Comparative Assessment of Nutrient Values and Heavy Metals Content of *Talinum triangulare* Collected from Farm Land (Post Service) and Dumpsite (Oko Fili) in Lagos, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2021/v40i2231482

Editor(s):  
(1) Dr. Rui Xiao, Southeast University, China.  
(2) Shakila Banu, Anna University, India.

Reviewers:  
(1) Madhuri Patil, India.  
(2) Shakila Banu, Anna University, India.

Complete Peer review History: [https://www.sdiarticle4.com/review-history/72990](https://www.sdiarticle4.com/review-history/72990)

Received 25 June 2021  
Accepted 05 September 2021  
Published 10 September 2021

ABSTRACT

**Introduction:** *Talinum triangulare* is a nutritious vegetable whose consumption is popular in Nigeria. Therefore, the necessity to consume a very quality and hygienic *T. triangulare* cannot be over emphasized.

**Aims:** To investigate the nutrient contents and level of heavy metals in *T. triangulare* collected from dumpsite and farmland.

**Place and Duration of Study:** Department of Botany, Lagos State University, (Oko fili in Alimosho Local Government Area) and farmland (Post Service in Ojo Local Government Area) between January to March, 2021.

**Methodology:** The data were analyzed using statistical package for social sciences (SPSS) version 20 and a standard procedure was used for t-test analysis.

**Results:** All the amino acids detected in *T. triangulare* from both dumpsite and farmland had no significant differences (p>0.05). There are no significant difference (p>0.05) between lead (Pb), cobalt (Co), copper (Cu), chromium (Cr) and selenium (Se) in samples examined across the two sampling sites, while arsenic (except in the soil from dumpsite) and nickel (except in plant from both sites) were not detected. However, the concentrations of heavy metals such as calcium(Ca),

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iron(Fe), potassium(K), magnesium(Mg), sodium(Na), phosphorus(P), and zinc (Zn) in both the soil and T. triangulare samples from the dumpsite are significantly(p<0.05) higher than that from the farmland. The respective values of these metals (mg/100g) in the plant at dumpsite and farmland are: Ca (343.400±206.475), Fe (82.000±29.839), K(90.900±10.748), Mg(1595.250±149.553), Na(2217.050), P(502.250±140.077) and Zn(60.620±8.739) respectively.

**Conclusion:** Therefore, T. triangulare examined in this study is safe for consumption, however its excess K, Na, and Mg content can be recommended for people with deficiency in those nutrients.

**Keywords:** Talinum triangulare; safety; amino acid; sites; metals; minerals; farmland; dumpsite; nutrients; values.

1. INTRODUCTION

Leafy vegetables are known to add taste, flavor, as well as substantial amounts of nutrients such as protein, fibre, mineral, and vitamins to human diet [1,2]. Leafy vegetables are important protective foods and highly beneficial for the maintenance of health and prevention of diseases as they contain valuable food ingredients which can be utilized to build up and repair the body. Omoyeni et al.[3] reported that increasing colon and stomach cancer correlate with low vegetable meals while Aregheore [4] revealed that green leafy vegetables provide cheap and abundant sources of protein which is a very important dietary macronutrient required for life with various metabolic and physiologic functions, including the regulation of appetite, food intake, body weight, and body composition. Its role in the regulation of blood pressure, glucose and lipid metabolism, bone metabolism, and the immune system has been documented in scientific literatures [5,6].

Therefore, contamination of leafy vegetables by heavy metals cannot be underestimated, as these foodstuffs are important components of the human diet. In an ecosystem, heavy metals occur naturally with different variations in concentrations, however, environmental pollution by heavy metals, even at low concentration and the long- term cumulative health effects that go with it; is of major health concerns all over the world [7]. The presence of heavy metals in the environment is of great ecological significance due to their toxicity at certain concentrations, translocation through food chains and non biodegradability which is responsible for their accumulation in the biosphere [8]. The anthropogenic activities usually result in pollution, especially in developing countries where low-end waste management is a common practice [9].

