Moss as Biomonitors of Vehicular Emissions Along Akure-Ilesa and Ife-Ibadan Roads in South Western Nigeria.

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DOI : https://doi.org/10.51583/IJLTEMAS.2025.1412000024

Received: 30 January 2024; Accepted: 10 February 2024; Published: 30 December 2025

ABSTRACT

Vehicular emission is one of the major sources of pollution to the roadside vegetation and soil. Degree of pollution by vehicles depends on the traffic congestions on the road. Higher quantity of environmental pollution could pose several hazards to humans, animals and plants. This study investigated the impact of vehicular emission on lower plant (moss) along Akure-Ilesa and Ife-Ibadan roads. The study aims at: quantify the heavy metal (HM) load in the moss and compare the degree of pollution of Akure-Ilesa road with Ife-Ibadan road. Passive and active methods of biomonitoring was carried out using moss as indicator, digestion of the sample was done using aqua-regia method of digestion and the investigated metals: lead (Pb), chromium (Cr), cadmium (Cd), copper (Cu) and zinc (Zn) were analyzed with the use of Atomic Absorption Spectrophotometer (AAS). Results of these study reveal considerable quantity of the investigated metals present in the indicator material (moss) and it also shows that, Akure-Ilesa road have higher concentration of these metals than Ife-Ibadan road. It can be concluded from these study that vehicular emission contributed to the HM load of roadside lower plants. It is recommended that controlled vehicular emission systems be adopted to reduce emissions and improve fuel efficiency.

INTRODUCTION

Environment is defined as the whole of circumstances surrounding a single organism or group of organisms particularly; combination of some external conditions that can affect and control the growth, development and survival of organisms (Farlex Incorporated, 2005). It consists of the flora, fauna, the abiotic factors, and the aquatic, terrestrial and atmospheric habitats. The environment is measured in terms of the most substantial aspects like air, water and food, and the less substantial, or the less important, the communities we live in (Gore, 1997).

As a result of human activities and some other animals in the environment, pollutants are discharged in quantities that affect the environment. A pollutant is any material/substance in the environment, which causes obnoxious effects, impairing the wellbeing of the environment, slowing down the quality of life and may ultimately lead to death. Such a substance has to be available in the environment beyond a set or acceptance limit, which could be either a desirable or tolerable limit. Therefore, environmental pollution is the presence of a pollutant in the environment; air; water; and soil, which may be lethal or toxic and will affect or harm the living things living in such polluted environment (Farlex Incorporated, 2005).

The remarkable increase in mobilization of human beings in the society has lead to an unusual rise in vehicular traffic on the major road ways. The vehicles release a considerable quantity of exhaust emission which consists of poisonous gases such as carbon II oxide, sulphur IV oxide, oxides of nitrogen etc. Seventy-five percent of the air pollution occurs through exhaust gases from automobiles. The emissions from the vehicles cause undesirable effects on plants, animals, soil and other environmental constituents (Arvind and Chandan, 2004).

Air quality can be monitored through measuring the pollutants directly in the air or in deposition, through constructing models depicting the distribution of the pollutants, or through the use of biomonitors (Markert *et al.*, 1997). Markert *et al.* (1997) described bioindicator/biomonitor as an organism, or part of it, that indicates the occurrence of pollutants on the basis of precise symptoms, reactions, morphological changes or concentrations.

Biomonitors can be grouped according to the way in which the reaction is manifested: reaction indicators, which are sensitive to air pollutants and which are used principally in studying the effects of pollutants on species make-up, and on physiological and ecological performance, and accumulation indicators that readily accumulate a variety of pollutants and are therefore used principally when monitoring the quantity of pollutants and their spread. source of organisms can further be used to categorize biomonitors into passive biomonitors, in which organisms that grow naturally in the study area are monitored and active biomonitors, in which the organisms are introduced into the research area under controlled situations for a definite period of time (Markert *et al.*, 1997).

The use of plants as indicators of air pollution has long been accepted. Many plants respond swiftly to low concentrations of air pollutants in predictable ways. As a result, plants are regarded to be more susceptible to air pollutants than humans and other animals as they are continuously exposed to air pollutants. Among diverse plant organs, leaves by virtue of their location, spread and structure are the main receivers of pollutants and a number of studies have proved that most noticeable effects of air pollution are expressed by foliage than any other parts of the plant. Being, the outer most layer, the epidermis is relatively more sensitive to hazards of air pollutants than other tissues.

