COMPARATIVE STUDIES ON MOSSES FOR AIR POLLUTION MONITORING IN SUB-URBAN AND RURAL TOWNS IN EKITI STATE

ADEBIYI, A. O.[1] **and *OYEDEJI, A. A.**[1, 2]

http://dx.doi.org/10.4314/ejesm.v5i4.10

Received 14th May 2012; accepted 16th August 2012

Abstract

The level of heavy metals deposition in Ido-Ekiti, a sub-urban town and Ipere-Ekiti, a rural town was investigated using mosses grown in the localities as possible bio-indicators. The sources of these heavy metals were discovered to include: vehicular emission and incineration of domestic wastes and the heavy metals from these sources were discovered to pose severe toxicological risks to the environment and human health. Samples of mosses were collected at eight different locations in each town. The samples were digested in an acid and the concentration of five heavy metals; Lead (Pb), Copper (Cu), Cadmium (Cd), Chromium (Cr) and Nickel (Ni) in the samples were determined using a flame atomic absorption spectrometer. The study reveals distinct variation in metal concentrations across the locations. It was reveals that the heavy metal concentration were mostly higher in moss samples than their corresponding substrates, this suggest that the heavy metals were concentrated in the atmosphere. The highest metal concentrations obtained in Ido-Ekiti than Ipere-Ekiti could be attributed to the higher anthropogenic activities in Ido-Ekiti. In order to minimize and control the high level of these heavy metals in the environment, the use of bio-fuel, closure of heavy industries located near residential areas, emission control legislation, reduction in fossil fuel combustion and significant decrease in leaded petrol combustion should be encouraged.

Keywords: *Anthropogenic, Bio-indicator, Environment, Heavy metal, Mosses, Pollution.*

Introduction

The increasing trend of environmental pollution of our dear ecosystem is a thing of great concern. Our environment has witnessed contamination from oil spills, used spent lubricating oil, heavy metal and lots more. The plants are the first recipients of the effects of any environmental contamination. Mosses are small non-woody plants that are typically 1-10cm tall, though some species are much larger. They grow close together in clumps or mats in damp or shady locations. They do not have flowers or seeds. They also lack vascular systems. There are approximately 10,000 species of mosses classified in the division bryophyta. The division bryophyta also consists of liverworts and hornworts. Bryophyta have been long considered to be insignificant in the economy of man except for those used in packing, plugging and decoration. Recent progress in environmental pollution studies has changed our understanding of bryophytes as useful plants. Vinay *et al.*, (2007) reported that bryophytes are efficient accumulators of heavy metals due to some properties which includes lacks of true root system which makes them to depend largely on atmospheric deposition for their mineral element requirement, lack of cuticle layer, which makes their tissues to be easily permeable to water, minerals, gaseous pollutants in the atmosphere as well as metal ions, possession of tissues with negatively charged groups which can act as efficient cation exchangers. In addition to these properties, Chakrabortty *et al.*, (2006) reported that bryophytes wide distribution and ease of collection make them to be efficient metal accumulators and bio-monitors. Earlier research works by Kovacs *et al.* and Rovinsky *et al.*, (1993) have shown that mosses have proved to be better bio-indicators of pollution because they are more sensitive to atmospheric pollution. The usefulness of mosses in determining heavy metal concentrations in different geographical areas has been discussed and demonstrated in several studies (Market *et al*., 2003).

[1]*Department of Plant Science, University of Ado-Ekiti, Ado-Ekiti, Nigeria*

[2]*Department of Biological Sciences, Niger Delta University, Wilberforce Island, Nigeria* *ayodele.oyedeji@yahoo.com

Environmental pollution is increasing day by day, posing a very serious problem to the flora and the fauna. This increase can be attributed to erosion, rapid increase on population, industrialization and urbanization, nuclear energy, release of chemicals used in industries as well as vehicular emission. A large number of pollutants including heavy metals released from these sources are adversely affecting our environment. Grodzinski (1991) observed that the pollution level of the environment can be evaluated by physiochemical methods of analysis of the concentration of the pollutants in the air, soil and plants. The rationale of this work is to determine the rate of pollution on the environment resulting from heavy metal deposit in our environment using mosses as pollution monitoring agents in sub-urban and rural towns in Ekiti State, Nigeria.

Methods

Sampling

Mosses and their substrate were collected around eight different locations in two towns: a sub-urban town, Ido-Ekiti and a rural town, Ipere-Ekiti. The locations in Ido-Ekiti include: Ekiti Parapo College, Oke-Bareke Street, Mechanic workshop, Odo-Agbe Street, Tad Oil petrol Station, Road side, Ido-Motor Park and Total Petrol Station while the locations in Ipere-Ekiti include: Ipere Community High School, Isaba Street, Oke-Odo Street, Road side, Odo-Odo Street, St. Peter Anglican Primary School, Idemo Street and Ipere Basic Health Centre. Samples were collected from different habitats ranging from blocks to walls of buildings, soils and culverts.

