Vol. 8. No. 3. 2019
©Copyright by CRDEEP Journals. All Rights Reserved.

Contents available at:
www.crdeepjournal.org

International Journal of Environmental Sciences (ISSN: 2277-1948)

Full Length Research Article

A Study of Heavy Metal Uptake by Mosses in Ekiti State University, Ado Ekiti, Nigeria

Adedeji Olayinka Adebiyi
Department of Plant Science and Biotechnology, Ekiti State University, Ado Ekiti, Nigeria

ARTICLE INFORMATION

Corresponding Author:
Adedeji O. Adebiyi

Article history:
Received: 11- 05- 2019
Revised: 15- 05-2019
Accepted: 17-05-2019
Published: 18-05-2019

Key words:
Mosses, heavy metals, pollution, bio accumulation factor, phytoremediation

ABSTRACT

This study was conducted to investigate metal uptake by mosses in Ekiti State University, Ado Ekiti, Nigeria. Moss samples and their substrates were collected at different locations in the University area. In each location, three subsamples were randomly collected based on their availability. These samples were then digested separately in acid and the concentrations of six elements (Fe, Cu, Pb, Cd, Cr, Ni) in the samples were determined by using a Flame Atomic Absorption Spectrophotometer. The bioaccumulation factor for each metal was calculated to determine the affinity of mosses for each metal. The mean concentrations (mg/kg) of heavy metals in the moss samples were found to be: Fe (580.83),Cu (13.10), Pb (0.03),Cd (0.04),Cr (0.43) and Ni (0.08) while in the substrates, the concentrations were Fe (253.00),Cu (6.46), Pb (0.01),Cd (0.05), Cr (0.20) and Ni (0.03).The concentrations of the heavy metals in the study area were below permissible limits. The concentrations of the heavy metals were higher in the moss plants than their substrates except Cd. Iron had the highest mean concentration while Pb had the least. The concentrations of these metals were observed to follow the trend Fe> Cu> Cr> Ni>Cd>Pb. The bioaccumulation factor for each metal except Cd was greater than 1. This implies that mosses have the capacity to accumulate and remove these heavy metals except Cd from the air in the study area and this might be useful for phytoremediation programs.

Introduction

Mosses are small non-woody plants that are typically 1-10cm tall, though some species can be taller. They belong to the division Bryophyta. It is estimated that there are about 25,000 bryophyte species known in the world which are made up of three separate classes: the Hepaticae (liverworts), Anthocerotae (hornworts) and Musci (mosses) (Goffinet and Shaw, 2009). Bryophytes are found in all ecosystems except marine and their ecological roles in any ecosystem are significant (Saxena and Harrinder, 2004).

Heavy metals are members of loosely defined subsets of elements that exhibit metallic properties. They generally refer to metals and metalloids which are associated with pollution and toxicity, but they also include some essential trace elements for survival of living organisms (Ademoroti, 1996). They are widely distributed in the environment and are not biodegradable, hence are not readily detoxified or removed by metabolic activities once they are available in the environment (Ademoroti, 1996). Thus, contamination of the environment by heavy metals has continued to receive attention not only in Nigeria but also all over the world. The incidence of heavy metal contamination from both natural and anthropogenic sources has increased concern about the health effects of chronic low–level exposures, particularly people living in urban environment who are more likely to be exposed to this threat. Naturally, heavy metals occur in rocks. But most of the heavy metals occurrences in the environment tend to originate from anthropogenic sources (Norhayati*et al.,* 2007).

Introduction of toxic metals into the environment results from different domestic and industrial activities, dead and decomposing animals and vegetation, fall out of atmospheric particulate and from rock and soil exposed to surface water (Babich and Stotzky, 1983). Other reported sources of heavy metals in the environment include automobiles, incineration of domestic wastes, power station and fossil fuel combustions (Krolak, 2001; Caselles *et al.*, 2002). Heavy metals like Cd, Pb, Cu, and Zn are fuel additives that are released into the atmosphere and carried into the soil through rain and wind (Kho *et al.*, 2007). Although, heavy metals are natural components of the environment, metals such as Pb, Cd, Hg, Ni and As have no known or reported biochemical importance and their appreciable concentration could become potential lethal hazards (Ademoroti, 1996). Some of them could find their way from plants and animals through food chain to man, attacking specific sites or organs of the body and diseases can develop as a consequence of exposure to these substances (Audu and Lawal, 2005). Given the toxicological risks posed by heavy metals to human health in particular and the environment at large, it becomes imperative to constantly monitor their content in the environment. Grodzinska (1990) referring to Martins and Coughtrey (1982) observed that the pollution of the environment can be evaluated by physiochemical methods of analyses of the concentration of the pollutants in the air, soil, or water by the use of bio indicators. Bio indicators generally refer to all organisms that provide information on the environment or the quality of environmental changes (Markert *et al.*, 2003). Many plants and animals have been used as bio indicators. But of all plants, mosses and lichens have been found to be the best bio indicators (Fernandez *et al.*, 2002).This is because these plants grow abundantly in natural habitats, urban areas and industrial locations (Aceto *et al.*, 2003). They have the ability to accumulate heavy metals with high efficiency and low selectivity. Besides, the ability of mosses in this regard could also be attributed to their small size, nakedness, and their high tolerance to different environmental conditions (Csintalan *et al.*, 2005). Other advantages as reported by Charkrabortty *et al.* (2006) include perenniality, ease of collection, wide distribution, large capacity for cat ion exchange and ability to retain heavy metals directly from precipitation and dry particulate matter owing to their lack of cuticle and true roots.

