International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 3 March 2023, pp: 584-593 www.ijaem.net ISSN: 2395-5252

Investigation of Heavy Metals Concentration in Trees as Indicator of Atmospheric Pollution along Abuja-Lokoja Highway, North-Central, Nigeria

Awodi Joel Ochala[1]Abiodun Davies Obaromi[2]Ebiloma Innah[3], Peter Enejo Onoja[4]

[1]*Science Department, School of Preliminary Studies, Kogi State Polytechnic, Lokoja.*
[2]*Department of Mathematics and Statistics, Federal University of Health Science Otukpo, Benue State*
[3] *Department of Biochemistry, School of Applied Science, Kogi State Polytechnic Lokoja.*
[4] *Department of Microbiology, School of Applied Science, Kogi State Polytechnic Lokoja*

Date of Submission: 01-03-2023 Date of Acceptance: 10-03-2023

ABSTRACTS

Rural-urban migration has increased vehicular traffic on the Abuja-Lokojahighway; also there is a notable increase in the industrial activities occasioned by nearness to market and energy source.The heavy metals laden emissions fromvehicular traffic and industries along the highway constantly lowers air quality. The emissions constitute health risk to persons living in settlements along the highway. The footprints of heavy metals from vehicular and industrial emissions are stored in near-by trees through bio-accumulation. In order to investigate the level of air pollution and pollution source along Abuja-Lokoja highway, the bark of agbatree (Prioriabalsamifera) were used as bio-indicator. The samples were subjected to AAS analysis to determine the elemental concentration of some heavy metals. Pollution parameters such as: Concentration, Contamination Factor (Cf) and Geoaccumulation index (Igeo) were determined and the values subjectedgraphical analysis. According to the analysis the concentration of all the elements analysed in most portion of the route falls within acceptable limits, however, there arethree zones of anomalous heavy metal concentrationswhich indicates pollution. The study further attributed the detected pollution to vehicular and industrial sources. Continuous pollution monitoring in the area is required to provide the necessary data for regulatory agencies and environmental watch groups.

Keywords: Emissions, bio-indicators, heavy metals, bio-accumulation, pollution monitoring.

I. INTRODUCTION

The Abuja-Lokoja highway is the only southern gateway to Abuja, the capital city of Nigeria; therefore, there is a high vehicular traffic. Also, the numbers of industries along the highway is increasing because of nearness to the huge Abuja market. Gaseous emission from industries and vehicles plying the Abuja-Lokoja highway is capable of impacting air quality along the highway and its adjoining areas. According to studies, the emission of gaseous volatile organic and inorganic pollutants in the form of particulate matters with sizes less than 10×10^{-6}m causes continuous decline of the quality of air (Makkonen, U. et al, 2010), consequently, leading to numerous diseases, death, ozone layer depletion, acid rain, smog, global warming, physiological problem and greenhouse effect.(Woodford C. 2010 and Wang J. et al 2013).

The 21st century is associated with rapid human population explosions, industrial growth and increased environmental pollution. The sustainability of technological growth is linked to increased exploitation of heavy metals and its derivatives. The consequence of this indiscriminate use of resource is continuous environmental degradation and health hazards. According to World Health Organisation, the increasing exposure to air pollution emanating from industrial activities, vehicular traffic and energy production is a major penalty for the current stage in industrialization and the demands for improved

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 3 March 2023, pp: 584-593 www.ijaem.net ISSN: 2395-5252

quality of life, (W.H.O, 2007). In the W.H.O 2014 report on air pollution, air pollution is identified as the culprit for the death of 7 million people in 2012. The air pollutants are released into the environment from various sources, such as; coal or gas driven power plants, other industries, and other mobile sources such as vehicles, aircrafts, and ships (W.H.O, 2014).

Despite the relative low amount of heavy metals in the atmosphere, there are significant deposition and accumulation of heavy metals in plants and soils. Some scholars opined that longer residence time and bioaccumulation enrichment of heavy metals increases susceptibility of human ingesting heavy metals in high concentration (Kachenko, A.G and B. Singh, 2006).

