Estimation of Heavy Metals Content at Traffic Inter-Change Ita-Marun Epe Lagos State Nigeria

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ABSTRACT

This study assesses the vehicular and traffic emission at Ita-marun Epe Lagos State. Road traffic area contains contaminants which affects human, animals and plants. Hence, the need to investigate the concentrations of these contaminants within the selected area.

Three deposition gauges of 0.15 by 0.20 mm were planted at selected sampling site for 30 days between December 2021 and January 2022. The Lagos State University Epe campus was used as the control experiment for this research work. Deposition flux for each site was determined. The contaminants levels of the heavy metals in particulate matter were evaluated using the Enrichment Factor (EF) analysis.

Deposition fluxes determined range from 31.8269-39.7836 g/m^2/month at the sampling site while it ranges 42.3934-51.0567 g/m^2/month at control site. Elemental analyses of all the samples collected were determined using the Energy Dispersive X-ray Fluorescence (EDXRF). EF reveals that 7 elements Ag, Cd, Cr, In, Mn, Sn, and Zn are highly enriched at sampling site while 6 elements S, Cl, Zn, Ge, As and W at the control site respectively.

Results shows that fluxes at the control site were higher than that of the sampling site. EF also reveals that seven elements at the sampling site and six elements at the control site were anthropogenically derived. Due to the findings of this research, a clean-up of this area is highly recommended.

Keywords: Vehicular and Traffic Emission, Deposition Gauges, Deposition Fluxes, Enrichment Factor

INTRODUCTION

Air pollutants emitted by motor vehicles are the largest component of air pollution recorded as a result of human activity, posing a threat to human health and natural resources [1, 2]. Along with the intensive development of urban agglomerations, hence an increase in the number of motor vehicles, the amount of toxic pollution in urban environment increases [3, 4]. Air pollution, the source of which is transportation, is related to the emission of solid particles from combustion engines [5]. [6] predicted that the share of non-fuel particles would continue to increase and by the end of 2020 it will average around 90% of the pollutant emissions from transportation sources such as traffic interchange.

Traffic interchange baseline data is essential for assessing suburbanization and urban sprawl effects in a developing country like Nigeria. One of such baseline data is the quantity of heavy metal contamination and its migration on the roadway. Heavy metals contamination is a subject of continuous interest within the scientific community, due to the toxic effects on the entire biosphere [7]. Anthropogenic activity is one of

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the most important sources of heavy metal pollution. Vehicular traffic is a human induced activity and a major source of contaminants released into the natural environment [8]. The worldwide high vehicular traffic density has led to accelerated emission rates, causing contamination of roadside soils [9]. The heavy metals can impair important biochemical processes posing a threat to human health, plant growth and animal life [10]-[13].

Investigation of road dust is important for many reasons [14]. Firstly, road dusts are inhaled by those who traverse the streets/highways and those who reside in the vicinity of major roads. In road dust pollution events, metals are released into the environment. Consequently, the public is exposed to the health hazards associated with such metals [15]. Secondly, during the periods of rainfall and strong winds, dust particles are deposited into the adjoining marine environment leading to sedimentation and metal contamination, thereby posing negative ecological impacts on aquatic organisms. Consumption of metal-contaminated seafood can adversely affect the human health [16]. Intake of dust particles laden with high concentrations of heavy metals may cause respiratory and cardiovascular diseases, cancer, birth defects, central nervous system impairment and death [17].

