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SEASONAL ASSESSMENT OF SOME TRACE METALS AND PHYSICO-CHEMICAL VARIABLES FROM POULTRY FARMS SURFACE SOILS IN OSUN STATE, SOUTHWESTERN NIGERIA

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ABSTRACT: *This study was conducted to assess the seasonal variations of arsenic, cadmium, copper, iron, lead and zinc and some physico-chemical variables of surface soils sampled from some poultry farms. This was with the view to evaluating the ecological impact of these agricultural farms on the farmlands within their vicinity. The physico-chemical variables were determined using standard methods, while metal concentrations were done with Flame Atomic Absorption Spectrophotometer following wet acid digestion. Quality control procedures included blank determination, recovery analysis and calibration of standards. Descriptive and inferential statistics were adopted for data interpretations. The concentration of metals (µg/g) gave the ranges: 87.51-1276.75 As, 0.03-2.03 Cd, 12.91-42.97 Cu, 59.07-699.47 Fe, 6.13-82.96 Pb and 23.74-202.27 Zn, with a variation pattern in sequence: As > Fe > Zn > Pb > Cu > Cd in both seasons. Major spatial differences in concentrations were observed for all physico-chemical variables in every part of the sampling locations. With the exception of Arsenic, the degree of pollution varied with, by values that were far below the maximum tolerable limits specified by Food and Agriculture Organisation and World Health Organisation for agricultural soils*

KEY WORDS: Surface soil, trace metals, physico-chemical variables, poultry farms, Osun State

INTRODUCTION

Poultry farming in Nigeria is as old as human history extending from an era of hunting and collection to that of subsistence backyard domesticated bird for the purpose of meeting the protein needs of the family. In Nigeria, poultry industry can be split into three major sections, viz.: small, medium and large scale production with 25% being supplied by commercial farms, 15% semi-commercial farms and 60% from courtyard farms (Okonkwo and Akubuo 2015). Poultry performs a vital economic, nutritional and socio-cultural function in the means of living of poor rural ménages in diverse growing countries, such as Nigeria. Poultry, aside from providing source of income and employment to people, it also adds importantly to human food as a main provider of meat, egg and raw materials to industries (Sebho 2016). Agriculturists and nutritionists have largely approved that growing the poultry sector of Nigeria is the quickest ways of bridging the protein deficits pace currently prevalent in the country (Amos 2020).

Organic waste is continuously generated anywhere there is poultry abode and the production of organic waste from poultry sector is increasing in proportion to the growth of chicken farming field. Poultry litter is an invaluable source of main plant nutrients and has been applied as a soil conditioner in agriculture. The increasing poultry farming in Nigeria, particularly in Osun State, generates huge quantities of poultry litter, which are applied to improve soil fertility. Thus, handling of poultry manure with concern for ecological quality should be a vital purpose when reusing poultry litters as soil conditioners (Anwar et al., 2017). In addition to providing nutrients, poultry waste influences metal dissolvability (Pinto et al., 2020). Soluble organic matter in poultry waste could add efficiently the organic ligands being required to create complexes with trace metals in the soil (Ogunwale et al., 2021). These chemicals can be migrated downward the soil section and may impair groundwater quality (Ogunwale et al., 2021). The common population has been vulnerable to trace metals via drinking water, inhaling dust and fumes, nutritional sources, and consumption of soil, with the utmost absorptions of trace metals notified to be found in seafood, rice, bread, fruits, fish, meat, grains, flours, processed or preserved foods, mushrooms, vegetables and poultry (Ogunwale et al., 2021).

The main pathways of trace element inputs to agricultural soils comprise atmospheric deposition, sewage slurry, animal manures, farm yard manure, continual use of agrochemicals, toxins and inorganic fertilizers (Ogunwale et al., 2021). Alternative source of trace metal introductions in poultry is by means of their feeds. Some trace elements like As, Cu, Fe, Mn, Ni, Co, Se, Al and Zn have complemented feeds preparation for goals of food preservatives for livestock and poultry diseases treatment, weight development and augmented egg output (Ogunwale et al., 2021). Feeding these elements to domesticated birds result in their higher absorptions in soil via excretion in the faeces or urine in addition to mineral additions of poultry. For instance, some limestones included to laying hen feedstuffs may comprise proportionally elevated amounts of Cd (Ogunwale et al., 2021).

Regardless of its beneficial uses trace metals, by animal feeds, will not merely contaminate the meat with trace metal at degrees of significant interest (Gerber et al., 2021), but can as well be excreted together with animal manure. As soon as in soil, trace metals could be transformed into its inorganic state, causing it water-soluble and letting it to settle on the surface soil horizon, and finally be meant for cultivation (Ogunwale et al., 2021). These trace metals have the tendency to accumulate in the soil, result in health issues for farm workers, farmers and produce eaters, or be migrated to adjacent lakes, springs, dams, creeks and streams. Diverse organic agriculturalists and their approvals are worried that utilizing marketable poultry waste is not compatible with the National Organic Standard (EC 2014). As a result of their deleterious nature, the application of some of the elements cited above for animal food preservatives had been prohibited in the European countries. In spite of what preceded, some preservatives containing appreciable levels of these elements are yet in making use of in some growing nations, like Nigeria (Maleki et al., 2014).

The bulky volume of poultry refuse produced annually is dispersed intensively over fairly small areas of land resulting into over accumulations that cause impending ecological hazards to the floras, edaphic, atmosphere, and water and endangers the quality of life (Ogunwale et al., 2021).

Trace metals are associated with diverse soils, dusts, air, sediments, water and plant components in varied routes and these relations define their mobility and presence availableness (Ogunwale et al., 2021).The degree upon which trace metals are amassed in the soil relies on the physiochemical qualities of the soil and the adequate effectiveness of crops to extract the metals from the soil. Trace metals amassed in grown soils can be transmitted to humans by diverse exposure routes resulting in deleterious effects on human health (Ogunwale et al., 2021).

Metal determination in chicken farm soil samples within the proximity of the poultry industry can give valuable data to estimate their bioavailability and the ability for pollution of soils. Many researches on metal contamination in soils have been conducted with regard to municipal sewage sludge use, roadside surface soils and street dusts in contrast very little research has been carried out in reference to metal impact from poultry activities on farm soil within the proximity of the chicken farms.

Information from the literature reveals that most of the past analyses on soil quality in the assessment area of Ejigbo, Isundunrin and Osogbo addressed essentially the impacts of leachate from domestic open waste dumpsites with few or no relation to other on-site hygienic states, precisely the effect of on-farm poultry refuse disposal sites. A good number of the reviewed literature focused only on physiochemical variables utilizing certain farmlands, while this present study utilized representative sampling and has comprehensive study on both physiochemical and trace metal variables of farmlands in poultry community. This manuscript to that end addresses the pollution of soil in the Nigerian poultry ecosystem with emphasis on the sundry contributors of pollution to agricultural lands that are generally utilized by indigenous communities for growing of both cash and food crops in Osun State.

The main significance of the work was to contribute to existing knowledge on the subject under study. Therefore, it was expected that this work would contribute to the existing literature on the subject**.** Findings from this work will be useful in the following areas:

1. Provision of information on the suitability status of soil sources of the community from the on-farm poultry sites.
2. Provision of pointer information on the effect of proximity of the poultry waste dump to arable lands inside selected poultry farms.
3. Soil quality issues control human and environmental wellbeing, so the more we examine and monitor our soil, the better we would be able to recognize and avert pollution problems.

The aim of this work is to evaluate the levels of As, Cd, Cu, Fe, Pb and Zn and physico-chemical variables of interest in poultry farm soils in selected poultry farms in Osun State.

MATERIALS AND METHODS

Sketch and Appropriateness of the Area under Study

The study region is made up of Ejigbo, Isundunrin and Osogbo poultry farms in Osun State, Southwestern Nigeria. These farms are entitled with the name of the possessors as Worgor (Ejigbo), Agboola Olorunsogo (Isundunrin) and Odunola (Osogbo).The map of the study region is demonstrated in Figure 1 while Table 1 indicates the geographic positions of the sampling sites. The study region situates on longitudes 004^0 16.095to 004^0 30.826´E and latitudes 07^0 45.195´and 07^0 53.961´N, while the ground level is within 311.81 to 357.23 m above water level. The clime of the study region is known to be tropical dry forest and savanna environment characterized by separate wet and dry seasons, normal of South West Nigeria. The mean annual rainfall is in the range of 1000 to 1250 mm while mean annual temperature is around 27^0C (Ogunwale et al., 2021). The state is surrounded in the south by Ogun State, in the North by Kwara State, in the west by Oyo State, and in the East by Ondo and Ekiti States. This diversity in its border demarcations has much favorable advantages on the patronage enjoyed by the mega farms. The sampling stations selected for this research were regarded appropriate because they exemplify some sample of poultry farm territories utilizing subsistence farming system in the state. In addition to, seasonal impact of the six trace metals of the surface soil of the poultry farms under research was being observed for the first-time. These trace metals were chosen for this study for many reasons. Arsenic, Cd and Pb signify serious health risks to humans by direct ingestion of the soil or by plant uptake and food chain contamination (Ogunwale et al., 2021). Copper, Fe and Zn are of great interest because they are necessary plant micronutrients (Ogunwale et al., 2021) that are also capable of causing health hazards at elevated concentrations.

