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Use of *LeptadeniaHastata* as a Biomonitor of Heavy Metal Pollution in Dutse

Abstract:

The leaves of *Leptadeniahastata*were tested as a possible biomonitor of heavy metal pollution in Dutse, Jigawa State, Nigeria. Concentrations of Cd, Cu, Pb and Zn were determined in unwashed and washed leaves and the associated soils collected from different sampling sites. The Cd, Cu, Pb and Zn concentrations ranged from 7.54-15.08, 8.33-12.50, 0.36-0.47 and 15.67-61.11 mg/kg in the unwashed leaves respectively, while in the washed leaves the concentration rangedfrom 5.01-8.12, 5.45-6.50, 0.19-0.25 and 14.67-30.00 mg/kg for Cd, Cu, Pb and Zn respectively. In the soil supporting the plant the values of Cd, Cu, Pb and Zn ranged from 2.22-6.75, 17.19-34.90, 0.74-1.07 and 34.44-82.22 mg/kg respectively. The results of the analysis showed that the concentrations of the heavy metals in the unwashed leaves were significantly higher than the washed leaves. The levels of Cu, Pb and Zn were found to be within the normal range, while Cd levels were found to be above the normal range. This indicates contamination of the plant with Cd. The result also showed that *Leptadeniahastata*can be used as a biomonitor of heavy metal pollution.

Key words: Heavy metals, pollution, *Leptadeniahastata*, biomonitor, Dutse,

Introduction:

During the last few decades, heavy metal contamination of biotic component of environment has attracted the attention of many researchers. The main reasons of these researches based on the heavy metal concentration may have a potential hazard in our food chain after a long period of procrastination (Aksay, 2008). Fossil fuels contain many kinds of heavy metals which are emitted during the combustion of those fuels. Furthermore, the wear of automobiletyres, degradation of parts and greases, peeling paint and metals in catalysts are all suspected as sources of heavy metal pollution (Sadeeq *et al.*, 1989;Jaradat&Momani 2009).Heavy metals are chemically very reactive in the environment, which results in their mobility and bioavailability to living organisms. People can be exposed to high levels of toxic metals by breathing air, drinking water, or eating food or edible plants that contains them.

Biological monitoring within a quality control programme involves the systematic use of living organisms for obtaining quantitative information on changes in the environment often due to anthropogenic activities (Dogan*et al.*,2014). Biological responses can be considered more representative than the data supplied by chemical or physical detectors, in that they are spatially and temporarily extensive, they also allow for estimating both the levels of pollutants and even more importantly the impact on biological receptors (Calzoni*et al.*, 2007).For this reason, in order to evaluate, minimize and avoid detrimental effects of toxic metals, there has been an emphasis on the use of natural bio-indicators to monitor atmospheric quantity in both urban and rural environment (Ng *et al.*, 2005). Botanical materials such as fungi, lichens, grasses, tree rings and leaves of higher plants have been used to detect the deposition, accumulation and distribution of metal pollution (Demirayak*et al.*, 2011; Fatoki, 2003; Aksoy, 2008; Saidu*et al.*, 2013).

Leptadeniahastata (pers.) Decne belong to the family Apocynaceae, is a climber plant with pale white, soft, grooved stem. Simple leaves with pale undersurface, latex white, paired dehiscent fruits (Abubakar*et al.*, 2012). It is typically grown in tropical dry lands in sandy soil. Local names for *L. Hastata* include: *yadiya* (Hausa) in Nigeria and Niger, *hagalhadjar* (Arabic) in Chad, *hayla* (Kusume) in Ethiopia, and *ekamongo* (Turkana) in Kenya (Thomas, 2014). *Leptadeniahastata* is a wild plant used as vegetable and as medicine by many African populations due to its nutritive and therapeutic value properties. Despite the fact that in some part of Nigeria the plant is classified as underutilized vegetables, while in other parts the high rate of consumption is highly pronounced (Abubakar*et al.*, 2012).

According to Wittig (1993), the basic criteria for the selection of a species as a biomonitor, it should be represented in large numbers all over the monitoring area, have a wide geographical range, should be able to differentiate between airborne and soil

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SaiduUsman ***et al,TheExperiment,2017.,Vol.39(1),2313-2320***

borne heavy metals, be easy to sample and there should be no identification problems. *LeptadeniaHastata* was selected for biomonitoring studies because it fulfills all the basic criteria given by Witting (1993). The aim of this study was to determine Cd, Cu, Pb and Zn concentrations in soil and in *LeptadeniaHastata* which was tested as a possible biomonitorof heavy metal pollution in Dutse,Jigawa state.