Ekiti State University is located in Ado Ekiti, Ekiti State, Nigeria. The population of students, staff and other workers within the university coupled with the industrial, commercial and vehicular activities must have impacted the environment.

In most of the investigations on biomonitoring of environmental pollution carried out in Nigeria (Kakulu, 1993; Ayodele and Ahmed, 1996; Awofolu, 2005), the substrates of the biomonitors were not analyzed.

This study therefore tends to assess metal uptake by mosses collected at different locations in Ekiti State University, Ado Ekiti, Nigeria.

Materials and Methods

Study area and sampling

The study was conducted in Ekiti State University, Ado Ekiti, Nigeria. Ectohydric mosses were collected from eight different locations in the University area. These locations include Faculties of Education, Social Sciences, Science, Arts, Agriculture, Administrative block Motor Park, SUB Business center and health center. In each location, a minimum of three samples were randomly collected depending on their availability in the rainy season (August, 2018). Samplings were done according to the Nordic guidelines (Kubin *et al.,* 2000). The samples were taken to the laboratory for further treatment.

Preparation and Analysis of Samples

The moss samples were separated from their substrates under dry conditions. Digestion of moss samples was done in the fume chamber in the laboratory of the Department of Plant Science, Ekiti State University, Ado Ekiti. The moss samples were then oven dried for 48 hours at 90 ^{o}C. Each sample was then subjected to wet digestion method adopted by Fatoba and Oduekun (2004) as follows: to 0.5 g of each oven dried moss sample in 100ml conical flask, 25 ml of concentrated trioxonitrate (v) acid, 4 ml of concentrated tetraxosulphate (VI) acid and 2 ml percloric acid were added sequentially. Heat was then applied to the mixture until a dense white fume appeared. It was then allowed to cool. Thereafter, 30 ml of deionized water was added and then filtered into separate sample.

Samples of moss substrates were dried at 105^{o}C and 0.5g of each sample was digested with a 3:1 solution of trioxonitrate (V) acid and perchloric acid (MAFF, 1986; Awofolu, 2005). The extracts were separated from their solid residues by centrifugation at 3500rpm. Each extract was put into separated sample bottles and labeled accordingly. Digested moss samples and their substrates were analyzed for Fe, Cu, Pb, Cd, Cr and Ni using Atomic Absorption Spectrophotometer, Buck Scientific Model 210 equipped with a continuum source background correction and attached to a computer. Results are given in mg/kg of the dry mass. These metals were chosen according to the significance of their presence in environments (Lantzy and Mackenzie, 1979).

Statistical Analysis

The means and the standard deviations were calculated and recorded. Analysis of Variance (ANOVA) was conducted on the data. Duncan's Multiple Range Test (DMRT) was usedto determine whether or not significant differences existed among the means.

Determination of Bioaccumulation factors

The bioaccumulation factor (BF) for each metal was calculated using the formula:

$$BF = \frac{\text{Concentration of heavy metals in moss}}{\text{Concentration of heavy metals in substrate}}$$

