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Road Construction and Vehicular Activities as Indicators for Heavy Metal Pollution in Osogbo Metropolis, South West Nigeria

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Abstract

The levels of heavy metals in soil samples from selected major roads under construction, burrow sites (a place where soil was obtained for road filling) and two roads under use have been investigated. Soil samples were collected and digested using standard methods. The digests were analyzed for Ni, Cr, Zn, Cd, Cu and Pb using Atomic Absorption Spectrophotometer. The data were subjected to descriptive statistics, non linear regression and one way analysis of variance (ANOVA). The results showed that cadmium had the highest Contamination Factor (CF). The Pollution Load Index of the roads under construction was higher than each of the Burrow site and one of the Trunk C roads analyzed for comparison. The Ecological Risk Factor of the sampling sites was less than 40 which indicated that, the levels of heavy metals on the road construction sites did not pose ecological risks to the environment. The Ecological Risk Index of each of all the sampling sites was less than 150 indicating that they fell within the low ecological risk category. The study established that the Burrow site did not contribute to the heavy metal concentration of the road under construction and the contamination was traced to vehicular activities.

Keywords: Heavy metal concentration, City pollution, Ecological risk factor, Burrow site, Vehicular density

1. Introduction

Heavy metals are generally regarded as substances with density five times higher than that of water, and can have adverse effects on animals and plants (Jarup, 2003). These metals are indestructible and many are toxic if present beyond permissible levels and thus, heavy metal pollution of the natural environment is a global issue. According to Kirpichtchikova et al. (2006), most metals are not degraded by microbes or chemical means but are oxidized in the presence of moisture and oxygen to cations which persist for a long period in soils. It has been reported that heavy metal pollution affects crop quality and production, water bodies, and threatens human and animal health via accumulation through the food chain, inhalation of air and skin contact (Satarug, Garrett, Sens, & Sens, 2010). These metals can be taken up by plants and animals from soil, air and water sources. In plants, they are absorbed along with water through the stomata or by the root hairs (Satarug et al., 2010). They may have stimulatory, toxic or inhibitory effects on biochemical processes in plants and animals (Gikas & Romanos, 2006).

Such effects in humans include altering DNA and RNA, reproductive system disorders, cancer, bone mineralization, Parkinson's disease etc. High concentrations of heavy metals in soil have been reported to have caused a number of deleterious effects on plants which include growth retardation, destruction of chlorophyll, disorders in biochemical activities, mutations and reproductive disorders (Gall & Rajakaruna, 2013).

Road construction has remained the major activity for the growth of industrial units, stimulating economic activities and this has led to the loss of forest cover and subsequent loss of soil fertility. Roadside soils often show an elevated amount of contamination that can be credited to automobiles (Mmolawa, Likuku, & Gaboutloeloe, 2011). The discharge of heavy metals is one of the most important environmental issues caused by road construction (Mafuyai, Kamoh, Kangpe, Ayuba, & Eneji, 2015). Erosion by wind and water facilitates the entry and spread of these metals in the environment (Morais, Costa, & Pereira, 2012). Indeed, heavy metals have been reported to receive much attention due to their toxicity (Su et al., 2012) and their presence is a useful pointer for contamination in soils (Ubwa, Abah, Ada, & Alechenu, 2013).

Heavy metal status of soils from some major roads in Nigeria has been reported, they include Ogbomoso, South West Nigeria (Yekeen & Onifade, 2012), Maiduguri (Uwah & John, 2014), Jos Metropolitan Area, Nigeria (Mafuyai et al., 2015) and in Parts of Owerri, Nigeria (Okereke, Nduka, Ukaoma, & Ogidi, 2019). Similar reports have been obtained in roadside soils along the Shenyang-Dalian highway in Liaoning Province, China (Hui et al., 2017). Similar studies have not been obtained in Osogbo in recent times. Indeed, due to large population and rapid urbanization, most people in Osogbo live close to busy roads where they can be exposed to metal pollution from various activities on the roads. It is therefore imperative to investigate the heavy metal status in top-soils of selected roads under construction in Osogbo metropolis, as an indicator for pollution of selected areas in Osogbo, the capital of Osun State, Nigeria.

2. Materials and Methods

2.1 Sampling sites and sample collection

The city of Osogbo, the capital of Osun State, is situated between latitude 7^o 6' N and 7^o 15' N, and longitude 3^o 17' E and 3^o 25' E; and covers about 268 km^2. It is located in the south-western part of Nigeria and about 100 km south of Ilorin, 115 km northwest of Akure and 88 km northeast of Ibadan. The capital city comprises of Olorunda and Osogbo Local Government Areas with a total population of 300,000 people (Oyelowo, Chima, & Oladoye, 2010; Taiwo, Michael, Gbadebo, & Oladoyinbo, 2019; Tijani & Onodera, 2009). Osogbo, being the capital of the State, is the focus of a large number of migrants due to political and socio-economic activities.

