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Research Article

EVALUATION OF TRACE METALS CONTAMINATION OF SOME POULTRY FARMS GROUNDWATER IN OSUN STATE, SOUTHWESTERN NIGERIA UTILIZING VARIOUS INDICES

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Abstract

Osun State is one of the highly prolific agricultural and poultry-keeping areas where extensive poultry production is carried out utilizing groundwater as the main source of water for poultry support and drinking water in the poultry community. The groundwater from four locations covering three poultry farms and a control site in Osun State were sampled and evaluated on seasonal basis for their metal contents and physico-chemical variables in a sequence to find out an all-encompassing categorization of metal contaminations. Metal contents in the acid digested samples were performed utilizing flame atomic absorption spectrophotometric technique. Quality monitoring procedures involved blank determination, spike recovery study and calibration of standards. Descriptive and inferential statistics were used for data interpretations. The contents of metals (µg/mL) were in this manner: 0.010-0.420 As; 0.300-0.360 Cd; 0.220-2.980 Cu; 18.090-106.120 Fe; 0.05-1.430 Pb and 8.440-60.280 Zn in both seasons. The degrees of groundwater contamination were determined utilizing contamination indices. The results affirmed that contamination indices values of Fe were highest among the evaluated metals. A compliance evaluation for agricultural applications was done based on the prescribed values of Canadian Council of Ministers of the Environment and Food and Agriculture Organization/World Health Organization. This finding revealed that the contents of metals in the water more than the toxic effect threshold and could result in deleterious health effects in both the birds and humans utilizing the waters for drinking purposes.

Keywords: Groundwater, Trace metal, Physico-chemical variables, Contamination indices, Poultry farms.

INTRODUCTION

Poultry has been the most freely available livestock species in Nigeria. The poultry sector has witnessed a very fast growth from a part-time yard operation to a more concentrated method of raising [1]. The thriving of the poultry sectors have and after that in the production of huge volumes of both solid and liquid wastes like poultry litter and excreta and farm death-rate. Many of these wastes are usually get rid of in landfilling, farmland, biosolid compositing, combustion, sewer, or may be subjected to surface water discharge and burial lacking any acceptable management method. Consequently, the poultry farming industry has given increase to a great number of concerns connected mostly with generation of odour and breeding of rodents, flies and other pest that cause local problems and spread disease [1]. Osun State is one of the highly prolific agricultural and poultry rearing animal areas where extensive poultry management is done utilizing groundwater as the main source of water for poultry support and drinking water in the poultry community. With the purpose of satisfying the urgent need of water service of the Osun State poultry farm, groundwater is being tapped via shallow hand operated pumps and deep hole drilled well not taking any methodical planning. The quality of groundwater in an area is a role of land usage composition [2] and so, the kinds of pollution the water resources are subjected to. The manifold potential sources of pollution to groundwater comprise agricultural products, landfills, subterranean storage cisterns, cesspools, surface impoundments, domestic, industrial and residential effluents, soil erosion, animal feedlots, intrusion from dumpsites and salt water encroachment [2].

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Manifold methods have been employed in quality assessment of groundwater. These methods involve experimental quantification (physico-chemical assessment) of the contaminants [3]; evaluation via mathematical modeling and simulation like PHREEQC model [4], geophysical techniques [5], application of water quality contamination indices and multivariate analytical methods [6, 7]. The usefulness of contamination indices and multivariate methods are coming into being more widespread in assessment of physico-chemical variables of water and has been described as efficient evaluation with regard to a specific period of time ([4, 8]. The use of various contamination indices and multivariable statistical procedures simplifies explanation of complicated data matrices by that estimating the water quality and other ecological phenomena [2, 6]. Furthermore, absorption or emission of metals in groundwater is mostly influenced by their geochemistry, in precise, kind and amounts of organic material, dissolved oxygen, biological oxygen demand, chemical oxygen demand, pH, temperature and cation exchange capacity [6]. From the time that they can act as non-diffuse sources of pollution in the course of man-made activities, groundwater are proper tool for quantifying the extent of metal enrichment utilizing the enrichment factor (EF), contamination factor (CF), pollution load index (PLI), geo-accumulation index (*I-geo*), quantification of anthropogenic input (Q_oC) and the most popular multidimensional statistics analytical procedures such as cluster analysis (CA). This research was therefore aimed to evaluate the origin and content of trace metals in groundwater around a few notable operational poultry farms in Osun State in a sequence to determine the extent of impact of poultry activities on groundwater utilizing water quality contamination indices and multivariable analytical methods. This will assist in developing required measures and policies to guarantee sustainable ecological management approaches that could result in healthier poultry practices in the region.

