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Environmental Impact Assessment of Vehicular Traffic along Major Roads in Delta State of Nigeria, Using Contamination and Enrichment Factors

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Authors' contributions

This work was carried out in collaboration between both authors. Author HOJ designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author OZT managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

This research was carried out to evaluate the impact of vehicular traffic, on the soil and grasses growing along major roadsides in Delta state, Nigeria. Soil and Guinea grass samples were collected from three major roads, and a control point in Delta State. The collected samples (plant and soil) were digested according to standard procedures, and their heavy metals (Fe, Cu, Pb and Ni) concentrations were analyzed by using the Atomic Absorption Spectrophotometry. Results obtained indicated that the soil and grass heavy metals concentrations were significantly ($p \leq 0.05$) higher than the control point, and varied across the sampled locations. It was observed from the resulted that, there was heavy metals accumulation in the soil and plants growing along the roadsides. Irrespective of the sampling location, the concentrations of the heavy metals followed this trend Fe >Pb >Ni > Cu. As revealed by the results, at Ughelli, the contamination factor was in this order Ni > Cu >Fe >Pb; then at Ozoro road, the contamination factor ranking was Ni >Pb >Fe Cu; while at Irri road, the contamination ranked Ni > Cu > Pb > Fe. This showed that Ni had the highest contamination factor, regardless of the road location. As portrayed by the results, the heavy metals enrichment factors were greater than 1. The results revealed that the heavy metals

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enrichment factors followed this ranking Ni > Cu > Pb in all the locations sampled. These results indicated that the roadsides soil and Guinea grass received their pollution from anthropogenic sources, and vehicular emissions in particular. The results obtained from this study revealed the urgency of the government to decongest vehicular traffic, to prevent accumulation of toxic heavy metals in the ecosystems.

Keywords: Contamination factor; enrichment factor; heavy metals; pollution; vehicular traffic.

1. INTRODUCTION

Environmental pollution resulting from road vehicular traffic activities had become a major concern to environmental engineers, due to its long-term accumulative nature and hazardous effect on the ecosystems [1]. Nigeria, being one of the developing countries in the world, had recorded increment in her vehicle population recently, and number of active vehicles population stands at 11,760,871 in 2018 [2]. Air pollution can results from toxic gaseous emissions from vehicles; and also these emissions had adverse effects on the human health, plant life, soil quality, water quality, climatic conditions, etc. [3]. According to Rai [4], toxic gaseous emissions into the atmosphere are harmful to human beings, as it can lead to various cardiopulmonary diseases. The increased in severity in air pollution is amplified by traffic congestion; as this will greatly increase the rate of the emissions. Therefore, proper evaluations of the roads networks and vehicle emissions standards are necessary for the environment [5].

Heavy metals pollution of the environment has become a serious global threat, due to rapid increase in industrialization and urbanization [6]. According to Zhang [7], some heavy metals (e.g. Pb, Cd, Cu and Zn) in roadsides soils and plants tissues, were observed to be significantly associated with transportation and highway traffic activities. Heavy metals are not easily biodegradable; hence, once they entered the ecosystem they accumulate within the food web [8,9]. According to [10], plants received heavy metals through adsorption; either from the soil through the roots or from the atmosphere through the leaves, or both through the roots and the leaves. When heavy metals are absorbed even in minute quantity, they have the ability of impairing some important biochemical processes of plants and animals [11]. Jarup [12] stated that heavy metals toxicity includes: memory loss, attention deficit and behavioral abnormality, cardiovascular diseases, etc. In a study carried out by Winther and Slentø [13], they observed that vehicles lubricants contributed the highest volume of Cadmium emission; while the brakes wear is responsible for the largest percentage of copper and lead emissions. The concentration and distribution of these heavy metals in the soil and plants growing along roadsides are influenced by: The nature of the plant, highway characteristics, prevailing climatic conditions, the geotechnical properties of the soil, roadside terrain, etc. [1,14].

