Assessment of Vehicular Pollution of Road Side Soils in Ota Metropolis, Ogun State, Nigeria

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***Abstract*--** **Vehicular emission has been found to constitute one of the major sources of soil pollution. We have investigated the influence of vehicular emissions on the accumulation of heavy metal in the roadside soils of Ota metropolis, Ogun State, Nigeria. The main objective of this research was to determine the impact of heavy metals such as copper, cadmium, lead, manganese, nickel and sulphate from vehicular pollution on soil around Ota. Seven locations were selected on the basis of their high concentration of vehicular traffic. Three sites with low traffic concentration were also selected outside the seven locations to act as control sites. Samples were taken in a period of three months in the dry season. The concentrations of five heavy metals and sulphate in the samples were determined with an atomic absorption spectrometer. The concentrations of the heavy metals from the seven main sites were higher than in the control sites. The concentration of each heavy metal and sulphate in the seven locations was below the European Union regulatory standard. Although these concentration are below the European Union regulatory standard, these heavy metals and sulphate, which over time are washed by erosion into the local areas used for farming, may pose health hazards. The enhancement of fuel quality and the adoption of emission standards to mitigate the impact of vehicular emissions on human health should be made mandatory.**

***Index Term* --** **Vehicular emission, environment, soil pollution, pollutants and bioaccumulation**

I. INTRODUCTION

The rapid increase in the use of vehicles for day to day transportation in most developing countries, coupled with a lack of emission standards in these countries, has contributed a great deal of concern over vehicular pollution [1, 2]. Vehicular emission is at its peak when there is an increase in population, together with increase in the number of vehicles on roads [3]. Most of the by-products of automobiles comprise of different fraction particles. These fractions include the ultrafine particles which are formed in the engines and tailpipes, fine particles produced mainly by chemical reactions, and coarse particles which are formed mechanically by the abrasion of road materials, tyres and brake linings [4].

Unlike developing countries, most developed countries have been able to reduce the trend of vehicular pollutant emissions in spite of population increases. This was as a result of their implementation of stricter standards imposed on the rates of emissions from different kinds of vehicles, the use of alternative or cleaner fuels like ethanol, improved technology, and transportation regulations [5]. Unfortunately, this kind of pollution control has failed in the developing countries due to lack of reliable information and research and the complexity of the factors contributing to vehicular pollution. In Nigeria, for instance, the State Environmental Protection Agency (SEPA) and the Federal Environmental Protection Agency (FEPA), now the National Environmental Standards and Regulations Enforcement Agency (NESREA) are charged with the responsibility of enforcing environmental laws, regulations and standards in order to deter people, industries and organizations from polluting and degrading the environment. However, these responsibilities were restricted to the control of air, water, and noise pollution, waste disposal and oil spillage. No consideration was given to soil pollution, especially by the major threats to environmental health.

Soils are seen to be contaminated as a result of anthropogenic activities and vehicular emission has been found to constitute one of the major sources of soil pollution. Several studies have been carried out on road side soils because they contain heavy metals. These heavy metals have adverse environmental and health effects [6, 7]. However, the majority of these studies have been performed in developed countries with a history of industrialization and the use of leaded fuel. Only very few of such studies have been carried out in developing countries like Nigeria [8, 9, 10]. As a consequent of various observations, different arms of the government environmental controlling agencies are interested in the effects of vehicular emissions on the soil and on the environment as a whole. In this report, we evaluate the concentrations of copper, cadmium, lead, manganese, nickel and sulphate on soil around Ota, the commercial and industrial hub of Ogun State, and make some useful recommendations to the government.

A. Scope of Study

The extent of vehicular pollution of soils in Nigeria is widespread and the effects are felt all around the nation. However, this study focuses on Ota metropolis considering seven major locations with considerable amount of traffic which significantly contributes to soil pollution.

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B. Limitation of Study

This study examines the impact of heavy metals such as copper, cadmium, lead, manganese, nickel and sulphate from vehicular pollution on soil around Ota in the dry season only.

