International Journal of Environment and Pollution Research

Vol.9, No.2 pp.1-24, 2021

Print ISSN: 2056-7537(print),

Online ISSN: 2056-7545(online)

SEASONAL CHEMICAL SPECIATION AND POTENTIAL MOBILITY OF HEAVY METALS IN THE SURFACE SOIL OF SOME POULTRY FARM ESTABLISHMENTS OF OSUN STATE, SOUTHWESTERN NIGERIA

Ogunwale[1], T. O., Oyekunle[2], J. A. O., Ogunfowokan[2], A. O. and Oluwalana[3], A. I.

[1]Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile – Ife-220 005, Nigeria
[2] Department of Chemistry, Obafemi Awolowo University, Ile-Ife-220 005, Nigeria
[3]Facilities Planning and Management (FP&M) Department, Iowa State University, Ames, Iowa-50010, USA

ABSTRACT: *This work examined the presence, availableness and mobility of metals in chosen poultry farm soils areas samples from Osun State. Metals in the stratified soil samples taken in both seasons were in sequence extracted into five phases and content of the extracted metals was conducted utilizing Flame Atomic Absorption Spectrophotometer. Quality control measures involved blank test, spike recovery test and calibration of standards. Descriptive and inferential statistics were adopted for data analyses The range of metals extracted from each of the five soil geochemical phases in mean percentages for both seasons are in this manner: carbonate bound (0.84-19.94), exchangeable (8.43-18.84), Fe-Mn oxide (13.95-21.18), organic matter (21.43-34.14) and residual (15.45-41.48). Potential metals in the examined soils ($mgkg^{-1}$) varies between 3.56-1181.62, 0.05-2.98, 10.72-75.06, 40.38-640.52, 3.32-96.69 and 9.80-219.12 for arsenic, cadmium, copper, iron, lead and zinc, while mean % mobility factors of all the metals in both seasons examined were ranged between 30.54-33.04, 33.29-34.49, 37.11-38.74, 15.37-17.58, 35.02-35.31 and 24.48-27.02 for As, Cd, Cu, Fe, Pb and Zn. In the poultry agro-ecological agriculture, values of metals in available forms do not vary statistically in both seasons. Nevertheless, bulk of the sampled metals have high abundance in residual and organic matter phases and for this reason, may not present ecological threat inasmuch as their overall fairly minor availableness and MFs of the metals in the examined soil.*

KEY WORDS: fractionation, mobility factor, heavy metals, speciation, poultry farmland

INTRODUCTION

The poultry farming is described by its industrialization, rapider increase in intake and market than any other foremost farming sectors in the universe. In accordance with Srivastawa *et al*. (2017), poultry offers a suitable form of animal protein to several people all over the universe. Furthermore, FAO (2010) expressed that poultry meat denotes about 33% of the total global meat input. Scanes (2016) stated also that to lessen child death rate and to improve motherly well-being, in sub-Saharan Africa, poultry products give an exceptional provenance of nutrient (e.g. B_{12}).

Bashahun and Odoch (2015) noted also that poultry meat and egg output is the most ecologically resourceful animal protein productivity system. Poultry and egg sales give direct income and source of self-sufficiency for numerous women who engaged in it.

In the last few years, the poultry farming has contributed splendid changes to meet the rising need for economical and riskless distribution of meat and eggs and this expansion has been enhanced by structural modifications within the field. This is typified by the sudden uprising and development of "land-autonomous" (industrial) agricultural sectors, and the growth and concentration of poultry activities (FAO 2010). The motivating forces behind structural modifications in poultry farmings are no distinct than those that influence other livestock productions: economic pull, modernization and markets of scale (FAO 2010). The ecological effects of poultry product comprise such effects to the end from feed output to animal output and butchering and natural effects on all ecological matrixes – soil, air, water and land, at domestic, national and international levels (FAO 2010).

Soil is one of the vital ecological constituents. Soil is significant as it portions as a mean for plant growth where it can reuse the nutrient and resources required by plant. Heavy metals may be introduced and present in the soil as a result of farming activities like use of poultry manure, therapeutic antibiotic and pesticides, biosolids, inorganic fertilizers and in refuse substances reused to the soil (Ogunwale *et al*., 2021). Soils are the major reservoirs for heavy metals discharged into the environment through aforesaid human activities and unlike organic contaminants which are oxidized to carbon (IV) oxide via bacterial activity, many metals do not undergo bacterial or chemical dissolution, and their total concentration in soils lingers interminably after their introduction (Ogunwale *et al*., 2021). Buildup of heavy metal in the environment turns out to be a health hazard because of their persistency, bioaccumulation and toxicity to floras, faunas and human beings (Ogunwale *et al*., 2020).

The quantification of total heavy metal content of soil samples is not adequate to evaluate the possible mobility and afterwards, the bioavailability of toxic metals to a living organism. Fundamental speciation information is crucial currently for the cause that toxicity and biological reaction of several elements count not on simply on their magnitudes but also on their chemical form (Ogunwale *et al*., 2021). Speciation of heavy metals in soil gives more specific information about the bioavailability of heavy metals. Speciation entails the application of sequential extraction techniques in the determination of chemical forms in which the elements present to be connected with the sample (Ogunwale *et al*., 2021). Speciation entails comprehension and quantification of different specified species, forms or phases in which an element present and is ultimately a role of mineralogical chemistry of sample being analyzed (Ogunwale *et al*., 2021). It can also assist to estimate how intensely they are kept in soil and how readily they may be released into soil solution. Various sequential extraction procedures, for instance the five-step method of Tessier *et al*. (1979; 1988), are usually employed to assess the real and possible mobility of metals in the ecosystem. These heavy metal accumulations may be distinctively influenced by plant absorption, and modifications in their quantities may provide a notion on the device subject to heavy metal

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Print ISSN: 2056-7537(print),

Online ISSN: 2056-7545(online)

absorption in relate to chemical accumulation in the soil (Odoh *et al*., 2011). Contaminating impacts of heavy metals in poultry farmlands depend on their chemical relations. Therefore, quantifying the chemical form of a metal in poultry farmlands is vital to evaluate its mobility and bioavailability.

Metal fractionation in poultry farmland samples within the locality of the poultry farm can give an estimable data to calculate their bioavailability and the ability for contamination of crops. Most research on metal contamination in soils have been conducted with respect to urban sewage sludge utilization, agricultural land, roadside soils and street dusts whereas, scanty work has been conducted regarding metal contribution from poultry farmland waste and poultry manure additional products (Obasi *et al.,* 2013; Odoh *et al*., 2011; Ogunfowokan *et al.,* 2013) specifically in Osun State. Observation from the literature notes explicitly that most previous researches on soil quality in the assessment area of Ejigbo, Isundunrin and Osogbo dwelled more on effect of leachate from domestic waste dumpsites with little or no knowledge to other on-site hygienic ecosystems, especially the impact of on-farm poultry refuse dump. A number of farmers reside within the farms; therefore, their well-being status is very essential for continued food production and economic sustainability (Christopher *et al*., 2017). This knowledge about the mobility of heavy metals in the soil is crucial so as to assess the likely toxicity of metal contamination and the possibility of its remediation in the soil (Odoh *et al*., 2011). It is therefore imperative for the farm expert to be able to determine the heavy metals in the soil at both the available and unavailable forms in order that he could be concentrated in managing the soil in a manner to avert phytotoxicity, or ecotoxicity to soil, vegetation, animals and human health (Adewuyi and Osobamiro 2016). The content of total heavy metals in the environment has been the focal point of most researchers in the in the field of environmental control and assessment because of their toxicity to organisms. Metals are added into a farm soil due to anthropogenic and geogenic activities. The speciation of a metal determines to a large extent, the toxicity of such metals in the environment. In contrast, there is dearth of reference data in respect to heavy metal behaviour in poultry farmlands and most especially on the status of heavy metals pollution in the Nigerian farm establishments (Oyekunle *et al*., 2011). Hence, it becomes crucial to study the levels of heavy metals in the farm soils in Nigeria before elevated level of harmfulness rises.

On the source of the above-mentioned facts, the aims of this study were to conduct in-depth study of the seasonal chemical speciation of As, Cd, Cu, Fe, Pb and Zn in some poultry farmlands of Osun metropolis. These were with a view to evaluating the heavy metal pollution status of the poultry farms soils in the area under study. These metals were chosen on account of their known potential enrichment and noxiousness resulting from anthropogenic activities, especially in poultry ecosystems.

