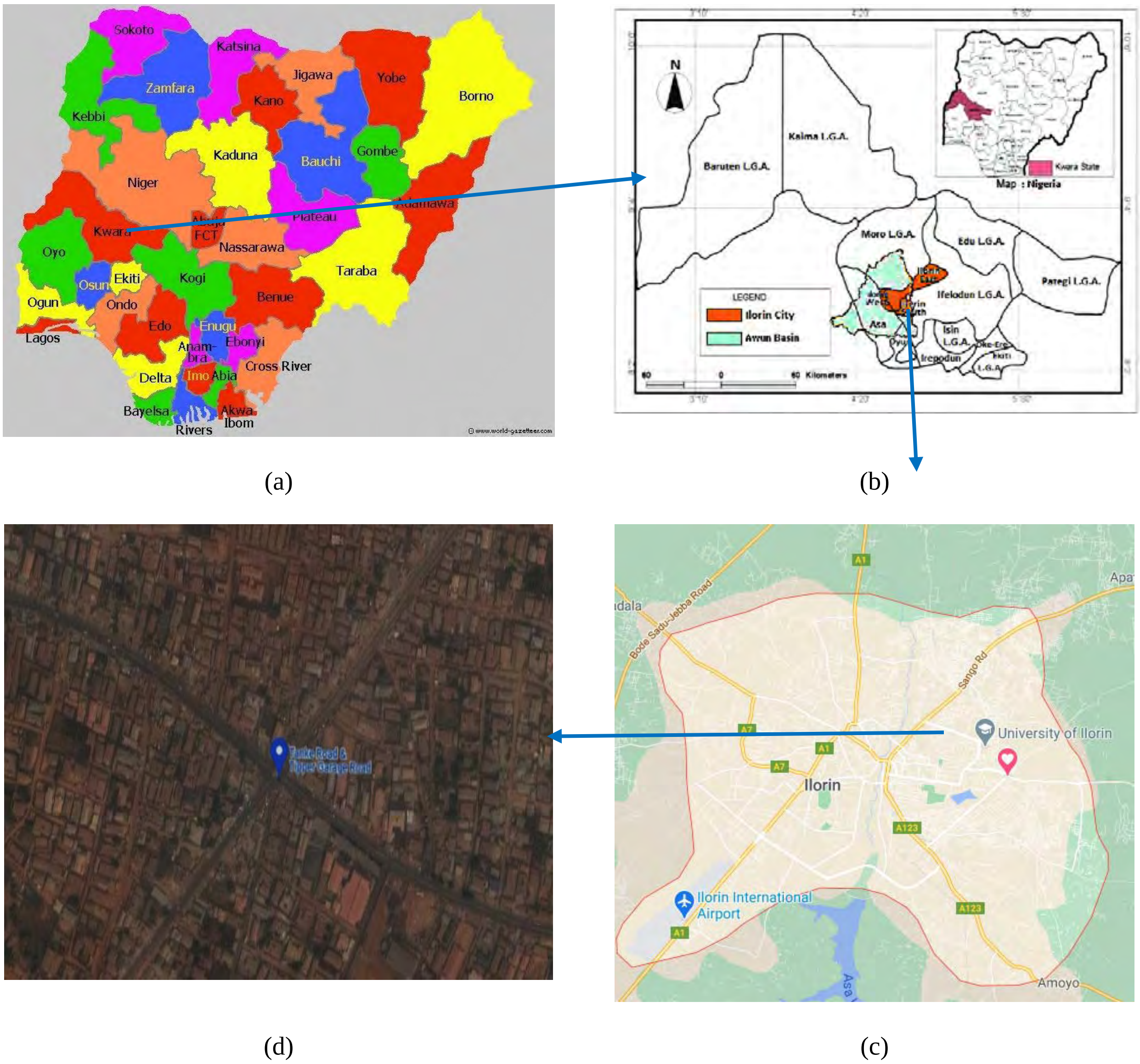

Fig. 1 Location of the study area.