Results

The concentrations of the heavy metals in mosses collected at different locations in Ekiti State University, Nigeria are presented in Table 1. The mean concentrations (mg/kg) of Fe were 834.33. 184.67, 128.67, 822.33, 294.00, 969.00, 854.33 and 559.33in Faculties of Education, Social Sciences, Science, Arts, Agricultural Sciences, SUB Business center, administrative block motor park and health center respectively. The concentration of Fe was statistically higher in SUB Business center than the other locations while it was statistically the same at Faculties of Education and Agricultural Sciences. The mean concentrations (mg/kg) of Cu were 13.63, 0.28, 8.13, 14.63, 8.40, 16.07, 26.30 and 17.33in Faculties of Education, Social Sciences, Science, Arts, Agricultural Sciences, SUB Business center, administrative block motor park and health center respectively. The concentration of Cu was statistically higher in Administrative block motor parkthan the other locations while it was statistically the same at Faculties of Science and Agricultural Sciences. The mean concentrations (mg/kg) of Pb were 0.01, 0.06, 0.11 and 0.04 in Faculty of Education, SUB Business center, administrative block motor park and health center respectively. Pb was below detection limits in the other locations. The concentration of Pb was statistically higher in administrative block motor park than the other locations .The mean concentrations of Cd in Faculties of Education, Social Sciences, Science, Agricultural Sciences, SUB Business center and health center were 0.03, 0.11, 0.03, 0.01, 0.06 and 0.11 respectively. Cd was below detection limits in Faculty of Arts and administrative block Motor Park. Cd concentration was statistically higher in the Faculty of Social Sciences and Health center than the other locations. However, there was no significant difference in the concentration of Cd between the two locations. The mean concentrations (mg/kg) of Cr were 0.35, 0.11, 0.26, 0.16, 1.22, 0.45, 0.54 and 0.39 in Faculties of Education, Social Sciences, Science, Arts, Agricultural Sciences, SUB Business center, administrative block motor park and health center respectively. The concentration of Cr inthe Faculty of Arts was statistically higher than that of the other locations. The mean concentrations (mg/kg) of Ni were 0.07, 0.05, 0.13, 0.07, 0.07, 0.11, 0.13 and 0.02 in Faculties of Education, Social Sciences, Science, Arts, Agricultural Sciences, SUB Business center, administrative block motor park and health center respectively. The concentration of Ni was significantly higher in Faculty of Science and administrative block motor park than that of the other locations. There was no significant difference in the concentration of Ni among Faculties of Education, Arts and Agricultural Sciences. The mean concentrations (mg/kg) of Fe, Cu, Pb, Cd, Cr and Ni in mosses collected at different locations in Ekiti State University were 580.83, 13.10, 0.03, 0.04, 0.43 and 0.08 respectively (Table 1). The concentrations of the heavy metals in moss substrates collected at different locations in Ekiti State University, Nigeria are presented in Table 2. Variations were also observed in the concentration of the metals across the locations. The mean concentrations (mg/kg) of Fe, Cu, Pb, Cd, Cr and Ni in moss substrates collected at different locations in Ekiti State University were 253.00, 6.46, 0.01, 0.05, 0.20 and 0.03 respectively (Table 2). The concentrations of the heavy metals were numerically higher in the mosses than their corresponding substrates.

The bioacummulation factors of the heavy metals are presented in Table 3. Pb had the highest bioacummulation factor of 3.00 while Cd had the least (0.80). Fe, Cu, Cr and Ni had bioacummulation factors of 2.29, 2.03, 2.15 and 2.67 respectively.

Table 1: Mean concentrations of heavy metals (mg/kg) in mosses collected at different locations in Ekiti State University, Nigeria

Location			**Concentration (mg/kg)**			
	Fe	**Cu**	**Pb**	**Cd**	**Cr**	**Ni**
FOE	834.33bc	13.63e	0.01d	0.03c	0.35e	0.07c
FOSS	184.67f	0.28g	BDL	0.11a	0.11h	0.05d
FOS	128.67g	8.13f	BDL	0.03c	0.26f	0.13a
FAR	822.33c	14.63d	BDL	0.01d	0.16g	0.07c
FA	294.00e	8.40f	BDL	BDL	1.22a	0.07c
SBC	969.00a	16.07c	0.06b	0.06b	0.45c	0.11b
ABM	854.33b	26.30a	0.11a	BDL	0.54b	0.13a
HC	559.33d	17.33b	0.04c	0.11a	0.39d	0.02e
Mean±	580.83	13.10	0.03	0.04	0.43	0.08
Standard deviation	321.70	7.36	0.04	0.04	0.33	0.04

Means with the same letters within columns are not significantly different (p≤ 0.05); BDL: Below detection limits
FOE: Faculty of Education, FOSS: Faculty of Social Sciences, FOS: Faculty of Science, FAR: Faculty of Arts, FA: Faculty of Agricultural Sciences, SBC: SUB Business Centre, ABM: Administrative block motor park, HC: Health center

Table 2: Mean concentrations of heavy metals (mg/kg) in moss substrates collected at different locations in Ekiti State University, Nigeria

Location			**Concentration (mg/kg)**			
	Fe	**Cu**	**Pb**	**Cd**	**Cr**	**Ni**
FOE	343.33c	5.63e	BDL	0.03c	0.14d	0.02c
FOSS	76.07f	0.13h	BDL	0.12a	0.06f	0.02c
FOS	63.00g	4.13f	BDL	0.03c	0.18c	0.05b
FAR	452.67a	6.63d	BDL	0.02cd	0.15d	0.06b
FA	86.27a	2.40g	BDL	BDL	0.56a	BDL
SBC	388.33b	7.20c	0.03b	0.06b	0.08e	0.02C
ABM	456.67a	16.27a	0.04a	BDL	0.24b	0.08a
HC	157.67d	9.30b	0.01c	0.11a	0.18c	BDL
Mean±	253.00	6.46	0.01	0.05	0.20	0.03
Standard deviation	166.36	4.68	0.02	0.05	0.15	0.03

Means with the same letters within columns are not significantly different (p≤ 0.05); BDL: Below detection limits
FOE: Faculty of Education, FOSS: Faculty of Social Sciences, FOS: Faculty of Science, FAR: Faculty of Arts, FA: Faculty of Agricultural Sciences, SBC: SUB Business Centre, ABM: Administrative block motor park, HC: Health center

Table 3: Bioaccumulation factors of the heavy metals

Heavy metals	Bioaccumulation factor
Fe	2.29
Cu	2.03
Pb	3.00
Cd	0.80
Cr	2.15
Ni	2.67

