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Effects of Lead-Contaminated Soil Through Battery Slag on the growth of *Amaranthus cruentus*

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ABSTRACT

The impact of battery slag contaminated soil on *Amaranthus cruentus* yield was studied. Lead is the dominant reactive component of battery slag. Seeds of *A. cruentus* were sown on soil contaminated with battery slag containing a high concentration of Lead. The battery slag soil was analyzed to know the level of Lead contamination. The contaminated soil was diluted with uncontaminated soil to obtain different levels of contamination. Ratio 4:0; 3:1; 2:2, 1:3 and 0:4 in proportionate mixture of contaminated to uncontaminated soil were made, respectively making a total of a 4kg soil in an experimental pot. Plant growth parameters were taken 5 weeks after sowing with the highest plant height of 15.2cm recorded in a plant grown on the least contaminated soil and 0.9cm recorded on the plant grown on the most contaminated soil. The same trend was recorded on the plant stem diameter with 0.3 and 0.05cm in most and least contaminated soil, respectively. The number of leaves per plant was not significantly different in 0:4, 1:3, and 2:2 contamination levels but a comparably smaller number of leaves recorded in plants grown on 3:1 and 4:0 contamination levels. Lead contamination greatly affected plant yield and farmers using abandon industrial dump sites would have yield loss due to lead contamination of such lands and this will amount to a loss of resources and due to bioaccumulation of lead in such plants, the consumer (man and animals) health are being greatly threatened.

Key words: Contaminated-soil, Heavy metals, Exide battery Lead, Leave-number, Plant-height, Stem-diameter, Lalupon, Ibadan.

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INTRODUCTION

Leafy vegetables play indispensable roles in human nutrition, especially as sources of vitamins A, B, C, and E, minerals and dietary fibre (Arasaretnam et al., 2018; Joao 2012; Aletor and Adeogun, 1995). Among these, *Amaranthus cruentus* seems to be more popular in Nigeria especially in the southwestern part of the country (Mensah et al., 2008). But a lot of factors hinder the production of enough quantity of the vegetable that is safe for human consumption. Key among these factors is unavailability of cultivable land due to the high rate of urbanization and rural-urban migration (Huub 2013; Saleh et al., 2014; Aluko, 2010). Most presumed available lands are polluted with heavy metals like Pb, Cd, Ni, As, Zn, etc as a result of industrial and domestic waste discharges (Galadima et al., 2011). Several studies have reported battery waste as also a major source of these metals especially its contribution to Pb concentration on dumpsites in Nigeria (Abdus-Salam,2009; Opaluwa et al., 2012; Akobundu and Nwankwoala, 2013; Ukpon et al., 2015). This anthropogenic act did not spare the periphery region of the cities around us which are mostly agrarian areas where it is expected to produce less polluted crops. Most of them are being made dumping ground in an illegitimate manner (Oni, 2010). Since ancient times, soil has been the repository of diverse wastes which include battery wastes (Adie and Osibanjo, 2009). It had been reported that from the total Pb usage globally, Lead battery consumed 71% making the highest percentage (Adie and Osibanjo, 2009) and this had resulted in a higher concentration of Pb in the environment. Nigeria is not exempted from the effects of dumping of Pb wastes, especially from battery manufacturing activities.

In Nigeria, there had been 3 notable industries manufacturing vehicle batteries. They were West African Battery Industry producer of Exide Battery in Ibadan (now closed down), Union battery Company in Nnewi and Metropolitan Battery (still existing) in Sango Ota (Oyediran and Aladejana, 2011; Adeagbo, 2011; Adie and Osibanjo, 2009). These industries had their dumpsite at the outskirt of the city of their location. Exide battery which used to be the biggest had two separate dumpsites at the neighbouring towns of Ibadan – Lalupon and Kumapayi, Olodo (Afolayan and Hamsat, 2017; Ogundiran and Osibanjo, 2008; Adejumo et al., 2011). Ogundiran and Osibanjo reported 34.8 to 41500, 9.2 to 9700 and 4.5 to 5670 concentration of Pb (in mg/kg) in Soil, plant roots and plant shoots respective at lalupon dumpsite where other metals (Zn and Ni) detected ranged from NOT DETECTED to VERY LOW quantity. Also, Adesoun et al. (2017) had reported the quantity of Pb (mg/kg) ranged from 495 to 40600, 234 to 2505 and 156 to 12125 in soil, root and shoots (of plant species), respectively in Lalupon battery slag dumpsite. Researchers in making effort to devise methods for soil decontamination through phytoremediation had however revealed that some plant species can grow well on Lead-contaminated soil (Ogundiran and Osibanjo, 2008; Adeosun et al., 2017). Phytoremediation is a process of using living plant to mop pollutants from polluted land or water body (Etim, 2012). Several plants had been studied to possess properties that make them fit for this purpose. Some of them have been discovered to have properties to accumulate and tolerate high concentration of heavy metals in their above-ground tissues (Brooks, 1998). Lalupon is an agrarian community which due to development had been witnessing the conversion of arable land for the construction of buildings hence increasing pressure in search of cultivable land (Adelekan, 2016; Wahab and Abiodun, 2018). Due to the shortfall of farmland in Lalupon there is a gradual migration of cropping activities towards the defunct exide battery dumpsite.