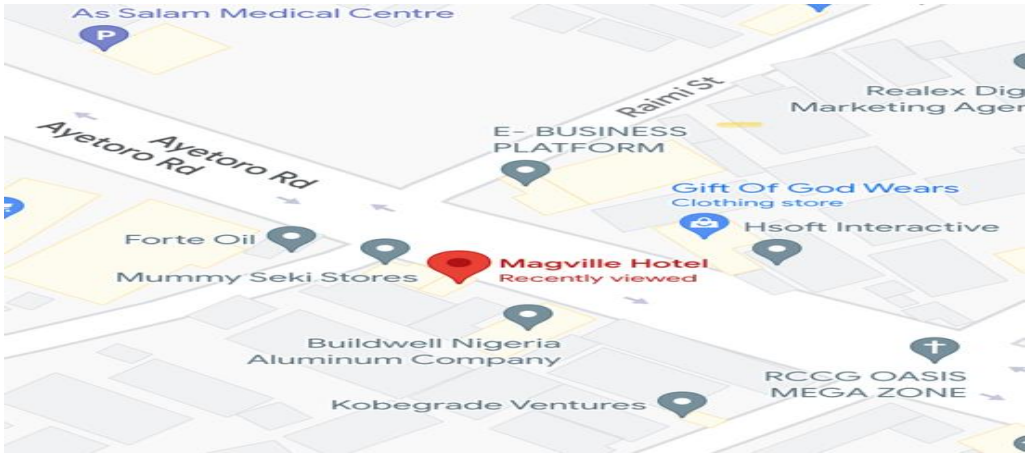
Study area

The study was conducted in Ita-Marun, Epe LGA, Lagos state as shown in Fig. 1. It is considered as one of the important national transport hubs. The high fluidity of traffic at the selected site has a significant impact on emissions— the emission of substances when starting and braking is higher than during smooth driving. Epe is located on coordinate 6^{o} 35'N 3^{o} 59'E in the northern side of Lekki Lagoon [18]. It has a surface area of more than 243km^2 and is sandwiched between two other lagoons, the Lekki lagoon (freshwater) in the east and Lagos lagoon (brackish water) in the west. The lagoon is connected to the sea through the Lagos Harbor [19]. Epe is best known for its construction of the motorized, shallow-draft barges that navigate the costal lagoons. By the 2006 Census the population of Epe was 181,409. It is a Yoruba town located next to the Lagos lagoon with 294 rural and 24 semi-urban communities. There are some industries that greatly pollute the environment through gaseous emission. Epe Area is polluted by both vehicular and mini-industrial activities which might contain heavy metals that can affect humans upon inhalation. Hence, the need for this study.

MATERIALS AND METHODS

Measurement of Deposited Particulate Matter

Three deposition gauges (0.2m diameter by 0.15m depth) were deployed permanently to each sampling spot in the selected area within Ita-marun for a period of one month [20]. Deposition gauge in which particles settled when left in a particular spot for a long time. The more time it is left at the sampling spot, the more the particulates that is likely to settle therein.



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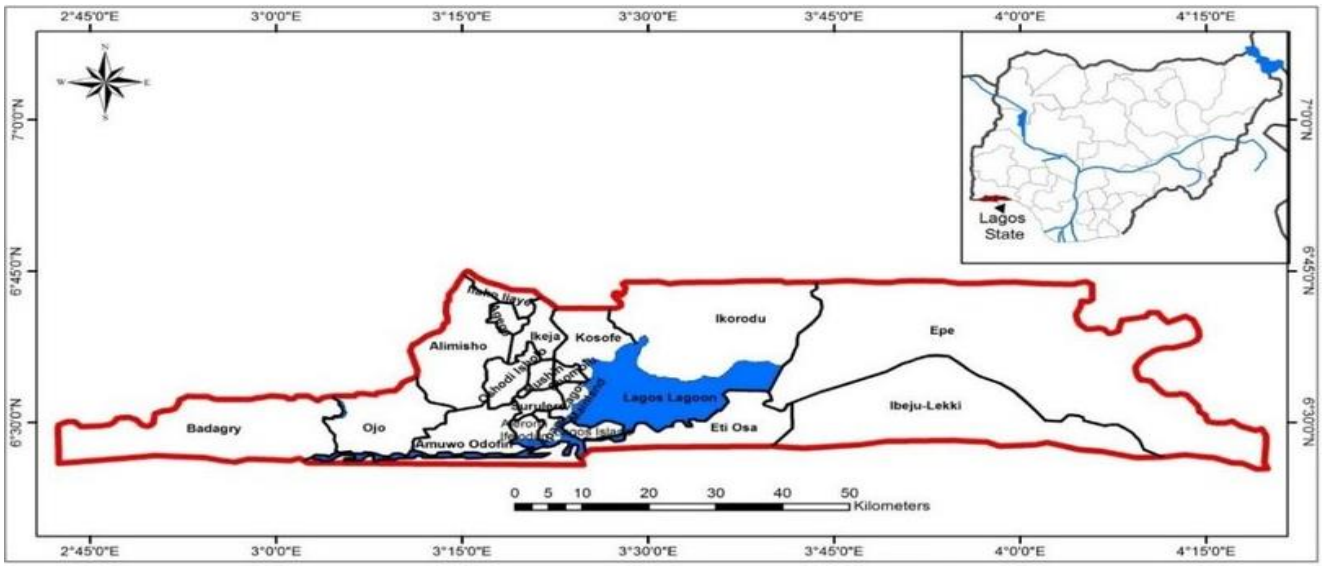