Fig. 2 Image of sample site.

2.3 Gravimetric analysis

Gravimetric analysis was performed inside the XRF laboratory of the Centre for Energy Research and Development (CERD) at the Obafemi Awolowo University (OAU), Ile-Ife, Osun state. The MCE filter papers were firstly measured to get their initial weight using a Sartorius Microweighing Balance which measures in micrograms (µg). This was done thrice for each filter paper. The average was taken so a more accurate data would be gotten. The filter papers were then taken to the field to get air samples. After the samples were collected from the field, they were taken back to the laboratory, they were then conditioned in a desiccator to allow for the removal excess humidity so that what we were measuring was just the collected samples. They were then measured to attain the final weight. This was done thrice for each filter-paper, and their individual average was then taken for more accurate data. The difference was then taken between the final weight and the initial weight. Similarly, the initial and final volumes in m^3 were measured, their differences were taken. After this, their mass concentrations in $\mu g/m^3$ was obtained by dividing their masses in µg by their volumes in m^3.

2.4 Quality assurance

Extreme precautions were taken to prevent any unintended contamination of the filter samples during all steps of handling and processing.

2.5 Laboratory processing

The post weighed MCE filter samples were first analyzed using a silver anode ED-XRF. 'E' stands for energy this is because it differentiates particle based on their energy. The ED-XRF used was equipped with a silicon detector. It was operated at a tube voltage of 25 KeV and tube current of 50 µA. The filter sample was placed in the ED-XRF desiccator. Radiation was generated from the anode and passed unto the filter sample. The radiation then goes into the elements in the filter sample and knocks out electrons from their inner orbitals and when these electrons are being replaced, x-ray energies known as characteristic X-rays are generated and reflected towards the detector which is usually a semiconductor. This semi-conductor converts characteristic x-rays to electric signals. The spectrometer's electronics digitizes the signal produced by the detector, sends it to a personal computer for display and analysis. This display was achieved using the AMPTEK PMCA (Multi-Channel Analyzer) software. Single element certified reference materials of (nickel, calcium), were used to perform the energy-channel calibration of the system. The measurement time was set to 1200s.

2.6 Spectra fitting

IEAE-QXAS-AXIL was used for the analysis. That is, the spectra gotten was loaded into AXIL and fitted into the available standards. After this, the elements that were detected by the (Energy Dispersive X-Ray Fluorescence) ED-XRF is then gotten.

3 Results and Discussion

Various characteristics of PM can be used to evaluate the causal effect between air pollution and potential emission sources, such as their formation and chemical composition, as shown by Götschi et al (2005). In a study on PM level in 21 cities within the European Community Respiratory Health Survey, anthropogenic pollution and crustal element sources were considered to be the two key factors responsible for the chemical composition of PM in air.

The mass concentration of each sample has been recorded in Table 1. It was obtained using the following formula:

$$mass\ conc. = \frac{m_2(\mu g) - m_1(\mu g)}{V_2(m^3) - V_1(m^3)} \quad (1)$$

Table 1 Mass concentration of samples acquired.

Date	Days of the week	Mass concentration (μg/m^3)
13-Feb	Wednesday	126.7
14-Feb	Thursday	2837.7
15-Feb	Friday	1965.6
17-Feb	Monday	3727.9
19-Feb	Wednesday	1452.6
21-Feb	Friday	865.7
25-Feb	Tuesday	323.2
27-Feb	Thursday	641.3
01-Mar	Saturday	7974.8
3-Mar	Monday	188.9
5-Mar	Wednesday	1142.9
7-Mar	Friday	527.6
9-Mar	Sunday	841.3
12-Mar	Wednesday	2299.9
14-Mar	Friday	11.6
16-Mar	Sunday	429.9
18-Mar	Tuesday	485.6
20-Mar	Thursday	491.8
22-Mar	Saturday	2362.5
25-Mar	Tuesday	2063.0
27-Mar	Thursday	1199.2
29-Mar	Saturday	600.4
2-Apr	Wednesday	1296.8
4-Apr	Friday	1449.2
8-Apr	Tuesday	767.8
10-Apr	Thursday	2289.8
12-Apr	Saturday	1937.5
14-Apr	Monday	2204.9
16-Apr	Wednesday	699.8
18-Apr	Friday	717.96

