GSJ: Volume 8, Issue 5, May 2020, Online: ISSN 2320-9186
www.globalscientificjournal.com

EPIPHYTIC *PLATYCERIUM ANDINUM* BAKER GROWING AROUND GENERATOR HOUSES: A BIOACCUMULATOR FOR HEAVY METALS

OZUZU, SANDRA. AMARACHI., OCHEKWU, EDACHE BERNARD

AND NDUKWU, BENJAMIN, CHINYEM.

Department of Plant Science and Biotechnology, University of Port Harcourt, Rivers State, Nigeria.

ABSTRACT

Platycerium andinum an epiphyte growing on plants found around generator houses was used to examine the presence and concentration of heavy metals in the substrata and plant body obtained from three sites in University of Port Harcourt (two polluted sites and a control site). The study was carried out to assess the presence of heavy metals accumulation used in aerobiological studies as bio-indicators and biomonitoring species. *P. andinum* and its substratum were collected from the sample areas and analyzed. Atomic Absorption Spectrophotometer method was used to determine the presence of heavy metals in the samples. Results from the study show that Copper was present in all samples (substrata and plant bodies) found in all sites; Cadmium was only present in the substrata of the polluted sites. Lead and Nickel were not detected in any of the samples. These results are discussed in the light of efforts towards monitoring and controlling increasing air pollution in the environment. The presence of these heavy metals in the epiphyte confirms that they are bio-accumulators and thus can serve as bio-indicators and bio-monitors. Therefore, the study recommends the use of epiphytes and their substratum for atmospheric air pollution monitoring.

Key words: Bio-indicators, Bio-monitors, Bio-accumulators, Generating set, Air Pollution, Epiphyte

Corresponding Author: OCHEKWU, E.B. (edacheb@gmail.com)

INTRODUCTION

The cause of environmental pollution is simply the release of heavy metals into the environment having their sources from both natural and anthropogenic means (Arif *et al*., 2015). Heavy metals constitute an ill-defined group of inorganic chemical hazards and those most commonly found at contaminated sites are Lead (Pb), Chromium(Cr), Arsenic(As), Zinc(Zn), Cadmium(Cd), Copper(Cu), Mercury(Hg) and Nickel(Ni). Due to the non-biodegradable, toxicity and bio-accumulative nature of these heavy metals, they continue to pose as a threat to both man and the environment. With regards to life, heavy metals can be beneficial to an extent but toxic when a certain threshold of internal concentration has been exceeded i.e. when its concentration level exceeds more than normal for the living entity to absorb (Klaus-J, 2010). Effective understanding of the biogeochemical processes and gauging ecosystem health has been successfully determined by the monitoring and assessment of heavy metals concentration in the environment (Ite and Ibok, 2014). The pollution levels in cities solely depends on the presence, size and character of the traffic intensity, the number of industries present in that area of interest, the number of population per area and waste utilization facilities (Parazych *et al*., 2016).

Epiphytes, which are plants that grow on other plants without causing any negative effect on that plant, can be used as bio-indicators because of their morphological and physiological characteristics. The epiphytes have been used for the assessment of heavy metals present in the atmosphere and /or biological effects of airborne contaminants (Ite *et al*., 2016).

Some heavy metals are released from atmospheric depositions from industries, urban effluents, traffic emissions and waste incinerators (Maryan *et. al*., 2015). These cause a lot of environmental hazards and also affects the wellbeing of man in general. The major source of heavy metals arises due to anthropogenic activities having natural causes. Apart from the already listed sources, others include vehicle exhaustion, agricultural sources which basically involves the use of pesticides, herbicides and insecticides and also excessive application of fertilizers. Generally, heavy metals like Arsenic, Barium, Beryllium, Germanium, Tin, Thallium, Tellurium, Gold, Indium, Lithium, Strontium, Platinum, get into the environment naturally by weathering of rocks, leaching into water bodies and volcanic eruptions. Also, more anthropogenic sources of heavy metals deposition into the environment are mining, quarrying, metal ore processing, release from agricultural wastes, release from industrial waste and discharge from auto exhausts.

