

Seasonal Appraisal of Heavy Metal Bioaccumulation in Amaranthus, Gruty-stalked Jatropha, Scent Leaf, Bitter Leaf and Water Leaf in Some Poultry Farms within the State of Osun, Southwest Nigeria

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Abstract Poultry wastes contain metals which have permissible limits in crops for safe consumption by man and animals. Seasonal contents of heavy metals in soil and edible portions of five broadly eaten vegetables in Nigeria [*Amaranthus (Amaranthus viridis)*, Gruty-stalked jatropha (*jatropha podagrica*), Scent leaf (*Ocimum gratissimum*), Bitter leaf (*Vernonia amygdalina*) and Water leaf (*Talinum triangulare*)] were evaluated in poultry farms within the state of Osun, Nigeria. Heavy metals contents in the digested samples were determined with Flame Atomic Absorption Spectrophotometer. Quality assurance techniques included blank determination, recovery analysis and calibration of standards. Descriptive and inferential statistics were used for data interpretations. Analytical results of poultry farm soils revealed that dry and wet seasons values for Cd, Cu, Fe, Pb and Zn were within the acceptable range, but As values for dry and wet seasons (323.10 and 351.41 $\mu\text{g/g}$ respectively) were higher than acceptable values of a typical agricultural soil. Highest contents of As (42.042 $\mu\text{g/g}$), Cd (0.550 $\mu\text{g/g}$) and Pb (0.618 $\mu\text{g/g}$) were recorded for *Amaranthus viridis*; the highest Cu level (0.998 $\mu\text{g/g}$) was present in *Ocimum gratissimum*; Fe had its highest content (148.031 $\mu\text{g/g}$) in *Vernonia amygdalina*; while *Talinum triangulare* had the highest Zn level (62.073 $\mu\text{g/g}$). Levels of heavy metals in vegetables were higher in the dry season than the wet season but this variation was not statistically different at $p < 0.05$. Similarly, the levels of As and Fe were above the safe values in plants in both seasons, while Cd, Cu, Pb and Zn were below the safe value. Enrichment factor values implied that the poultry farm soils were significantly enriched with Cu, Pb and Zn, but heavily enriched with As, Cd and Fe as a result of anthropogenic inputs. Specifically, the soils were heavily contaminated with the duo of very toxic elements, As and Cd.

Keywords: heavy metals, poultry soil, vegetables, enrichment factor, bioaccumulation factor

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1. Introduction

Presently, livestock is one of the fastest growing agricultural subsectors in developing countries. Its share of agricultural Gross Domestic Product (GDP) is already thirty-three (33) per cent and is quickly increasing [1]. This growth is driven by the rapidly increasing demand for livestock products, population growth, urbanization and increasing incomes in developing countries [2]. Poultry breeding is culturally acceptable to people all over the world and provides an excellent source of protein for poor communities because it requires little capital, labour

or land. In recent years, the high demand for livestock and poultry products in Nigeria has caused a dramatic increase in the growth of the livestock and poultry farming industry [3].

Poultry wastes contain heavy metals which have permissible levels in crops for safe consumption by man and animals. Trace metals as micronutrients are essential for biological organs. They are obtained from soil through agricultural plant products and subsequently become a major source of bioaccumulation of different kinds of heavy metals in human organs. In addition to their essentiality for plant growth and/or human nutrition, some micronutrient elements may also be toxic to both animals and humans at higher levels such metals include Cu, Cr,

Fe, Mo, Ni, Se and Zn. Other heavy elements, like As, Cd, Hg and Pb may also inadvertently get into the food chain and cause health risks to humans and animals. These heavy metals can accumulate in the soil and in plants, determined by human activities going on in a place and may present a possible health risk to people who inhale or swallow contaminated soil or eat infected food crops cultivated on soils of polluted areas. Although plants often absorb trace elements to some degree, in nearly all instances the quantities they take up are too insignificant to cause risk.

Pollution in plants is of concern for two major reasons. Firstly, pollutants may have direct phytotoxic effect on the plants themselves, leading to a decline in crop yield and threatening food supplies. Secondly, the plants may serve as a medium for spreading pollutants into the food chain. Since crops take up nutrients from the soil, the availability of heavy metals in high contents is likely to correspond to high contents in agricultural produce from affected soils. Extensive long-term investigations on the uptake of soil metals by plants reveal that metals can concentrate in edible tissues of plants [4]. Eating of vegetables is one of the routes by which heavy metals get into the food chain. Prolong eating of unsafe concentrations of heavy metals via foodstuffs may result in chronic concentration of heavy metals in the body systems of humans and may be the cause of various biochemical processes, like cardiovascular, nervous, kidney and bone diseases [4].

Several concerns have been said as regards the quality of air we breathe, the water we drink and the soils that grow our food [5,6,7]. Majority of poultry in Nigeria takes place in the ecologically derived savanna and transitional regions where vegetables are also grown in great amounts. There is even a notion believed by some vegetable consumers that vegetable from poultry is high in nutritious content. Notwithstanding, there is a greater likelihood for vegetable from these poultry sites to be concentrated with heavy metals from the farms. Agricultural industrial wastes introduce several dozen of toxic substances and chemicals into farms and garden soils, including such well noted toxic metals as As, Cd and Pb. Many plants and crops obtain these toxic metals from the soil, increasing the possibility of their hazardous effect on human health as crops and plants get into the food chain.

Researches show that the availability of toxic heavy metals like As, Cd and Pb are connected with poultry farms and declines soil fertility and agricultural yield [8] besides increasing the toxic quantities of heavy metals in foodstuff from poultry communities. There is immoderate utilization of farmland in Osun State area such as utilizing poultry waste as manures without appropriate soil treatment and dumping of poultry waste residues. In addition, poultry industry is one of the activities in the area that is capable of causing cumulation of agriculturally originated contaminants in soil and crops. There is paucity of data with respect to seasonal levels of potentially toxic metals in the soils and planted vegetables of highly patronized poultry farms in Osun State. Thus, aim of this work was to quantify the content of As, Cd, Cu, Fe, Pb and Zn in soil and edible portions of regularly consumed vegetables grown on soils of poultry farms within Osun State and assess the levels of bioaccumulation of the

metals by the vegetables and the risk of their frequent eating.

