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Seasonal Variation of Heavy metals in *q. Quelea*, *c. Gariepenus*, n. *Septemfascia* and *t. Swinderianus* in Gyawana Ecosystem, Adamawa State, Nigeria

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Abstract

Heavy metals are metallic elements that are toxic and have high density, specific gravity or atomic weight, they occur naturally in the ecosystem with large variations in their concentration. This study was conducted in Gyawana ecosystem, Adamawa State, Nigeria, to compare seasonal variation in the concentrations of heavy metals in the study animals [birds (Quelea quelea), catfish (Clarias gariepenus), grasshoppers (Nomadacris septemfascial) and cane rats (T. swinderianus)]. A total of four hundred and eighty (480) adult of each Q. quelea, C. gariepenus, and T. swinderianus were collected and a total of nine hundred and sixty (960) N. septemfascia were trapped from the wild. The organs of bird, fish, rat and the whole grasshopper were dried in a furnace at 105^{o}C and ground. The ground samples temperature was gradually increased to a maximum of 550^{o}C and then digested with tri-acid mixture (HNO_3: HCO_4: H_2SO_4) in the ratio of 10:4:1, respectively. Determination of the heavy metals was done directly on each final solution using a Buck Scientific 210A Model, Atomic Absorption Spectrophotometer (AAS) and the values obtained were expressed in milligram per gram. The result shows that, the concentration of arsenic was higher during the dry season than wet season in all the animals studied. And statistically, there was no significant difference in the mean concentrations of arsenic in wet and dry season ($p < 0.05$). The mean concentration of Cadmium (Cd) was higher during the wet season in birds and grasshoppers with 1.437±0.015mg/g, and 1.694±0.004mg/g respectively than dry season with 0.213±0.005mg/g in birds and 0.754±0.001mg/g in grasshoppers. However, dry season fish (0.656±0.002mg/g) and rats (0.621±0.003mg/g) values were higher than those of wet season fish (0.154±0.002mg/g) and rats (0.166±0.002mg/g). The mean concentration of Cobalt (Co) was higher during the dry than wet seasons in the entire study animal. Consumption of grasshoppers should however, be restricted since their heavy metal levels were near the maximum permissible level, to avoid bioaccumulation. Pesticides residue levels and other heavy metals like mercury, nickel and lead should be studied to monitor their concentration in the animals of Gyawana ecosystem. The heavy metal concentrations in the study animals of both season were within the permissible limit, therefore, it is safe to consume the animals.

Keywords: Seasonal Variation; Heavy Metals; Q. quelea; C.gariepenus; N. septemfascia; T. swinderianus

Introduction

Heavy metals occur naturally in the ecosystem with large variations in their concentration (McDowell *et al.* 2006; Mohsen and Salisu, 2008; Salwa *et al.* 2012).They are metallic elements that are toxic and have high density, specific gravity or atomic weight. Heavy metals occur naturally in the soil from the pedogenetic processes of weathering of parent materials at levels that are regarded as trace (<1000 mg/g) and rarely toxic (Kabata-Pendias and Pendias, 2001; Pierzynski *et al*. 2000).

Arsenic is a naturally occurring element found in soil, cereals, seafood, meat, mushrooms, baked foods, fats/oils, wine, beer, soft drinks, juices, coffee, and cocoa. Sea foods, cereals, mushroom, and poultry, usually have the highest arsenic levels. (Akan *et al.* 2014). Arsenic occurs in two forms: organic and inorganic. Arsenic (As) constitutes one of the most important environmental contaminants when global human health hazards are considered. Epidemiological studies reveal that chronic human exposure may be associated with peripheral artery disease, cardiovascular effects, diabetes mellitus, various cancers and adverse reproductive effects and exposure to high levels of arsenic can lead to death (Amusan *et al*. 2005; WHO, 2006).

The general human exposure is primarily through the ingestion of food, but in some areas, drinking water, smelting activities, coal combustion and contaminated soils contribute to an additional environmental exposure. Arsenic toxicity varies with several factors including concentration, rate of absorption and the chemical form ingested (WHO, 2001; Amusan *et al*. 2005).

