International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 10 Issue 4 ǁ 2022 ǁ PP. 04-10

Examination of Wet Atmospheric Deposition Fluxes For Odogunyan Industrial Estate in 2015 And 2020

Adebanjo, S.A.[1*], Alade, A.O.[2], Duduyemi, O. [1], Adeosun, A.O.[1], Oyeyinka, O.E.[1], Popoola, A.O[3], and Jimoda, L.A.[2]

[*1]*Department of Chemical Engineering, Lagos State University Epe campus Lagos, Nigeria*
[2]*Department of Chemical Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria*
[3]*Environmental Research Laboratory, Department of Chemical Engineering, LAUTECH, Ogbomoso, Nigeria*

Abstract
Human exposure to Particulate Matter (PM) in ambient air has been associated with numerous health effects that infiltrate the respiratory system and reduce pulmonary function. These pollutants also do damage to the environment, destroys insects and contributes to peeling, deterioration of steel structures, weathering of stone buildings and statues by acid rainfall. In addition, plant-based accumulation of ozone reduces forest biomass and changes the species composition of grassland vegetation and causes impact on staple food crops. This study examine the atmospheric wet deposition fluxes at Odogunyan industrial estate Ikorodu Lagos, determine if there has been an increase in deposition fluxes within the time frame, and therefore look for steps to monitor excessive polluting load due to atmospheric deposition. Deposition gauges of 0.15 m by 0.2 m were planted for one month and harvested from three different locations within the selected area in Odogunyan at a distance of 100m apart around the industries at Odogunyan. The harvested gauges were taken to the laboratory for further analysis. Deposition fluxes were determined and samples were later taken to the Central for Energy and Research Development (CERD) at Obafemi Awolowo University, Ile-Ife Osun State, Nigeria for characterization using X-Ray Fluorescent Spectrometer, after which trace metal and enrichment factor were determined. Results shows that wet deposition flux of aerosol measured along the industrial area were 0.3185, 0.5213, 0.4132 $\mu g/m^2$.day. for Idi Oro, Odonla road, and Olopomarun respectively. Nineteen elements (Fe, Ti, K, Ga, Rb, Y, Sr, Nb, Ni, Br, Se, Mn, Zr, V, Ca, Zn, Cu, Cr, As) were characterized from the samples. Enrichment factors show that all elements are below the standard of 10 which denotes crustal origin derived except Se, Ga, Br As and Nb that were highly enriched with EFs of 16334.175, 536.18, 288.269, 256.918 and 143.315 respectively. Five new elements were detected which are Ga, As, Se, Br, Y and Nb whose values are >10 denoting anthropogenic origins. Hence a cleanup of the environment is recommended.
Keywords: *Particulate Matter, Deposition gauge, deposition fluxes, Enrichment Factots, Crustal origin, Anthropogenic.*

Date of Submission: 06-04-2022 Date of acceptance: 22-04-2022

I. INTRODUCTION

The problem of air pollution in the metropolitan cities and around manufacturing areas has taken on a severe proportion. Air pollution is growing steadily due to the spiraling use of fossil fuel by large power generation plants and the transport sector [1, 2]. It can be established in Nigeria (especially in Lagos) that the industrial and transportation sectors emit gaseous pollutants and acid deposition which can cause structural and functional changes in the human environment leading to subtle ecosystem degradation [1, 3, 13]. Increased air pollutant concentrations due to human activities result in more air pollutant accumulation, with adverse effects on human health, crop yields, land and marine habitats [4]. Atmospheric deposition fluxes greatly contribute to ecosystems [4, 5] by supplying bio-geochemically important elements such as nitrogen oxide, magnesium, potassium, Iron and phosphorus, through the naturally occurring processes of dry and wet deposition, atmospheric constituents such as ozone, nitrogen and sulphur containing compounds and particulate matter can find their way into soil, marine, fresh water bodies and plant and animal tissue [5, 12]. However, dry deposition is the free fall of atmospheric trace gases and particulate matter directly from the atmosphere to Earth. This study was carried out in the wet season with a view to compare it with previous study carried out in the year 2015 as published by Adebanjo, *et al.* 2020 [12] in order to know if there has been improvement control of the harmful heavy metals on the ecosystem and human within the Odogunyan Industrial area. The objectives of this work includes; characterization collected aerosol samples, determine the enrichment factors and compare and analyze the results.