Discussion

The mean concentration of Fe observed in this study fell within the normal ranges in plants. FNB (1980) reported that the permissible limit of Fe in plants is 1000mg/kg. Since the concentrations of Fe obtained in all the locations in the study area were within this limit/range, one may say that Fe poses no threat in the study area. Leetham *et al.* (1982) reported that the Fe content in mosses collected from unpolluted areas is generally lower than 500 µgg^{-1}. Therefore, it is logical to say that the study area is unpolluted with Fe. In a study for polluted area in Norway, Steinnes *et al.* (1994) recorded a high Fe concentration of 530-1025 mg/kg. The findings of the present study agree with this. Belozerova (2002) reported that Fe is usually emitted during combustion of fossil fuels. Hopke*et al.* (1980) had earlier reported high levels of Fe in the roadside grass samples which they attributed to vehicular emission. This suggests that vehicular emission in the study areas may have also contributed to the Fe concentrations observed in this study. Bykowszezenko *et al.* (2006) recorded mean Fe level of 233.9µgg^{-1} in a study to determine heavy metal concentration in mosses of Slowinski National Park, Poland. Results obtained in the present study are higher than this value. Also, the concentration of Fe in the present study is lower than that reported by Guray *et al.* (2007) who recorded a mean value of 2003.87µgg^{-1} for Fe in a study where mosses were used to monitor atmospheric heavy metal deposition in Duzce province of Turkey.

The mean concentration of Cu in mosses in this study was within the permissible limit in plants. According to Reeves and Baker (2002), the normal range of Cu in plants is 5-25 mg/kg. This indicates that the study area was not polluted with Cu. Ruhling and Steinnes (1998) had earlier reported that Cu mainly originated from metal industry, mining, coal-fired plants and traffic. Thus, the suspected source of Cu observed in this study may be attributed to traffic, considering the absence of the above mentioned industries in the study area. The Cu concentrations observed in the present study are higher than values reported by Ekpo *et al.* (2012) but fell within the range reported by Bradford *et al.* (1996) in China.

The mean concentration of Pb in the study area was below the normal range. According to FAO / WHO (1976), the normal range of Pb in plants is 20 – 100 mg/kg. Since Pb concentration in the study area fall below the normal concentrations, it is therefore logical to say that Pb did not constitute pollution in the study area. The values reported for Pb in this study were lower when compared with the values recorded in previous investigation by Kakulu (1993) in northeastern, Nigeria. The author recorded values of 201 µgg^{-1}, 241 µgg^{-1} and 190 µgg^{-1} in Jos, Maiduguri and Bauchi respectively. These areas were classified as high pollution zones. The author also recorded values of 106 µgg^{-1} and 89 µgg^{-1} in Potiskum and Gombe respectively and classified them as medium pollution zones while values 10 µgg^{-1} and 16 µgg^{-1} were recorded in Wikki and Gubi and these were classified as low pollution Zones. From the foregoing, it becomes clear that the study area may be considered unpolluted with Pb as the mean concentration of Pb encountered in this study was less than 10 µgg^{-1}. The low Pb concentration recorded in this finding may be due to relatively low traffic density in the study area. Pb pollution has been shown to be commensurate with vehicular density / population (Adu *et al.*, 2012). Smith (1976) reported that the use of Pb as antiknock additives in gasoline in many parts of the world has resulted to its release from vehicular exhaust and it contaminates the environment. Pb – containing particulates often settle onto roadside vegetation by sedimentation, resulting in high Pb content in roadside vegetation (Ho and Tai, 1988). When compared with the result obtained by Guray *et al.* (2007) in Duzce, the mean concentration of Pb in the study area was lower. The authors recorded a range of 4.96 - 63.65 µgg^{-1}. Variations in vehicular emission and other anthropogenic activities may be responsible for this. Pb remains the major trace element in urban environment due to its long residence time in the environment (Olowoyo and Van Herdeen, 2010).

The mean Cd concentration in the study area was below permissible limits. According to FAO/WHO (1976) the normal concentrations of Cd in plants should not exceed 2.4 mg/kg. Thus, Cd did not constitute pollution in the study area. Cd mainly spread to the environment through emissions from metal industry (Herpin *et al.,* 1996). The absence of such industry in the study area may be responsible for the low level of Cd reported in this study. However the observed concentrations of Cd observed in this study may be attributed to density of motor cars and other anthropogenic activities. Ho and Tia (1988) had earlier reported that the major source of elevated levels of Cd in roadside plants was motor vehicles. Cd in the environment in low concentration could be from natural sources. Awofolu (2005) puts forward that the largest sources of Cd release to the environment is from industrial activities, burning of fossil fuel and incineration of municipal waste materials. This assertion was also supported by Olowoyo and Van Herdeen (2010) that Cd in the environment is traced to urban metal smelting companies, burning of household wastes and paint manufacturing industries while Scerbo *et al.* (2010) mentioned that Cd in the environment is traced to di – methyl cadmium used in the production of tetraethyl lead and it is emitted by vehicles. These further lend credence to the fact that the concentration of Cd observed in this study can be traced to vehicular emissions as well as incineration of domestic wastes. Vegetation and forest fires could also be culprits as confirmed by EC (2001) that 25% of natural Cd emission is estimated to come from vegetation as exudates and slough. The mean value of Cd reported in the study area were lower when compared with the value reported by Fatoba and Oduekun (2004) who used mosses to assess heavy metal deposition in Ilorin, Nigeria. Also, Fatoba *et al.* (2013) recorded higher Cd concentration in mosses collected around some petroleum product depots in Nigeria. This may be due to higher traffic density and anthropogenic activities in these areas. However the mean value obtained for Cd in this study is comparable to those reported by Ekpo e*t al.*(2012). Cd is a heavy metal with high poisonous ability and it is a non – essential element in foods and natural waters and it accumulates principally in the kidneys and livers.