Researches had shown that plants growing roadsides act as remediating agents, to the toxic gaseous emissions, emitted by the vehicular traffic passing the roads. Carrero [15] observed that plants growing along roadsides tend to have higher heavy metals concentration; and in the process cleansing the soil, by effectively lowering the heavy metals concentration in the soil. Panda and Rai [16] stated that the leaves of plants growing along roadsides act as a reservoir for the particles emitted by traffic; which altered their morphological and biochemical qualities during the process. Therefore, plants are cost effective method of remediating gaseous emissions from vehicular movement, industrial and domestic activities; and be considered as an essential part, in any method adopted in cleansing the contaminated air quality [16,17]. Bioaccumulation factor, contamination factor and enrichment factor have been extensively applied to determine the degree of heavy metals contamination of plants growing along roadsides. Sulaiman and Hamzah [18] reported that plants growing along roadside have higher contamination factors than the same plants species from control sites. According to [19] as the sampling point from the main road increased from 20 m to 750 m, the accumulation of the heavy metals in the plant body and soil samples declined significantly.

Apart from plants, researches results had proved that automobiles emissions have poisonous effects on human beings. Dheeraj [20] and Lurie [21] observed that vehicular activities are the main contributors to resuspension of particulate matter from heavy metals and other carcinogenic substances; and the activities of rickety vehicles (which are available in large quantity in Nigeria) will help to increase the rate of $PM_{2.5}$ pollution in the environment. According to [22], vehicular emission had potential health implications on residential buildings, schools and hospitals closed to the roads. It had been reported [23,24] that $PM_{2.5}$ has hazardous effects on the body, as it can lead to respiratory system infection and retard growth rate in children. Although, some studies had being done on heavy metals contamination of roadside soils and plants in Nigeria, due to vehicular traffic activities [25]. Till date, no compressive research had been carried out on the impacts of vehicular traffic aided-air pollution, on plants growing along major roads in Delta state of Nigeria. Thus, this present research was carried out to investigate effect (bioaccumulation of heavy metals) of vehicular traffic on predominate grass Guinea grass (*Megathyrsus maximus*) growing along the roadsides in Delta state. Three sites of different geographical co-ordinates were selected, and the heavy metals (lead “Pb”, iron “Fe”, nickel “Ni”, and copper “Cu”) concentrations in the soil and plant samples were evaluated according to standard procedures.

2. MATERIALS AND METHODS

2.1 Study Area Description

The three sites used in this research were located along major roads in Delta State, which are subjected to subject to various volume of vehicular traffic. The sites were: Ughelli community along Ughelli-Port Harcourt expressway; Ozoro community along Ughelli-Asaba expressway and Irri community along Oleh -Uzere road (Fig. 1). The control point was located at about 5 km from the Oleh-Uzere road, with no recorded history of vehicular movement. All the sampled locations experienced two major climatic seasons, which are: wet season, that starts from April and ends in October, with the mean annual rainfall of about 1800 mm; and the dry season that start November and ends in March. The atmospheric temperature ranges from 20°C to 29°C during the rainy season; and 25°C to 35°C during the dry season [26]. The geology of Isoko and Ughelli regions is flat plain with no highlands. The Oleh-Uzere road cuts across vast area of flat plain with extensive wetland. The major source of air pollution in the study area is gas flaring, by the oil exploration and production companies, operating in the state. Detail description of the study sites is presented in Table 1.

2.2 Samples Collections and Preparation

The sampling was done at during the end of rainy season (November, 2020). At each site, Guinea grass which is one of the predominant grasses in all the sites was sampled at 20 m away from the main road; while the corresponding soil was sampled from the spot at the depth of 0–30 cm. All the soil and grass sampled were put in black polyethylene bags, labeled accordingly and taken immediately to the laboratory for chemical analyses.