The criteria for the selection of roads for the study area were based on the major road constructions being undertaken. The study Road Stretches (RS) represented alphabetically as A to F were: Ilesa Garage–Suzzy (RSA**)**, Suzzy–Okebale Roundabout (RSB**),** Okebale Roundabout–Testing Ground (RSC**)**, Testing Ground–Stadium Roundabout (RSD**)**, Olorunkemi– Suzzy (RSE) and UNIOSUN –Sasa (RSF) as well as the burrow site (G). A, B, C and D were Roads under construction with simultaneous vehicular movement (D > A > C > B); E was a trunk C road with very low vehicular activities; F was also a trunk C road but with high vehicular activities involving commercial and private vehicles; G was a burrow site, i.e., the place where the construction companies normally obtain soil to fill the roads. Road E and F were used as controls.

A total of eighty eight (88) samples were taken from the aforementioned areas of study with seventeen from RSA, four from RSB, ten from RSC, five from RSD, nine from RSE, twenty three from RSF and twenty from G. The soil samples were obtained with plastic spoons at a depth of about 0.5 cm from the surface of the roads. The sampling points and locations are as presented in Figure 1. The samples were air–dried at a clean section of the laboratory, sieved through 2 mm mesh and placed in white plastic bags. Samples from each road stretch were combined and labelled appropriately; RSA, RSB, RSC, RSD, RSE and RSF were labelled as samples A, B, C, D, E and F, respectively while the combined samples from burrow site was labelled as sample G. They were all kept at a dry place pending the analysis.

2.2 Sample digestion

Wet digestion method was used as earlier described by Addis and Abebaw (2017). All reagents used were of analytical grade and distilled–deionized water was used for rinsing and sample preparation. Soil sample (air–dried, ground, and sieved) of 1.0 g was weighed into a digestion tube. Aqua regia of 12 mL and 3 mL of H_2O_2 were measured and added into the digestive tube and gently swirled to mix the sample properly. The digestion tubes were then placed on a digestion furnace (Surgifield Medical, Model SM1008, England, UK) and heated at 180°C for 3 h inside a fume cupboard. All the digests were cooled, filtered through Whatman No 42 filter paper and diluted to 100 mL with distilled–deionised water. Each sample was digested in replicates of three, transferred to acid–washed stoppered glass bottle, labelled and kept for analysis with Atomic Absorption Spectrophotometer (AAS – PG990, United Kingdom). The concentrations of, Cd, Pb, Ni, Cr, Zn and Cu in the samples were then determined. The blank was prepared in a similar way using distilled–deionized water. The instrument working calibration was made by diluting commercial Scharlau Japan stock solution (1000 ppm) standard with distilled–deionized water. A recovery study was carried out by spiking portions of the samples with known amounts of the analytical standards of cadmium, lead, nickel, chromium, zinc and copper. All of these were dried, homogenized, and passed through the digestion and analytical steps. The mean percent recoveries were determined by dividing the experimental concentration with the spiked concentration for each of the metals.

2.3 Data analysis

The measurements were done in triplicate. Data were subjected to descriptive statistics, non linear regression and one way analysis of variance (ANOVA). Duncan's multiple range test (IBM SPSS Statistics 20) was carried out to establish the significant level at $P < 0.05$. Results were expressed as means ± Standard Deviation (SD). In addition, the Contamination Factor (CF) for the metals were calculated and used to assess the extent of contamination at each of the sampling sites. The CF for a particular metal is the ratio of the concentration of the metal in the soil to the concentration of the background or target value. CF is a good index for contamination assessment and to guide decision making (Yahaya, Abubakar, & Abdu, 2021).

The pollution load index (PLI) at each of the sampling site was also calculated to assess the combined metal concentration at the sampling site and it took into consideration the contribution (sum) of the contamination factors of each metal at a study site. It is suitable for site assessment and decision making (Yahaya et al., 2021). Furthermore, the Ecological Risk Factor (ERF) was determined to evaluate the potential ecological risk associated with the presence of each metal. It was obtained as a product of the individual toxic response factor and contamination factor (Yahaya et al., 2021). The Potential Ecological Risk Index (PERI) was calculated to determine the ecological risk at each sampling site. It was obtained as the cumulative effect of the ecological risk factor of each metal. It is a good index for site quality assessment (Yahaya et al., 2021).