II. MATERRIALS AND METHODS

Study Area

Figure 1 shows the map of Ota township map while Figure 2 shows the traffic congestion of the Ota metropolis. Table 1 shows the seven locations and the control sites. It should be noted that no industrial activity is apparent near the vicinity of the sampling area

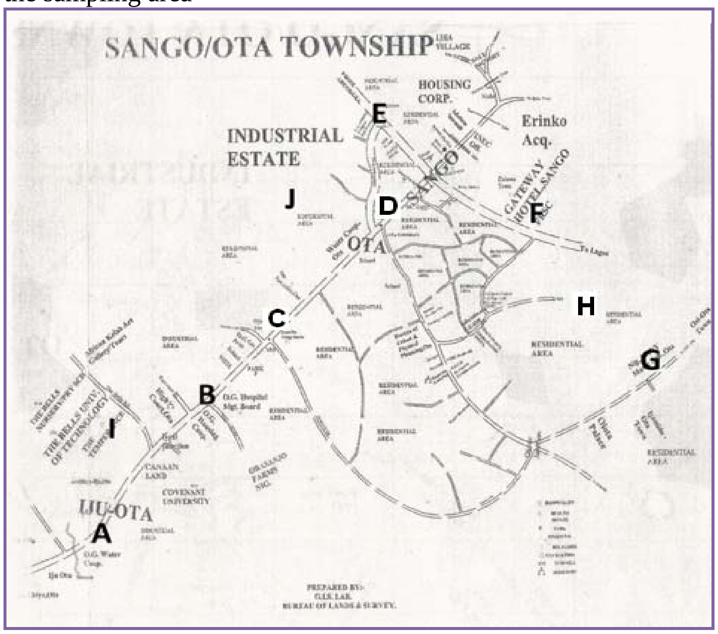


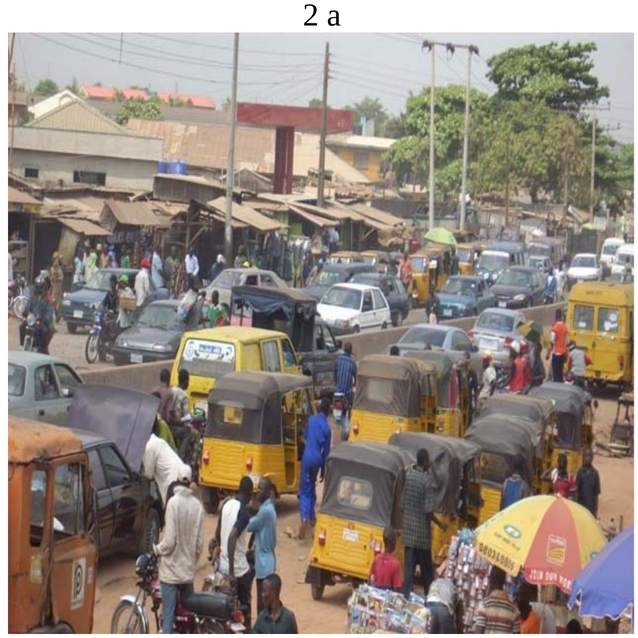
Fig. 1. A Map of Ota Township, Ogun State (study area).

TABLE I
Seven sampling locations and control sites

Seven Main Sites	Three Control Sites
A. Iju-Ota water Cooperation Road	I. Residential Area
I. Housing Estate Road	
J. Maltina Road	
K. Toll Gate Road	J. Residential Area
L. Joju Road	
M. Oju-Ore Road	
N. AIT Road	H. Residential Area

This study focuses on seven major locations in Ota metropolis with considerable amounts of traffic that could significantly contribute to soil pollution. Ota is a town in the Ado-Odo Local Government of Ogun state, Nigeria, with an estimated population of 526,565 [11]. It covers an area of 878 square kilometers and lies at latitude 6° 58' N and longitude 3° 41' E. Ota town, where Covenant University is located, has the third largest concentration of industries in Nigeria [12]. The nature of the roadways is one of the factors that contribute to vehicular pollution because the availability of good roads ensures that vehicles spend less time on the road; this in turn ensures that the surrounding soil is less polluted.