2. Materials and Methods

2.1. Description and Suitability of the Sampling Locations

The study area included Ejigbo, Isundunrin and Osogbo poultry farms in Osun State, Southwestern Nigeria (Figure 1). The derived savanna climate of the state has two broadly classified seasons: rainy season that starts from April and ends in October, and dry season that lasts between November to March [9]. The annual rainfall varies from 1110 mm in the northern areas to 1277.70 mm in the southern areas [9]. Geographically, the area under study constitutes a fraction of the Basement Complex of Southwestern Nigeria and it is naturally covering by hard crystalline igneous and metamorphic rocks (9). The soil types of the study zone primarily associated with Iwo and Egbeda categorization. They have been figured out as montmorillonite soils which are by far the most extensive and the almost all essential soils within the Tropical belts for both food and tree cash crop farming. The locations are of rural setting and large percentage of the total poultry land is used mainly for the raising of poultry birds and growing of food crops such as vegetables, maize, yam, cocoyam, cassava, sweet potatoes and soyabean. Crops harvested from this confined catchment enjoy wide patronage by consumer intermediaries from Osun State and its environs. The poultry farmers here actively and regularly apply agrochemicals to improve bird and crop yield as seemed necessary without a follow-up evaluation of how these agrochemicals (concentrates, additives, organic manure and herbicides) affect the environment of the confined catchment. The sampling stations chosen for this study were considered appropriate for the reason that all of them have been in operation for more than twenty-five years. Besides, seasonal analysis of heavy metal contamination of the soils and vegetables of the poultry farms selected was being studied for the first time.

2.2. Sampling and Pre-treatment

Composite samples of soils were taken from Agboola, Odunola and Worgor farms and gardens on seasonal basis, comprising of four representative months of December, 2014 and January, February and March, 2015 for dry season and four representative months of July, August, September and October, 2015 for rainy season. For each month, twelve soil samples were taken at 0 to 15 cm depth via soil auger at intervals of 10 m apart within a poultry farm. The sub-samples were taken along independent zig-zag routes to obtain randomness. The auger was carefully cleaned after each sampling exercise to prevent cross-contamination. The soil samples were taken in polythene bags and labelled accordingly. The soil samples were air-dried at ambient temperature for five days to prevent microbial deteriorations and crushed in a porcelain mortar and sieved via a 2 mm plastic sieve to get fine soil particles.

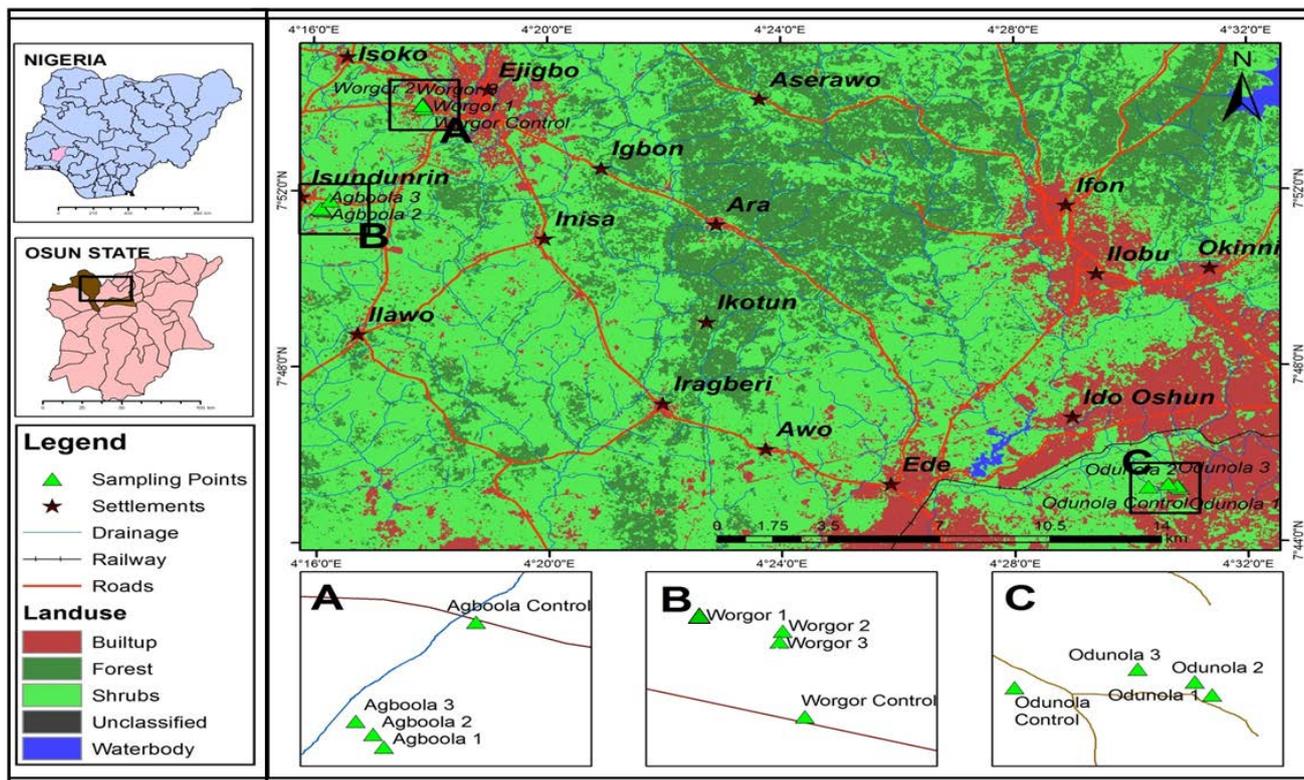


Figure 1. Map of the Study Area Showing Sample Locations

Vegetable samples were taken with gloved hands to prevent contamination. Samples of green vegetable amaranthus (*Amaranthus viridis*), bitter leaf (*Vernonia amygdalina*), scent leaf (*Ocimum gratissimum*), Jatropha (*Jatropha podagrica*) and water leaf (*Talinum triangulare*) were taken by arbitrarily collecting some mature leaves from the plants until a sizable bundle was gathered from each farm where soil samples were taken. Vegetable samples were washed with tap water and distilled water to remove dirt and other particulate matters. Each bundle was then sub-divided to give triplicate samples weighing about 100 g fresh mass and air-dried for 24 to 48 hours to avoid biochemical alterations. Prior to assay, fresh vegetable samples were oven-dried to a constant mass at a temperature of 65°C so as to prevent enzymatic activity. Samples were then pulverized by means of a porcelain mortar, sieved via 1 mm mesh sieve, and stored in polyethylene bags in a desiccator prior to further assay.