Some metals, such as Mn, Cu, Zn, Mo and Ni, are essential or beneficial micronutrients for microorganisms, plants and animals. Their absence may cause deficiency diseases but at high concentrations have toxic effects and pose an environmental threat. On the other hand, heavy metals such as Cd and Pb have been known to have no biological importance. These toxic elements find their way into the environment usually as a result of pollution arising from human activities, and consequently contaminate the different environmental media on which human life depends. The level of heavy metals in soils and forms in which they exist are influenced by pedogenic processes [10]. Studies have shown that concentrations of heavy metals in edible parts of plants is directly associated with their concentrations in soils, but their levels differ significantly with plant species, and sometimes with the genotypes within the same plant species [11]. Soil-to-plant transfer of heavy metals is the major pathway of human exposure to soil contamination [12]. For instance, study by Jin et al.[13] have shown that lifetime exposure to low level soil contamination with cadmium (Cd), caused renal dysfunction in residents living near the contaminated sites of the study areas. Various studies have also shown that dumpsite soils in south-western Nigeria and other part of the country support plant growth and biodiversity and as such they have been extensively used for cultivating varieties of edible vegetables and plant based foodstuffs [14]. These practices pose serious health and environmental concern due to the anthropogenic contaminations of these waste soils with intolerable level of chemical materials [15]. Hence, there is need to evaluate the chemical forms or species of these heavy metals since they control their bioavailability or mobility which ultimately control heavy metal soil-plant transfer [16].

The availability and nutritional composition of waterleaf make it one of the most sought after vegetables. Some articles on waterleaf has revealed that it contains important nutrients and phytochemicals such as flavonoids and...
polyphenols, crude protein, lipids, essential oils, cardiac glycosides, omega -3-fatty acids, minerals, soluble fibres, phosphorus and vitamins [17]. However, sources of this vegetable often need assessment, considering the current scope of pollution in Nigeria [18,19]. On the sensory evaluation basis, dark, green, big leaf of waterleaf may appear safe and of good quality to most consumers, but this alone cannot guarantee that the vegetables are safe for consumption. While the amounts of the nutrient constituents in some more commonly used leafy vegetable species in Nigeria have been studied to some extent [20], the lesser known regional and local species remain virtually neglected. At present, there is scanty information on comparative assessment of proximate composition and amino acid of leafy vegetable especially *Talinum triangulare* collected from dumpsite and farmland in Lagos State, Nigeria. Therefore, the present study aimed to examine the nutrient, amino acids and level of heavy metals in soil and *Talinum triangulare* from dumpsite in Oko fili (Alimosho Local Government Area) and farmland (Ojo Local Government Area) in Lagos State, Nigeria in a bid to ascertain its safety for human use and consumption.

2. MATERIALS AND METHODS

2.1 Sample Collection and Preparation

The starting point (10m away from the road) was cleared using a cutlass and marked with a carved wooden peg. Then the field was slightly cleared to create a footpath. At the dumpsite and farmland, a study site of 150×30 m was measured with a measuring tape, demarcated with wooden pegs and rope. Dominant plant species (*T. triangulare*) from each sample plot were uprooted, while the soil particles were collected from the roots. The plants were kept in a paper bag, tied and labelled with a masking tape and a marker. The soil and plant samples were taken to the laboratory for heavy metal analysis.

2.2 Sample Extraction

5g each of the samples was weighed into a porcelain crucible and ashed in a muffle furnace at 550°C for 4hs. Thereafter the residue was allowed to cool, and then dissolved with 5ml of dilute nitric acid. The mixture was diluted to 25ml with distilled water and the solution filtered through whatman filter paper. The filtrate was saved for the determination of metals.

2.3 Digestion and Measurement of Heavy Metals (Cu, Cr, Co, Pb)

Heavy metals, Cu, Zn, Cr, Mn, Co, and Pb were determined using atomic absorption spectrophotometer. The Ca, Mg, Fe Na, P and K contents of the sample were determined using atomic emission spectrometer [21].

2.4 Amino Acids analysis

A set of amino acid standards (Merck Germany) were used to calibrate the HPLC (High performance liquid chromatography) while identification of the amino acids in the samples was carried out by comparison with the retention times of the standards.