The mean concentration of Cr obtained in this study was below the permissible limit. WHO (1996) reported that the permissible limit of Cr in plants was 13.0 mg/kg. Thus, Cr did not constitute pollution in the study area. EPAQS (2008) reported that the main natural source of airborne Cr is forest fire. Therefore, the low level of Cr obtained in this study is not surprising, considering the fact that bush burning is not a common practice in the locations used in the study area. Other activities that may have contributed to the Cr concentration observed in this study are vehicular emissions, incineration of domestic wastes as well as other anthropogenic activities. Vehicular emissions and incineration of domestic wastes have been put forward as reasons for increased Cr concentration in the environment (Guray *et al*., 2007; Shakya *et al.*, 2001). The mean concentration of Cr observed in this finding was lower than those reported by Ogunkunle and Fatoba (2012) in Southwest Nigeria. The mean value was also lower than those obtained by Ekpo*et al.*(2012) in the Niger Delta region of Nigeria except Aba. Aline *et al.* (2012) had earlier reported higher levels of Cr in Brazil.

The mean concentration of Ni observed in this study was within the normal range in plants. FAO/WHO (1976) and FNB (1980) reported that the normal range and concentration of Ni in plants were 0.02-50mg/kg and 100µg/g respectively. Therefore, since the mean concentration of Ni in the study area was below these figures, the study area can be considered to be unpolluted with Ni. The principal sources of Ni are metal refinery and smelting, coal burning, steel industry and industrial waste sludge (Fernandez *et al.*, 2002). Nickel is emitted through combustion of plants as Ni sulfate and oxidic nickel (EC, 2001). The low concentration of Ni observed in this study is not surprising as such industries are not in existence in the study area. The wide range of trade involving using/repairing components or devices containing Ni or its alloys especially stainless steel (alloy wheel in cars) has apparently increased its concentration in the environment. Incineration of municipal garbage and sewage sludge has also been confirmed to account for Ni existence in the environment. Thus, the observed concentration of Ni in this study may be attributed to these sources. Markert (1998) reported that Ni is commonly found in petroleum in substantial amount and the burning of petroleum contributes the greatest emission of Ni. Garty (1993) also reported that Ni is discharged into the atmosphere by vehicular emission as well as due to wear of tyre particles and that this may be scattered into the ambient air and contaminate the environment. The rate of smoking these days in the urban areas has also contributed to higher Ni concentration in the suspected polluted areas in this study. WHO (2000) asserted that the mainstream cigarette smoke contains 0.04-0.58 micrograms Ni/cigarette and consuming 20 cigarette/day will increase the ambient Ni value by 15 times. It is suspected that smokers in the study area added to Ni pollution in the area. In comparison with data from a study by Fatoba and Oduekun (2004) in Ilorin, Nigeria, the mean Ni concentration obtained in this study was lower. The author attributed the high Ni concentration in ITC and Global soap and detergent industry in this town to industrial activities in these locations. The mean value recorded for Ni in this finding were also lower than the values obtained in urban and rural areas of Brazil in a study conducted by Aline *et al.* (2012). The results obtained in this study are also lower than values reported by Ekpo *et al.* (2012).
Variation in the level of the heavy metals in mosses across the locations in the study area is in line with previous studies (Gupta (1995; Shakya *et al.,* 2001; Ekpo *et al.* (2012; Fatoba *et al*., 2013). The variations suggest that ambient levels of atmospheric pollutants depend upon strength of the sources and efficiency of their dispersion (WHO, 2001).