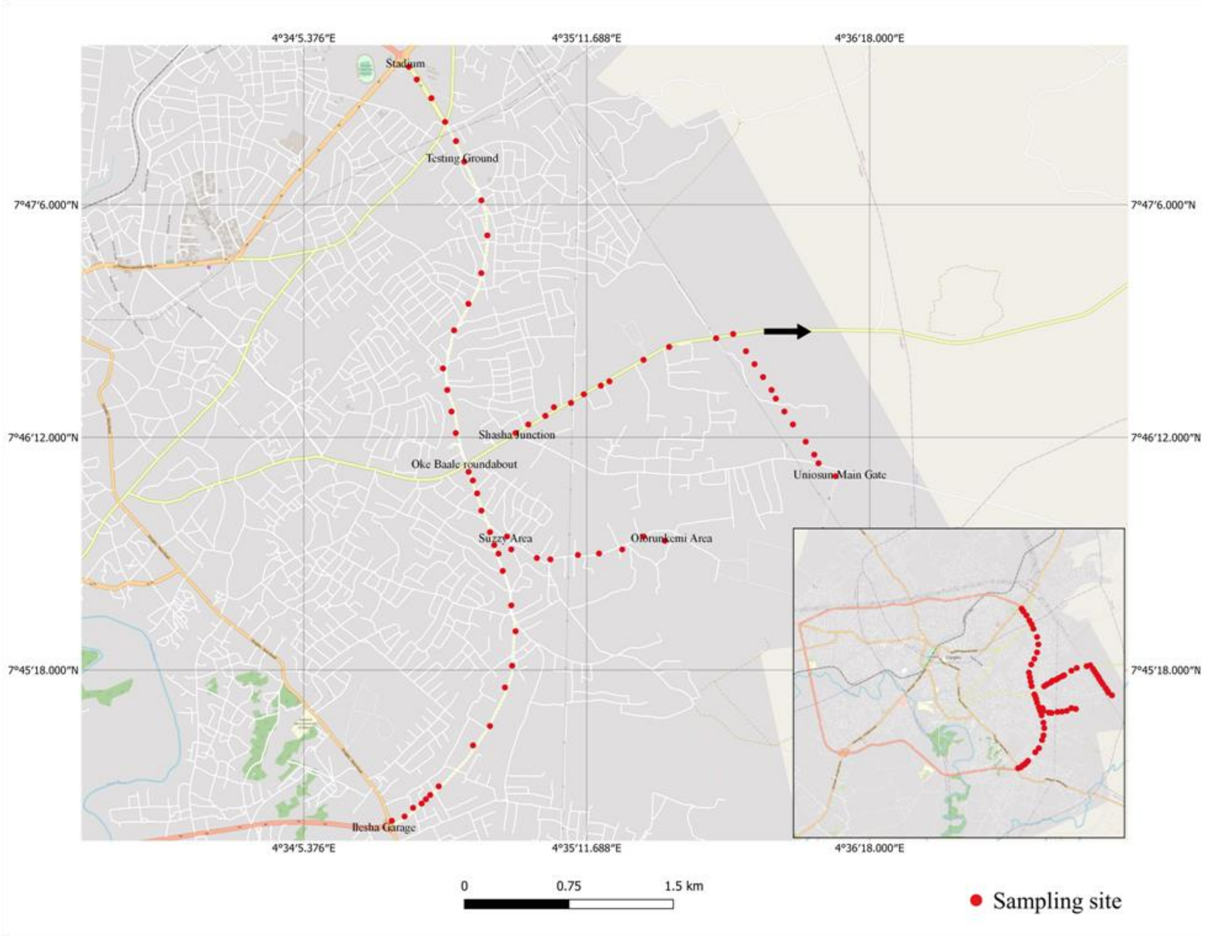

Figure 1. Map of the roads under construction showing the sampling location.

3. Results and Discussion

3.1 The levels of heavy metals

The concentrations of the heavy metals, their ranges and comparison of their average values with the levels reported for other countries are as shown in Table 1, Table 2 and Table 3, respectively. The concentration of Nickel in the samples ranged from 7.22 to 15.15 mg/kg and the least and highest values were obtained in samples E (Olorunkemi–Suzzy road) and C (Okebaale Roundabout – Testing Ground), respectively. The levels were significantly different ($P < 0.05$). Low concentration of Nickel is expected from sample E, although it is under usage, but only a few numbers of vehicles ply it. Sample C with the highest level of Ni is not significantly different from sample D (Testing Ground – Stadium Roundabout). Both roads were under construction and the reason for the high level could be attributed to private and commercial vehicular activities that took place simultaneously with the construction work. The level of Nickel in each of samples C and D was significantly higher than the concentration recorded in sample G. As shown in Table 3, comparison of the average levels of Nickel in all the samples showed that it was lower than the levels reported for other countries as well as the permissible levels by United States Environmental Protection Agency (USEPA) and Department of Petroleum Resources (DPR) in Nigeria. Low level of Nickel is of advantage because it has been reported that Nickel is a carcinogenic agent that can also induce systemic reactions (Suzuki, Yabuki, & Ono, 2008). Report indicated that Nickel finds its way into the ambient air as a result of the combustion of coal, diesel oil and fuel oil (Cempel & Nikel, 2006).