Similar literature studies on the above topic had been reviewed. The subsequent gaps (which this existing work attempts to fulfill) were identified: (i) There are recorded works on soil pollution, most of which occur in Nigeria, but there are just a couple that emphasized on evaluation of farm soil on poultry productions. This work investigated the soil quality attributes of Ejigbo, Isundunrin and Osogbo metropolis with focus on the chemical speciation studies of soil from poultry farm. (ii) This work was a comprehensive study of poultry farms soil quality of soils in Ejigbo, Isundunrin and Osogbo environs, and acts as creative integration of statistic methods to expose the principal contributors to soil pollution in the area. (iii) Another main gap was in the feature of site of the study. Diverse of the literatures studied were conducted on Southwestern region, none focused on the soil quality condition of poultry farm in Ejigbo, Isundunrin and Osogbo community. The similar studies were performed in Osun State and environs occasionally without emphasized on poultry farm soil of these communities. This study was a comprehensive study on the appropriateness of arable lands from poultry community.

METHODOLOGY

Assessment Area

The assessment station involved Ejigbo, Isundunrin and Osogbo poultry farms in Osun State, Southwestern Nigeria. The map of the study area is exhibited in Figure 1, while Table 1 provides the geographical locations of the sampling sites. The assessment station situates within longitudes 004^0 16.095´to 004^0 30.826´E and latitudes 07^0 45.195´and 07^0 53.961´N of the Greenwich Meridian, whilst the ground level is within 311.81 to 357.23 m above water level. It has interstate boundaries with Oyo State to the West, Kwara State to the North, Ondo and Ekiti States to the East whilst Ogun State to the South The clime of the assessment area is of Humid to Sub humid Tropical continental or Derived Savannah group which is characterized by a distinct wet and dry season (Ogunwale et al. 2021). The wet seasons runs between Mid-March to Mid-November in the South and from early April to early November in the Northern area. There is a little dry season spell in August in which there are few intense rainstorms (Ogunwale *et al*., 2021). The two rainfall summits in June and September with a dry spell in August yields the bimodal rainfall of southwestern Nigeria. The dry season remain from early November to end March during which the harmattan winds commonly devoid of moisture pervade the enormous area of the Southwestern region of Nigeria. Rainfall is largely convectional with storms of high force and short period occurring varying from 1110-1277.70 mm (Ogunwale *et al*., 2021). The temperature in Osun is fairly high all through the year. The diurnal ranges are generally greater than the monthly ranges largely in the dry season when temperatures could fall low as 18^0C-21^0C. The highest temperatures are usually recorded in March and April, which is almost 32^0C (Federal Ministry of Agriculture and Rural Development 2012). The prevailing formations in the area are Cretaceous deposits with strata out of Tertiary and Quaternary Period. The major sorts of soils in the assessment areas are Alfisols and Ultisols (Federal Ministry of Agriculture and Rural Development 2012). The assessment stations are agricultural and small-size industrial communities. The poultry farmland occupies over 75% of the studied territories. The farming activity in the studied areas deals mainly with rearing of growers, broilers, layers and crop cultivation like yam, cassava, maize, pepper, okra, leafy vegetables, cocoyam, tomatoes, sweet potatoes, soyabean, cowpea, pawpaw, avocado, cucumber, water lemon, coconut, pineapple, mango, banana, plantain, citrus and oil palm. Farmers in this place unsuitably apply agrochemicals (therapeutic antibiotic, inorganic fertilizer, herbicides

Vol.9, No.2 pp.1-24, 2021
Print ISSN: 2056-7537(print),
Online ISSN: 2056-7545(online)

and pesticides) on their farm land as growth enhancers on birds and to increase crop-productivities without taking cognizance of their effects.

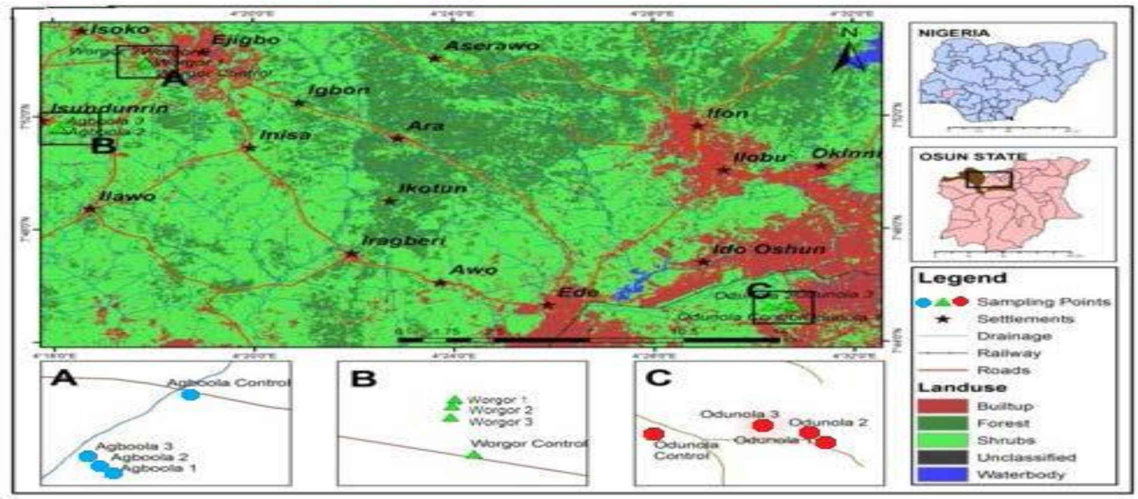

Figure1. Map of the Study Area Presenting Sampling Locations

Sampling Site	Latitude (N)	Longitude (E)	Elevation (m)
Agboola 1	07^{0} 51.540'	004^{0} 16.134'	318.52
Agboola 2	07^{0} 51.563'	004^{0} 16.119'	311.81
Agboola 3	07^{0} 51.587'	004^{0} 16.095'	311.82
Agboola Control	07^{0} 51.767'	004^{0} 16.261'	328.88
Worgor 1	07^{0} 53.961'	004^{0} 17.855'	353.87
Worgor 2	07^{0} 53.948'	004^{0} 17.852'	357.23
Worgor 3	07^{0} 53.927'	004^{0} 17.850'	356.62
Worgor Control	07^{0} 53.857'	004^{0} 17.875'	362.41
Odunola 1	07^{0} 45.196'	004^{0} 30.826'	317.30
Odunola 2	07^{0} 45.243'	004^{0} 30.778'	323.39
Odunola 3	07^{0} 45.290'	004^{0} 30.622'	313.94
Odunola Control	07^{0} 45.223'	004^{0} 30.283'	323.70

Table 1. Geographical Locations of the Sampling Sites

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Print ISSN: 2056-7537(print),

Online ISSN: 2056-7545(online)

Sterilization of Apparatus

All glass, polypropylene tubes and Teflon beakers utilized were initially washed with liquid detergent, cleaned with tap water and distilled water, and then soaked in 10% HNO_3 (v/v) for 48 hours. They were washed again with liquid detergent and rinsed thoroughly with doubly distilled water three times. After that, the apparatus were oven-dried for 12 hours at a temperature of 80^0C (Ogunwale *et al*., 2021).

Reagents Made Use of and their Provenances

All the reagents employed, namely nitric acid (HNO_3), (Riedel-deHaen, Germany), hydrochloric acid, (HCl), (Sigma-Aldrich, Germany), hydrofluoric acid (HF), (British Drug House, BDH, Chemical Ltd, Poole, England), sulphuric acid (H_2SO_4), (Sigma-Aldrich, Germany), perchloric acid ($HClO_4$), (Sigma-Aldrich, Germany), acetic acid (HOAc), (Sigma-Aldrich, Germany), potassium dichromate, ($K_2Cr_2O_7$) pellets (British Drug House, BDH, Chemicals Ltd., Poole, England), magnesium chloride, ($MgCl_2$) pellets (British Drug House, BDH, Chemicals Ltd., Poole, England), hydroxylamine chloride, ($NH_2OH.HCl$) pellets (British Drug House, BDH, Chemicals Ltd., Poole, England), ammonium acetate (CH_3COONH_4) (British Drug House, BDH, Chemicals Ltd., Poole, England) and doubly distilled water, were of high quality. From the list above, reagent I (25% of HOAc comprising 0.04 M $NH_2OH.HCl$ filled in to 1000 mL) and reagent II (3.2 M CH_3COONH_4 and 1.0 M $MgCl_2$) were formulated. These were applied to formulate stock solutions (Ogunfowokan *et al*., 2013).

Sample Collection and Analytical Procedure

Five sampling spots at a distance of 10 m from each other were demarcated from which soil samples were collected within a particular sampling site. Samples were taken during the dry season of 2014 and in the wet season of 2015 making use of clean stainless Dutch soil auger calibrated from 0-15 cm depths (tilling stratum). The sub-sample were taken along autonomous irregular manners to achieve randomness and mixed together to form a composite sample. The Dutch soil auger was cautiously cleaned after each sampling practice, to prevent cross- contamination (Ogunwale *et al*., 2021). The soil sampling spots were cleared of residues before sampling and labelled suitably. Soil samples were air-dried for about 5 to 7 days to avert microbial deterioration in a well-ventilated room in the research laboratory before being crushed in a ceramic mortar and screened in a 2 mm mesh plastic sieve to get fine soil fragments and then preserved in labelled polyethylene bags before analysis (Ogunwale *et al*., 2021). A total of 96 soil samples were brought to the research laboratory for analysis.

