Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2019, 6(11):47-53**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Exposure to Traffic Related Particulate Matter at and Around Major Intra-Urban Intersection of Akowonjo Metropolis

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Abstract This study investigated a traffic related Particulate Matter (PM) and heavy metals at and around major intra-urban traffic intersections of Akowonjo metropolis. Wet deposition method was used to obtain the samples; the PM samples were collected using deposition gauges (0.2m x 0.15m) at the selected points around the Akowonjo metropolis during the period of July to August 2018 for the wet season. The collected samples were filtered and dried, they were then analysed using the X-ray fluorescence (XRF) spectroscopy to characterise the particulate samples for possible elements and heavy metals. Our scope involves obtaining the Deposition flux, Enrichment Factor (EF) to deduce whether they are crustal origin or anthropogenic sources. The deposition flux ranges from 2.2632g/m^{2}day to 40.738g/m^{2}day. The data showing the characterized elements show that high concentrations were observed for Ca, K, Fe and Tiat all of the selected spots. The EF analysis revealed that the sources of PM at the various spots; SP_1 -SP_4 is from crustal origin, except for As and Ba at SP_4, with EF>10, and in turn showing that the source for these two elements at the specific spot is anthropogenic.

Keywords Deposition flux; Enrichment Factor; Characterised elements; Anthropogenic; PM

1. Introduction

Air pollution is an extremely hazardous environmental condition, which can affect plant, man, and in turn economic growth and mortality rate of a country [1,2]. Particulate matter is a major type and one of its prominent causes are traffic related i.e. burning of fossil fuels etc. Traffic on roads has significantly increased in the U.S. and elsewhere over the past 20 years [3]. Road transport became a significant air pollution source in the last century, and is now one of the largest emission sources in megacities with subsequent adverse effect on human health [4-5]. The problems of emissions are generally most critical at traffic junctions like intersections and roundabout of urban centres. They have been observed to have higher traffic congestion and in turn be a site for higher concentration or amounts of particulate matter in the atmosphere. Major intra-urban traffic intersections (TIs) are largely known as pollution hotspots but studies focusing on determination of concentration of $PM_{1.0}$, $PM_{2.5}$ and PM_{10} particulates at and around such traffic intersections are sparse, and therefore taken as the focus of this present study [6]. In addition to particulate matter, poisonous gases are also hazardous substances which when released into the atmosphere contribute adversely to human life and environmental safety.

The measurement of heavy metals in PM is, therefore, extremely important for toxicological, environmental, and occupational health studies [7]. This will assist in formulating appropriate policy strategies to mitigate the adverse impacts of these particulate matters on atmospheric air quality [6]. The study aim was to assess and identify the atmospheric particulate matter based on composition and size, deposited during the wet season at and around major intra urban traffic intersections of Akowonjo metropolis. The objectives of the study were to:

1) determine deposition flux of atmospheric particulates deposited during wet season 2) identify and characterize heavy metals composition of the particulates deposited in the selected points 3) identify the contributing source of particulate matter deposited using enrichment factor analysis.

2. Materials and Method

2.1. The Study Area

The study area was in Lagos State, the former capital of Nigeria, and largely known for its reputation as one of the megacities in the country. The Specific area where the spots were picked is Akowonjo. It is a semi-urban community in Lagos state, Nigeria, under Alimosho local government area of Lagos state. The study area consists of various monuments; about 6 different banks, other establishments and even residential homes. It is a major traffic area, and thus attracts the mass in vehicles and even on foot.

The latitude and longitude coordinates for Akowonjo is $6^0$36'59.99"N, $3^0$18'60.00"E. in this study area four different specific locations were picked for the deposition sampling, around the two major traffic intersections; Fig (1)SP_1- Lat 6.60624, Long 3.30996, SP_2- Lat 6.60624, Long 3.30999, SP_3- Lat 6.60625, Long 3.30996, SP_4- Lat 6.60627, Long 3.31012. Fig.2.1 shows the sampling site map.