The chromium contents of the soil samples ranged from 14.41 mg/kg (Sample G) to 46.08 mg/kg (Sample D). The values were significantly different ($P < 0.05$). Thus, the levels of Cr in samples B, C, E and G were not significantly different ($P < 0.05$) and were all significantly lower than those in samples A, D and F. The chromium contents of the roads under construction (Samples A, D and F) were significantly higher than that of burrow site (sample G); this could be attributed to private and commercial vehicular activities that took place simultaneously with the construction work. Chromium content of sample E is expected to be significantly lower than sample F ($P < 0.05$) based on fewer and large numbers of vehicles that ply them, respectively. Comparison of the average chromium contents with other countries (Table 3) showed that, the level recorded in this study was less than the levels in Asia and Europe. Comparison with international standards showed that the level of chromium in this study was less than National Environmental Standards and Regulations Enforcement Agency (NESREA), WHO and DPR, but the value was almost twice the tolerable level by USEPA. Higher level of chromium is dangerous to humans because it has been linked to cancer pathogenesis (Liu, Shen, Liu, Wang, & Li, 2007).

The zinc contents of the samples ranged from 4.25 mg/kg in sample E to 30.24 mg/kg in sample F. The levels of zinc in the samples were significantly different ($P < 0.05$). Highest level of zinc in sample F could be attributed to vehicular density. The levels of zinc at the burrow site (sample G) and sample D were not significantly different but were significantly lower than level of zinc in sample F. Thus, the levels of zinc in the samples varied from one sample to the other and the variation was in line with vehicular activities on the roads outside and around the construction site. The average level of zinc in this study was lower than values from other countries as well as local and international regulatory bodies (Table 3). Zinc is a raw material in the production of brake lining because of its heat conducting properties. Consequently, its particles could be released due to continual mechanical abrasion of the vehicles. Also zinc particles could be released to the environment due to combustion processes of engine oil and motor vehicle tire attrition (Shinggu, Ogugbuaja, Barminas, & Toma, 2007). It has been asserted that among the heavy metals, Zn is the least toxic and very essential component of healthy diet; however beyond the tolerable limit, for an instance zinc sulfate tablets, containing 150 mg elemental zinc, it could lead to health-related complications such as diarrhea, fever, nausea, lethargy and vomiting (Fischer, Giroux, & L'Abbe, 1984; Samman & Roberts, 1987).

The concentrations of cadmium in the samples ranged from 0.24 mg/kg in sample G to 1.40 mg/kg in sample D, and were significantly different ($P < 0.05$). The Cd contents of samples E and G were not significantly different ($P < 0.05$) and the value was the least among the samples. Sample D had the highest concentration of Cd. The average level of Cd in this study was higher than the tolerable levels in Asia but lower than the tolerable levels in Europe and UK. Comparison with local and international regulatory bodies showed that the value was higher than the tolerable level approved by WHO and USEPA. The level was however lower than 3 mg/kg from NESREA/FEPA, but comparable with 0.8 mg/100g from DPR. Cadmium in the samples could be caused by combustion of lubricating oil and wearing of tires from road abrasion (Deska, Bombik, Marciniuk-Kluska, & Rymuza, 2011). According to Ahmed et al. (2015), cadmium is a classic carcinogen which could lead to hepatic, renal, and pulmonary injury.

The copper contents of the samples ranged from 6.72 mg/kg in sample E to 20.43 mg/kg in sample D. The values were significantly different at $P < 0.05$. The copper content of samples G and E (Olorunkemi–Suzzy) were not significantly different but were significantly lower than the copper contents of other samples ($P < 0.05$). Obviously, low vehicular movement must have contributed to the low level of Cu in sample E and lack of vehicular movement must have plausibly accounted for the low level of copper at the burrow site. Just like the majority of other heavy metals that were considered in this study, the highest level of copper was obtained in sample D. Thus, apart from Ni and Zn, where samples C and F had the highest concentrations, respectively, sample D had the highest levels of Cr, Cd and Cu. Comparison of the average levels of copper in all the samples showed that they were lower than reported values from other countries, and both the national and international regulatory bodies. Presence of Cu in soil samples has been reported by Akbar, Hale, Headley and Athar (2006) to be a reflection of activities involving either engine wear, thrust bearings, bushing or bearing metals.