II. Materials and Methods

Sampling site

Thus study was carried out in Odogunyan, one of the industrial areas within Lagos State. Odogunyan lies on the latitude 6.6781° N and Longtitude 3.5155° E respectively in ikorodu Local Government area of the Lagos State.

Sampling Procedure

The sampling was carried out between May 2020 and June 2020 respectively being the typical Lagos state wet climates. Deposition gauges (0.2m diameter by 0.15m depth) were deployed to the chosen locations (Olopomarun, Odonla road and Idi oro) within the selected industrial area for a period of 30 days [8]. The planted deposition gauges were harvested after 30 day and taken to the analytical laboratory in the department of Chemical engineering Lagos State University in order to determine the deposition fluxes. Rain water and sediment in the deposition gauges during the wet season were collected, filtered through dry pre-weighed Whatman (125mm diameter, Cat No 1001 – 125) filter paper on digital weighing balance (model PA2101). These filter papers were desiccated in desiccators to prevent further settlement of particles until they are completely dried. The filter paper and the particles were reweighed to determine the deposition fluxes. The particulates were then taken to the Center for Energy Research Development at Obafemi Awolowo University Ile-Ife for characterization using X-ray Fluorescence (XRF) spectrometer. The Enrichment Factor of the element detected was determined by taken crustal element data from Taylor and McLenman, (1985) [7]

The equations for determining the deposition fluxes and the enrichment factors are;

$$DF = \frac{\Delta W}{At} \qquad 1$$

Where DF is deposition flux (mg/m^{2}day), A is the area of the deposition gauge m^2 and t the duration (days).
Factor analysis using enrichment factor was determined as follows

$$EFx = \frac{[Cs/Cref]aerosol}{[Cs/Cref]crust} \qquad 2$$

respectively. 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 PM and in the Earth's crust, respectively.