Cadmium is a white shining but tarnisheable metal, similar in several characteristics to Zinc and Tin. Cadmium is not found to a great extent in nature, its presence in the earth crust is estimated to range between 0.15 to 0.11mg/g with a Zn/Cd ratio around 250:1; depending strictly on the nature of rocks (WHO, 2006). Cadmium can be present as a result of volcanic emission and release from vegetation. It is not essential to plant growth, but under certain conditions can accumulate in some plants to levels that are hazardous to animals and humans. Some sewage sludge contains enough cadmium to encourage air pollution and by seeping into the soil and ground water from hazardous waste dumps (Yargholi and Azimi, 2008). Cadmium is classified as a soft acid, preferentially complexing with sulphides (Chiroma *et al.* 2012). Its accepted range in soil as stated by Ebong *et al.* (2008) as (0.01 - 300) mg/g. Cadmium was listed by EPA as one of the 129 priority pollutants and among the 25 hazardous substances. Ingestion of high level of cadmium severely irritates the stomach leading to vomiting and diarrhoea. Cadmium and its compounds are known as human carcinogens and smokers get exposed to significant amount of cadmium than non-smokers. Other effects associated with cadmium include damage of lungs, fragile bones and kidney disease, and this should attract the attention of environmentalists, Government agencies and other private bodies. (Sabine and Wendy, 2009). (Furness, 1996). But ATSDR, (2012) reported that environmental exposure can elevate blood cadmium concentrations to above10 μg/dl.

Cobalt is a naturally occurring element that does have beneficial applications for instance; cobalt is an essential component of vitamin B_{12}. Cobalt has been added to pigments to produce a distinct blue colour. Lithium ion batteries contain cobalt; in the medical field cobalt-60 is used in radiotherapy and for sterilizing medical equipment. Hip replacements are also made of cobalt. Regardless of these perceived advantages, cobalt is not without its problems. Cobalt can accumulate to toxic levels in the liver, kidney, pancreas and heart, as well as the skeleton and skeletal muscles. Cobalt has been found to produce tumors in animals and is likely a human carcinogen as well (Edward 2015). Cobalt makes its way through the environment and cannot be destroyed. People working in industrial settings have an increased risk of exposure to toxins, including cobalt. Also, its been reported that hip replacements containing cobalt have caused problems due to nano particles of cobalt breaking away and contaminating the body. Heart and lung problems have been shown to follow exposure to levels of cobalt near or even under current occupational exposure limits (Koedrith and Seo, 2011). Low levels of cobalt exposure negatively impact lung function and other studies have linked cobalt to occupational asthma (Rehfisch *et al.* 2012; Walters *et al.* 2012). Occupational exposure to cobalt powder has been linked to vision and hearing problems. Patients with hip implants containing cobalt are suffering from similar effects including tinnitus deafness, vertigo and blindness (Apostoli *et al.* 2012). This study was carried out mainly to compare seasonal variation in the concentrations of heavy metals in the study animals [birds (*Quelea quelea)*, catfish (*Clarias gariepenus)*, grasshoppers (*Nomadacris septemfascial)* and cane rats (*T. swinderianus*)] in Gyawana Ecosystem, Adamawa State, Nigeria. Heavy metals have a serious impact on the environment and can threaten the ecosystem's stability. The consumption of metal-contaminated animals as food, poses a significant risk to the local population, thereby causing bioaccumulation and biomagnification hence, the need for this study.

Materials and Methods

Study Area

The study was conducted in Gyawana ecosystem, Lamurde Local Government Area, Adamawa State of Nigeria. Gyawana is located at latitude 9˚.35' N and longitude 11˚.55' E and is 135 meters above Sea level. Lamurde Local Government Area lies between longitude 9˚.36' 03.92"N and latitude 11˚.47' 36.25"E at an elevation of 137 meters above sea level (Adebayo and Tukur, 2004). Adamawa State is located in the North Eastern part of Nigeria, and lies between latitudes 7˚ and 11˚ N and between longitudes 11˚ and 14˚ E. It is on an altitude of 185 meters above Sea level and covers a land area of about 39,741km^2 (Fig.1). Two seasons are obtainable in the State; the wet (rainy) and dry seasons. The months of May to October constitute the wet season, during which no place receives less than 600mm of rainfall. The months of November to April constitute the dry season, during which the dry wind (harmattan) period is experienced between the months of November and February. The months of March and April are the hottest with an average temperature of 42˚C, while November, December and January are the coolest months with an average temperature of 11˚C (Adebayo *et al*. 2012).

Sample Collection and Treatment

The study was conducted for a period of twelve (12) months (December 2017 to November, 2018). bird (*Q. quelea*), fish (*C. gariepenus)*, grasshopper (N. *septemfascia)* and Cane rats (*T. swinderianus)* were collected once every first week of a month from various locations (Gokumbo, Italiah, Nguro Bemun Rivers, Canal Rivers A and B and sugar cane farms of the Savanna Sugar Company); in Gyawana ecosystem, Lamurde local Government Area, Adamawa State, Nigeria.