In lalupon, some of the plant species found growing (not cultivated) on the battery waste dumpsite were *Gomphrena celosioides, Sporobolus pyramidalis, Imperata, cylindrica, Chromolaena odorata* (Adeosun et al., 2017; Ogundiran and Osibanjo, 2008). It is good to note that according to Ogundiran and Osibanjo (2008) the level of Pb concentration decreased at increasing distance from the vicinity of the waste dump site. At short distance to the dumpsite there are farming activities engaged by the neghbouring inhabitants/farmers which involves the cultivation of *A. cruentus* hence this study focused on the effect of dumpsite on the growth of and Pb concentration in *A. cruentus* considering the decreasing amount of battery slag in the soil as one moves away from the dumpsite towards the human settlement. around Lalupon, Ibadan. So bulk sample obtained from the center of the site would be amended to represent what might be obtained as one moved away from the dumpsite.

The aim of this study is to assess the effect of battery slag dumpsite on the growth and Pb concentration in *A. cruentus* considering the decreasing amount of battery slag in the soil as one moves away from the dumpsite towards the human settlement around Lalupon, Ibadan.

MATERIALS AND METHODS

This experiment was carried out in the Department of Crop Protection and Environmental Biology (CPEB) Rooftop screen house (to monitor the quality and quantity of water for wetting and to control leaching of the Pb component), University of Ibadan at the onset of raining season. Two different sources of soil were used in this experiment. Contaminated soil was obtained from battery slag dumped [heavily polluted with Pb] soil at Lalupon (a shutdown Battery Industry’s dumpsite) Ibadan-Iwo Road, Nigeria which lies between longitude 7º28 ¹ N and latitude 4º04 ¹ E (Figure 1). The samples were obtained from the middle of the site at 0 to 15 cm deep from the surface of the dumpsite using local hoe while wearing a protective glove mask and boots. The soil was analyzed to have a pH value of 6.95 and contained 365.20 mg/kg Zinc). Uncontaminated soil was (analyzed to have a pH value of 7.10 and contained 142.16 mg/kg Zinc) obtained from the experimental garden of CPEB, a well-drained sandy soil (Soil texture analysis showed that the soil is a sandy soil, 87% of sand, 6% of silt and 7% of clay) under forest trees within the faculty of Agriculture and Forestry, University of Ibadan. The garden was divided into four parts and samples were collected from each of the parts (from 0 to 15 cm below soil surface), these were thoroughly mixed to form composite samples. Seeds of *A. Cruentus* were obtained from Genetic Resources Unit, National Horticultural Research Institute (NIHORT), Jericho, Ibadan.

Soil Preparation

The soils from the two different sources were thoroughly mixed separately to obtain a homogenous soil. Different levels of contamination were achieved by measuring the varying quantity of soil from the two sources and mixed thoroughly. The total quantity of soil in each pot was 4kg as given below;4kg uncontaminated soil = 0% Lead Contamination Treatment, and replicated 5 times. 3 kg uncontaminated soil mixed with 1kg contaminated soil = 25% Lead Contamination Treatment, and replicated 5 times. 2kg uncontaminated soil mixed with 2kg contaminated soil = 50% Lead Contamination Treatment, and replicated 5 times. 1kg uncontaminated soil mixed with 3 kg contaminated soil = 75% Lead