Sampling Map

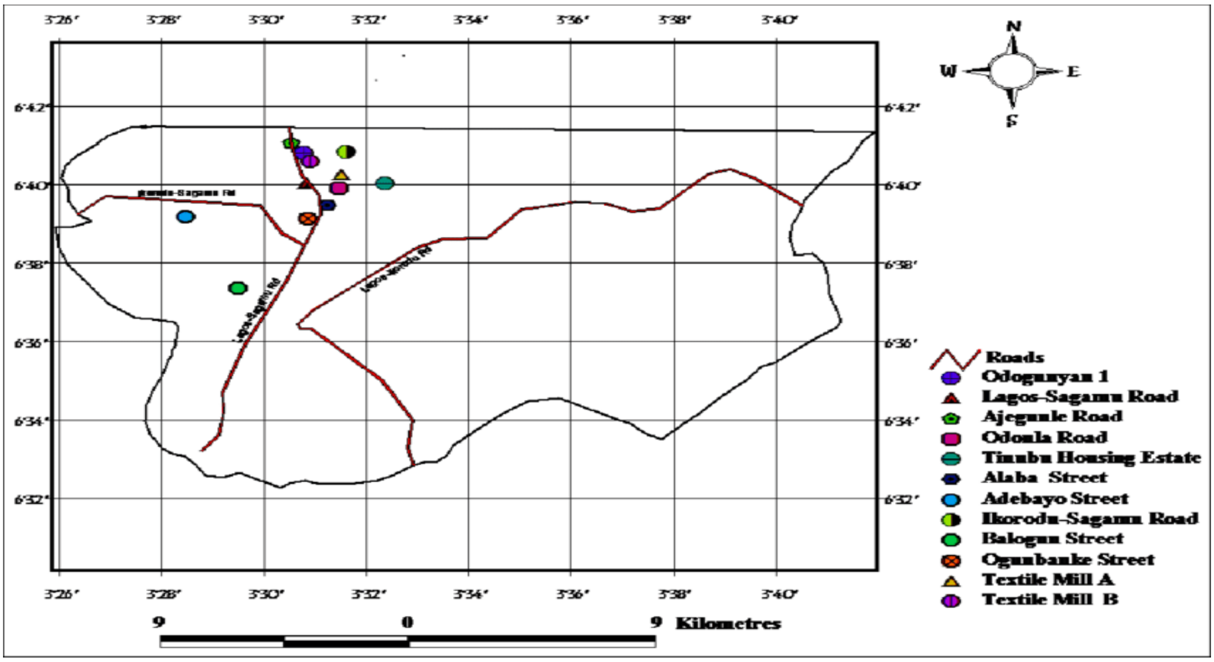

Fig.1: Selected Industrial Area in Odogunyan, Lagos State.

III. RESULTS AND DISCUSSION

Table 1: Wet Deposition Fluxes of Aerosols Odogunyan industrial area

Sampling	W1 (mg)	W2 (mg)	ΔW (mg)	Area (m^2)	Time (days)	Dep.flux (mg/m^2.day)
1	1.4	1.7	0.3	0.03142	30	0.3183
2	1.4	1.8	0.4	0.03142	30	0.5213
3	1.4	1.7	0.3	0.03142	30	0.4132

The Wet deposition fluxes (Table 1) of aerosol measured Odogunyan industrial area were 0.3185, 0.5213, 0.4132 mg/m^2.day. for Idi Oro, Odonla road, and Olopomarun respectively. The measured deposition flux ranged from 0.4132$\mu g/m^2$.day at Odonla to 0.5213mg/m^2.day at Olopomarun. Anthropogenic sources like traffic-related emissions and construction activities could be responsible for higher deposition flux at Odonla than the other sampling locations along the highway. This implied that Odonla was more polluted than the remaining sampling locations. Overall deposition fluxes values for each location were found to have a good agreement with the study previously carried out by Adebanjo et al (2019) [10].

Table 2: Characterized wet Samples for Odogunyan Industrial Area 2020

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
K	39	738.576	530.461	1825.108	1.176	0.844	2.905	1.642	0.904
Ca	40	170.159	127.775	901.586	0.278	0.209	1.430	0.653	0.580
Ti	47.9	2218.17	2204.661	1165.645	4.337	4.310	2.279	3.642	0.964
V	51	364.714	252.576	449.728	0.759	0.526	0.936	0.740	0.168
Cr	52	145.903	124.139	256.655	0.310	0.264	0.545	0.373	0.123
Mn	55	370.729	358.556	549.73	0.832	0.805	1.234	0.957	0.196
Fe	56	11390	10080	12580	26.034	23.040	28.7543	25.943	2.334
Ni	59	460.372	333.425	490.145	1.109	0.803	1.180	1.031	0.164
Cu	64	92.155	66.159	231.733	0.241	0.173	0.605	0.340	0.190
Zn	65	127.377	167.792	171.429	0.338	0.445	0.455	0.413	0.053
Ga	69.7	38.999	113.595	238.22	0.111	0.323	0.678	0.371	0.234
As	74.9	48.493	27.719	132.903	0.148	0.085	0.406	0.213	0.139
Se	79	83.213	186.039	80.886	0.268	0.560	0.261	0.376	0.158
Br	80	72.101	87.873	145.129	0.235	0.287	0.474	0.332	0.103
Rb	85	35.954	75.024	58.3	0.125	0.260	0.202	0.196	0.056
Sr	88	51.043	58.975	77.246	0.183	0.212	0.278	0.224	0.039
Y	88.9	100.447	115.12	155.676	0.365	0.418	0.565	0.449	0.085
Zr	91	351.673	153.148	210.938	1.306	0.569	0.783	0.886	0.310
Nb	92.9	329.875	409.909	327.096	1.251	1.553	1.240	1.349	0.146

Sample1 is from Idi oro; sample 2 is from Odonla road; sample 3 is from Olopomarun

Nineteen elements were characterized from the samples as shown in Table 2 above. Fe, which was the highest ranged from 23 040 ($\mu g/m^3$) x10^6 at Odonla road to 28.754 ($\mu g/m^3$) x10^6 Olopomarun while Ga has the lowest value ranged from 0.111 ($\mu g/m^3$) x 10^6 at Idi oro to 0.678 ($\mu g/m^3$) x10^6 at Olopomarun. Hence, Fe was chosen as reference element [15, 16].