Soil Sampling Collection and Sample Pre-treatment

Seventy two surface soil samples were taken at randomly at designated sites from each of the three chosen poultry farms at a depth of 0-15 cm employing a Dutch soil auger. Twenty-four control samples were also taken (at about 3 km past each farm) in fallow fields where neither poultry operation nor commercial or industrial activities were being conducted. As such, a total of 96 surface soil samples were taken from the three study areas for analysis. The samples were put in labeled decontaminated large polyethylene zip-lock bags, bulked together to form a composite sample and conveyed to the research laboratory. On the same day of collection, each soil sample was extracted from the plastic packaging and spread over sheets of clean white plain paper for air-drying for about seven days to avoid microbial decomposition (Ogunwale et al., 2021). They were homogenized, made lump free by lightly crushing continually making use of an acid pre-washed mortar and pestle, and transited a 2 mm plastic sieve prior to analysis and substituted in the plastic bags.

Analyses of Some Physico-chemical Variables of Soil Samples

Particle size distribution elsewise regarded as mechanical analysis, or granometeric analysis was carried out applying Buoyocous hydrometer technique (UAE University Manual 2013) with 100 mL 5% sodium hexametaphosphate (calgon) as the dispersant agent. Each soil sample was categorized in line with the USDA textural method (USDA 2021). Soil pH was assessed in water suspension (1:2.5) employing the Orion Research Analog pH meter/model 301. Soil electrical conductivity (EC) was evaluated in a 5:1 water/soil suspension applying dual range water proof digital EC meter (UAE University Manual 2013). Oxidation reduction potential was determined with calibrated water instrument analyzer (Ultra meter II 6 Psi serial 6207639) in 2:1 water/soil suspension (UAE University Manual 2013).

The cation exchange capacity (CEC) was done by extracting the cations with 1 M ammonium acetate buffered at pH 7. Thirty (30) mL of 1 M CH_3COONH_4 was added to 5 g of the soil. The suspension was agitated for 2 hours and then centrifuged for 15 minutes at 6000 rpm. After centrifugation and filtration, the filtrate was transferred into a 120 mL flask and two other volumes of 30 mL CH_3COONH_4 were added sequentially after 30 min of agitation and centrifugation. The final filtrates were filled in to 120 mL with CH_3COONH_4 solution (UAE University Manual 2013).Calcium (Ca) and magnesium (Mg) were conducted by Flame Atomic Absorption Spectrometer while potassium (K) and sodium (Na) were conducted by Flame Photometry. The exchangeable acidity (EA) was measured in a 1:10 (w/v) ratio of soil to solution of 1 M KCl by titrimetric method (UAE University Manual 2013). The effective cation exchange capacity (ECEC) was worked out as the total exchangeable bases plus exchangeable acidity.

Percentage base saturation (%BS) was computed as the percentage of the sum of exchangeable bases divided by ECEC. Available phosphorous (AP) was extracted with Bray solution II and the phosphate carried out with the colorimetric micro-vanadate-molybdate method expressed by UAE University Manual, (2013). Organic carbon was done by a process of wet oxidation method with a technique that is derived from the Walkley-Black method (UAE University Manual 2013).Total nitrogen (TN) was determined with an adapted version of the Kjeldahl technique and nitrate (NO_3^-) through brucine colorimetric method (UAE University Manual 2013). A micro-Kjeldahl digestion rack was used to decline the time dictated for the digestion. Sulphate (SO_4^{2-}) was done through turbidimetric method, while chloride (Cl^-) was carried out by means of Mohr titration method with silver nitrate (College of Science 2013).

Sample Preparation and Trace Metals Analysis

One gram of the air-dried fine soil sample selected by coning and quartering method, was weighed and moved into an acid washed, Teflon beaker comprising 10 cm^3 concentrated nitric acid. The mixture was gently evaporated over a duration of 1 hour on a thermostated hot plate at a temperature of 120°C. Each of the solid residues got was digested further for 10 minutes with 5 mL 3:1 concentrated HNO_3 and $HClO_4$ mixture at 120°C before heating on a hot plate and heated sporadically to assure a fixed temperature of 150°C over 5 hours until the acid fumes of were finally evaporated (Ogunwale et al., 2021). The mixture was allowed to cool to room temperature and then placed into a 50 mL volumetric flask and filled in to the standard mark with distilled water after rinsing the reacting vessels, to regain any remaining metal. The filtrate was then preserved in pre-cleaned polyethylene storage bottles in readiness for analysis. In a sequence to validate the effectiveness of the HNO_3–$HClO_4$ method of sample digestion a recovery analysis was conducted by means of spiking 1 g of twenty-four (24) and ten (10) various soil samples each with 1000 cm^3 of standard solutions of As, Cd, Cu, Fe, Pb and Zn. Trace metal concentrations were carried out using a Flame Atomic Absorption Spectrophotometer (FAAS) (Chem Tech Analytical Alpha Star Model 4) at the Centre for Energy Research and Development (CERD) of the Obafemi Awolowo University, Ile-Ife, Nigeria. The instrument backgrounds and functioning states were compliant with the producer's specifications. The instrument was standardized with analytical grade standard metal solutions (1 mg/dm^3) in replicates. All analyses were run in triplicates.

RESULTS AND DISCUSSION

Physico-chemical Properties of Soil of the Poultry Farms

Recovery test presented % recoveries > 85%. The results of some physico-chemical properties of the soils, considered as mean±standard deviation, are revealed in Table 2 and examined thoroughly.

The soil temperatures of the poultry farms varied from 25.53±0.9^{0}C to 26.93±0.5^{0}C with the maximum and minimum values recorded during the dry and wet seasons, respectively (Table 2). The amount of heat took in by the soil is determined by the quantity of solar energy penetrating the soil. Ocean's large thermal inertia results in temperature difference by reason of uptake of sun energy and succeeding discharge to the environment (Agbede 2016). For the period of wet season, low value of temperature would be resulting from freshwater flow. Soil temperature during wet season diminished adjusted with the atmospherical temperature. Derived savannah agricultural crops do best under warm soil states with the best range prescribed at 25–35^{0}C (Maleki et al., 2014). The minimum and maximum temperatures (25.50^{0}C and 26.90^{0}C) are healthy for derived savannah soil and are necessary for the natural growth of agricultural crops (Ogunwale et al., 2021).With respect to the above data, the soil temperatures were declared good for crop production since they fell within the prescribed range. The spatial distribution ranges of temperature at the sampling stations were mostly alike as temperatures were fairly lower during the wet season than dry season. The non-significance of soil temperature for both seasons has been likewise notified and minor differences have been attributed to change in clime states (Ogunwale et al., 2021).

The mean percentages of particle size distribution in the sample soil for both seasons ranged from 10.83±0.17 to 18.14±0.91%, 11.38±0.25 to 23.85±0.47% and 60.34±0.61 to 76.22±1.35% for silt, clay and sand, respectively. In this work, the soils of poultry sites contained higher sand and lower clay and silt contents than the control site. The results asserted with the findings of Oluyemi et al. (2012) who examined the soil attribute within a solid waste dumpsite in Ile-Ife Campus, Nigeria, which is in the same derived savannah land area as Ejigbo, Isundunrin and Osogbo. In line with Amos et al. (2014), soils with distinct high sand and low clay content possess high pollutant percolating possibilities. All the same the soils of the poultry sites mostly contained high sand fractions (<80.00%) that enables high permeability of water and leachates, the textural class (sandy loam and sandy clay loam) may be suited for hygienic poultry landfills (Amos et al., 2014). The soils from the control sites be composed of clay fractions so they revealed medium plasticity and support surface water flooding and pollution. Thus, clayey texture of the control soils would facilitate low permeability of water and leachates (Amos et al., 2014).