Mosses are cryptogams that flourish very well in a humid climate. Ectohydric mosses have been used as biomonitors – in most cases, terricolous bryophytes. They have many properties that make them appropriate for monitoring air pollutants (Onianwa, 2000; Zechmeister and Hohenwallner, 2006). These species acquire nutrients from wet and dry deposition and they do not possess real roots. Nutrient uptake from atmosphere is enhanced by their poorly developed cuticle, large surface to wet ratio, and their pattern of growing in groups. Other qualifying properties include a slow growth rate, undeveloped vascular bundles, ease of sampling, and the possibility to determine concentrations in the annual growth segments (Onianwa, 2000). Air pollutants are discharged on mosses in aqueous solution, in gaseous form or attached to particles.

The release of some substances into the environment by vehicles leads to the pollution or contamination of the environment. The rate and amount of pollution due to vehicular emission cannot be estimated. Hence, this study attempts to determine the accumulation of heavy metals in the studied plant (mosses: active and passive study) along high vehicular traffic roads in Nigeria using Akure-Ilesa and Ife-Ibadan roads as a case study. It is expected that the findings obtained from this study will widen the knowledge on the danger of heavy metals pollution in the environment by providing information on its spread; it may also provide information on the danger of roadside farming-a common practice among peasant rural farmers.

MATERIALS AND METHODS

Study Area

Two major roads were used for this study; Akure-Ilesa road and Ife-Ibadan road. Akure-Ilesa and Ife-Ibadan roads are located within the South Western part of Nigeria with different longitude and latitude locations. Akure: lat 7 15N and long 5 5E, Ilesa: lat 7 37N and long 4 40N, Ife: lat 7 30N and long 4 31E and Ibadan: lat 7 22N and long 3 58E. Akure-Ilesa road a distance of about 50 km and not dualised while Ife-Ibadan road a distance of about 48 km and the road dualised, both roads were very busy. These research roads lead to different major cities like Abuja, Benin, Ado Ekiti, Lagos and to some other parts of the country; this could be easily taken as the reason for the high proportion of the traffic of these roads.

Traffic Density

A 4-day 8 hours' personal traffic count was conducted from 7-10 am, 12-3 pm and 5-7 pm at locations along the two separated roads to know the volume of traffic.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

Study material

Moss sample growing naturally in another environment (non-native) was collected and introduced using a moss bag into the two study sites in October 2013 during the rainy season and collected/harvested after a period of six months (April 2014). The heavy metal load of the moss was analyzed before the introduction and after harvesting using Aqua regia method of digestion and the heavy metals analyzed by Atomic Absorption Spectrophotometer (AAS). The moss samples that were encountered on the study area serve as passive biomonitors.

Digestion of Plant Samples

Aqua-regia method of digestion was used; 3 ml of Nitric acid ($HNO_{3)}$ and 1ml of Hydrochloric acid (HCl) to 2.5 g of each plant sample were added. The digestion was carried out on hot plate inside fume cupboard. The digests were allowed to cool to room temperature, then filtered with No 42 filter paper and made up to 25 ml of solution with distilled water (Mulgrew and Williams, 2000).

Determination of Heavy Metals in the Moss Sample

The samples were subjected to Atomic Absorption Spectrophotometer (AAS) using GBC A Vanta PM Version 2.02 for metal analysis (Mulgrew and Williams, 2000). The metals investigated were: Pb, Zn, Cd, Cr and Cu.

Data Analysis

The data generated from this study were analyzed statistically by using Statistical Package for Social Sciences (SPSS). Analysis of Variance (ANOVA) was used to test for significant differences among the concentrations of the heavy metals and the means separated with Duncan Multiple Range Test (DMRT).

RESULTS

The points chosen for the traffic count survey were Federal University of Technology, Akure (FUTA) gate junction and Ife/Ipetumodun junction. The traffic along the single lane Akure-Ilesa road was heavy consisting of 73% (494) cars, 5% (39) trucks, 17% (112) buses while luxury buses and pick-ups have 5% (36) totally 681 vehicles per hour. On the other hand, the double lane Ife-Ibadan road traffic was also heavy consisting of 59% (534) cars, 26% (245) buses, 10% (90) trucks while pick-ups and luxury buses have 5% (39) totaling 908 vehicles per hour (Table 1).