MATERIALS AND METHODS

Characteristics and Appropriateness of the Study Area

The research area involved Ejigbo, Isundunrin and Osogbo poultry farms in Osun State, Southwestern Nigeria. The map of the study area is shown in Figure 1, while Table 1 provides the geographical points of the sampling sites. The study area 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, while the ground elevation is within 311.81 to 357.23 m above water level. It has tropical dry forest and derived savanna vegetation, identified with Precambrian crystalline fundamental complex rocks. The prevailing rocks make up sets of gneisses and quartzite [9]. The most important climatic seasons are wet or rainy season, which begins in March or April, and comes to an end in October and the dry season, which begins in November and comes to an end in March or April. This area was taken for this assessment for the cause that they contained some of the state's major poultry sectors, which together provide 8.50% of the entire egg output and 10.30% of the total broiler production [10]. Besides, they have been in business for over twenty-five years and the poultry activities count great extent on the usage of groundwater. Additionally, many of the poultry farms operation in the state have been going on in these places and the farm yield (broilers and eggs) enjoys considerable patronage on day-to-day basis from towns in Osun State and other nearby states.

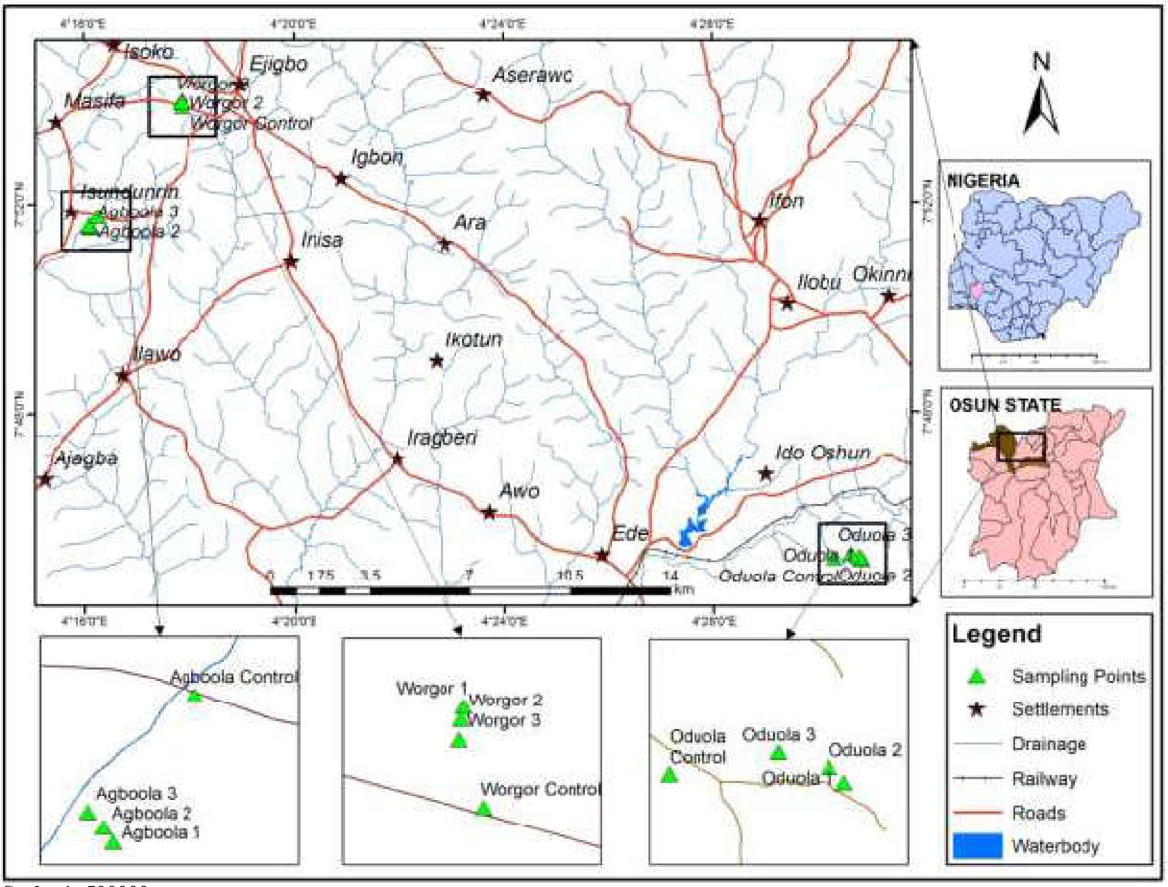
The leading causes of trace metal inputs into poultry farms groundwater are runoff and percolation from agricultural farms, poultry-keeping, landfills, unused poultry pen buildings, poultry facilities, above and below ground fuel storage sites, growing populations, rapid economic growth and atmospherical fallout. The land use in the poultry industry is distinct, like avocado, coconut, oil palm, teak, gmelina, cashew, citrus, cocoa, cherry (*Chrysophyllum albidum*) and food crop plantations in the poultry groundwater area.