Table 2 also revealed the soil texture and textural categorizations. The textural assay of the poultry farm soils revealed that sand>clay>silt in both seasons. The textural assay categorized the soil as sandy loam or sandy clay loam in both seasons. There was an insignificant variation in soil texture through the sampling site. As a result of higher percentage of sand particles, the soil likely to release nutriment readily as it was highly porous causing infiltration of water to the subsoil. Soil high in sand keeps fewer metals inside it (Caporale and Violante 2016). The variation in particle size range affirms that these soils were not caused on the normal process of fundamental parent material but fairly from deposited fragments (Okoronkwo et al., 2006).

The oxidation-reduction or redox potential (Eh) implies the oxidation or reduction power of the chemical system in soils (Agbede 2016). In the area under study, the seasonal values of Eh ranged from 342.00±0.21 to 343.33±0.48 mV and 343.17±0.24 to 347.67±1.25 mV, yielding an overall mean of 342.75±0.55 mV and 344.54±0.79 mV for dry and wet seasons, respectively (Table 2). The Eh values shown opposite correlations to the pH. Lower values of Eh were found in dry season and higher values in the wet season. High Eh in wet season was ascribed to the reality that chemical structures in soils possibly contained higher oxidation potentials as a result of more oxygen disintegrating chemically in soil through rain water percolation and related processes. Generally, the Eh values of the soil of the area under study demonstrated non-significant variations all through the study season which, in relation to Edet et al. (2011), signified that the soil would adequately promote crop production.

Soil pH varied from 6.90 to 8.00 during dry season and 7.05 to 7.48 during wet season (Table 2) signifying a neutral to slightly alkaline pH. As a result, neutral soil from the control site may likely to have an increased micronutrient dissolvability and mobility along with increased trace metal concentration in the soil (Amos et al., 2014). The soil pH was higher in dry season than wet season probably as a result of redox variations in the soils and water column aside from the impact of clime (Agbede 2016). Derived savannah soil likely to possess neutral and moderately alkaline pH as notified by diverse authors (Oluyemi et al., 2012; Oyedele et al., 2015; Ogunwale et al., 2021). The slightly alkaline or neutral pH states obtained during the wet season months might be caused by the oxidation of $Al(OH)_3$ and $Al(OH)_4^-$ to neutral oxide (Wang et al., 2019). Furthermore, soil neutrality might have resulted also from disintegration of derived savannah plant litter (Amos et al., 2014). In relation to USDA (2021), the soils possessing pH 8.5 to 10.0 are regarded as alkali soils, and those containing below 8.5 are saline soils. With this standard, the soil from the area under study can be categorized as low sodic soils as they contain pH below 8.5 in both the dry and wet seasons of the study period.

pH is one of the factors which control the bioavailability and the mobility of trace metal in the soil and as expressed by (Ogunwale et al., 2021), trace metal mobility diminishes with increasing soil pH by virtue of precipitation of hydroxides, carbonates or development of insoluble organic compounds. Trace metals are usually more active at pH <7 than at pH >7. The concentration of trace metals mobilized in soil ecosystem is a function of pH, attributes of metals, redox states, soil chemistry, organic matter content, clay content, cation exchange capacity and other soil attributes (Ogunwale et al., 2021).The moderate soil pH values implicit that trace metals availability for plant absorption is medium in the sample soils. The pH of the soil in both seasons was within agricultural limits of 6-8 which demonstrated that they could adequately sustain plant growth.

The values of mean electric conductivity (EC) values of different soil samples in both seasons were below the 200 µS/cm (Table 2). Therefore, soil from the areas under study could be classified as medium sodic soil category which is suited for most plants if recommended amounts of fertilizers are applied. The soil is permeable to water and good environment for cultivating crops.

The occurrence of organic carbon enhances the cation exchange capacity of a given soil and helps the soil to keep nutrients that could be incorporated by plants (Ogunwale et al., 2021). Values of total organic carbons (TOCs) in the soils under analysis for dry and wet seasons presented in Table 2 varied from 1.51±0.11 to 3.84±0.23% and 2.74±0.18 to 5.29±0.35%, for dry and wet seasons, respectively. The TOC values could be rated as moderate to high, derived from the grouping of soil %TOC prescribed by Weil and Brandy (2017) signifying a likelihood of higher holding of nutrients within the soil. The moderately high quantity of TOC of the poultry soils is indicative of deterioration or occurrence of degradable and compostable refuses (Ogunwale et al., 2021).

The distribution of TOC nearly succeeded the occurrence of soil kind this is to say, soil low in clay content was low in TOC and as the clay content increased, the TOC content also increased in harmony with Emmanuel (2014). In this work, the TOC values were lower during dry season and higher during wet season. A plentiful available of organic matter in the soil sile, fairly fast rate of collecting of fine grained inorganic matter and moderate oxygen content of the soil in the surface soils were factors, in line with Ogunwale et al. (2021), that possibly could be accountable for high organic matter in the soils.

Soil organic matter (SOM) improves the effectiveness of soils for agricultural utilizations. It provides necessary nutrients and has unsurpassed ability to retain water and take in cations. It also serves as a source of food for soil microbes and by that aids to improve and control their activities (Ogunwale et al., 2021). The organic matter in the soil samples varied from 2.62±0.20 to 6.62±0.41% and 4.72±0.38 to 9.12±1.60% for dry and wet seasons, correspondingly. The poultry soils had high amounts of organic matter, about 6.62±0.41% and 9.12±1.60% for both dry and wet seasons which might be accountable for the increase in the soil pH as in comparison to that of the control soil. This remark was corroborated by Amos et al. (2014) who expressed that disposal waste sites contained suggestively higher pH characteristics and soil organic matter as in comparison to the control soil. Weil and Brandy (2017) also confirmed that high OM (>4.0%) in soils is favorable for trace metal ligand production. Higher organic matter content in the poultry sites than that of the control could be owing to the presence of solid waste, liquid manure, slurry, dung water, pet feaces, wildlife feaces, seagull and goose droppings, straw, litter spent feed, food waste and the higher quantity of poultry litters since more than half of poultry wastes generally compose of garden waste, unhatched egg shell, paper, preservative in feeds, dead birds carcass, drug/medicinal preparation, feather, ash, maggot, rodents, flies and so on which are improperly disposed in unsanitary conditions. Sandy soil with high organic matter content may tolerate pollutants to seep through them readily which may pollute groundwater sources (Emmanuel 2014). From the organic matter position, the soil would sustain agricultural productions.

The poultry soil %N was between 0.10±0.01% and 0.19±0.01% for dry season and 0.20±0.01% and 0.27±0.02% for wet season and it was higher than that of the control soil which was between 0.08 ± 0.01% and 0.09±0.01% for dry season and 0.14±0.01 and 0.19±0.01% for wet season. This result largely agreed with the earlier observation of Oyedele et al. (2015) who remarked that %N in the topsoil of southwestern Nigeria is usually between 0.10% and 0.25% in derived savannah regions. Agbede (2016) signified that nitrogen content is an indicator of biomass and they are accountable for the overall restoration of microbial flora. Largely, if it is less than 0.20%, it will be enough to meet the N needs of micro flora that breakdown the remains (Agbede 2016). In line with Amos et al. (2014) the low values of nitrogen contents indicated high disintegration and effective mineralization process of the soil area. In this work, %N in soil was higher during wet season probably as a result of the high activities of micro-organisms which breakdown dead plant organic matter which was more on the surface soil strata at that season of the year. The lower value of percentage nitrogen during dry season may be attributed to low levels of organic matter and less nitrogen manufacturing bacterial activities during this season.

Oluyemi et al. (2012) ascribed the high values of nitrogen to the liberation from the breaking down of a huge number of soil organisms in the derived savannah ecosystem. The soil organism may be a fertile provenance of N as demonstrated by steady consumption by earthworm which produce cast on the soil. Breakup leaves by earthworm may be enriching the dietary attribute of the substrate detritus (Oluyemi et al., 2012).

The mean value of Cl^- recorded in this study ranged between 75.71±4.16 mg/kg and 194.01±6.83 mg/kg and 146.53±9.83 mg/kg and 219.79±7.09 mg/kg, yielding an overall mean of 115.53±6.43 mg/kg and 180.14±11.18 mg/kg for dry and wet seasons, respectively (Table 3). Chloride level was found to be higher in wet season than in dry season. Chloride content which was medium during this study may be attributable to anthropogenic activities and inclusion of Cl^- rich chemicals like NH_4^+, Ca, Mg and Na into poultry feeds formulation, supplements, medications and water consumed by the animals which are added to the soil in animal manure, natural rainfall, irrigation waters and fertilizers especially KCl. It could also be attributed to the huge amount of biosolids, agricultural and other animal waste deposited in the site. Chloride is commonly available at surrounding levels of around 50 mg/kg in several soils (Agbede 2016). From the results above, it can be concluded that the levels of soil chlorides in all the sampling sites were such that would sustain adequate plant growth devoid of wilting as a result of imbalance osmoregulation.