Determination of Heavy Metal Concentrations in Moss Samples

The moss samples collected were sun dried for five days, grinded with a mortar and pestle into a fine powdered form. 1.2g of each moss samples were weighed into crucibles on an analytical balance. The weighted samples were then transferred into plastic containers of 100ml capacity. Each sample was then subjected to total digestion method as adopted by Bernhard Welz (1985). The concentration of lead, nickel, copper, chromium and cadmium in each digested sample were determined using Atomic Absorption Sector Photometers (Buck Scientific Model, 210).

Determination of Heavy Metal Concentration in Moss Substrates

The substrates (1.2g) were weighed into crucible on analytical balance. Weighted samples were transferred into plastic containers of 100ml capacity. Each sample was then subjected to total digestion method adopted by Bernhand Welh (1985) as above. The concentration of lead, Nickel, Capper, Chromium and Cadmium in each digested sample were determined using Atomic Absorption Section Spectrophotometer.

Determination of pH Values of Moss Substrates

The pH values of the moss substrate were determined using universal pH indicator paper.

Statistical Analysis

Duncans Multiple Range test was employed to determine the significant difference among the means.

Results and Discussions

Ekiti Parapo College; The mean concentrations of lead, copper, cadmium, chromium and Nickel in the moss samples collected were 15.72μg.g^{-1}, 24.66μg.g^{-1}, 9.25μg.g^{-1}, 74.91μg.g^{-1} and 22.50μg.g^{-1} respectively (Table 1). When the mean concentration of the heavy metal were statistically compared, it was observed that there was no significant difference between the mean concentration of lead and cadmium, while there was significant difference among the mean concentration of copper chromium and nickel at 5% level of significance (Table 3).

The mean concentrations of lead, copper, cadmium, chromium and Nickel in the moss substrate collected were 6.49μg.g^{-1}, 3.14μg.g^{-1}, 0.00μg.g^{-1}, 17.85μg.g^{-1} and 8.62μg.g^{-1} respectively (Table 2). When the mean concentration of the heavy metal were statistically compared, there was no significant difference between the mean concentration of lead and copper while there were significant differences among Cadmium Chromium and Nickel at 5% level of significant (Table 3).

Oke Bakare Street; The mean concentrations of Lead, Copper, Cadmium, Chromium and Nickel in the moss sample were 5.99μg.g^{-1}, 20.79μg.g^{-1}, 0.92μg.g^{-1}, 44.99μg.g^{-1} and 6.84μg.g^{-1} respectively (Table 1). When the means of the heavy metal were statistically compared, it was observed that there was no significant difference between the means concentration of Lead and Nickel, while there were significant differences among Copper, Cadmium and Chromium at 5% level of significance (Table 3).

The mean concentrations of Lead, Copper, Cadmium, Chromium and Nickel in the moss substrates were 3.49μg.g^{-1}, 4.84μg.g^{-1}, 0.92μg.g^{-1}, 14.08μg.g^{-1} and 2.08μg.g^{-1} respectively (Table 2). When the mean concentrations of the heavy metals were statistically compared, it was observed that there are significant differences among the mean concentration of all metals at 5% level of significance (Table 3).

Mechanic Workshop; The mean concentrations of Lead, Copper, Cadmium, and Nickel in the moss samples were 127.28μg.g^{-1}, 252.39μg.g^{-1}, 3.39μg.g^{-1}, 87.45μg.g^{-1} and 11.30μg.g^{-1} respectively (Table 1). When the means concentrations of the heavy metal were statistically compared, it was observed that there was significant difference between the mean concentrations of all metals at 5% level of significance (Table 3).

The mean concentrations of Lead, Copper, Cadmium, Chromium and Nickel in the moss substrates were 42.93μg.g^{-1}, 82.68μg.g^{-1}, 0.92μg.g^{-1}, 21.60μg.g^{-1} and 9.81μg.g^{-1} respectively (Table 2). When the means of the heavy metal were statistically compared, it was observed that there is significant difference between the mean concentrations of all metals at 5% of significance (Table 3).

Odo Agbe Street; The mean concentrations of Lead, Copper, Cadmium, Chromium and Nickel in the moss samples were 3.74μg.g^{-1}, 10.15μg.g^{-1}, 0.00μg.g^{-1}, 66.08μg.g^{-1} and 2.97μg.g^{-1} respectively (Table 1). When the mean concentrations of the heavy metal were statistically compared, it was observed that there was no significant difference between the mean concentration of lead and Nickel, while there was significant difference among Copper and Cadmium; Chromium at 5% level of significance (Table 3).

The mean concentration of lead, copper, cadmium, chromium and Nickel in moss substrates were 0.75μg.g^{-1}, 2.18μg.g^{-1}, 0.00μg.g^{-1}, 7.03μg.g^{-1} and 0.89μg.g^{-1}, respectively (Table 2). The mean concentrations of the heavy metals were statistically compared; it was observed that there was no significant difference between the mean concentration of lead and nickel, while there was significance difference among Copper and Cadmium at 5 % level of significance (Table 3).