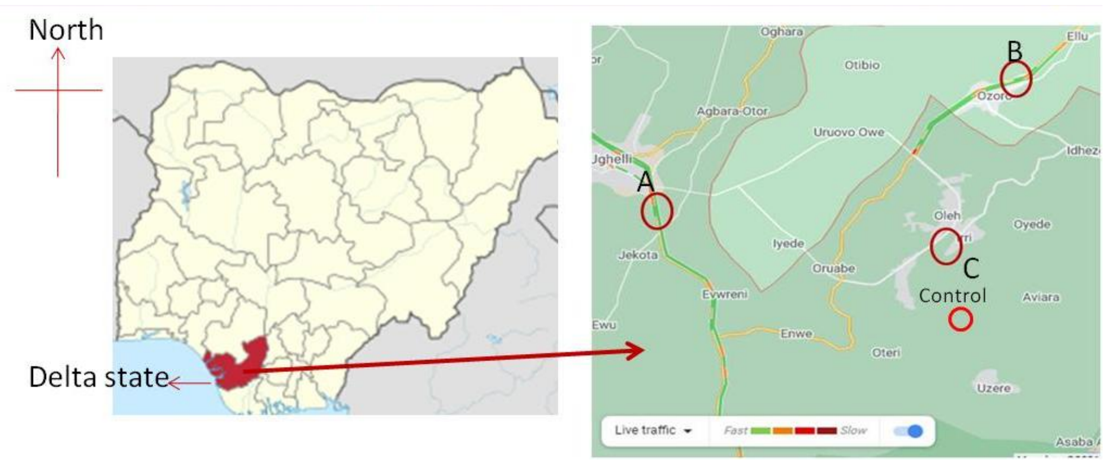


Fig. 1. Locations of the three study sites
Source: [27]

Table 1. Description of the sample sites

Spatial point	Geographical coordinates	Remarks
Site A (Ughelli-Port Harcourt Road)	Lat. 5.458^{o}N; Long 6.022^{o}E	Activities taking place in this site is just heavy vehicular movement. This is the East-West road. Vehicles going to Rivers, Akwa Iboma and other neighboring states, from Western Nigeria states pass through this road.
Site B (Ozoro community)	Lat. 5.550^{o}N; Long 6.243^{o}E	Activities taking place in this site include petty trading, heavy vehicular holdup due to the military checkpoint, and a low volume dumpsite. Most vehicles going to Eastern Nigeria from Delta State pass through this road.
Site C (Irri road)	Lat. 5.400^{0}N; Long 6.211^{o}E	Activities taking place in this site include farming and low vehicular movement.
Site D (Control)	Lat. 5.424^{o}N; Long 6.208^{o}E	Natural vegetation and no vehicular movement.

2.3 Preparation and Chemical Analyses of the Soil Samples

The soil samples collected from the sites were dried at room temperature for two weeks, before they were crushed and sieved with a 2-mm gauge stainless steel sieve. 10 g of the sieved soil sample was digested with 10 mL of a mixture of three concentrated acids (trioxonitrate (V) acid, hydrochloric acid (HCl) and tetraoxosulphate(VI) acid) mixed at the ratio of 5:1:1. Then the digested soil sample was filtered into a volumetric flask, with a whatman^{TM} No1 filter paper, and diluted with distilled water up to the 100 ml mark of the volumetric flask [28]. The heavy metals concentration in the digested soil samples were analyzed by using the Atomic Absorption Spectrophotometer, according to the ASTM International standard.

2.4 Preparation and Chemical Analyses of the Plant Samples

The Guinea grass was washed under running water to remove all soil and debris, before it was air-dried in the laboratory for two weeks. Then the air-dried Guinea grasswas divided into two parts; the root and shoot. Each part was then pulverized with an electric blinder, and sieved with a 2--mm gauge stainless steel sieve. Then 2 g of the sieved crushed plant part was poured into a round-bottom conical flask, and was digested with a mixture of three concentrated acids (trioxonitrate (V) acid, hydrochloric acid (HCl) and tetraoxosulphate(VI) acid) mixed at the ratio of 5:1:1. The digested plant sample was then filtered into a volumetric flask, using whatman^{TM} No1 filter papers, and diluted with distilled water up to the 100 mL mark [28]. The heavy metals concentration in the digested soil samples were analyzed by using the Atomic Absorption Spectrophotometer, according to the ASTM International standard.

2.5 Contamination Factor Analyses

2.5.1 Bio concentration factor (BCF)

The bio concentration factor of the Guinea grass was calculated by using the expression in given in equation 1 [29].

$$\text{bio concentration factor} = \frac{Conc.in\ Root}{Conc.in\ soil} \quad (1)$$

The BF is rated in the range shown below:

BCF ≤ 1.00 = The plant can only absorb the heavy metal, but does not accumulate it.
BCF > 1.00 = The plant can absorb and accumulate the heavy metal [29].

2.5.2 Translocation factor (TF)

Translocation factor is the ability of a plant to transfer the absorbed heavy metals from the root system to the upper parts of the plant (shoot system). It is calculated as at the ratio of the heavy metals concentration in the leaves to the heavy metals concentration in the roots; and it is calculated with the expression given in Equation 2 [30].

$$\text{Translocation factor} = \frac{Conc.in\ leaves}{conc.in\ roots} \quad (2)$$

2.5.3 Contamination factor (Cf)

Contamination Factor is the ratio of the heavy metal concentration at the sampled site to the heavy metal concentration at the control point; and it is calculated with the expression given in Equation 3 [31].

$$\text{Contamination Factor} = \frac{Conc.at\ sampled\ point}{Conc.at\ control\ point} \quad (3)$$

The contamination factor scale is as presented below:

Cf < 1 = low contamination,
1 < Cf < 3 = moderate contamination,
3 < Cf < 6 = considerable contamination,
Cf > 6 = high contamination [32].

