Evaluation of Heavy Metal Concentrations and Proximate Compositions of *Amaranthus spinosus* L. and *Talinum triangulare* J. and Soils Collected from Dumpsites in Some Selected Areas in Lagos State, Nigeria

Oluwole Surukite O.[*], Makinde Sunday C. O., Ogun Mautin L., Nwachukwu Ifeanyi R.

Department of Botany, Lagos State University, Ojo, Nigeria

Abstract   Anthropogenic activities usually results in pollution, especially in developing countries where low-end waste management is the common practice. Thus, this research evaluates the concentration of heavy metals (Mn, Cu, Zn Pb, and Cd) and proximate compositions of *Amaranthus spinosus* and *Talinum triangulare*. Soils were collected in three dumpsites from three different Local Government areas (Alimosho, Amuwo-Odofin and Ojo) in Lagos State, Nigeria. The sampled vegetables and soils were determined using Standard techniques and atomic absorption spectrophotometer for the metal concentration analysis. The level of each metal concentration to the dumpsites was compared to World Health Standard. The results revealed that the two vegetables sampled contained appreciable quantities of nutrients needed for normal human development. Also, the heavy metal analysis shows the concentrations ranges from Mn (0.034-709mg/Kg), Cu (1.624-3.637mg/Kg), Zn (0.671-1.256mg/Kg), Pb (0.000-0.007mg/Kg) and Cd (0.000-0.007) in *Amaranthus spinosus*; Mn (0.336-0.073mg/Kg), Cu (0.206-1.834mg/Kg), Zn (0.006-0.680mg/Kg), Pb (0.000-0.003mg/ Kg) and Cd (0.000-0.002mg/ Kg) in *Talinum triangulare*; and Mn (0.000-1.300 mg/Kg), Cu (1.348-1.732 mg/Kg), Zn (0.149-1.100mg/Kg), Pb (0.000-0.008mg/Kg) and Cd (0.000-0.002mg/Kg) in the soil samples of the three dumpsites. However, *Amaranthus spinosus*, *Talinum triangulare* and soils of most of these dumpsites accumulated minimal concentrations of these metals. In fact Pb and Cd were not detected in some vegetables and soils. All the concentrations of metals studied in soil and vegetables were found to be lower than the maximum permissible limit of heavy metal in soil and vegetable stated by the World Health Organization (WHO) which implies that the vegetables are presently safe for human consumption. Thus, the higher concentration of metals in wastes of dumpsites and their vegetables, the increased threat it posed to the consumers. Hence, it therefore recommends that consumption of *Amaranthus spinosus*, *Talinum triangulare* and other vegetables from dumpsites should be avoided.

Keywords   Heavy metals, Proximate composition, Amaranthus spinosus, Talinum triangulare, Dumpsite, Soil

1. Introduction

The contamination of soil and vegetables by heavy metals is a global environmental issue. Heavy metals are generally referred to as those metals that possess a specific density of more than 5 g/cm^3 and adversely affect the environment and living organisms [1]. Heavy metals, being persistent and non-biodegradable, can neither be removed by normal cropping nor easily leached by rain water [2]. They might be transported from soil to ground waters or may be taken up by plants, including agricultural crops. For

this reason, the knowledge of metal-plant interactions is also important for the safety of the environment [3]. Source of anthropogenic contamination include the addition of manures, sewage sludge, fertilizers and pesticides to soils. Several studies has identified the risks in relation to increased soil metal concentration and consequent plant uptake [4,5]. Analysis of vegetables grown in locations close to industries in Greece has been reported to elevate the levels of heavy metals contamination [6,7,8]. The results of the study indicated significantly higher levels of metal accumulation in leafy vegetables as compared with root vegetables. However, some micro-elements are toxic to both animals and plants at high concentrations. For instance, copper (Cu), zinc (Zn) arsenic (As), cadmium (Cd), mercury (Hg) and lead (Pb) are toxic even at small concentrations [3]. These metals can pose a significant health risk to humans, particularly in elevated concentrations above the very low body requirements [8].

So, the metals must be controlled in food sources in order to assure public health safety [9]. Excessive amount of heavy metals in food cause a number of diseases, especially cardiovascular, renal, neurological, and bone diseases [10]. These metals could reach food chain through various biochemical processes and ultimately biomagnified in various trophic levels and eventually threaten the health of human.

There has been increasing interest in determining heavy metal levels in public food supplied. However, their concentration in bio-available form is not necessarily proportional to the total concentration of the metal [11,12]. The quality of ecosystem becomes altered, when heavy metals find their way, somehow, into it through human and natural activities. These activities are one of the most pressing concerns of urbanization in developing countries like Nigeria, which result in the problem of solid, liquid and toxic waste management. Such waste may be toxic or radioactive nature [13,14]. Such waste management problems include heaps of uncontrolled garbage, roadsides littered with refuse, streams blocked with rubbish, prevalence of automobile workshops and service stations, inappropriately disposed toxic waste and disposal sites that constitute a health hazard to residential areas [15,16,17].

Lagos State is a Metropolitan city with a good number of industries of various categories, markets, and trades. These anthropogenic activities usually result in pollution, especially in developing countries where low-end waste management is the common practice [18]. Large amounts of wastes are generated and dumped daily [19,20]. There is a serious environmental concern, considering that a larger fraction of the wastes is hazardous in nature [21]. The population increase and the rapid growth of industrial processes particularly in major cities have led to the birth of new world and thus have greater impact on human and the environment. The expansion of industrialization have given birth to environmental pollution and the greater volume of industrial chemical discharge has added to the growing pack of untreated domestic waste which contains heavy metals. The evacuation of domestic, commercial and industrial garbage which may contain toxic materials such as Pb, Cu, Cd, Hg, Mn, and Zn from batteries, insecticides, nail-polish, cleaners, polyvinyl chloride made containers, pesticides and other various products in the world is a predicament that continues to grow with human development [22,23,24].

The disposal of materials that contains heavy metals in open dumpsites are of concern and pose dangers to people in contact with the soil and plants of these sites in which they are disposed. In Nigeria, leachates from refuse dumpsites constitute a source of heavy metal pollution to both soil and aquatic environments [25,26]. In some cases, wastes are dumped recklessly with no regards to the environmental implications, while in some dumpsites, wastes are burnt in the open and ashes abandoned at the sites. The concentrations of heavy metals in soil around waste dumpsites are influenced by types of wastes, topography, runoff and level of scavenging [27,28]. Once heavy metals are deposited in the soil, they are not degraded and persist in the environment for a long time causing serious environmental pollution [29]. There is a growing concern about the possibility of soil contamination resulting in the introduction of elements in food chains through uptake by plants and thereby affecting food safety [30]. They accumulate in soil and plants having a negative influence on physiological activities of plants such as photosynthesis, gaseous exchange and nutrient absorption which result in plant growth reduction and dry matter accumulation [31]. Although the rate of metal uptake by plants could be influenced by factors such as metal species, plants species and so on [32].