Tad Oil Petrol Station; The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in the moss sample were 76.87μg.g^{-1}, 78.81μg.g^{-1}, 2.16μg.g^{-1}, 45.25μg.g^{-1} and 10.11μg.g^{-1} respectively (Table 1). When the mean concentration of the heavy metals was statistically compared, it was observed that there was no significant difference between the mean concentration of Lead and Copper. Also there was no significant difference between the mean concentration of cadmium and Nickel, while chromium is significantly different to all the other metals at 5% level of significance (Table 3).

The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in moss substrates were 9.48μg.g^{-1}, 18.86μg.g^{-1}, 0.00μg.g^{-1}, 8.55μg.g^{-1} and 2.23μg.g^{-1} respectively (Table 2). When the mean concentration of the heavy metals were statistically compared it was observed that there were no significant differences between the mean concentration of Lead and chromium while there was significant difference between the mean concentration of Copper, Cadmium, Nickel at 5% level of significance (Table 3).

***Road Side*;** The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in the moss samples were 28.95μg.g^{-1}, 35.54μg.g^{-1}, 0.92μg.g^{-1}, 85.63μg.g^{-1} and 9.22μg.g^{-1} respectively (Table 1). When the mean concentrations of the heavy metals were statistically compared, it was observed that there was significant difference between the

mean concentrations of all metal at 5% level of significance (Table 3).

The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in moss substrates were 3.63μg.g^{-1}, 3.63μg.g^{-1}, 0.00μg.g^{-1}, 11.31μg.g^{-1} and 1.19μg.g^{-1} respectively (Table 2). When the mean concentrations of heavy metals were statistically compared, it was observed that there was no significant difference among the mean concentration of Lead, Copper and Nickel, Also there was no significant difference between the mean concentration of Cadmium and Nickel, while the mean concentrations of Chromium is significantly different from all other metals at 5% level of significance (Table 3).

***Ido-Motor Park*;** The mean concentrations of Lead, Copper, Cadmium, Chromium and Nickel in moss sample were 32.72μg.g^{-1}, 60.44μg. $^{-1}$, 1.54μg.g^{-1}, 65.61μg.g^{-1} and 3.27μg.g^{-1} respectively (Table 1). When the mean concentrations of heavy of metals were statistically compared it was observed that there was no significant difference between the mean concentration of Copper and Chromium, Also there was no significant difference between the mean concentration of Cadmium and Nickel, while the mean concentration of Lead is significantly different from all other metals at 5% of significance (Table 3).

The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in moss substrates were 5.57μg.g^{-1}, 9.92μg.g^{-1}, 0.00μg.g^{-1}, 28.91μg.g^{-1} and 0.89μg.g^{-1} respectively (Table 2). When mean concentration of the heavy metals were statistically compared, it was observed that there was significant difference among the mean concentration of Lead and Copper, Lead and Chromium, while there was no significant difference between the mean concentration of Cadmium and Nickel at 5% level f significant (Table 3).

***Total Petrol Station*;** The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in moss samples were 53.66μg.g^{-1}, 40.13μg.g^{-1}, 1.23μg.g^{-1}, 63.10μg.g^{-1} and 4.76μg.g^{-1} respectively (Table 1). When the mean concentrations of the heavy metals were statistically compared, it was observed that there was significant difference among all the metals at 5% level of significance (Table 3).

The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in moss substrates were 17.22μg.g^{-1}, 8.46μg.g^{-1}, and 0.00μg.g^{-1}, 9.80μg.g^{-1} and 0.00μg.g^{-1} respectively (Table 2). When the mean of heavy metals were statistically compared, it was observed that there is significant difference among concentration of Lead and Copper. While there was no significant difference between the mean concentration of Cadmium and Nickel at 5%l level of significance (Table 3).

Ipere Community High School; The mean concentrations of Lead, Copper, Chromium Cadmium and Nickel in moss samples were 20.22μg.g^{-1}, 38.44μg.g^{-1}, 18.31μg.g^{-1}, 68.63μg.g^{-1} and 4.15μg.g^{-1} respectively (Table 5). When the mean concentrations of the heavy metals were statistically compared, it was observed that there was significant difference among all the metals at 5% level of significance (Table 7).

The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in moss substrates were 6.99μg.g^{-1}, 11.60μg.g^{-1}, 0.00μg.g^{-1}, 8.30μg.g^{-1} and 1.78μg.g^{-1} respectively (Table 6). When the mean concentrations of the heavy metal were compared, it was observed that there was significant difference among all the metals at 5% level of significance (Table7).

***Isaba Street*;** The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in moss Samples were 13.73μg.g^{-1}, 23.45μg.g^{-1}, 0.92μg.g^{-1}, 55.31μg.g^{-1} and 9.51μg.g^{-1} respectively (Table 5). When the mean concentrations of the heavy metal were statistically compared, it was observed that there was significant difference among all the metals at 5% level of significant (Table 7).