Aliquots of 20 μL of standard solution, containing 0.20 mg/ml of each amino acid in 0.1 M HCl, were used for calibration. Similarly, 20 μL of the sample extracts were diluted with 180 μL of the reaction buffer (0.15 M sodium hydrogen carbonate, pH 8.6 with NaOH), and then mixed by vortex. The resulting solutions were incubated at 70 °C in a water bath for 15 min. The reaction was stopped by placing the vials in an ice bath for 5 min. A total of 400 μL of the dilution buffer [mixture of 50 ml of acetonitrile, 25 ml of ethanol, and 25 ml of 9 mM sodium dihydrogen phosphate; 4 % dimethylformamide; and 0.15% triethylamine (pH 6.55 with phosphoric acid)] was added, followed by thorough mixing and centrifugation (5 min, 5000 rpm). 20 μL of the clear supernatants were then injected into the HPLC. Dabsyl derivatives of free amino acids were separated on an Agilent 1100 HPLC system, using a reversed-phase Spherisorb ODS 2 column (25.0 cm × 0.46 cm; 5 μm particle size).

Detection was achieved with a UV detector set at 254 nm. Free amino acid quantification was accomplished by the absorbance recorded in the chromatograms relative to external standards. Under the assay conditions described, a linear relationship between the concentration of amino acids and the absorbance at 254 nm was obtained in the tested range. The results were expressed as mean values and standard error, for the two sampling sites (farmland and dumpsite). The compound identification was based on the comparison between the retention time of the standards of the amino acids and those in the samples. Quantitation was based on the external standard method using calibration curves fitted by linear regression analysis Data were acquired and processed using Agilent Chemstation software.
2.5 Statistical Analysis

The data on the plant and soil samples from both dumpsites and farmland are computed using Statistical Package for Social Science (SPSS, Version 20) while the mean concentration of heavy metals, nutrients and amino acids at both sites were analysed using t-test and the level of significance at 95% confidence was set at p ≤0.05.

3. RESULTS

3.1 Amino Acids and Metals Concentration in *Talinum triangulare* from Dumpsite and Farmland

As shown in Table 1, the amino acid profile of *Talinum triangulare* collected from dumpsite in Oko fili and farmland in Post service in Lagos State include aspartic acid, glutamic acid, serine, glycine, histidine, arginine, threonine, alanine, proline, tyrosine, valine, methionine, cysteine, iso-leucine, leucine, phenylalanine and lysine. Comparatively, there was no significant difference (p>0.05) between the values of all amino acids in *T. triangulare* from both dumpsite and farmland as presented in Table 1.

The heavy metals concentration in soil and *Talinum triangulare* grown on a dumpsite (Oko fili) in Alimosho Local Government Area and a farmland in Ojo, Lagos state, Nigeria as presented in Table 2. It showed that there are no significant difference (p>0.05) between lead (Pb), cobalt (Co), copper (Cu), chromium (Cr) and selenium (Se) across the two sampling sites, while arsenic (except in the soil from dumpsite) and nickel (except in plant from both sites) were not detected. However, the concentrations of heavy metals such as calcium (Ca), iron (Fe), potassium (K), magnesium (Mg), sodium (Na), phosphorus (P), and zinc (Zn) in both the soil and *T. triangulare* samples from the dumpsite are significantly (p<0.05) higher than that from the farmland.

3.2 Frequency Distribution of Metals and Amino Acids between Dumpsite and Farm land

The frequency of heavy metals (As, Ca, Co, Cr, Cu, Fe, Mg, Mn, Ni, Na, Pb, Se and Zn) and amino acids (aspartic acid, glutamic acid, serine, glycine, histidine, arginine, threonine, alanine, proline, tyrosine, valine, methionine, cysteine, iso-leucine, leucine, phenylalanine and lysine) in *T. triangulare* from the dumpsite and farmland are presented in Figs 1 and 2 respectively. At dumpsite, the most frequent metal in the plant and soil respectively was sodium, while the least was selenium and arsenic for the plant and soil respectively. On the contrary, magnesium and sodium respectively were the most frequent metals in plant and soil from the farmland; while their respective least metals was cobalt and lead. In term of the amino acids contents, the most frequent amino acids across the two sites (dumpsite and farmland) was glutamic acid (Glu) while the least was threonine (Thr).