2 a



2 b

Fig. 2. Traffic congestion in Ota metropolis

Samples and Sampling Locations

A sample each was collected in each of the seven selected locations monthly over a period of 3 months (December - February) and one sample each were taken from each of the control sites making it a total of 24 samples. Areas with obvious signs of disturbance, such as animal burrowing, engine oil spillage and landfills, were avoided. Sampling spots were cleared of debris before actual sampling started [13, 14]. 500 g of composite soil samples were collected within a distance of 0-5 meters from the edge of the main road at each location. All soils collected were sampled at the surface (0 to 10 cm in depth) using a hand-driven stainless steel auger. The soil samples were kept in labeled polythene bags and taken to the laboratory for analysis [14, 15].

Methods of Laboratory Analysis

The data used in this assessment were obtained by analyzing the soil samples with a Perkin Elmer 3300 atomic absorption spectrometer. The size of each large clod was first reduced and the sample was spread on a tray in a layer not thicker than 15 mm. Thereafter, the various samples were placed in a drying oven at a temperature of 40°C. They were left in the oven for 24 hours to remove the moisture in the samples. Each oven-dried sample was crushed into particles and passed through a 2 mm sieve (EPA method 3052) [16]. However, before crushing commenced, stones, fragments of glass and other noticeable impurities were removed by hand. 1g of each soil sample was accurately weighed and treated with 10 ml of high purity of concentrated HNO_3. The mixture was placed on a hot plate until it became dry. It was then cooled. This procedure was repeated with another 10 ml aliquot of concentrated HNO_3 followed by 10 ml of 2 M HCl. Each digested soil sample was then warmed in 20 ml of 2 M HCl to redissolve the metal salts. The extract was filtered with filter papers and the volume was then adjusted to 25 ml with double distilled water. The concentrations of copper, cadmium, lead, manganese, nickel and sulphate in each sample were determined on a Perkin Elmer 3300 Atomic Absorption Spectrometer equipped with AA Winlab software.

III. RESULTS

Table 2 shows comparisons of the results of this study with results from other studies and the European Union regulatory standards. Figures 3 - 9 compare the variations in the concentrations of copper, cadmium, lead, manganese, nickel and sulphate in the soil samples over three months with the controls. The site labeled I (Fig. 1) was the control for sites A and B; the site labeled J was the control for sites C, D and E; while the site labeled H was the control for the sites F and G.

TABLE II
comparing the values of this experiment with values of other studies

Metals	This study	[17] Study in USA	[18] Study in China	[19] Study in Poland	[20] Study in India	[21] Study in Ethiopia	EU Reg. Standard
Cu	6.98 - 42.36	2.86-101	7.26-55.1	2.0-18.0	5.34-198.23	23.7 - 93.0	50-114
Cd	0.01 - 0.35	NA	0.02-0.33	0.1-1.7	NA	0.12 - 1.61	1.0-3.0
Pb	0.01 - 26.60	4.62-55.4	9.95-56.0	7.1-50.1	ND-623.95	20.3 - 325.4	90-300
Mn	21.17- 95.48	43-2532	134-1740	83-1122	NA	NA	1500
Ni	0.33 - 64.40	2.44-69.4	7.73-70.9	2.0-27.0	343-1409	47.3 - 200.6	50.0
SO_4	1.0-101.45	NA	NA	NA	NA	NA	1000