The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in moss substrates were 2.75μg.g^{-1}, 4.11μg.g^{-1}, 0.00μg.g^{-1}, 12.07μg.g^{-1}, and 1.78μg.g^{-1} respectively (Table 6). When the mean concentrations of the heavy metal were statistically difference among the mean concentration of Copper, Cadmium, and

Chromium, while there was no significant different between the mean concentration of Lead and Nickel at 5% level of significant (Table 7).

Oke-Odo Street; The mean concentrations of Lead, Copper, Chromium Cadmium and Nickel in moss samples were 3.99μg.g^{-1}, 12.57μg.g^{-1}, 2.77μg.g^{-1}, 68.36μg.g^{-1}, and 6.84μg.g^{-1} respectively (Table 5). When the mean concentrations of the heavy metal were statistically compared, it was observed that there was no significant difference between the mean concentration of cadmium and Lead, while there was significant difference between the mean concentration of Cadmium and Nickel at 5% level significant (Table 7).

The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in moss substrates were 1.50μg.g^{-1}, 6.29μg.g^{-1}, 0.00μg.g^{-1}, 9.30μg.g^{-1} and 0.87μg.g^{-1} respectively (Table 6). When the means of heavy metals were statistically compared, it was observed that there was no significant difference among the mean concentration of Lead, Cadmium and Nickel, while there is no significant difference between the mean concentration of copper and chromium at 5% level of significance (Table 7).

***Road Side*;** The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in moss samples were 12.48μg.g^{-1}, 14.75μg.g^{-1}, 1.23μg.g^{-1}, 48.52μg.g^{-1} and 8.92μg.g^{-1} respectively

(Table 5). When the mean concentrations of the heavy metals were statistically compared, it was observed that there was no significant difference between the mean concentration of Lead and Copper, also there was no significant difference between the mean concentration of lead and Nickel, while the mean concentration of Cadmium and Chromium are significantly difference from other metals at 5% level of significance (Table 7).

The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in moss substrates were 1.50μg.g^{-1}, 2.24μg.g^{-1}, 0.00μg.g^{-1}, 9.30μg.g^{-1} and 0.00μg.g^{-1} respectively (Table 6). When the mean concentrations of the heavy metal were statistically compared, it was observed that there was significant difference among the mean concentration of Lead, Copper and Chromium, while there was no significant difference between the mean concentration of cadmium and Nickel at 5% level of significance (Table 7).

Odo-Odo Street; The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in moss samples were 5.49μg.g^{-1}, 20.55μg.g^{-1}, 0.00μg.g^{-1}, 42.73μg.g^{-1} and 3.67μg.g^{-1} respectively (Table 5).When the mean concentrations of the heavy metals were statistically compared, it was observed that there was no significant difference between the mean concentration of lead and Nickel, while there was significant difference among the mean concentration of Copper Cadmium, and Chromium at 5% level of significant (Table7).

The mean concentrations of Lead, Copper, Chromium, 0.75μg.g^{-1}, 3.63μg.g^{-1}, 0.00μg.g^{-1}, 0.00μg.g^{-1}, 3.62μg.g^{-1} and 0.89μg.g^{-1} respectively (Table 6).When the mean concentrations of the heavy metals were statistically compared, it was observed that there was no significant difference between the mean concentration of Lead and Nickel, while there was significant different among the concentration of Copper, Cadmium and Chromium at 5% level of significant (Table 7).

***St. Peter Anglican Primary School*;** The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in moss samples were 3.49μg.g^{-1}, 24.41μg.g^{-1}, 0.27μg.g^{-1}, 69.13μg.g^{-1} and 1.78μg.g^{-1} respectively (Table 5).When the mean concentrations of the heavy metals were statistically compared , it was observed that there was no significant difference between the mean concentration of Cadmium and Nickel, while there was significant difference among the mean concentration in Lead, Copper and Chromium, at the 5% level of significant (Table7).

The mean concentrations of Lead, Copper, Cadmium and Nickel in moss substrates were 2.00μg.g^{-1}, 8.95μg.g^{-1}, 0.00μg.g^{-1}, 6.03μg.g^{-1} and 1.78μg.g^{-1} respectively (Table 6). When the mean concentrations of the heavy metals were statistically compared, there were no difference between the mean concentration of Cadmium and Nickel, while there was

significant difference among the mean concentration of Lead, Copper and Chromium at 5% level of significance
(Table 7).

***Idemo Street*;** The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in moss samples were 8.24μg.g^{-1}, 12.57μg.g^{-1}, 0.92μg.g^{-1}, 34.19μg.g^{-1} and 3.57μg.g^{-1} respectively (Table 5). When the mean concentrations of the heavy metals were statistically compared, it was observed that there was significant difference between the mean concentrations of all metals at 5% level of significance (Table 7).