Generally, this study examined the concentration of heavy metals in bark of agba tree (Prioriabalsamifera) trees along Abuja-Lokoja highway in order to identify anomalies. The research further probed into the sources of the pollution using Contamination Factor (Cf) and Geoaccumulation index (Igeo)calculated and plotted graphs.The study achieved following:

a. Ascertained heavy metals contamination in the atmosphere using bark of agbatrees as biomonitor along Abuja-Lokoja highway.
b. Evaluated background concentrations of heavy metals using samples obtained at 1-2 kilometres away from the highway.
c. Evaluated variation in heavy metals concentrations in trees at specific locations along Abuja-Lokoja highway in order to ascertain additional pollutants besides vehicular emissions.
d. Investigated emissions from industrial activities along the highway such as the ethanol producing plant at Jamata, beside the Murtala Muhammed Bridge, Jamata.
e. Examined the effects of edaphic factor and underlying geology in the distribution of heavy metals in the biomonitor.

II. LITERATURE REVIEW

There are several studies on the evaluation of atmospheric pollution by heavy metals using bioindicators. Classical studies by Whatmuff (2002) and McBride (2003) discovered that increasing concentration of heavy metals in the soil increased the crop intake. According to these studies, plantation near highways are often exposed to atmospheric pollution aerosols containing heavy metals, these aerosols can be deposited directly on the soil and absorbed by plants or alternatively deposited on the leaves and fruits and then adsorbed in the tissues.

Panek and Zawodny (1993) elicited that pollution of roadside and plants by combustion of leaded petrol products are localized and limited to a belt of several metres wide on either side of the road, and that for similar geology and vegetation, the level of pollution decreases with the distance from the road. According to the research by Gheraf and Yusuf (2006), vehicle exhausts and other industrial activities emits heavy metals, consequently, plants, soil and resident along roads with busy traffic are amenable to increasing level of contamination with heavy metals.

To measure heavy metals concentrations in the atmosphere some Scientists suggested the use of bio-indicator. These bio-indicators are material such leaves, root and stems of plants which can be used indirectly to measure environmental pollution. The measurement of heavy metals in the atmosphere is preferably executed using bio-monitors because they are cheap and easy to access; also they have higher concentration (bioaccumulation) than air and rainwater (Wolterbeek B, et al, 2010 and Rai, P.K, 2014).

Ikechukwu and Percy (2015) in their study on assessment of trace metals concentration in tree barks as indicator of atmospheric pollution within Ibadan city, South-West, Nigeria alluded that tree bark samples could potentially serve as bioindicators for Cu, Pb, Zn, Cr, and possibly Co and Cd.

Also, Okunola et al (2008) studies on the concentration of Cd & Zn in the soil and vegetation along roadsides in Lagos, Nigeria concluded that automobiles are a major source of these metals along the roadside environment. In another study, Haiya and Stuanes, (2003) posited that, plants can absorb metals from soil as well as from deposit on the parts of the plant exposed to the air from polluted environments.

Both Lion G.N and Olowoyo J.O, (2013) established that Heavy metals play crucial roles in the biochemical, biological, chemical, catabolic, metabolic, and enzymatic reactions in living cells . However, excess amount of heavy metals has adverse effects on plants and animals causing various kinds of diseases (Anhwange B.A et al, 2009, Baytak S. 2014).

STUDY AREA

The study area is Abuja-Lokoja road, located in the North Central, Nigeria. The area is located partly within the Basement Complex and

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 3 March 2023, pp: 584-593 www.ijaem.net ISSN: 2395-5252

mostly within the Nupe Sedimentary basin. The area is part of the grassland savanna. The most prominent weather is rain season and dry season (harmattan). The Abuja-Lokoja highway stretches about 160km.