2.3. Digestion of Samples

Accurately weighed 0.2-0.5 g of the air-dried (< 2 mm) composite soil sample from each of the three zones (in triplicates) were weighed into a Teflon beaker, 5 mL of 70% HNO₃ was included and the beaker was covered with a watch glass. This was put in a thermostatically regulated hot plate sustained at 120°C for about 2 hours. Refilling of the acid concentration was carried out at intervals to prevent causing the content to total evaporation. The beaker was permitted to cool and 5 mL concentrated HNO₃, 2 mL 60% HClO₄ and 5 mL 40% HF was included. The beaker was replaced on the hot plate with a digestion

temperature of 180-200°C. When the solution begins to be clear, the digestion was regarded complete. The watch glass was now tilted sideways to volatilize most of the acid concentration at approximately 100°C. The Teflon beaker was taken away from the hot plate and got cooler after which 5 mL HNO₃ of 6 M HNO₃ was inputted. More boiling and gentle heating for about 5 minutes was conducted. The watch glass was washed with triply distilled water into the beaker. The content of the beaker was quantitatively transferred into a 50 mL volumetric flask and filled up with triply distilled water to the level.

Likewise, 1 g of oven-dried and ground sample of each type of the vegetables was weighed (in triplicates) into a 100 cm³ Teflon beaker. This was followed by the inclusion of 10 cm³ mixtures of analytical grade HNO₃ and HClO₄ in the ratio 3:1. The beakers were then enclosed with watch glasses and left overnight. Digestion was performed on a hot plate at a temperature of about 90°C in a fume hood until about 4 cm³ of the mixture was left in the beaker. A further 10 cm³ of the acid mixture was then included and dried to a volume of about 4 cm³ while still on hot plate, giving a clear solution. The solution procured was cooled to room temperature and quantitatively transferred into a 50 cm³ volumetric flask where it was filled up to the level utilizing distilled water. These were stored in polyethylene bottles prior to assay. The worked-up samples above were analysed for their heavy metal contents employing the Flame Atomic Absorption Spectrophotometer (Model: PG 990) present at the Department of Chemistry and Industrial Chemistry Laboratory, Bowen University, Iwo, Nigeria. The analysis was performed in accordance with the manufacturer's handbook.

2.4. Data Analyses

2.4.1. Bioaccumulation Factor (BAF)

The bioaccumulation factor (BAF) is the ratio of the content of the element in the vegetable to that in the corresponding soil. This was calculated for each vegetable sample to quantify the bioaccumulation effect of vegetable on the uptake of heavy metals from the soils [10]. The BAF was computed as in Eq. (1):

$$BAF = \frac{C_{plant}}{C_{soil}} \quad (1)$$

where C_{plant} and C_{soil} represent the heavy metal contents in vegetable and soils, respectively.

2.4.2. Enrichment Factor (EF)

The enrichment factor (EF) has been computed to obtain the degree of soil contamination and heavy metal accumulation in soil and in plants planting on contaminated site with respect to soil and plants planting on uncontaminated soil [11] as follows in Eq. (2):

$$EF = \frac{\text{Contents of metals in soils at contaminated site}}{\left(\frac{\text{Contents of metals in soil}}{\text{at uncontaminated site}} \right)} \quad (2)$$

2.5. Quality Assurance and Quality Control

Suitable quality assurance techniques and safety measures were conducted to ascertain validity of the data. Double distilled deionised water was utilized all through the study. Glassware was suitably rinsed, and the reagents were of analytical grade. Reagents blank tests were utilized to check the instrument interpretations. For substantiation of the analytical method, a recovery analysis was conducted by spiking and homogenizing diverse already analyzed samples with varied quantities of standard solutions of the metals. Despite the fact that FAAS proffers possible benefits like analytical specificity, good detection limit, excellent precision and moderately low cost, its calibration was vital to assess the reaction of the analytical method in respect of identified quantities to the standards of the heavy metals of concern so that the reaction to unidentified quantities in the samples could be dependably estimated. For the FAAS 20, 17.5, 15, 12.5, 10, 7.5, 5, 2.5 and 1 $\mu\text{g/mL}$ contents of each metal solution were newly prepared by serial dilution for the quantification of metals in soil and plant samples. These solutions were run on the FAAS to procure the working calibration graph which was utilized to evaluate the levels of heavy metals in the samples by automatic interpolation with the calibration graph. The coefficient of variation of replicate analyses was conducted for the measurements to compute analytical precision.

3. Results and Discussion

The validity of the analytical methods used in this work was well-tried in relation to sensitivity, recovery, precision and accuracy. Table 1 shows the values for

FAAS measuring stipulations, limit of detection (LOD) and percentage recovery (%R) for the heavy metals. Under the experimental procedures adopted, the standard calibration curves observed signified high proportionality value with correlation values (r^2) varying from 0.9783 to 0.9990. Recoveries of heavy metals varied between 93.68% in Fe and 98.02% in Cu. These detected values were within permissible level. The computed LOD values (Table 1) which varied between 0.002 $\mu\text{g Zn/g}$ and 0.500 $\mu\text{g Fe/g}$ were in good conformity with the values reported by Oyekunle *et al.* [6].