However, Water leaf (*Talinum triangulare* J.) is a cosmopolitan weed belonging to the family *Taliniaceae* and commonly found in the humid tropics. It has been recorded for several countries in West and Central Africa [33,34]. Water leaf is eaten as a vegetable throughout the tropics including many countries in West and Central Africa. *Talinum triangulare* leaves are used in the preparations of slightly slimy soups and stews to compliment the starchy main dishes [33,34]. In southern Nigeria, where is called 'Gbure', it is commonly mixed with Jute mallow (*Chochorus olitorius*). South American used water leaf in treating some ailments such as contusions, inflammations and tumors. Decoctions are used for painful eyes and aid recovery of blows and falls [35]. More so, a phytochemical analysis on *Talinum triangulare* revealed that it contains some vital phytochemical used for medicinal purposes. These phytochemical include tannins, alkaloids, saponins, and flavonoids, which suggests its potential medicinal and dietary benefits [33].

Amaranthus spinosus L. is both annual and perennial herb belongs to family *Amaranthaceaea*, with common name (Spiny amaranth, prickly amaranth, spiny pigweed (English). It is commonly or widely distributed within tropical and subtropical regions of Africa, Southeast Asia and USA. In Nigeria especially Yoruba community all species are referred to as "*tete*" even though they may add a second name to indicate a particular variety or species. *Amaranthus spinosus* is widely used because of it medicinal, nutritional and otherwise properties; which includes treatment of gonorrhea; an emmenagogue, emollient and antipyretic; applied externally to treat eczema, burns, wounds, boils, earache, haemorroids and so on [36,37,38].

Thus, Picking of vegetables like *Talinum triangulare* (waterleaf) and *Amaranthus spinosus* growing naturally on non-agricultural land or sourcing it from the contaminated environment may pre-dispose humans to toxic pollutants. In addition, Waterleaf and Amaranthus propagates prolifically; it has extensively produced adventitious roots which have the potential to absorb toxic substances from aqueous media [39].

It is on this basis that this study was designed to evaluate the concentrations of heavy metals in both soils and leafy

vegetables from some selected dumpsites in Lagos state, Nigeria.

2. Materials and Methods

Collection of Plant Materials

The soils and two vegetables (*Talinum triagulare* and *Amaranthus spinosus*) (Figures 2 and 3) were collected from dumpsites located in three different Local government areas in Lagos State, Namely; Alakija Dumpsite in Amuwo-Odofin Local Government area, Ketu-Ijanikin

Dumpsite in Ojo Local Government area and Agbado-Oke-Odo Dumpsite in Alimosho Local Government area (Figure 1). The soils were collected at a depth of about 15cm around the plants' roots.

Processing of Plant Materials

The fresh leaves of the vegetables were thoroughly and separately washed with deionized distilled water. Afterwards, they were dried in the oven by exposing the leaves to a constant temperature at 45 ℃ for 3-4 days. The leaves were then grounded into fine powder using dried pestle and mortar.
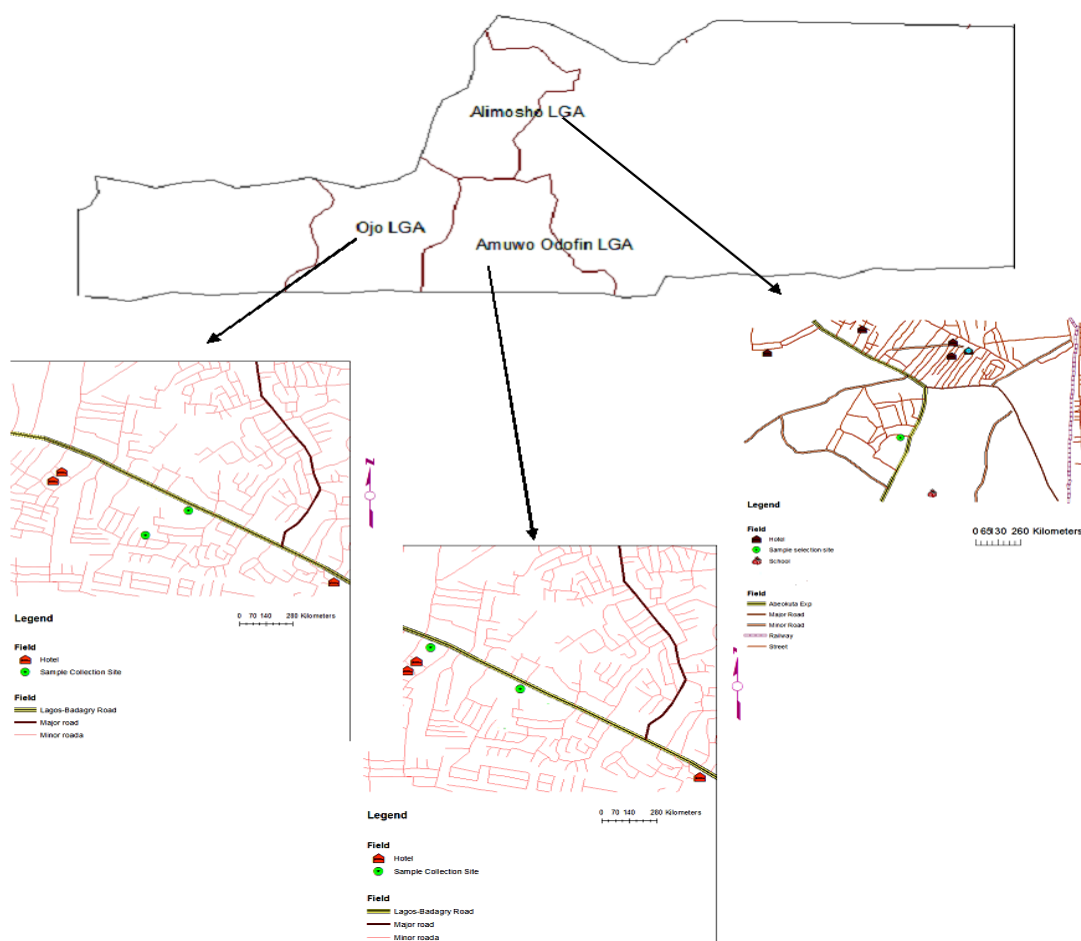

Figure 1.   Map of Lagos State showing the sample locations

Figure 2.   Image showing *Amaranthus spinosus*

Figure 3.   Image showing *Talinum triangulare*

Proximate Analysis

The proximate analysis for leafy vegetable samples for moisture, ash, crude fibre and fat were carried out following the standard methods of AOAC [40]. Nitrogen was determined by micro-kjeldahi method as described by Pearson [41] and the percentage nitrogen was converted to crude protein by multiplying by 6.25. Carbohydrate was determined by difference. All findings were performed in triplicates.

Heavy Metal Analysis

The heavy metal constituents of the leafy vegetable were analysed using the solution obtained by dry ashing the samples at 550 ℃ and dissolving the ash in distilled deionized water in flask. All the metals (Mn, Cu, Zn, Pb, and Cd) were analysed using atomic absorption spectrophotometer (Buck Scientific Model 200A). The same procedure was repeated for soil samples [42].

Statistical Analysis

All the data collected were in triplicates and this was subjected to univariate statistical analysis using mean standard deviation and bar charts.

3. Results and Discussion

3.1. Results

Proximate Analysis of *Amaranthus spinosus* in different dumpsites

Table 1 shows the proximate composition of *Amaranthus spinosus* in the three dumpsites. Thus, the result revealed that the *Amaranthus spinosus* from Alakija dumpiste has the highest percentage moisture contents while, Agbodo-Oke-odo and Ketu-Ijanikin had similar moisture contents (Figure 4). *A. spinosus* for Alakija had the highest protein content followed by Agbodo-Oke-Odo while the least values were recorded in Ketu-Ijanikin (Table 1, Figure 4). The crude fibre of *A. spinosus* in Alakija has the highest mean values followed by those in Agbado-Oke-Odo while Ketu-Ijanikin having the least crude fibre contents (Table 1, Figure 4).