| Amino acids (g/100g)         | Dumpsite     | Farmland    |
|------------------------------|--------------|-------------|
| Aspartic Acid (Asp)          | 1.595±0.714a | 2.550±0.453a|
| Glutamic Acid (Glu)          | 7.620±3.790a | 7.750±2.022a|
| Serine (Ser)                 | 2.525±2.227a | 2.885±1.478a|
| Glycine (Gly)                | 5.795±3.825a | 6.950±3.338a|
| Histidine (His)              | 2.380±1.188a | 2.135±0.219a|
| Arginine (Arg)               | 2.447±0.811a | 2.940±0.933a|
| Threonine (Thr)              | 0.690±0.240a | 0.816±0.305a|
| Alanine (Ala)                | 1.560±0.608a | 2.265±0.092a|
| Proline (Pro)                | 1.395±0.502a | 1.657±0.245a|
| Tyrosine (Tyr)               | 1.765±0.643a | 1.995±0.148a|
| Valine (Val)                 | 2.977±1.334a | 2.816±1.378a|
| Methionine (Met)             | 1.481±0.550a | 1.612±0.407a|
| Cysteine (Cys)               | 1.567±0.655a | 1.265±0.219a|
| Iso-Leucine (Ile)            | 1.200±0.001a | 1.361±0.380a|
| Leucine (Leu)                | 2.069±1.034a | 1.911±0.083a|
| Phenylalanine (Phe)          | 2.535±0.588a | 2.615±0.714a|
| Lysine (Lys)                 | 2.422±0.959a | 3.215±0.459a|

*Mean± SD with same superscript in the row = no significant difference (p>0.05)*
Table 2. Heavy metals contents in *Talinum triangulare* from dumpsite and farmland in Lagos, Nigeria

| Heavy Metals | Dumpsite | Farmland | | | | |
|--------------|----------|----------|----------|----------|----------|----------|
|              | 
| (mg/100g)    | *T. triangulare* | Soil | *T. triangulare* | Soil | *T. triangulare* | Soil | |
| Arsenic      | ND       | 0.004±0.002 | ND | ND | ND | ND | |
| Calcium      | 343.400±206.475<sup>a</sup> | 379.700±42.144<sup>b</sup> | 219.100±120.490<sup>ab</sup> | 214.500±152.523<sup>bb</sup> | |
| Cobalt       | 0.004±0.003<sup>b</sup> | 0.026±0.033<sup>b</sup> | 0.001±0.000<sup>b</sup> | 0.016±0.014<sup>b</sup> | |
| Chromium     | 0.053±0.057<sup>b</sup> | 0.365±0.276<sup>b</sup> | 0.004±0.001<sup>b</sup> | 0.095±0.078<sup>b</sup> | |
| Copper       | 3.240±0.863<sup>b</sup> | 2.135±1.294<sup>b</sup> | 2.110±0.325<sup>b</sup> | 1.160±0.099<sup>b</sup> | |
| Iron         | 82.000±29.839<sup>a</sup> | 1008.400±961.09<sup>b</sup> | 61.640±8.853<sup>ab</sup> | 306.200±147.078<sup>bb</sup> | |
| Potassium    | 90.900±10.748<sup>a</sup> | 293.600±11.172<sup>b</sup> | 68.350±4.172<sup>ab</sup> | 228.900±88.529<sup>bb</sup> | |
| Magnesium    | 1595.250±149.553<sup>a</sup> | 399.450±14.213<sup>b</sup> | 1578.800±36.204<sup>ab</sup> | 299.700±16.405<sup>bb</sup> | |
| Nickel       | 3.000±1.344<sup>a</sup> | 5.485±0.714<sup>b</sup> | 2.015±0.092<sup>a</sup> | 3.240±0.594<sup>bb</sup> | |
| Sodium       | 0.120±0.084<sup>b</sup> | ND | 0.030±0.014<sup>b</sup> | ND | |
| Phosphorus   | 2217.050±1421.214<sup>a</sup> | 1389.950±940.523<sup>b</sup> | 895.600±24.183<sup>bb</sup> | 1053.950±219.557<sup>bb</sup> | |
| Lead         | 502.250±140.077<sup>a</sup> | 318.700±12.445<sup>b</sup> | 215.900±10.465<sup>ab</sup> | 241.800±81.317<sup>bb</sup> | |
| Selenium     | 0.006±0.001<sup>b</sup> | 0.044±0.029<sup>b</sup> | 0.001±0.001<sup>b</sup> | 0.002±0.001<sup>b</sup> | |
| Zinc         | 0.001±0.000<sup>b</sup> | 0.011±0.011<sup>b</sup> | ND | 0.008±0.004<sup>b</sup> | |