Source; [17, 18, 19, 20, 21, 22]; ND= Not Detected; NA =Not Available

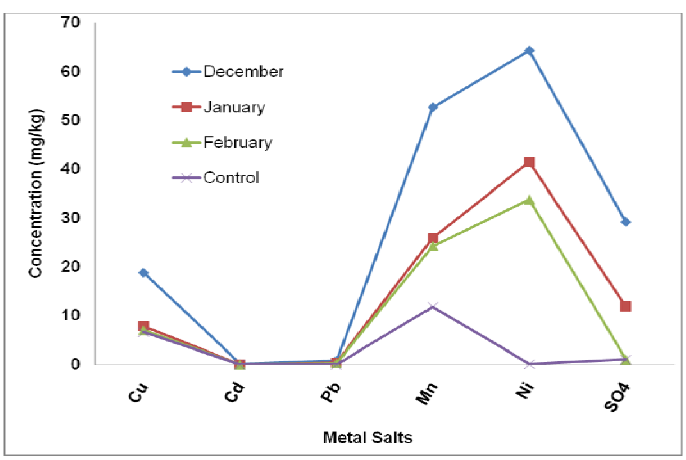


Fig. 3. Concentrations of heavy metals in location A over 3 Months

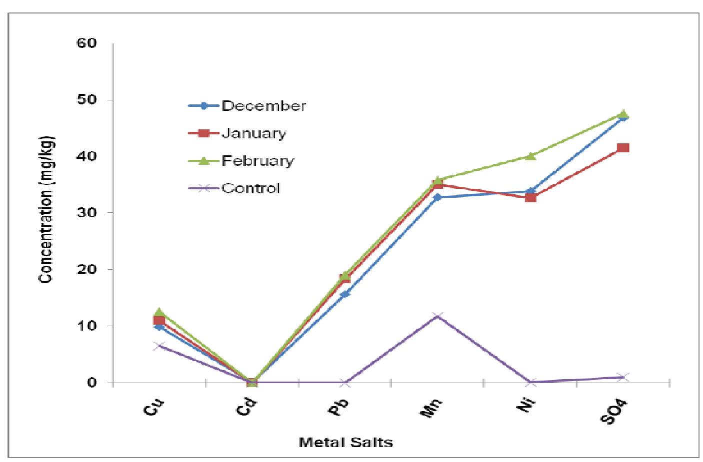


Fig. 4. Concentrations of heavy metals in location B over 3 Months

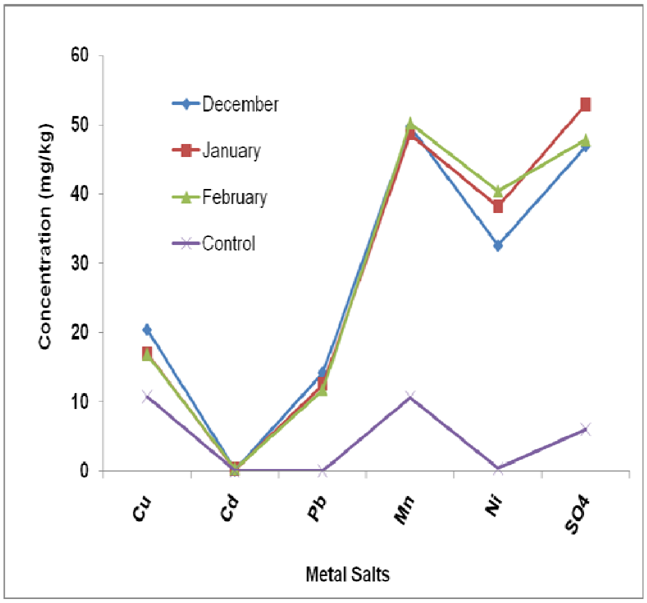


Fig. 5. Concentrations of heavy metals in location C over 3 Months

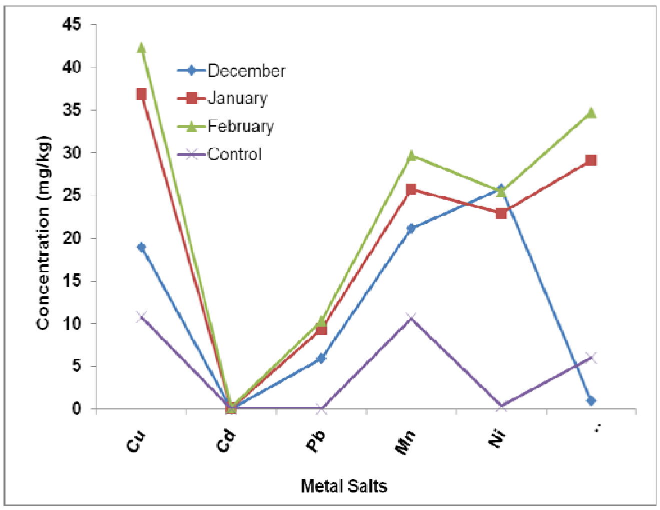


Fig. 6. Concentrations of heavy metals in location D over 3 Months

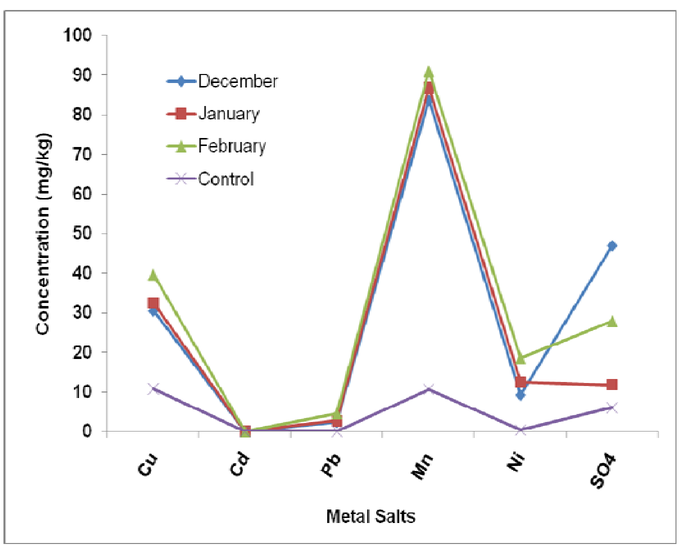


Fig. 7. Concentrations of heavy metals in location E over 3 Months

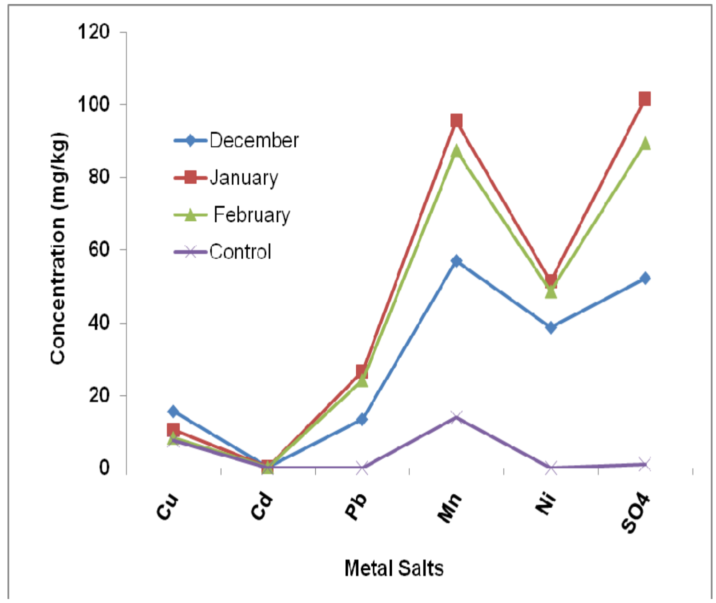


Fig. 8. Concentrations of heavy metals in location F over 3 Months

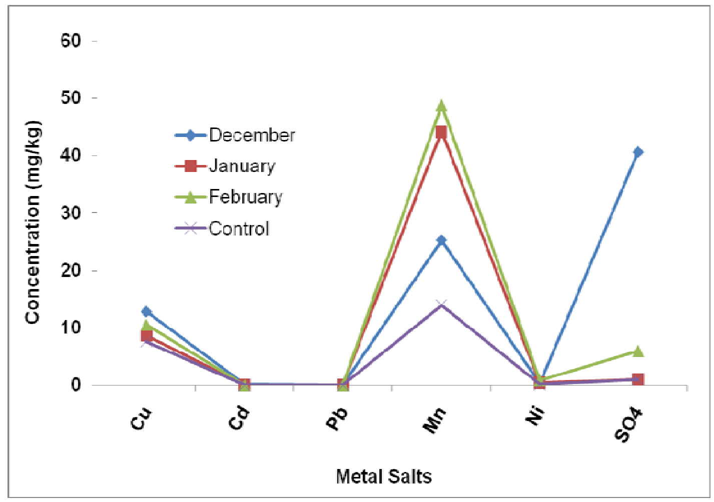


Fig. 9. Concentrations of heavy metals in location G over 3 Months

IV. DISCUSSIONS

From Figures 3-9 (sites A-G), it is seen that the concentrations of metals fluctuated within the three months with highest concentration in the month of February. The highest concentrations recorded for copper for the seven sites were 18.8 mg/kg, 12.63 mg/kg, 20.44 mg/kg, 42.36 mg/kg, 39.75 mg/kg, 15.62 mg/kg and 10.55 mg/kg respectively. The highest concentrations of metals were obtained in the month of February, except for Figure 3 where it is seen that the highest metal concentrations were obtained in