Fig. 1 Geographical map of Ita-marun interchanges Epe, Lagos State.

The sampling period covered dry seasons that are typical of Lagos State climates. The dry season was between October 2021 and February 2022.

The gauges were rinsed with distill water and sediment in the deposition gauges were collected and filtered through dry pre-weighed Whatman (125mm diameter, Cat No 1001 – 125) filter paper on digital weighing balance (model PA2102). The filter papers were desiccated in a desiccator to prevent further settlement of particles until it was completely dried. The filter paper and the particles were reweighed to determine the mass of the particles collected. The deposition flux was determined using equation 3.1 according to [20]

$$\text{Deposiion Flux} = \frac{\Delta Wp}{A.t} \qquad 3.1$$

Where:

ΔWp = Change in weight of particulate matter (g), A = Area of the deposition gauge (m^2) and t = Durationof exposure (month)

A flux is the rate of flow of particle or substances across a membrane or boundary. The samples collected after pre analysis was performed were taken to central research laboratory, Tanke Ilorin for characterization. The elemental analysis of all the samples collected were carried out using the Energy Dispersive X-ray Fluorescence (EDXRF) spectrometry. The EDXRF spectrometer (ECLIPSE III, AMTEK INC. MA; USA) is a self-contained miniature X-ray tube system. The detection system for all the measurements is a Model XR-100CR, which is a high-performance X-ray Detector with preamplifier and a cooler system, which uses a thermoelectrically cooled Si-PIN photodiode as an X-ray detector. The power to the XR-100CR is provided by a PX2CR power supply. The detector is coupled to the pocket MCA 8000A Multichannel Analyzer. The resolution of the detector for the 5.9 keV peak of 55Fe is 220 eV FWHM with 12μs shaping time constant for the standard setting and 186 eV FWHM with 20μs time constant for the optional setting. The optional setting was used for our measurements with the resolution of 186 eV for the 5.9 peak of 55Fe. The quantitative analysis of samples was carried out using the XRF-FP Quantitative Analysis Software package. This converts elemental peak intensities to elemental concentrations and or film thickness.

Determination of Enrichment Factor (EF)

The contaminants level of the heavy metals in particulate matter study was evaluated using the enrichment

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factor (EF) analysis. The enrichment factor (*EFx*) for an element *x* is defined as:

$$EF_x = \frac{[C_s/C_{ref}]_{aerosol}}{[C_s/C_{ref}]_{crust}} \quad 3.3$$

Where:

C_x and C_{ref} are the concentrations of the element x and the reference element, while $(C_x/C_{ref})_{aerosol}$ and $(C_x/C_{ref})_{crust}$ are the proportions of the element concentrations in the particulate matter and in the Earth's crust' respectively. An element will be chosen as indicator based on the type of industries located in these areas for enrichment factor to be used. Therefore, Fe was chosen because it is the conventional element for the main source of the Earth's crust[21-23]. Crustal element data were taken from [24].

RESULTS AND DISCUSSION OF RESULT

Determination of Fluxes of Ita-Marun

Fluxes were determined from the collected samples as shown in Table 1 and Table 2 for the control experiment. Spot 3 has the highest flux of 39.784 g/m^2/month, Spot 1 and Spot 2 has 31.827 g/m^2/month respectively. The total flux for Ita-marun as calculated from was 103.437 g/m^2/month. This confirmed that particles are dispersed around as well settled at the sampling site. The results shows that anthropogenic activities around the spot 3 is on the high side. Also, the result from the control experiment carried out in LASU Epe campus shows that spot 1 which located around the cadet angle recorded 51.06 gm^2/month while the spot 2 located at the old security post near the new Campus gate recorded 42.40 g/m^2/month respectively [19,25].