Table 1. Geographical Locations of the Sampling Sites

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

Field and Scientific Research Methods

Water samples were taken on seasonal basis from both the poultry farms and control sites. For wet season, sampling extended over the months of July to October, 2014, while for dry season, samples were taken in the months of December, 2014 to March, 2015. A total of thirty-two samples were adopted utilizing plastic bucket attached to a graduated polymer rope.



Scale: 1: 500000

Figure 1. Map of the Assessment Area Showing Sampling Locations

In this respect, a total of four hand dug wells were selected for this study. The samples were taken in 2.5 L pre-treated white plastic kegs and BOD containers. Sampling plastic containers and BOD containers utilized in the sampling were first washed with liquid detergent and rinsed with distilled water. They were then awash with 10% nitric acid for 48 hours. This was succeeded by intensive cleansing with distilled water for three times. Earlier to sample collection, the containers were cleansed with the water samples at the study site four times before being filled in to the brim with the sample. The normalized water kit analysis device (Ultra meter II^{TM} 6 Psi serial 6207639) was utilized on-siteto carry out the temperature of the water samples while pH was done utilizing regularized portable pH meter. Samples for dissolved oxygen (DO) and five-day biochemical oxygen demand (BOD_5) were collected in oxygen containers (250/300 mL reagent containers). Dissolved oxygen samples were determinate on the spot promptly on collection with Winkler's chemical agents 1 ($MnSO_4$) and Winkler's chemical agents 2 (alkali azide) solutions. Biochemical oxygen demand samples were taken in black reagent containers and maintained in the dark fume chamber at environment temperature (about 20 ± 2^0C) for five days after which they were treated for oxygen determination [11]. Total organic carbon, total organic matter and chemical oxygen demand were conducted by wet-oxidation digestion method. All samples were taken in triplicates, stored in icebox and transferred to the research laboratory, made cold at a temperature of 4^0C till analysis to keep their on-sitequalities and tests were conducted in triplicate and the results summed up to reduce mistakes [11].

Digestion of Water Samples for Metals Analysis

The samples were digested making use of the method expressed somewhere else [3]. Twenty (20) mL of water sample was put in a 100 mL Teflon beaker. Five (5) mL of conc. HNO_3 was put together. This was transferred to a mild boiling on a thermo stated hot plate. Refilling of content was carried out with 1:1 (v/v) HNO_3: $HClO_4$ till whole digestion was completed. Each digested sample was permitted to become cooler, measurably transferred to a 25 mL volumetric flask and filled in to the reference measurement with distilled water. Out of this, an aliquot was picked up for FAAS analysis. All digestions were conducted on a hot plate in fume chamber. Doubled distilled water and analytic grade chemical agents were utilized all through this study. Reagent blank analysis was conducted to reduce contamination of metal of concern [11].

Geochemical Indices

To compute the degree of anthropogenic contamination of trace metals in varied degrees of content in groundwater samples, enrichment factor (EF), contamination factor (CF), pollution load index (PLI), index of geo-accumulation (*I-geo*) and quantification of anthropogenic input (Q_oC) were employed.