Materials and Methods:

In the preparation of reagents, analytical grade chemicals and distilled deionized water were used. All glass wares were washed with detergent and rinsed with distilled water before drying in the oven at 105°C. All weighing were on Electronic Analytical Balance (FA2104N).

The Study Area

The study area is Dutse, the capital city of Jigawa state (Fig. 1). It is also the political, economical, and cultural centre of the state (world Gazetteer, 2007). Dutse is located between latitudes $11^{0}42^{1}$N and 11^{0} 04^{1}N and longitudes $9^{0}20^{1}$E and $9^{0}31^{1}$E. It has an estimated population figure of 246,143 (NPC, 2006). The area around Dutse is very rocky with some low hills. The people of Dutse are mainly farmers producing food crops like maize, millet, guinea corn and cash crops like cotton and groundnuts. The daily rainy season lasts from May to September with an average rainfall of between 600mm to 1000mm (world Gazetteer, 2007).

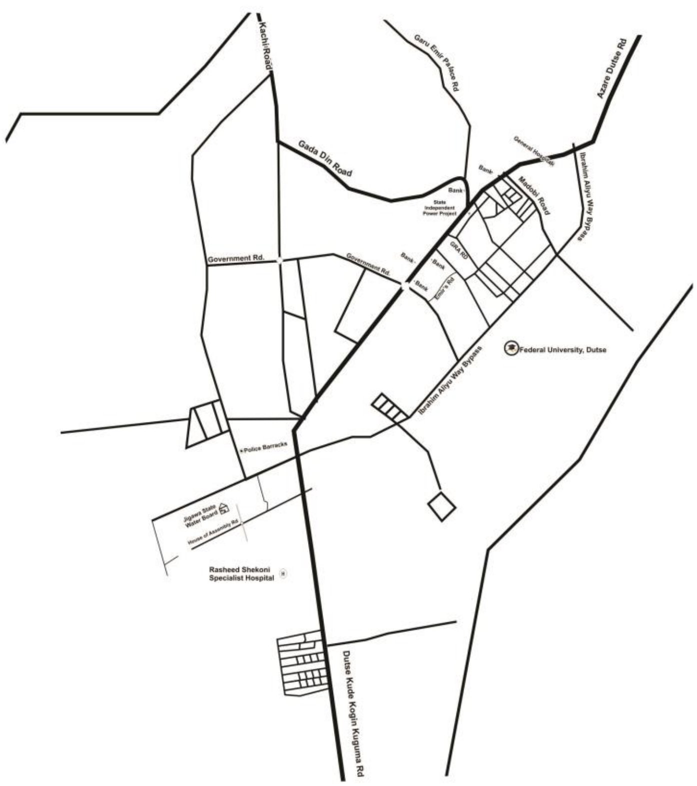

Fig. 1: Map of Dutse showing the Sampling Sites

Sample and Sampling

A total of 24 samples of both soils and plants were collected from different locations namely, Ibrahim Aliyu bypass, Garu-Emir palace road, SaniAbacha way, Kachi road, GRA road, Dutse-Azare road and Dutse-Gaya road. These were further grouped into highly traffic roads, highways and commercial areas based on the activity taken place on each road. For the uncontaminated controls, samples were collected from Sakwaya, a town 15km away from Dutse city centre.

Three soil samples (0 - 10cm deep) were randomly taken from three points at each sampling site and mix together to form a composite sample and three composite samples were prepared for each sampling site (Okunola*et al.*, 2007). Similarly, the same procedure was adopted for the sampling of the plant (Atayese*et al.*, 2009).

Sample Treatment

The plant samples (*Leptadeniahastata*) were divided into two sub-samples. One sub-sample was thoroughly washed with distilled water to remove dust particles, the other sub-sample remained unwashed. All plant samples were dried in an oven at 100^{o}C for 24hrs, crushed in a mortar and passed through 250µm sieve (Ma & Hong, 2006). Each soil sample was air dried to constant weight and then passed through a 2mm sieve. The resultant powder was package in a plastic bottle for the analysis of the heavy metals (Cd, Cu, Pb, and Zn).