A total of four hundred and eighty (480) adult of each *Q. quelea*, *C. gariepenus*, and *T. swinderianus* were collected making a sub total of forty (40) per month from cultivated areas near streams and rivers side which are a potential source of contamination due to the use of pesticides and agro-chemicals. Using insect nets, a total of nine hundred and sixty (960) N. *septemfascia* were trapped from Gyawana rice farms and Savanna Sugar Company (sugar cane farms) that is eighty (80) per month. Wet tissue samples of the grasshoppers were rinsed with deionized water to remove heavy metals attached on them, and then transferred to pre-weighed polypropylene vials. The *T. swinderianus* were trapped using mouse glue traps. Blood samples were collected from the lower limb vein of trapped rats and birds using micro-capillary tube. Each blood sample was then dropped on a Whatman No.1 filter paper to air dry. The *T. swinderianus* and *Q. quelea* were then sacrificed immediately by suffocation using 2mls of 5% chloroform in air tight transparent plastic containers as described by (Iyanda, 2013). The length of each *Q. quelea*, *C. gariepenus*, *T. swinderianus* were measured using a meter rule and the weight was measured using a Pesola Spring Balance. The study animals were washed with de-ionized water to remove any attached heavy metals on their body surface and dissected using dissecting instruments as soon as they were sacrificed. The brain, liver and flesh were removed separately for the different sexes and transferred into sterile sample bottles which were labeled and taken to the Animal Production Laboratory of Adamawa State University, Mubi, Adamawa State, Nigeria, for digestion.

Determination of Heavy Metals

Each organ of bird (*Q. quelea*), fish (*C. gariepenus)*, (*T. swinderianus)* and the whole grasshopper (N. *septemfascia)* were dried in a furnace equipped with circulation system at 105^{o}C until it reached a constant weight, and properly homogenized using porcelain mortar and pestle before 5.0gram was taken for digestion. The ground samples of the animals were transferred to a porcelain basin and put into a muffle furnace, whose temperature was gradually increased to a maximum of 550^{o}C. The samples were digested with tri-acid mixture (HNO_3: HCO_4: H_2SO_4) in the ratio of 10:4:1, respectively at the rate of 5mls per 5.0gram of sample and placed on a hot plate of 100^{o}C temperature. Digestion was allowed to continue until the liquor became clear. All the digested liquor was filtered through Whatman 541 filter paper and diluted with 25mls of distilled water. Determination of the heavy metals was done directly on each final solution using a Buck Scientific 210A Model, Atomic Absorption Spectrophotometer (AAS) in the Chemistry Laboratory of Adamawa State University, Mubi and Determination of arsenic was done in the Chemistry Laboratory of Ahmadu Bello University Zaria, Kaduna State, Nigeria. The values obtained from AAS were expressed in milligram per gram (mg/g) (APHA, 1995; AOAC, 2000; APHA, 2005).

Data Analysis

Student t-test was used to test for differences of heavy metals levels between the wet and dry season in the study animals [birds (*Q. quelea)*, catfish (*C. gariepenus)*, grasshoppers (*N. septemfascial)* and cane rats (*T. swinderianus*)] using a statistical software package (SPSS for Windows). The results were presented as mean±standard error and P > 0.05 was regarded as not statistically different.

Results

The mean concentrations of arsenic in each study animal by season are presented in Fig.1; arsenic was present in all the study animals and in both wet and dry seasons. However, the mean concentration of arsenic was generally higher during the dry season than wet seasons. The concentration of arsenic was higher during the dry season (0.054±0.002mg/g) than wet season (0.031±0.000mg/g) in birds; this may be due to excess accumulation and less excretion of this metal. Fish had the highest mean concentration of As (0.034±.003mg/g) during the dry season than wet season with a value of 0.032±0.003mg/g. A higher mean concentration of 0.035±0.000mg/g was also observed for dry season compared to 0.034±0.000mg/g for wet season in grasshoppers; and rats, which had the least concentration of arsenic, still had a higher value of (0.032±0.000mg/g) during dry season compared to (0.031±0.000mg/g) in wet season. In all the animals studied statistically, there was no significant difference in the mean concentrations of arsenic in wet and dry season (p <0.05).