Enrichment Factor (EF): A diversity of standardizing approaches has been adopted to explain both natural geochemical changes in addition to give baseline relations to determine metal enrichment. Enhanced explanations are procured by standardizing metal content in groundwater to average shale or benchmark content of an assumed Al or Fe contents [12]. Enrichment factor (EF) is a worthy means to distinguish the metal source between anthropogenic and naturally effect [13, 14]. Enrichment factor is commonly differentiated by Al because of its high natural content, slight anthropogenic contamination, it is a basic element of clays, and the metals to Al degrees in the crust are moderately stabilized [13, 15]. Nevertheless, in this analysis we used Fe to calculate EF for the reason that it is the fourth main element in the earth's surface and most frequently has no contamination issue. Furthermore, in accordance with Naji and Ismail [2011]; the principal merits of adopting Fe as a standardizer are: (1) Fe is intrinsic in fine solid crust; (2) its geochemical is almost that of several trace metals; and (3) its natural groundwater content likely to be invariable. Iron (Fe) has been adopted effectively by several scientists to standardize metals contamination in river, soil, dust, coastal sediments [12, 13, 16, 17, 18]. The EF for Fe-standardized data is described by:

$$EF = \frac{\left[{}^{M_x}/_{Fe_x}\right] sample}{\left[{}^{M_c}/_{Fe_c}\right] shale} \quad (1)$$

where $M_x$is the content of metal in the appraised sample, $Fe_x$is the content of Fe in the appraised sample, $M_c$is the content of metal in the conventional shale or benchmark and $Fe_c$is the content of Fe in the conventional shale or benchmark. In this study, benchmark content] 4, 19] was utilized as benchmark or pristine content for those metals since no such data was found for the assessment area. The benchmark groundwater contents utilized were [4, 19] in µg/mL: 0.05 for As; 0.0.10 for Cd; 0.44 for Cu; 4.10 for Fe; 4.40 for Pb and 3.50 for Zn (Table 3). The EF contents were explained as represented by Naji and Ismail [6] where EF<1 implies no enrichment, EF<3 is slight enrichment, EF=3-5 is moderate enrichment, EF=5-10 is moderately severe enrichment, EF=10-25 is severe enrichment, EF=25-50 is very severe enrichment and EF>50 is extremely severe enrichment.

Contamination Factor and Pollution Load Index: Contamination factor analyzes the metal enrichment in the water. To evaluate the degree of contamination of trace metals in poultry farm groundwater and also give a measure of the degree of total contamination in accordance with a specific poultry farm, contamination factor and pollution load index have been used [20]. The contamination factor (CF) variable is depicted as:

$$CF = \frac{C_{metal}\ (Sample)}{C_{metal}\ (Benchmark)} \quad (2)$$

where CF is the contamination factor, C_{metal} is the metal content of pollutant in water sample, C_{metal} $(Benchmark)$ is the benchmark content for the metal and 'n' is the number of metals evaluated. The CFanalyzes metal enrichment in the groundwater. The geochemical benchmark contents in continental crust averages of the trace metals under consideration described by Edet *et al*. [4] was used as benchmark contents for the metal. The CF was categorized into four classes [4, 17, 18]. Where the contamination factor: CF < 1 denotes low contamination; 1 ≤ CF< 3 implies moderate contamination; 3 ≤ CF ≤ 6 signifies considerable contamination and CF > 6 suggests very high contamination. In accordance with Akoto *et al*. [20], CF values between 0.5 and 1.5 indicated that the metal is wholly from geogenic processes; while CF values more than 1.5 implicit that the sources are more probable to be anthropogenic.

Each poultry farm site was evaluated for the degree of metal pollution by using the method obtained from the pollution load index (PLI) devised by Akoto *et al.* [20], in this manner:

$$PLI = n\sqrt{CF_1 \times} CF_2 \times CF_3 \times \ ... CF_n \quad (3)$$

in which n is the number of metals investigated (six in this research) and CF is the contamination factor computed as expressed in an earlier equation. The PLI may be used to evaluate the degree of metal contamination. A PLI above 1 infers that on average, metal contents are above the tolerable levels. An index less than 1 indicates that average levels of metals are less than the ideal guidelines but does not inevitably revealed that there is no anthropogenic sources or other enrichment over benchmark [20]. The PLI also gives uncomplicated but relative means for evaluating a site nature, in which a value of PLI < 1 signify perfection; PLI = 1 represent that merely conventional levels of pollutants are found and PLI >1 would reveal degradation of site nature [20].