2.5.4 Enrichment factor (EF)

Enrichment factor of the Guinea grass was calculated by using the expression given in equation 4. Iron was adopted as the reference metal, as it is particularly stable in most soil, and its concentration is not easily affected by anthropogenic activities [33].

$$Enrichment\ factor = \frac{C_x/C_{fe}(Sample)}{C_x/C_{fe}(Control)} \quad (4)$$

C_x = heavy metal concentration at the sampled point
C_{fe} = Concentration of the reference element.

The enrichment factor scale is as presented below:

EF ≤ 2 = low minimal
2 < EF ≤ 5 = moderate
5 < EF ≤ 20 = significant
EF > 20 = very high [33].

2.6 Statistical Analysis

Data obtained from this study were analyzed by using Statistical Package for Social Sciences (SPSS version 22.0), and the statistical significance level was defined at p < 0.05. Charts were plotted from the data obtained in this study, by using the Microsoft Excel for Windows.

3. RESULTS AND DISCUSSION

3.1 Effect of Road Location on the Heavy Metals Contamination Level

The ANOVA results of the effect of site location on the heavy metal concentrations in the soil and plant samples are given in Table 2. As presented in Table 2, the site location had significant (p ≤ 0.05) effect on all the heavy metals investigated in this study. In addition, the ANOVA results further revealed that the parts of the grass tested significantly (p ≤0.05) influenced the heavy metals concentration in the Guinea grass sampled in this research.

3.2 Heavy Metals Concentrations

The statistical descriptions of the heavy metals (Fe, Pb, Cu and Ni) concentrations in the roadside soils and grass samples, sampled from the three locations (Ughelli, Ozoro and Irri) and the control site are presented in Table 3. As shown in Table 3, the heavy metals concentrations at the three locations sampled, were significantly (p ≤0.05) higher than the value obtained from the control point. This depicted that the gaseous emissions from the vehicles had significant (p ≤0.05) effect on the heavy metals concentrations of the soil and grasses growing along the roadsides. This was in conformity with the observation of previous researchers. Nabulo [34] stated that plants that grow within 30 m of the edge of a road are exposed to air pollutants; thus, increasing the heavy metals contents of their roots and shoots systems. According to [35] Pb, Ca, Cu, and Zn are the major heavy metal pollutants of the roadside environments. As shown in Table 3, at Ughelli, the iron and copper concentrations were higher at the roots than in the soil; while the lead and nickel concentrations were lower in the roots than in the soil. Likewise, at Ozoro, the iron, lead and nickel concentrations were higher in the roots than in the soil; while the copper concentration was lower in the root than in the soil. Then at Irri, the iron, copper and lead concentrations were higher in the soil than in the root; while the nickel concentration was higher in the root than in the soil.

As presented in Table 3, at Ughelli, the grass leaves contain the highest Fe, Cu and Ni concentrations. Similarly at Ozoro, the grass leaves contain the highest Fe and Ni concentrations; while at Irri, the grass leaves contain the highest Fe, Cu and Ni concentrations. The lowest concentrations recorded for some of the heavy metals at the grass leaves, can be attributed to the high concentration of the heavy metals in the soil, and the barrier created by the grass roots. According to Liu [29] grasses roots usually act as a barrier for heavy metals translocation from the roots to the leaves. The higher heavy metals contents recorded in the grass root and leaves, when compared to the control values can be primarily attributed to its accumulation in the soil, through anthropogenic activities such as vehicular activities; which is in similar trend, as reported earlier [18]. Ogundele [25] in their research on the effect of traffic emission on the environment reported that, emissions from heavy vehicular traffic were responsible for the high accumulation of Pb, in the tissues of plants growing along roadsides. Additionally, Onder [36] reported that particles materials emitted by vehicles brakes tyres can increased the Ni concentration of soil and plants growing the heavy traffic roads.