Quantification of Total Heavy Metals in the Poultry Farm Soil

Precisely weighed 1.0 g soil sample was digested in Teflon beakers with 30 mL aqua regia (HCl: HNO_3; 3:1) on a thermostated hot-plate between 150 and 180^0C. The content of the Teflon beaker was refilled as needed with more aqua regia to prevent total dryness (Ogunwale *et al*., 2021). After about 2 hours of digestion, the Teflon beaker with its content was taken down from the hot-plate to undergo heating slowly. Subsequently, 5 mL HF was put and digested for additional 30 minutes.

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Print ISSN: 2056-7537(print),

Online ISSN: 2056-7545(online)

The Teflon beaker with the content was let to slightly low to room temperature earlier than the content was determinately transferred into a 25 mL volumetric flask and was filled in to the measure with doubly distilled water (Ogunwale *et al*., 2021). A blank quantification was carried out applying the method explained above not having the sample. The As, Cd, Cu, Fe, Pb and Zn contents were done applying the Flame Atomic Absorption Spectrophotometer (FAAS) PG 990 Model (PG INSTRUMENTS Analytical) by automatic interpolation with respect to the graduation chart at the Chemistry and Industrial Chemistry Laboratory, Bowen University, Iwo, Nigeria (Ogunwale *et al*., 2021).Soil pH was measured potentiometrically in 1 M KCl with a soil/drawn out ratio of 1:5 in three replicates per sample. The organic carbon was quantified using Tiurin procedure. It was oxidized to carbon (IV) oxide with $K_2Cr_2O_7$ back-titration in the presence of H_2SO_4. The unreacted $K_2Cr_2O_7$ was titrated with ammonium ferrous sulphate (FAS). In view of that the average content of carbon in soil organic matter was equivalent to 58%, the correction factor 1.724 was put forth to determine the percentage of organic matter from the content of organic carbon (Uduma and Jimoh 2013).

Sequential Extraction of As, Cd, Cu, Fe, Pb and Zn from Poultry Farmlands

The standard procedure devised by Tessier *et al*. (1979; 1988) as summed up with revision in Ogunfowokan *et al*. (2009) was employed in the extraction. Sequential extraction method was applied to fractionate six metals poultry farmland in the dry and wet seasons into functionally determined geochemical fraction into exchangeable, bound to carbonate, bound to Fe-Mn oxides, bound to organic matter and residual fractions in this analysis. Precisely, measuring 1.0 g of air-dried poultry farm soil sample was exposed to sundry leaching treatments to set apart the heavy metals into five functionally determined fractions (Ogunfowokan *et al*., 2009). All extractions were done in 20 mL polypropylene centrifuge tubes. The subsequent supernatant aqueous layer was carefully filtered into analytic vials and considering for AAS quantification of As, Cd, Cu, Fe, Pb and Zn. When vigorous shaken was required, the samples were agitated lengthwise on a mechanical shaker at 250 oscillations per minute with a strike of 8 cm. Heating of the samples was conducted by means of thermostated hot-plate. Standards for all metals were formulated per extraction stage in the equivalent matrix as the extracting reagent to diminish matrix influences (Ogunfowokan *et al*., 2009). Standard addition procedure and benchmark corrections employing blanks were employed to reduce interfering. At least one duplicate and one spike sample was performed per two samples to ascertain the precision of the procedure. The spike recovery and the precision were obtained within 100±10%. Suitable quality control measures and recovery analysis were conducted. The extractions of the individual fractions were performed on poultry farmland samples from each assessment area in this manner:

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Exchangeable Phase (F_1)

The assessed soil sample was extracted at room temperature with 20 mL of $MgCl_2$ at pH 7.0 for 1 hour, with vigorous shaking. Nevertheless, $MgCl_2$ was applied to prevent an increase in the dissolvability of heavy metals within the soil solution environment.

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Print ISSN: 2056-7537(print),

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Carbonate-bound Phase (F_2)

The filtrate out of F_1 was extracted at room temperature with 20 mL of 1 M NaOAc solution modified to pH 5.0 with HOAc. Vigorous shaking was maintained for 5 hours.

Fe-Mn Oxides-bound Phase (Reducible) (F_3)

The filtrate out of F_2 was extracted with 20 mL of 0.04 M $NH_2OH.HCl$ in 25% (v/v) HOAc at 96±10^{0}C with occasional shaking for 5 hours.

Bound to Organic Matter (Oxidizable) Phase (F_4)

To the filtrate out of F_3 was put 7.5 mL of 0.02 M HNO_3 and 12.5 mL of 30% H_2O_2 modified to pH 2.0 with HNO_3. The mixture was made warm to 85^{0}C for 2 hours with occasional shaking. A second 7.5 mL aliquot of 30% H_2O_2 was put and made warm up more for 3 hours at 85^{0}C with sporadic shaking. Following temperature reduction, 12.5 mL of 3.2 M CH_3COONH_4 in 20% (V/V) HNO_3 was put to avoid the accumulation of extracted metals into the oxidized sediments and the mixture was diluted to 40 mL. Vigorous shaking for 30 minutes then followed.

Residual Phase (F_5)

The filtrate from F_4 was digested with 15 mL concentrated HNO_3 and later heated for 1 hour, filtered and washed with 10 mL of hot 3 M HNO_3. It was made up to 50 mL distilled water.

Mobility Factor of Heavy Metals

The association used by dint of Ogunfowokan *et al*. (2009) was applied to quantify the mobility factor of the metals in soil samples, in which instance

$$\%MF = \frac{sum\ of\ labile\ phases}{sum\ of\ all\ phases} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [1]$$

wherein MF is the mobility factor, sum of labile phases are F_1 and F_2 while sum of all phases are F_1 to F_5, respectively while also F_1 = Exchangeable metal concentration phase; F_2 = Metal concentration bound to carbonate phase; F_3 = Metal concentration bound to Fe-Mn oxide phases; F_4 = Metal concentration bound to organic matter phase and F_5 = Residual metal concentration phases.

RESULTS AND DISCUSSION

Result of Mean Physico-chemical Variables and Total Heavy Metals in the Soil

The mean pH of the soils in both seasons (Table 2) assessed ranged from 7.20–8.10 and 7.02-7.28, respectively, signifying neutral, slightly alkaline and moderately alkaline. The mean total organic carbon (TOC) value in both seasons (Table 2) varied from 0.62–1.90%.and 0.79-1.99%, respectively. Table 2 also reveals the mean total organic matter in dry and wet seasons ranged between 1.07-3.27% and 1.37-3.42%, respectively. Result of total As, Cd, Cu, Fe, Pb and Zn, in dry and wet seasons soils in some poultry farm of Osun State were presented in Table 3, while that of individual sequential extraction fractions of these heavy metals with Tessier procedure were revealed in Figures 2 to 7, respectively.

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Print ISSN: 2056-7537(print),
Online ISSN: 2056-7545(online)

The variation in pH of the soils (Table 2) intensify the displacement of the ions H^+ accumulated on the exchange sites of the absorbing composite from soil towards the soil solution. pH is one of the variables which influence the bioavailability and the transport of heavy metal in the soil and in accordance with (Borjesson and Katterer, 2018), heavy metal mobility reduces with increasing soil pH as a result of precipitation of hydroxides, carbonates or deposition of insoluble organic complexes. Heavy metals are largely more active at pH <7 than at pH >7. The amount of heavy metals mobilized in soil biota is a role of pH, attributes of metals, oxidation-reduction states, soil chemistry, organic matter concentration, clay level, cation exchange capacity and other soil parameters (Uduma and Jimoh 2013). The matrix organic carbon and organic matter concentration is as a result of crop remains and poultry manure applied in the farmland which bring about augmented decomposition in the soils and action of earthworms.