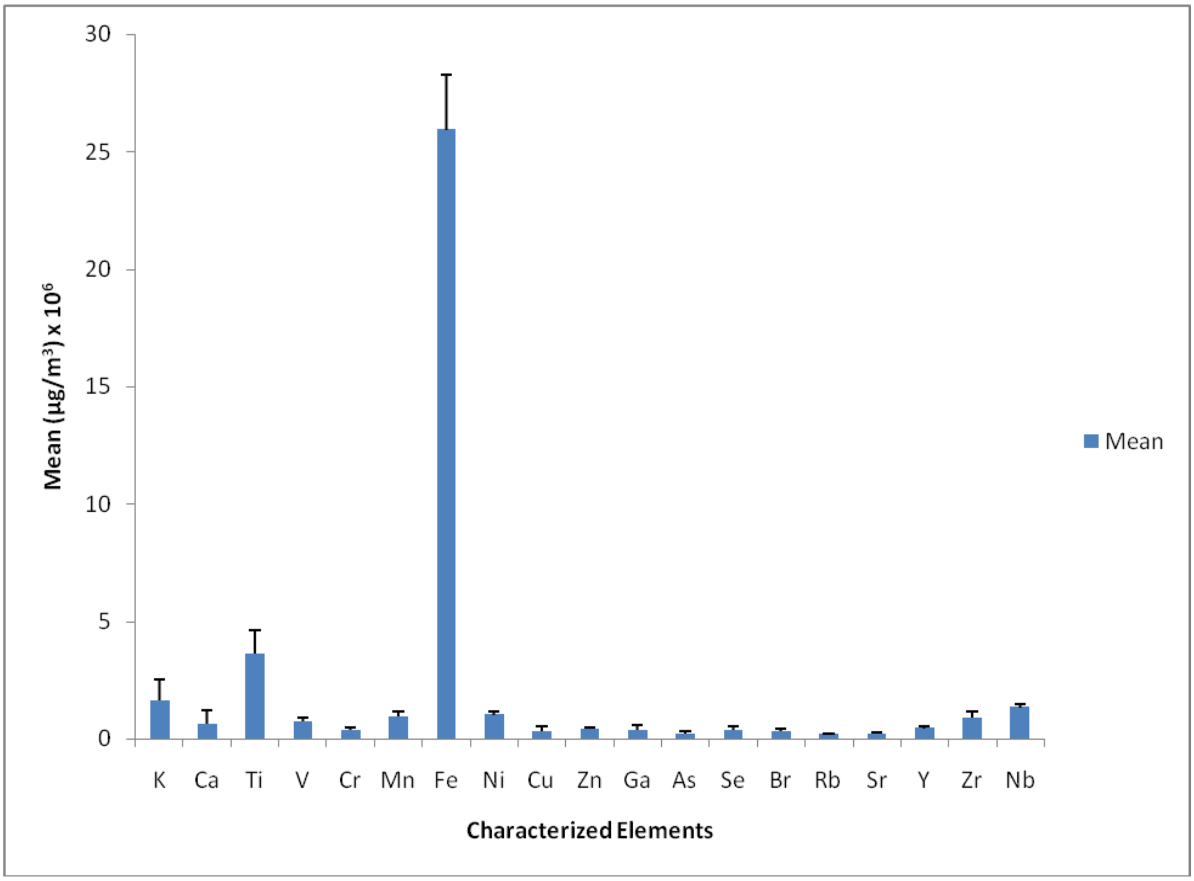

Fig.2: Mean and standard deviation of the characterized Elements from all locations