Copper exists in a stable metallic state forming monovalent and divalent cations and it is an example of a transition metal (WHO, 2004). It is derived from a Latin word "Cuprum" from which chemical symbol "Cu" emerged from. It is notably observed that once some heavy metals like Copper get into the environment, removing them are almost impossible. High level of its absorption by man can cause destruction of the red blood cells which if not treated leads to anaemia, gastrointestinal distress and damage of target organs. Also, excess Copper intake by plants causes inhibition in growth, affects photosynthesis and respiration, reduction in biomass, chlorosis, reduction in the level of chlorophyll present, alteration of chloroplast, degradation of the grana stacking, affects the biosynthesis of photosynthetic machinery, decrease in photochemical activities, oxidative stress and increase in antioxidant responses (Inmaculada, 2005).

Nickel is an example of a hard metal having a silvery-white colour. It is usually denoted "Ni" and some have been observed to be insoluble in water (insoluble Ni compounds). An examples of these insoluble Ni compounds are Carbonates, sulphides. Some others are soluble in water which are nitrate, sulphate and chloride. Humans take in Ni either by ingestion, inhalation or absorption through the skin. When Ni is inhaled, respiratory tract irritation is induced, occurrence of chemical pneumonia, increase in the number of pulmonary cells and finally occurrence of pneumoconiosis. It can also lead to fetal death, development of cancer, induction of tumour, production of mutants and dermatitis. In plants, it is absorbed through their roots and are carried by passive diffusion and active transport (Cuiyun *et al*., 2009) and when absorbed in excess they cause leaf chlorosis, necrosis, wilting, disruption in photosynthesis, inhibition of growth and development.

Cadmium is denoted by "Cd". It occurs naturally on earth. It exists as a divalent cation. It is a soft metal having bluish-white colouration. It shows an oxidation state of +2 in most of its compounds. It has been observed to possess a lower melting point in the group of transition metals. They are known for accumulating for a long period of times in the human body and the environment in a whole. Its accumulation has led to the damage of target organs (kidney, bone, prostrate, etc). It is the causal factor of the "itai-itai" disease of China and Japan, which consumed a lot of lives in time past. Humans can be exposed to Cd when they consume staple food such as wheat, rice, etc. They can be fully eliminated through urinary excretion. They also affect the bones and are potential casual agents for cancer. They can also cause impairment of the pulmonary function (Bernard, 2008). In plants, they affect many important processes like transpiration, stomatal opening and photosynthesis. It causes chlorosis, leaf rolls, stunted growth, reduce absorption and transportation of several elements like Nitrate, reduction in water content, plasma membrane permeability and disturbs the chloroplast membrane. It has also been seen to decrease the "chlorophyll a" content in some other plants (Rodrigo *et al*., 2012).

Lead is denoted by the symbol “Pb” which stands for the Latin word “Plumbum” which means “Soft Metal”. It has silvery-white colour and it is highly malleable and ductile. It is a soft metal and melts at a low temperature. Pb occurs largely in the environment where man’s activities such as mining and smelting are high. The presence of high concentration of Pb in the environment affects the living entities of the environment negatively like mild mental retardation, cardiovascular outcomes all in adults. In pregnant women, it causes miscarriages, minor malformations, still births and premature births. They can also cause hypertension, neurological effects, convulsions, lethargy, paralysis, ataxia, tremors, renal damage, cancer and decreased sperm count. The efficient uptake of this element by the plant depends majorly on the leaf morphology (Palllavi and Rama, 2005). Excess Pb intake inhibits root growth, causes stunted growth, chlorosis, inhibits the activities of enzymes, change in hormonal status, decreases germination in some other plants, decreases dry weight, decline in photosynthesis rate, distorted chloroplast ultrastructure, restrained synthesis of chlorophyll, etc. Generally, high heavy metals contents have deleterious effects on plants and animals (Tables 1 and 2)