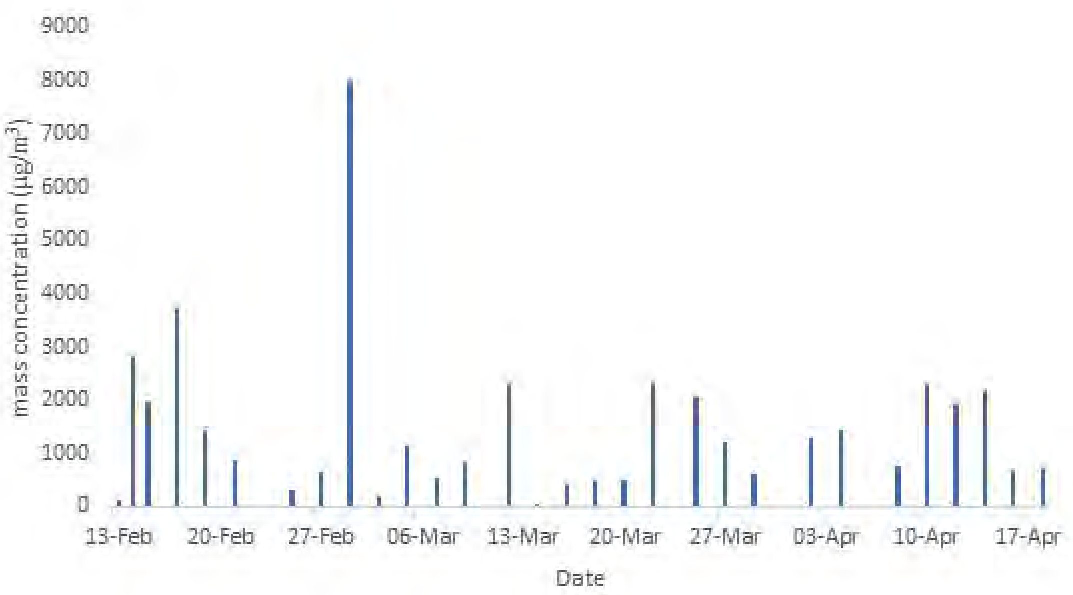

Fig. 3 Summary of sample mass concentration.

From Table 1, the highest mass concentration was recorded on the 1st of March with a value of 7974.8 µg/m^3. This could be as a result of too many human activities such as the movement of more vehicles, the use of generators as a result of power outage, also the moving of people on road shoulders which results in saltation, i.e., re-suspension of particles into the air.

The mean concentration in Table 2 was obtained using the following formula:

$$mean = \frac{\sum individual\ conc}{number\ of\ days} \quad (2)$$

Table 2 Mean concentration of some metals found.

Element	Mean concentration (ng/m^3) ± SD(ng/m^3)
V	5007.8 ± 64.9
Cr	2562.6 ± 102.4
Mn	3550.8 ± 104.7
Fe	3191.6 ± 156.4
Ni	3084.1 ± 225.3
Cu	1432.1 ± 213.9
Cd	1.1 ± 27.8
Pb	604.2 ± 158.1