Enrichment Factor Analysis

Elements such as Al, Si, Ti, Fe are commonly used as a point of reference for the calculation of factors, because they are very abundant in crustal material and are not significantly affected by pollution [9]. The EF for each element in the sampling were calculated as shown in Table 3, using the iron (Fe) as reference element in this study, based on the average elemental concentration data of the upper continental crust [7, 14]. Six contamination categories of EF are recognized, which are increasing with contribution of the anthropogenic origins: <1 background concentration, 1- 2 depletion to minimal enrichment, 2 – 5 moderate enrichment, 5 – 20 significant enrichment, 20 – 40 very high enrichment and > 40 extremely high enrichment.

The result obtained for enrichment factors (EFs) is presented in Table 5 Se, Ga, Br, As and Nb were significantly enriched with EFs of 16334.175, 536.18, 288.269, 256.918 and 143.315 respectively. High EFs (> 100) were obtained for Se, Ga, Br As and Nb, indicating their anthropogenic origins, such as combustion of fossil hydrocarbons, vehicular traffic and emissions of metal-working industries [11, 6]. Also, at all the three locations, Se, Ga, Br As and Nb are extremely higher in values because the sampling shows anthropogenic nature studied area.

V, Cu, Zn, and Zr appear to be moderately enriched. Other elements, such as K, Ca, Ti, Fe, and Sr were shown to have low enrichment factors. Most of the crustal components showed smaller values of EF. Low EF values for these elements were also observed by [12], in the same study area. Among these elements, Cu is an additive in high-temperature lubricant and is present in brake linings, approximately 1–10% by weight, and it has been used successfully as a good tracer for wear emission of road traffic. Zn is associated with wear tire debris because Zn is added to tires during vulcanization and is responsible for 1–2% of the tires by weight. Emissions from vehicle exhaust and wear abrasion are both important sources of Zr [6].

Table 3: Enrichment factor for year 2020

Elements	Mean $(\mu g/m^3)10^6$ 2020	ERA	Mean $(\mu g/m^3)10^6$ Crustal	ERC	EF_{2020}
K	1.642	0.0633	20900	0.371	0.170
Ca	0.653	0.0252	41500	0.737	0.034

Ti	3.642	0.1404	5700	0.101	1.387
V	0.740	0.0285	135	0.002	11.902
Cr	0.373	0.0144	100	0.002	8.087
Mn	0.957	0.0369	950	0.017	2.186
Fe	25.943	1.0000	56300	1.000	1.000
Ni	1.031	0.0397	75	0.001	29.822
Cu	0.340	0.0131	55	0.001	13.401
Zn	0.413	0.0159	70	0.001	12.793
Ga	0.371	0.0143	1.5	0.000	536.182
As	0.213	0.0082	1.8	0.000	256.918
Se	0.376	0.0145	0.05	0.000	16334.175
Br	0.332	0.0128	2.5	0.000	288.269
Rb	0.196	0.0075	90	0.002	4.720
Sr	0.224	0.0086	375	0.007	1.297
Y	0.449	0.0173	33	0.001	29.529
Zr	0.886	0.0342	165	0.003	11.655
Nb	1.348	0.0520	20	0.000	146.319