The recovery of each of the metals was higher than 90%.

3.2 Contamination factor

It has been proved that the contamination factor of a metal has a direct proportionality to the extent of pollution and or contamination of that metal (Lacatusu, 1998). According to the author, when the contamination factor is lower than 1, it indicates lower risk, while values greater than 1 denote higher risks. Accordingly, the contamination factors for the heavy metals in each of the samples at all the sampling sites are as shown in Figure 2. The contamination factor of each of the various sampling sites was less than 1 except sites C and F. This implies that road C (under construction with simultaneous vehicular movement) and F (a trunk C road, busy because staff and commercial vehicles ply it) were slightly polluted with Cd whereas the other sampling sites fell within the range of very slight contamination to very severe contamination for all the heavy metals. None of the roads was severely or excessively polluted as a result of road construction activities. However, the contamination factor of Cd was found to be higher than those of the other heavy metals at all the sampling sites.

Table 1. Concentration of heavy metals in the soil samples (mg/kg).

Samples	**Ni**	**Cr**	**Zn**	**Cd**	**Cu**
A	10.43 ± 2.81^{b}	23.31 ± 14.77^{b}	15.42 ± 7.93^{b}	1.08 ± 0.19^{c}	10.69 ± 6.59^{b}
B	11.76 ± 2.16^{b}	14.60 ± 1.43^{a}	20.75 ± 3.17^{c}	0.58 ± 0.23^{b}	9.32 ± 4.01^{ab}
C	15.15 ± 0.70^{c}	14.88 ± 0.14^{a}	15.67 ± 0.23^{b}	0.69 ± 0.01^{b}	7.20 ± 0.09^{a}
D	14.68 ± 0.45^{c}	46.08 ± 0.11^{c}	18.98 ± 5.86^{ab}	1.40 ± 0.09^{c}	20.43 ± 0.82^{c}
E	7.22 ± 7.25^{a}	14.72 ± 14.24^{a}	4.25 ± 3.77^{a}	0.24 ± 0.24^{a}	6.72 ± 5.77^{a}
F	10.35 ± 0.16^{b}	20.54 ± 0.61^{b}	30.24 ± 0.16^{d}	0.54 ± 0.06^{b}	10.35 ± 0.12^{a}
G	7.84 ± 3.76^{a}	14.41 ± 15.61^{a}	18.09 ± 18.81^{ab}	0.24 ± 0.42^{a}	7.32 ± 8.91^{a}
Total Mean	11.06 ± 4.06	21.22 ± 13.64	17.63 ± 10.07	0.68 ± 0.46	10.29 ± 6.13
% Recovery	91.34 ± 10.5	100.00 ± 2.7	95.50 ± 4.7	94.75 ± 7.01	98.66 ± 3.34

The results are presented as means ± SD for three samples (n = 3).

$^{a\text{-}d}$ Means followed by different letters on the same column are significantly different at P < 0.05**.**

Samples - A: Ilesa Garage–Suzzy, **B:** Suzzy–Okebale Roundabout**, C:** Okebale Roundabout–Testing Ground, **D:** Testing Ground–Stadium Roundabout, **E:** Olorunkemi–Suzzy, **F:** UNIOSUN–Sasa, G: Burrow Site

A, B, C, D: Roads under construction with simultaneous vehicular movement

E: Control (a trunk C road, not busy because few vehicles ply the road)

F: Control (a trunk C road, busy because staff and commercial vehicles ply it)

G: (burrow site, i.e., the place from where the construction companies obtain soil to fill the road)

Table 2. The range of the concentrations of heavy metals in each of the soil samples (mg/kg).

Samples	**Ni**	**Cr**	**Zn**	**Cd**	**Cu**
A	9.32–13.62	11.50–39.87	7.60–23.45	0.90–1.28	6.74–18.30
B	9.44–13.72	13.12–15.98	17.42–23.72	0.34–0.80	6.91–13.95
C	14.52–15.9	14.73–15.01	15.40–15.81	0.68–0.70	7.10–7.25
D	14.18–15.05	46.00–46.21	15.30–25.74	1.30–1.46	19.91–21.37
E	7.15–14.5	5.52–7.22	5.52–7.22	ND–0.72	0.58–12.02
F	10.21–10.53	20.00–21.20	30.10–30.42	0.49–0.60	10.21–10.43
G	4.22–11.72	2.1–31.97	4.08–39.47	ND–0.73	1.47–17.57