Procedure:

1g each soil and plant samples were ashed in a muffle furnace at 460^{o}c for 24hrs, and weighed ash digested in concentrated HNO_3,evaporated to near dryness on a hot plate and made upto volume with 1% HNO_3. The weighed ash of soils was digested in 10ml aqua regia (HNO_3: HCl, 1:3) in a digestion tube on a heating block for a total of 9hrs (2hrs at 25^{o}c, 2hrs at 60^{o}c, 2hrs at 105^{o}c and 3hrs at 125^{o}c). All digested samples were centrifuged, then made up to volume with 1% HNO_3(Al-shayeb *et al.*, 1995). Concentration of Cd, Cu, Pb, and Zn were measured in the extracts of soil and plants using atomic absorption spectrophotometer (Buck scientific model 210 VGP).
Statistical analyses were processed using SPSS 16 version. Paired t-test was used to compare two sample groups (washed and unwashed). Relationship between metals was evaluated using Pearson correlation.

Results and Discussion:

The mean concentrations of heavy metals (Cd, Cu, Pb and Zn) in the unwashed and washed leaves of *leptadeniahastata* and the soils from different sampling sites are presented in Figures 2 (a, b, c and d) and 3 (a, b, c and d) respectively. A comparison of concentrations in the leaves and the soils reveals that highways has the highest average heavy metal concentrations followed by high traffic roads and then commercial areas, while the control site had the least concentrations. This may be due to higher activity and higher vehicular traffic in the sampling sites when compared with the control site. Similar kinds of observations were made by Aksoy, (2008) while studying *ChicoriumIntybus* L. as a possible biomonitor of metal pollution. Yilmaz*et al.*, (2006) while studying *Aesculushippocastanum* L. as a biomonitor of Pb, Cd, Zn and Cu also reported higher levels of heavy metals in the urban roadside, city center and suburban roadsidewhen compared with rural areain theTherace region of Turkey.

The result also reveals higher heavy metals concentration in soils than in the leaves of L. *Hastata*with the exception of Cd. This is due to excessive accumulation of heavy metals in soil through traffic emission and the resultant heavy metal uptake by the plant. The result is in agreement with that of other researchers (Onder*et al.*, 2007; Saidu*et al.*, 2013).

Cadmium concentrations varies from site to site in both plant and soil samples. The highest mean Cd concentration was found in unwashed leaves of commercial areas (15.08 mg/kg) as compared to the control site (7.54 mg/kg). While in soil samples, Highways had the highest Cd concentration (6.75 mg/kg) and the control site had the least concentration (2.22 mg/kg). Plant

ISSN-2319-2119
RESEARCH ARTICLE

SaiduUsman *et al,TheExperiment,2017.,Vol.39(1),2313-2320*

Cd concentration was found to be significantly higher than the soil Cd concentration. The higher Cd content in plant appears to be due to a direct deposition and foliar absorption more than the translocation from roots to the upper part of the plants. Similar result was also reported by Atayese*et al.*, (1999).The general population is exposed to Cd via ingestion or inhalation. Plants exposed to Cd at toxic levels exhibit chlorosis and reduced growth. Cd in agricultural soil is mainly derived from the Cd present in fertilizers and sewage sludge applied in the crop field (Dara and Mishra, 2012). Recent studies in Australia have shown that the Cd content of soils and its uptake by plants have increased after repeated, long term additions of superphosphate containing 38 – 48 µgCdg-1 (Misra and Dinesh, 2012). According to Ross (1994), the concentration of Cd considered to be toxic in soil is 3 – 8 mg/kg, while its concentration in contaminated plants is 0.03 – 3.8mg/kg. Our values exceeded the ranges reported by Ross (1994). However, Aksoy and Ozturk (1996) reported 603 mg/kg of Cd for the leaves of P. *Dactylifera*. Similarly, high concentration of Cd (77.2 – 136.3 mg/kg) was reported by Divrikli*et al.*, (2006).The values of Cd in plant (L. *hastata*) were found to be above the normal range, which indicates contamination of the plant with Cd.