Geo-accumulation Index (*I-geo*): The index of geo-accumulation [21] assessment method was utilized to evaluate the level of contamination. This index involved the measured value of each variable and the assumed evaluation guideline (benchmark) content. The index of geo-accumulation (*1-geo*) was quantified like this:

$$I - geo = log_2[C_n/1.5 \times B_n] \quad (4)$$

where C_n is the measured content of element n in the pelitic component of sediment (<2µm) and B_n is the geological benchmark for the element n. B_n is either practically measured or obtained from the literature (conventional shale content). The factor 1.5 was added to comprehend likely differences of the benchmark contents that are by cause of lithogenic variations. In this analysis, the *I-geo* was adapted for the assessment of the degree of trace metal contamination in the groundwater of some poultry farms in Osun State. In the variation, C_n was the measured content of element n in the groundwater sample and B_n the benchmark content for the trace element 'n' in groundwater obtained from the literature (Table 3).The benchmark contents of the trace metals were the same as used in the enrichment factor determination. Lu *et al.* [22] provides the subsequent explanation for the geo-accumulation index: *I-geo*< 0 = practically unpolluted; 0 <*I-geo*< 1 = unpolluted to minimally polluted; 1 <*I-geo*< 2 = minimally polluted, 2 <*I-geo*< 3 = minimally to strongly polluted; 3 <*I-geo* < 4 = strongly polluted; 4 <*I-geo* < 5 = strongly to extremely polluted; and *I-geo*> 5 = extremely polluted, the highest grade revealing a 100-fold enrichment higher than conventional values.

Quantification of Groundwater Contamination (QoC): The fifth method utilizing the quantification of anthropogenic content of metal utilized the content in the control samples to typify the lithogenic metal. This was computed compliant with Equation (5):

$$Q_OC = \frac{\bar{x} - \bar{x}_C}{\bar{x}} \quad (5)$$

where $\bar{X}$ = mean content of the metal in the groundwater under analysis, and $\bar{X}_C$ = average content of the metal in the control samples [23]. All five indices were utilized to assess the effect of the poultry activities on the enclosing groundwater.

Groundwater Quality Guidelines (WQGs): With the purpose of estimating adverse ecological effects in contaminated groundwater, several water quality guidelines (WQGs) have been fully formed regarding the period of time [19]. In this analysis, we juxtaposed our total content with WQG of threshold effect limit (TEL), which contains threshold effect contents and toxic effect threshold (TET), which comprises probable effect contents (PEC) as depicted by CCME, [24] and Olkowski, [25] to assess the probable ecological effects of the metal contents in the groundwater (Table 3). Threshold effect contents should be utilized to determine waters that are unlikely to be unfavorably affected by water-related contaminants, while the PECs should be utilized to determine groundwater that are likely to be noxious to poultry-abode organisms [24, 25, 26].

Quality Monitoring: To check questionable contaminations, all glass and propylene ware used were first awash in 10% HNO_3 for 48 hours, analytically cleansed with phosphate-free liquid soap and then cleansed with double distilled de-ionized water and acetone. From then on, all the glassware were dried in the oven at 100^0C for 24 hours, while the plastic ware were left to dry at ambient temperature and far ahead designed for water sample collection. All chemical agent stock solutions be composed of 1000 mg/L of the metals As, Cd, Cu, Fe, Pb and Zn and were of high reagent quality supplied by British Drug House, BDH, Chemical Ltd, Poole, England. The chemical agent and methodical blanks were checked after six samples during the analysis as measure of the quality monitoring program.

Analysis of Statistical Data: Normal statistical studies like mean, minimum, maximum, standard deviation (SD) and coefficient of variation (CV) were determined as an access point in relations to an insight of the comportment of the trace metal findings. With the intention of examining the distinctive attributes of poultry groundwater, the concentrations of heavy metals content in well water were caused to undergo one-way analysis of variance (p = 0.05). Linear coefficient correlation was utilized to estimate correlation matrix between metal contents and physico-chemical variables in the groundwater sample. Multivariable analyses; cluster analysis (CA) was conducted utilizing the Paleontological Statistics Software Package (PAST) version 2.17 to figure out correlation along with the differences in the content between diverse variables.