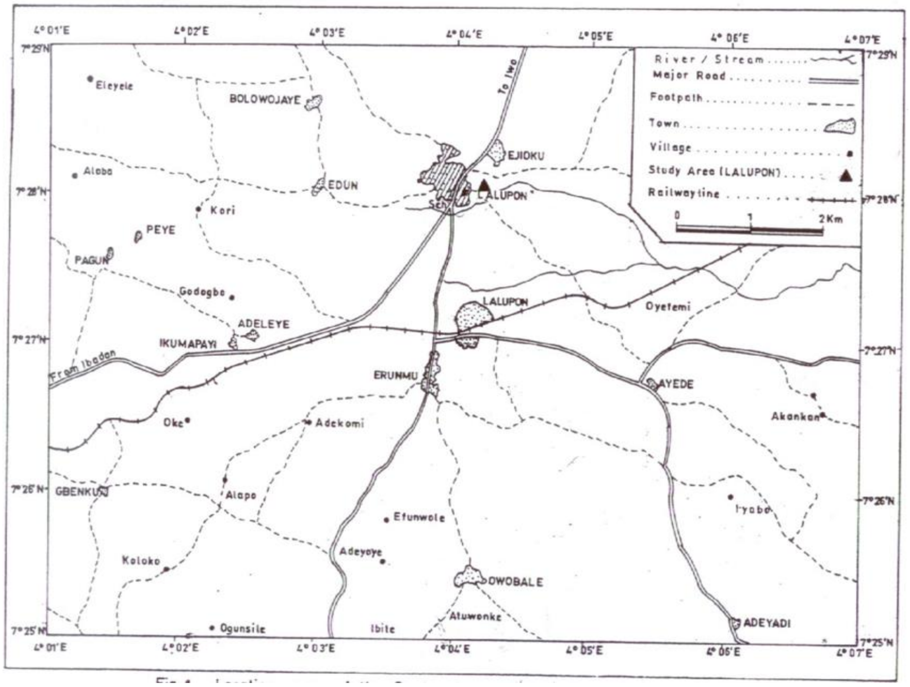

Figure 1. Map of Ibadan showing Lalupon, the sampling site.

Contamination Treatment, and replicated 5 times. 4 kg contaminated soil = 100% Lead Contamination Treatment, and replicated 5 times. *A. cruentus* L seeds were sown on the prepared soil (after moistening with well water obtained from CPEB, University of Ibadan). The sowing was by broadcasting (a glass-bottled coca cola crown level-full of the seeds). The water used to moist the soil and subsequent for wetting was initially analyzed to contain Lead (Pb) value lower than the sensitivity limit of the spectrophotometer. The subsequent wetting was done every morning using water from the same source as above.

Data Collection and Analysis

The growth parameters were monitored at 2 to 5WAS (week after sowing). At maturity (5 WAS) the plants were observed for growth parameters by taking the stem height from the soil surface (using meter rule), stem diameter at 1cm above soil level (using a vernier caliper) and manual counting of number of leaves. Data were analyzed by Descriptive statistics and one-way analysis of variance (ANOVA) and differences were considered to be statistically significant at $P<0.05$. Least significant difference (LSD) test was further carried out to establish the pairs that showed significant differences.

Plant Sample Preparation for Lead (Pb) Analysis

The harvested plant samples were sun-dried for a period of three days. Sun drying is a means of drying Agricultural products in Tropical Africa (Abugre, 2011). The drying process was monitored with a gradual and adequate manual turning (raking the spread plants) to facilitate uniform drying and eliminate mold. This was followed by milling the brittle leaves and stems (edible parts) into particle size. The milled plants were sieved with a 0.5 mm sieve to obtain analyzable fine sample. One gram (1g) was measured (using an analytical balance) from each treatment for metal analysis.

Acid Digestion

Lead (Pb) in vegetable samples was extracted following acid digestion procedure as follows: 1.0 g of the dry weight from each sample was weighed into a digestion tube and 10ml of 98% nitric acid was added which was placed in a water bath and allowed to boil for about 72 h. The resulting pale-yellow solution after digestion was made up to 25 ml with de-ionized water and stored, ready for metal analysis.