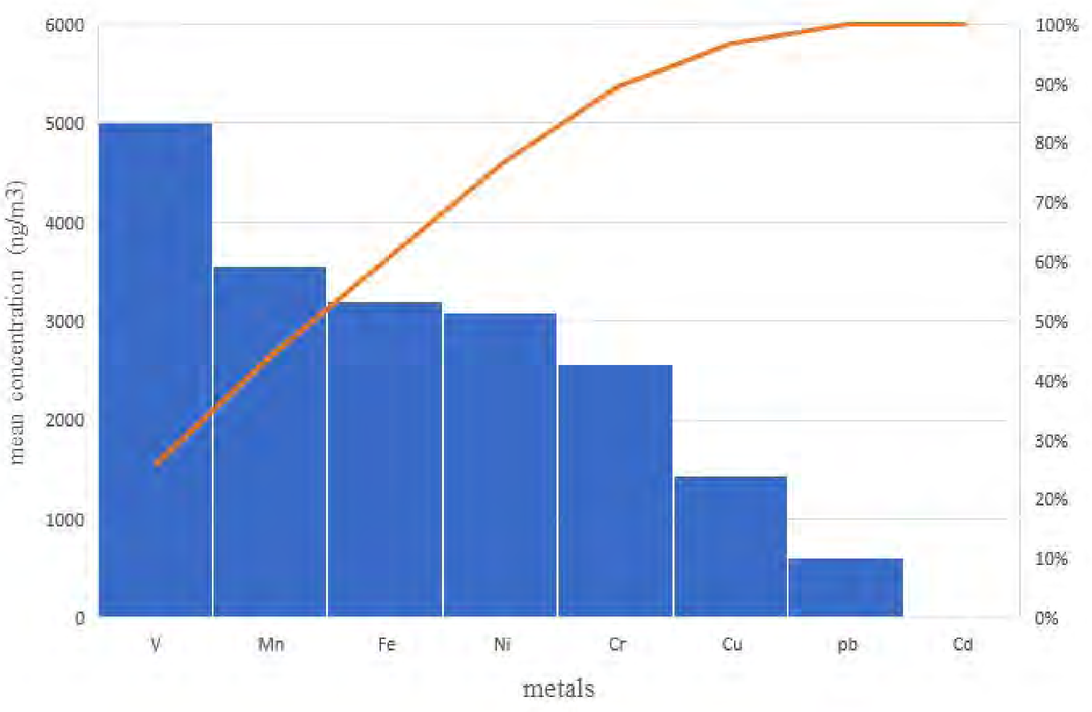

Fig. 4 Summary of mean concentration of some metals found.

This mean that mass concentration is used to determine if the WHO standards were exceeded or not.

From Table 2, it can be noticed that cadmium had a SD (Standard Deviation) higher than the value given. This is said because cadmium has no peak and therefore has a reading of zero as shown in Table 4. This is supported by various reviewed literature.

According to the Queensland government, Australia, as assessed on the 9th of July 2019, the major source of airborne lead is said to be from motor vehicle emissions from the addition of tetraethyl lead in motor vehicle fuels. According to the research they carried out, inhaling or consuming lead and its compounds can affect the human body, particularly the nervous system, and may result in growth and developmental problems in children. The Environmental Protection (Air) Policy 2008 (EPP Air) objective for airborne lead was set at 0.5 µg/m^3 based on an annual average. This takes into consideration the slow rate of removal from the body and is low enough to maintain blood lead levels below 0.1 µg/mL. From Table 3, it can be shown that the EPA policy (2008) was not exceeded for 3 days out of the selected 7 days i.e., 8th, 10th, and 14th of April, while the rest exceeded the EPA policy (2008) i.e., 12th, 18th, 22nd, 29th of March. From Fig. 5, it can be considered that vehicular (motor cycles, Petrol generators, light, and heavy-duty vehicles) activities were highest on the 29th of March and lowest on the 8th of April.

From Table 4, cadmium was reported to be in the atmosphere one day out of the reported seven (7) days which is on the 22nd of March. According to the Nordic Council of Ministers in their 2003 cadmium review, they stated the following as the various sources of anthropogenic sources of cadmium:

1. Stationary fossil fuel combustion
2. Non-ferrous metal production
3. Iron and steel production

4. Cement production
5. Waste disposal (incineration)

Table 3 Lead concentration.