RESULTS AND DISCUSSION

Groundwater Quality and Trace Metals Variables

Temperature is not an issue in uncontaminated water, but turn out to be a crucial issue in contaminated water. The available temperature values of the groundwater at all the study sites under consideration were within the prescribed limit (25 to 30^0C) recommended by FAO/WHO for poultry drinking water. The temperature of groundwater samples ranges from 26.90 to 27.65^0C during dry and wet seasons. The lowest and highest values (26.70^0C and 27.65^0C) were obtained at Odunola and Agboola farms, respectively. This was anticipated because of the connection between DO and temperature. A groundwater with high degree of DO is mostly moderate in temperature. The likely sources of moderately high temperature in the poultry groundwater involve water removal during dry season for poultry drinking, delousing, deworming, vaccination, medication, watering gardens, irrigating crops, municipal extractions and other agricultural uses are likely to rise under clime variation. The moderate variation in the temperature of groundwater is determined by the season, area under study, sampling duration, intensity of solar energy, insolation, light intensity and evaporation encompassing the groundwater. The result obtained complied with the results of other scholars [28]. pH value is a major indicator which measures the fitness of water for numerous uses [3]. The pH values varied from 6.78 to 7.18 during dry and wet seasons (Table 2). Hydrogen ion content (pH) in the groundwater continued neutral all through the assessment season in all the study stations with the highest values taken place in the wet season resulting from infiltration of effluent in neutral form and occurrence of bicarbonate which causes chemical reaction in solution [28]. The pH values of the groundwater at all the stations fell within the threshold of 6.5-8.5. By and large, moderate variations in pH values all through varied seasons of the year is ascribed to factors like decline of temperature, degradation of organic matter and extraction of CO_2 by photosynthesis via bicarbonate dissolution [29]. Dissolved oxygen is regarded as one of the most significant variables for evaluating water quality [28]. Its correlation with water body provides direct and indirect information for example bacterial activity, photosynthesis, availableness of nutrients, stratification, and so forth [29]. The DO contents in this work varied from 12.41±1.46 mg/L at Worgor to 17.28±1.83 mg/L at Control and 10.85±1.27 mg/L at Worgor to 12.12±1.75 mg/L at Control in the dry and wet seasons, correspondingly (Table 2). The oxygen content contained higher values in the dry season possibly by virtue of increased in temperature and the duration of radiant sunshine that could alter the level of dissolvable gases (oxygen and carbon dioxide). During dry season, the length of days and intense sunshine appeared to hasten photosynthesis by phytoplankton, utilizing CO_2 and emitting oxygen. This probably explains for the larger amounts of O_2 observed during dry season. A similar remark is established by Edet *et al.* [30]. Nonetheless, the mean DO content of the poultry farm well water implied that the groundwater prospective for poultry growth was absolutely encouraging if organic contaminants are guided against.

In this study, the variations in the BOD_5 values for groundwater in mg/L for the assessment area of groundwater in dry season ranged from 1.13±0.02 (Control) to 3.66±0.08 (Odunola) and from 1.27±0.02 (Control) to 3.29±0.06 (Odunola) in wet season (Table 2). The overall mean BOD_5 value for dry and wet seasons (2.74±0.67 mg/Land 2.56±0.58 mg/L) of the poultry well water indicated that the water might be considered a mildly contaminated water since it contained BOD_5 more than 2.00 mg/L. This statement follows the categorization of Radojevic and Bashkin [31]who expressed that water bodies with BOD_5 concentrations < 1.00 mg/L were asserted very clean, 1.10-1.90 mg/L clean, 2.00-2.90 mg/L moderately contaminated, 3.00-3.90 mg/L contaminated, 4.00-10.00 very contaminated and > 10.00 mg/L extremely contaminated. The results clearly signified that the water sources were becoming more contaminated from organic load outlook. The reported content of COD contained in dry and wet season samples from each site evaluated varied degree of contamination (Table 2). The values of COD ranged from 3.13 – 18.40 mg/L and 5.94 – 20.80 mg/L, yielding an overall mean of 11.35 mg/L and 14.37 mg/L for the dry and wet seasons, correspondingly. The levels of COD in all the samples were lower in the dry but higher in the wet season than the NESREA [32] prescribed limit of 10.00 mg/L. The elevated values of COD in this analysis were in agreement with the study of Taiwo *et al.* [33] who obtained a high value of COD in groundwater nearly a well inside the proximity of poultry-keeping. The increased COD values might also be as a result of casual released of animal waste substances into the groundwater and their percolation into the groundwater during rainfall. No noticeable seasonal variations were found in all the samples. Control site revealed inconsequential COD content while the content was much observable in the poultry farm hand-dug well water samples in concordance with the finding by Taiwo *et al.* [33]. The high values of COD were found at most of the sampling sites unless at the control site signifying some comparative contamination of well water result in oxidizable organic substances. The leachate produced as a result of dumping up of wastes from the poultry-keepings might have infiltrated the wastewater via the soil and together with groundwater [33].The high levels of COD are suggestive of possible mixing of organic pollutant in the water in present area [33]. Hence, it could be inferred that the groundwater in the poultry farm neighborhood showed a very small amounts of organic pollution. Total organic carbon (TOC) of the water samples from each site are presented in Table 2. The content of TOC in the analyzed water samples varied from 0.31– 1.78% in dry season and 0.93 – 3.64% in wet seasons. Samples taken from Odunola poultry farm contained the highest values in both seasons. Temporal significant seasonal variations of TOC were observed in all samples. These values were; however, less than the satisfactory prescribed limit of 5.00% [32]. The significantly higher TOC content in wet season in comparison to the dry season could be due to bird population which produces vast amounts of organic substance and nutrients during this period of the season. Water bodies get fire-retardant chemicals, wood refuse pesticides, herbicides, empty feed bags, rotten feed, empty vials, packaging materials, feathers or other debris and partially covered in its neighborhood would favor high organic matter [25]. The available content of TOM in poultry farm well water during the assessment period ranged from 0.53–3.07% and 1.60–6.27% in dry and wet seasons, respectively. Samples from Odunola farm had the maximum contents in both seasons possibly as a product of filtration of animal refuse and sewage sludge intrusion from close to community into the groundwater during rainfall. The overall mean of TOM of the water samples in both seasons (1.97% and 3.15%) were found to be more than the FAO/WHO prescribed limit of 3%, in wet season thus from TOM outlook, the quality of water was mildly polluted.