Mean ±SD with different superscript in the row = significant difference (p<0.05). ND= not detected.
Fig. 1. Frequency distribution of heavy metals in *Talinum triangulare* from dumpsite and farmland in Lagos, Nigeria

Fig. 2. Frequency distribution of amino acid in *Talinum triangulare* from dumpsite and farmland in Lagos, Nigeria
4. DISCUSSION

In this study, there was no significant difference between the values of all amino acids obtained in *Talinum triangulare* from dumpsite and farmland. The study also revealed glutamic acid as the most abundant and threonine as the least occurrence amino acids respectively across the dumpsite and farmland. This finding is similar to the report of Ogungbenle et al.[22] that found glutamic acid and cystine as the most abundant and least amino acids in *T. triangulare*. However, all the values of amino acids in this study are lower than that reported by Ogungbenle et al.[22]. In contrast to the present findings, Chinyere and Obasi[2011] reported leucine and the aromatic amino acids (phenylalanine and tyrosine) as the most predominant amino acids in *T. triangulare*. However, Arowora et al.[23] reported leucine as the most outstanding amino acid whose content is dominant in all the leafy vegetables which they investigated. The range of values of amino acids recorded at both dumpsite and farmland are within the range recommended for water leaves by Arowora et al. [23]. Thus, *T. triangulare* from both sites could be regarded as plants that contain their appropriate amino acids. Adeyeye and Oyarekua [24] have reported that *Talinum* species is good for consumption as a result of their richness in amino acids. Gold [25] divulged that major value derived from consumption of *T. triangulare* and other leafy vegetables are attributable to the leucine content and their importance some of which are: healing and repair of muscle tissues, clotting at site of injuries, production of growth hormones, regulation of blood sugar, increasing endurance and provision of energy in the body.

The heavy metals concentration in soil and *Talinum triangulare* grown on dumpsite and farmland indicated that values of calcium(Ca), iron(Fe), potassium(K), magnesium(Mg), sodium(Na), phosphorus(P), and zinc (Zn) concentrations in both the soil and *T. triangulare* samples from the dumpsite are significantly higher than that from the farmland. This findings buttress the report of Rajkumar et al. [26] that *Talinum* species (waterleaf) has the potential to accumulate heavy metals from dumpsites. The values of metals recorded in the soil and water leaf for this study are lower than those reported by Eze [27] at dumpsite and farmland in Gombe; Ebong et al. [28] for municipal dumpsite in Uyo; and Babayemi et al. [29] in waterleaf from dumpsite and farmland. Furthermore, a study conducted by Kimani [30] in Kenya on the Dandora waste dumpsite in Nairobi showed higher levels of heavy metals in Pb, Cd, Cu and Cr in the soil samples when compare to the values obtained in the present study. Similarly, Hammed et al.[31] which worked on three sites at Idi-Ose in Akinyele Local Government reported concentration of heavy metals in dumpsite soils that exceeded what was recorded in this study. Studies have shown that if the Ca/P (Low Calcium, high phosphorus intake) is more than the normal amount, calcium may be lost in the urine and thus decreasing the calcium level in bones [32]. Thus, food is considered good if the ratio is above one and poor if the ratio is less than 0.5[33]. For the present study, the ratio of Ca/P is above 0.5 and this affirmed that *T. triangulare* from both dumpsite and farmland are good food for consumption. Similar result have been reported on Ca/P ratio of leaf, stem and root of waterleaf [34]. Also, Na/K, in the body is of great concern for prevention of high blood pressure. A Na/K ratio of 0.6 is recommended [33]. However, the Na/K ratio recorded in this study is above the recommended value of 0.6.

The contributions of plant’s minerals to human health have been reported. For instance, Na is required for balance of extracellular body fluid while calcium is responsible for the formation of bone [34]. Deficiency of Ca and P lead to a disease common among women called Osteomalacia (Bone thinning) and Osteoporosis (Adult ricket) [24]. Mg ions regulate over 300 biochemical reaction in the body through their role as enzyme co-factors. They also play a vital role in the reactions that generate and use of ATP, the fundamental unit of energy within the body’s cells [22].