Characterization of Collected Samples

Samples collected were processed in the analytical laboratory in the Department of Chemical Engineering Lagos State University Epe Campus and taken to Central Research Laboratory, Tanke Ilorin for characterization using the XRF. Twelve elements as shown in Table 3 were detected which are as follows Ag, Cd, Cr, Fe, Ln, Mn, Pd, Rh, Ru, Sn, Ti, and Zn.

Table 1: Dry Deposition Flux of Ita-marun Epe

SITE	W1 (g)	W2 (g)	ΔW (g)	A (sq m)	T(month)	AT(sq m.month)	ΔW (mg)	F(g/sq m/month)
S1	0	1	1	0.03142	1	0.03142	1000	31.8269
S2	0	1	1	0.03142	1	0.03142	1000	31.8269
S3	0	1.25	1.25	0.03142	1	0.03142	1250	39.7836
								103.4374

Table 2: Dry Deposition Flux Control Experiment LASU Epe Campus

SITE	W1 (g)	W2 (g)	ΔW (g)	A (sq m)	T(month)	AT(sq m.month)	ΔW (mg)	F(g/sq m/month)
S1	1.6001	3.2043	1.6042	0.03142	1	0.03142	1604.2	51.0567
S2	1.6201	2.9521	1.332	0.03142	1	0.03142	1332	42.3934
								93.4501

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Table 3: Characterized Dry Samples for Ita-marun Epe

Elements	Molecular Mass	Sample 1 (ppm)	Sample 2 (ppm)	Sample 3 (ppm)	Sample 1 $(\mu g/m^3)10^6$	Sample 2 $(\mu g/m^3)10^6$	Sample 3 $(\mu g/m^3)10^6$	Mean $(\mu g/m^3)10^6$	STD
Ag	107.8	94940	125050	53200	417.736		234.080	325.908	91.828
Cd	112.4	15820	30660		72.578	140.661	0.000	106.619	67.541
Cr	51.98		27860		0.000	59.109	0.000	59.109	48.262
Fe	56		97040	171210	0.000	454.702	802.241	628.471	389.602
In	114.8	148930	43470	95570	334.333	97.586	214.545	215.488	96.654
Mn	55		497150		0.000	2163.110	0.000	2163.110	1766.172
Pd	106.6	86490	17740		376.320	77.187	0.000	226.753	179.032
Rh	102.5	208470	54160		872.170	226.588	0.000	549.379	412.394
Ru	101.07	33710	52430		139.064	216.290	0.000	177.677	107.317
Sn	118.7	134030	54450	107410	649.362	263.805	520.390	477.852	160.251
Ti	47.8		31780	282380	0.000	62.003	550.929	306.466	266.737
Zn	65			11910	0.000	0.000	31.598	31.598	25.800

It was discovered that Rh has the highest concentration of 208470 ppm in sample 1, Mn has the highest concentration of 497150 ppm sample 2 while Ti has the highest concentration of 282380 ppm in sample 3. The daily average was determined and the concentrations of Rh (872.170 $(\mu g/m3)10^6$) was the highest in sample 1, Mn (2163.110 $(\mu g/m3)10^6$) while Fe (802.241 $(\mu g/m3)10^6$). Characterization of samples of the control experiment (Table 4) also shows same number of elements and Fe still have the highest concentrations as well [26].

The mean and standard deviation were determined and plotted as shown in Fig. 2 and Fig. 3. Although, the fluxes were higher when calculated at the control site, the characterized concentrations at the sampling site were higher than that of the control site. This shows that the traffic inflow and out flow of the sampling site were higher coupled with the anthropogenic activities at the sampling site.