The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in moss substrates were 2.99μg.g^{-1}, 8.04μg.g^{-1}, 0.00μg.g^{-1}, 2.26μg.g^{-1} and 0.00μg.g^{-1} respectively (Table 6). When the mean concentrations of the heavy metals were statistically compared, it was observed that there was no significance difference between the mean concentrations of Cadmium and Nickel, while there was significance difference among the mean concentration of Lead, Copper and Chromium at 5% level of significance (Table 7).

Ipere Basic Health Centre; The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in moss samples were 5.79μg.g^{-1}, 14.51μg.g^{-1}, 0.00μg.g^{-1}, 29.16μg.g^{-1} and 2.38μg.g^{-1} respectively (Table 5). When the mean concentrations of the heavy metal were statistically compared, it was observed that there was significance difference among the mean concentrations of all metals at 5% level of significance (Table 7).

The mean concentrations of Lead, Copper, Chromium, Cadmium and Nickel in moss substrates were 0.75μg.g^{-1}, 1.48μg.g^{-1}, 0.00μg.g^{-1}, 3.52μg.g^{-1} and 0.00μg.g^{-1} respectively, (Table 6). When the mean concentrations of the heavy metals were statistically compared, it was observed that there was no significance difference between the mean concentrations of Cadmium and Nickel, while there was significant difference among the mean concentration of Lead, Copper and Chromium at 5% level of significance (Table 7).

pH Values of Moss Substrates collected from Ido-Ekiti and Ipere-Ekiti

The results of pH values of moss substrates collected from different locations in Ido-Ekiti and Ipere-Ekiti were as shown in Tables 4 and 8 respectively. The pH values ranged for 4.0 in Ekiti Parapo college to 8.0 in Oke Bareke street and Ido garage in Ido-Ekiti while it ranges from 4.0 in Ipere health centre to 8.0 in Odo-odo Street in Ipere-Ekiti.

Comparison of some heavy metal concentrations between Ido-Ekiti and Ipere-Ekiti.

Ido-Ekiti; The average mean concentration of lead, Copper, Chromium and Nickel in mass samples collected in Ido-Ekiti were 43.11μg.g^{-1}, 65.36μg.g^{-1}, 2.43μg.g^{-1}, 65.15μg.g^{-1} and 8.81μg.g^{-1} respectively (Table 9). When the average mean concentrations of the heavy metal were statistically compared, it was observed that there was no significance difference among the concentration of Lead, Copper and Chromium, also there was no significance difference between the mean concentration of Cadmium and Nickel at 5% level of the significance (Table 9).

***Ipere-Ekiti*;** The Average mean concentration of Lead, Copper, Chromium, Cadmium and Nickel in moss samples collected in Ipere-Ekiti were 9.14μg.g^{-1}, 20.16μg.g^{-1}, 3.13μg.g^{-1}, 52.10μg.g^{-1} and 5.28μg.g^{-1} respectively (Table 9). When the average mean concentrations of the heavy metal were statistically compared, it was observed that there was significant difference between the mean concentration of Copper and Chromium, while there was no significant difference among Lead and Nickel, Cadmium and Nickel at 5% level o f significance (Table 9).

The results of analysis of the mosses sampled in Ido-Ekiti were shown in the Table 1. The concentrations of the heavy metals are relatively low when compared with data from the investigation conducted by Fatoba and Oduekun (2004) in Ilorin. This can be attributed to higher anthropogenic activities at Ilorin. Kakulu (1993) stressed the importance of urbanization in heavy metals deposition. However, the concentrations of the heavy metals are relatively higher in locations such as Tad oil petrol station, Mechanic workshop

and Ekiti Parapo College than others such Odo-Agbe Street and Oke-Bareke Street. This can be attributed to relatively higher traffic density around these areas. Ho and Tia (1988) reported that the major source of elevated level of Copper, Zinc, Iron and Calcium in road side plants was motor vehicle. This assertion is confirmed by the fact that these metals are important components of many alloy pipes, wires and tyres in motor vehicle. The metals are released into the environment as a result of mechanical abrasion and normal errs and tears. The results of analysis of the mosses sampled in Ipere Ekiti were as shown in Table 5. The concentrations of the heavy metals are very low. However, the concentrations of the heavy metals were relatively higher in areas such as Ipere community high school, St. Peter Anglican Primary School and Isaba Street than others such as Odo-Odo Street and Ipere Basic Health Centre. This can be attributed to relatively higher traffic density around these areas. A comparison of heavy metals concentration in mosses and their substrate in both towns revealed that the metals are of higher concentration in mosses than substrates (Table 3 and Table 7). This suggest that the metals are of atmospheric origin and not naturally prevalent.