Table 1. FAAS Measuring Stipulations, Limit of Detection and % Recovery for Heavy Metals in the Soil

Heavy Metal	Current (mA)	Measuring Stipulations Wavelength	Silt Width (nm)	Calibration Curve, r^2	Computed LOD $\mu\text{g/g}$	Quantity Spiked	Quantity Quantified	% Recovery
As	12	193.7	0.5	0.9852	0.200	50.0	47.83	95.65
Cd	8	228.8	0.7	0.9783	0.030	50.0	48.31	96.62
Cu	6	324.8	0.5	0.9855	0.020	50.0	49.01	98.02
Fe	-	248.3	0.2	0.9990	0.500	50.0	46.84	93.68
Pb	10	283.3	0.7	0.9836	0.050	50.0	46.33	92.66
Zn	8	213.9	0.7	0.9918	0.002	50.0	48.54	97.08

The mean contents of the heavy metals ($\mu\text{g/g}$) in the poultry farm soil and vegetables of the area under study are revealed in Table 2 and Table 3 for dry and wet seasons. The contents of the metals were commonly higher in samples from the sampling location than the control location. There are also seasonal differences between dry and wet seasons samples. The occurrences of accumulation of metals in soil samples in both seasons was: As > Fe > Zn > Cu > Pb > Cd, while in the vegetables, the occurrences was: Fe > Zn > As > Cu > Pb > Cd. Heavy metal content values were higher in soil samples in contrast to vegetables samples. Ogunwale *et al.* [9] expressed that the level of heavy metals in vegetables were usually lower than the soil samples. These findings may be ascribed to root system which appears to serve as a limit for bioaccumulation of metals (Table 3). Likewise, from Table 3, vegetables taken during dry seasons had larger content of metals while those taken during wet seasons had lower contents of all the metals. This could be ascribed to wet season rainfall which got rid of contaminants from the vegetables.

Heavy metal contents revealed difference among varied vegetables taken from Agboola, Odunola and Worgor farms (Table 3). The differences in heavy metal contents in vegetables of the same site may be attributable to the variations in their morphology and physiology for heavy metal absorption, elimination, cumulation and reservation [9]. The absorption and bioaccumulation of heavy metals in vegetables is controlled by several factors like climate, atmospheric depositions, the contents of heavy metals in soils, the sort of soil, the extent of full growth and form and structure of the plants at the period of the collection [9]. The range and mean contents of heavy metals ($\mu\text{g/g}$) in leafy vegetables are presented in Table 3, where the contents of heavy elements ($\mu\text{g/g}$) ranged between 9.877-41.795 for As, 0.056-0.503 for Cd, 0.639-0.998 for Cu,

82.128-148.031 for Fe, 0.088-0.536 for Pb and 11.526-62.073 for Zn for the dry season and ranged between 8.869-42.042 for As, 0.035-0.550 for Cd, 0.083-0.906 for Cu, 58.320-107.120 for Fe, 0.046-0.618 for Pb and 10.603-47.306 for Zn for the wet season. The overall mean content of Fe was between 116.434 and 83.075 µg/g for dry and wet seasons which were in good harmony with the 111-378 mg/kg contents reported in vegetables by Arora *et al.* [12]. The maximum intake of Fe (148.031 µg/g) was in *Vernonia amygdalina* after that *Ocimum gratissimum* (136.932 µg/g), *Talinum triangulare* (123.080 µg/g), *Jatropha podagrica* (98.516 µg/g) and *Amaranthus viridis* (58.320 µg/g). The contents of Fe in all the vegetables were above the prescribed safe value of WHO/FAO by Alloway [13]

The highest mean content of Zn (62.073 µg/g) was present in *Talinum triangulare* followed by *Amaranthus viridis* (43.355 µg/g). The overall mean content of Zn (31.137 and 26.792 µg/g) in vegetables of some poultry farms in Osun State was very similar to the values reported in vegetables from Beijing, China (32.01-69.26 mg/kg) (18). Elevated content of As shown by *Amaranthus viridis* (42.042 µg/g) was this double greater than the suggested safe value of PFA [Prevention of food adulteration (0.02-7 mgkg⁻¹) [13]. The overall mean of As contents in vegetables was between (23.045 and 22.094 µg/g) which was less than the value obtained for vegetables in Titagarh, West Bengal, India by Gupta *et al.* [15]. Nevertheless, it was more than the results (1.81-7.57 mg/kg) of Sharma *et al.* [16] in Varanasi, India or the values (8.78-21.5 mg/kg) obtained by Rattan *et al.* [17] in Delhi, India.

The overall mean Cu content in vegetables (0.827 and 0.521 µg/g) was lower in contrast to the findings (15.66-34.49 mg/kg) observed in Titagarh west Bengal, India [15] and also less than the Cu content of 61.20 mg/kg in vegetables from Zhengzhou city, China [14]. Nevertheless, the difference of Cu content in vegetable in the present work was closely verified by the 5.21-18.2 mg/kg Cu value obtained by Arora *et al.* [16] in a similar work and was also in good harmony with the contents obtained in Varanasi, India (10.95-28.58 mg/kg) by Sharma *et al.* [16].

Elevated Cu content (0.998 µg/g) was available in *Ocimum* whereas the overall mean content was 0.827 and 0.521 µg/g for dry and wet seasons respectively. These contents were lower than the mean contents (32.74 mg/kg and 36.41 mg/kg) observed by Sharma *et al.* [16] in Varanasi India of the mentioned vegetables.

The maximum content of Pb (0.618 µg/g) was demonstrated by *Amaranthus viridis* followed by 0.536 µg/g in *Talinum triangulare*. These contents were below the acceptable tolerance limit of WHO for Pb [13]. Lead contents in edible parts of all the vegetables studied in the present work were below the permissible limits suggested by WHO/FAO, [4]. The overall mean Pb content in vegetables (0.365 and 0.188 µg/g) was less than the values found in Yargalma, North Nigeria, (5.9325 mg/kg) [18] and also relatively less than the Pb value found in China (0.18-7.75 mg/kg) [14]. The maximum accumulation of Cd was of the order *Amaranthus viridis* (0.550 µg/g) > *Talinum triangulare* (0.503 µg/g) > *Jatropha podagrica* (0.428 µg/g). In all the instances, the contents were lower than the WHO/FAO level [13]. The overall seasonal mean Cd contents of 0.248 and 0.238 µg/g observed in the vegetables were less than the contents found in vegetables from Yargalma, Northern Nigeria (0.50 mg/kg) [17] and vegetables from Turkey (25 mg/kg) [19]. Nevertheless, data of this paper were very close to the results of Sharma *et al.* (2006) (0.5-4.36 mg/kg) in vegetables from Varanasi, India [19].