Relating to phosphates (PO_4^{3-}), the values varied from 5.63±0.74 to 36.21±1.85 mg/kg and 5.29±1.12 to 33.24 mg/kg, yielding an overall mean of 14.09±1.11 mg/kg and 16.52±1.32 mg/kg for dry and wet seasons, respectively (Table 3). The ability of poultry soil to hold or liberate PO_4^{3-} is one of the paramount phenomena which influence the concentration of inorganic/organic PO_4^{3-} in the overlying soils. In this work, higher values of inorganic PO_4^{3-} were recorded during wet season and low values during dry season. The higher values available may be coming from decomposing dead organic matter from the top soil layer and possibly, dissolution of phosphate containing underlying rock soils or applied phosphate fertilizers.

The poultry site maintained higher levels of available phosphorous **(**AP) ranging from 21.45±1.48 to 50.71±2.56 mg/kg and 23.41±1.53 to 57.49±2.62 mg/kg while the control site values varied between 10.60±0.78 mg/kg and 18.61±1.34 mg/kg for dry season and 12.10± 0.84 and 23.90 ±1.63mg/kg for wet seasons (Table 3). This could be ascribed to the occurrence of high amount of organic matter and plants disintegration at the poultry farm sites (Ideriah *et al.,* 2017). High concentrations of phosphorous normally add to healthful development of plants (Agbede 2016). All the soil samples containing of AP values above 10 mg/kg which is an indication of the suitability of the soil for crop production (Weil and Brandy 2017). Seasonal differences of AP signified that wet season values were higher than those of the dry season. Phosphorus is one of the vital elements required for growth of plants and animals and is a mainstay of the Krebs's cycle and deoxyribonucleic acid (DNA).

Also the mean nitrate (NO_3^-) values varied between 7.02±1.10 to 33.53±2.73 mg/kg and 5.16±1.08 to 27.10±2.56 mg/kg, producing an overall mean of 18.03±1.50 mg/kg and 21.49±1.89 mg/kg for dry and wet seasons, respectively (Table 3). At large, the NO_3^- values were high during wet season and low during dry season (Table 3). The highest NO_3^- values recorded during wet season may be ascribed to intense rainfall, its originating source and weathering of rocks which emits dissolvable alkali metal nitrates, the majority of which are settled into the derived savannah top soils (Oyedele et al., 2015). One more likely route of NO_3^-entrance is by means of oxidation of NH_3 form of N to NO_2^- and then subsequently to NO_3^- (Weil and Brandy 2017). From the findings, it is obvious that the NO_3^- of the soil samples fell under medium category on the basis of Weil and Brandy (2017) and would sustain plant growth.

The sulphate (SO_4^{2-}) level of the soil sample had a mean of 1.69±0.06 mg/kg and ranged from 0.32±0.03 mg/kg at Agboola control to 3.75±0.45 mg/kg at Odunola 3 (dry season) with a mean of 3.91±0.22 mg/kg and ranged from 0.92 ± 0.02 mg/kg at Agboola control to 6.45±0.53 mg/kg at Odunola 3 (wet season) (Table 3). The ability of soil to have or give off S is one of the main phenomena which influence the uptake of inorganic/organic S in the overlying soils. In this work, higher values of inorganic S were obtained for the duration of wet season and low values during dry season. The highest values obtained during wet season might be as a result of liberating of SO_4^{2-}out of dead organic matters from the top stratum and low values could be consequently of transfer of top stratum of soils by intense floods.

The cation exchange capacity (CEC) is the measure of exchangeable cation for each unit weight of dry soil. It also performs a vital function in soil fertility because of its connection with soil pH, clay percentage structure and on the soil organic matter content (Agbede 2016). Data of this work showed that soils from the poultry sites had fairly higher values of CEC ranging from 1.36±0.08 to 1.79±0.15 Cmol/kg soil in dry season and 1.53±0.03 to 1.96±0.08 Cmol/kg soil in wet season as in comparison to that of the control site which varied between 0.78±0.05 to 0.95±0.06 Cmol/kg soil and 0.86±0.01 to 1.05± 0.02 Cmol/kg soil for dry and wet seasons, respectively (Table 3).

Even though the clay contents at the poultry site was much smaller than that at the control site, it was likely that a considerable portion of exchangeable bases at the poultry site occurred as a water-soluble form instead of an exchangeable form adsorbed at cation exchange sites. The higher the CEC values and organic matter in the vicinity of the poultry field could help plants in picking up nutrients more easily (Amos et al., 2014).

Effective cation exchangeable capacity (ECEC) levels were moderate to high varying respectively from 0.82±0.08 to 1.94±0.18 Cmol/kg soil and 0.91±0.08 to 2.10±0.19 Cmol/kg soil for dry and wet seasons (Table 3). Similarly, the ECEC condition of poultry soils were higher than those of the control and far more than 0.70 Cmol/kg soil considered as being acceptable for crop activity (Weil and Brandy 2017). The ratio of CEC that met the needs of basic cation (Ca, Mg, K and Na) is called percentage base saturation (%BS). This attribute is directly proportional to soil acidity (Amos et al., 2014). As the %BS rises, the pH rises. High base saturation is favored but not necessary for tree fruit formation (Agbede 2016). The presence of nutrient cations like Ca^{2+}, Mg^{2+}, and K^+ to plants rises with rising %BS. Base saturation is generally approximately 100% in arid region soils. Base saturation lower than100% implies that portion of the CEC is possessed by hydrogen and/or aluminium ions. Base saturation more than 100% signifies that dissolvable salts or lime may be available, or that there is a methodological problematic with the study. All the soil samples investigated possessed very high base saturation (>85.00%) and were higher than 60%, the prescribed level recognized for ecological region (Amos *et al*., 2014). This also succeeded the sample found by Oyedele et al. (2015) for fertile cultivated soils. The exchangeable acidity (EA) was moderately low ranging between 0.04±0.01 to 0.18±0.06 Cmol/kg soil and 0.05±0.02 to 0.20±0.07 Cmol/kg soil for both seasons.

All the soil samples possessed high Ca^{2+} values more than 0.30 Cmol/kg soil which is considered as lower value for productive soils (Weil and Brandy 2017). Exchangeable K^+ ranged from 0.20±0.03 Cmol/kg soil to 0.31±0.09 Cmol/kg soil and 0.21±0.04 Cmol/kg soil to 0.34±0.12 Cmol/kg soil in poultry soils for the two seasons; these values were higher than the levels in control soils and beyond 0.15 Cmol/kg soil which is established as the prescribed level of exchangeable K^+ in soils (Weil and Brandy 2017). The inference of these is that the soil was abundant in nutrients; an evidence of wholesome produce ability outside of any contribution of inorganic fertilizers.

Mean Trace Metals Concentrations of Poultry Farm Surface Soils

The total contents As, Cd, Cu, Fe, Pb and Zn in the poultry farm surface soil samples for dry and wet seasons are presented in Table 4. The noticeable differences in concentrations between December to March and July to October samples might be attributable to seasonal variations, as these months categorized as dry and wet seasons, respectively. The frequent and seasonal variations in the clime in proportion to season were basically considered in the ecological parameters, which in good sequence had a direct or indirect impact on the poultry activities. The seasonal variation, abiotic and biotic variables influence the metal cycle of varied derived savannah ecosystems. The minimum levels found for dry season samples might be ascribed to absorption of metal by plants for their biologic processes and redox activities in soils which might be available in the surface soil and also following dislodgment of soil pore water less in metals by manure infiltration during this season. The maximum metal values found during wet season might be attributable to intense rainfall, land runoff, its originating source and weathering of rocks which released dissolvable metal, the greater part of which settled on the surface stratum of the soil during this period (Ogunwale et al., 2020). The higher values of trace metals concentration during wet season might also be as a result of oxidation and precipitation of dissolvable makes up of trace metals migrated into the soil during heavy rainstorm.