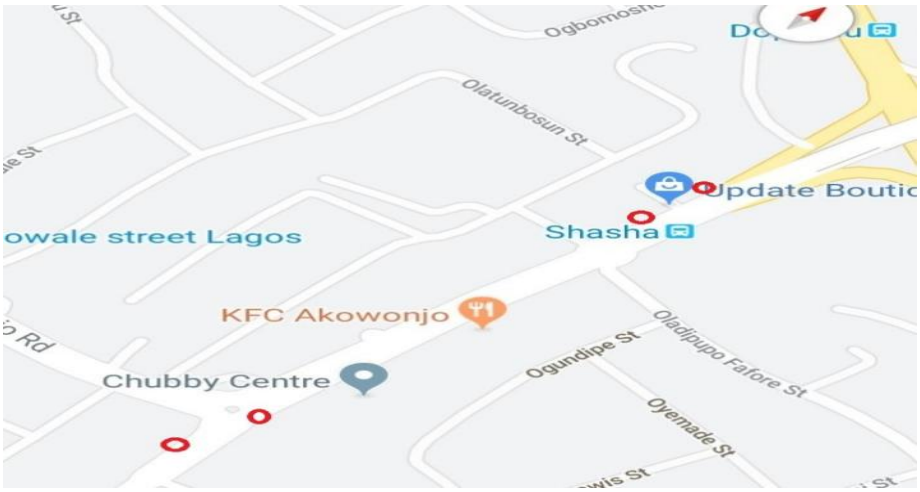

Figure 2.1: Sampling Map

The particular study area was chosen because it is a major area for traffic, and since this study is focused on traffic related particulate matter, the selected study area will provide us with sufficient data needed for the deposition analysis and the particulate matter observation, in relation to traffic. The deposition was carried out for a period of 30 days, after which the gauges were harvested.

2.2. Sample Procedure

Deposition gauges; which would in turn aid the deposition flux measurement, were planted at 4 traffic locations within the sampling site. The sampling period covered wet season, with July to August 2018 chosen as the study period. The gauges were planted for a period of 30 days; after which it was harvested and preserved by the addition of two drops of copper sulphate in order to prevent microbial growth, before it was taken to the lab for preparation and analysis; rain water and sediment in the deposition gauges during the wet season were collected and filtered through dry pre-weighed Whatman (125 mm diameter, Cat No 1001 – 125) filter paper on digital weighing balance (model PA2102). The filter papers were desiccated in a glass box to prevent further settlement of particles until they were completely dried [7]. The filter paper and the particles were reweighed in order to determine the mass of the particles collected. The deposition flux was determined using Eqn. (1);

$$DF = \frac{\Delta W}{AT} \quad (1)$$

Where: DF = deposition flux, DW = weight of sample, A = area of the deposition guage, T = duration of deposition.

2.3 Characterization of Heavy Metals in Deposited Particulate Matter

The technique used for characterization in this study is the X-ray fluorescence technique. The XRF technique is preferred for use in this study, as it is a multi-element detector; this means that it can identify all the elements contained in a sample at a time, unlike other techniques in which the particular element required would need to be specified; like the AAS technique. XRF technique is also preferred because it is a non-destructive technique; this means that the analyzed samples can be reanalyzed or reused, and are not destroyed during the process of analysis. The elements detected are 18, they include; Potassium (K), Calcium (Ca), Titanium (Ti), Venadium (V), Chromium (Cr), Manganese (Mn), Iron (Fe), Nickel (Ni), Copper (Cu), Zinc (Zn), Arsenic (As), Rubidium (Rb), Strotium (Sr), Yttrium (Y), Zicronium (Zr), Niobium (Nb), Barium (Ba), Lead (Pb). Eqn 2 was used to calculate the Enrichment Factor (EF); used for comparing the atmospheric aerosol elements concentration, and the crustal values, to determine the source of PM.

$$EFx = \frac{(C_x/C_{ref})_{aerosol}}{(C_x/C_{ref})_{crust}} \quad (2)$$

Where; *Cx* and *Cref* are the concentrations of the element x and the reference element, while *(Cx/Cref)aerosol* and *(Cx/Cref)crust* are the proportions of the element concentrations in the particulate matter and in the earth's crust respectively [7]. The EFs were calculated by obtaining crustal elements data from literature [8]. Crustal element data were taken from Taylor and McLennan [8].

3. Results and Discussion

3.1. Deposition flux

The deposition fluxes around the selected spots during the wet season were observed to have a wide margin when compared, using the spots points. The deposition flux ranges from 2.2632 to 40.7378g/m^{2}day. The highest deposition flux was observed at SP_4, with a value of about 40.7378g/m^{2}day, while the lowest deposition flux was observed at SP_2, with a value of 2.2632g/m^{2}day. The area is observed to be a major site for hawking, restaurants, a good number of banking industries, and other commercial activities. A graph of the deposition flux values for each spot is shown in Fig. 3.1.