The results of well-water analysis for As, Cd, Cu, Fe, Pb and Zn are shown in Table 3. Also the comparison of results with benchmark level, threshold effect level, probable effect level of those trace metals in groundwater and prescribed highest levels of trace metals in poultry drinking water have been presented in the same Table [24, 25, 26]. The level of the trace metal constituents in groundwater sample (Table 3) shows that in all the study sites, As, Cd, Cu, Pb, Fe and Zn were more than the FAO/WHO prescribed limits for poultry-keeping groundwater during dry and wet seasons with the exemption at the Control station. Also, a high content of metal loads was obtained during the wet season in contrast to dry season which could be ascribed to high runoffs from poultry pen house, agricultural and the emission of ill-treated wastewater effluents, manure, chicken processing facilities, runoff and wastewater from instreaming community, which are characteristics of the assessment area into the well water.

Table 2. Mean Physico-chemical Variables of some Poultry Farms Hand-dug Well Samples for Dry and Wet Seasons

Sampling Site	Temp. (^0C)	pH	DO (mg/L)	BOD_5 (mg/L)	COD (mg/L)	%TOC	%TOM
			Dry Season				
Agboola	27.65	6.95	14.98	2.06	12.53	1.47	2.53
Odunola	26.90	6.83	12.41	3.66	18.40	1.78	3.07
Worgor	27.60	6.78	15.28	3.09	11.33	1.02	1.76
Control	27.10	7.10	17.28	1.13	3.13	0.31	0.53
Max.	27.65	7.10	12.41	3.66	18.40	1.78	3.07
Min.	26.90	6.78	17.28	1.13	3.13	0.31	0.53
Overall mean	27.31	6.92	14.99	2.49	11.35	1.15	1.97
SD	0.32	0.12	1.73	0.77	1.45	0.45	0.64
CV	1.17	1.73	11.54	30.92	12.78	39.13	32.49
			Wet Season				
Agboola	27.35	7.15	11.09	2.81	15.80	1.56	2.69
Odunola	27.70	6.98	11.45	3.29	20.80	3.64	6.27
Worgor	26.70	7.12	10.85	2.85	14.92	1.17	2.02
Control	27.00	7.18	12.12	1.27	5.94	0.93	1.60
Max.	27.70	7.18	12.12	3.29	20.80	3.64	6.27
Min.	26.70	6.98	10.85	1.27	5.94	0.93	1.60
Overall mean	27.19	7.11	11.38	2.56	14.37	1.83	3.15
SD	0.37	0.07	0.49	0.58	2.57	0.54	0.86
CV	1.39	1.08	4.21	22.66	17.88	29.51	27.30
FAO [27]		6-9	5				