Assessment of poultry surface soils for the concentration values of trace elements is vital for satisfactory crop activity. As a result, the mean concentration (± standard deviation) of metals in the soils is revealed in Table 4. The result indicates that the metal loads from the chicken ranch surface soils were found to be slightly higher than the control area (3 km out of the poultry farm site) with the exemption of Cu which was found in traces in all the soils. Results of this study agreed to a large extent with those of Ogunwale et al. (2021) and Olkowski (2012) who reported that As, Cd, and Pb were anthropogenic metals, and besides outside intervention, are commonly not plentiful in surface stratum soils. On the outline of the comparative variation, the data of CV infers that all the studied variables are heterogeneous in the ecological matrixes. The concentrations of these variables demonstrated medium variableness which is most probable connected with human induced activities.

In this study, the total levels of As had in dry and wet season samples revealed varied degree of contamination as shown in Table 4. The values of As ranged from 87.51 to 1133.09 µg/g and 108.64 to 1276.75 µg/g, yielding an overall mean of 568.05 µg/g and 636.54 µg/g for dry and wet seasons, respectively. The highest As concentrations (1133.09 in dry season and 1276.75 µg/g in wet season) were found at Agboola 2. These values were more than the prescribed limit 30 µg/g of FAO standard (FAO/WHO Guideline 2011) and also higher than the target and intervention values allowable by Nigeria Department of Petroleum Resources (EGASPIN 2020) as indicated in Table 4. The major causes of high soil As in all the sampling sites could be because of the extensive application of As compounds as insecticides, herbicides, and defoliants for agricultural operation. Also, As is broadly applied as a feed chemical addition for poultry productions [e.g. Roxarsone (3-nitro-4-hydroxyphenylarsonic acid] and the manufacturing poultry manures could signify a substantial source of soil As in all the areas under study. Arsenic was largely applied 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).

With growing usage of As not merely as growth improvers, but also as feed preservatives to fighting diseases in highly concentrated poultry operation, manure use has become as a prominent cause of environmental pollution of this metal. Metal like As which is commonly present in the compound named roxarsone are added to feed concentrates as a means to avoid disease, increase weight gain and feed transformation, and improve egg efficiency (Ogunwale et al., 2021). Normally, animals can assimilate simply 5–15 percent of the metals they use up. The more than half is then excreted in manure. Portion is taken up by the soil, but As can also finish up in water bodies where they become more very severe. Elevated concentration of As in all the sampling sites could also be owing to the ages of the farms as all the farms studies have been in operation for over 25 years and the application of roxarsone-treated feed for their chick, grower, layer and broiler could have added tremendously to the elevated levels of As found.

Cadmium concentrations in crystal rocks range from 1 to 90,000 µg/g (Kabata-Pendias 2011) with igneous and metamorphic rocks normally containing lower Cd concentrations than the sedimentary deposits. The mean concentrations of Cd determined at the various areas of study were 0.83 µg/g and 1.10 µg/g for dry and wet seasons, respectively and ranged from 0.03–1.92 µg/g and 0.06 – 2.03 µg/g, for the respective seasons. These values were far below the natural limits of 3.0-5.0 µg/g in soil as prescribed by EC (2014) and MAFF (1992). The values of the Cd concentrations found for both seasons were all far less than the maximum tolerable levels proposed for agricultural soil. These values were in harmony with the results of Asawalam and Eke (2018), Njoku and Ayoka (2015), Oluyemi et al. (2012) and Oyekunle et al. (2011) who evaluated the trace metal concentrations and trace metal pollutants from disposal site and agricultural soils in Owerri, Imo, Ile-Ife and Osogbo, Nigeria respectively. Despite the fact this trace metal concentration fell under the critical tolerable concentration level, its persistency in the soils of the poultry site could set in motion its ample absorption by plants and common biota.

The concentration of Cu in the studied soil samples ranged from 12.91 to 28.40 µgg^{-1}and 20.70 to 42.97 µgg^{-1} in the dry and wet seasons, respectively (Table 4). Samples picked up from Odunola 2 and Odunola 3 poultry farm soils maintained the highest concentrations in both seasons. The highest values evaluated were many times below the FAO/WHO standard limits of 140 µgg^{-1} (FAO/WHO 2011). For the control soil, the range was from 12.91 to 16.06 µgg^{-1} and 20.78 to 29.61 µgg^{-1} for dry and wet seasons, respectively.

Townsend et al. (2010) present that the mean concentrations of As, Cr and Cu in control soil samples of their study were 1.34, 8.62 and 6.05 µgg^{-1}, respectively. Alternative study determined that average Cu concentration in Canadian soil was likely to be 20 µgg^{-1}, with a range between 2 and 100 µgg^{-1}(British Columbia Ministry of Environment, Lands and Parks 2011). These values concurred with the values found in this study. Slightly higher but not significantly different values of Cu were, however, available in this study. High levels of Cu on these locations could be traced to the application of Cu as feed preservatives majorly in the form of $CuSO_4$ (Ogunwale et al., 2021). Copper is supplemental to the diet of some growing animals at levels up to 250 ppm to augment their growth rate and improve feed transformation productivity. Manure formed by these animals contains high concentrations of Cu. The use of such manure to agriculture soils produces an increase in soil Cu concentration (Ogunwale et al., 2021). In excess, preeminent levels of Cu can become toxic to plants, deleteriously affect organisms that feed on these plants, and enter aquatic ecosystems by means of surface run-off and leaching (Shange et al., 2012).

Iron though not categorized as a noxious metal, because of its high concentrations and chemical form impact the speciation and toxicity of Pb (Ladele et al., 2019). Iron was present to be the second foremost metals as in comparison with other trace metals in the chicken ranch soil. Iron is essential for nearly all living organisms, involving in a broad diversity of metabolic processes, such as oxygen transfer, DNA formation, and electron transfer (Ladele et al., 2019). It is identified that acceptable Fe in a diet is very essential for reducing the prevalence of anaemia. The levels of Fe ranged from 59.07–626.22 µg/g and 95.79–699.47 µg/g in dry and wet seasons, correspondingly (Table 4). Samples from Worgor 3 poultry farm had the highest concentrations in both seasons. High concentration of Fe (626.22 and 699.47 µg/g) in the soil samples was found at Worgor 3 (one of the most aged poultry farms), while all the control sites (uncultivated area) revealed the lowest values. The differences of Fe in all the sampling points could be as a result of changes in the soil compositions of the poultry farms locations. Anthropogenic additions could also be from potential sources including feed preservatives, corrosion of building materials, battery cage, pumps, sprinklers, tanks, feeding trough, water trough or drinkers, laying boxes, casing pipes and indiscriminate disposal of scrap Fe in open areas resulting from poultry operation, among others (Ogunwale et al., 2021).

The maximum Fe contents of 626.22 and 699.47 µg/g found during the two seasons in this study might be closely related to sampling locations in line with the observation of Wuana and Okieimen (2011) that the degree of trace metal pollution in urban areas varied in relation to site. Nevertheless, the concentrations of Fe in this study were below FAO, EU prescribed limit of 5000 µg/g for agricultural soil (FAO/WHO 2011).

The concentration of Pb in the examined samples varied from 6.13 to 63.63 µg/g and 10.15 to 82.96 µg/g in dry and wet seasons, respectively (Table 4). Samples taken from Odunola 1 and Odunola 3 had the highest concentrations of Pb during both seasons. This might be resulting from the past atmospheric deposition of Pb based on combustion of gasoline having Pb additives and from long-range fugitive giving off provenance non-ferrous metal smelting contribution as metals are not decomposable. In addition, Odunola poultry farm fall under the area with intermediate vehicular traffic of the urban centre of Osogbo, the capital town of Osun State, in which instance the atmospheric deposition could be high. It could also be owing to agricultural herbicides/pesticides like lead arsenate which might have been applied to control some parasitic pests and weeds on the farms.

Dependent on the origin of wastes, inclusion of poultry waste to agricultural soils involuntarily points towards the accumulation of trace metals like Pb in soil (Ogunwale et al., 2021). Longstanding application of these biosolids on agricultural lands repeatedly causes the accumulation of elevated levels of heavy metals like Pb in soils (Ogunwale et al., 2021). Furthermore, in nations like Nigeria where there is high urgent need for food, poultry meat, eggs and feathers, polluted arable land is used for crops like rice, wheat, cereal grains, groundnut, vegetable and soyabean which are employed to feed the farm animal.