Copper is essential to plants for synthesizing chlorophyll and for the activity of some enzymes. However, at higher levels (about 0.1 mg/l), Cu can inhibit growth (Dara and Mishra, 2012). According to Yilmaz*et al.*, (2006), 5-20 mg/kg Cu was normal, while less than 4 mg/kg was considered deficient and above 20 mg/kg was considered toxic for plant growth. In this study, the values of Cu ranged from 17.19 mg/kg to 34.90 mg/kg in soil and 8.33 mg/kg to 12.50 mg/kg in unwashed leaves of *Leptadeniahastata*. High traffic roads had the highest mean Cu concentrations in both the plant (12.50mg/l) and the soil (34.90 mg/kg) samples. Our results showed that the Cu concentrations were within the normal levels presented by Yilmaz*et al.*, (2006). Similar concentration levels of Cu as observed in this study have been reported by Aksoy, (2008).

Lead is considered as general protoplasmic poison which is accumulative, slow-acting and subtle. It produces a variety of symptoms (Dara and Mishra, 2012). Pbaccumulates with age in bones aorta, and kidney, liver and spleen. It can enter human body through uptake of food (65%), water (20%) and air (15%) (Nazir*et al.*, 2015). The occurrence of Pb in higher amount is due to traffic volume (Jaradat and Momani, 1999). The highest Pb concentration was found in high traffic road soils (1.07 mg/kg) as compared to the control site (0.74 mg/kg). In the unwashed leaves of L. *hastata*, the highest Pb concentration was found in highways (0.47 mg/kg), while control site had the least concentration (0.36 mg/kg). Similar levels (0.338 – 0.523 ppm) have been reported by Dogan*et al.*, (2014) while studying heavy metal accumulation in the leaves of some plant species. According to Ross (1994), Pb concentrations in soil considered toxic ranged between 100 – 400 ppm, while its concentration in contaminated plant ranged between 30 – 300 ppm. The Pb values in this study are far below the levels limit reported by Ross (1994).

Zinc is one of the most important trace elements that play a vital role in the physiological and metabolic process of many organisms. However, higher concentrations of Zn in soil can be toxic to soil organisms (Nazir*et al.*, 2015). Plants with symptoms of Zn deficiency experience a retarded elongation of cells. Mean Zn concentrations ranged from 34.44 – 82.22 mg/kg in the soil samples, with the highways having the highest concentration (82.22 mg/kg) and the control site having the least levels (34.44 mg/kg). Also, in the unwashed leaves of *L. Hastata*, the highest mean concentration was found in highways (61.11 mg/kg) as compared to the control site (15.67 mg/kg). Similar concentration levels of Zn as observed in this study were reported by Aksoy (2008). The normal levels of Zn in plants are reported to lie between 10–100ppm and 17-25 ppm in soil (Yilmaz*et al.*, 2006). While Zn concentrations in plant and soil considered being toxic are 100–400 ppm and 70–400 ppm respectively (Ross, 1994). In general, Zn is not at harmful levels or major threat to the environment in the present study.

Table 1 present the total percentage of heavy metals removed from the leaves of *Leptadeniahastata*through washing. Washing the leaves significantly reduced the heavy metal concentrations from all the study sites. It can also be seen that the amount of metal removed by washing differs from site to site depending on the pollutant levels at the sampling sites. The reduction for Pb was 46.8%, 48.7%, 56.8% and 47.2% for highways, commercial areas, hightraffic roads and control sites respectively. The percentage removal was the highest in high traffic roads (56.8%) as compared to the other sites. The reason for this is the differences in the atmospheric deposition of these metals and the variation in the traffic densities in the sampling sites. Similar result was obtained by Aksoy, (2008) who reported removal of 8 – 56% of Pb in a similar study.Yilmaz*et al.,* (2006) have also reported similar removal percentage of Pb (57.14%) from urban roadside in *AesculushippocastanumL*. The ability to distinguish airborne and soil borne contamination was assessed by washing the leaves. The results obtained in this research indicate that substantial aerial depositions on the leaves for the metals are removed by washing procedure.

The basic criteria for the selection of a species as a biomonitor, it should be represented in large numbers all over the monitoring area, have a wide geographical range, should be able to differentiate between airborne and soil borne heavy metals, be easy to sample and there should be no identification problems. In accordance with the present results, *LeptadeniaHastata*possesses all the characteristics for its selection as a biomonitor of heavy metal pollution.