December. The relatively high metal concentration of some of the samples could be attributed to accumulation due to runoffs from contaminated areas [17]. The average concentrations of copper is substantially higher than concentrations of copper in the control soil samples except for site J (10.75 mg/kg) where the value is slightly higher than that of location G (10.55 mg/kg). The range of concentrations of copper observed was also considerably lower than the range 50-114 mg/kg by the European Union regulatory standard for copper in soil [23]. These results suggest that the soils around major road in Ota metropolis are contaminated with copper as a result of heavy vehicular traffic. Copper is derived from engine wear, from thrust bearings, bushing and bearing metals, which are common along roadside in the study sites. In a similar study in Nigeria, the results obtained for copper are higher than 18.00 mg/kg and 1.48 mg/kg reported by [24] and [15] respectively. The concentration of copper obtained from this study is lower than the concentration obtained from those conducted in Kaduna (48.00 mg/kg) [25] and Yauri (96.13 mg/kg) [17].

When the concentration range obtained from this study was compared with the levels in similar studies elsewhere, the concentration of copper was lower than the concentration recorded for those conducted in the United States, China, Ethiopia and India [18, 19, 22, 21] respectively. The implication of excess copper through the food chain when taken by man is that it causes gastrointestinal irritation [26].

The highest concentrations recorded for cadmium in the seven sites were 0.13 mg/kg, 0.07 mg/kg, 0.35 mg/kg, 0.18 mg/kg, 0.12 mg/kg, 0.33 mg/kg and 0.11 mg/kg respectively. All the sites investigated had their cadmium levels lower than the recommended 1 – 3 mg/kg limit specified by EU standard. However, the sources of cadmium in the urban areas are much less well defined than those of lead. Metal plating, lubricating oils, old tyres that are frequently used, and the rough surfaces of the roads which increase the wearing of tyres were considered the likely sources of cadmium [27]. The concentration range of cadmium obtained from this study is lower than the concentration obtained from those conducted in Kaduna and Lagos [25, 28]. When cadmium concentration range obtained from this study was compared with the levels in similar studies elsewhere, the concentration of cadmium obtained from this study is lower than the concentration obtained from those conducted in the United States, Ethiopia and Poland [18, 22, 20], except for concentration recorded in China [19]. Several health hazards are associated with exposure to polluted soil with children being more susceptible to the risk.