The mean total level (mgkg^{-1}) of As, Cd, Cu, Fe, Pb and Zn in both seasons were found in the range of 3.56-1181.62, 0.05-2.98, 10.72-75.06, 40.38-640.52, 3.32-96.69 and 9.80-219.12, respectively (Table 3). The permissible level of As, Cd, Cu, Fe, Pb and Zn in the soil is between 20-40, 1-3, 50-140, 400-5000, 50-300 and 150-300, mgkg^{-1}, respectively (FAO/WHO 2011). The values of all the metals analyzed apart from As were considerably below the tolerable limits. Prevailing man-made practices that have increased contents of As in the poultry farmland are uses of As encompassing pesticides and animal manure (for instance Roxarsone (3-nitro-4-hydroxyphenylarsonic acid) in poultry drop and as the wood additive chromated copper arsenate (CCA). Arsenic was extensively used as a pesticide in the form of lead arsenate Ca_3AsO_4, Paris-Green (copper acetoarsenite), H_3AsO_4, MSMA (monosodium methanearsonate), DSMA (disodium methanearsonate), sodium arsenite, organic arsenical herbicides and cacodylic acid (Ogunwale *et al*., 2021). These products were employed to eradicate insect and plant pests in the soil and its comprehensive application has resulted into localized soil As contents of 516.98 – 956.78 mgkg^{-1} (Ogunwale *et al*., 2021). The application of As in the form of Roxarsone in poultry feed to handle parasites and induce the efficiency of eggs in poultry has increased total As value by 14-76 mg kg $^{-1}$ in poultry drop (Donald 2010). The use of this waste onto soil can thereby elevate the As contents in the soil which is a routine practice in the area under studied. Probably the most general but ignored source of As in the soil is from the widespread utilization of CCA preserved lumber, which can largely increase As contents in soils subsequent to where it is applied, where the treatment process occurred, or where inappropriately discarded (Ogunwale *et al.,* 2021). To meet dietary prerequisites, different micro-elements are incorporated in feeds and preservatives for poultry beyond the bird’s require. Use of these chemical in deliberately adds potentially toxic metals to the soil.

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Print ISSN: 2056-7537(print),

Online ISSN: 2056-7545(online)

Sampling Site	pH	%TOC	%TOM
	Dry Season		
Agboola 1	7.65±0.23	1.89±0.13	3.26±0.23
Agboola 2	7.20±0.20	1.75±0.14	3.02±0.22
Agboola 3	7.50 0.22	1.06±0.11	1.83±0.16
Agboola C	7.30±0.20	0.72±0.10	1.24±0.13
Odunola 1	8.10±0.25	1.77±0.12	3.05±0.20
Odunola 2	7.60±0.23	1.80±0.13	3.10±0.21
Odunola 3	7.80±0.24	1.90±0.16	3.28±0.24
Odunola C	7.70±0.24	0.83±0.14	1.43±0.14
Worgor 1	7.63±0.23	1.63±0.12	2.81±0.20
Worgor 2	7.49±0.20	1.55±0.11	2.67±0.19
Worgor 3	7.56±0.21	1.32±0.1	2.28±0.17
Worgor C	7.55±0.22	0.62±0.09	1.07±0.13
Min.	7.20	0.62	1.07
Max.	8.10	1.90	3.28
Overall mean	7.59	1.40	2.42
SD	0.22	0.15	0.19
CV	2.90	10.71	7.85
	Wet Season		
Agboola 1	7.26±0.09	1.95±0.18	3.36±0.21
Agboola 2	7.03±0.06	1.82±0.16	3.14±0.20
Agboola 3	7.15±0.08	1.38±0.11	2.38±0.18
Agboola C	7.21±0.07	0.91±0.10	1.57±0.14
Odunola 1	7.18±0.06	1.84±0.17	3.17±0.19
Odunola 2	7.20±0.07	1.91±0.18	3.29±0.23
Odunola 3	7.12±0.06	1.99±0.20	3.43±0.24
Odunola C	7.02±0.05	0.88±0.10	1.52±0.16
Worgor 1	7.23±0.08	1.71±0.15	2.95±0.18
Worgor 2	7.26±0.07	1.62±0.14	2.79±0.17
Worgor 3	7.13±0.06	1.51±0.13	2.60±0.16
Worgor C	7.28±0.09	0.79±0.1	1.36±0.13
Min.	7.02	0.79	1.37
Max.	7.28	1.99	3.42
Overall mean	7.17	1.53	2.63
SD	0.08	0.12	0.16
CV	1.12	7.84	6.08
Annual mean	7.38	1.47	2.52

Table 2. Mean Physico-chemical Variables of Poultry Farms Surface Soil Samples for the Dry and Wet Seasons

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Print ISSN: 2056-7537(print),

Online ISSN: 2056-7545(online)

Sampling Site	As	Cd	Cu	Fe	Pb	Zn	Total metal load
				Dry Season			
Agboola 1	957.10±61.03	2.33±0.18	47.78±7.65	275.60±20.53	67.30±12.25	120.45±18.05	1470.56
Agboola 2	1048.09±72.18	1.84±0.13	53.50±7.72	374.83±25.41	63.60±11.50	113.65±16.43	1655.51
Agboola 3	675.19±50.26	1.95±0.15	55.83±7.90	425.55±27.10	59.53±10.40	167.45±20.31	1385.5
Agboola C	5.48±0.86	0.08±0.03	10.72±2.54	42.18±5.52	3.32±0.86	11.60±2.50	73.38
Odunola 1	572.80±52.13	2.82±0.20	48.50±7.68	428.30±27.23	74.10±14.30	128.91±18.50	1255.43
Odunola 2	454.30±48.10	1.52±0.12	61.23±8.14	366.52±25.36	58.50±10.32	104.80±16.28	1046.87
Odunola 3	403.60±46.11	2.09±0.15	58.25±7.96	530.26±28.50	66.73±12.20	148.39±19.50	1209.32
Odunola C	3.56±0.26	0.06±0.02	13.17±2.65	46.20±5.70	6.88±1.63	13.26±2.70	83.13
Worgor 1	540.18±49.28	1.77±0.14	54.26±7.79	512.30±27.80	60.90±11.20	183.38±22.18	1352.79
Worgor 2	515.10±50.08	1.75±0.13	48.60±7.70	362.12±25.35	57.65±10.25	141.91±19.20	1127.13
Worgor 3	582.63±51.26	1.79±0.15	59.36±8.06	582.13±28.70	68.40±12.30	146.26±19.45	1440.57
Worgor C	4.80±0.38	0.05±0.01	11.28±2.62	40.38±5.50	5.16±1.53	9.80±2.10	71.47
Min.	3.56	0.05	10.72	40.38	3.32	9.80	71.47
Max.	1048.09	2.82	61.23	582.13	74.10	183.38	1655.51
Overall mean	480.24	1.50	43.54	332.20	49.34	107.49	1014.31
SD	50.75	0.10	6.83	25.90	10.93	16.20	120.37
CV	10.57	6.67	11.15	7.80	22.15	15.07	11.87
			Wet Season				
Agboola 1	1040.30±28.65	2.42±0.15	55.62±8.96	313.32±30.98	87.60±15.14.08	150.11±20.30	1649.37
Agboola 2	1181.63±32.40	2.63±0.18	61.12±9.10	444.70±31.35	81.68±13.69	142.06±19.80	1913.81
Agboola 3	735.28±23.50	2.14±0.12	64.38±9.30	490.15±32.70	77.20±11.08	196.05±22.60	1565.2
Agboola C	8.10±1.30	0.09±0.02	15.20±3.60	45.28±8.40	5.26±1.80	18.13±3.10	92.06
Odunola 1	645.20±22.08	2.98±0.20	68.80±9.80	504.38±35.10	96.67±16.20	158.09±21.90	1476.14
Odunola 2	501.61±22.00	2.09±0.13	71.03±9.86	378.45±32.40	73.07±11.03	129.60±18.60	1155.85
Odunola 3	430.51±21.48	2.73±0.19	75.06±9.93	608.37±40.20	92.28±15.69	174.80±22.30	1383.75
Odunola C	6.40±1.20	0.08±0.02	18.28±3.87	50.93±9.50	7.08±2.08	17.20±3.05	99.97
Worgor 1	626.80±21.90	2.06±0.11	58.15±8.99	605.27±39.80	72.25±11.40	219.12±26.60	1583.65
Worgor 2	592.48±22.10	2.43±0.14	62.08±9.10	419.30±31.26	76.06±11.60	166.28±21.80	1318.63
Worgor 3	647.90±22.50	2.30±0.12	65.13±9.75	640.52±41.40	88.32±13.70	181.20±20.30	1625.37
Worgor C	6.95±1.23	0.07±0.01	19.66±3.93	48.20±9.40	7.66±2.2.05	14.03±2.20	96.57
Min.	6.40	0.07	15.20	45.28	5.26	14.03	92.06
Max.	1181.62	2.98	75.06	640.52	96.67	219.12	1913.81
Overall mean	535.26	1.84	52.88	379.07	63.76	130.56	1163.37
SD	64.93	0.13	8.95	30.93	12.74	18.69	142.09
CV	12.13	7.07	16.93	8.16	19.98	14.32	12.21
Annual mean	507.75	1.67	48.21	355,64	56.55	119.03	
Permissible limit	20	3	100	5000	100	300	

Table 3. Mean Total Metal Levels in the Soil of the Area under Study Dry and Wet Seasons (mgkg^{-1})Mean Heavy Metals Fractionation among the Soil Geochemical Phases

All the heavy metals evaluated in this study were found in the five geochemical phases. The residual fractions contain a significant amount of all the metals assayed. Heavy metals (As, Cd, Fe, Pb and Zn) fractionated in residual fractions contain the highest percentage i.e., for dry season: As (25.39), Cd (26.29), Fe (41.48), Pb (25.07) and Zn (31.42) and in wet season: As (25.61), Cd (24.71), Fe (38.46), Pb (23.82) and Zn (31.54) (Table 4). In the dry and wet seasons Cu (25.93 and 25.90) contained the uppermost percentage in organic matter fraction.