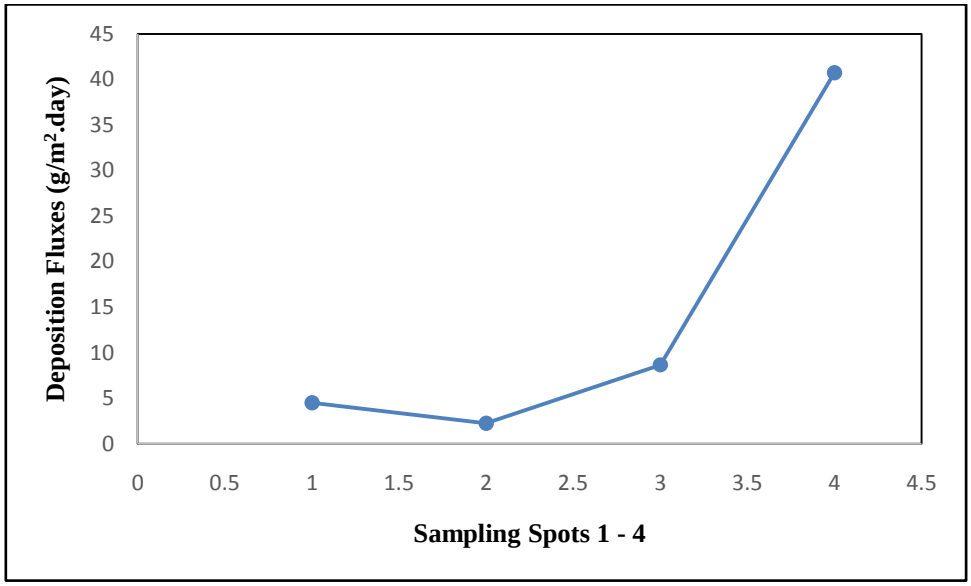

Figure 3.1: Graph of Deposition Flux Curve

3.2. Characterization of the deposition samples for wet and dry season

The particulate matter obtained at the sampling spots were pooled together and then characterized, and elements such as K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, As, Rb, Sr, Y, Zr, Nb, Ba and Pb were identified. Among the analyzed heavy metal concentrations, Ca showed the highest concentrations followed by K, Fe and Ti. Since there was limited or non-standards for mobile source, the data in this study was compared with the convention for protection of the marine Environment for North East Atlantic (the OSPAR commission [1990 – 2005];

OSPAR Commission 2008) [9]. Very high concentration of Ca, K, Fe, and Ti were observed in all the sampling spots. An unusually high amount of Ba, was observed at SP_4. Although, anthropogenic activities might be the reason for the result obtained in this study. All characterized values are higher than the standards and the study reported elsewhere [10-11]. A pictorial representation of the characterized elements concentration in µg/m^3, is shown in Figs (3.2-3.5)