The concentration of Fe in the study was distinctly higher than that of the other metals. This finding agreed with the previous work of Ekpo *et al*. (2012) who studied the levels of trace metals in moss species in some cities of the Niger Delta Region of Nigeria and reported that the metal with the highest concentration among the twelve metals studied was Fe. This finding also agreed with the work of Bykowszczenko *et al.* (2006) who used mosses as bioindicatiors of heavy metal deposition in Poland and reported that Fe had the highest concentration out of the five metals studied. Madani and El-Tigani (2012) also reported that Fe had the highest concentration out of the five metals investigated in mosses collected in Jebel Marra, Darfur, Sudan. The results of this work is also in accordance with the earlier work of Ogunkunle *et al.* (2012) who used mosses as bio monitors of heavy metal deposition in the atmosphere in Nigeria. The authors reported that Fe had the highest concentration out of the six metals investigated. Study on the heavy metal concentration in abattoir dumping site soil in Nigeria revealed that the level of Fe was the highest among the eight metals in the area of the study (Yahaya *et al.,* 2009). In another study by Hoque *et al.* (2014), Fe was found to have the highest level out of the five metals investigated in decomposed solid waste and landfill sites of Bangladesh. These may be attributed to the level of their concentrations in the atmosphere. Chipev and Kovachev (2006) and Herpin *et al*. (1996) reported that heavy metal concentration varied greatly in moss samples depending on environmental impact. Poblet *et al*. (1997) reported that the concentration of Cd, Cr, Cu, Fe, Ni, Pb, V and Zn found in mosses varied greatly with the air quality. However, the variations in the concentration of the metals in the moss samples may also be attributed to variations in the uptake efficiency of mosses for different metals. Berg *et al*. (1995) reported that the chemical composition of deposition has a large effect on the accumulation of pollutants because the uptake efficiency of the mosses for individual elements varies considerably. Zeichmeister *et al.* (2003) reported that the uptake efficiency of most common heavy metals follow mostly the order Pb> Co > Cr >Cu, Cd, Mo, Ni, U > Zn >As. The uptake efficiency is affected by competition for free cat ion exchange sites, for instance, the presence of sea salts and acidic deposition have been found to have an effect on the absorption of metals by mosses (Gjengedal and Steinnes,1990). Thoni *et al*. (1996) reported that the concentrations of heavy metals in mosses are usually affected by the site where mosses are growing.

The bioconcentration factors for all the metals except Cd were greater than 1. This suggests that mosses have high affinity for the metals except Cd and can therefore serve as accumulators of the metals. This may be explored in phytoremediation programs in the study area. In a previous study by Busoic *et al*. (2012), it was reported that the moss *Polytrichum commune* had high affinity for the heavy metals studied. The result of the present study is in line with this.

Conclusion

The results of the present investigation confirm the presence of heavy metals in the environment of Ekiti State University, Ado Ekiti, Nigeria, particularly in the atmosphere. Even though the concentrations of the heavy metals investigated in the study area were generally low, heavy metals are capable of bio accumulating in organisms. Thus, it might be necessary to investigate and monitor their contents in the environment from time to time, considering the toxicological risks posed by such metals to human health in particular and the environment at large.The bioaccumulation factor for each metal except Cd was greater than 1. This implies that mosses have affinity for these metals in the study area. Hence, they have the capacity to accumulate and remove them from air and this might be useful for phytoremediation programs in the study area.

References

Aceto, M., Abollino, A., Conca, R., Malandrino, M., Mentasti, E. and Sarzanini, C. (2003). The use of mosses as environmental metal pollution indicators. *Chemosphere*, 50:333-342.

Ademoroti, C.M.A. (1996). Environmental chemistry and toxicology.Foludex Press Ltd., Ibadan. 171- 201.

Adu, A.A., Aderinola, O.J., Kusemiju, V. (2012). Heavy Metals Concentration in Garden Lettuce (*Lactuca sativa* L.) grown along Badagry Expressway, Lagos, Nigeria. *Transnational Journal of Science and Technology,* 2(7):115-130.

Aline, C.M., Rosane, L., Jucara, B., Alois, S. and Ronaldo, W. (2012). Mosses as indicators of atmospheric metal deposition in an industrial area of southern Brazil. *Acta Botanica Brasilica.* 26(3):553-558.

Audu, A.A. and Lawal, A.O. (2005). Variations in metal contents of plants in vegetable garden sites in Kano metropolis. *J. Applied Sci. and Environ. Manag*. 10(2): 105-109.

Awofolu, O.R. (2005). A survey of trace metals in vegetation, soil and lower animals along some selected areas in the metropolitan city of Lagos. *Environmental Monitoring and Assessment*, 105:431-447.

Ayodele, J.T. and Ahmed, A. (1996). Monitoring air pollution in Kano by chemical analysis of scot pine needles for heavy metals. *J. Chem. Soc., Nigeria*, 21: 81-86.

Babich, H. and Stotzky, G. (1983).Environmental Biogeochemistry. Ecol. Bull. (Stockholm). 35:315-323.

Belozerova, E. (2002), Methodical aspects of potential health risk assessment related to accumulated waste. International Symposium on Children's Health and Environment, Istanbul, 52 – 70.

Berg, T., Royset, O. and Steinnes, E. (1995). Moss *Hylocomiumsplendens* used as bio monitor of atmospheric trace element deposition: Estimation of uptake efficiencies. *Atmos.Environ*,29: 353-360.

Busoic, G., David, I., Mihaela, S. and lliescu, N. (2012). Evaluation of the capacity for bioaccumulation of some heavy metals in three aquatic plant species. Water resources and wetlands, Ed. PetreGstescu. William Lewis Jr. PetreBretcan. Conference proceedings, 14-16 September 2012, Tulcea-Romania.