This corroborates the results of Elijah et al. (2020), who expressed that highest proportion of As, Cd, Fe, Pb and Zn were present in residual fraction, respectively, while Singh (2011) expressed that highest proportion of Cu was present in organic matter component. The highest proportion of heavy metals present in residual form may be as a result of the chemical structure of the source rock of tropical derived savannah soils fertile in silicates minerals (Adewuyi and Osobamiro 2016). The association of elevated content of metals with this fraction is as a result of buildup of these metals via the silicates mineral surface (Ogunbanjo *et al*., 2016). Elevated percentage amount of metals in the residual phase has been described to be influenced by means of the high content of silicates deposits in the soil (Adewuyi and Osobamiro 2016; Ipeaiyeda and Ogungbemi 2020) and may restrict the mobility and bioavailability of heavy metals tied to these inorganic materials.

On the other hand, metals in residual phase can be regarded moderately more immovable to ecological variations considering metals in all the first four phases, which are usually reactive pertaining to metal dynamics measure (Akinyemi et al., 2012; Elijah *et al*., 2020). Rainfall and disintegration reactions control the availableness of metals in soils because they are present in substantial amounts in tropical derived savannah soils. Metals inherent in the mineral lattice layer of silicates and well crystallized oxide materials are expected to be released in acidic forms because; moderately slight variations in oxidation-reduction toward acidic forms would result in decrease of silicates types resulting into dissolution of inherent metals (Hollingsworth *et al*., 2021). The phase can be adopted as a reference to the extent of contamination of the soil. The smaller the proportions of the metal found in this phase, the greater the contamination of the area (Elijah *et al*., 2020).

Soil oxidation-reduction reaction , neutral in soil pH and moderate to high organic matter assisted to hold some significant phase of metals contents as residual (immovable), which afterwards cause more metals distributed again to not available conditions (Dabrowska, 2012) and consequently, cause metal less mobility. The percentage of metals extracted in residual phase in both seasons generally follows this sequence: Fe>Zn>Cd>As>Pb>Cu. This corresponds to the work of Ramirez *et al*. (2020), who noted that As, Cd, Fe, Pb and Zn were largely held by the residual phase. The residual phase of Fe is a crucial depository of Fe in the soil assayed. This result is corresponding to the results of many scholars, who obtained the maximum percentage of Fe in the residual phase (Iwegbue 2011; Ololade *et al*., 2015; Otabor 2019). The uniformity of Cu with organic phase is attributable to its strong tendency to form biological composites and accumulate to biological colloids (Loganathan *et al*., 2012a). Regardless of the account that Cu seems possibly less bioavailable, its persistency in chicken farm soil suggests it may be subjected to stabilization as a result of either bacterial disintegration of organic material as a result of high levels of microbial action in soil-water runoff, or variations in pH and oxidation-reduction forms, like the oxidizing background that is encountered during soil passage at the early phases of a sampling (Haynes *et al.*, 2020). Intermediary between the residual and the exchangeable phases are the other two phases, oxidizable and reducible, which are less mobile than exchangeable phase. Nevertheless, the heavy metals in these phases can be released to the environment with changes in oxidation-reduction reaction, pH, and temperature of the water and soils infiltration in the course of runoff.

To end with, results of the speciation study revealed that the highest levels of As, Cd, Cu, Fe, Pb, and Zn in the poultry farmland of the area under study for dry and wet seasons found most in the residual phase. Fractionation frameworks revealed that a major proportion of metals were identified with the residual phase at all sites (25.39% and 25.61% As, 26.29% and 24.71% Cd, 17.62% and 15.45% Cu, 41.48% and 38.46% Fe, 25.07% and 23.82% Pb, 31.42% and 31.54% Zn) (Table 4). This implies that in poultry farmland, the metals mainly present in the immobile phase, which is not easily bioavailable; so, they do not cause elevated environmental hazard. The increased percentages of residual phase most likely reveal the geological attributes of the samples (Adewuyi and Osobamiro 2016). Generally, Fe and Zn contained the maximum percentage of residual phase. Several other scholars have also recorded elevated percentages of metals in the residual phase of soil and sediment. For instance, for soil and sediment from Tokyo, Kumar *et al.* (2010) found 60-90% of Cu, Zn, Pb, and Cd in the residual phase; and for agrarian soil and sediment from the North Eastern States of India, Singh (2011) recorded 40-80% of Fe, Mn, Cu, Ni, Pb, Zn, Cr, and Co in the residual phases. Thus, the only possible lithogenic origin of heavy metals at poultry environs was poultry operations (Ogunwale *et al.*, 2021). Various operations that take place in and around poultry’s like packing and discharging of commodities, cleaning, fuelling, maintenance practice which include repairing of poultry pen house, roof, fence, battery cage, brooder box, hovers, lamp (kerosene lamp), laying boxes, egg trays, delousing, deworming, vehicle, servicing of generator and grinding machines emissions, agricultural activities, application of agrochemicals, therapeutic antibiotics, agricultural runoff, bush burning, uncontrolled deforestation for poultry expansion to be influencing factors to the dumping of noticeable quantities of refuses openly into the land (Okoro *et al.*, 2012).

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Online ISSN: 2056-7545(online)

Phase	As	Cd	Cu	Fe	Pb	Zn	Total
Dry Season							
Exchangeable	17.24	14.75	18.48	17.47	16.41	8.43	92.78
Carbonate bound	9.75	16.39	18.75	0.84	18.87	12.48	77.08
Fe-Mn Oxide	18.55	21.31	19.22	13.95	17.84	13.54	104.41
Organic matter	23.97	22.95	25.93	26.25	21.84	34.14	155.08
Residual	25.39	26.29	17.62	41.48	25.07	31.42	167.27
Wet Season							
Exchangeable	18.84	15.29	18.64	18.24	17.56	11.71	100.28
Carbonate bound	11.20	16.47	19.94	1.13	19.33	13.06	81.13
Fe-Mn Oxide	19.51	21.18	20.14	15.27	17.86	14.26	108.22
Organic matter	24.81	22.35	25.90	26.91	21.43	31.10	152.50
Residual	25.61	24.71	15.45	38.46	23.82	31.54	159.50

Table 4. Mean Percentage Metals in Various Geochemical Phases of the Poultry Farm Soil

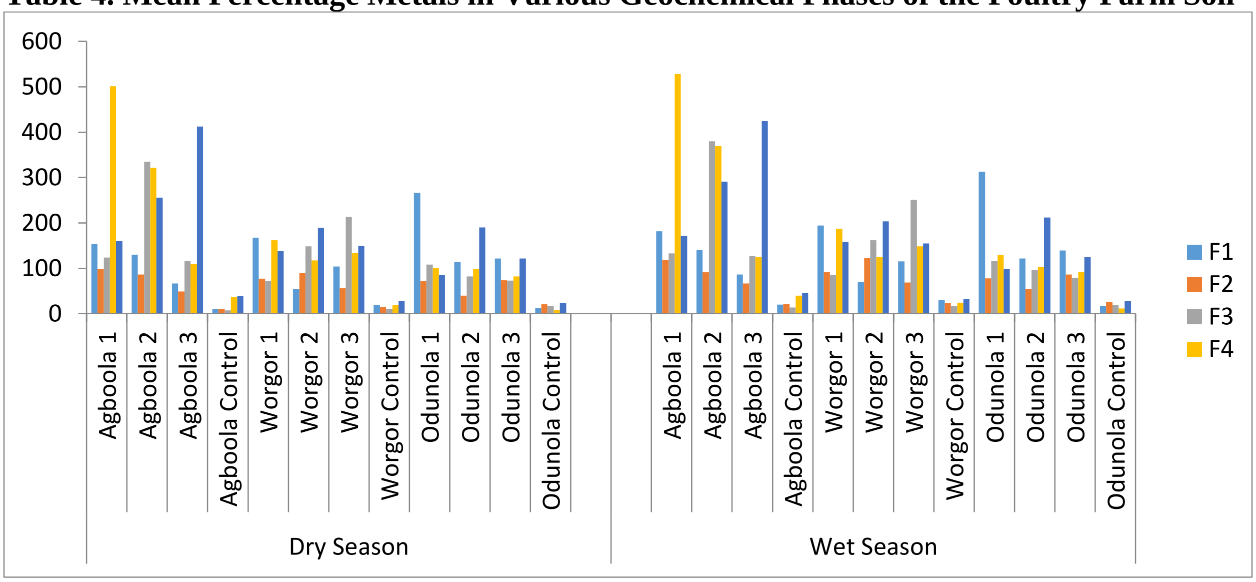

Figure 2. Mean As Levels (mg/kg) in Various Geochemical Phases in Poultry Farm Soils Samples in the Study Site (Dry and Wet Seasons)