The comparison of heavy metals deposition between Ido-Ekiti and Ipere-Ekiti revealed that the metals are of higher concentration in Ido-Ekiti than Ipere Ekiti (Table 9). This can be attributed to higher anthropogenic activities such as fossil fuel combustion, vehicular activities and incineration of domestic wastes within the sub-urban town, Ido-Ekiti than the rural town, Ipere Ekiti. Earlier Scientists (Kakulu, 1993; 1998; Krolak, 2001; Fatoba and Oduekun, 2004) reported that the source of heavy metals in the atmosphere include vehicular emissions, incineration of domestic wastes, fossil fuel combustion and so on. However the low concentration of the heavy metals obtained in Ipere Ekiti can be linked to occasional emission from vehicles, generation and incineration of domestic wastes.

Conclusion and Recommendations

The results of the present investigation confirmed the presence of heavy metals in the environment. In the study, the areas where the highest concentrations were recorded were locations prone to device traffic situation such as the filling stations, and mechanical workshop in sub-urban town. Therefore, in order to reduce the possible bio accumulation of these metals in organisms, establishments such as filling station and mechanical workshops should be sited far from residential areas. Also, it might be necessary to investigate and monitor the heavy metal contents of the environment from time to time, considering the toxicological risks posed by such metals to human health in particular and the environment at large. In order to minimize and control the high level of these heavy metals in the environment, the use of bio-fuel, closure of heavy industries located near residential areas, emission control legislation, reduction in fossil fuel combustion and significant decrease in leaded petrol combustion should be encouraged for the safety of our dear environment.

References

Chakrabortty, S., Paratkar, G. T. and Kets, V.G. (2006), Biomonitoring of trace elements: Air pollution using mosses. *Aerosol and Air Quality Research,* 6(3) 247-258.

Fatoba, P.O. and Odekun, T. I. (2004), Assessment of Metal Deposition in Illorin Metropolis using Mosses as Bioindicators. *Nigerian Journal of Pure and Applied Science,* 19: 1549-1552.

Grodzinski, K. (1990), Long-term Ecological monitoring in the parks of Poland. In Ecologicalrisks: perspectives from Poland and the United States. National Academics Press, 252pp.

Ho, Y.B. and Tia, K.M. (1998), Elevated levels of lead and other metal in roadside soil andGrasses and their uses to monitor aerial deposition in Hong Kong. *Environment pollution,*
49:37-51.

Kakulu, S. E. (1993), Biological monitoring of atmospheric trace mental deposition in

Northern eastern Nigerian. *Environment Monitoring and Assessment,* 28:137-143.

Kovacs, M.; Kaszab, L., Penksza, K., Szoke, P. and Turosanyi, G. (1993), Multi element analysis of the species in a forest in the Hungarian for forest steppe. *Phytocoenologia,* 23:357.

Krolak, E (2001), Heavy metals content in falling dusts, soil and dandelion (*Tarazacum officinale*) in southern Podlasie Lowland. *Electronic journal of Polish Agricultural University,* 4(1):1-13.

Market, B. B., Breure, A.M., and Zeichemister, H.G. (2003), Definitions, Strategies and Principles for Bioindication/Biomonitoring of the Eviroment. In: Market, B,A., Breure, A.M., and Zeichemeister, H.G., (eds) Elservier, Oxford. Pp. 3-39.

Rovinsky, F.Y., Bursteva, L.V., Chickeva, T.B. and Market, B. (1993), Heavy metals in the vegetation as indicator for the environmental pollution in the area of the former USSR. In Plants as bio-indicators for heavy metals in the terrestrial environment. UCH Publishers Limited Cambridge, U.K. Pp. 507-514.

Vinay, S., Asthana, A. K., Virenda, N. and Yunus, M. (2007), Bryophytes: A useful tool in heavy metals monitoring. *EnvironNews*, 13:4.

Table 1 Average Concentrations ± s.d (μg.g^{-1}) of some heavy metals in moss sampled in Ido-Ekiti

Locations	Pb	Cu	Cd	Cr	Ni
Ekiti Parapo College	15.72±0.00	24.66±1.92	9.25±0.00	74.91±1.15	22.50±1.03
Oke Bareke	5.99±0.75	20.79±1.52	0.92±0.00	44.99±0.00	6.84±0.51
Mechanic Workshop	127.28±1.98	252.39±0.73	3.39±0.54	81.45±0.76	11.30±0.51
Odo-Agbe	3.74±10.81	10.15±0.73	0.00±0.00	66.08±0.87	2.97±0.52
Tad oil Petrol Station	76.87±10.81	78.81±0.42	2.16±0.83	45.25±0.76	10.11±0.52
Road Side	28.95±0.43	35.54±0.00	0.92±0.00	85.63±0.38	9.22±1.36
Ido-Garage	32.72±0.36	60.44±2.93	1.54±2.93	65.61±28.73	3.27±0.51
Total Petrol Station	53.66±0.87	40.13±0.42	1.23±0.54	63.10±0.87	4.76±0.51
$\bar{X}$±S.D	43.11±41.96	65.36±78.74	2.43±2.93	65.13±15.18	8.87±6.18