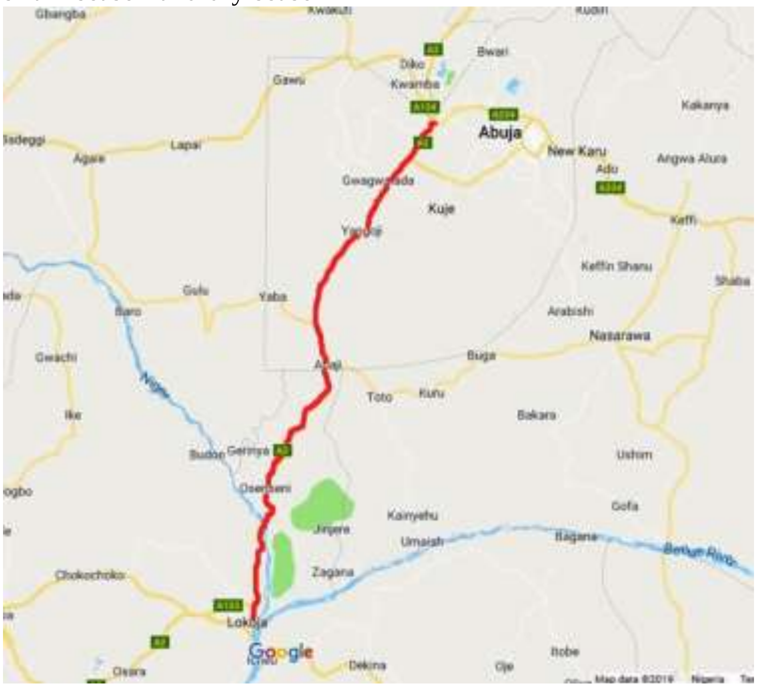

Fig. 1.0 Geographical map showing Abuja-Lokoja highway

III. METHODOLOGY

Sample collection

The investigation of air pollution along the Abuja-Lokoja highway was done by sampling of bark of agbatrees within 2-10 metre away from the road shoulders. Control samples were obtained from 500-1000metres away from the road where the environment is unaffected by vehicular emissions.

The samples were collected from 26 locations; this includes samples from selected in towns along Abuja-Lokoja highway. Using Global Positioning System (GPS) all samples were geotagged and label appropriately. The barks of selected trees were removed at about 2 metres above the ground using stainless steel knife. Duplicates of samples were collected from both sides of the road after which they mixed to obtain even samples.

In the laboratory samples were oven dried, pulverized into uniform size, digested and subjected to Atomic Absorption spectrophotometer (AAS) analysis to determine elemental concentrations for Cu, Cr, Pb, Zn. Results obtained from the AAS analysis were used to obtain pollution indicator such asGeoaccumulation Index (Igeo), Contamination Factor (Cf).

IV. RESULTS

Degree of contamination factor $C_f$was applied to determine anomalous concentration of each of the element under investigation.

$C_f = C_e/C_b$

Where Ce is the concentration of each element in the sample and C_b is the background value for the element.

Geoaccumulation index (Igeo) is a parameter which measures heavy metals contamination of the sample in respect to the background natural level of the element.

$$Igeo = \log_2 \frac{Cn}{1.5 \text{ X } Bn}$$

Where B_n is the background concentration of the element and C_n is the concentration measured. Based on the Igeo values, the level of pollution is determined.

Locations	Conc. (ppm)	Contamination Factor (Cf)	Geoaccumulation index (Igeo)
A1	102.75	11.74	0.017
A2	65.00	7.43	0.027
A3	39.50	4.51	0.044
A4	27.75	3.17	0.063
A5	20.25	2.31	0.087
A6	13.00	1.49	0.135
A7	19.75	2.26	0.089
A8	28.25	3.23	0.062
A9	15.00	1.71	0.117
A10	13.50	1.54	0.130
A11	13.00	1.49	0.135
A12	19.75	2.26	0.089
A13	30.00	3.43	0.059
A14	31.25	3.57	0.056
A15	25.25	2.89	0.070
A16	23.25	2.66	0.076
A17	22.00	2.51	0.080
A18	15.00	1.71	0.117
A19	10.25	1.17	0.171
A20	8.25	0.94	0.213
A21	15.25	1.74	0.115
A22	8.75	1.00	0.201
A23	18.25	2.09	0.096
A24	15.25	1.74	0.115
A25	15.75	1.80	0.111

Table 1.0 Cu Concentration (ppm). Cf and Igeo

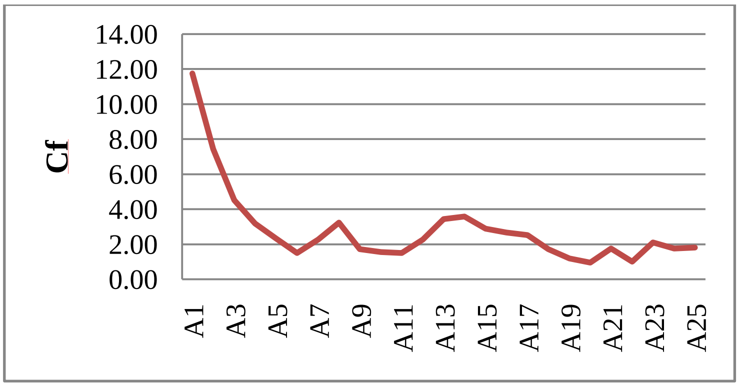

Fig. 1.0 Cu Contamination Factor (Cf)