Samples – A: Ilesa Garage–Suzzy, **B:** Suzzy–Okebale Roundabout**, C:** Okebale Roundabout–Testing Ground, **D:** Testing Ground–Stadium Roundabout, **E:** Olorunkemi– Suzzy,
F: UNIOSUN–Sasa, **G:** Burrow site

A, B, C, D: Roads under construction with simultaneous vehicular movement

E: Control (a trunk C road, not busy because a few vehicles ply it)

F: Control (a trunk C road, busy because staff and commercial vehicles ply it)

G: Burrow site, i.e., the place where the construction companies obtain soil to fill the road
ND: Not Detected

3.3 Pollution load index

The pollution load index gives an indication of the extent of contamination at the sampling sites by taking into account the individual contributions of the metals. The pollution load index for each of the study site is less than 1 as shown in Figure 3 and followed a descending order: F > C > B > D > E > G > A. Each of the roads under construction (B, C and D) had a higher pollution load than the Burrow site (G) and road E used for comparison. However, road F which was not under construction at the time of this study had a higher pollution load than roads A, B, C, D and E. This might have been due to the high traffic density on road F from the commercial and staff vehicles.

Table 3. Comparison of the total average levels (mg/kg) of the heavy metals in this study with levels from other countries and tolerable levels from national/international regulatory bodies.

Country/Regulatory bodies	Ni	Cr	Zn	Cd	Cu	Reference
Osogbo, Nigeria (all sites mean)	11.06	21.22	17.63	0.68	10.29	This study
Asia (CSEPA)	40	150	200	0.3	50	Hu et al., 2017
Europe (Germany)	200	500	600	5	200	He et al., 2015
UK	230	N/A	N/A	1.8	N/A	He et al., 2015
NESREA/FEPA	70	100	421	3	100	Ogbonna et al., 2020
WHO		100		0.1	100	Ogbonna et al., 2020
USEPA	72	11	1100	0.48	270	He et al., 2015
DPR	35	100	140	0.8	36	DPR, 2002

NESREA/FEPA: National Environmental Standards and Regulatory Enforcement Agency/Federal Environmental Protection Agency

DPR: Department of Petroleum Resources

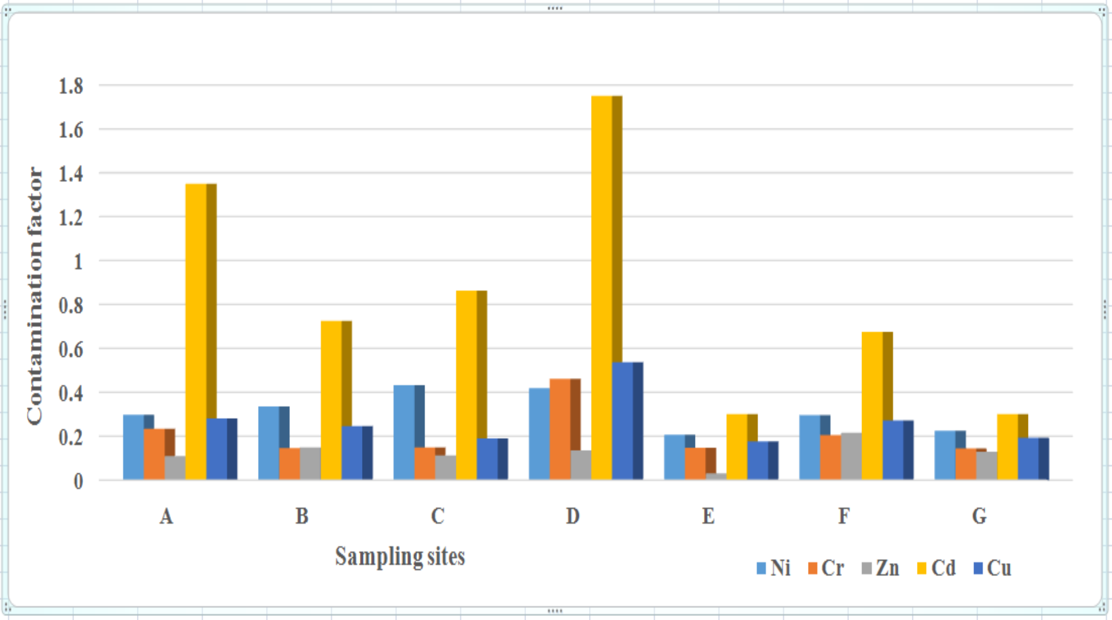

Figure 2. Contamination factor for the heavy metals at the sampling sites.