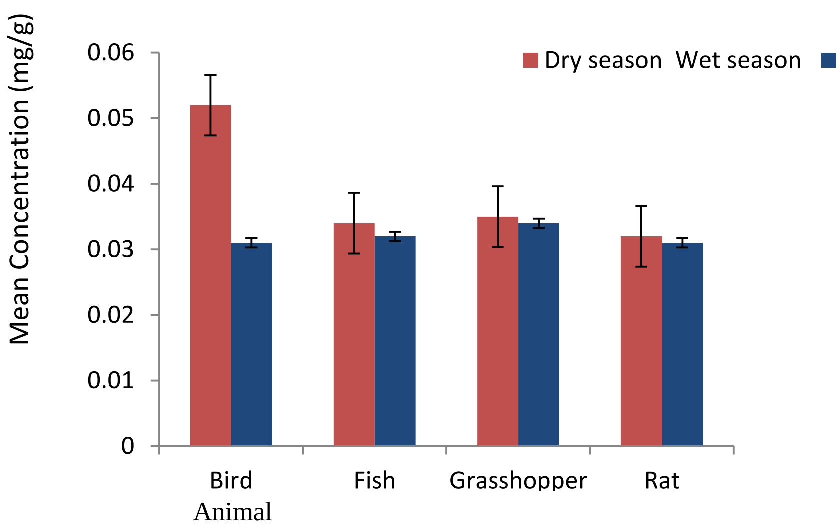

Figure 1: Comparison of the Mean Concentrations of Arsenic between Wet and Dry Seasons

Comparison of the Mean Concentrations of Cadmium between Wet and Dry Seasons

Cadmium was present in both seasons in all the study animals as shown in Fig.2. The mean concentration of Cd was higher during the wet season in birds and grasshoppers with 1.437±0.015mg/g, and 1.694±0.004mg/g respectively than dry season with 0.213±0.005mg/g in birds and 0.754±0.001mg/g in grasshoppers. However, dry season fish (0.656±0.002mg/g) and rats (0.621±0.003mg/g) values were higher than those of wet season fish (0.154±0.002mg/g) and rats (0.166±0.002mg/g) (p <0.05). Low wet season metal levels could also result from low bio-availability due to reduced metal concentrations in the river and ecosystem arising from dilution, associated with heavy rains during the rainy season.

Comparison of the Mean Concentrations of Cobalt in the Study Animals between Wet and Dry Seasons

The mean concentrations of Cobalt in each study animal by season are presented in Figure 3. Cobalt was present in all the study animals in both wet and dry seasons; however, the mean concentration of Co was higher during the dry than wet seasons in the entire study animal. Birds had a higher mean concentration of 0.955±0.096mg/g during the dry season than wet season with 0.187±0.993mg/g. A higher mean concentration of 0.880±0.011mg/g was also seen for the dry season compared to 0.830±0.001mg/g for wet season in fish. Cobalt concentration was higher during the dry season with a value of 1.263±0.018mg/g than in the wet season (0.243±0.006mg/g) in grasshoppers. Rats also had a higher value of 0.525±0.003mg/g during the dry season compared to 0.159±0.005mg/g in the wet season. In birds, grasshoppers and rats ($p < 0.05$), while in fish ($p > 0.05$). Higher dry season levels could be attributed to changes associated with higher water temperatures during the dry season

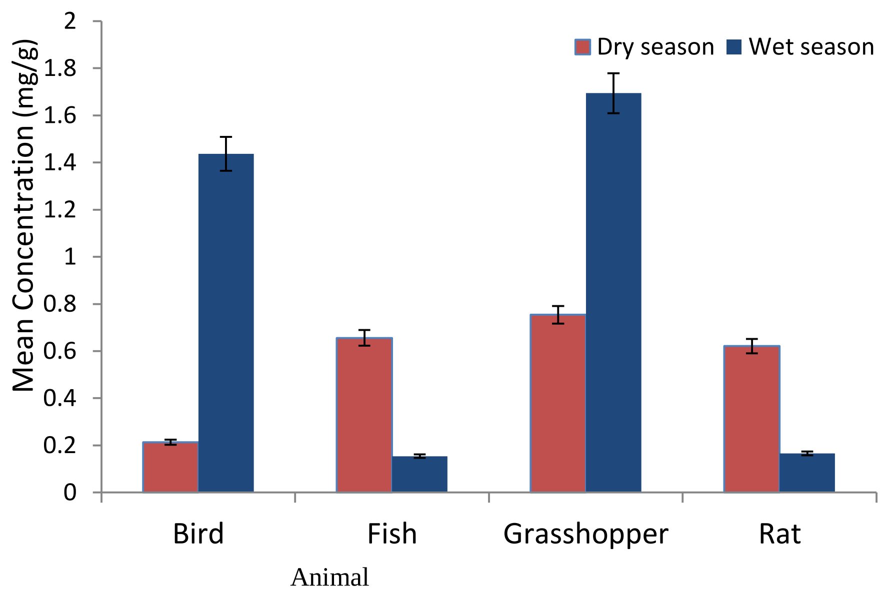

Figure. 2: Comparison of the Mean Concentrations of Cd between Wet and Dry Seasons.