Table 1: Heavy metals sources and their effect on plants

Heavy metals	**Sources**	**Plant effect**
Lead	Battery industry, auto exhausts, paint etc.	The pores in a plants leaves let in carbon dioxide needed for photosynthesis and emit oxygen.
Nickel	Coal, diesel oil, metal plating, steel and non-ferrous alloys	Nickel deficiency production array of effects on growth and metabolism of plants, including reduced growth, and

	tobacco smoke etc	induction senescence, leaf and meristem chlorosis alterations in N metabolism, and reduced Fe uptake.
Copper	Pulp and paper, electrical goods, utensils, electronics, chemicals etc.	Copper does not break down in environment and because of these, can accumulate in plants and animals when it found soil. Once copper reaches soil only limited amount of plant has chance of survival.
Aluminium	Ore bauxite, recycling, foil wrappings, transport industries, food and beverages cans, and building and construction industries.	Excess of Al concentration in soil causes reduction in number and size of leaves shoot growth. They affect growth of plant when seen high concentration, disrupt the life in soil, creates hostile environment thereby reducing the earthworm and microorganism that break down the soil and makes nutrient available by plant.
Zinc	Batteries, pennies and dice casting from cars, galvanizing alloys, rayon, paper etc.	High concentrated zinc is harmful to plant as it causes death.

Source: Heavy metal existence and toxicity for plants (Nagajyotic, *et al.,* 2010).

Table 2: Sources and health effects of the heavy metal analysed

Heavy metal	Sources	Health effect
Lead	Battery industry, auto exhausts, paints	Affect nervous and renal systems, causes weakness, headache, brain damage, convulsion, constipation and cancer
Aluminium	Steel, machinery, dye, textile, medicine	Cancer (suspected)
Copper	Pulp and paper, electrical goods, utensils, chemicals, electrons etc	Fertilizers sever mucosal irritation, cancer
Zinc	Galvanizing alloys, rayon, paper etc	Cancer
Nickel	Coal, diesel oil, metal plating, steel and non-ferrous alloy	Lung cancer, respiratory problems

Source: Effect on Heavy Metals on Human Health (Manju . 2015)

The aim of this study is to assess the level of heavy metals present in the epiphytes under study around generating sets and to determine if the epiphyte can be successfully used as bio-indicators and bio-monitors of these heavy metals in the environment.

MATERIALS AND METHODS

A total of three sites were studied. These sites are one location from University of Port Harcourt Teaching Hospital (4°90'03"N 6°92'71"E) and two locations from

Delta Park in University of Port Harcourt (for plant sample 1; 4°90'18"N 6°90'52"E, for plant sample 2; 4°90'17"N 6°90'54"E, for the control; 4°90'16"N 6°90'50"E) plate 1.

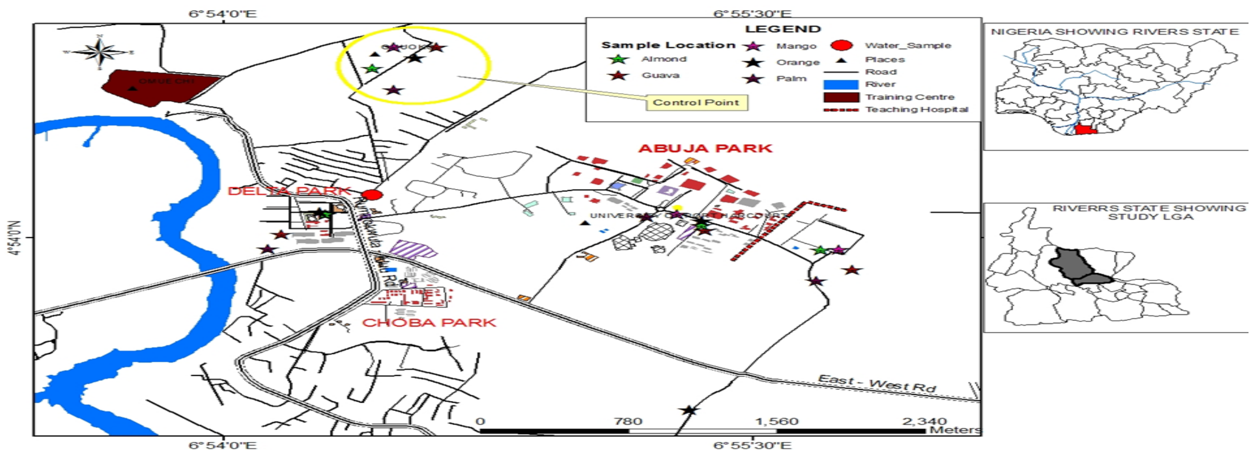

Plate 1: Map of University of Port Harcourt showing various sample site

The epiphytes and their substratum (referred to soil) were collected in June in 2017. The epiphytes were collected using a knife and then put in polyethene bags which were properly tied to prevent the epiphytes from dying. The duplicate of the samples was taken to the University of Port Harcourt Herbarium for proper identification while the others were taken to the Physiology Research Laboratory of University of Port Harcourt for further analysis and pre-treatment. The control was collected from UPTH while the other two samples were collected from Delta Park. The elements tested for were Lead, Cadmium, Copper and Nickel.