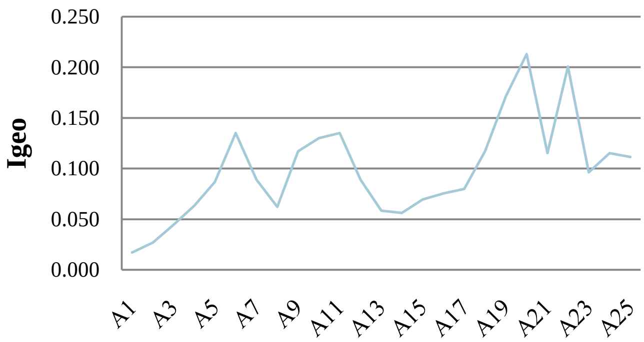

Fig. 2.0 Cu Geoaccumulation Index (Igeo)

Besides the extremely Cu concentration at A1 (Giri), generally, Cu concentrations are fairly distributed above the WHO threshold for plants.

Locations	Conc. (ppm)	Contamination Factor (Cf)	Geoaccumulation index (Igeo)
A1	0.00	0.00	0.000
A2	0.00	0.00	0.000
A3	0.00	0.00	0.000
A4	0.00	0.00	0.000
A5	0.00	0.00	0.000
A6	0.00	0.00	0.000
A7	0.00	0.00	0.000
A8	0.00	0.00	0.000
A9	0.00	0.00	0.000
A10	0.00	0.00	0.000
A11	0.00	0.00	0.000
A12	0.00	0.00	0.000
A13	0.00	0.00	0.000
A14	124.25	124.25	0.014
A15	0.00	0.00	0.000
A16	0.00	0.00	0.000
A17	0.00	0.00	0.000
A18	0.00	0.00	0.000
A19	0.00	0.00	0.000
A20	0.00	0.00	0.000
A21	38.75	38.75	0.045
A22	69.00	69.00	0.025
A23	0.00	0.00	0.000
A24	0.00	0.00	0.000
A25	0.00	0.00	0.000

Table 2.0 Cr Concentration (ppm). Cf and Igeo

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 3 March 2023, pp: 584-593 www.ijaem.net ISSN: 2395-5252

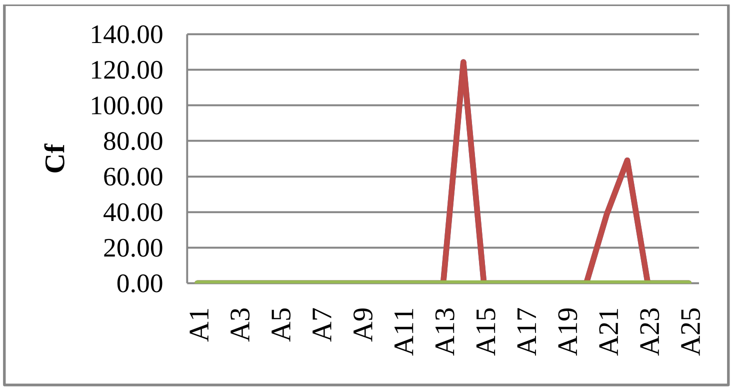

Fig. 3.0 Cr Contamination Factor (Cf)

There are two major peak at A9 (Ahoko) and A13 (Magajiya). Geologically, the two Lokojafalls within the Nupe basin.

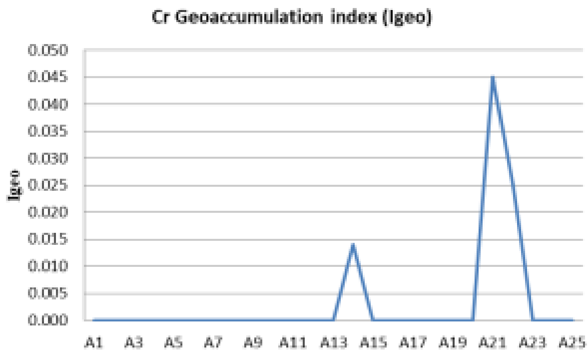

Fig. 4.0 Cr Geoaccumulation index (Igeo)

There are two major peak at A9 (Ahoko) and A13 (Magajiya). Geologically, the two Lokoja falls within the Nupe basin.