Enrichment Factor

Enrichment Factor (EF) values helps in determining whether a certain element has additional or anthropogenic sources other than its major crustal sources. Sources of metal in particulate include both natural and anthropogenic processes [27]. Iron (Fe) has the highest concentrations (Table 5 and Table 6) and was used as a reference element for the EF evaluation with respect to crustal abundance, with an assumption that the contribution of its anthropogenic source to the atmosphere is negligible [28]-[30]. According to standard, when EF < 10 is taken as an indication of crustal-derived trace metals source in the atmosphere and these are termed the non enriched elements (NEEs). In contract, an EF value of > 10 is considered to indicate non-crustal source or anthropogenically-derived trace metal source, and these are referred to as anomalously enriched elements (AEEs). [31, 32].

EF reveals from Table 5 that only two elements have EF < 10. Hence, the sampling site was greatly influenced by the human activities (anthropogenic) which has led to the increase in concentration of the of the other elements detected while EF from Table 6 shows that only 6 out of the 21 elements detected was highly enriched.

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Table 4: Characterized Dry Samples for Control Experiments

Elements	Molecular Mass	Sample 1 (ppm)	Sample 2 (ppm)	Sample 1 $(\mu g/m^3)10^6$	Sample 2 $(\mu g/m^3)10^6$	Mean $(\mu g/m^3)10^6$	STD
Si	28		170583		194.9520	97.4760	97.4760
S	32	6576	35203	8.5891	45.9794	27.2842	18.6952
Cl	35.5	50121	38828	72.6243	56.2610	64.4426	8.1817
K	39	55597	82365	88.5013	131.1116	109.8065	21.3051
Ca	40	178691	300184	291.7404	490.0963	390.9184	99.1780
Ti	47.9	35155	37203	68.7316	72.7357	70.7336	2.0020
V	51	2026	2277	4.2174	4.7399	4.4786	0.2612
Cr	52	1424	1208	3.0224	2.5639	2.7931	0.2292
Mn	55	7663	12832	17.2027	28.8065	23.0046	5.8019
Fe	56	274380	304590	627.1543	696.2057	661.6800	34.5257
Ni	59	2415	1036	5.8157	2.4949	4.1553	1.6604
Cu	64	3656	1484	9.5504	3.8766	6.7135	2.8369
Zn	65	352315	5697	934.7133	15.1145	474.9139	459.7994
Ge	73		460		1.3706	1.3706	0.0000
As	74.9		526		1.6081	1.6081	0.0000
Zr	88		206		0.7399	0.7399	0.0000
Sr	91	728	943	2.7040	3.5026	3.1033	0.3993
Pb	207	1737	214	14.6759	1.8081	8.2420	6.4339
W	183.6	12409		92.9915		92.9915	0.0000
Po	208.9	834	1435	7.1111	12.2356	9.6733	2.5622
Ac	227	4272	2725	39.5814	25.2480	32.4147	7.1667