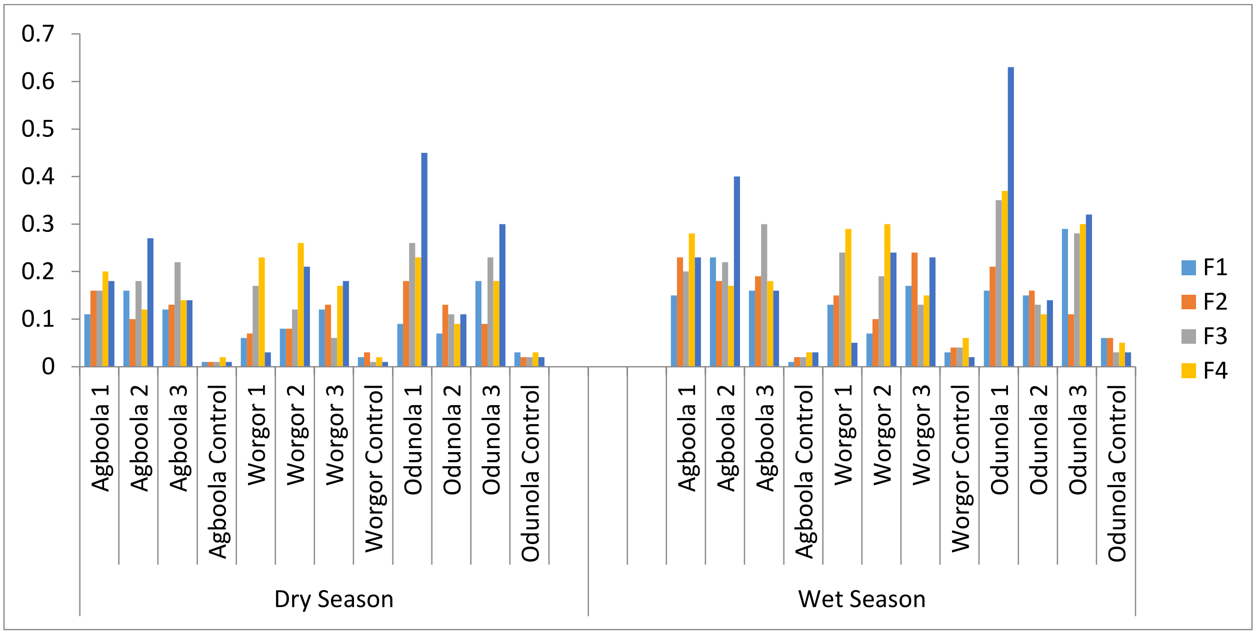

Figure 3. Mean Cd Levels (mg/kg) in Various Geochemical Phases in Poultry Farm Soils Samples in the Study Site (Dry and Wet Seasons)

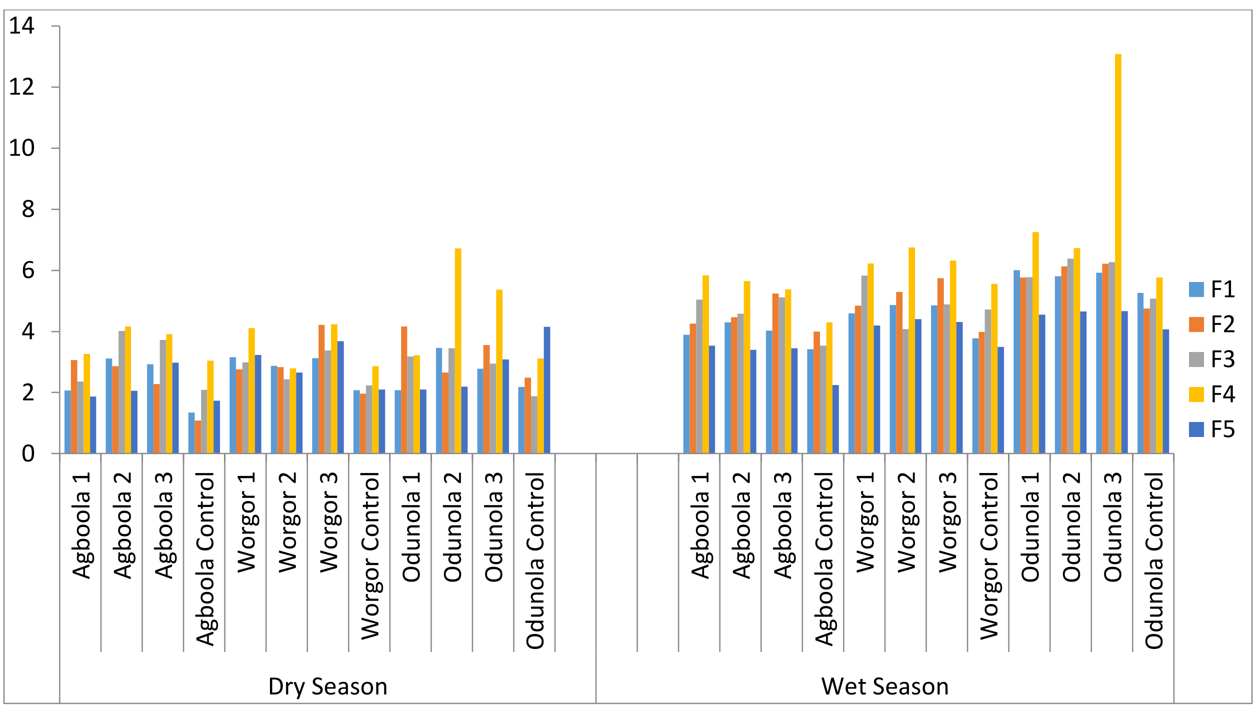

Figure 4. Mean Cu Levels (mg/kg) in Various Geochemical Phases in Poultry Farm Soils Samples in the Study Site (Dry and Wet Seasons)

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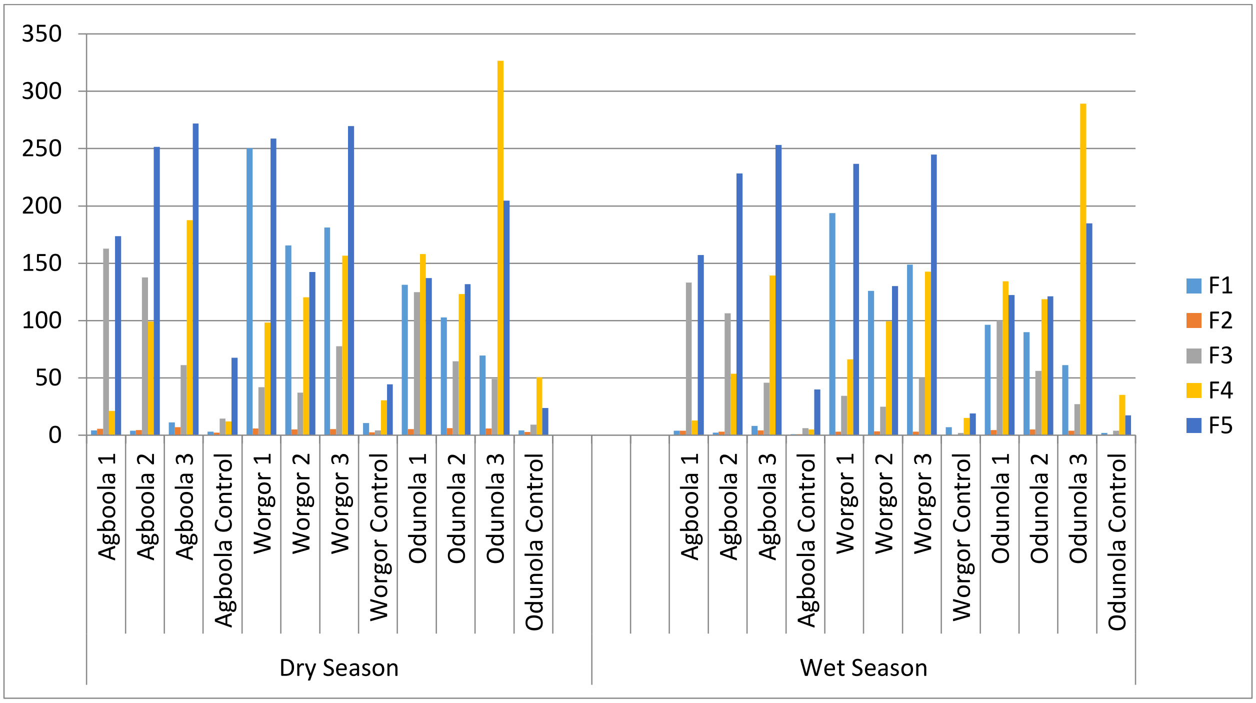