Bykowszczenko, N., Baranowska-Bosiacha, I., Bosiacha, B., Kaczmarek, A. and Chlubek, D. (2006). Determination of Heavy Metal Concentration in Mosses of Slowinski National Park Using Atomic Absorption Spectrometry and Neutron Activation Analysis Methods. *Polish Journal of Environmental Studies* 15(1): 41-46.

Caselles, J., Colliga, C. and Zornoza, R. (2002). Evaluation of trace element pollution from vehicle emissions in Petunia plants. *Water, Air and Soil Pollution*. 136(1-4):1-9.

Charkrabortty, S., Jha, S.K., Puranik, V.D., and Paraktar, G.T. (2006). Use of mosses and lichens as biomonitors in the study of air pollution near Mumbai. *Evansia*, 23:1-8

Chipev, N. and Kovachev, A. (2006). Preliminary data on heavy metal contents in lichens from the Livingstone Island. *Bulgarian Antarctic Research: Life Sciences*, 2: 106-109.

Csintalan, Z., Juhtsz, A., Benk, S., Raschi,A. and Tuba, Z. (2005). Photosynthetic response of forest floor moss species to elevated CO_2 levels by natural CO_2 vents. *Cer. Res. Com*. 33: 177- 180.

Ekpo, B.O., Uno, U.A., Adie, A.P. and Ibok, U.J. (2012). Comparative Study of Levels of Trace Metals in Some Cities of the Niger Delta Region of Nigeria. *International Journal of Applied Science and Technology.* 2(3):127-135.

European Communities (2001), Ambient air pollution by As, Cd and Ni compound, Official Publications of the European Communities, 10 – 318.

Expert Panel on Air Quality Standard (2008), Guidelines for metals and metalloids in ambient air for the protection of human health. Department of Environment, Food and Rural affairs, London UK.http://www.defra.gov.uk/corporate/consult/metals-metalloids/.

F.A.O./ W.H.O. (1976). List of maximum levels recommended for contaminants by the joint F.A.O./ W.H.O. Codex Alimentarians Commission. 2nd Series. CAL/FAL, 3: 1-8.

Fatoba, P.O., Ogunkunle, C.O., Oyedeji, S. and Salawudeen, M.B. (2013). Heavy Metal Depositions around some Petroleum Product Depots in Nigeria, using Mosses as Biomonitors.*The Bioscientist*, 1(1):99-105.

Fatoba, P.O. and Oduekun, T.I. (2004). Assessment of metal deposition in Ilorin metropolis using mosses as bioindications. *Nig. J. Pure and Applied Sci*. 19: 1549-1552.

Fernandez, J.A., Ederra, A., Nunez, E., Martinez, A.J., Infante, M., Heras, P., Elias, M.J., Mazimpaka, V. and Carballeira, A. (2002).Biomonitoring of metal deposition in northern Spain by moss analysis. *Sci. Total Environ*. 300:115-127.

Gatty, J., (1993).Lichens as biomonitors for heavy metal pollution. In plants as Bio monitors (B. Markert, editor), Plants as Bio monitors, VCH, Wenham, 193-263.

Gjengedal, E. and Steinnes, E. (1990).Uptake of metal ions in moss from artificial precipitation. *Environmental Monitoring and Assessment*, 14:77-87.

Godzik, B. and Grodzinska,K. (1991). Heavy metals in mosses of Mazurian landscape park, Poland. *Ochr*. 49(1):81-86.

Grodzinska, K. (1990). Long – term ecological monitoring in the park of Poland. In: Ecological risks and Perspectives from Poland and the United States. National Academic Press.Pp 252.

GurayUyar, Muhmmet Oren and MahirInce (2007), Atmospheric Heavy Metal Deposition In Duzce Province by Using Mosses as Biomonitors.PSP Volume 16- No 2.

Herpins, U., Berlekamp, J., Markert, B., Wolterbeek, B., Grodzinska, K. Siewers,U., Lieth, H. and Werkert, V. (1996). The distribution of heavy metals in a transect of the three states: the Netherland, Germany and Poland determined with the aid of moss monitoring. *Science of the Total Environment,* 187:185-198.

Ho, Y.B. and Tai, K.M. (1988). Elevated levels of lead and other metals in roadside soil and grass and their use to monitor aerial deposition in Hong Kong. *Environmental Pollution*, 49:37-51.

Hopke,P.K., Lamb, R.E. and Natuseh, D.F.S. (1980). Multi elemental characterization of urban roadway dust. *Environment, Science and Technology*, 14:164-172.

Hoque, M.A., Haque,M.A., Mondal, M.S.A. (2014). Seasonal Effects on Heavy Metal Concentration in Decomposed Solid Waste of DNCC and DSCC Landfill Sites. *Civil Engineering and Architecture* 2(1): 52-56.

Kakulu, S.E. (1993). Biological monitoring of atmospheric trace metal deposition in north-eastern Nigeria. *Environmental Monitoring and Assessment*, 28 (2):137-142.

Kho, F.W.L., Law, D.L., Ibrahim, S.H. and Sentian, J. (2007). Carbon monoxide levels along roadsides. *Int. J. Environm. Sci. Tech*. 4(1):27-34.