Locations	Conc. (ppm)	Contamination Factor (Cf)	Geoaccumulation index (Igeo)
A1	2.25	0.08	2.475
A2	4.50	0.16	1.237
A3	5.00	0.18	1.114
A4	0.25	0.01	22.274
A5	5.25	0.19	1.061
A6	7.50	0.27	0.742
A7	8.25	0.30	0.675
A8	10.00	0.36	0.557
A9	14.75	0.53	0.378
A10	16.50	0.59	0.337
A11	22.00	0.79	0.253
A12	25.55	0.92	0.218
A13	27.75	1.00	0.201
A14	24.25	0.87	0.230

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 3 March 2023, pp: 584-593 www.ijaem.net ISSN: 2395-5252

A15	30.75	1.11	0.181
A16	34.75	1.25	0.160
A17	39.00	1.41	0.143
A18	40.00	1.44	0.139
A19	41.25	1.49	0.135
A20	42.75	1.54	0.130
A21	33.75	1.22	0.165
A22	42.50	1.53	0.131
A23	48.00	1.73	0.116
A24	47.75	1.72	0.117
A25	46.25	1.67	0.120

Table 3.0Pb Concentration (ppm). Cf and Igeo

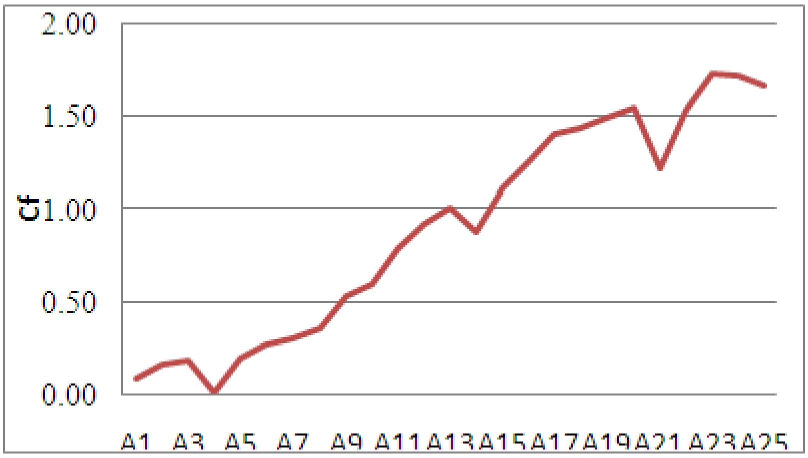

Fig. 5.0 Pb Contamination Factor (Cf)

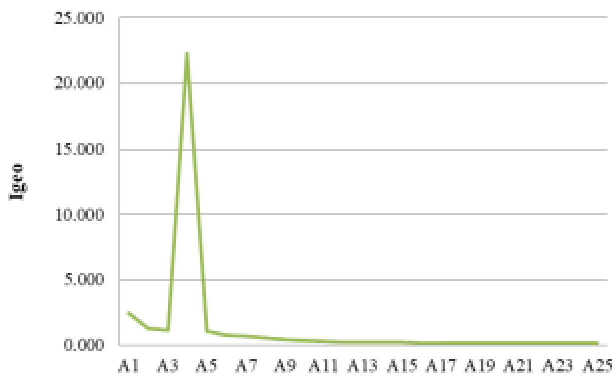

Fig. 6.0 PbGeoaccumulation index (Igeo)

Locations	Conc. (ppm)	Contamination Factor (Cf)	Geoaccumulation index (Igeo)
A1	263.00	13.84	0.014
A2	160.75	8.46	0.024
A3	116.25	6.12	0.033
A4	33.50	1.76	0.114

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 3 March 2023, pp: 584-593 www.ijaem.net ISSN: 2395-5252

A5	300.25	15.80	0.013
A6	396.25	20.86	0.010
A7	280.75	14.78	0.014
A8	259.00	13.63	0.015
A9	9.40	0.49	0.406
A10	8.75	0.46	0.436
A11	12.50	0.66	0.305
A12	40.25	2.12	0.095
A13	86.25	4.54	0.044
A14	98.25	5.17	0.039
A15	80.25	4.22	0.048
A16	60.25	3.17	0.063
A17	37.25	1.96	0.102
A18	38.50	2.03	0.099
A19	40.00	2.11	0.095
A20	42.25	2.22	0.090
A21	240.25	12.64	0.016
A22	24.25	1.28	0.157
A23	98.25	5.17	0.039
A24	100.75	5.30	0.038
A25	99.25	5.22	0.038