The data in Table 3 shown that the increasing order of content of heavy metals in the vegetables was of the order Fe > Zn > As > Cu > Pb > Cd. Identical results were observed by Abou Audu *et al.* [20] who reviewed the accumulation of heavy metals (Fe, Zn, Pb and Cd) on crops in Gaza Strip. The same results were also found by Do'a [21] who observed that the maximum content was Zn, followed by Cu, Cr, Ni, Pb and Cd for two crops (*Cyperus malaccensis* and *Scrpustripueter*). The findings signified that the metal content in the vegetables followed the trend *Talinum triangulare* > *Vernonia amygdalina*, *Amaranthus viridis* > *Ocimum gratissimum* > *Jatropha podagrica*. Therefore, *Talinum triangulare* showed the strongest affinity to concentrate these metals from soils.

Table 2. Mean Values of Heavy Metals in Poultry Farms Soil of the Area under Study for Dry and Wet Seasons (µg/g)

Sampling Site	Content of Elements (µg/g)						Total Load per Sampling Site (µg/g)
	As	Cd	Cu	Fe	Pb	Zn	
Dry Season							
Agboola	674.82 ± 35.98	1.35 ± 0.23	60.33 ± 1.56	470.20 ± 13.80	47.54 ± 3.23	112.69 ± 8.33	1366.93 ± 50.87
Control	4.84 ± 0.93	0.04 ± 0.01	5.27 ± 0.83	8.26 ± 0.98	3.03 ± 0.63	12.22 ± 1.73	33.66 ± 2.85
Odunola	634.45 ± 29.48	1.96 ± 0.06	70.14 ± 2.37	477.79 ± 15.55	62.94 ± 4.88	120.69 ± 9.78	1367.97 ± 50.91
Control	2.69 ± 0.73	0.08 ± 0.02	8.63 ± 0.98	7.78 ± 0.96	6.38 ± 0.88	10.62 ± 1.43	36.18 ± 2.90
Worgor	616.77 ± 22.47	1.46 ± 0.05	68.57 ± 1.62	365.68 ± 11.95	43.46 ± 3.13	96.81 ± 6.70	1192.75 ± 43.98
Control	5.03 ± 0.97	0.02 ± 0.00	6.44 ± 0.86	6.96 ± 0.86	5.08 ± 0.61	133.57 ± 7.49	32.56 ± 2.75
Overall mean ± S.D	323.10 ± 19.48	0.82 ± 0.04	36.56 ± 3.95	222.78 ± 15.13	28.07 ± 2.06	60.34 ± 3.60	671.67 ± 35.75
CV	6.03	4.88	10.80	6.79	7.34	5.97	5.32
Wet Season							
Agboola	730.09 ± 43.43	2.14 ± 0.26	91.92 ± 4.37	539.14 ± 31.13	61.52 ± 1.62	133.57 ± 7.49	1558.38 ± 73.56
Control	6.92 ± 0.93	0.07 ± 0.02	8.38 ± 0.95	17.03 ± 1.05	5.81 ± 0.75	20.03 ± 1.41	58.28 ± 4.81
Odunola	691.90 ± 27.65	3.04 ± 0.29	100.44 ± 6.98	546.96 ± 32.45	73.44 ± 3.44	140.53 ± 7.74	1556.31 ± 68.23
Control	5.62 ± 0.76	0.11 ± 0.01	11.55 ± 0.98	14.88 ± 1.57	7.81 ± 0.86	17.80 ± 1.36	57.75 ± 4.78
Worgor	666.21 ± 21.24	2.31 ± 0.28	103.54 ± 6.78	445.46 ± 22.85	55.35 ± 2.68	115.76 ± 6.79	1388.63 ± 53.85
Control	7.73 ± 0.79	0.09 ± 0.01	10.68 ± 1.24	12.83 ± 1.35	8.11 ± 0.90	15.08 ± 1.25	54.52 ± 4.76
Overall mean ± S.D	351.41 ± 23.16	1.29 ± 0.08	54.42 ± 5.49	262.72 ± 18.99	35.34 ± 3.61	73.80 ± 6.66	778.98 ± 49.77
CV	6.59	6.20	10.09	7.23	10.22	9.02	6.39
Elemental Conc. of natural soil	0.1-40	0.01-2.00	2-250	26000	2-300	1-900	

Source: Alloway (1995).

Table 3. Mean Heavy Metal Content ($\mu\text{g/g}$) in Vegetable Grown in Poultry Farms of the Study Sites Dry and Wet Seasons