Conclusion:

The results of the analysis showed that the concentrations of the heavy metals (Cd, Cu, Pb and Zn) in the unwashed leaves of *Leptadeniahastata*were significantly higher than in the washed leaves. This is due to aerial deposition of the studied heavy metals. High traffic roads had the highest levels of Cu, while Commercial areas had the highest level of Cd, where as the highways had the highest levels of Pb and Zn in the leaves of *L. Hastata*. The levels of Cu, Pb and Zn were found to be within the normal range, while Cd levels were found to be above the normal range. This indicates contamination of the plant with Cd. The result also showed that *Leptadeniahastata*can be used as a biomonitor of heavy metal pollution.

The leaves of *Leptadeniahastata*are widely used as vegetable all over Dutse and its environment. For this reason, it is strongly recommended that the leaves should be washed thoroughly before eating or otherwise not be eating. This willreduce the rate of ingestion heavy metals into the body system.

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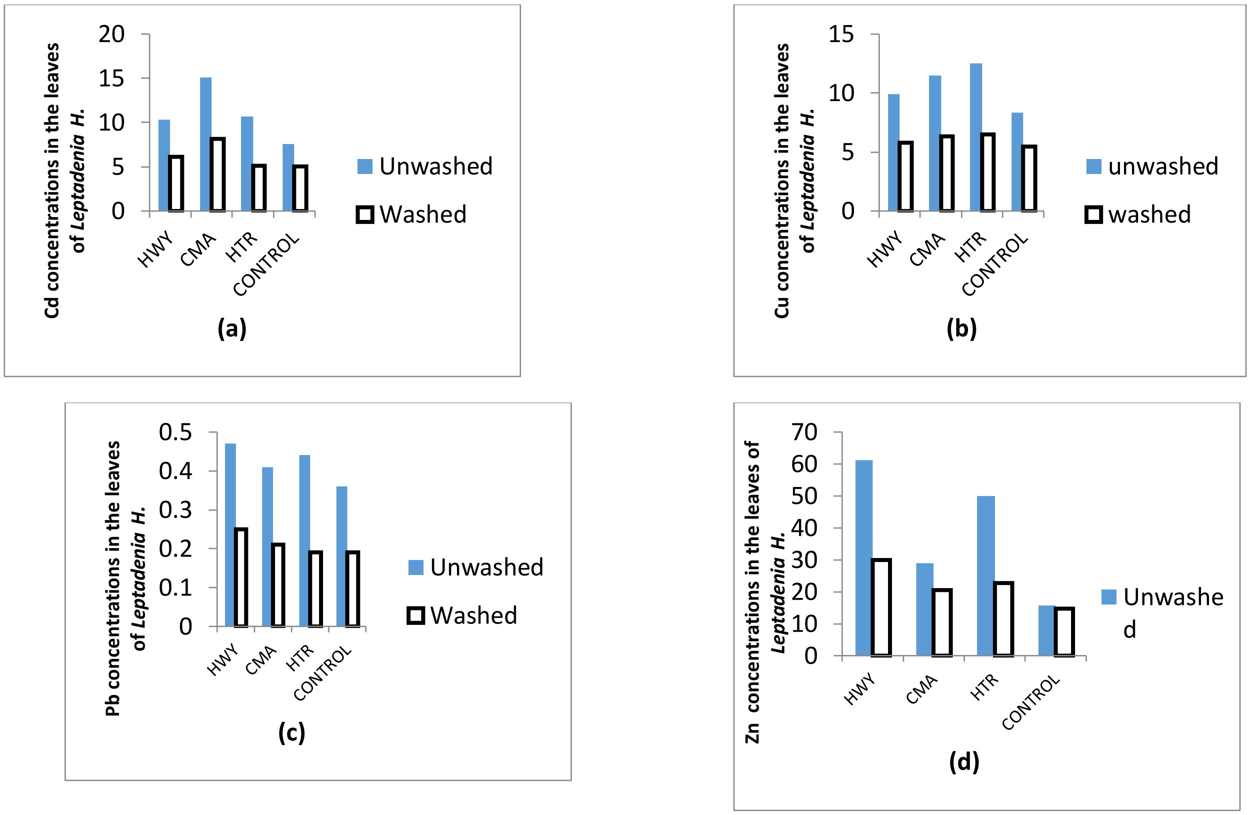
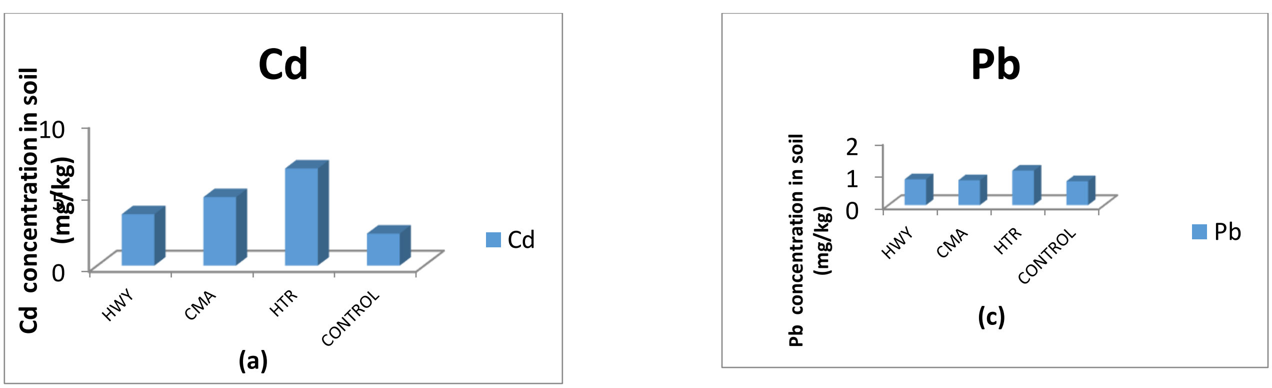