Heavy Metals Analysis

The solutions obtained from the digestion procedure were analyzed for Pb using a flame atomic absorption spectrophotometer (AAS, Perkin Elmer model 2130) (AOAC, 2005). Certified standard reference material was used to ensure accuracy and the analytical values were within the range of certified value. The AAS was calibrated for both lead by running different concentrations of certified reference standard solutions. Blanks and reference samples were used to control the quality of the analyses. Blanks and standards were run

Table 1. Growth of *A. cruentus* grown on battery slag-contaminated soils from Lalupon amended with uncontaminated soil.

Levels of Lead (Pb) Polluted Treatment	Plant Heights (mm)	Stem Diameters (mm)	Number of Leaves Produced
0%	15.87a	0.27a	9.0a
25%	9.50b	0.23a	8.7a
50%	4.20c	0.17b	5.7b
75%	1.40d	0.09c	2.67c
100%	0.87d	0.05c	4.33b
LSD (P<0.05)	2.698	0.067	1.8191

Table 2. Lead Pb concentration (g/Kg) in tissues (Leaves and Stems) of *A. cruentus* grown on battery slag-contaminated soils from Lalupon amended with uncontaminated soil.

Levels of Lead Pollution Treatment	Mean Lead Load (g/Kg)
0%	0.00008a
25%	0.28317b
50%	0.56597c
75%	1.03560d
100%	1.15190e
LSD (P<0.05)	0.015

after five determinations to calibrate the instrument. Coefficients of variation of replicate analysis were determined for precision of analysis and variations below 10% were considered correct.

RESULTS AND DISCUSSION

Growth Parameter of *A. cruentus* As Influenced by Levels of Soil Contamination with Battery Slag

The growth parameters of the *A. cruentus* in relation to levels of polluted soil showed significant differences (P<0.05). The analysis of growth of the *A. cruentus* in all the treatments at 5 WAS was presented in Table 1. The control (0% Pollution level) plant had the best average height values of 15.2 cm which was slight lower than what Ogunyemi et al. reported in (2009) using same soil source as a control in Pb analysis. The difference could be due to the ageing of the soil in the crop garden of CPEB and progressive deposition of vehicular emission. The height reported in the 25% contamination treatment (least contaminated treatment) was smaller than what was reported by Ogunyemi et al. (2009) in the highest polluted dumpsite studied which is an indication of how polluted the soil would be despite the level of amendment. The stem diameter of the vegetable was the highest (0.30 cm) in the control soil which followed the same pattern of stem height compared with Ogunyemi *et al* (2009) who reported 0.66 cm in the soil from CPEB. The stem diameter decreased as the levels of contamination increased (25, 50, 75 and 100%). Treatments 0, 25 and 50% were not significantly different (at P>0.05) in the number of leaves produced, but were relatively higher than the number of leaves produced per plant in the other two treatments (75 and 100% levels of contamination). Summarily the results of this study showed a reduction in growth parameters (plant heights, stem diameters and a number of leaves) of *A. cruentus* as the Lead concentration increases. This was in agreement with the study carried out by Mensah et al. (2008) on the exposure of vegetables (Carrot, Lettuce and Cabbage) to Pb.

The reduction of growth could have been due to metal inhibition of protein synthesis and respiration in the roots (Muhammad et al., 2008; Billet et al., 1974). Inhibition of protein synthesis does affect plant cells division and multiplication with a resultant effect on plant growth and biomass. Plant growth and dry matter yield reductions observed in the polluted *A. cruentus* are in line with those reported on corn (Narwal et al., 1990), and tomato and eggplant (Khan and Khan, 1983). Excess Lead concentration resulted in dwarf plant with the plant biomass decreased as Lead concentration increased. The decreases in plant height and the number of leaves were not only related to the Lead concentrations, but also to the growth duration under Lead stress. It was observed at 3 WAS that plants in the 75 and 100% pollution treatments began to retard in growth and dying towards the 5WAS. This showed that *A. cruentus* cannot be a good species for phytoremediation which is advantageous to public health because there would not even be any yield at such concentration. Those in 25 and 50% treatments did not die but reduced in growth in that order, an indication of stress due to excessive Lead (Pb).