Krolak, E. (2001). Heavy metal content in falling dust, soil and dandelion (*Taraxacumofficinale* Webb) in southern Podlasie lowland.*Electronic Journal of Polish Agricultural Universities*. 4(1):1-13.

Kubin, E., Lippo, H. and Poikolainen, J. (2000).Heavy metal loading. In: Malkonen E (ed). Forest condition in a changing environment- The Finnish case- Forestry Sciences 65, Kluwer Academic Publishers. Dordrecht, pp 60-71

Lantzy, R.J. and Mackenzie, F.T. (1979). Atmospheric trace metals: global cycles and assessment of man s impact. *Geochim.Cosmochim.Acta*, 43: 511-525.

Leethman, J.W., McNary, T.J., Dodd, J.L. and Lauenroth, W.K. (1982). Response of soil nematodes, rotifers and tardigrades to three levels of season long sulphur dioxide exposure. *Water, Air and Soil Pollution,* 17:343-356.

MacNee, W. and Donaldson, K. (2000). How can ultrafine particles be responsible for increased mortality. *Monaldi Archives of Chest Disease*, 55(2):135-139.

MAFF, (1986).The analysis of agricultural materials, reference book 427. Ministry of agriculture, fisheries and food, London.

Markert, B.A., Breure, A.M. and Zeichmeister, H.G. (2003). Definitions, strategies and principles for bioindication / biomonitoring of the environment. Elsevier, Oxford. Pp 3-39.

Markert, B. (1998). Distribution and biogeochemistry of inorganic chemicals in the environment In: Schumann,. G. Markert. B (Ed.). *Ecotoxicology*. Wiley-Spectrum Co-publication. New York. Pp: 165-222.

Martin, M.H. and Coughtrey, P.J. (1982).Biological monitoring of heavy metals.*Pollution, Land and Air*. Appl. Sci. Publishers, London. Pp 136-142.

Modani and El-Tigani (2012). Heavy metal contents in moss samples from Jebel Marra, Darfur, Sudan. *Sudan J. Sci*. 5(1):2-4.

Norhayati, M.T., Poh, S.C. and Maisarak, J. (2007). Determination of heavy metal contents in soils and indoor dusts from nurseries in Dungun, Terengganu. *The Malaysian Journal of Analytical Sciences*, 11(1):280-286.

Ogunkunle, C.O. and Fatoba, P.O. (2012). Cellular Compartmentalization and Heavy Metal Load in the Moss *Banbula lambarensia* Around a Mega Cement Factory in Southwest Nigeria. *Ife Journal of Science* vol. 14 no.2.

Olowoyo, J.O., van Heerden, E. (2010), Trace element concentrations from lichen transplants in Pretoria. South Africa. *Envirn. Sci. Pollut. Res*. DOI 10.1007/s11356-010-0410-3

Poblet, A., Andrade, S., Scaqliola, M., Vodopivez, C., Curtosi, A., Pucci, A. and Marcovecchio, G. (1997). The use of epilithicAntartic lichens (*Usnea aurantiacoatra* and *U. antartica)* to determine the deposition of heavy metals in the Shetland Islands. Antartica.*Science of the Total Environment*, 267:187-194.

Ruhling, A. &Steinnes, E. (1998).Atmospheric heavy metal deposition in Europe 1995-1996.Nordic Council of Ministers*,* 15: 21 - 44

Saxena, K. and Harrinder, S. (2004). Uses of bryophytes.*Resonance,* 9(6): 56-65.

Scerbo, R., Ristori, T., Possenti, L., Lampugnami, L., Barale, R., Barghigiani, C. (2001), Lichen (*Xanthoriaparrientina*) bio monitoring of trace element contamination and air quality Assessment in Pisa Province, Italy.*Sci. Total Environ.* 286:27-40

Shakya, K., Chettri, M.K. and Sawidis, T. (2001). Appraisal of some mosses for bio monitoring airborne heavy metals in Kathmandu valley. *Eco print,* 8(1): 69 – 75.

Smith, W.H. (1976). Contamination of the roadside ecosystem.*J. Air Pollut.Assoc*., 26:753-766.

Steinnes, E., Ramback, J.P. and Hanssen J.E. (1994). Large scale multi-element survey of atmospheric deposition using naturally growing moss as a biomonitor. *Chemosphere*, 25:735-752.

Thoni, L., Schnyder, N., Krieg, F. (1996). Comparison of metal concentrations in three species of mosses and metal freights in bulk precipitations.*J. Anal. Chem*. 354:703-708.

W.H.O. (2001).Guidelines for Air Quality. Geneva: World Health Organization.

Yahaya, M.I., Mohammad, S., Abdullahi, B.K. (2009). Seasonal Variations of Heavy Metal Concentration in Abattoir Dumping Site Soil in Nigeria.*Appl. Sci. Environ. Manage*., 13(4): 9-13

Zeichmeister, H.G. Grodzinska, K. and Szarek-Lukaszewska, G. (2003).Bryophytes.Markert, B., Breure, A.M. and Zeichmeister, H.G. (Eds.). Elsevier, Oxford. Pp 329-375.