Date	Concentration (ng/m^3) ± SD (ng/m^3)
12th March	683.6 ± 156.4
18th march	722.3 ± 225.3
22nd March	559.4 ± 213.9
29th March	1031.3 ± 239.4
8th April	294.9 ± 64.9
10th April	463.5 ± 102.4
14th April	474.1 ± 104.7

From the various sources listed above, only numbers 1, 4 and 5 are a possible source of cadmium in this study this is because this area has no Mining activity going on nearby. According to the Nordic Council of Ministers in their 2003 report, they affirmed that Cadmium is a heavy metal with high toxicity. Cadmium is toxic at very low exposure levels and has acute and chronic effects on health and the environment. Chronic cadmium exposure produces a wide variety of acute and chronic effects in humans. Cadmium accumulates in the human body and especially in the kidneys. According to the current knowledge, kidney damage (renal tubular damage) is probably the critical health effect. Other effects of cadmium exposure include:

I. Disturbance of calcium metabolism.
II. Hypercalciuria and formation of stones in the kidney.
III. High exposure can lead to lung cancer and prostate cancer.

They went ahead to state that cadmium is not degradable hence it stays longer in the atmosphere. From our result, we can further state that people in this area are prone to cadmium related health issues after a long-term exposure to it.

Table 4 Cadmium concentration.

Date	Concentration (ng/m^3) ± SD (ng/m^3)
12th March	0 ± 32.1
18th March	0 ± 25.9
22nd March	8.0 ± 8.0
29th March	0 ± 35.95
8th April	0 ± 44.9
10th April	0 ± 21.0
14th April	0 ± 26.9

According to Hulskotte et al. (2006), it was ascertained that brake wear is a very good source of copper in the environment. They further stated that Brake wear of road vehicles is due to forced deceleration, during which brake linings are subject to large frictional heat generation. This wear generates brake lining particles which are partly released to the environment. Not all the worn brake material will be emitted as airborne particulate matter. This depends strongly on particle size distribution. From Fig. 5, copper was highest on the 12^{th} of March. This can be said to be as a result of many numbers of forced deceleration of road vehicles, thereby generating wear lining particles which are therefore released into the environment.

Table 5 Copper concentration.

Date	Concentration (ng/m^3) ± SD (ng/m^3)
12th March	3879.5 ± 111.1
18th March	862.3 ± 134.1
22nd March	2235.9 ± 134.8
29th March	630.2 ± 408.3
8th April	329.7 ± 284.2
10th April	1438.9 ± 264.9
14th April	648.3 ± 334.8

Zinc in the air is said to generate from automobile sources, wear and tear of vulcanized rubber Tyres, lubricating oil and corrosion of galvanized vehicular parts (Karar et al., 2006). They also stated that a significant amount of road dust is present on the road, and on the road shoulders, being deposited from automotive exhaust and kept in suspension by vehicular movement. Hence, this source can be identified as road dust. From Table 6, it was noted that zinc emission was highest on the 12^{th} of March. This can be said to be as a result of a lot of vehicular activities that could lead to the emission of zinc on that day.

Table 6 Zinc concentration.

Date	Concentration (ng/m^3) ± SD (ng/m^3)
12th March	789.0 ± 269.9
18th March	……………….
22nd March	………………..
29th March	480.1 ± 201.3
8th April	………………
10th April	340.7 ± 271.0
14th April	533.1 ± 176.2

Nickel is emitted into the atmosphere as a result of the combustion of oil (crude) i.e. kerosene, petrol, diesel. Crude oil is said to contain a certain amount of nickel (15 ppm). Residual oil is said to have higher nickel contents. The concentration of nickel in coals and oil has been determined to be the major factor affecting uncontrolled nickel emission from combustion sources. In cement production, nickel is produced.