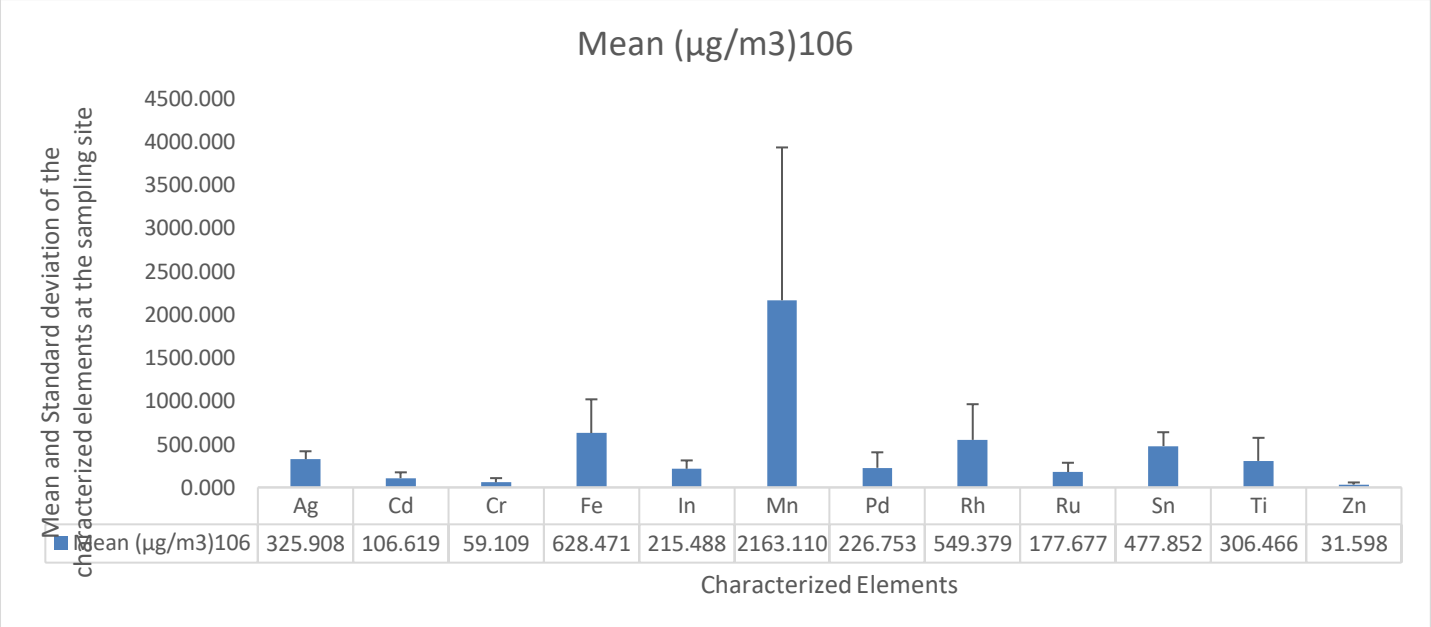

Fig.2: Mean and standard deviation of the characterized elements at Ita-marun

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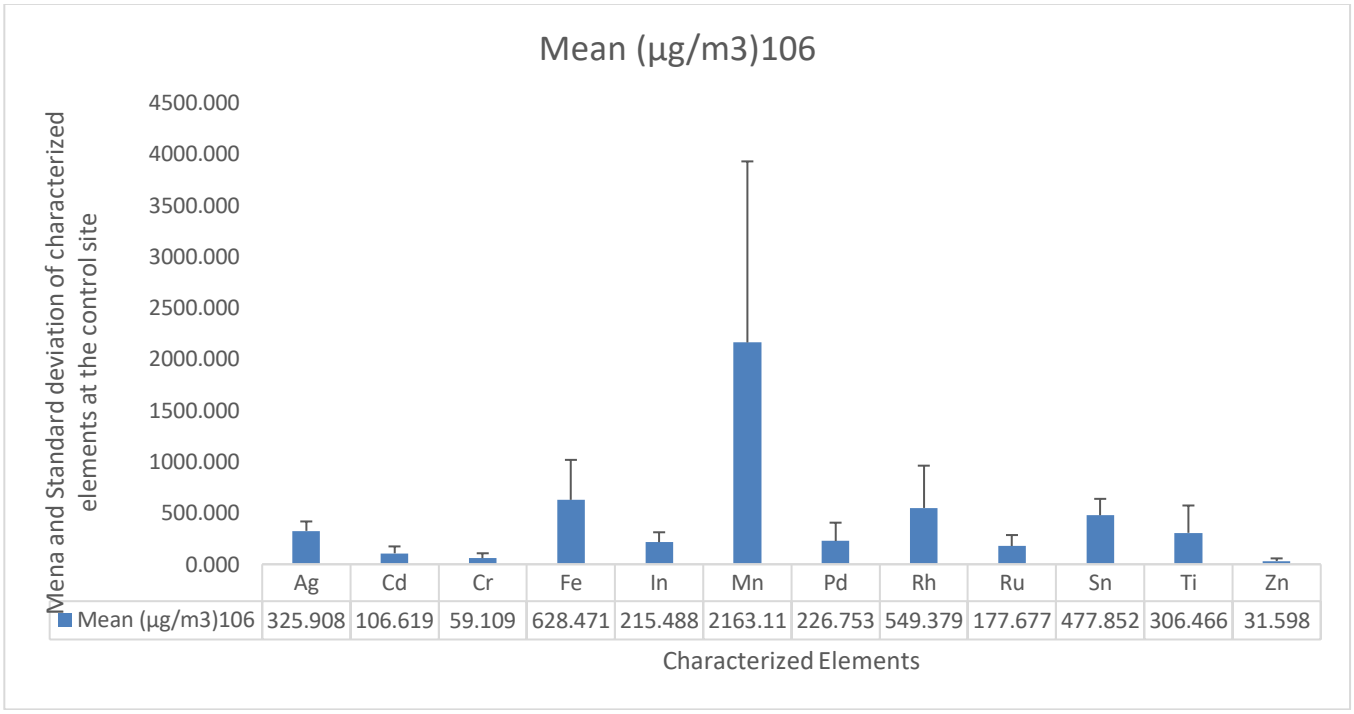