Zinc is an essential nutrient in humans and animals and is necessary for the function of a large number of metallo-enzymes, while an excess of zinc can result in a decreased availability of dietary copper, and the development of copper deficiency but zinc deficiency has been associated with dermatitis, anorexia, growth retardation, poor wound healing, hypogonadism with impaired reproductive capacity, impaired immune function, and depressed mental function; and congenital malformations in infants [35].

Copper is an essential nutrient that is incorporated into a number of metalloenzymes involved in haemoglobin formation, drug/xenobiotic metabolism, carbohydrate metabolism, catecholamine biosynthesis, the
cross linking of collagen, elastin, and hair keratin, and the antioxidant defense mechanism. Symptoms associated with copper deficiency in humans include normocytic, hypochromic anaemia, leukopenia, and osteoporosis [36].

Iron is also a component of various tissue enzymes, such as the cytochromes, that are critical for energy production, and enzymes necessary for immune system functioning. The fact that serum copper has been found to be low in some cases of iron deficiency anaemia suggests that iron status has an effect on copper metabolism [37]. Iron deficiency includes symptoms such as reduced resistance to infection, reduced work productivity, reduced physical fitness, weakness, fatigue, impaired cognitive function, and reduced learning ability, increased distractibility, impaired reactivity and coordination, itching, and inability to regulate body temperature [38]. Apart from the values of K, Na and Mg especially from the dumpsite’s samples which exceeded WHO/FAO [39] maximum recommended limits, other metals obtained in soil and plant for this study are within the standard permissible limits. In same trend, Hammed et al.,[31] and Oluyemi et al.[40] had reported the levels of As, Co, Cd, Cu, Fe, Ni, Pb and Zn in water leaf, being lower than the recommended levels.

5. CONCLUSION

In this study, glutamic acid is the most abundant and threonine is the least amino acids at both dumpsite and farmland. The range of values of amino acids recorded at both dumpsite and farmland are within the range recommended for water leaves. The heavy metals concentration (Ca,Fe,K,Mg,Na, P, and Zn) in soil and Talinum triangulare are higher at dumpsite than farmland. Due to the ratio of Ca/P which was above 0.5, T. triangulare from both dumpsite and farmland are considered good food for consumption. The concentrations of heavy metals except (K, Na and Mg) in the soil and plant are within standard recommended limits. Therefore, T. triangulare examined in this study is safe for consumption, however its excess K, Na, and Mg content can be recommended for people with deficiency in those nutrients.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Aja PM, Okaka AN, Onu PN, Ibiam U, Urako AJ. Pakistan Journal of Nutrition. Phytochemical Composition of Talinum Triangulare (Water Leaf) Leaves. 2010;9(6):527–529.
2. Jena V, Dixit S, Gupta S. Risk assessment of heavy metal toxicity through edible vegetables from industrial area of Chhattisgarh. Int. J. Res. Environ. Sci. Technol. 2012;2:124-127.
3. Omoyeni OA, Olaofe O, Akinyeye RO. Amino acid composition of ten commonly eaten indigenous leafy vegetables of South-West Nigeria. World Journal of Nutrition and Health. 2015;3(1):16-21.
4. Areghoere EA. Nutritive value and inherent antinutritive factors in four indigenous edible leafy vegetables in human nutrition in Nigeria: A review. Journal of Food Resource Science. 2012;1(1):1-14.
5. Millward DJ, Layman DK, Tomé D, Schaafsma G. Protein quality assessment: impact of expanding understanding of protein and amino acid needs for optimal health. American Journal of Clinical Nutrition. 2008;87:1576–1581.
6. Wolfe RR. Branched-chain amino acids and muscle protein synthesis in humans: myth or reality?. Journal of International Social and Sports Nutrition. 2017;14:30.
7. Tahar K, Keltoum B. Effects of heavy metals pollution in soil and plant in the industrial area, West Algeria. Journal of Korean Chemical Society. 2011;55:1018-1023.
8. Aekola FA, Salami N, Lawal SO. Research Communications in chemistry. 2008;1(1):24 – 30.
9. Babajide IA. Best available environmentally sound management practices in e-waste control. unpublished.2009;7-15.
10. Herawati N, Suzuki S, Hayashi K, et al. Cadmium, copper, and zinc levels in rice and soil of Japan, Indonesia, and china by soil type. Bull. Environ. Contam. Toxicol. 2000;64:33–39.
11. Kabata-Pendias A, Pendias H. Trace Elements in Soils and Plants CRC, Press Boca Raton, FL. 1984:315.
12. Cui Y, Zhu Y, Zhai R, Chen D, Huang Y, Qiu Y, Liang J. Transfer of metals from soil to vegetables in an area near a smelter in Nanning, China. Environ. Int. 2004;30:785-791.
13. Jin T, Nordberg M, Frech W, Dumont X, Bernard A, Ye TT, Kong Q, Wang Z, Li P, Lundström NG, Li Y, Nordberg GF. Cadmium biomonitoring and renal dysfunction among a population environmentally exposed to cadmium from smelting in China (ChinaCad). Biomed. 2002;15:397-410.