This is because nickel can be a component of both the feed process, feed materials and the fuel such as oil that is burned in cement process kiln and dryers (Cempe and Nikel, 2006). It was lowest on the 10th of April and the highest on the 22nd of March. This is as later could be as a result of the influx of PM from the Dangote Cement Factory located at Asa dam area of Ilorin metropolis. It could also be said that there much more combustion of oil on that day.

Table 7 Nickel concentration.

Date	Concentration (ng/m^3) ± SD(ng/m^3)
12th March	4282.5 ± 444.9
18th March	1298.6 ± 328.4
22nd March	6429.3 ± 574.4
29th March	4863.5 ± 622.2
8th April	1733.4 ± 365.3
10th April	1292.8 ± 260.9
14th April	1688.7 ± 304.2

Chromium is another metal that was found in the study. It was highest on the 18th of March 2019 and lowest on the 14th of April 2019. Chromium is said to be associated with industrial activities (Mugica et al., 2002). The chromium found in this study can be said to be as a result of particles moving from industrial sites to the area. Dangote cement production factory is located at Asa Dam area of Ilorin. Long exposure to chromium of workers and neighbors of industries can cause irritation of the respiratory system, perforation of nasal passages and lung cancer (Mugica et al., 2002).

Table 8 Chromium concentration.

DATE	Concentration (ng/m^3) ± SD(ng/m^3)
12th March	1067.4 ± 733.8
18th March	2130.5 ± 662.4
22nd March	2044.6 ± 933.4
29th March	1716.5 ± 472.7
8th April	1003.7 ± 669.1
10th April	495.0 ± 640.6
14th April	148.9 ± 327.7

Iron is emitted into the atmosphere from wear and tear of brake pads and other automobile parts (Karar et al., 2006). From the graph, Iron had the highest emission on the 8th of April. This might be as a result of the wear and tear of brake pads of a lot of vehicles. Iron causes conjunctivitis, choroiditis and Retinist if it contacts and remains in the tissue. Chronic concentrations of iron oxide fumes or dust may result in the development of benign pneumoconiosis. Inhalation of iron oxide may enhance the risk of lung cancer development (Lenntech, accessed on19/07/2019).

Table 9 Iron concentration.

Date	Concentration (ng/m^3) ± SD(ng/m^3)
12th March	4405.2 ± 718.3
18th March	447.4 ± 196.4
22nd March	561.1 ± 272.9
29th March	2107.8 ± 1106.9
8th April	10799.2 ± 2845.5
10th April	1650.8 ± 479.3
14th April	2369.5 ± 481.2

The presence of manganese in the atmosphere is said to be as a result of the presence of manganese tricarbonyl compound which was added in unleaded petrol (Karar et al., 2006). On the 8th of April, the highest amount of manganese was reported. This could be as a result of much vehicles using petrol with manganese tricarbonyl compound as additives. Williams et al. (2012) affirmed in their journal that inhalation of particulate compounds containing manganese such as manganese dioxide or manganese tetroxide can lead to a response that is inflammatory in the lungs. This is characterized by an infiltration of macrophages (A type of immune cell that has granules (small particles) with enzymes that are released during infections, allergic reactions, and asthma. Neutrophils, eosinophils (NCI dictionary) and leucocyte phagocytize (envelope and destroy) the deposited manganese particles. Damage to lung tissue is usually not serious but may include local areas of edema. Symptoms and signs of lung irritation and injury may include cough, bronchitis, pneumonitis, and minor reductions in lung function. Occasionally, pneumonia may be the result.

Table 10 Manganese concentration.

Date	Concentration (ng/m^3) ± SD (ng/m^3)
12th March	2408.1 ± 879.1
18th March	12021.4 ±5408.7
22nd March	3363.5 ± 870.8
29th March	1223.2 ± 229.3
8th April	5140.8 ± 3745.4
10th April	1700.95 ± 1624.5
14th April	1327.3 ± 171.6

Vanadium is a trace metal found in many earth materials, including petroleum and coal. It is emitted as particulate matter when these materials are burned, and can also be released as accidental, or “fugitive,” emissions during mining, extraction, and processing. The health risks of exposure to airborne vanadium particles are not as well documented as those for other metallic airborne contaminants such as mercury or lead, but growing evidence suggests breathing vanadium-rich aerosols can impair respiratory functions and exacerbate conditions such as asthma and chronic obstructive pulmonary disease (COPD) (William, 2015).