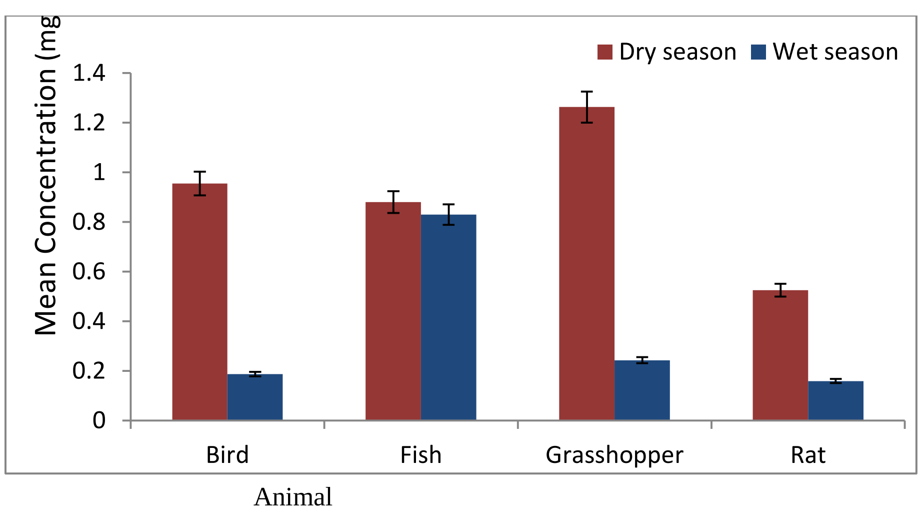

Figure 3: Comparison of the Mean Concentrations of Co between Wet and Dry Seasons

Discussion

Arsenic have the highest mean concentration in dry season birds, dry season fish, wet season grasshoppers and dry season rats. While the wet season birds, wet season fish, dry season grasshoppers and wet season rats, have the least mean concentration in this study. The highest mean concentrations of cadmium was observed in wet season birds, dry season fish, wet season grasshopper and dry season rats, while the least mean concentrations were in dry season birds, wet season fish, dry season grasshopper and wet season rats. The high concentration of Cadmium in *C. gariepinus* during the wet season may be associated with the life style of the species by spending more time at the bottom of lakes or rivers in this season. All the animals had higher mean concentrations of cobalt in the dry season compared to the wet season. The highest mean concentrations of these heavy metals in grasshoppers during the wet season than the dry season may be because of its nature of exposure to the application of chemicals such as fertilizers, pesticides and herbicides which are more in the wet than dry season. The high mean concentration of cadmium, in wet season birds, may be due to availability of immature grains which were under the applications of chemicals. The dry season rats had almost all the metals in high concentration in the dry season than the wet season; this could be due to excess accumulation and less excretion of these metals in the dry season as stated by Nussey *et al.* (2000). Higher dry season levels could be attributed to changes associated with higher water temperatures during the season. Higher temperatures can cause higher activity and ventilation rates in animals. This is due to increasing temperatures that lower the oxygen affinity of the blood and increases the rate of pollution accumulation (Obasohan and Eguavoen, 2008). A higher metabolic rate may also induce more frequent feeding sessions, which in turn might result in increased metal concentrations, if these metals are taken up via the food chain (Nussey *et al.* 2000). Low wet season metal levels could also result from low bio-availability due to reduced metal concentrations in the river and ecosystem arising from dilution, associated with heavy rains during the rainy season. Similar observations were reported in fish by Obasohan and Eguavoen (2008) in Ogba River, Benin City, Nigeria.

Conclusion

The seasonal variation of the mean concentrations of heavy metals (As, Cd and Co) in this study shows that, grasshoppers had higher concentration levels in the wet season, than the dry season, while rats had higher mean concentrations of these metals in the dry season compared to the wet season and cadmium was higher in the wet season than the dry season in Quelea birds (*Quelea quelea*). Fish had higher mean concentrations of all the studied heavy metals in the dry season than in wet season.