Digestion of samples

1g of sample was weighed into a clean conical flask of 250ml capacity. 2ml of concentrated Nitric acid; 2ml of 52% Perchloric acid were added and the mixture was heated to boiling until a clean solution of digest was obtained. The digest was cooled to room temperature and was diluted to 50ml volume with distilled-deionized water. The solution was filtered through Whatmann No, 1 filter paper.

The filtrate was analyzed for Cadmium, Lead, Copper and Nickel by Atomic Absorption Spectrophotometric method (AAS).

RESULTS ABD DISCUSSION

The result from the analysis carried out on the samples indicate the presence of some heavy metals in both substrata and tissues of the plant specimens. In particular, copper, which was present in all samples and had its greatest concentration value (20.65mg/kg) in substratum 2 and its least concentration value (12.05mg/kg) in the tissues of plant 2. Nickle and lead were not detected in all the samples. Cadmium had its highest concentration value (3.35mg/kg) in substratum 2 and its least concentration value (2.40mg/kg) in the tissues of the plant control and also in substratum 1; it was also not detected in the tissues of plant 1 and plant 2 (Tables 3 and 4). The values were compared with WHO standard (WHO 1996) (Table 5).

Table 3: Heavy Metal Concentration in the different Plant Substrata

SN	SUBTRATA	Cd (mg/kg)	Pb (mg/kg)	Ni (mg/kg)	Cu (mg/kg)
1	Sample 1	2.65	ND	ND	12.35
2	Sample 2	2.40	ND	ND	15.05
3	Sample 3	3.35	ND	ND	20.65

Table 4: Heavy Metal Concentration in the Tissues of the Different Plant Samples

SN	SUBTRATA	Cd (mg/kg)	Pb (mg/kg)	Ni (mg/kg)	Cu (mg/kg)
1	Sample 1	2.40	ND	ND	19.40
2	Sample 2	ND	ND	ND	19.50
3	Sample 3	ND	ND	ND	12.95

Table 5: WHO permissible limits for heavy metals in plant and soil

Element	Target value of soil (mg/kg)	Permissible value of plant (mg/kg)
Cd	0.8	0.02
Zn	50	0.60
Cu	36	10
Cr	100	1.30
Pb	85	2
Ni	35	10

Source; WHO (1996) Permissible limits of heavy metals in soil and plants (Geneva: World Health Organization) Switzerland.

The study investigates the likely absorption and accumulation of heavy metals that could emanate from exhaust fumes of power generating sets by epiphytes on receiving trees. Results from the study showed varying levels of the heavy metals on both the tissues of the plant species and their substrata. However, some results were not detectable and could not directly correlate the presence of the heavy metals. This may indicate that these species of epiphytes do not uptake these heavy metals. The presence of some of the heavy metals in the samples also show that they are common in the atmosphere and the epiphytes can bio-accumulate them. Since air pollutants are mobile, wind helps in the dispersion of these pollutants. Also, wind can play a major role in the mobility of air pollutants where these pollutants are transported from their source of emanation to different regions, sometimes not around the source leading to the settling of the pollutants on the site studied (Leonardo et al., 2010).

CONCLUSION

The heavy metal that pose the greatest threat among the four heavy metals studied is Copper, which attains the greatest concentration value and was present in all samples studied. It is required that the results obtained from this study will not only enhance the knowledge of epiphytes been used as good bio-indicators and bio-monitors but also create a public awareness on the effects of reducing the level of heavy metal release from generating sets and other sources to prevent health complications and environmental degradation.