24. Adeyeye EI, Oyarekua MA. Proximate composition and some nutritionally valuable minerals in the dehulled seeds and seeds of Anacardium occidentale and Blighia saphida. Bio. Biotech Res. Asia. 2008;05(1):99-106.

25. Cobb GP, Sands K, Waters M, Wixon BG, Dorward-King E. Accumulation of heavy metals by vegetables grown in mine wastes. Environ. Toxicol. Chem. 2000;19:600-607.

15. Benson NU, Ebong GA. Heavy metals in vegetables commonly grown in a tropical garden ultisol. Journal of Sustainable Tropical Agricultural Resources. 2005;16:77-80.

16. Ikhouria EU, Urumnatsoma SOP, Okeimen FE. Preliminary investigation of chemical fraction and heavy metal accumulation in plant maize (Zea mays) grown on chromated copper arsenate (CCA) contaminated soil amended with poultry droppings. African Journal of Biotechnology. 2010;9:2675-2682.

17. Ravindra S. Fabrication of antibacterial cotton fibres loaded with silver nanoparticles via “Green Approach”. Colloids and Surfaces A: Physicochemical and Engineering Aspects. 2010;367(1): 31-40.

18. Olujimi O, Steiner O, Goessler W. (Pollution indexing and health risk assessments of trace elements in indoor dusts from classrooms, living rooms and offices in Ogun State, Nigeria. Journal of African Earth Sciences. 2015;101:396-404.

19. Ogundele LT, Owode OK, Hopke PK, Olise FS. Heavy metals in industrially emitted particulate matter in Ile-Ife, Nigeria. Environmental Research. 2017;156:320-325.

20. Kola F. Proximate composition of bungu leaves and seed. Biochemistry. 2004;16.

21. AOAC. Approved methods of the (AOAC 1990), 8th ed. St-Paul, MN.

22. Ogungbenle HN, Akinsola AF, Olatunde OC, Lijoka AO. Chemical, Functional properties and Amino acid composition of Water leaf (Talinum triangulare), Chemistry Research Journal. 2018; 3(3):7-16

23. Arowora KA, Ezeonu CS, Imo C, Nkaa CG. Protein Levels and Amino Acids Composition in Some Leaf Vegetables Sold at Wukari in Taraba State, Nigeria.
35. Sandstead HH. Zinc in human nutrition. New York, NY, Academic Press; 1981.

36. ATSDR. Toxicology profile for Lead. Atlanta, Georgia, United States. US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry; 2007.

37. Michael JG, Susan AL, Aedin C, Hester HV. Introduction to Human Nutrition, Great Britain: A John Wiley & Sons, Ltd., Publication Wiley-blackwell; 2009.

38. Beard JL. Iron biology in immune function, muscle metabolism and neuronal functioning, Journal of Nutrition. 2001;131 (2S-2):568-579.

39. World Health Organization (WHO). Permissible Limits of Heavy Metals in Soil and Plants. Geneva, Switzerland: World Health Organization; 1996.

40. Oluyemi EA, Feuyit G, Oyekunle JAO, Ogunfowokan AO. Heavy metal concentration in soil of Talinum triangulare in dumpsites in Ota, Nigeria. Int. J. Environmental Science and Technology. 2008; 2:89–96.

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Peer-review history:
The peer review history for this paper can be accessed here:
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