Table 4: Characterized wet Samples for Odogunyan Industrial Estates 2015

Elements	Molecular mass	Sample 1 (ppm)	Sample 2 (ppm)	Sample 3 (ppm)	Sample 1 (μg/m^3)10^6	Sample 2 (μg/m^3)10^6	Sample 3 (μg/m^3)10^6	Mean (μg/m^3)10^6	STD
Cl	35.5	21307	50092	22643	30.873	72.582	32.809	45.422	19.222
K	39	Nil	12402	3269	0.000	19.742	5.204	8.315	8.355
Ca	40	18593	38139	12429	30.356	62.268	20.292	37.639	17.894
Ti	47.9	25469	40333	25899	49.795	78.855	50.635	59.762	13.506
V	51	2231	2245	1742	4.644	4.673	3.626	4.315	0.487
Cr	52	2435	3539	2022	5.168	7.511	4.292	5.657	1.359
Mn	55	12758	38901	12139	28.640	87.329	27.251	47.740	27.999
Fe	56	249429	633119	288049	570.123	1447.129	658.398	891.883	394.269
Ni	59	2245	1966	2866	5.406	4.734	6.902	5.681	0.906
Cu	64	Nil	3365	389	0.000	8.790	1.016	3.269	3.926
Zn	65	18274	60427	12739	48.482	160.317	33.797	80.865	56.500
Ge	73	1267	388	1082	3.775	1.156	3.224	2.718	1.127
Sr	88	270	556	217	0.970	1.997	0.779	1.249	0.535
Zr	91	109326	143300	107559	406.068	532.257	399.505	445.943	61.092
Pb	207	1286	5221	2339	10.865	44.112	19.762	24.913	14.053
Ta	180	1484	3421	5831	10.903	25.134	42.840	26.292	13.064
Rb	85	349	666	556	1.211	2.311	1.929	1.817	0.456
Mo	96	679	567	730	2.661	2.222	2.860	2.581	0.267
Cd	112	72902	77359	50188	333.266	353.641	229.431	305.446	54.391

Source: [12]

The characterized samples in the wet season for the year 2020 at odogunyan industrial estate (Table 2) revealed nineteen elements of which five of them (As, Be, Br, Y and Nb) . an indication that the environment is further occupied with anthropogenic activities that is damaging the quality of air in the industrial estate. On the other hand, in 2015, Adebanjo *et al.* carried out same research in the selected industrial estate where same numbers of elements (Table 4) were reported but with a difference of Ge, Pb, Ta, Mo and Cd being detected [12, 17].

Table 5 shows the enrichment factor for the two years. In 2015, eight (8) elements (Cl, Zn, Ge, Zr, Pb, Ta, Mo and Cd) were enriched in that their enrichment factors were > 10 being the threshold. Cl has the lower value of 22.056 from the enriched elements while Cd has 96418.22. In 2020, eleven elements (V, Zr, Zn, Cu, Ni, Y, Nb, As, Br, Ga and Se) out the nineteen characterized elements were highly enriched. This shows that the anthropogenic activities in the area are extremely high.

Table 5: Comparison of concentrated element reported 2015 and 2020

Elements	EF_{2015}	EF_{2020}
Cl	22.056	Nil
K	0.025	0.170
Ca	0.057	0.034
Ti	0.662	1.387
V	2.017	11.902
Cr	3.571	8.087
Mn	3.172	2.186
Fe	1.000	1.000
Ni	4.781	29.822
Cu	3.752	13.401
Zn	72.923	12.793
Ge	114.399	Nil
Ga	Nil	536.182
Sr	0.210	1.297
Zr	170.607	11.655
Pb	125.811	Nil
Ta	829.846	Nil
Rb	1.274	4.720
Mo	108.613	Nil
Cd	96406.229	Nil
As	Nil	256.918
Se	Nil	16334.175
Br	Nil	288.269
Y	Nil	29.529
Nb	Nil	143.315

IV. CONCLUSION

The present study has pointed out that the wet deposition of the characterized samples at Odogunyan industrial estate do not only reflect anthropogenic activities at estate, but also shows that the environment needs an urgent clean up since eleven out the nineteen detected elements have their enrichment factor > 10. Anthropogenic sources like traffic-related emissions and construction activities could be responsible for higher deposition fluxes as well as EF and they pose negative effects on the environment

REFERENCES

[1]. Bourcier H., Wong T.W., Tam A.K.W., Lau S.K.W., Ng I.T.S., Yu A.H.S. and Yeung D. (2009). A study of the air pollution index reporting system. Tender Ref. AP 07 – 085. Final Report/June 27, 2009, Environmental Protection Department (EPD) of the Hong Kong

[2]. Ishikawa, T., Laden, F. L.M., Neas, D.W., Dockery and J. Schwartz, 1995. Association of fine particulate matter from different sources with daily mortality in six U.S. cities. Environ.Health Perspect 108: 941-947.