The crude carbohydrate content of *A. spinosus* found in Ketu-Ijanikin has the highest values followed Agbado-Oke-Odo with Alakija having the least crude carbohydrate contents (Table 1, Figure 4). The crude fat contents of *A. spinosus* in both Alakija and Ketu-Ijanikin showed similar values while Agbado-Oke-Odo has the least values. The ash contents of *A. spinosus* in both Agbado-Oke-Odo and Alakija have similar values while Ketu-Ijanikin contains the least values of Ash contents (Table 1, Figure 4).

Table 1. Proximate composition (%) of the *Amaranthus spinosus* in different dumpsites

| Vegetable/Location	Moisture	Protein	Crude Fibre	`CHO	Fat	Ash
AGBADO-OKE-ODO						
Mean ±S.D	4.90 ±0.01	26.11 ±0.09	16.33 ±0.08	48.74 ±0.14	0.15 ±0.003	3.62 ±0.02
Range	4.84 - 4.98	25.30 −26.92	14.70 – 17.83	47.00 -50.54	0.15 – 0.16	3.58 – 3.65
ALAKIJA						
Mean ±S.D	5.15 ±0.19	30.30 ±0.17	22.96 ±0.04	36.80 ±0.18	0.94 ±0.003	3.78 ±0.01
Range	5.03 -5.67	29.95 – 30.65	22.28 – 23.60	35.90 -37.52	0.90 – 0.96	3.75 – 3.81
KETU-IJANIKIN						
Mean ±S.D	4.74 ±0.12	24.11 ±0.12	9.68 ±0.06	57.12 ±0.69	0.82 ±0.07	3.18 ±0.03
Range	4.65 -4.85	23.90 – 24.52	8.62 – 10.71	55.65 -58.02	0.74 – 0.88	3.10 – 3.27

SD = Standard deviation
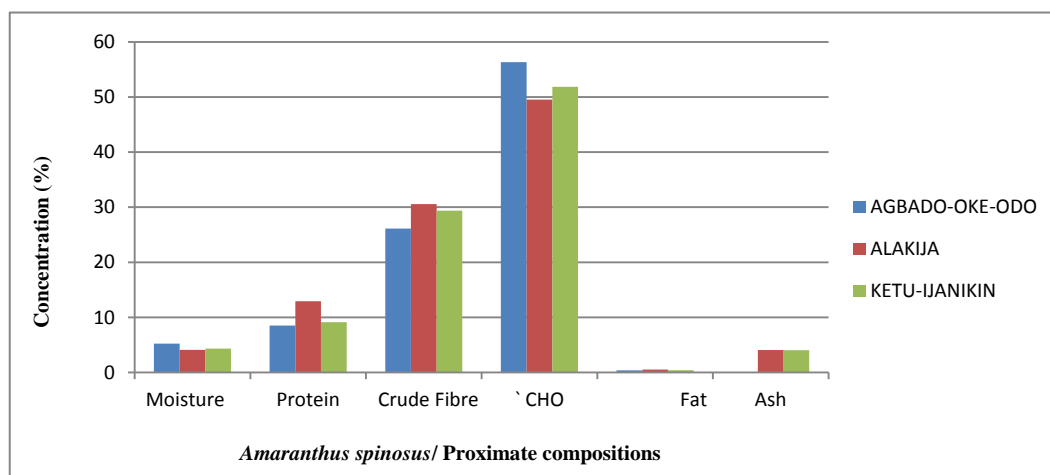
Figure 4. Comparison of the proximate compositions of *Amaranthus spinosus* collected from different locations

Proximate Analysis of *Talinum Triangulare* in different dumpsites

Table 2 shows the proximate analysis of *Talinum Triangulare* collected from three different dumpsites sampled. Thus, the result revealed that Agbado-Oke-Odo has the highest moisture contents followed by those in Ketu-Ijanikin while, those in Alakija had the least moisture contents (Table2, Figure 5).

The percentage protein contents of *Talinum Triangulare* collected in Alakija has the highest values while those in both Agbodo-Oke-Odo and Ketu-Ijanikin had similar values. The crude fibre contents of *Talinum Triangulare* collected in both Alakija and ketu-Ijanikin has similar values while

Agbado-Oke-Odo had least values for crude fibres (Table 2, Figure 5).

The carbohydrate contents of *Talinum Triangulare* collected in Agbo-Oke-Odo has the highest values while, those in Alakija and Ketu-Ijanikin had similar carbohydrate contents (Table 1, Figure 5). The crude fat content of *Talinum Triangulare* collected from Alakija has the highest values, while those from Agbado-Oke-Odo and Ketu-Ijanikin in crude fats are similar. The ash contents of all the *Talinum Triangulare* samples collected from the three different locations are similar, with Agbado-Oke-Odo showing the greatest affinities (Table 2, Figure 5).

Table 2.   Proximate composition (%) of *Talinum Triangulare* in different dumpsite

| Vegetable/Location	Moisture	Protein	Crude Fibre	`CHO	Fat	Ash
AGBADO-OKE-ODO						
Mean ±S.D	5.24 ±0.14	8.51 ±0.09	26.12 ±0.05	56.32 ±0.58	0.38 ±0.05	4. 27 ±0.05
Range	5.13 - 5.43	8.26 –8.76	25.53 – 26.73	55.23 -57.08	0.33 – 0.45	4.20 – 4.40
ALAKIJA						
Mean ±S.D	4.10 ±0.11	12.93 ±0.03	30.56 ±0.05	49.52 ±2.70	0.53 ±0. 03	4.08 ±0.11
Range	3.97 - 4.55	12. 58 – 13.37	29.42 –31.72	45.78 -49.94	0.50 – 0.57	3.97 – 4.55
KETU-IJANIKIN						
Mean ±S.D	4.34 ±0.14	9.12 ±0.03	29.36 ±0.08	51.84 ±0.84	0.41 ±0.03	4.03 ±0.11
Range	4.21 -4.71	8.88 – 9.42	28.78 – 29.99	50.00 -53.63	0.37 – 0.45	3.89 – 4.40

SD = Standard deviation
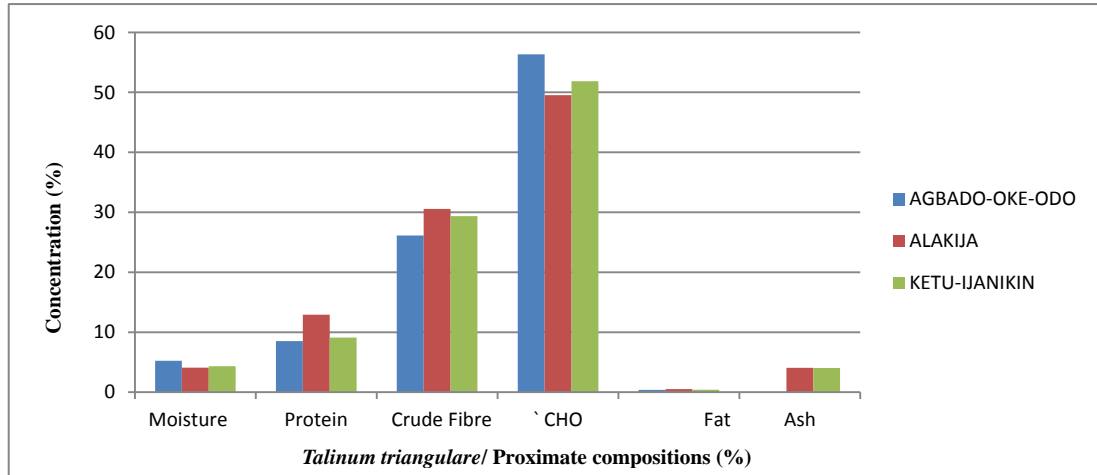
Figure 5.   Comparison of the proximate compositions of *Talinum triangulare* collected from different locations