Site	Vegetable	Common Name	As	Cd	Cu	Fe	Pb	Zn	Total Load per Sampling Site ($\mu\text{g/g}$)
Dry Season									
Agboola	<i>Jatropha podagrica</i>	Gruty-stalked jatropa	23.940 \pm 4.450	0.428 \pm 0.080	0.762 \pm 0.096	98.516 \pm 10.180	0.362 \pm 0.071	24.781 \pm 5.260	148.789 \pm 13.650
	<i>Talinum triangulare</i>	Water leaf	28.301 \pm 5.230	0.328 \pm 0.050	0.826 \pm 0.097	123.080 \pm 12.880	0.437 \pm 0.083	44.093 \pm 7.360	
	<i>Vernonia amygdalina</i>	Bitter leaf	18.183 \pm 3.160	0.062 \pm 0.002	0.953 \pm 0.100	114.036 \pm 12.160	0.358 \pm 0.061	26.391 \pm 5.380	
	<i>Ocimum gratissimum</i>	Scent leaf	12.634 \pm 3.110	0.089 \pm 0.002	0.998 \pm 0.110	136.932 \pm 13.260	0.088 \pm 0.002	11.526 \pm 3.860	
Oduola	<i>Talinum triangulare</i>	Water leaf	41.795 \pm 6.230	0.094 \pm 0.003	0.793 \pm 0.080	102.328 \pm 10.350	0.536 \pm 0.093	62.073 \pm 8.080	207.619 \pm 23.490
	<i>Vernonia amygdalina</i>	Bitter leaf	15.763 \pm 3.230	0.421 \pm 0.050	0.748 \pm 0.080	148.031 \pm 15.190	0.360 \pm 0.070	17.218 \pm 3.930	
	<i>Amaranthus viridis</i>	Green vegetable	NA	NA	NA	NA	NA	NA	
	<i>Talinum triangulare</i>	Water leaf	33.863 \pm 5.460	0.503 \pm 0.070	0.896 \pm 0.080	82.128 \pm 9.920	0.483 \pm 0.080	48.238 \pm 7.860	
Worgor	<i>Vernonia amygdalina</i>	Bitter leaf	9.877 \pm 2.860	0.056 \pm 0.002	0.639 \pm 0.070	126.420 \pm 12.980	0.296 \pm 0.050	14.773 \pm 3.760	152.066 \pm 14.540
	Range		NA-41.795	NA-0.437	NA-0.998	NA-148.031	NA-0.536	NA-62.073	
	Overall Mean \pm S.D		23.045 \pm 4.340	0.248 \pm 0.070	0.827 \pm 0.090	116.434 \pm 12.200	0.365 \pm 0.080	31.137 \pm 7.050	
	CV		18.833	28.225	10.883	10.478	21.918	22.642	
Wet Season									
Agboola	<i>Jatropha podagrica</i>	Gruty-stalked jatropa	17.982 \pm 3.980	0.326 \pm 0.060	0.083 \pm 0.002	62.081 \pm 7.230	0.046 \pm 0.003	19.036 \pm 4.006	99.554 \pm 10.940
	<i>Talinum triangulare</i>	Water leaf	21.826 \pm 4.230	0.307 \pm 0.051	0.395 \pm 0.053	91.113 \pm 10.630	0.073 \pm 0.006	34.283 \pm 8.605	
	<i>Vernonia amygdalina</i>	Bitter leaf	14.605 \pm 3.720	0.035 \pm 0.002	0.653 \pm 0.062	86.401 \pm 10.240	0.055 \pm 0.003	22.031 \pm 5.806	
	<i>Ocimum gratissimum</i>	Scent leaf	11.60 \pm 3.28	0.056 \pm 0.056	0.760 \pm 0.062	100.281 \pm 11.801	0.066 \pm 0.004	10.603 \pm 3.120	
Oduola	<i>Talinum triangulare</i>	Water leaf	36.108 \pm 5.230	0.062 \pm 0.002	0.492 \pm 0.050	79.034 \pm 9.105	0.318 \pm 0.080	47.306 \pm 8.620	163.320 \pm 18.840
	<i>Vernonia amygdalina</i>	Bitter leaf	13.903 \pm 3.770	0.324 \pm 0.091	0.383 \pm 0.050	107.120 \pm 11.920	0.109 \pm 0.040	13.680 \pm 2.908	
	<i>Amaranthus viridis</i>	Green vegetable	42.042 \pm 0.850	0.550 \pm 0.093	0.723 \pm 0.063	58.320 \pm 6.650	0.618 \pm 0.090	43.355 \pm 8.430	
	<i>Talinum triangulare</i>	Water leaf	32.353 \pm 4.280	0.437 \pm 0.088	0.906 \pm 0.087	69.001 \pm 7.630	0.323 \pm 0.083	39.008 \pm 8.006	
Worgor	<i>Vernonia amygdalina</i>	Bitter leaf	8.869 \pm 2.220	0.043 \pm 0.003	0.291 \pm 0.050	94.321 \pm 10.830	0.088 \pm 0.006	11.826 \pm 3.250	115.437 \pm 11.890
	Range		8.869-42.042	0.035-0.550	0.083-0.906	58.320-107.120	0.046-0.618	10.603-47.306	
	Overall Mean \pm S.D		22.094 \pm 3.960	0.238 \pm 0.060	0.521 \pm 0.090	83.075 \pm 10.140	0.188 \pm 0.040	26.792 \pm 6.100	
	CV		17.923	25.210	17.275	12.206	21.277	22.768	
Safe level (FAO/WHO)			5.00	1.50	30	48	2.50	60	

Source: Alloway (1995).

Table 4 reveals the bioaccumulation factor (BAF) of various heavy metals in the vegetables. In *Jatropha podagrica*, the BAF was Cd > Zn > Fe > As > Cu > Pb; in *Talinum triangulare* it was Zn > Fe > Cd > As > Cu > Pb; in *Amaranthus viridis*, the BAF trend was Zn > Cd > Fe > As > Pb > Cu; in *Ocimum gratissimum*, it was Fe > Zn > Cd > As > Cu > Pb, while in *Vernonia amygdalina*, BAF sequence was Fe > Zn > Cd > As > Cu > Pb. The findings revealed that Zn had the highest BAF in all the vegetables in both seasons. Related results were observed by Do'a [13] where they obtained that Zn had the highest BAF among other metals and the sequence was Zn > Fe > Cd > Ni > Co > Pb. They also observed that the high mobility of Zn with a natural presence in the soil and the low reservation of Zn in the soil than other toxic cations may elevate the BAF of Zn. In a research carried out by

Opaluwa *et al.* [22], the highest BAF of metals was for Cu and the sequence was Cu > Co > Fe > As > Zn > Ni > Pb.

For both seasons, the BAF pattern for heavy metals in the vegetables was in the common sequence of Zn > Fe > Cd > As > Cu > Pb. Among the heavy metals, BAF values were obtained to be higher for Zn, Fe, Cd and As whereas comparatively lower BAF values were present in Cu and Pb. Overall mean BAF values of As, Cd, Cu, Fe, Pb and Zn in dry and wet seasons were lower than one in the vegetables signifying that the vegetables did not accumulate the heavy metals to noticeably harmful levels. Generally, there was little indication of crop contamination by means of chicken operation. The use of poultry manures, poultry litters and agrochemicals may, however, enhance the metal level of unpolluted soils in the future.