Moss sample were encountered at a point along Akure-Ilesa road in October 2013 towards the end of rainy season and at two point in April 2014 towards the end of dry season. It was discovered that, there was a slight increase in Pb and Cr contents of the moss towards the end of the dry season, while slight decrease was observed in Cd, Cu and Zn contents. When the metals were statistically compared, it was discovered that the metals were statistically different at $p>0.05$. (Table 2). Also, in Ife-Ibadan road, moss sample were encountered in two points each during the two seasons and the heavy metal contents in the dry season was found to be more than the rainy season when statistically compared (Table 3).

Table 4 shows the heavy metal concentration in the introduced moss (active biomonitor). The samples were analyzed before introduction into the study site and analyses done after six months of introduction reveals a considerable accumulation of the investigated metals. The metals were subjected to statistical analysis and it was revealed that the metals were significantly different at $p>0.05$.

Table 1: Traffic counts along Akure-Ilesa and Ife-Ibadan roads per hour

Location/type of vehicle	Cars	Trucks	Buses	Luxury buses and pick-ups
Akure-Ilesa volume count	494	39	112	36

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

Percentage occurrence	73 %	5 %	17 %	5 %
Ife-Ibadan volume count	534	90	254	39
Percentage occurrence	59 %	10 %	26 %	5 %

Table 2: Heavy metal concentrations (mg/kg) the encountered moss along Akure - Ilesa road in October 2013 and April 2014

Heavy metal concentration (mg/kg)

Sample Location	Pb	Cr	Cd	Cu	Zn
October 2013 Point 1 **October 2013**	0.311	0.214	0.192	0.158	1.380
April 2014 Point 1	0.311	0.218	0.183	0.139	1.342
Point 2	0.312	0.214	0.193	0.159	1.381
Mean ± S.D	0.312±0.001[c]	0.216±0.003[b]	0.188±0.007[b]	0.149±0.141[a]	1.362±0.028[d]

Table 3: Heavy metal concentrations (mg/kg) in the encountered moss along Ife - Ibadan in October 2013 and April 2014

Heavy metal concentration (mg/Kg)

Sample Location	Pb	Cr	Cd	Cu	Zn
October 2013 Point 1	0.241	0.201	0.102	0.032	0.420
Point 2	0.142	0.191	0.163	0.070	0.488
Mean ± S.D	0.192±0.070[b]	0.196±0.007[b]	0.133±0.043[ab]	0.051±0.027[a]	0.454±0.048[c]
April 2014 Point 1	0.341	0.311	0.110	0.052	0.920
Point 2	0.142	0.201	0.163	0.070	0.488
Mean ± S.D	0.242± 0.141[b]	0.256± 0.078[b]	0.137±0.037[ab]	0.061± 0.013[a]	0.704± 0.305[c]

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

Table 4: Heavy metal contents of the introduced moss sample (Active monitoring) at introduction and after six months of introduction along Akure-Ilesa and Ife-Ibadan Roads

Heavy metal concentration (mg/kg)

	Pb	Cr	Cd	Cu	Zn
At introduction	0.211	0.204	0.120	0.118	1.280
After 6 months Akure-Ilesa Road 1	0.341	0.311	0.211	0.162	1.432
2	0.342	0.301	0.263	0.170	1.488
3	0.342	0.356	0.237	0.161	1.407
4	0.341	0.302	0.213	0.162	1.410
5	0.401	0.314	0.242	0.162	1.420
Mean ± S.D	0.357 ± 0.030^{c}	0.321 ± 0.024^{c}	0.238 ± 0.021^{b}	0.164 ± 0.004^{a}	1.437 ± 0.036^{d}
Ife-Ibadan Road 1	0.315	0.320	0.194	0.176	1.400
2	0.381	0.241	0.196	0.171	1.420
3	0.316	0.242	0.197	0.173	1.405
4	0.341	0.311	0.201	0.164	1.426
5	0.320	0.312	0.201	0.159	1.436
Mean ± S.D	0.340 ± 0.030^{b}	0.296 ± 0.037^{b}	0.198 ± 0.003^{a}	0.166 ± 0.008^{a}	1.421 ± 0.015^{d}

DISCUSSION

The incredible increase in mobilization of human society has lead to exceptional rise in vehicular traffic on the major road ways. The vehicles release a substantial quantity of exhaust emission which consists of poisonous gases like carbon monoxide, sulphurdioxide, oxides of nitrogen etc. 75 % of the air pollution takes place through exhaust gases from automobiles (Chandra and Kumar, 2004) The emissions from the vehicles resulted into adverse effects on plants, animals, soil and other environmental components. The tremendous increase in the use of vehicles for day to day mobilization in most developing countries, together with lack of emission standards in these countries, has contributed a great deal of concern over vehicular pollution (Amusan *et al.,* 2003; Ibrahim, 2009).