It is worthy to note that when using epiphytes as bio-indicators, bio-monitors and bio-accumulators, both the plant tissues and their substrata should be investigated so as to get better results since both have been seen to have different levels of accumulation judging from this study carried out which means that the tissues of plant samples do not only accumulate these heavy metals but also their substrata has been found in the environment. These heavy metals affect the growth of the epiphyte and if not properly controlled will lead to the death of the epiphyte and other plants (Gabisu and Alkorta, 2001). The presence of these heavy metals in the epiphytes confirms that they are bioaccumulators and thus serve as bioindicators and biomonitors. The use for atmospheric air pollution monitoring is hereby recommended.

REFERENCE

Arif, T.J., Mudseen, A., Kehkashan, S., Arif, A., Inho, C., Qazi, M. and Rizwanul, H. (2015). Heavy Metals and Human Health: Mechanistic Height I ntoToxicity and Counter Defence System of Anti-oxidants. *International Journal of Molecular Sciences*.

Bernard, A. (2008). Cadmium and Its Adverse Effects on Human Health. *International Journal of Medical Research.* 128(4): 557-564.

Cuiyun, C., Dejun, H. and Jianquan, L. (2009). Functions and Toxicity of Nickel in Plants: Recent Advances and Future Prospects. *Clean Soil, Air and Water*. 37:304-313.

Gabisu, C. and Alkorta, I. (2001). Phytoremediation of organic contaminants in soils. *Bioresource Technology*. 79(3): 273-286.

Inmaculada, Y. (2005). Toxic Metals in Plants. *Brazilian Journal of Plant Physiology*. 17(1): 145-156.

Ite, A.E., Udousoro, I. I. and Ibok, U. J. (2014). Distribution of Some Atmospheric Heavy Metals in Lichen and Moss Samples Collected From Eket and Ibeno Local Government Areas of Akwa-Ibom State, Nigeria. *American Journal of Environmental Protection.* 2(1): 23-31.

Ite, A.E., Uwem, U.U., Usoro, M.E., Edet, W.N., Emmanuel, J.U., Akanimo, N.E.,Usenobong, F.U. and Anietimfon, I.U. (2016). Heavy Metals in Epiphytic Lichens and Mosses of Oil Producing Communities of Eket and Ibeno, Akwa-Ibom State, Nigeria. *American Journal of Environmental Protection*. 4(3): 38-47.

Klaus-J, A. (2010). What are “Heavy Metals” in Plant Sciences? *Acta Physiologiae Plantarum*. 32(4): 615- 619.

Leonardo, L., Mazillia, B.P., Damatto, S.R., Sakibi, M. and de Oloveira, S.M.B. (2010). Assesssment of Atmospheric Pollution in the Vicinity of a Tin and Lead industry using Lichen Species, *Canoparmelia texana. J. Environm Radioact.* 101: in press.

Manju M. (2015). Effect of Heavy Metals on Human Health. *International Journal of Research Granthaalauah (Social Issues and Environmental Problems)*. 1-7

Maryan, M.R., Soheilm S., Hoda, K. and Rezvan, S. (2015). Natural and Anthropogenic Source of Heavy Metals Pollution in the Soil Samples of an Industrial Complex; a Case Study. *Iranian Journal of Toxicology*. 9(29): 1336-1341.

Nagajyotic, P.C., Lee, K.D. and Sreekanth, T.V.M. (2010). Heavy Metal Occurrence and Toxocity for Plants. Environ Chem Lett. **8**:199-216.

Pallavi, S. and Rama, S.D. (2005). Toxic Metals in Plants. *Brazilian Journal of Plant Physiolog*. 17(1):35-52.

Parazych, A., Zduńczyk, A. and Astel, A. (2016). Epiphytic Lichens as Bio-indicators of air pollution by Heavy Metals in an Urban Area (Northern Poland). *Journal of Elementology*. 21(3): 781-795.

Rodrigo W., Eder, S., Roberta, P.M., Alexandra, L., Marcelo, M., Paulo A.H. and Zenilda L.B. (2012). Effects of Cadmium on Growth, Photosynthetic Pigments, Photosynthetic Performance, Biochemical Parameters and Structure of Chloroplasts in the Agarophyte *Gracilaria domingensis* (Rhodophyta, Gracilariales). *American Journal of Plant Sciences*. 3:1077-1084.

WHO (2004). *Copper in Drinking Water*. World Health Organization Department of Public Health and Environment. Geneva.

WHO (1996) Permissible limits of heavy metals in soil and plants (Geneva: World HealthOrganization), Switzerland.