Table 4. Mean Bioaccumulation Factor (BAF) of Heavy Metals from Soil to Vegetables taken at the Three Study Sites (Dry and Wet Seasons) ($\mu\text{g/g}$)

Site	Vegetables	As	Cd	Cu	Fe	Pb	Zn	Total
Dry Season								
Agboola	<i>Jatropha podagrica</i>	0.035±0.001	0.317±0.001	0.013±0.001	0.210±0.001	0.008±0.000	0.220±0.001	0.803±0.002
	<i>Talinum triangulare</i>	0.042±0.002	0.243±0.003	0.014±0.000	0.262 ± .001	0.009±0.000	0.391±0.001	0.961±0.008
	<i>Vernonia amygdalina</i>	0.027±0.001	0.046±0.001	0.016±0.000	0.243±0.001	0.008±0.0001	0.234 ± .001	0.574±0.004
Odunola	<i>Ocimum gratissimum</i>	0.020 ± .000	0.045±0.000	0.014±0.000	0.287±0.001	0.002±0.001	0.096±0.000	0.464±0.003
	<i>Talinum triangulare</i>	0.066±0.001	0.048±0.000	0.011±0.000	0.214±0.000	0.009±0.000	0.514±0.001	0.862±0.007
	<i>Vernonia amygdalina</i>	0.025±0.001	0.215±0.002	0.011±0.001	0.310±0.001	0.006±0.001	0.143±0.002	0.710 ±0.005
Worgor	<i>Amaranthus viridus</i>	NA	NA	NA	NA	NA	NA	NA
	<i>Talinum triangulare</i>	0.055±0.000	0.345±0.001	0.013±0.000	0.225±0.001	0.011±0.000	0.498±0.002	1.147±0.017
	<i>Vernonia amygdalina</i>	0.016±0.000	0.038±0.000	0.009±0.000	0.346±0.001	0.007±0.000	0.153±0.001	0.569±0.003
Overall Mean ± S.D		0.033±0.016	0.162±0.036	0.013±0.000	0.262±0.004	0.008±0.000	0.281±0.003	0.759±0.056
Wet Season								
Agboola	<i>Jatropha podagrica</i>	0.025±0.000	0.152±0.001	0.001±0.000	0.115±0.000	0.001±0.001	0.143±0.000	0.437±0.004
	<i>Talinum triangulare</i>	0.030±0.000	0.143±0.001	0.004±0.000	0.169±0.001	0.001±0.0001	0.257±0.002	0.604±0.005
	<i>Vernonia amygdalina</i>	0.020±0.000	0.016±0.000	0.007±0.000	0.160±0.000	0.001±0.000	0.165±0.001	0.369±0.002
Odunola	<i>Ocimum gratissimum</i>	0.016±0.000	0.018±0.000	0.008±0.000	0.183±0.000	0.001±0.000	0.075±0.000	0.301±0.002
	<i>Talinum triangulare</i>	0.052±0.000	0.020±0.000	0.005±0.000	0.144±0.000	0.004±0.000	0.337±0.002	0.562±0.003
	<i>Vernonia amygdalina</i>	0.020±0.000	0.107±0.000	0.004±0.000	0.196±0.000	0.002±0.000	0.097±0.000	0.426±0.003
Worgor	<i>Amaranthus viridus</i>	0.063±0.000	0.238±0.000	0.007±0.000	0.131±0.000	0.011±0.000	0.375±0.001	0.825±0.007
	<i>Talinum triangulare</i>	0.049±0.000	0.189±0.000	0.009±0.000	0.155±0.001	0.006±0.000	0.337±0.001	0.745±0.005
	<i>Vernonia amygdalina</i>	0.013±0.000	0.019±0.000	0.003±0.000	0.212±0.000	0.002±0.000	0.102±0.000	0.351±0.002
Overall Mean ± S.D		0.032±0.000	0.100±0.000	0.005±0.000	0.163±0.003	0.003±0.000	0.210±0.001	0.513 ± .001

Table 5. Mean Enrichment Factor Contents in Soil

Site	Metal	Mean Content ($\mu\text{g/g}$)	Control ($\mu\text{g/g}$)	EF
Dry Season				
Agboola	As	674.82	4.84	139.43
	Cd	1.35	0.04	33.75
	Cu	60.38	5.27	11.45
	Fe	470.20	8.26	56.92
	Pb	47.54	3.03	15.69
	Zn	112.69	12.22	9.22
Odunola	As	634.45	2.69	235.86
	Cd	1.96	0.08	24.50
	Cu	70.14	8.63	8.13
	Fe	477.79	7.78	61.41
	Pb	62.94	6.38	9.87
	Zn	120.69	10.62	11.36
Worgor	As	616.77	5.03	122.62
	Cd	1.46	0.02	73.00
	Cu	68.57	6.44	10.65
	Fe	365.68	6.96	52.54
	Pb	43.46	5.08	8.56
	Zn	96.81	9.03	10.72
Wet Season				
Agboola	As	730.09	6.92	105.50
	Cd	2.14	0.07	30.57
	Cu	91.92	8.38	10.97
	Fe	539.14	17.07	31.66
	Pb	61.52	5.81	10.59
	Zn	133.57	20.03	6.67
Odunola	As	691.90	5.62	123.11
	Cd	3.04	0.11	27.64
	Cu	100.44	11.55	8.70
	Fe	546.96	14.88	36.76
	Pb	73.44	7.81	9.40
	Zn	140.53	17.80	7.89
Worgor	As	666.21	7.73	86.18
	Cd	2.31	0.09	25.67
	Cu	103.54	10.68	9.69
	Fe	445.46	12.83	34.20
	Pb	55.35	8.11	6.82
	Zn	115.76	15.08	7.68

The enrichment factors (EFs) of the poultry farm soils for the heavy metals were present to be in the ranges of As (86.18 to 235.86), Cd (24.50 to 73.00), Cu (8.13 to 11.45), Fe (31.66 to 61.41), Pb (6.82 to 15.69) and Zn (7.68 to 11.36) and in the ranking sequence of $As > Fe > Cd > Pb > Cu > Zn$. In addition, there was a significant variation in EFs contents among the heavy metals ($p < 0.05$). The EF contents higher than 1 signify higher presence and abundance of metals in the contaminated soil. Therefore, subject to the plant nature, there could be possible rise of metal accumulation in plants species planted on the soil [11]. Among the metals evaluated, the severely enrichment were present in instances of As, Fe and Cd for the poultry soils (Table 5).