Figure 5. Mean Fe Levels (mg/kg) in Various Geochemical Phases in Poultry Farm Soils Samples in the Study Site (Dry and Wet Seasons)

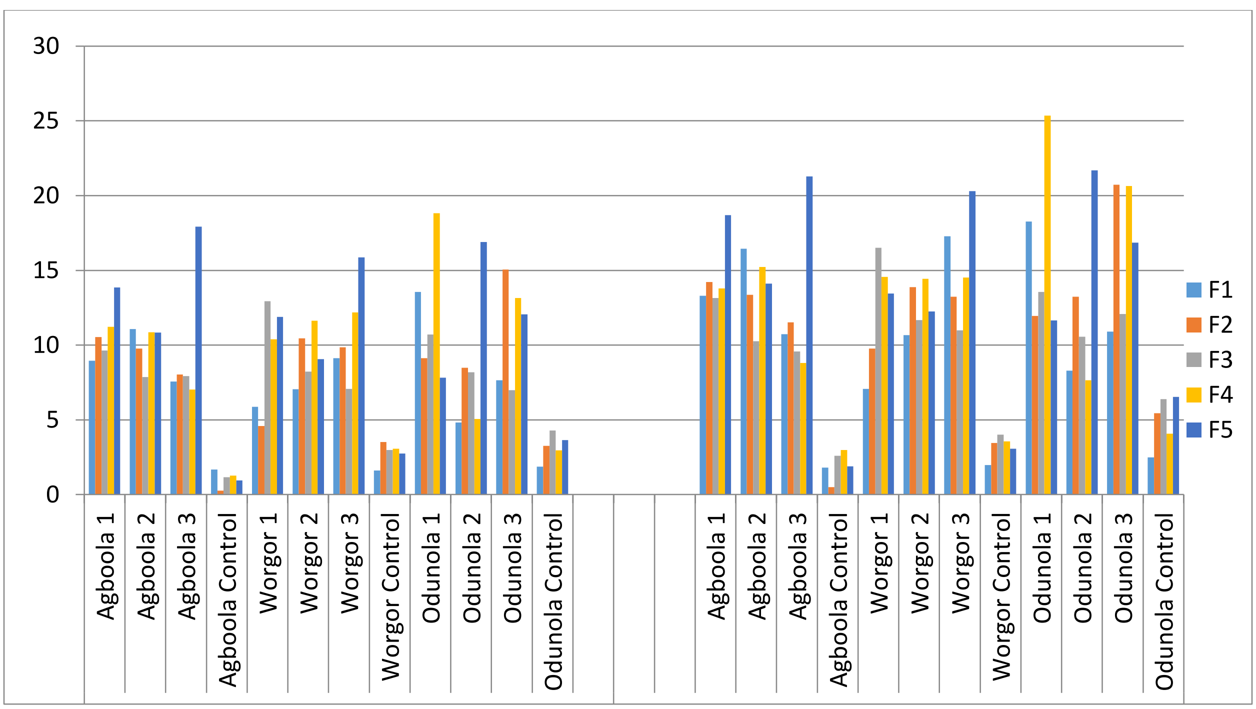

Figure 6. Mean Pb Levels (mg/kg) in Various Geochemical Phases in Poultry Farm Soils Samples in the Study Site (Dry and Wet Seasons)

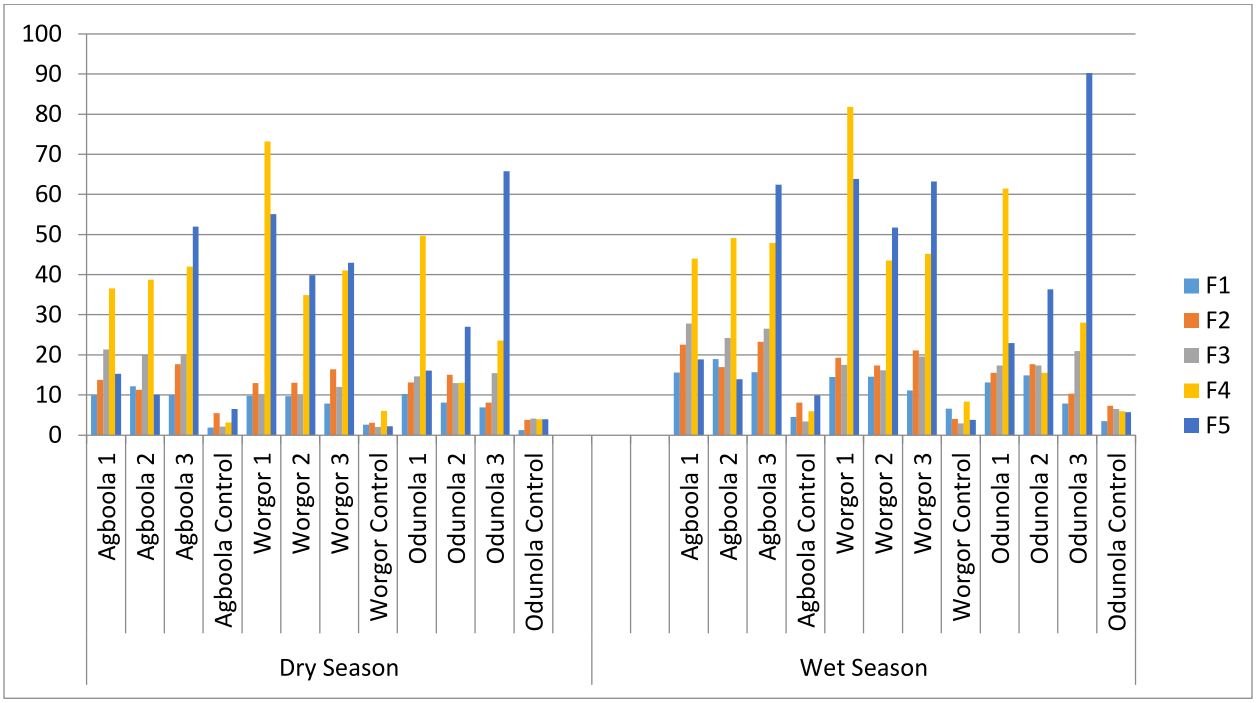

Figure 7. Mean Zn Levels (mg/kg) in Various Geochemical Phases in Poultry Farm Soils Samples in the Study Site (Dry and Wet Seasons)

Mean Available and Mobility Factors of the Metals in Soil

Mobility of a metal is a measure of its bioavailability. Mobility of a metal is measured by how much of it is available in the first two geochemical phases (the labile phases), in relation to how much of the metal is available in all the five phases. It measures the relative quantity of the metal weakly bound to the soil constituents (Adewuyi and Osobamiro 2016).

Total metals quantification for both seasons in the studied site follows this pattern: As Fe<Zn<Pb<Cu<Cd, while mobility factors of these metals in soil for dry and wet seasons follow similar pattern: Cu<Pb<Cd<As<Zn<Fe (Table 5). The mobility factor (MF) differed in individual soils and among metals (Adewuyi and Osobamiro 2016). Medium %mobility factor (%MF) might be inferred as indicator of fairly low likelihood and low ecological availableness of heavy metals (Ogunfowokan *et al*., 2009; 2013; Adewuyi and Osobamiro 2016) as revealed in all the sampled soils. Metals under assessment are more mobile in wet season in comparison to dry season. Reduction in temperature, pH, elevated precipitation (rainfall), oxidation-reduction transformation and increase breakdown of organic material in wet season may explain high MF indexes and high levels of heavy metals observed in wet season. While elevated temperature, pH, low precipitation

(rainfall), dwindle breakdown of organic material and plant uptake might explain the reduction in heavy metal levels in the dry season (Table 3). The certainty that higher levels of the metals extracted were obtained in residual and organic phases, which are not easily mobile may justify the medium MF values of the studied soils since, mobility and bioavailability of metals are commonly determined by means of organic material and clay deposits, which serve as major adsorbent materials (Ogunfowokan *et al*., 2013; Ajala *et al*., 2014).

Moderate levels of heavy metals present in labile phases in poultry farmlands may be resulting from the fact that poultry industries are more continually cultivated contrasted to control site. Cultivating, ridging, furrowing, and dumping of chicken dropping all-year round uncover the soil from rhizosphere to top surface and bury organic material into the soil. Organic material which consist humus, humic acid and fulvic acid with high chelating quality provide more binding surfaces for heavy metals accumulation. Heavy metals that are bonded to these biological components may become available because some of them are water soluble. Tilling and harrowing also enhances aeration thereby rising oxygen content in the soil which enlarges vertical water system and absence of oxygen is dwindled (Adewuyi and Osobamiro 2016). The utilization of farming implements also enhances exposure to sunshine and accelerates photo-redox transformations, which speeds up release of metals ascribed to primary and secondary mineral components in the soil. Deterioration of organic material under oxidizing forms can result in release of soluble trace metals bound to this constituent (Ogunfowokan *et al.*, 2009; Adewuyi and Osobamiro 2016). As metals are removed with crops during harvest in farmed soils, emptiness are created in the soil solution, rearrangement from the other soil components is emanated in other to maintain balance in the soil (Adewuyi and Osobamiro 2016).