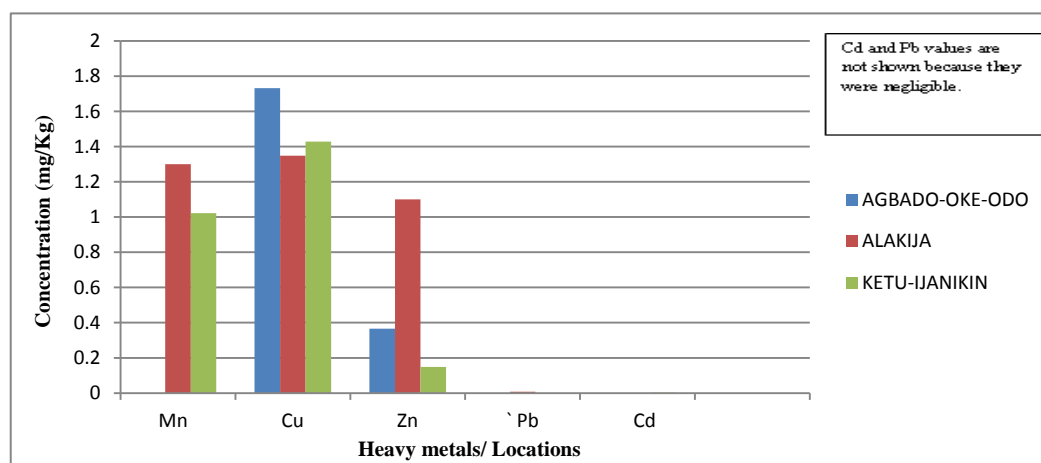**Heavy Metal Concentration Analysis *Amaranthus spinosus***

Table 3 shows the heavy metal concentrations analysis of *Amaranthus spinosus* collected from three different dumpsites. Thus, the result revealed that the *Amaranthus spinosus* collected from Ketu-Ijanikin has the highest Manganese (Mn) contents followed by those in Agbado-Oke-Odo while, those in Alakija had the least Mn contents (Table 3, Figure 6). Also, the Copper (Cu) concentrations in Ketu-Ijanikin has the highest

concentrations while, Agbodo-Oke-Odo and Alakija had similar mean Cu concentrations (Table 3). More so, Ketu-Ijanikin has the highest mean Zinc (Zn) concentration values followed by Agbado-Oke-Odo while Alakija had the least mean Zn concentration values (Table 3, Figure 6). Lead (Pb) and Cadmium (Cd) concentrations in both Agbado-Oke-Odo and Alakija were not detected but those in Ketu-Ijanikin shows similar mean concentration for Pb and Cd values (Table 3, Figure 6).

Table 3. Heavy Metal Analysis (Mg/Kg) Of *Amaranthus Spinosus*

Vegetable	Mn	Cu	Zn	Pb	Cd
AGBADO-OKE-ODO					
Mean ±S.D	0.164 ±0.001	1.624 ±0.001	1.000 ±0.707	0.000 ±0.000	0.000±0.000
Range	0.160 -0.170	1.623 – 1.624	1.000 -1.100	0.000 – 0.000	0.000 – 0.000
ALAKIJA					
Mean ±S.D	0.034 ±0.002	1.644 ±0.003	0.671 ±0.019	0.000 ±0.000	0.000 ±0.000
Range	0.034 -0.035	1.640 – 1.648	0.658 – 0.679	0.000 – 0.000	0.000 – 0.000
KETU-IJANIKIN					
Mean ±S.D	0.709 ±0.006	3. 637 ±2.547	1.256 ±0.002	0.007 ±0.060	0.007 ±0.000
Range	0.702 -0.713	1.551 – 1.571	1.254 -1.259	0.002 – 0.004	0.000 – 0.007
SD = Standard deviation					

Figure 6. Comparison of Heavy Metal concentrations in *Amaranthus spinosus* from three different dumpsites

Heavy Metal Concentrations Analysis *Talinum triangulare*

Table 4 shows the heavy metal analysis of *Talinum triangulare* collected from three different dumpsites. Thus, the result revealed that the Manganese (Mn) mean concentrations of *Talinum triangulare* in Alakija has the highest mean values followed by those in Agbado-Oke-Odo while, those in Ketu-Ijanikin had the least concentrations (Table 4, Figure 7).

Also, the *Talinum triangulare* in Ketu-Ijanikin has the mean concentrations of Copper (Cu) followed by those in Alakija while, Agbado-Oke-Odo had the least mean concentration values of Cu (Table 4). Moreso, Ketu-Ijanikin has the highest Zinc (Zn) mean concentration values followed by those in Alakija while Agbado-Oke-Odo had the least mean concentration values of Zn (Table 4).

The Lead (Pb) concentration values of *Talinum triangulare* collected in Alakija has highest values while Pb was not detected in plants sampled from Agbado-Oke-Odo and Ketu-Ijanikin. Moreover, Cadmium (Cd) concentrations in the three locations had similar values (Table 4, Figure 7).

Table 4. Heavy Metal Analysis (mg/Kg) of *Talinum Triangulare*

| Vegetable	Mn	Cu	Zn	Pb	Cd
AGBADO-OKE-ODO					
Mean ±S.D	0.057 ±0.000	0.206 ±0.000	0.006 ±0.002	0.000 ±0.00	0.002±0.003
Range	0.568 -0.569	0. 204 – 0.206	0.006 -0. 007	0.000 – 0.000	0.000 – 0.002
ALAKIJA					
Mean ±S.D	0.073 ±0.057	0.947±0.001	0.533 ±0.000	0.003 ±0.000	0.002 ±0.000
Range	0.070 -0.080	0.946 – 0.948	0. 533 – 0.535	0.000– 0.003	0.000 – 0.002
KETU-IJANIKIN					
Mean ±S.D	0.336 ±0.046	1.834 ±0.016	0.680 ±0.013	0.000 ±0.000	0.002 ±0.000
Range	0.334 -0.336	1.832 – 1.852	0.630 -0.730	0.000 – 0.000	0.000 – 0.002
SD = Standard deviation					
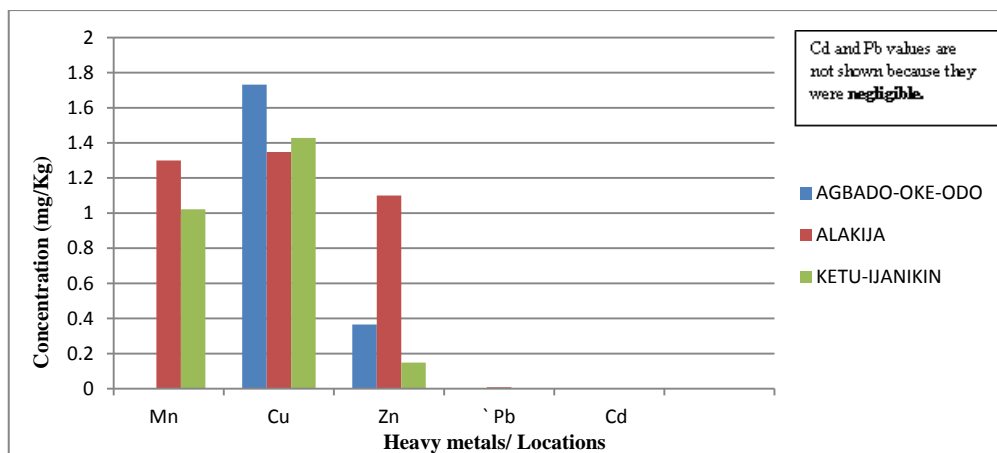
Figure 7.   Comparison of Heavy Metal concentrations in *Talinum triangulare* from three different dumpsites