The concentration of lead in this study ranged from 0.01mg/kg in site G to 26.6mg/kg in site F. This range of observed lead was extremely lower than EU upper limit of 300 mg/kg [29] and was at lower concentrations than the maximum tolerable levels proposed for agricultural soil, 90 – 300 mg/kg [30]. The observed highest lead concentration of site F suggests long accumulation of some level of lead, most likely from vehicle emissions, since there are no industrial activities within the area. Although the concentration in site F was close to 25 mg/kg, the lead obtained in the present study did not exceed reported background values of 25 mg/kg of lead in soil [31]. The high concentrations of lead observed could be attributed to lead particle from gasoline combustion which consequently settles on roadside soils. At the same way, vehicles are often moving slowly as a result of the heavy traffic jam in this area and this may account for the high level of lead. This is in line with [32] report that traffic junction and cross roads, records higher levels of metals. Also, it is therefore not surprising that high level of lead is associated with sites B because it has junctions that serve as a mini garage for buses and passenger vehicles. This is in addition to the auto mechanic work that dominates the business in the area. Conversely, Site G has the least concentration value of lead and this could be expected, because of the least volume of vehicles recorded on the road.

The concentration of lead obtained from this assessment is lower than the concentration obtained from those conducted in Kaduna (76.92 mg/kg), Iwo (126 mg/kg) and Yauri (30.09 mg/kg) [25, 33, 17]. In a related global study, the lowest concentration of lead obtained from this assessment is lower than the least concentration recorded for those conducted in the United States (4.62 mg/kg), China (9.95 mg/kg), Ethiopia (20.3 mg/kg) and Poland (7.1 mg/kg) [18, 19, 22, 20]. The highest concentration of lead obtained from this study is lower than the highest concentration recorded for those conducted in the United States (55.4 mg/kg), China (56.0 mg/kg), Poland (50.1 mg/kg), Ethiopia (325.4 mg/kg) and India (623.95 mg/kg) [18, 19, 20, 22, 21] respectively.

It was revealed by [34] that higher lead concentration in soils has toxic effect on microorganisms inhabiting the soil which consequently alters the flora and fauna of a location. Lead is especially toxic to children [35, 36] and can result in impaired mental and physical development, decreased hemi biosynthesis, elevated hearing threshold and decreased serum levels of vitamin D. In adult, lead is the major cause of hypertension, impairment of central nervous system and other respiratory problems [37]. The neuro-toxicity of Lead is of particular concern because evidence from prospective longitudinal studies show that neurobehavioral effect, such as impaired academic performance and difficulty in motor skills may persist even after persons Pb level have returned to normal [36].

The concentration of manganese ranged from 21.17 mg/kg - 95.48 mg/kg in all the locations. In this study, the levels of manganese in soils were relatively low. The highest level of manganese obtained was lower than 408 mg/kg reported by [38]. Soil generally contains 200 – 3000 mg/kg of manganese with an average value of 600 mg/kg [39]. The concentration of manganese obtained from this study is lower than the concentration recorded for those conducted in Yauri (608.11 mg/kg) and Kaduna (132 mg/kg) [17, 25]. When the highest manganese concentration obtained from this study was compared with the levels in similar studies elsewhere, the concentration of manganese obtained is lower than the concentration recorded from those conducted in the United States (2532 mg/kg), China (1740 mg/kg), and Poland (1122 mg/kg) [21, 19, 20]. In contact with man, manganese is relatively harmless: the body absorbs it and excretes the excess [40].

The highest concentration of nickel (64.4 mg/kg) obtained from this study is lower than the highest concentration recorded for Yauri (107.13 mg/kg) [17] while the concentration from this study on the other hand was higher than the concentration recorded in Iwo (7.55 mg/kg) [33]. When the concentration obtained from this study were compared with the levels in similar studies elsewhere, the lowest concentration of nickel (0.33 mg/kg) obtained in this study is lower than the least concentration recorded for those conducted in the United States (2.44 mg/kg), China (70.9-77.3 mg/kg), Poland (2.0 mg/kg), Ethiopia (47.3 mg/kg) and India (343 mg/kg) [18, 19, 20, 22, 21] respectively. The highest concentration of nickel (64.4 mg/kg) obtained in this study is lower than the highest concentration recorded for those conducted in the United States (69.4 mg/kg), China (77.3 mg/kg), Ethiopia (200.6 mg/kg) and India (1409 mg/kg) [18, 19, 22, 21]. It was different for Poland where the highest concentration obtained in this study was higher than the highest concentration recorded (27.0 mg/kg) [20]. Diseases related to high level of heavy metal in the system include lung tissue damage, respiratory illness, liver and kidney failure and others [42, 43].