[3]. WHO. (2008). Health aspects of air pollution with particulate matter, ozone and nitrogen dioxide. World Health Organization. Copenhagen.;94.

[4]. Fatoba PO, Ogunkunle CO, and Olawepo GK. (2012). Assessment of Atmospheric Metal Depositions in the Industrial Areas of the Southwest of Nigeria. Ethiopian Journal of Environmental Studies and Management. 5:260–267.

[5]. Moaref, S., Sekhavatjou, M.S. and Hosseini, A.A. (2014). Determination of Trace Elements Concentration in wet and dry Atmospheric Deposition and Surface soil in the Largest Industrial city, Southwest of Iran. International Journal of Environmental Research.;8: 335-346.

[6]. Adebanjo S.A, Jimoda, L.A. Alade, A.O and Alagbe E. (2019). Elemental composition of particulates deposition in some selected industrial area of Ikeja, Lagos Nigeria. Journalof the Nigeria society of chemical Engineers: 34(1): 62-70.

[7]. Taylor SR, McLennan SM. (1985). The Continental Crust: its Composition and Evolution. Blackwell Scientific Publications, Oxford;

[8]. Adebanjo S.A., Sokenu I. and Gbadebo, O. (2019). Atmospheric deposition of particulate matter and around inter-urban metropolis. Journal of Scientific and Engineering Research 6(10); 33-38.

[9]. Herrera, M., Saarikoski, S and Niemi, J. V. (2014). Chemical and Source Characterization of Submicron Particles at Residential and Traffic Sites in the Helsinki Metropolitan Area, Finland. Aerosol and Air Quality Research.;10:1–14.

[10]. Adebanjo ,Sunday Adekunle, Jimoda , Lukuman Adekilekun, Alade, Abass O., Adedeji, Kasali Aderinmoye, Raji, Wuraola Abake and Sonibare, Jacob Ademola. (2019). Deposition fluxes of Particulate matter of some selected industrial area within Lagos State. Lasu Journal of Engineering Science and Technology 1(1): 1-13

[11]. Melaku S, Morris V, Raghavan D, Hosten C. (2008). Seasonal Variation of Heavy Metals in Ambient Air and Precipitation at a single site in Washington, DC. Environmental Pollution.; 155:88-98.

[12]. Adebanjo A Sunday,Jimoda A. Lukman, and Alade O. Abass and Duduyemi O. (2020).Elemental Composition of Total Wet Particulate Matter Deposition in the selected Industrial Areas within Lagos state. Journal of Scientific and Engineering Research 7, (10): 182-192

[13]. Adedeji ,O.H., Olayinka, O.O. and Oyebanji, F.F. (2013). Assessment of Traffic Related Heavy Metals Pollution of Roadside Soils in Emerging Urban Centres in Ijebu-North Area of Ogun State, Nigeria. Journal of Applied Science and Environmental Management 17:509-514.

[14]. Singh A, Kulshrestha, D, Huang and L. Ma, (2014). Characterizing spatial distribution and temporal variation of PM10 and PM2.5 mass concentrations in an urban area of Southwest China. Atmos. Pollut. Res., 6: 842-848.

[15]. Oladosu, Y., Uzairu , A and Ujoh, J.O. (2012). Determination of sulphur dioxide concentrations in ambient air of some selected traffic areas in Kaduna metropolis. Res. J. Applied Sci.Eng.Technol., 6: 2923-2930.

[16]. Janssen, N.A.H., Van Mansom, D.F.M., Van Der Jagt K., Harseema, H. and Hoek, G. (1997). Mass concentration and elemental composition of airborne particulate matter at street and background locations. Atmos Environ; 31(8):1185–993.

[17]. Alamu O.A., Jimoda, L.A., Alade, A.O., and Adebanjo, S.A. (2019) Elemental Characterization of Aerosols in Wet Deposition along a Dense Traffic Highway in Ogbomoso, Nigeria Engineering & Technology Research Journal 5(1) pp. 7 – 17.