Table 2 Average Concentrations ± s.d ($\mu g.g^{-1}$) of some heavy metals in moss substrates in Ido-Ekiti

Locations	Pb	Cu	Cd	Cr	Ni
Ekiti Parapo Collage	6.49±0.43	3.14±0.42	0.00±0.00	17.55±9.36	8.62±1.36
Oke Bareke	3.49±0.43	4.34±0.42	0.92±0.00	14.08±0.44	2.08±0.52
Mechanic Workshop	42.93±1.14	82.68±0.73	0.92±0.00	21.62±0.44	9.81±0.00
Odo-Agbe	0.75±0.00	2.18±0.73	0.00±0.00	7.03±0.44	0.89±0.00
Tad oil Petrol Station	9.48±0.87	18.86±0.73	0.00±0.00	8.55±0.43	2.23±0.64
Road Side	3.63±0.00	3.63±3.77	0.00±0.00	11.31±1.30	1.19±0.57
Ido-Garage	5.57±0.58	9.92±0.84	0.00±0.00	28.91±0.43	0.89±0.00
Total Petrol Station	17.22±8.00	8.46±0.42	0.00±0.00	9.80±0.76	0.00±0.00
$\bar{X}$±S.D	11.20±13.76	16.65±27.23	0.92±0.00	14.86±7.47	3.21±3.78

Table 3 Mean Concentration (ug.g $^{-1}$) of some Heavy Metals in Moss samples and their Substrates in Ido-Ekiti.

Locations	Ekiti parapo college		Oke-Bareke street		Mechanic workshop		Odo-Agba street		Tad oil Petrol Station		Road Side		Ido-Garage		**Total Petrol Station**	
Treatment	Moss	Substrate	Moss	Substrate	Moss	Substrate	Moss	Substrate	Moss	Substrate	Moss	Substrate	Moss	Substrate	Moss	Substrate
Pb	15.72^{d}	6.49^{bc}	5.99^{c}	3.49^{c}	127.28^{b}	42.93^{b}	3.74^{c}	0.75^{c}	76.87^{a}	9.48^{b}	28.95^{c}	3.63^{b}	32.70^{b}	5.74^{c}	53.66^{b}	17.22^{a}
Cu	24.66^{b}	3.14^{bc}	20.79^{b}	4.84^{b}	252.39^{a}	82.68^{a}	10.15^{b}	2.18^{b}	78.81^{a}	18.86^{a}	35.54^{b}	3.63^{b}	60.44^{a}	9.92^{b}	40.13^{c}	8.46^{c}
Cd	9.25^{d}	0.00^{c}	0.92^{d}	0.92^{c}	3.39^{c}	0.92^{c}	0.00^{d}	0.00^{c}	2.10^{c}	0.00^{d}	0.92^{c}	0.00^{c}	1.54^{c}	0.00^{d}	1.23^{e}	0.00^{d}
Cr	74.9^{a}	17.85^{a}	44.99^{a}	14.08^{a}	81.45^{c}	21.62^{c}	60.08^{a}	7.04^{a}	45.25^{b}	8.55^{b}	85.63^{a}	11.31^{a}	65.61^{a}	28.91^{a}	63.30^{a}	9.80^{b}
Ni	22.00^{c}	8.62^{c}	6.84^{c}	2.08^{d}	11.30^{d}	9.81^{d}	2.97^{c}	0.89^{c}	10.11^{c}	2.23^{c}	9.22^{d}	1.19^{ab}	3.27^{c}	0.89^{d}	4.26^{d}	0.00^{d}
Mean	24.26	7.27	16.55	4.86	94.19	30.20	23.39	2.63	33.58	6.21	30.65	4.35	30.17	10.91	26.20	6.75

Table 4 pH values of moss substrates collected in Ido-Ekiti

Locations	pH values
Ekiti Parapo College	4.0
Oke Bakere street	8.0
Mechanic Workshop	7.0
Odo-Agbe street	6.0
Tad oil Petrol Station	8.0
Road Side	5.0
Ido-Garage	8.0
Total Petrol Station	5.0

Table 5 Average concentrations ± s.d. ($\mu g.g^{-1}$) of some heavy metals in moss sampled in Ipere–Ekiti

Locations	Pb	Cu	Cd	Cr	Ni
Ipere Com. High Sch.	20.22±1.29	38.44±1.45	18.31±0.00	68.63±0.00	4.15±0.15
Isaba Street	13.73±0.43	23.45±0.42	0.92±0.00	55.81±0.76	9.51±0.51
Oke-Odo Street	3.99±0.43	12.57±1.11	2.77±0.00	68.36±4.59	6.84±0.51
Road Side	12.48±6.28	14.75±1.67	1.23±0.57	48.52±0.43	8.92±0.00
Odo-Odo Street	5.49±2.17	20.55±0.42	0.00±0.00	42.73±1.57	3.67±0.51
St, Peter Ang. Pry sch.	3.49±0.43	24.41±0.84	0.27±0.00	69.13±0.87	1.78±0.00
Idemo Street	8.24±0.00	12.57±0.42	0.92±0.00	34.19±0.43	3.57±0.00
Ipere BasicHealth Cen.	5.79±0.87	14.51±0.73	0.00±0.00	29.16±0.43	2.38±0.52
$\overline{X}$ ± S.D	9.19±5.87	20.16±8.79	3.13± 6.19	52.10±16.03	5.23±2.93