Samples – **A**: Ilesa Garage–Suzzy, **B**: Suzzy–Okebale Roundabout, **C**: Okebale Roundabout–Testing Ground, **D:** Testing Ground–Stadium Roundabout, **E**: Olorunkemi–Suzzy, **F:** UNIOSUN–Sasa, **G**: Burrow Site

3.4 Ecological risk assessment

3.4.1 Ecological risk factor

The results obtained for the ecological risk factor are shown in Figure 4. The ecological risk factor for all the heavy metals was found to be lower than 40. This implies that the presence of the metals on the roads posed low ecological risks. Cd had the highest ecological risk factor at all the sampling sites. This result was consistent with the results obtained for the contamination factor of the metals at the various sites.

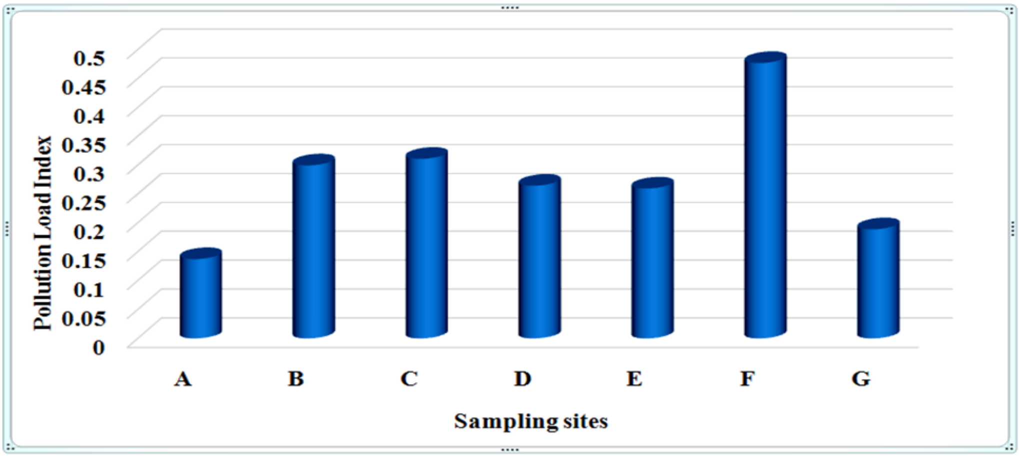

Figure 3. Pollution Load Index for the metals at the sampling sites.
Samples – **A**: Ilesa Garage–Suzzy, **B**: Suzzy–Okebale Roundabout, **C**: Okebale Roundabout–Testing Ground, **D**: Testing Ground–Stadium Roundabout, **E**: Olorunkemi–Suzzy,
F: UNIOSUN–Sasa, **G**: Burrow site

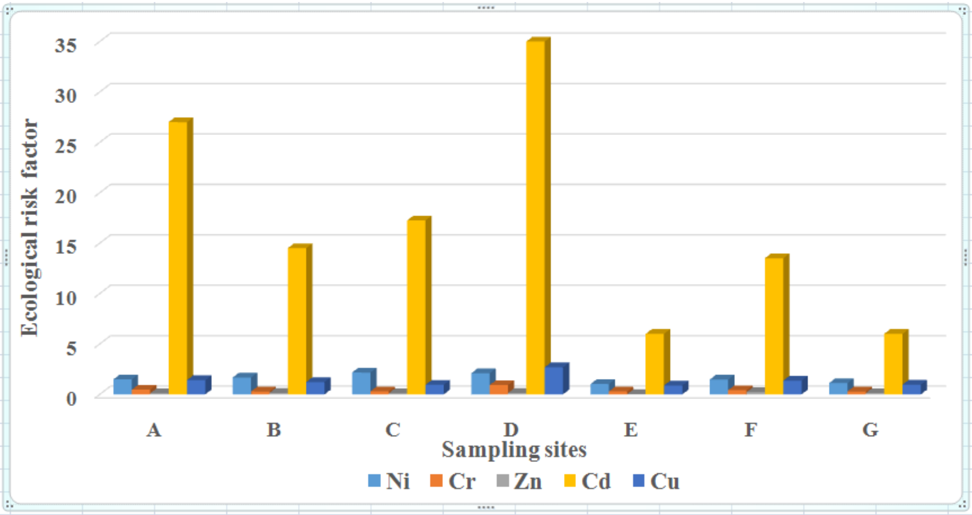

Figure 4. Ecological risk factor for the metals at the various sampling sites.
Samples – **A**: Ilesa Garage–Suzzy, **B**: Suzzy–Okebale Roundabout, **C**: Okebale Roundabout–Testing Ground, **D**:Testing Ground–Stadium Roundabout, **E**: Olorunkemi–Suzzy,
F: UNIOSUN–Sasa, **G**: Burrow Site