The concentration of sulphate in this study ranged from 1mg/kg in sites A, C and G to 101.45 mg/kg in site F. There are no extensive studies on how the level of sulphate in soil relates to vehicular traffic but its deposition in the soil can be related to the settling of atmospheric sulphur dioxide [41]. The concentration of all the heavy metals in the seven locations was below that of the European Union regulatory standard. The value of nickel in site F (101.45 mg/kg) was higher than the 50mg/kg stipulated for the concentration of nickel in a safe soil. Since there are no major industrial activities going on in the various sites, the various concentrations of heavy metals in the soil were attributed to vehicular traffic. All the samples from the main experiments had higher concentration than that of their various controls because all the control locations have considerably lower traffic than that of the main sites. It could be inferred that the level of heavy metals in the roadside soil is affected by the quantity of traffic.

To reduce metal concentration of food chain and ecosystem from vehicular emissions, an appropriate land use policy which prohibits the use of road side lands, especially within 30 m either side of the road, for farming, grazing or as a source of pasture to feed livestock is required [2]. Although some states in Nigeria, including Osun state already have statutory edict banning the sun-drying of food stuff such as pepper, onions, okro amongst others along road sides, the enforcement of its compliance needs to be pursued and indeed be made a national policy [2]. Further steps should include legislation against use of smoking vehicles to prevent severe environmental pollution. In addition, regular weeding of the right of way by appropriate organ of government could reduce foliar absorption of the metals that may be contained in the emission [2].

Various studies have shown that heavy metals such as Pb, Cd, Ni, amongst others are responsible for certain diseases that have lethal effects on man and animals, and due to their accumulation and long time retention by plants and animals, these metals are very dangerous [42, 43]. Also, soils contaminated especially at roadsides may constitute a health hazards if the metals are transferred to groundwater reservoirs [44].

Conclusion

The impacts of vehicular emissions on soil and other aspects of the environment are presently alarming. Though this problem has been a characteristic of the developed country, it has been found that the impact could be more hazardous in the developing countries such as Nigeria. This is due to the fact that no proper consideration has been given to soil pollution and its implications. Several health hazards are associated with exposure to polluted soil with children being more susceptible to the risk. Exposure to some of these pollutants results in reduced oxygen transport capacity of the hemoglobin, increased risk of chest pain for persons with heart disease, impaired reaction timing, and prolonged exposure to it at higher levels can result in death. Therefore, in order to prevent the accumulation of heavy metal contamination in the road side soils and to maintain the ecological balance in the future, some immediate measures that would engender environmental quality need to be taken.

For further research work, the concentration of heavy metals and sulphate in road side soil samples should be examined for the wet season and the result is compared with what is obtainable in the dry season. This would give a diverse representation of what happens in the Ota metropolis.

Recommendations

1. The state government should have its own vehicle inspection and maintenance facilities in order to ensure the roadworthiness of vehicles in the state.
2. There should be extensive awareness campaign on the adverse effect of pollution on the environment and the populace.
3. Appropriate legislation to enhance the performance of regulatory agencies should be provided and a technical committee should also be established in order to develop emission standards for Nigeria and provide a means for its implementation.
4. Enhancement of fuel quality and the placement of emission standards to mitigate the impact of vehicle emissions on human health should be adopted.
5. Remediation of overly contaminated soil should be introduced by using various techniques and technologies such as; isolation, immobilization, toxicity reduction, physical separation and extraction.

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