Heavy Metal Concentration Analysis Soils Sampled

Table 5 shows the heavy metal analysis of soil samples collected from three different dumpsites. Thus, the result revealed that the concentrations of Manganese (Mn) in soils of both Alakija and Ketu-Ijanikin were similar in values compared to the soil samples collected from Agbado-Oke-Odo (Table 5, Figure 8). The concentration of Copper (Cu) in soil samples collected in Agado-Oke-Odo has the highest concentrations while the soils of both Alakija and Ketu-Ijanikin had similar concentrations for Cu (Table 5, Figure 8). The concentration of Zinc (Zn) in the soils of

Alakija has the highest values while the concentrations in both the soils of Agbado-Oke-Odo and Ketu-Ijanikin had similar values (Table 5). The concentration of Pb in the soils of Alakija has the highest values while Pb was not detected in soils of both Agbado-Oke-Odo and Ketu-Ijanikin respectively.

More so, the soil sample of Ketu-Ijanikin has the highest concentration of Cadmium (Cd) while Cd was not detected in the soils of Agbodo-Oke-Odo and Alakija (Table 5, Figure 8).

Table 5.   Heavy Metal Analysis (mg/Kg) of Soil Samples

| Vegetable	Mn	Cu	Zn	Pb	Cd
AGBADO-OKE-ODO					
Mean ±S.D	0.000±0.00	1.732 ±0.007	0.366 ±0.590	0.000 ±0.000	0.000±0.000
Range	0.000 -0.000	1.735 – 1.738	0.366 -0. 369	0.000 – 0.000	0.000 – 0.000
ALAKIJA					
Mean ±S.D	1.300 ±0.000	1.348 ±0.001	1.100 ±0.780	0.008±0.013	0.000 ±0.000
Range	1.300 -1.300	1.346 – 1.350	1. 100 – 1.100	0.000– 0.008	0.000 – 0.000
KETU-IJANIKIN					
Mean ±S.D	1.022 ±0.240	1.428 ±0.050	0.149 ±0.460	0.000 ±0.000	0.002±0.003
Range	1.020 -1.022	1.423 – 1.428	0.147 -0.148	0.000 – 0.000	0.002 – 0.002

SD = Standard deviation
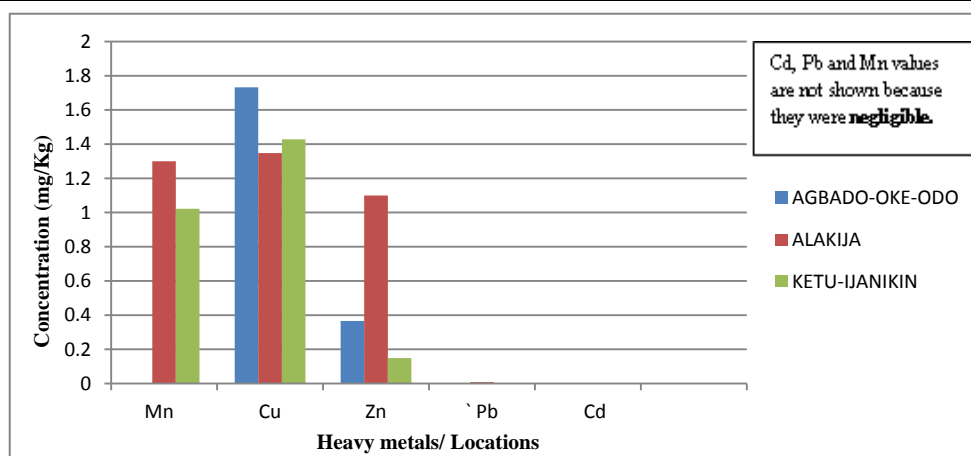
Figure 8.   Comparison of Heavy Metal concentrations in Soil collected from three different dumpsites

3.2. Discussion

Proximate Analysis of *Amaranthus spinosus* and *Talinum triangulare*

The proximate analyses of the two leafy vegetables obtained from the three different dumpsites are shown in Tables 1 and 2. The percentage moisture contents of *Amaranthus spinosus and Talinum triangulare* varied from 4.74% to 5.24% in the two leafy vegetables from the three locations. These values were lower than those reported earlier for some Nigerian leafy vegetables by Onwordi *et al.* [43]. The variations in the moisture contents based on locations were supported by Oluwole *et al.* [33,44]. This was attributed to differences in soil composition and or soil characteristics such as soil water content and soon. However, the moderate moisture content provides for increased activity of water soluble enzymes and co-enzymes needed for metabolism of these two vegetables [45]. The crude protein content varied from 24.11-30.30% in *Amaranthus spinosus* (Table 1) and between 8.51-12.93% *Talinum triangulare* (Table 2) between three locations. This result was lower than what was reported by Onwordi *et al.*[43], Fagboun *et al.* [46] and Asaolu *et al.* [47] in some vegetables such as Bitter leaf (50.64%), Indian Spinach (58.80%), Bush-buck (66.60), Scent leaf (62.71%), *Amaranthus hydridus* (49.02%), *Hibiscus sabdariffa* (46.56%), *Telfairia occidentalis* (61.70%). But the result of this finding was higher than the findings of Oluwole *et al.* [44]. Thus, plant foods that supply the body with more than 12% of their caloric value from protein have been reported to be good source of protein [48]. This shows that the two leafy vegetables are rich source of protein.

The crude fibre content ranged from 9.68-16.33% in *Amaranthus spinosus* (Table 1) and 26.12-29.36% in *Talinum triangulare* (Table 2). This fell within the reported range values (8.50-20.90%) for some Nigerian Vegetables [49]. Dietary fibre helps to lower serum cholesterol level, risk of coronary heart diseases, constipation and diabetes [50]. The carbohydrate ranged from 36.80-57.12% in *Amaranthus spinosus* (Table 1) and 49.52-56.32% in *Talinum triangulare* (Table 2). The value obtained for carbohydrates was above the range of 30.05% as reported by Sanni and Olaofe [51]. Also, the carbohydrate content of *A. cruentus* (30.10%) could be comparable to 29.4%, 31.34% and 32.84% of *A. cruentus*, *Cochorus olitorius* and *A. argenta* respectively as reported by Onwordi *et. al.* [43] but the value was higher than the values reported for some leafy vegetables consumed in Nigeria which includes *Vernonia amygdalina* (8.65%), *O. gratissimum* (1.22%) and *Hibiscus sabdarifa* (15.79%) reported by Asaolu *et al.,* (2012); and Oluwole *et al.* [44] for *Ocimum gratissimum* and *Amaranthus cruentus*. Carbohydrate constitutes a major class of naturally occurring organic compounds which are essential for the maintenance of life and also provide raw materials for many industries [52]. Also, it was above the values reported by Oluwole *et al.* [44]

The percentage fat content ranged from 0.15-0.94% in *Amaranthus spinosus* (Table 1) and 0.38-0.53% in *Talinum triangulare* (Table 2). These values were lower compared to those in some vegetable by Asaolu *et al.* [47] and Oluwole *et al*. [44] such as *A. cruentus* and *O. gratissimum* are 1.62% and 3.59% respectively.