Fig.3: Mean and standard deviation of the characterized elements at LASU control Experiment

Table 5: Enrichment Factor for the Collected samples at Ita-marun

Elements	Mean (µg/m3)106	ERS	Mean ppm	Molecular Mass	Mean (µg/m3)106	ERC	EF
Ag	325.908	0.519	0.07	107.8	0.000	0.000	216665.171
Cd	106.619	0.170	0.2	112.4	0.001	0.000	23793.094
Cr	59.109	0.094	100	51.98	0.212	0.002	57.046
Fe	628.471	1.000	56300	56	128.686	1.000	1.000
In	215.488	0.343	0.1	114.8	0.000	0.000	94165.451
Mn	2163.110	3.442	950	54.9	2.129	0.017	208.062
Pd	226.753	0.361		106.4	0.000	0.000	
Rh	549.379	0.874		102.5	0.000	0.000	
Ru	177.677	0.283		101.07	0.000	0.000	
Sn	477.852	0.760	2	118.7	0.010	0.000	10097.732
Ti	306.466	0.488	5700	47.8	11.121	0.086	5.643
Zn	31.598	0.050	70	65	0.186	0.001	34.838

Table 6: Enrichment Factor for the control Experiment LASU Epe Campus

Elements	Mean (µg/m3)106	ERSC	Mean cru ppm	Molecular Mass	Mean (µg/m3)106	ERC	EF
Si	97.476	0.147	281500	28	321.714	2.500	0.059
S	27.284	0.041	260	32	0.340	0.003	15.626
Cl	64.443	0.097	130	35.5	0.188	0.001	66.535
K	109.806	0.166	20900	39	33.269	0.259	0.642
Ca	390.918	0.591	41500	40	67.755	0.527	1.122

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Ti	70.734	0.107	5700	47.9	11.144	0.087	1.234
V	4.479	0.007	135	51	0.281	0.002	3.099
Cr	2.793	0.004	100	52	0.212	0.002	2.559
Mn	23.005	0.035	950	55	2.133	0.017	2.098
Fe	661.680	1.000	56300	56	128.686	1.000	1.000
Ni	4.155	0.006	75	59	0.181	0.001	4.474
Cu	6.713	0.010	55	64	0.144	0.001	9.088
Zn	474.914	0.718	70	65	0.186	0.001	497.339
Ge	1.371	0.002	1.5	73	0.004	0.000	59.642
As	1.608	0.002	1.8	74.9	0.006	0.000	56.832
Zr	0.740	0.001	165	88	0.593	0.005	0.243
Sr	3.103	0.005	375	91	1.393	0.011	0.433
Pb	8.242	0.012	125000	207	1056.122	8.207	0.002
W	92.992	0.141	1.5	183.6	0.011	0.000	1608.899
Po	9.673	0.015		208.9	0.000	0.000	0.000
Ac	32.415	0.049		227	0.000	0.000	0.000

CONCLUSIONS

The data obtained from the characterized samples gives evidence that heavy metals conclusion are being released by vehicular traffic and anthropogenic activities going onin the selected sampling site. It also show that the air qualty in the sampling site could be affected by the vehicular emission. The mean concentration value of the heavy metals obtained exceeded the WHO and USEPA standard. Enrichment factor show that seven (7) elements in the sampling site (Ita-marun) are non crutal derived (anthropogenic) since they are greater than 10 which was the treshold limit while six (6) elements reflect this at the control experiment site. Others are within the acceptable limits that is they are crustal derived elements. Therefore, a clean-up of the samopling is highly reccommended.

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