Table 6 Average concentrations ± s.d ($\mu g.g^{-1}$) of some heavy metals in moss sampled in Ipere-Ekiti

Locations	Pb	Cu	Cd	Cr	Ni
Ipere Com. High Sch.	6.99±0.43	11.60±0.00	0.00±0.00	8.30±0.00	1.78±0.10
Isaba Street	2.75±0.86	4.11±0.84	0.00±0.00	12.07±0.76	1.78±0.90
Oke-Odo Street	1.50±0.00	6.29±2.33	0.00±0.00	9.30±0.00	0.87±0.00
Road Side	1.50±0.00	2.42±0.42	0.00±0.00	9.30±0.87	0.00±0.00
Odo-Odo Street	0.75±0.00	3.63±0.00	0.00±0.00	3.62±0.00	0.89±0.00
St, Peter Ang. Pry school	2.00±0.43	8.95±0.84	0.00±0.00	6.03±0.00	1.78±0.00
Idemo Street	2.99±0.00	8.04±0.00	0.00±0.00	2.26±0.76	0.00±0.00
Ipere Basic Health Cen.	0.75±0.00	1.48±0.00	0.00±0.00	3.52±0.43	0.00±0.00
$\overline{X}$ ± S.D	2.40±2.03	5.37±3.40	0.00±0.00	6.73±3.56	0.89±0.82

Table 7 Mean Concentration (ug.g $^{-1}$) of some Heavy metals in Moss samples and their Substrates in Ipere-Ekiti.

Locations	Ipere Com. High Sch.		Isaba Street		Oke-Odo Street		Road Side		Odo-Odo Street		St, Peter Ang. Pry sch.		Idemo Street		Ipere BasicHealth Cen.	
Treatment	Moss	Substrate	Moss	Substrate	Moss	Substrate	Moss	Substrate	Moss	Substrate	Moss	Substrate	Moss	Substrate	Moss	Substrate
Pb	20.22^{C}	6.99^{c}	13.73^{c}	2.75^{c}	3.99^{cd}	1.50^{c}	12.48^{bc}	1.50^{c}	5.49^{c}	0.75^{c}	3.49^{c}	2.00^{c}	8.24^{c}	2.99^{b}	5.49^{c}	0.75^{c}
Cu	38.94^{b}	11.62^{a}	23.45^{b}	4.11^{b}	12.57^{b}	6.29^{b}	14.75^{b}	2.42^{b}	20.55^{b}	3.62^{a}	24.41^{b}	8.95	12.57^{b}	6.04^{a}	14.51^{b}	1.48^{b}
Cd	18.31^{d}	0.00^{c}	0.92^{e}	0.00^{d}	2.77^{d}	0.00^{c}	1.23^{d}	0.00^{d}	0.00^{d}	0.00^{d}	0.92^{d}	0.00^{d}	0.92^{e}	0.00^{d}	0.00^{e}	0.00^{d}
Cr	68.63^{a}	8.30^{b}	-55.81^{a}	12.07^{a}	68.63^{a}	9.80^{d}	48.52^{a}	9.13^{a}	42.73^{a}	3.02^{b}	69.13^{a}	6.03^{b}	34.19^{d}	2.26^{c}	29.16^{a}	3.52^{a}
Ni	64.16^{c}	1.76^{d}	9.41^{d}	1.78^{c}	6.84^{c}	6.89^{c}	8.92^{c}	0.00^{d}	3.87^{c}	1.78^{d}	1.78^{d}	1.78^{d}	3.27^{c}	0.00^{d}	2.38^{d}	0.00^{d}
Mean	22.99	4.43	19.68	4.38	26.00	3.98	17.08	3.52	1.51	27.00	27.00	3.59	12.08	2.34	11.02	1.36

Table 8 pH values of moss substrates collected in Ipere-Ekiti.

Locations	pH Values
Ipere Community High School	6.0
Isaba Street	6.0
Oke-Odo Street	5.0
Road Side	5.0
Odo-Odo Street	8.0
St- Peter Anglican Primary School	5.0
Idemo Street	7.0
Ipere Basic Health Centre	4.0

Table 9 Comparison of some heavy metal concentrations in Moss sampled in Ido-Ekiti and Ipere-Ekiti

Heavy Metals	Ido-Ekiti	Ipere-Ekiti
Pb	43.11[a]	9.14[c]
Cu	65.36[a]	20.16[b]
Cd	2.43[b]	3.13[d]
Cr	65.15[a]	52.10[a]
Ni	8.81[b]	5.28[c d]