3.3 Environmental Pollution Assessment

3.3.1 Bio-concentration and translocation factor

The bio concentration factors for the of the grass sample at the various locations are presented in Fig. 2. As revealed in Fig. 2, the iron BCF was greater than 1 in all the three locations. It was further observed that the copper BCF was greater than 1 at Ughelli, but was less than 1 at Ozoro and Irri roads. The lead BCF was less than 1 at Ughelli and Irri roads, but was greater than 1 at the Ozoro, as portrayed by the results. Lastly, the nickel BCF was less than 1 at the Ughelli road, but was greater than 1 at the Ozoro and Irri roads. This portrayed that at Ughelli road, the grass only absorbed Fe and Cu, and does not accumulated them; but the grass absorbed and accumulated the Pb and Ni. Similarly, at Ozoro road, the grass only absorbed Fe, Pb and Ni, and does not accumulated them; while the grass absorbed and accumulated the Cu metal. Then at the Irri road, the grass only absorbed Fe and Ni, and does not accumulated them; while the Cu and Pb metals were absorbed and accumulated by the grass. According to Satpathy [37], if BCF < 1, then the grass only absorbed the

Table 2. The ANOVA results of the effect of sampling point on the heavy metals concentration of the soil, grass roots and grass leaves

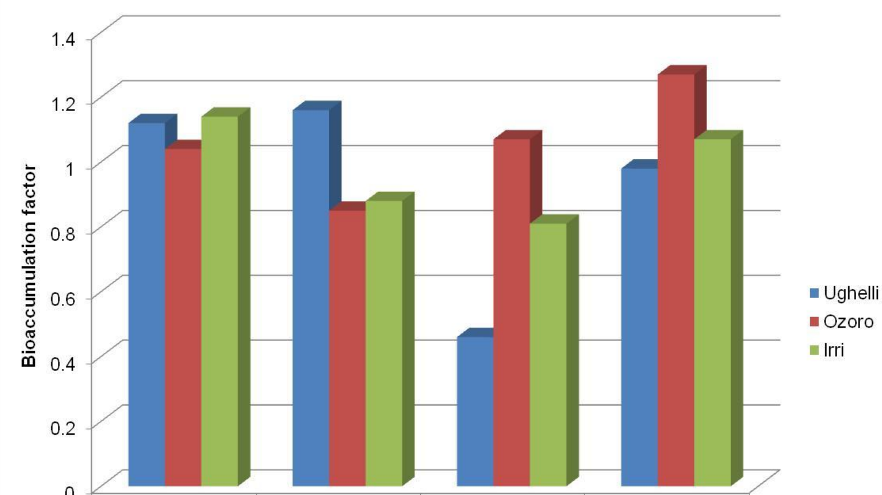
Source		Sum of Squares	df	Mean Square	F	p-value
Site	Fe	30352241.64	3	10117413.88	1540.78	1.45E-27*
	Cu	47.64	3	15.88	416.54	8.01E-21*
	Pb	8223.19	3	2741.06	672.55	2.79E-23*
	Ni	364.17	3	121.39	795.43	3.81E-24*
Tested Part	Fe	326589.56	2	163294.78	24.87	1.41E-06*
	Cu	0.77	2	0.39	10.15	6.41E-04*
	Pb	851.38	2	425.69	104.45	1.43E-12*
	Ni	17.65	2	8.83	57.84	6.62E-10*
Site * tested Part	Fe	456759.78	6	76126.63	11.59	4.31E-06*
	Cu	4.801338889	6	0.80	20.99	1.86E-08*
	Pb	1020.298311	6	170.05	41.72	1.55E-11*
	Ni	15.06767222	6	2.51	16.45	1.91E-07*