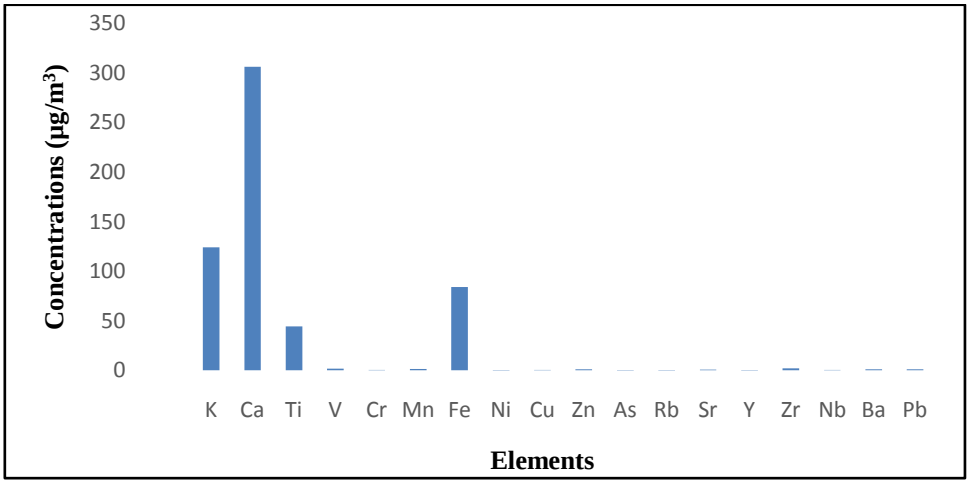

Figure 3.2: Characterized Elements at SP_1

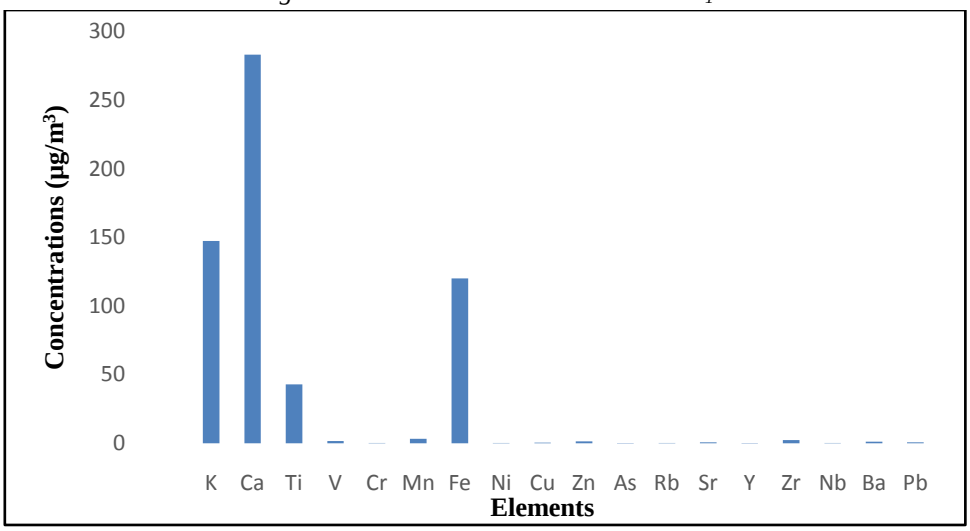

Figure 3.3: Characterized Elements at SP_2

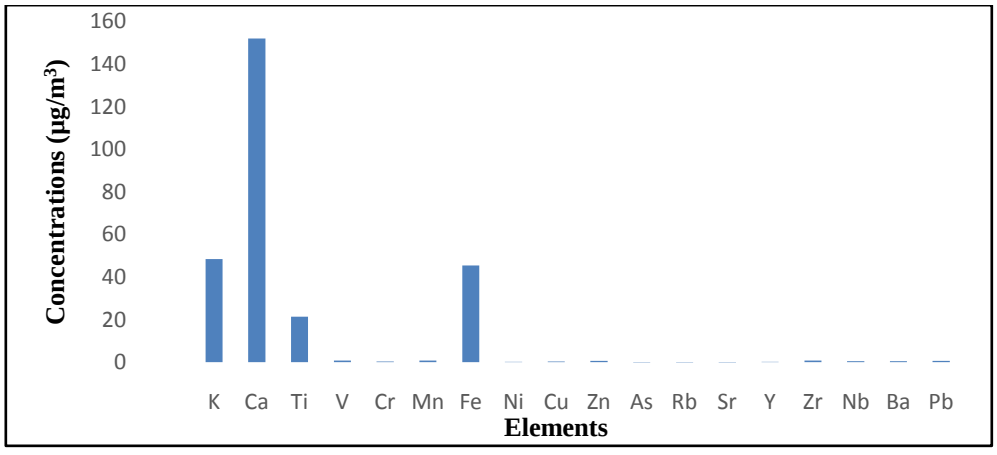

Figure 3.4: Characterized Elements at SP_3

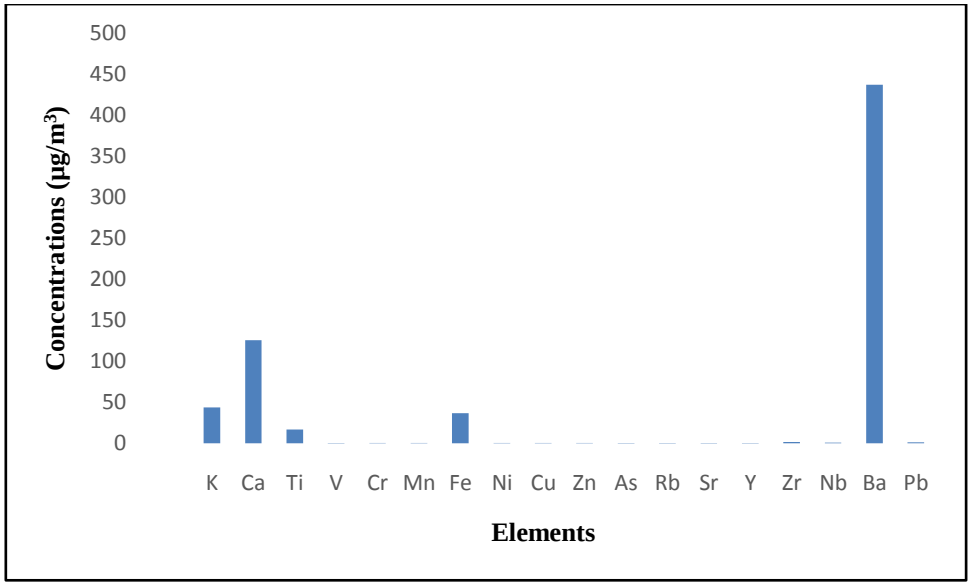

Figure 3.5: Characterized Elements at SP_4

3.3. Enrichment Factor

The analyzed elements can be divided into two major groups: earth crust elements tracer and anthropogenic tracers [7]. As such, separating natural and anthropogenic components is one of the main tasks of aerosol measurements, so that the source can be determined and appropriate solution can be proffered. The Enrichment Factor (EF) is traditionally used for separating crustal derived from anthropogenic components [12]. In this study, Ca was used as a reference element to determine the EF with respect to crustal elements and the elemental concentration of the particulates obtained [13]. It is customary that when EF <10, a large fraction of the element can be attributed to crustal derived tracemetal sources in the atmosphere NEEs and when EF >10, a large fraction of the element can be attributed to non-crustal or anthropogenic sources trace metal in the atmosphere AEES [14]. This study shows that from SP_1 – SP_3, the PM source is of a crustal origin, while the sources of As and Ba at SP4 are anthropogenic. The enriched elements in the particulates as reported were relatively volatile elements. Other elements have their EF < 10 indicating that they are crustal derived elements, and as such their sources are natural [10].These have been outlined in Table 3.1.

Table 3.1: Enrichment Factors for the Characterized Elements