The percentage ash content ranged from 3.18-3.75% in *Amaranthus spinosus* across the three locations (Table 1) and 4.03-4.27% in *Talinum triangulare* across the three locations (Table 2). Thus, the ash content was higher in *Talinum triangulare* than those of *Amaranthus spinosus* across three locations (Tables 1 and 2). Thus, the ash content obtained are lower to those of *O. gratissimum* reported by Fagboun *et al.,* [46] and *A. hybridus* [45] and also there was lower ash contents of *A. cruentus* (30.88%) and *O. gratissimum* (7.12%) respectively as reported Oluwole *et al.* [44]. Ash content is of significant importance in foods as they account for the mineral constituents [53]. However, various differences were observed in the proximate compositions of *Amaranthus spinosus* and *Talinum triangulare* across the three locations. These differences have been reported by Oluwole *et al.* [33,44], they attributed these variation to abiotic factors such as water, soil mineralization, and so on within and around the locations.

Heavy Metal Concentrations of Plants and Soil Samples Used

The concentration of heavy metals in plants and soil samples are presented in Tables 3-5. Results above showed that Manganese (Mn) obtained from *Amaranthus spinosus* in Ketu-Ijanikin is higher than others, whereas the quantities Mn found in three areas sampled were lower than the World Health Organization (W.H.O) of 5000mg/Kg [54] (Table 3). This result was similar to the findings of Adaikpoh [55] who found similar results on distribution and enrichment of heavy metals in soils from waste dumpsites within Imoru and environments, Southwest Nigeria. Also, the concentrations of Mn obtained in *Talinum triangulare* in three areas were lower than the W.H.O standards (Table 4). More so, the concentrations of Mn found in the soils of the sampled locations were between the permissible limits of W.H.O, indicating safety of the soils. Thus, all the concentration of manganese values was found to be lower than the World Health Organization standard for manganese in soil. This is because Manganese is found naturally in the most soils as it is one of the most essential minerals for life [56].

The concentrations of Copper (Cu) found in *Amaranthus spinosus* collected from Ketu-Ijanikin (3.637mg/ Kg) were higher than those collected from Alakija (1.644mg/Kg) and Agbado-Oke-Odo (1624) respectively (Table 3). Thus, the results of Cu collected from three dumpsites were lower than W.H.O limits of 5.0-20.0 mg/Kg [54,57]. Also, the Cu concentrations found in *Talinum triangulare* from Ketu-Ijanikin (1.834mg/Kg) were higher than other two collected from Alakija (0.947mg/Kg) and Agbado-Oke-Odo (0.206 mg/Kg) respectively (Table 4). The results from Ketu-Ijanikin three dumpsites were lower than W.H.O limits of 5.0-20.0 mg/Kg [57]. More so, the concentration of Cu

found in the soils of the three dumpsites ranging from 0.206-1.834mg/Kg were lower compared to W.H.O standard limits of 5.0-20.0 mg/Kg [57]. These results agree with work of Ogundele *et al.* [23], when they undergo the assessment of heavy metal pollution of waste dumpsites in Kwara State using *Carica papaya*, *Musa spp.* and *Corchorus olitorous* as Indicators. The soil showed heavy metal contents below the threshold values reported in literature for agricultural soils, therefore establishing the suitability of the soil for planting [58]. Also, there are a few studies which also demonstrated contamination of forage plants by human waste accumulation activities.

The concentration of Zinc (Zn) found *Amaranthus spinosus* collected from Ketu-Ijanikin and Agbado-Oke-Odo was higher than those of Alakija (Table 3). This result is lower than W.H.O standard limits of 10-150 mg/kg as reported Boularbah *et al.* [57]. This finding also agreed with work of Ogundele *et al.* [23], although, the Zn levels in the plants were lower than the recommended limits of 60.0 mg/kg in normal plant; hence, there is need to monitor the accumulation level. Also, concentration of Zinc (Zn) found *Talinum triangulare* collected from Ketu-Ijanikin and Alakija was similar and higher than those of Agbado-Oke-Odo (Table 4). This result is lower than W.H.O standard limits of 10-150 mg/Kg as reported Boularbah *et al*. [57]. It also, concurred with findings of Ogundele *et al.* [23,24], it reported that although, the Zn levels in the plants were lower than the recommended limits of 60.0 mg/Kg in normal plant, there is need to monitor the accumulation level. More so, the concentration of Zinc (Zn) found in the soils collected from Alakija were higher than those of Ketu-Ijanikin and Agbado-Oke-Odo (Table 5). This result is lower than W.H.O standard limits of 10-150 mg/Kg as reported Boularbah *et al*. [57]

The concentration of Lead (Pb) and Cadmium (Cd) were not detected in samples *Amaranthus spinosus* collected from Alakija and Agbado-Oke-Odo but those found in the *Amaranthus spinosus* collected Ketu-Ijanikin (Table 3) were lower than W.H.O standard limits of 100mg/Kg and 3mg/Kg respectively as reported by Ilori *et al.* [54]. Ilori *et al.* [54] findings also confirmed the finding of this study when they reported similar results in their work titled: Investigation of heavy metal content on dumpsites soil and vegetables grown: a case study of Ilesha metropolis, Nigeria. Also, the concentrations of Lead (Pb) were not detected in samples of *Talinum triangulare* collected from Ketu-Ijanikin and Agbado-Oke-Odo (Table 4) but those found in the *Talinum triangulare* collected Alakija were lower than W.H.O standard limits of 100mg/Kg as reported by Ilori *et al.* [54]. Whereas, Cadmium (Cd) (0.002mg/Kg) was discovered in all the samples of *Talinum triangulare* collected from different locations studied. However, this result was lower than the W.H.O standard of 3mg/Kg as reported [54]. More so, Pb were not detected in the soils collected Agbado-Oke-Odo and Ketu-Ijanikin respectively but was detected in the soil of Alakija (Table 5). The detected concentration was within the permissible limits of W.H.O as

reported by Ilori *et al.* [54]. Whereas, Cd was not detected in the soil samples of Agbado-Oke-Odo and Alakija while the concentration found in the soil of Ketu-Ijanikin were within the limits of W.H.O. [54].

Moreover, one or more of these controlling factors may have been responsible for the wide variation in the concentration and pattern of uptake observed for the various metals in the plants and soils. The measure of concentration of these metals in the vegetables reflected their corresponding concentrations in the soil. Thus, agreed with what some authors have noted, that plant uptake of metal from soil is largely determined by the concentration of the metal in the soil matrix [59]. Manganese had low significant concentration compared to W.H.O standard which means there is a likelihood of anthropogenic input on the vegetables and soils from the dumpsites.