On the other hand, the quantity of As in labile phase in both seasons is moderate, its %MF is low, meaning that less As is mobile in the soil and may not be easily translocated to the plant. Cadmium is among the moderate bioavailable in the sampling point for both seasons. This might be owing to the attributes of the poultry farmland, the sources of Cd and mild rate of evaporation that might occur during the sampling period. Ali *et al*. (2019) inferred that Cu moves via the soil in the organic phase. They also expressed that the conduct of Cu was closely related to its tendency for organic material. The Fe contains the lowest MF in both seasons. This may be resulting from the point that more Fe is occluded in the residual phase, which is immovable in the soil. Medium level of Pb in available phase and low mobility in the soil may establish the view that Pb is immovable in soil and when released to soil; it is normally transformed from soluble Pb compounds to fairly insoluble SO_4^{2-} or $PO_4^{3-}$by-products (Fadiran *et al*., 2014; Adewuyi and Osobamiro 2016). It also makes up complexes with organic material and clay deposits, which restricts its mobility. The amount of Zn in soils is at least an extent greater than the amount of some other metals in the sample. Its concentration in the soil solution is normally smaller in comparison with total amount. Zinc readily complexes with organic and clay materials, but its soluble conditions are very mobile and easily available for plants, especially under slightly acidic forms (Ogunfowokan *et al*., 2013).

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Print ISSN: 2056-7537(print),

Online ISSN: 2056-7545(online)

The mobility factor (MF) values of the metals in all the sites for both seasons follow the sequence: Cu>Pb>Cd>As>Zn>Fe. These values do not follow any particular pattern concerning poultry surface soil depth. Related result was noted by Osakwe and Egharevba (2008). The moderately high mobility factor (MF) recorded for Cu is fairly in harmony with the high percentage of oxidizable phase considered from the chemical fractionation findings. The low %MF value found in some sites is therefore an indication of the high stability of these metals in the samples for both seasons (Ogunfowokan *et al.*, 2013). A medium % MF value for heavy metals in the poultry farmlands for dry and wet seasons have been extrapolated as an evidence of moderately slight tendency and ecological availableness (Ogunfowokan *et al.*, 2013). In general, the mobility factors in all the study seasons were under 100, signifying low contamination owing to the metals.

The chemical partition of the metals studied revealed the geochemical attribute of the six heavy metals and their possibility interaction with manifold chemical phases in the soils around the chicken farms. The findings revealed that the heavy metal concentrations present in the residual phase was higher than those took into account in any of the preceding extractions exclude in the instance of Cu where organic phase prevalent and are strictly and after that Fe-Mn oxides. The heavy metal partition findings given an entire depiction that high percentages of the metals were present to be intensely bound to soil medium i.e. in a condition not easily present for releasing into the food chain exclude Cu.

This awesome significance of the residual phase in this research elucidates clearly the difficulty of differentiating between benchmark and anomalous concentrations of heavy metal contamination when just total metal analyses are conducted. The fairly high mobility factor found in Cu affirms the high susceptibility and ecological availableness of Cu in some of the soils studied. This study reveals that the metals studied do not present ecological threats since the total metal content of Cu which demonstrated high susceptibility and ecological availableness in this research was very low. Subsequently, farmers can be encouraged to repossess and utilize the sites for farming, manufacturing, commercial and construction, household and school purposes in a sustainable manner.

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Online ISSN: 2056-7545(online)

Sampling Site	As	Cd	Cu	Fe	Pb	Zn
			Dry Season			
Agboola 1	24.28	33.33	40.65	2.53	35.95	24.39
Agboola 2	19.21	31.33	36.87	1.31	41.35	25.43
Agboola 3	15.32	33.33	32.93	2.71	32.18	19.55
Agboola Control	19.43	33.33	26.16	2.94	36.40	38.34
Worgor 1	39.68	23.21	36.43	36.87	22.91	14.07
Worgor 2	24.01	21.33	42.00	33.70	37.73	21.14
Worgor 3	24.39	37.31	39.38	25.78	35.10	20.16
Worgor Control	35.66	55.56	35.94	16.69	36.83	35.45
Odunola 1	53.37	22.31	47.01	22.04	37.76	22.55
Odunola 2	29.22	39.22	34.28	24.25	30.64	30.39
Odunola 3	41.41	27.55	33.67	11.48	41.37	12.55
Odunola Control	40.50	41.67	39.95	4.15	32.06	29.76
Range	19.43-53.37	21.33-55.56	26.16-47.01	1.31-36.87	22.91-41.37	12.55-38.34
Overall mean ± S.D	30.54 ± 0.74	33.29 ± 0.88	37.11 ± 1.04	15.37 ± 0.40	35.02 ± 1.03	24.48 ± 0.55
CV	2.42	2.64	2.80	2.60	2.94	2.25
			Wet Season			
Agboola 1	26.49	34.86	36.13	2.68	37.62	29.59
Agboola 2	18.22	34.17	39.15	1.69	42.95	29.13
Agboola 3	18.46	35.35	39.92	3.34	35.95	22.14
Agboola Control	29.58	27.27	42.37	5.28	23.70	39.70
Worgor 1	39.91	32.56	36.72	39.13	27.44	17.15
Worgor 2	28.14	18.89	39.99	36.26	39.00	22.30
Worgor 3	24.91	44.57	40.57	39.59	40.00	20.08
Worgor Control	41.87	36.84	36.01	14.09	33.83	41.41
Odunola 1	53.17	21.51	40.10	24.53	37.41	21.95
Odunola 2	30.00	44.93	40.20	25.41	35.06	31.99
Odunola 3	43.26	30.77	33.58	11.51	38.95	11.58
Odunola Control	42.43	52.17	40.15	7.44	31.81	37.24
Range	18.22-53.17	18.89-52.17	33.58-42.37	1.69-39.59	23.70-42.95	11.58-41.41
Overall mean ± S.D	33.04 ± 0.78	34.49 ± 0.92	38.74 ± 1.09	17.58 ± 0.48	35.31 ± 1.07	27.02 ± 0.62
CV	2.36	2.67	2.81	2.73	3.03	2.29

Table 5. Mean Mobility Factors (%MF) of the Metals in the Samples (Dry and Wet Seasons)

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Print ISSN: 2056-7537(print),

Online ISSN: 2056-7545(online)

CONCLUSION

The levels of As, Cd, Cu, Fe, Pb and Zn in the geochemical phases assessed for the poultry farmland in the both seasons followed the succeeding sequence: Residual>Organic matter>Fe-Mn oxide>Exchangeable>Carbonate bound fractions, respectively. The chemical partition of the metals studied demonstrated the geochemical attribute of the six heavy metals and their possible interaction with diverse chemical phases in the soils around the poultry farms in Osun State. The results pointed out that the heavy metals contents present in the residual phase was higher than those found in any of the earlier extractions exclude in the instance of Cu where organic matter phase dominated and exactly after that residual phase. The heavy metal partition results proffered an overall picture that high percentage of the metals were found to be intensely bound to soil medium i.e. in a condition most stable, less reactive and less bioavailable for releasing into the food-chain apart from Cu. The vast significance of the residual phase in this study demonstrates clearly the difficulty of differentiating between benchmark and anomalous concentrations of heavy metal contamination when only total metal analyses are determined.

The fairly moderate mean mobility factor present in Cu verifies the mild susceptibility and ecological availableness of Cu in some of the soil studied. This study demonstrates that the metals studied do not present ecological threats since the total metal content of Cu which demonstrated high susceptibility and ecological availableness in this study fell below the specified limits in the soil. The results of the speciation have given the present condition of metal contamination and the possible contaminants in the poultry farm. More study can be conducted on the speciation of heavy metals in other ecological matrices in the neighborhood of the poultry farm. It is suggested that soils from this area under study should be well controlled to preclude discharge of occluded heavy metals into bioavailable form. There is also the need for continuous monitoring of Nigerian poultry farm soil to determine their quality status. This will serve as a guide to the poultry farmer on action plans to be taken. Regular testing of soil and poultry feed for metals to ensure that they were not above desirable limits. Soil quality issues influence human and ecological health, so the more we study and monitor our soil, the better we would be able to recognize and avert contamination problems. The work has provided information on the extent of heavy metal pollution in the poultry farm soils as a way of measuring the environmental health of the area under study as a result of heavy metal pollution. The work had also added to the baseline data on heavy metals chemical speciation and mobility studies in our environment.

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