3.4.2 Potential ecological risk index

The result obtained for the potential ecological risk index is as shown in Figure 5. The potential ecological risk index takes into account the contributions of each of the heavy metals and provides a broader picture of the extent of contamination at each of the sampling sites. From the result obtained, the potential ecological risk index of the roads followed a descending order: F > C > E >D. Thus, road F (used for comparison) had the highest value which was even higher than the roads under construction (A, B, C and D) and the Burrow site (G) as well as road E that was also used for comparison. However, each of the values lied within the low ecological risk category (< although, analysis of the results from this study showed that none of the sampling sites would pose risk to the people, however, the level of cadmium with an average level that was higher than the tolerable level approved by WHO and USEPA called for worry and concern. This is attributed to the fact that heavy metals have potential to accumulate and worst still, they have been reported to remain in soil for extended periods because they degrade slowly, posing a severe risk to ecosystems

150). Thus, they will not pose risk to the people. and threatening human health through exposure pathways such as inhalation of dust, dermal contact, and ingestion of crops grown in the soil. Indeed, vehicular emission is needed to be under serious control. Results from a study by Kristensson et al. (2004) revealed that gaseous emissions were higher in Sweden than in the USA and Switzerland, foremost due to the lower-fraction catalytic converters in Sweden.

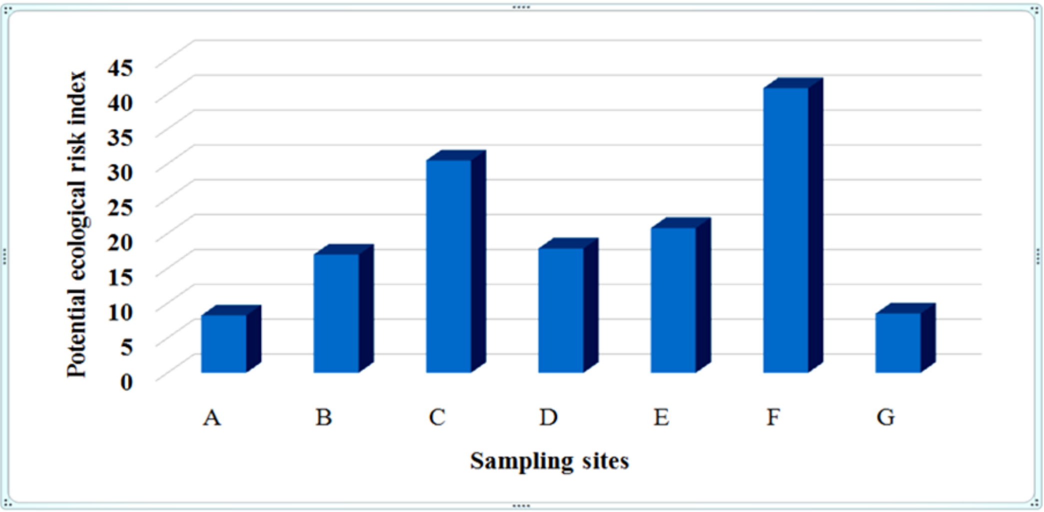

Figure 5. Potential ecological risk index of the metals at the sampling sites.
Samples – **A:** Ilesa Garage–Suzzy, **B**: Suzzy–Okebale Roundabout, **C**: Okebale Roundabout–Testing Ground, **D:** Testing Ground–Stadium Roundabout, **E**: Olorunkemi–Suzzy,
F: UNIOSUN–Sasa, **G:** Burrow site

4. Conclusion

The study established the levels of heavy metals in the samples and analysed the influence of the generated data on the inhabitants of the area where the construction work took place with respect to contamination, pollution and ecosystem. The results showed that cadmium had the highest concentration and its average level was higher than the tolerable level approved by WHO and USEPA. The UNIOSUN access road had the highest contamination factor with respect to all the heavy metals investigated although it was not under construction at the time of this study. The UNIOSUN access road also had a higher pollution load than each of the roads under construction, the Burrow site and Olorunkemi–Suzzy (a control) which might have been due to the high vehicular density from the commercial and staff vehicles. The ecological risk factor for all the roads were found to be lower than 40 implying that, the presence of the heavy metals on the roads posed low ecological risks to the society. The Potential Ecological Risk Index (PERI) of each of the sites lied within the low ecological risk category (< 150) indicating that none of the sampling sites would pose risk to the people. It is however advisable to check the status of the soil at the burrow sites before they are approved to fill the road. Also vehicular emission should be controlled to check the pollution load, contamination factor and ecological risk index.

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