From the outcome of this study, the following recommendations could be made:

- Consumption of grasshoppers from the study areas should be restricted since their heavy metal levels were near the maximum permissible level to avoid bioaccumulation.
- The heavy metal concentrations in the study animals of both seasons were within the permissible limit, therefore, it is safe to consume the animals.

References

Adebayo, A.A. and Tukur A.I. (2004). *Adamawa State in map*. Paraclete publishers Yola. Pp 27-31

Adebayo, A.A., Onu, J.I., Adebayo, E.F. and Anyanwu, S.O. (2012). Farmer's Awareness, Vulnerability and Adoption to Climate Change in Adamawa State, Nigeria. *British Journal of Arts and SocialScience,* **9**(2): 106- 115.

Akan, J.C., Abdulrahman, F.I., Sodipo, O.A. and Akandu, P.I. (2009). Bioaccumulation of some heavy metals of six fresh water fishes caught from lake Chad in Doron Buhari, Maiduguri, Borno State, Nigeria. *Nigeria Journal of Applied Science and Environmental Manag*ement, **4:** 103 -111

Akan, J.C., Mohmoud, S., Yikala, B.S. and Victor, O. O. (2012). Bioaccumulation of Some

Heavy Metals in Fish Samples from River Benue in Vinikilang, Adamawa State, Nigeria

American Journal of Analytical Chemistry, **3:** 727-736

Akan, J.C., Sodipo, O.A., Liman, Y. and Chellube , Z.M. (2014). Determination of Heavy Metals in Blood, Urine and Water Samples by Inductively Coupled Plasma Atomic Emission Spectrophotometer and Fluoride Using Ion-Selective Electrode. *Journal of Analytical and Bioanalytical Techniques*, **5**(6): 1-2.

Amusan, A.A., Ige, P.V. and Olawale, R. (2005).Characteristics of Soils and Crops Uptake of Metals in Municipal Waste Dumpsite in Nigeria. *Journal of Human Ecology*, **17** (3): 167-71.

AOAC. (2000). *Association of Official Analytical Chemists*. Official methods of analytical Chemists. 18th ed. Washington, D.C. Pp 117-121

APHA, (1995). (American Public Health Association), *Standard methods for the examination of water and waste-water* 15th Edition, Washington, D. C. Published jointly by American Public Health Association, American Water Works Association and Water Environment Federation (APHA-AWWA-WEF), Pp 1134.

APHA, (2005). (American Public Health Association), *Standard methods for the examination of water and waste-water* 21st Edition,Washington, D. C. Published jointly by American Public Health Association, American Water Works Association and Water Environment Federation (APHA-AWWA-WEF), 800 1 Street, NW, Washington, Pp 36

Apostoli, P., Catalani, S., Zaghini, A., Mariotti, A., Poliani, P.L., Vielmi, V., Semeraro, F., Duse,S., Porzionato, A., Macchi, V., Padovani, A., Rizzetti, M.C. and Decaro, R. (2012). High doses of cobalt induce optic and auditory neuropathy. *Journal of Experimental Toxicology and Pathology*. **12:** 87-95. ATSDR. (2012). *Toxicological profile for Cadmium*. Agency for Toxic Substances and

Disease Registry, Atlanta: US Department of Health and Human Services, December, 2012

Ebong, G. A., Akpan, M. M., and Mkepenie, V. N. (2008). Heavy Metal Contents of Municipal and Rural Dumpsites Soil and Rate of Accumulation by *Carica Papaya and TalinumTriangulare*in Uyo, *Journal of hazardous substances research,* **5** (2): 281-90.

Edward, G. (2015). Toxic Metals: the health dangers of cobalt. *www.globalhealingcenter.com/ natural- health/toxic-metal-danger-*

Iyanda, A and O. Adeomi. (2013). Assessment of oxidative stress status and select heavy metal levels in serum of rats fed on cooked phosphide – powder residue contained cowpea. *Journal of Medical Science.* **2**(1) 55 – 59

Kabata-Pendias, A. and Pendias, H. (2001). *Trace element in soil and plant* .CRC Press,Boca Raton,Fla,USA, 2nd edition, pp:241.

Koedrith, P. and Seo, Y.R. (2011). Advances in carcinogenic metal toxicity and potential molecular markers. *International Journal of Molecular Science* **12**(12): 9576-9595.