Elements	SP1	SP2	SP3	SP4
K	0.82	1.06	0.65	0.71
Ca	1.00	1.00	1.00	1.00
Ti	0.88	0.93	0.86	0.82
V	1.39	1.55	1.30	0.19
Cr	0.50	0.38	0.74	0.72
Mn	0.12	0.37	0.18	0.11
Fe	0.14	0.22	0.16	0.16
Ni	0.14	0.38	0.43	1.10
Cu	0.79	0.81	1.03	2.05
Zn	1.30	1.94	1.44	1.27
As	2.63	3.98	5.51	10.70
Rb	0.10	0.19	0.10	0.07
Sr	0.10	0.14	0.04	0.04
Y	0.25	0.15	0.81	0.92
Zr	0.71	0.93	0.59	1.51
Nb	0.94	0.77	3.31	5.07
Ba	0.09	0.12	0.08	98.97
Pb	2.22	1.72	2.80	6.56

Conclusion

The measurement of the wet deposition samples concentration elements were conducted at four selected spots at the traffic intersection at and around Akowonjo metropolis, Lagos, Nigeria. The deposition flux was observed to be highest at spot 4, while the lowest flux was observed at spot 2; which could be by varying reasons; settling, wind direction and speed etc. Particulate Matter was collected, and EDXRF technique was used to determine the concentration of the elements in the particulate samples.

In the deposition, At SP_4, an un-usually high concentration amount of Barium was observed and Arsenic. The EF analysis showed very high enrichment for elements As and Ba; they were found to be enriched in the samples which indicate their nature of origin could be from any anthropogenic sources; Vehicular emission, Industrial, Fuel and oil combustion.

Acknowledgments

The authors acknowledged the efforts of the reviewers for their constructive criticism that further puts the works in the right perspective. We also appreciate the Centre for Energy Research and Development (CERD) Obafemi Awolowo University, Ile-Ife Nigerian for assisting us to characterized the PM samples.

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