Lead levels found from this assessment were below those present in England and Wales. Weil and Brandy (2017) expressed that the total Pb content of natural British soils ranged from 2 to 300 µg/g, while Gregory et al. (2015) recorded 75 µg/g as the mean value for Pb in urban surface soils of England and Wales. The poultry soils had lower Pb contents because most of them are sited in isolated areas. By examining the common range of the total Pb content, it seems that the total Pb content in all the poultry soils were below the critical concentration of 400 μg/g (ICRCL 2017).This indeed revealed the compliant of the petrochemical sector in Nigeria to manufacture non-leaded fuel. The causes for the higher levels of Pb mentioned for other countries in comparison to Isundunrin, Ejigbo and Osogbo are accountable to be attributable to urbanization, industrialization and higher automobile exhaust levels caused by higher traffic volume as previously reported (Ogunwale et al., 2021).

In the case of Zn concentrations in this work varied from 23.74 to 169.33 µg/g and 29.85 to 202.27 µg/g in the dry and wet seasons, respectively. Zinc (primarily in the state of ZnO) is needed in poultry for growth, feather and skeletal enlargement and reproduction (Olkowski 2012). The highest concentration of Zn in this study was obtained in Worgor 1 poultry farm soils during dry and wet seasons, correspondingly. The distribution of several biosolids, for instance, composts, poultry manure and municipal sewage sludge (MSS) to land could unknowingly add toward the accumulation of trace metals like As, Cd, Cr, Cu, Pb along with Hg, Se, Ni, Mo, Zn, Sb, in the soil (Wuana and Okieimen 2011). Some animal wastes like livestock, poultry and pig manures produced in agriculture are generally supplied to crops and meadows either in the state of solids or semisolids (Wuana and Okieimen 2011).Although most compost can be viewed as esteemed fertilizers, in the poultry and pig sector, the Zn is incorporated in foods as growth supplemental which, by extension, may have the potential to result in metal contamination of the soil (Olkowski 2012; Ogunwale et al., 2021).

The manures that are produced from animals by means of their diet keep greater amounts of As, Cu, Fe and Zn and if persistently dispensed to unlawful areas of land, can give rise to rational buildup of these metals in the longer period of time in a given soil ecosystem. Natural concentrations of Zn in soil range from 1 to 900 μg/g (Weil and Brandy 2017). Gregory et al. (2015) expressed that the Zn concentration in the soils of England and Wales ranged from 5 to 3648 μg/g with the mean value of 82 μg/g. In this study, the concentration of Zn fell under this range except the mean value (99.95 and 123.91 μg/g) were higher than the background value. This could be owing to the higher contribution of Zn in the poultry ecosystems by industrial farm animal operation. Ogunwale et al. (2021) noted that the total Zn levels in contaminated soils in industrialized nations may constitute hundred to thousand times higher than those in unpolluted soils. Burkholder et al. (2007) described that the mean Zn concentration of 410 μg/g were recorded in soils taken from urban roadside soils in Bradford. This value was higher than the values found in this study.

Even though the values of most trace metals studied were below FAO/WHO prescribed levels for agricultural soils, wastes from restricted animals disposed of on agricultural land unceasingly not having an adequate nutrient management plan could bring about over-fertilization of the soils, harmful runoff, and percolating of pollutants. These present usual risks to adjacent water ecosystem and also may affect drinking water provenances as obtained by Ogunwale et al. (2021). Immoderate uses of that soil could give rise to cumulative effect and may ultimately become toxic to health. Since the soil is regarded as reservoir for trace metals and run-offs can disintegrate and sweep away these metals, there is the likelihood of conveying the disintegrated metals into very close rivers which the occupants of Ejigbo, Isundunrin and Osogbo metropolis rely on for drinking and domestic uses. This can sooner or later result in rise in the proportion upon which the trace metals enter the food chain of the general public. From the Tables, the values found from the assessment area were precisely higher than the control site, an evidence of some degree of contamination of the poultry farm soils. The concentration of varied trace metals researched was in the subsequent diminishing sequence across the seasons: As > Fe >Zn > Pb > Cu> Cd.

CONCLUSIONS

An evaluation of As, Cd, Cu, Fe, Pb and Zn, and some physico-chemical variables from the three chosen locations of some poultry farms in Osun State was conducted on seasonal basis in comparison with the control soil samples and the ecological soil guiding principle. The homoscedasticity (homogeneity of variance) in the soil metals and physico-chemical attributes of the three stations of the poultry farms and control sites throughout the study periods implies analogous spatial ecological conditions of the factory farms. The physico-chemical constituents load help permeability of trace metals from the soil surface. The results also pointed out that Agboola, Worgor and Odunola farm soils were significantly contaminated with trace metals, although some trace metals concentrations were below the prescribed limit. The soils within the vicinity of the poultry farm studied are considered largely healthy for plants sustainability and livestock survival, furthermore, the continuing agricultural practices could result in increase in accumulation of trace metals in the soil after a while. Hence, poultry farmers should be proactive in guiding against practices that could adversely compromise the health of their practicing ecosystems. Broadly speaking, the leading factors to trace metal contents still look to be of man-made sources together with land use activities. It can be made known that poultry industry should be sited far off from human domicile and As, Cd, Fe, Pb and Zn should be managed in a strict manner. So as to achieve decline soil pollution emanating from poultry practices, there is the need for continuous surveillance of Nigerian poultry farm soil to assess their quality status. This will serve as a blueprint to the poultry farmer on strategies to be done. The utilization of trace metals additives like As, Fe and Zn in poultry feed should be declined vastly or stopped. The work has provided information on the extent of trace metal pollution in the poultry farm soils as a way of measuring the environmental well-being of the area under study as a result of trace metal pollution. The work had also added to the baseline data on trace metals contents and soil physicochemical variables studies in our environment.

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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