4. Statistical Analysis

Analysis of variance (ANOVA) was employed to ascertain whether groups of variables had impacts on contents of the mean result found. Sites revealed significant impact on difference among group means of the heavy metals at various farm sites. This signified that there were some extents of contribution of these metals between sites as a result of chicken activities. The correlation coefficient of the metals in the soil samples was revealed in Table 6. There existed strong positive correlations among contents of metals in soil. These correlations were statistically different ($p < 0.05$), indicating common source of contamination, which could be from animal feed additives. Furthermore, positive correlation signifies mutual occurrence and enrichment of the metals in soils. More so, other factors for significant relationship of the metals in soil are similar atomic radii and similar chemical and physical characteristics influencing elemental relationship in soil parent material source. The commonly weak correlations among some metals in soil assessed signified that other sources apart

from chicken activity might have added to metal load in samples like atmospheric deposition.

Table 6. Intermetal and Sampling Points Correlation

	As	Cd	Cu	Fe	Pb	Zn
As	1.00000					
Cd	0.10328	1.00000				
Cu	-0.95904	0.18271	1.00000			
Fe	-0.89185	-0.54203	0.72718	1.00000		
Pb	-0.43579	0.85023	0.67290	-0.01847	1.00000	
Zn	-0.19012	-0.99615	-0.09578	0.61364	-0.80078	1.00000

Agglomeration schedule of cluster analysis (CA) was conducted on results utilizing nearest neighbour linkage and Euclidean distance as a measure of proximity between samples (Figure 2). The hierarchical cluster assay utilizing nearest neighbour method yielded two clusters, between which the variables were statistically ($P < 0.05$) different. The first cluster included Fe and As group and Cu and Pb group. These elements were categorized as anthropogenic in source. The second cluster distinguished the lithogenic Cd. The relationship among the sampling locations between the poultry farms were described utilizing cluster analysis as represented in Figure 2 below. As the samples were collected from the sundry parts of Osun State, variations in soil structure and form, land use nature and trend and ecological factors all presents variations in the content of heavy metals in dissimilar farms areas assessed. Similar analyzes by Ogunwale *et al.* [9] present As to be strongly connected with animal food additives since arsenic roxarsone, Cu and Pb have been noted to be connected with diverse industries and metal smelting practices. In accordance with Ogunwale *et al.* [9], Cu, Fe and Pb were connected with poultry related sources like sanitary products, veterinary medicines, growth hormones, food additives, poultry litters, agrochemical wastes.

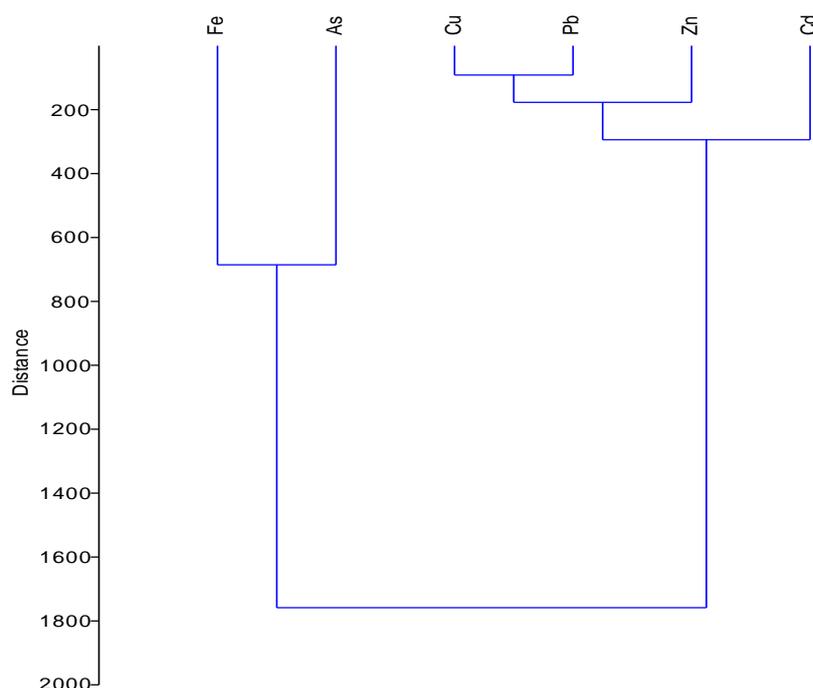


Figure 2. Dendrogram Obtained from Hierarchical Cluster Analysis of Heavy Metals Content in Evaluated Soils

5. Conclusion

The trend of trace element bioaccumulation factor (BAF) was revealed to be intrinsically mild. Part of that trend could be described by the impact of ecosystem on physiological functions subject to the absorption, translocation and accumulation of heavy metals. This work also revealed that the vegetables under study did not present the risk associated with the metal in any form to the people who consume them as they were available to be inefficiency of necessary elements like Cu and Zn. From another point of view, they were present to have higher than allowed limits of metals like As which is toxic metal. The work also established the appropriateness of *Amaranthus viridis*, *Jatropha podagrica*, *Ocimum gratissimum*, *Talinum triangulare* and *Vernonia amygdalina* as a good bioindicators of ecological contaminants with *Talinum triangulare* differentiated as the best phytoremediator of the five plant species. Government of Nigeria should task and resource scientists to enact the maximum permissible levels for heavy metal values in soils and vegetable crops while steps should be adopted to decline heavy metal contamination and nutrient loading of poultry manure and soils to preserve the safeness of both farmers and consumers.

Statement of Competing Interests

The authors declare that they have no competing interests.

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