Table 11 Vanadium concentration.

Date	Concentration (ng/m^3) ± SD (ng/m^3)
12th March	17635.9 ± 5822.9
18th March	2074.8 ± 1204.7
22nd March	3916.4 ± 1076.3
29th March	3580.7 ± 1338.6
8th April	814.4 ± 428.6
10th April	1743.2 ± 665.9
14th April	5289.3 ± 821.4

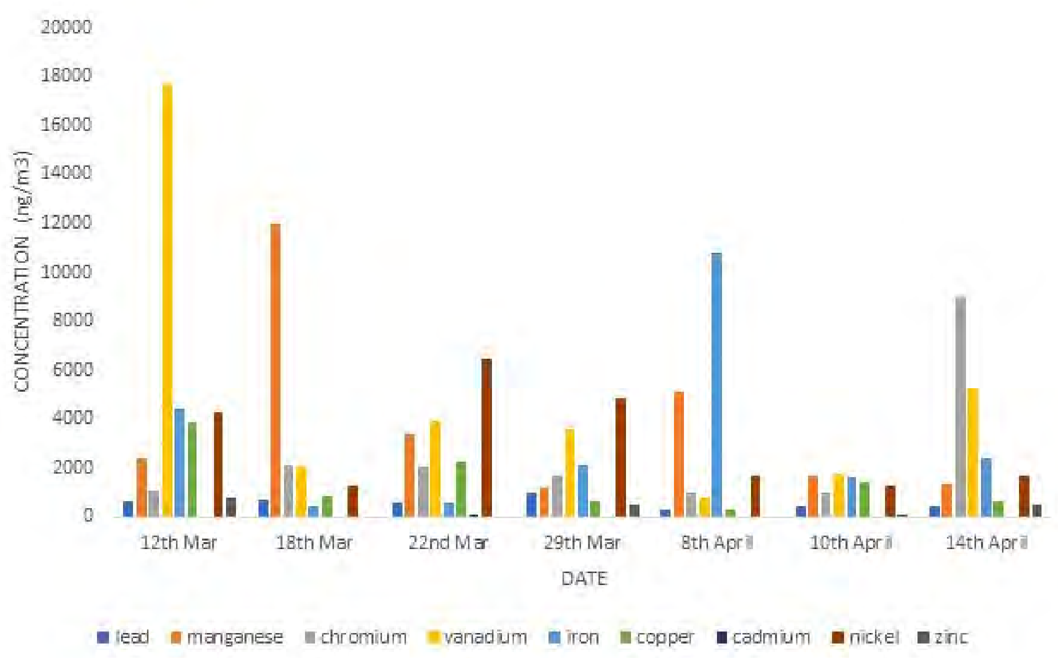

Fig. 5 Summary of the concentrations of metals found.

3 Conclusion

ED-XRF was used to characterize airborne particulate matter (PM_{10} and $PM_{2.5}$) collected at tipper garage area of Ilorin, Kwara State. The study of the Atmosphere particles from this area revealed that major, minor and trace elements leading to the characterization of different sources such as vehicular emission, crustal dust fuel-oil, and industrial process. It was also concluded that the main source of the PM at this area was the anthropogenic sources i.e., as a result of human activities. The PM mass and chemical concentrations obtained at the selected site were excessively high but not as high as the WHO standards. Even though it is not as high as the WHO standard, it is imperative to note that people living at such area stand a great risk of contracting diseases related to these elements such as cancer of the lungs, abnormality in children, conjunctivitis, cardiopulmonary diseases, asthma, etc.

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