** = significant at Duncan p ≤0.05; ns = not significant at Duncan p ≤0.05;*

Table 3. Heavy metals concentration of the soil, grass roots and leaves samples

Location	Tested part	Heavy metals			
		Fe	Cu	Pb	Ni
Ughelli	Soil	$2060.33^c±66.98$	$3.50^a±0.30$	$39.63^c±4.82$	$4.36^a±0.41$
	Roots	$2304.33^b±11.06$	$4.06^b±0.08$	$18.56^b±0.32$	$4.28^a±0.28$
	Leaves	$2590.00^a±21.63$	$4.05^b±0.23$	$17.29^a±0.34$	$5.22^b±0.57$
Ozoro	Soil	$3084.67^a±65.85$	$4.50^c±0.40$	$50.57^b±2.94$	$7.30^a±0.23$
	Roots	$3362.67^b±46.53$	$3.82^b±0.10$	$54.18^c±1.26$	$9.30^b±0.46$
	Leaves	$3481.67^c±78.23$	$2.72^a±0.27$	$47.37^a±1.76$	$11.65^c±0.71$
Irri	Soil	$1256.33^b±40.10$	$2.13^b±0.21$	$23.73^c±3.35$	$2.95^b±0.10$
	Roots	$1168.67^a±32.01$	$1.87^a±0.06$	$19.20^a±0.27$	$3.16^a±0.63$
	Leaves	$1326.33^c±63.17$	$2.32^c±0.08$	$21.94^b±0.74$	$4.15^c±0.26$
Control	Soil	$1110.33^c±65.36$	$1.20^b±0.10$	$14.89^c±0.24$	$0.42^a±0.13$
	Roots	$886.67^a±84.10$	$1.06^a±0.03$	$9.31^b±0.35$	$0.66^b±0.03$
	Leaves	$1006.33^b±25.58$	$1.11^a±0.02$	$4.79^a±0.29$	$0.77^c±0.08$

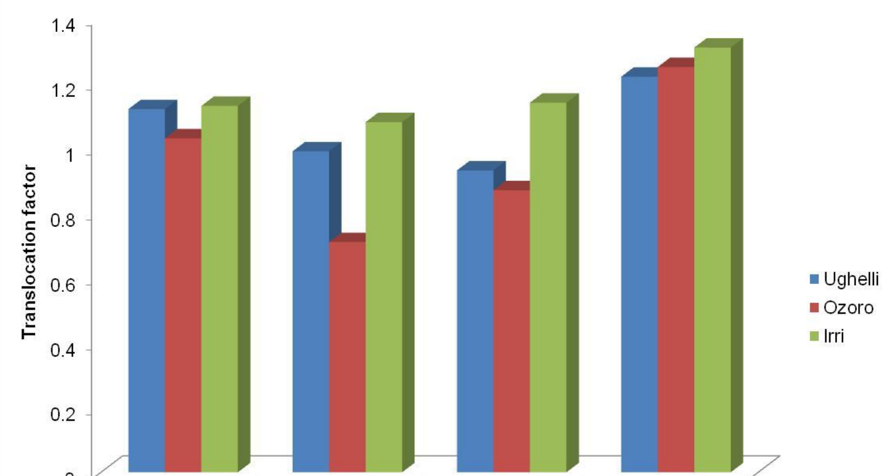
Rows with the same common letter superscript for them location, are not significantly different at p ≤0.05



	Iron	Copper	Lead	Nickel
Ughelli	1.12	1.16	0.46	0.98
Ozoro	1.04	0.85	1.07	1.27
Irri	1.14	0.88	0.81	1.07

Heavy metals

Fig. 2. Bio-concentration factors of the heavy metals



	Iron	Copper	Lead	Nickel
Ughelli	1.12	0.99	0.931	1.22
Ozoro	1.03	0.71	0.87	1.25
Irri	1.13	1.08	1.14	1.31

heavy metal

Fig. 3. Translocation factor of the heavy metals

metal and does not accumulate it; but if BCF > 1, then it indicated that the grass did not only absorbed the metal but accumulated it. Al-Ali [38] stated that higher concentrations of the contaminants of the soil, usually leads to lower BCF values of the grasses growing on it. These results are in line with other studies reports [39], which stated that high BCF of plants growing close to roadsides signified that anthropogenic activities (vehicular emissions) were responsible for the increment of the heavy metals concentration in the soil and plant samples.

Results of the translocation factor of the Guinea grass, in respect to the various sampling locations are presented in Fig. 3. As presented by the results, at Ughelli and Ozoro roads, the Fe and Ni translocation factor was greater than 1; while the Cu and Pb translocation factor was less than 1. Then at Irri road, the Fe, Pb, Cu and Ni translocation factor was greater than 1. The findings of this study are similar to the previous results [18], and they showed that the absorption of heavy metals from the atmosphere by the plants leaves and stem, is equally as important as the translocation of heavy metals from the soil to plant body. Similar results were recorded by [19] for Plantago plant, on study carried along major traffic roads.