Sampling Site	Cl^-	PO_4^{3-}	NO_3^-	SO_4^{2-}	Available P	Ca^{2+} Cmol//kg soil	Mg^{2+} $\longrightarrow$	Na^+	K^+	CEC	EA	ECEC	%BS
						Dry Season							
Agboola 1	146.68 ± 7.12	11.14 ± 1.09	16.31 ± 1.53	0.38 ± 0.02	21.45 ± 1.48	0.73 ± 0.12	0.41 ± 0.09	0.21 ± 0.05	0.25 ± 0.06	1.60 ± 0.12	0.13 ± 0.04	1.73 ± 0.15	92.49 ± 1.80
Agboola 2	108.82 ± 6.76	13.82 ± 1.14	20.28 ± 1.60	0.95 ± 0.03	26.91 ± 1.52	0.59 ± 0.09	0.38 ± 0.08	0.17 ± 0.03	0.22 ± 0.03	1.36 ± 0.08	0.08 ± 0.02	1.44 ± 0.13	94.44 ±1.90
Agboola 3	104.11 ± 6.51	23.16 ± 1.76	12.99 ± 1.27	0.54 ± 0.02	29.48 ± 1.64	0.82 ± 0.17	0.45 ± 0.11	0.16 ± 0.02	0.20 ± 0.03	1.63 ± 0.14	0.06 ± 0.02	1.69 ± 0.14	96.45 ± 1.92
Agboola Control	75.71 ± 4.16	5.29 ±1.12	11.29 ± 1.10	0.32 ± 0.02	10.97 ± 1.46	0.35 ± 0.04	0.17 ± 0.04	0.10 ± 0.01	0.16 ± 0.02	0.78 ± 0.05	0.04 ± 0.01	0.82 ± 0.08	95.12 ± 1.91
Worgor 1	94.63 ± 5.76	24.09 ± 1.79	16.78 ± 1.88	2.75 ± 0.27	50.71 ± 2.56	0.64 ± 0.11	0.37 ± 0.08	0.20 ± 0.04	0.24 ± 0.05	1.45 ± 0.10	0.12 ± 0.03	1.57 ± 0.12	92.36± 1.83
Worgor 2	99.36 ± 5.79	33.24 ± 1.83	26.40 ± 2.03	2.78 ± 0.35	42.46 ± 2.08	0.61 ± 0.10	0.34 ± 0.07	0.24 ± 0.06	0.29 ± 0.08	1.48 ± 0.11	0.14 ± 0.04	1.62 ± 0.14	91.36 ± 1.84
Worgor 3	118.29 ± 6.92	20.91 ± 1.34	21.83 ± 1.92	2.57 ± 0.27	30.09 ± 1.55	0.58 ± 0.08	0.40 ± 0.10	0.18 ± 0.03	0.23 ± 0.03	1.39 ± 0.10	0.09 ± 0.03	1.48 ± 0.11	93.92 ± 1.89
Worgor Control	75.71 ± 4.17	8.17 ± 1.07	5.16 ± 1.08	0.66 ± 0.05	18.61 ± 1.34	0.37 ± 0.05	0.19 ± 0.05	0.12 ± 0.02	0.16 ± 0.02	0.84 ± 0.04	0.05 ± 0.02	0.89 ± 0.09	94.38 ± 1.90
Odunola 1	194.01 ± 6.83	9.48 ± 1.18	20.24 ± 2.01	1.62 ± 0.26	25.17 ± 1.48	0.70 ± 0.11	0.28 ± 0.06	0.22 ± 0.04	0.27 ± 0.07	1.47 ± 0.13	0.16 ± 0.05	1.63 ± 0.13	90.18 ± 1.81
Odunola 2	156.15 ± 6.58	7.87 ± 1.13	23.39 ± 2.22	3.34 ± 0.43	25.69 ± 1.56	0.79 ± 0.14	0.39 ± 0.09	0.20 ± 0.04	0.26 ± 0.07	1.64 ± 0.14	0.18 ± 0.06	1.82 ± 0.17	90.11 ± 1.80
Odunola 3	118.29 ± 6.98	6.47 ± 0.87	27.10 ± 2.56	3.75 ± 0.45	31.59 ± 1.63	0.81 ± 0.16	0.42 ± 0.11	0.25 ± 0.06	0.31 ± 0.09	1.79 ± 0.15	0.15 ± 0.05	1.94 ± 0.18	92.27 ± 1.85
Odunola C	94.64 ± 5.76	5.44 ± 0.72	14.58 ± 1.45	0.64 ± 0.03	10.60 ± 0.78	0.42 ± 0.06	0.21 ± 0.04	0.14 ± 0.02	0.18 ± 0.02	0.95 ± 0.06	0.06 ± 0.02	1.01± 0.10	94.06 ± 1.90
Overall mean ± S.D	115.53 ± 6.43	14.09 ± 1.11	18.03 ± 1.50	1.69 ± 0.09	26.98 ± 1.43	0.62 ± 0.10	0.33 ± 0.07	0.18 ± 0.03	0.23 ± 0.04	1.37 ± 0.08	0.10 ± 0.02	1.47 ± 0.11	93.10 ± 1.88
CV	5.57	7.88	8.32	5.33	5.3	16.13	21.21	16.67	17.39	5.84	20	7.48	2.02
						Wet Season							
Agboola 1	168.43 ± 10.74	13.17 ± 1.21	20.03 ± 1.62	1.14 ± 0.05	23.41 ± 1.53	0.81 ± 0.14	0.47 ± 0.10	0.24 ± 0.07	0.27 ± 0.08	1.70 ± 0.04	0.14 ± 0.05	1.92 ± 0.18	88.54 ± 2.16
Agboola 2	193.79 ±12.80	16.99 ± 1.34	32.83 ± 2.96	1.31 ± 0.06	28.51 ± 1.58	0.66 ± 0.12	0.42 ± 0.05	0.21 ± 0.05	0.24 ± 0.05	1.53 ± 0.03	0.09 ± 0.03	1.62 ± 0.14	94.44 ± 2.23
Agboola 3	207.97 ± 14.48	26.92 ± 1.82	13.31 ± 1.31	1.60 ± 0.09	32.79 ± 1.68	0.85 ± 0.16	0.48 ± 0.11	0.20 ± 0.04	0.21 ± 0.04	1.74 ± 0.05	0.07 ± 0.02	1.81 ± 0.17	96.13 ± 2.38
Agboola C	155.93 ± 10.63	5.91 ± 1.01	12.37 ± 1.12	0.92 ± 0.02	20.40 ± 1.52	0.37 ± 0.08	0.20 ± 0.04	0.12 ± 0.02	0.17 ± 0.03	0.86 ± 0.01	0.05 ± 0.01	0.91 ± 0.08	94.51 ± 2.30
Worgor 1	189.07 ± 11.20	25.91 ± 1.72	19.67 ± 1.91	4.09 ± 0.45	57.49 ± 2.62	0.70 ± 0.13	0.41 ± 0.05	0.23 ± 0.06	0.28 ± 0.09	1.62 ± 0.03	0.15 ± 0.05	1.77 ± 0.16	91.53 ± 2.17
Worgor 2	160.71 ± 10.66	36.21 ± 1.85	30.19 ± 2.08	4.28 ± 0.55	45.97 ± 2.11	0.63 ± 0.12	0.39 ± 0.04	0.30 ± 0.09	0.32 ± 0.11	1.64 ± 0.03	0.16 ± 0.05	1.80 ± 0.16	91.11 ± 2.10
Worgor 3	212.70 ± 14.62	22.00 ± 1.38	23.90 ± 1.91	4.78 ± 0.38	33.62 ± 1.64	0.61 ± 0.11	0.46 ± 0.07	0.22 ± 0.05	0.26 ± 0.07	1.55 ± 0.02	0.10 ± 0.04	1.65 ± 0.15	93.94 ± 2.18
Worgor C	146.53 ± 9.83	15.26 ± 1.26	7.02 ± 1.10	3.95 ± 0.20	23.90 ± 1.63	0.39 ± 0.09	0.21 ± 0.04	0.15 ± 0.03	0.18 ± 0.03	0.93 ± 0.02	0.04 ± 0.01	0.97 ± 0.08	95.88 ± 2.13
Odunola 1	219.79 ± 7.09	12.48 ± 1.23	22.08 ± 2.05	6.18 ± 0.40	27.14 ± 1.61	0.72 ± 0.13	0.33 ± 0.04	0.26 ± 0.07	0.30 ± 0.10	1.61 ± 0.02	0.17 ± 0.06	1.78 ± 0.16	90.45 ± 2.19
Odunola 2	174.89 ± 10.91	11.27 ± 1.22	25.60 ± 2.16	6.35 ± 0.51	26.08 ± 1.58	0.83 ± 0.14	0.42 ± 0.05	0.24 ± 0.07	0.29 ± 0.09	1.78 ± 0.06	0.20 ± 0.07	1.98 ± 0.18	89.90 ± 2.15

Odunola 3	170.16 ± 10.86	6.52 ± 0.85	33.53 ± 2.73	6.45 ± 0.53	33.75 ± 1.66	0.84 ± 0.16	0.47 ± 0.06	0.31 ± 0.10	0.34 ± 0.12	1.96 ± 0.08	0.14 ± 0.05	2.10 ± 0.19	93.33 ± 2.20
Odunola C	161.71 ± 10.67	5.63 ± 0.74	18.04 ± 1.50	5.88 ± 0.38	12.10 ± 0.84	0.44 ± 0.10	0.23 ± 0.04	0.18 ± 0.03	0.20 ± 0.04	1.05 ± 0.02	0.05 ± 0.02	1.10 ± 0.12	95.45± 2.21
Overall mean ± S.D	180.14 ± 11.18	16.52 ± 1.32	21.49 ± 1.89	3.91 ± 0.22	30.43 ± 1.64	0.65 ± 0.11	0.37 ± 0.08	0.22 ± 0.05	0.26 ± 0.06	1.50 ± 0.09	0.11 ± 0.03	1.61 ± 0.13	92.93 ± 2.40
CV	6.21	7.99	8.79	5.63	5.39	16.92	21.62	22.73	23.08	6	27.27	8.07	2.58
Annual mean	147.84 ± 8.97	15.31 ± 1.28	19.76 ± 1.86	2.80 ± 0.37	28.71 ± 1.59	0.62 ± 0.10	0.35 ± 0.06	0.20 ± 0.04	0.25 ± 0.05	1.44 ± 0.07	0.11± 0.03	1.54 ± 0.14	93.02 ± 2.18

Table 3. Mean Major Ions (Anions and Cations) of Poultry Farm Soil Sample for Dry and Wet Seasons