Table 4.0 Zn Concentration (ppm). Cf and Igeo

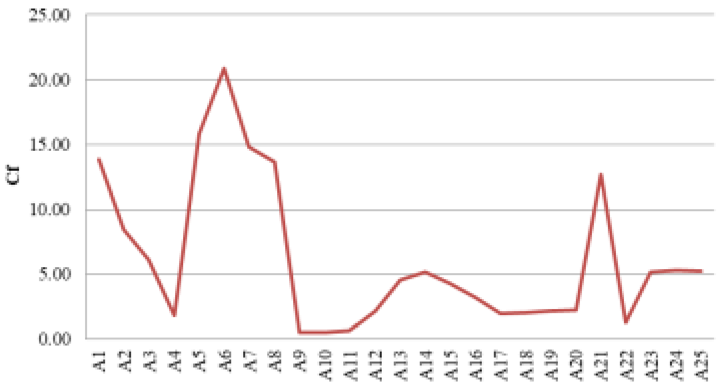

Fig. 8.0 Zn Contamination Factor (Cf)

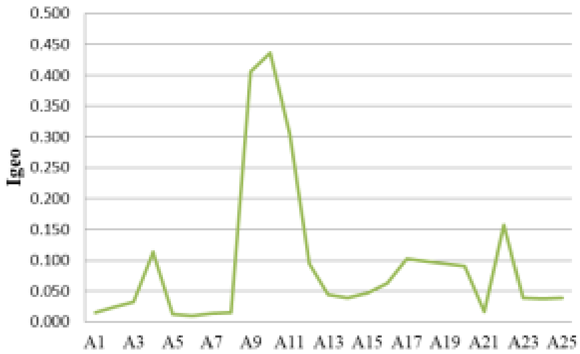

Fig. 9.0 Zn Geoaccumulation index (Igeo)

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 3 March 2023, pp: 584-593 www.ijaem.net ISSN: 2395-5252

Zn concentration peaks at location A8 (NNPC Pump Station before Abaji) and A21 (Jamata).

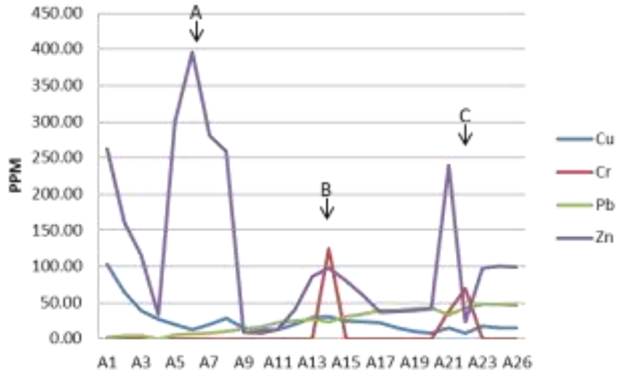

Fig. 9.0 Plot of Cu,Cr,Pb,Znconcentration (PPM)

V. INTERPRETATIONS

The study observed that there are three zones (A,B,C) of high peaks of all the four elements. These high anomalous zones are connected to industrial emission and geological enrichment in addition vehicular emissions. Zone A is around the Nigerian National Petroleum Cooperation (NNPC) pipeline pumping station,Abaji this facility has existed for several decades, therefore the anomalous figure may be attributed to emissions from the station. The Zone B is around Ahoko; geological the area is underlay by shale. According to a study around Ahoko area, the approximate order of trace metal enrichment is as follows: Zr> Y > U > Zn > Co > Mo >Sr>Pb> Cr > Ba > V > Cu > Ni >Rb, (S.A. Akinyemiet al 2015). The Zone C is between Jamata and Magajiya, beside the shale geology, the high concentration of Zinc is attributed industrial emission from the Ethanol producing plant at Jamata.

VI. CONCLUSION

The study revealed that some areas under investigation shows significant signs of air pollution based on the bio-indicator analysed. There is need for more extensive work around the three zones marked as high anomaly; also further investigation is required to accurately delineatethe anthropogenic inputs from natural source. Furthermore, the Jamata section of the highway should be closely monitored since the source of air pollution is still in operation.