Concentration of Lead (Pb) In *A. cruentus* As Influenced by Levels of Soil Contamination with Battery Slag

Analyses of Lead (Pb) concentrations in the edible parts (Leaves and Stems) showed a linear increase in the vegetable in the order of pollution levels. The mean concentrations ranged from 8 mg to 1151.9 mg as shown in Table 2. In this study all except the control treatment produced vegetable with concentration far above 0.3 mg/Kg which is the safe limit as recommended by FAO/WHO (Shuaibu et al., 2013). This is an indication that quite a number of human (children and adults) consuming the *A. cruentus* grown in the vicinity of Lalupon battery slag dumpsite have been exposed to some amount of Lead concentration from *A. cruentus.* The high concentration of Pb in *A. cruentus* is as high as previous reported by Adeosun et al. (2017) in plants like *G. celosioides*, *S. pyramidalis, I. cylindrica C. odorata* and *R.corymbosa.* Consuming vegetables grown on such dumpsite can be more detrimental to human health (McGrath et al., 1994) and any distant cannot be assumed as safe until validated by research.

CONCLUSION

This study revealed that the accumulation of Pb metal by *A. cruentus* planted on soil polluted by battery slag causes a reduction in its growth and the rate of increasing concentration of Lead is directly proportional to the decrease rate of *A. cruentus* growth. This will be an economical lose since time and labour will yield no result and more populace would be endangered health wise due to the exposure to the dangerous heavy metal. Further research is necessary to ascertain how protein synthesis is inhibited in *A. cruentus* by the presence of 190. heavy metals. Monitoring exercise is essential to ensure no farming. activities on industrial waste sites such as the battery slag dumpsite at Lalupon, Ibadan to ensure appropriate protection of human health until full land recovery. It is recommended that government moves into the site and ensure total mopping harnessing phytoremediation.

REFERENCES

Abdus-Salam N (2009). Assessment of Heavy Metals Pollution in Dumpsites in Ilorin Metropolis. Ethiopian Journal of Environmental Studies and Management 2 (2): 92-99.

Abugre C (2011). Assessment of some traditional leafy vegetables of upper East Region and influence of stage of harvest and drying method on nutrients content of Spider Flower (*cleome gynandra* L*.).* Master thesis from Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Adeagbo OA (2011). Impact of waste batteries dumpsite on the water quality of parts of Ibadan northeast (sheet 261), southwestern Nigeria. Global journal of pure and applied sciences, 17: 2.

Adejumo SA, Togun AO, Adediran JA, Ogundiran MB (2011). Field assessment of progressive remediation of soil contaminated with lead-acid battery waste in response to compost application. Pedologist. 54(3):182-193.

Adelekan IO (2016). IBADAN CITY DIAGNOSTIC REPORT. Working Paper #4. Urban Africa Risk Knowledge, University of Ibadan.

Adeosun AA, Adejumo SA, Srivastava P (2017). Lead Accumulation and Distribution at Cellular level in Native Plants Growing on Battery Wastes Contaminated Sites in Ibadan, Nigeria. International Journal of Plant & Soil Science 16(5): 1-15.

Adie GU, Osibanjo O, Assessment of Soil-pollution by slag from an automobile battery manufacturing plant in Nigeria. African Journal of Environmental Science and Technology, 3(9): 239-250.

Afolayan AO, Hassan AT (2017). Accumulation of Lead, Cadmium and Iron in Topsoil of Ori-Ile Battery Waste Dumpsite and Surrounding Gradient Point Areas at Olodo, Ibadan, Nigeria. International Journal of Mineral Processing and Extractive Metallurgy. 2(5): 68-78

Aletor VA, O.A. Adeogun (1995). Nutrient and anti-nutrient components of some tropical leafy vegetables. Food Chem. 53: 375-379.

Aluko OE (2010). The Impact of Urbanization on Housing Development: The Lagos Experience, Nigeria. Ethiopian Journal of Environmental Studies and Management. 3: 3: 64-74.

AOAC (Association of Official Analytical Chemists) (2005). Official Methods of Analysis. Association of Official Analytical Chemists. Washington DC. 15th ed. 11-14.

Arasaretnam S, Kiruthika A, Mahendran T (2018). Nutritional and mineral composition of selected green leafy vegetable of selected green leafy vegetables. Ceylon Journal of Science. 47 (1): 35-41.

Billet JE, Koeppe DE, Miller RJ (1974). Sorption of heavy metals cations by corn mitochondria and the effects on electron and energy transfer reaction. Physiol. 30: 226-230.