The idea of using mosses to estimate atmospheric heavy metal deposition was developed in the late 1960s by Rühling and Tyler (1968). It is based on the fact that mosses, especially the carpet-forming species, obtain most of their nutrients directly from precipitation and dry deposition; there is little uptake of metals from the substrate. The moss use for these study was able to obtain/accumulate the investigated metals to a considerable level which prove the ability of mosses in absorbing atmospheric particles from direct precipitation and dry deposition.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue XII, December 2025

Zn was found to have the highest concentration of all the investigated metals in the study area, followed by Pb and Cu was found to have the least concentration. This is comprehensible since tyre wears released zinc (Kabata-Pendias and Pendias, 1994). In addition, Zn is used in brake linings owing to their heat conducting properties and as such released during mechanical abrasion of vehicles and from engine oil combustion and tyres of motor vehicle (Dolan *et al.*, 2006; El-Gamai, 2000; Hjortenkrans *et al.*, 2007). The high concentration of Zn in this study may also be due to number of vehicles that pass through the studied roads. USEPA (1996) also reported that lubricant oil adds Zn to soils closest to major roads in metropolitan areas. Natural occurrences such as volcanic eruption, forest fires, dust storms and sea spray also add to the continuous cycling of Zn through nature.

The higher level of Pb might be from the deposition from automobile exhaust since most petroleum fuel is made up of tetraethyl lead as antiknock (Lenntech Water Treatment and Air Purification, 2004). Large amount of fertilizers is frequently added to soils in intensive farming systems to supply adequate NPK for crop development. The compounds used to provide these fundamentals contain trace quantities of heavy metals (e.g Cd and Pb) as impurities, which after persistent fertilizer application may extensively increase their content in the soil (Jones and Jarvis, 1981). The use of certain phosphate fertilizers ineffectually adds Cd and other potentially toxic elements to the soil such as F, Hg and Pb (Raven *et al.*, 1998) these may also contribute to the high level of Pb in the study area. Moreover, some common pesticides used quite at length in agriculture and horticulture in the past contained considerable concentrations of metals. Lead arsenate was applied in fruit orchards for many years to control some parasitic insects (McLaughlin *et al.,* 2000).

The moss sample used as biomonitor (both passive and active) was effective because they were able to accumulate the investigated heavy metals within the short period of its introduction into the study area. These findings supported the report of Zechmeister *et al.* (2003a), who reported that mosses are excellent biomonitors as they possess numerous properties that make them appropriate for monitoring air pollutant. Onianwa (2000) reported that nutrient uptake from the environment in mosses is enhanced by their poorly developed cuticle, large surface to wet ratio and their pattern of growing in groups. Air pollutant are deposited on mosses in aqueous solution, gaseous form or attached to particles (Onianwa, 2000). The concentration of heavy metals recorded in the moss sample after introduction with values higher than the recommended daily intake by World Health Organization/Food and Agricultural Organization (WHO/FAO) is an indication of the pollution level of the environment under consideration.

The investigated heavy metals were found to accumulate more during the dry season than during the rainy season, this could be suggestive of leaching of these heavy metals by rainfall into the sub-soil layers as researchers have demonstrated that heavy metals have the ability of being leached out when poorly adsorbed to topsoil (Zanders *et al.*, 1999). Imray and Langley (2001) also reported that changes in concentration of heavy metals overtime in soil layers may occur due to factors such as breakdown and leaching. The moss sample accumulate more metals in Akure-Ilesa road than Ife-Ibadan road, hence, Akure-Ilesa road can be described to be more polluted than Ife-Ibadan road, this is understandable as traffic density was lower in Akure – Ilesa road but more congested due to being a single lane road as compared to Ife-Ibadan road (from traffic count).

CONCLUSION

Heavy metal accumulation by plant tissues, its presence in the soil persistently or its presence in ground waters is not a healthy sign for the environment. Controlling air pollution from motor vehicles is essential if the adverse effects will be nip in the bud. The reason for different concentrations of heavy metals in the moss used for this study may be due to the density of the traffic. The level of contamination was more pronounced in Akure-Ilesa road than Ife-Ibadan road. The use of moss for the monitoring of the pollution status of the study area has proved useful. This has also complemented several reports of the usefulness of mosses in assessing pollution status of the environment.

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