Fig. 2. Mean Cd (a), Cu (b), Pb (c) and Zn (d) concentrations (mg/kg) in unwashed and washed leaves of *Leptadeniahastata.* (HWY = Highways, CMA = Commercial areas, HTR = Highly Traffic Roads)



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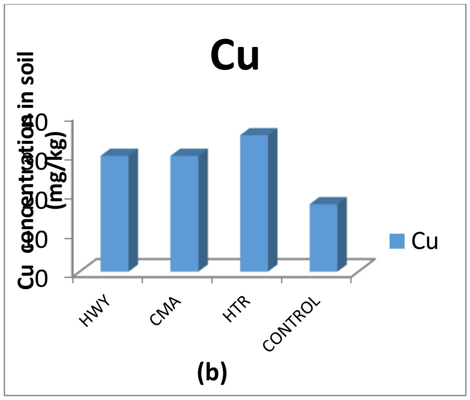

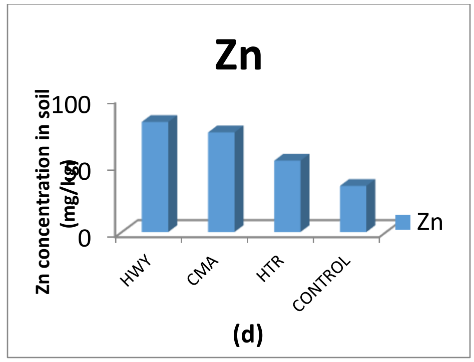

Fig. 3. Mean Cd (a), Cu (b), Pb (c) and Zn (d) concentrations (mg/kg) in the soil samples. (HWY = Highways, CMA = Commercial areas, HTR = Highly Traffic Roads)

Table 1: Total percentage of heavy metals removed from the leaves of *Leptadenia H.* by washing

Sites	Cd	Cu	Pb	Zn
HWY	40.9	41.4	46.8	50.9
CMA	46.2	44.7	48.7	28.6
HTR	52.3	48.0	56.8	54.6
CONTROL	32.3	34.6	47.2	6.4

HWY = Highways, CMA = Commercial areas, HTR = Highly Traffic Roads

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ISSN-2319-2119

RESEARCH ARTICLE

SaiduUsman *et al,TheExperiment,2017.,Vol.39(1),2313-2320*

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Author(s) & Affiliation

***SaiduUsman[1] and Busari Abdulakeem[1].**

[1]Department of Chemistry, SuleLamido University, Kafin Hausa, P.M.B.048, Jigawa State, Nigeria.