4. Conclusions

This research has shown that there is heavy metal pollution on dumpsite soils which are as result of the effect of heavy metal containing wastes that are improperly disposed there. Thus, buildups of heavy metal on these dumpsites are capable of being leached to the nearest place of uptake by vegetables and other plants around them. Although, the soil and vegetable studied were found to be safe for now but there are concerns for the gradual and continuous buildup which has started and indicated in the obvious differences of the dumpsites' metal concentrations. This study showed that continuous harvesting and cultivation of consumable vegetables in or around dumpsites is highly risky to human and also it is necessary to take measures to stop harvesting and cultivating vegetables for human consumption.

From the findings of this research, it is therefore recommended that despite the richness of the proximate compositions of *Amaranthus spinosus and Talinum triangulare* collected from the three different dumpsites, heavy metals concentrations present are capable of posing threats to humans health as a result of it bioaccumulation properties. Thus, vegetables from these dumpsites should be avoided

ACKNOWLEDGEMENTS

REFERENCES

[1]   Jarup, L. (2003). Hazards of heavy metal contamination, *British Medical Bulletin*, 68: 167–182.

[2] Khadeeja R., Sobin A., Umer, R., Muhammad, I., Saadia, H., Tehreema, I. and Shahla R. (2013). Comparison of Proximate and Heavy Metal Contents of Vegetables Grown with Fresh and Wastewater, Pakistan Journal of Botany, 45(2): 391- 40. 59.

[3] Divrikli U., Horzum N., Soylak M. and Elci L. (2006). Trace Heavy Metal Contents of Some Spices and Herbal Plants from Western Anatolia, Turkey, International Journal of Food Science Technology, 41: 712-716.

[4] Whatmuff, M.S. (2002). Applying bio-solids to acid soils in New South Wales: Are guidelines soil metal limits from other countries Appropriates. *Aust. J. Soil Res.*, 40: 1041-1056.

[5] McBride, M.B. (2003). Toxic metals in Sewage Sludge-amended soils: Has proportion of beneficial use discounted the risks. *Adv. Environ. Res.*, 8: 5-19.

[6] Suruchi and Pankaj, K. (2011). Assessment of Heavy metal contaminations in Diffferent vegetables grown in and around urban areas. *Research Journal of Environmental Toxicology*, 5(8): 162-179.

[7] Voutsa, D., Grimanis, A. and Samara, C. (1996). Trace elements in vegetables grown in an industrial area in relation to soil and air particulate matter. *Environ. Pollution,* 94: 325-335.

[8] Gupta, S.K., Herren, T., Wenger, K., Krebs, R. and Hari, T. (2000). In situ gentle remediation measures for heavy metal-polluted soils, in Phytoremediation of Contaminated Soil and Water, N. Terry and G. Banuelos, Eds., Lewis Publishers, Boca Raton, pp. 303–322.

[9] WHO (1995) Inorganic lead. Geneva, World Health Organization, International Programme on Chemical Safety. Environmental Health Criteria, pp.165.

[10] Chailapakul O, Korsrisakul S, Siangproh W, Grudpan K (2007) Fast and simultaneous detection of heavy metals using a simple and reliable microchip-electrochemistry route: An alternative approach to food analysis. *Talant*a 74: 683-689.

[11] Opaluwa, O.D., Aremu, M.O., Ogbo, L.O., Magaji, J.I., Odiba. I.E. and Ekpo, E.K. (2012). Assessment of Heavy Metals in Water, Fish and Sediments from UKE Stream, Nasarawa State, Nigeria. *Current World Environment*, 7(2): 213-220.

[12] Nwachukwu, M.A., Feng, H. and Allinor, J. (2010). Assessment of Heavy Metal Pollution in Soil and their Implications within and Around Mechanic Villages. *International Journal of Environmental Science and Technology*, 7(2): 347–358.

[13] Onibokun, A.G. and Kumuyi, A.J. (1996). Urban poverty in Nigeria: towards sustainable strategies for its alleviation. Centre for African Settlement Studies and Development, Ibadan, Nigeria. CASSAD Monograph Series.

[14] United Nations Development Programme, UNDP (2006). Practical Action. Technology Challenging Poverty. United Nation Development Programme Report.

[15] Adewole, M.B. and Uchegbu, L.U. (2010). Properties of Soils and Plants Uptake within the Vicinity of Selected Automobile Workshops in Ile-Ife, South Western Nigeria, Ethiopian *Journal of Environmental Studies and Management*, 3(3): 23-28.

[16] Rotich, K.H., Zhao, Y. and Dong, J. (2006). Municipal solid waste management challenges in the developing countries-Kenyan case study. *Waste Management*, 26: 92-100.

[17] Ebong, GA; Akpan, MM; Mkpenie, VN (2008). Heavy Metal Contents of Municipal and Rural Dumpsite Soils and Rate of Accumulation by Carica papaya and Talinum triangulare in Uyo, Nigeria. *E-Journal of Chemistry* 5 (2): 281-290.

[18] Babayemi, JO; Dauda, KT (2009). Evaluation of solid waste generation, categories and disposal options in developing countries: a case study of Nigeria. *Journal of Applied Sciences and Environmental Management* 13(3): 83-88. ISSN: 1119-8362.

[19] Musa, SD; Ifatimehin, OO (2013). Human Health Implications of Waste Dump Cultivated Vegetables in Anyigba, Kogi State, Nigeria. *Research Journal of Environmental and Earth Sciences* 5 (12): 710-713.

[20] Babayemi, JO; Ogundiran, MB; Osibanjo O (2016). Overview of environmental hazards and health effects of pollution in developing countries: a case of Nigeria. *Environmental Quality Management* 26 (1): 51-71.

[21] Babayemi, JO; Ogundiran, MB; Osibanjo, O (2017). Current levels and management of solid wastes in Nigeria. *Environmental Quality Management* (in press).

[22] Pacyna J. M and E. G. Pacyna, 2002. An assessment of global and regional emissions of trace metals to the atmosphere from anthropogenic sources worldwide Norwegian Institute for Air Research (NILU), Kjeller, Norway.

[23] Ogundele, D. T, Bodunde, V. T and Bale, A. T (2013). Assessment Of Heavy Metal Pollution Of Waste Dump Sites In Kwara State Using Carica Papaya, Musa Spp And Cocorhrous Olitorous As Indicators, *IOSR Journal of Environmental Science, Toxicology And Food Technology*. 6 (2): 1-4.

[24] Ogundele, LT; Owoade, OK; Hopke, PK; Olise, FS (2017). Heavy metals in industrially emitted particulate matter in Ile-Ife, Nigeria. *Environmental Research* 156: 320- 325.

[25] Odukoya, O.O., Bamgbose, O. and Arowolo, T.A. (2001). Heavy metals in top soils of Abeokuta dump sites *Global Journal of Pure and Applied Sciences*, 2001, Vol 7(3), pp 467-472.

[26] Mapanda, F., Mangwayana, E.N., Nyamangara, J. and Giller, K.E. (2005). Impacts of sewage irrigation on heavy metals distribution and contamination. *Environ Intern* 31: 05-812.

[27] Ideriah, J.K., Omuaru, O.T. and Adiukwu, U.P. (2005). Heavy metal contamination of soils around municipal solid wastes dump in Port Harcourt, Nigeria. *Global Journal of Environmental Sciences*, 4: 1-4.