Sampling Site	As	Cd	Cu	Fe	Pb	Zn	Total Metal Burden
Dry Season							
Agboola 1	1042.12 ± 14.71	1.43 ± 0.07	17.81 ± 0.86	325.81± 4.57	55.10 ± 1.62	105.04± 3.26	1547.31
Agboola 2	1133.09 ± 15.49	0.94 ± 0.03	22.49 ± 0.81	424.28± 4.85	51.26 ± 1.58	101.45 ±3.04	1733.51
Agboola 3	760.19 ± 13.41	1.05 ± 0.06	20.75 ± 0.95	472.70± 4.96	49.15 ± 1.47	150.42± 3.88	1454.26
Agboola C	104.45 ± 3.22	0.05 ± 0.02	12.91 ± 0.55	59.07 ± 1.65	6.13 ± 0.16	26.35 ± 0.85	208.96
Worgor 1	625.70 ± 9.15	0.87 ± 0.03	22.11 ± 0.84	562.61± 6.48	47.67 ± 1.45	169.33± 3.80	1428.29
Worgor 2	600.12 ± 8.91	0.85 ± 0.02	19.72 ± 0.92	408.67± 4.63	48.00 ± 1.47	121.29± 3.59	1198.65
Worgor 3	667.81 ± 9.28	0.89 ± 0.03	27.29 ± 0.96	626.22± 9.17	57.31 ± 1.68	133.45± 3.64	1512.97
Worgor C	109.85 ± 3.66	0.03 ± 0.01	15.19 ± 0.56	62.27 ± 1.68	14.91 ± 0.35	23.74 ± 0.76	225.99
Odunola 1	657.88 ± 9.32	1.92 ± 0.07	21.49 ± 0.87	478.91± 6.65	63.63 ± 1.75	112.70± 3.46	1336.53
Odunola 2	539.44 ± 6.42	0.62 ± 0.02	28.40 ± 0.98	416.24± 4.82	44.47 ± 1.43	92.75 ± 2.03	1121.92
Odunola 3	488.46 ± 4.87	1.19 ± 0.07	25.32 ± 0.86	584.17± 6.96	55.63 ± 1.52	136.03± 3.68	1290.8
Odunola C	87.51 ± 1.83	0.07 ± 0.02	16.06 ± 0.56	73.13± 1.64	16.74 ± 0.48	26.88 ± 0.89	220.39
Range	87.51-1133.09	0.03-1.92	12.91-28.40	59.07-626.22	6.13-63.63	23.74-169.33	
Overall mean ± S.D	568.05 ± 11.98	0.83 ± 0.01	20.80 ± 0.65	374.51 4.66	42.50 ± 1.28	99.95 ± 2.96	
CV	2.11	1.2	3.13	1.24	3.01	2.96	
Wet Season							
Agboola 1	1135.38±17.24	1.26 ± 0.06	27.73 ± 0.87	373.39 ± 4.73	74.57 ± 2.16	134.75 ± 4.12	1747.08
Agboola 2	1276.75±18.08	1.68 ± 0.08	28.68 ± 0.89	504.89 ± 4.78	70.62 ± 1.96	129.40 ± 3.98	2012.02
Agboola 3	830.28 ± 10.36	1.19 ± 0.04	30.27 ± 0.91	550.36 ± 5.81	63.21 ± 1.88	183.95 ± 5.22	1659.26
Agboola C	143.08 ± 2.51	0.07 ± 0.02	20.78 ± 0.68	104.17 ± 2.02	10.15 ± 1.45	36.65 ± 1.26	314.9
Worgor 1	721.70 ± 9.73	1.11 ± 0.04	31.74 ± 0.92	664.68 ± 7.38	62.13 ± 1.12	202.27 ± 6.38	1683.63
Worgor 2	687.28 ± 9.34	1.48 ± 0.05	33.54 ± 0.94	479.38 ± 4.75	62.98 ± 1.94	153.16 ± 4.22	1417.82

Worgor 3	742.79 ± 9.80	1.35 ± 0.06	33.58 ± 0.96	699.47 ± 7.46	77.38 ± 2.18	164.96 ± 4.98	1719.53
Worgor C	130.44 ± 1.47	0.06 ± 0.02	25.47 ± 0.85	100.42 ± 1.99	17.02 ± 0.75	29.85 ± 1.48	303.26
Odunola 1	740.10 ± 9.81	2.03 ± 0.08	35.92 ± 0.96	564.29 ± 6.52	81.40 ± 3.19	141.46 ± 4.38	1565.2
Odunola 2	596.61 ± 6.84	1.14 ± 0.04	38.32 ± 0.98	437.24 ± 4.67	62.76 ± 1.89	111.58 ± 2.32	1247.65
Odunola 3	525.47 ± 6.63	1.78 ± 0.06	42.97 ± 0.99	668.31 ± 7.45	82.96 ± 3.25	163.43 ± 3.87	1484.92
Odunola C	108.64 ± 1.17	0.09 ± 0.03	29.61 ± 0.87	95.79 ± 1.03	25.14 ± 0.78	35.46 ± 0.88	294.73
Range	108.64-1276.75	0.06-2.03	20.78-42.97	95.79-668.31	10.15-82.96	29.85-202.27	
Overall mean ± S.D	636.54 ± 19.42	1.10 ± 0.03	31.55 ± 0.95	436.87 ± 12.95	57.49 ± 1.83	123.91 ± 3.86	
CV	3.05	2.73	3.01	2.96	3.18	3.12	
Permissible. Limit (FAO/WHO, 2011)	7.20^{**}	3.00^{**}	140.00^{**}	5000.00^{*}	300.00^{**}	300.00^{**}	

Table 4. Mean Total Metal Levels in the Surface Soil of the Study Area (Dry and Wet Seasons) (μgg^{-1})

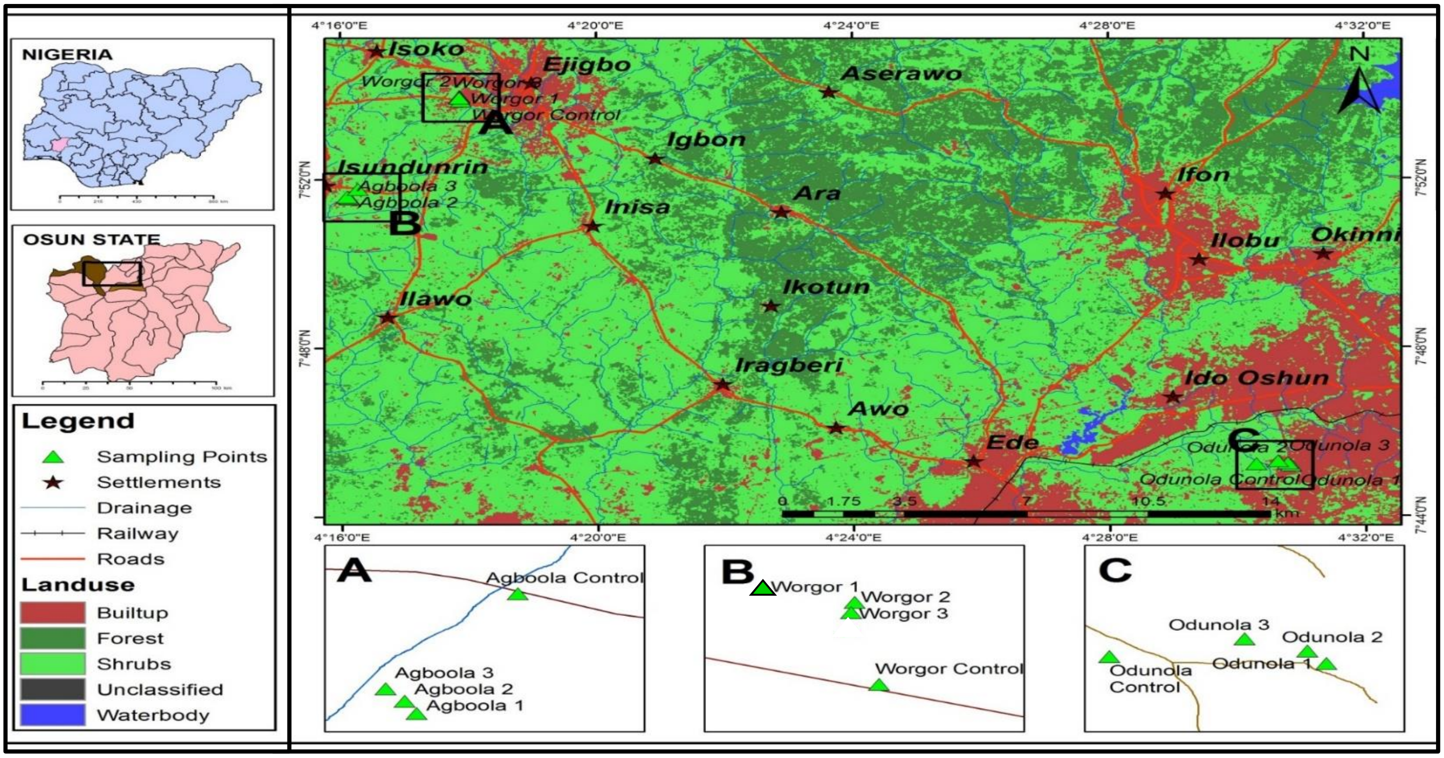

Figure 1. Map of the Study Area Signifying Sample Locati