3.3.2 Contamination factor and enrichment factor

The results of the contamination and enrichment factors of the soil samples collected from the three locations are displayed in Table 4. The results showed that the heavy metals contamination factors were greater than I in all the sampled locations. As revealed by the results, the ranking of the contamination factor at Ughelli was in this order Ni > Cu >Fe >Pb; then at Ozoro road, the ranking was in this order Ni >Pb >Fe Cu; while at Irri road, the ranking was in this order Ni > Cu > Pb > Fe. This showed that Ni had the highest contamination factor, in all the three sampled locations. The Ni contamination was at considerable degree at Irri road, but became high degree at the Ughelli and Ozoro roads, respectively. The high contamination factors (Cf ≥2) generally recorded at the Ughelli and Ozoro road is an indication that the soil received most of the pollution through anthropogenic sources, and vehicular emissions in particular [40]. In comparison, the heavy metals contamination factors at the rural (Irri) road were lower than the results contamination factors results obtained from the urban (Ughelli and Ozoro) roads. This affirmed that the roadside soil received most of its contamination from intensive vehicular intrusions. Furthermore, the study revealed that Fe, Ni and Pb contamination factors obtained at Ozoro road were higher, than the Fe, Ni and Pb contamination factors obtained at the Ughelli road. The high heavy metals contamination factors recorded at the Ozoro road, against the values recorded at Ughelli and irri roads, could be attributed to the leachates seepage from the dumpsite near (about 250 m) the collection point. Akpomrere [41] reported that leachates from dumpsite are able to increase heavy metals concentrations in the soil and water bodies; thus, their locations should be sited at a safer distance from sources of drinking water and other agricultural activities.

The distribution patterns of the heavy metals EF at the three sampled locations are presented in Table 4. The results revealed that the heavy metals followed a decreasing EF of this order Ni > Cu > Pb in all the roads sampled in this study. As shown by the results, Ni had the highest EF, while Pb had the least EF, irrespective of the sampling location. Results presented in Table 4 indicate that Cu enrichment ranges between 1.349 and 1.572, Pb enrichment factor ranges between 1.223 and 1.434, while the Ni enrichment factor ranges between 5.594 and 6.256. The EF values reveled that traffic emissions, which include vehicular emission, fuel combustion, etc. are responsible for the environmental pollution. Combustion of leaded fuel, usually result to Pb contamination of the environment [42]. Dolan [35] reported that vehicles operations, such as: fuel combustion, wear and tear of the tires, fuel leakages, rusting of the metallic parts, etc. tend to release heavy metals into the ecosystems. Citing [43] Pb and Cu are some of the heavy metals pollution associated vehicular traffic.

Table 4. Contamination and enrichment factors of the heavy metals

Factor	Site	Heavy metals			
Contamination factor		**Fe**	**Cu**	**Pb**	**Ni**
	Ughelli	1.86	2.92	2.66	10.38
	Ozoro	2.78	3.75	3.40	17.38
	Irri	1.13	1.78	1.59	7.02
Enrichment factor	Ughelli	1	1.572	1.434	5.594
	Ozoro	1	1.349	1.223	6.256
	Irri	1	1.568	1.408	6.208

4. CONCLUSION

This study was initiated to evaluate the impact of traffic emissions on the environment. Soil and grass samples were collected from four different locations, within Delta State, and their heavy metals (Fe, Cu, Pb and Ni) concentrations tested according to standard procedures. Results obtained from the chemical analyses revealed that the vehicular traffic emissions, significantly ($p \leq 0.05$) affected the heavy metals concentrations of the soil and grass samples. The heavy metals concentrations of the soil samples collected from the three roadsides, were significantly ($p \leq 0.05$) higher, than the results obtained from the control point. At Ughelli roaed, the iron and copper concentrations were higher at the grass roots than in the soil; while at Ozoro road, the iron, lead and nickel concentrations were higher in the roots than in the soil; then at Irri road, the iron, copper and lead concentrations were higher in the soil than in the root. As revealed by the results, the bio concentration factors of the heavy metals in the sampled grass, varied across the various locations. Additionally, as revealed by the results, the ranking of the heavy metals contamination factor at Ughelli was in this order Ni > Cu >Fe >Pb; then at Ozoro road, the ranking was in this order Ni >Pb >Fe Cu; while at Irri road, the raning was in this order Ni >Pb >Cu > Fe. As portrayed by this study, the vehicular emission (anthropogenic activities) is the main source of the heavy metals contaminations of the environment. The results obtained from this study revealed the urgency of the government to decongest vehicular traffic, to prevent accumulation of toxic heavy metals in the ecosystems.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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