Brooks RR. Plants that hyperaccumulate heavy metals: Their role in phytoremediation, microbiology, archeology, mineral exploration and phytomining. Cambridge University Press, Cambridge; 1998.

Etim EE (2012). Phytoremediation and Its Mechanisms: A Review. International Journal of Environment and Bioenergy 2(3): 120-136.

Galadima A, Garba ZN, Leke L, Almustapha MN, Adam IK (2011). Domestic Water Pollution among Local Communities in Nigeria-Causes and Consequences. European Journal of Scientific Research, 52 (4): 592-603.

Huub S (2013). Challenges for Crop Production Research in Improving Land Use, Productivity and Sustainability. Sustainanability. 5: 1632-1644.

Joao SD (2012). Nutritional Quality and Health Benefits: A Review/. Food and Nutrition Science. 3: 1354-1374.

Khan S, Khan NN (1983). Influence of Lead and Cadmium on the growth and nutrient concentration of tomato eggplant. Plant and Soil 74: 387-394.

McGrath SP, Chang AC, Page AL, Wilter E (1994). Land application of sewage sludge: Scientific perspectives of heavy metal loading limits in Europe and the United States. Environ. Rev., 2: 108-118.

Mensah E, Allen HE, Shoji R, Odai SN, Kyei-Baffour N, Ofori E, Mezler D. (2008). Cadmium (Cd) and Lead (Pb) Concentrations Effects on Yields of Some Vegetables Due to Uptake from Irrigation Water in Ghana. International Journal of Agricultural Research. 3 (4): 243-25.

Mensah JK, Okoli RI, Ohaju-Obodo JO, Eifediyi K (2008). hytochemical, nutritional and medical properties of some leafy vegetables consumed by Edo people of Nigeria. African Journal of Biotechnology, 7 (14): 2304-2309.

Muhammad S, Iqbal MZ, Mohammad A (2008). Effect of lead and cadmium on germination and seedling growth of Leucaena leucocephala. J. Appl. Sci. Environ. Manage. 12(2):61-66

Narwal RP, Singh M, Dahiya DJ (1990). Effect of Cadmium on plant growth and heavy metal contents of corn (Zea mays). Crop Res. 3(1): 13-20.

Ogundiran MB, Osibanjo O (2008) Heavy metal concentrations in soils and accumulation in plants growing in a deserted slag dumpsite in Nigeria. African Journal of Biotechnology. 7 (17): 3053-3060.

Ogunyemi S, Awodoyin RO, Opadeji T (2003). Urban agricultural production: heavy metal contamination of *Amaranthus cruentus* L. grown on domestic refuse landfill soils in Ibadan, Nigeria. Emir. J. Agric. Sci. 15 (2): 87-94.

Oni AA, 2010. Physico-chemical parameters and toxicity of solid waste and leachates on selected animals at Aba-Eku landfill site, Ibadan, Nigeria. Ph.D. Thesis. Department of Zoology, University of Ibadan. 330p.

Opaluwa OD, Aremu MO, Ogbo LO, Abiola KA, Odiba IE, Abubakar MM, Nweze NO (2012). Heavy metal concentrations in soils, plant leaves and crops grown around dump sites in Lafia Metropolis, Nasarawa State, Nigeria. Advances in Applied Science Research. 3 (2):780-784

Oyediran IA, Aladejana JA (2011). Assessment of Impact and Safety Status of Remediation of Lead Contaminated Soil using Excavation Method: A Case Study of Olodo, Ibadan, outhwestern Nigeria. Proceedings of the Environmental Management Conference, Federal University of Agriculture, Abeokuta, Nigeria.

Saleh Y, Badr AM, El Banna F, Shahata A (2014). Agricultural Land-use change and Disappearance of Farmlands in Kaduna Metropolis-Nigeria. Science World Journal. 9:1.

Shuaibu K, Yahaya M, Abdullahi UK (2013). Heavy metal levels in selected green leafy vegetables obtained from Katsina central market, Katsina, Northwestern Nigeria. African Journal of Pure and Applied Chemistry. 7(5): 179-183.

Wahab B, Abiodun O. (2018) Strengthening Food Security through Peri-Urban Agriculture in Ibadan, Nigeria Ghana Journal of Geography. 10(2): 50-66.