REFERENCES

[1]. Akinyemi, S.A. Adebayo O.F,Madukwe H.Y, Aturamu A.O,OlaOlorun O.A. W.M. Gitari, A. Momoh& A.O. Ojo, “Geochemistry of Ahoko claystone-shale sequence, south eastern Bida Basin, Nigeria: implications or tectonic setting, provenance and source area weathering” http://www.tandfonline.com/loi/ttrs20 (Accessed July, 2022)

[2]. Anhwange, A, Kagbu J.A, Agbaji, E. B and Gimba, C,A “Trace metal contents of some common vegetables grown on irrigated farms along the banks of river Benue within Makurdi Metropolis,” Electronic Journal of Environmental, Agriculturaland Food Chemistry, vol. 8, no. 11, pp. 1150–1155, 2009.

[3]. B.Wolterbeek, S. Sarmento, andT. Verburg, “Is there a future for biomonitoring of elemental air pollution? Areview focused on alarger-scaled health-related (epidemiological) context,” Journalof Radioanalytical and Nuclear Chemistry, vol. 286, no. 1, pp.195–210, 2010.

[4]. C.Woodford, Air Pollution, 2010, http://www.explainthatstuff.com/air-pollution-introduction.html.

[5]. G. N. Lion and J. O. Olowoyo, “Population health risk due to dietary intake of toxic heavy metals from Spinaciaoleracea harvested from soils collected in and around Tshwane, South Africa,” South African Journal of Botany, vol. 88, pp. 178–182, 2013.

[6]. Gheraf H, Yusuf N (2006). Assessing Mn, Fe, Cu, Zn and Cd pollution in bottom sediments of Wadi Al-Arab Dam, Jordan. Chemosphere 65:2114–2121.

[7]. Google Map 2019

[8]. Haiyan, W. and A.O. Stuanes, 2003. Heavy metal pollution in air-water-soil-plant system of zhuzhou city, hunan province, china. Water Air Soil Pollut., 147: 79-107.

[9]. Ikechukwu and Percy (2015) Assessment of Trace Metals Concentration in Tree Barks as Indicator of Atmospheric Pollution within Ibadan City, South-West, Nigeria. Journal of Analytical Methods in Chemistry Volume 2015

[10]. J. Wang, Z. Hu, Y. Chen, Z. Chen, and S. Xu, "Contamination characteristics and possible sources of PM10 and PM2.5 in different functional areas of Shanghai, China," AtmosphericEnvironment, vol. 68, pp. 221–229, 2013.

[11]. Kachenko, A.G. and B. Singh, 2006. Heavy metals contamination in vegetables grown in urban and metal smelter contaminated sites in Australia. Water Air Soil Pollut., 169: 101-123.

[12]. McBride MB (2003) Cadmium concentration limits in agricultural soils: Weaknesses in USEPA's risk assessment and the 503 rule Human and Ecological Risk Assessment. 9: 661-674.

[13]. Okunola et al (2008) Assessment of heavy metals bioavailability in dumpsites of Zaria Metropolis, Nigeria African Journal of Biotechnology Vol. 7 (2), pp. 122-130

[14]. Panek E, Zawodny Z (1993). Trace metals in the roadside mountain soils of Sierra Nevada, Spain. Environ. Geochem.Health. 15(4):229–235.

[15]. Singh, S. and M. Kumar, 2006. Heavy metal load of soil, water and vegetables in peri-urban Delhi Environ. Monitor. Assess., 120: 79-91.

[16]. U. Makkonen, H. Hell´en, P. Anttila, and M. Ferm, "Size distribution and chemical composition of airborne particles in south-eastern Finland during different seasons and wildfire episodes in 2006," Science of the Total Environment, vol. 408, no.3, pp. 644–651, 2010.

[17]. Whatmuff, M.S., 2002. Applying biosolids to acid soil in New South Wales: Are guideline soil metal limits from other countries appropriate. Aust. J. Soil Res., 40: 1041-1056.

[18]. WHO, 2007. Health Risks of Heavy Metals from Long-Range Transboundary Air Pollution. Joint Task Force on the Health Aspects of Long-range Transboundary Air Pollution, Geneva.

[19]. Woodford. C, Air Pollution, 2010, http://www.explainthatstuff.com/air-pollution-introduction.html.(Accessed July, 2022).

[20]. World Health Organization Guidelines for heavy metal WHO Geneva (2007).