[28] Abidemi, O. (2011). Levels of Pb, Fe, Cd and Co in soils of automobile workshop in Osun State, Nigeria, *Journal of Applied Sciences and Environmental Management*, 15: 355-362.

[29] Oyelola, O.T., Babatunde, A.I. and Odunlade, A. K. (2009). Health implications of solid waste disposal: case study of Olusosun dumpsite, Lagos, Nigeria". *International Journal of Pure and Applied Sciences*, 3: 1-8.

[30] Pujar, K.G., Hiremath, S.C., Pujar, A.S., Pujeri, U.S. and

Yadawe, M.S. (2012). Analysis of Physico-Chemical and Heavy Metal Concentration in Soil of Bijapur Taluka" Karnataka Science Revision. *Chemistry Community*, 2: 76-79.

[31]   Fagbote, E.O. and Olanipekun, E.O. (2010). Evaluation of the status of heavy metal pollution of soil and plant (*Chromolaena odorata*) of Agbabu Bitumen Deposit Area, Nigeria". *American-Eurasian Journal of Scientific Research* 5: 241-248.

[32] Amusan, A., Ige, D. and Olawale, R. (2005). Characteristics of soils and crops' uptake of metals in municipal waste dump sites in Nigeria, *Journal of Human Ecology*, 17(3): 167-171.

[33] Oluwole, S.O., Ogun, M.L. and Balogun, O.A. (2018). Effects of different watering regimes on the growth of *Talinum triangulare* Jacq. (Waterleaf). *Journal of Research and Review in Science.* 5: 14-23.

[34] Oluwole, S.O., Ogun, M.L. and Durowoju, S.Y (2019a). Effects of Different Organic Manures on the growth of water leaf (*Talinum triangulare*), *International Journal of Innovative Science and Research Technology*, 4(5): 1123-1129.

[35] Ebenso, I.E and Okafor, N.M. (2002). Alternative diet for growing *Archachatina marginata* snails in South-eastern, Nigeria. *Tropical Science*. 42 (3): 144-145.

[36] Olufemi, B. E., Assiak, I. E., Ayoade G. O. and Onigemo, M. A. 2003. Studies on the effect of *Amaranthus spinosus*. Leaf extract on the Hematology of growing pigs. *African Journal of Biomedical Research* 6: 149-150.

[37] Olumayokun, A., Olajide, B., Ogunleya, R., Temitope, O. and Erinle, S. (2004). Anti -inflammatory properties of *Amaranthus spinosus*. *Pharmaceutical Biology*, 42(7): 521-525.

[38] Anjali G. and Nishikant R. (2019). Nutritional and medicinal potential of *Amaranthus spinosus, Journal of Pharmacognosy and Phytochemistry 8(3): 3149-3156.*

[39] Kumar, A; Prasad, MNV; Sytar, O (2012). Lead toxicity, defense strategies and associated indicative biomarkers in *Talinum triangulare* grown hydroponically. *Chemosphere* 89: 1056–1065.

[40] AOAC, (2005): Official methods of Analysis of Association of Analytical Chemists. AOAC International, 18th ed; Horrowitz, W.(ed) vol 1 & 2, AOAC International Maryland, USA pp 774-784.

[41] Pearson, D. (1976). Chemical analysis of food, 7th (ed.), Churchill, London, pp.218-336.

[42] AOAC. (1990). Official Methods of Analysis. Association of Official Analytical Chemists 15[th]Ed. Washington. DC.

[43] Onwordi, C. T., Ogungbade, A.M. and Wusu, A.D. (2009). The proximate and mineral composition of three leafy vegetables commonly consumed in Lagos, Nigeria. *Afr. J. Pure Applied Chem.*3: 102-107.

[44] Oluwole, S.O., Fajana, O.O., Ogun, M.L., Ogbe, A.A. and Ademola, O.A. (2019b). Proximate and Mineral Composition Analysis of the Leaves of *Amaranthus cruentus* and *Ocimum gratissimum* in some selected areas in Lagos State, Nigeria *International Journal of Ecosystem*, 9(1): 6-11.

[45] Iheanacho, K., and Ubebani, A. C. (2009). Nutritional composition of some leafy vegetable consumed in Imo- State. Nigeria. Journal of Applied Science and Environment Management 13 (3): 35-38.

[46] Fagbohun, E.D., Lawal, O.U and Ore, M.E. (2011). The proximate, Mineral and Phytochemical Analysis of the leaves of OcimumgratissiliumL. Melanthera Scandens (Schum & Thonn) Roberty and Leeaguiheensis G. Don. *International Journal of Applied Biology and Pharmaceutical Technology*. 3 (1): 15-22.

[47] Asaolu, S.S., Adefemi, S.O., Oyakilome, I.G., Ajibulu, K.E and Asaolu, M.F. (2012). Proximate and mineral composition of Nigeria leafy vegetables. *Journal of Food Reseach* 1(3): 214-218.

[48] Ali, A. (2009). Proximate and mineral composition of the marchubeh (asparagus officinalis). *World Diary and Food Science*, 4(2): 142-149.

[49] Isong, E., and Idiong, U.(1997). Nutrient content of the edible leaves of seven wild plants from Nigerian. *Plant Foods for Human Nutrition* 51:79-84.

[50] Ishida, H., Suzuno, H., Sugiyama, N., Innami, S., and Todokoro, T. (2000) National evaluation of chemical component of leaves stalks and stem of sweet potatoes (*Ipomea batata) Food Chem*. 68: 359-367.

[51] Sanni, O. and Olaofe, O. (1998). Mineral content of Agricultural products. Journal of Food Chemistry, 30(1): 73-77.

[52] Ebun-Oluwa P.O, Alade AS (2007).Nutritional potential of Belandier Nettle spurge *Jatropha cathatica* seed. *Pak. J. Nutr.*, 6: 345:348.

[53] Edema, M and Okiemen, F.E (2000), Proximate Composition of some nutritionally valuable mineral functional properties of walnut (*Tetracapedium chonophorum*). *Pakistan Journal of Science and Industrial Research* 43: 267-707.

[54] Ilori A.O., Thompson, S. O. and Ajayi, O. O. (2018). Investigation of Heavy Metal Content on Dumpsites Soil and Vegetables Grown: A case study of Ilesha metropolis, Nigeria*International Journal of Advances in Scientific Research and Engineering* 4(12): 178-183.

[55] Adaikpoh, E. (2013). Distribution and Enrichment of Heavy Metals In Soils From Waste Dump Sites Within Imoru And Environs, Southwest Nigeria," *Journal of Environment and Earth Science, 3*: 45- 54.

[56] Dara, S.S. (2013). *A textbook of environmental chemistry and pollution control S*chand and Company Limited. Newa Delhi. pp 167-223.

[57] Boularbah, A., Schwartz, C., Bitton, G., Aboudrar, W., Ouhammou, A. and Morel, J. L. (2006). Heavy metal contamination from mining sites in South Morocco: 2. Assessment of metal accumulation and toxicity in plants. *Chemosphere*, 63, 811–817.

[58] Ebong, .G.A., Etuk, .M.S. and Essien, J.P. (2007). Impact of Mechanized Farming on the Heavy Metals Load of an Ultisol located in the Niger Delta Region of Nigeria. *Journal of Applied Sciences*. ISSN 1812-5654.

[59] Wild, A. (1988) "Plant nutrients in soil: phosphate". *Russell's soil conditions and plant growth*, 11: 695-742.