View of Table 3 reveals the statistics of trace metal constituents in groundwater of the assessment area. The result implies that the mean content of the investigated variables (As, Cd, Cu, Fe, Pb and Zn) ranged between 0.010-0.326; 0.030-0.210; 0.220-2.930; 18.090-101.600; 0.050-0.810 and 8.440-56.180 µg/mL, respectively for dry season and 0.020-0.420; 0.040-0.360; 0.310-2.980; 22.130-106.120; 0.080-1.430 and 10.280-60.280 µg/mL, respectively for wet season. Amongst the obtained trace metal components, Fe contains the highest overall mean value of 73.920 µg/mL while Cd contains the least 0.138 µg/mL for dry season. Also, Fe recorded the highest standard deviation 12.867 µg/mL, come next Zn 8.050 µg/mL while Cd recorded the least value of 0.004 µg/mL for dry season. Likewise, Fe recorded maximum overall mean value of 82.385 µg/mL and Cd 0.218 µg/mL with least overall mean for wet season. On such a basis of the comparative variation, the finding of coefficient of variation (CV) implies that all the analyzed variables are analogous. For instance, Zn and Fe maximum the list with some values of 17.417%; 19.582%; 20.013% and 22.858% for both seasons, respectively. The compatible low coefficient of variation value (CV) (4.638-22.858), show identical sources of metals in the well water system under assessments. In addition, the FAO/WHO prescribed limit for poultry drinking water quality taken on to declare the suitability of groundwater for poultry efficiency in the research area signified that all the variables examined in both seasons were found to be more than the maximum prescribed limit for poultry drinking with exemption of Control in all the sampling locations. Arsenic in groundwater may arise from being extensively used as feed preservatives, herbicides, pesticides and fungicides from arsenical (3-nitro-arsonic acid), lead arsenate, sodium arsenate and cacodylic acid which are routine in the sampling stations [9, 24, 25, 26]. The overburden of Cd in the site was attributable to the dumping of metal-contaminated animal manure in the vicinity of the well and discharged to the environment in wastewater form. Leachate from dumpsite adds magnanimously to the Cd content in the ecosystem and food, specifically the agricultural products is the other source of Cd [24, 25, 26]. The key provenances of Cu in groundwater contain leachate from copper salts, copper chloride, and disinfectant chemicals, concentrate feed by-product, anti-microbial vaccine, poultry landfill, runoff from agricultural field and geological make-up of the soil/rock having the water. The rusting of metal roofs, fences, water pipes, metallic feeder drinking trough and head cover, metallic drawer, galvanized pump parts frequently given rise to sharp levels of Fe "red water". Other foremost provenances of Fe comprises nature of rock and soil which accommodate the especially the igneous rock, leachate from poultry refuse dumps, poultry waste, and discharge from manure stockpile [24, 25]. The homes plumbing system made of lead or alloy could be another likely source of Pb in the poultry well water, though its dissolving is controlled by many factors like pH, temperature, hardness of water and its exposure duration. Water having high levels of metal reveals deleterious effects on poultry and human health. The consequences of the presence of increased levels of metals especially those like As, Cd, Cu, Fe, Pb and Zn on poultry-keeping are that certain concentrations combinations and/or ratios may have antagonistic effects causing sub-optimal efficiency [34]. Even then most effects are not "all or none" kind [34]. There may be severe detriments to weights, feed conversions and egg efficiency and quality regularly lacking any clinical indications [34]. Studies have revealed that undue dissolved As, Cd, Cu, Fe, Pb and Zn contents in poultry groundwater results in odour, bad taste, precipitation issues, blocking of lines to watering troughs or objectionable discoloration or deposit, decreases in day-to-day gains and feed intake [24, 25, 26].

In addition, a high level of metal in poultry commonly leads to metal toxicity, which may result in harsh taste, skin lesions, low efficacy of feed conversion, stunted growth and poor feathering, encourages accumulation of *Clostridium perfringens* in the chicken intestinal content and so may increase the likelihood of necrotic enteritis [25], while in human, its effects cancer, hyperkeratosis (scaling skin) in the body system. Obviously, trace metals like As, Cd, Cu, Fe, Pb and Zn have also been expressed at extreme levels in groundwater in areas of Nigeria owing to geological building block of the basic rocks in the vicinity of the well [3].

Geochemical Indices

Enrichment Factor (EF): The result from this analysis indicated that EF values of the metals ranged from 0.045 to 0.348 for As; -0.068 to 0.149 for Cd, 0.029 to 0.069 for Cu, 1.000 to 1.000 for Fe; 0.003 to 0.013 for Pb, and 0.544 to 0.789 for Zn, respectively in both seasons (Table 4).

Table 3. Mean Levels of Heavy Metals (µg/mL) in Groundwater of some Poultry Farms in Osun State

Sampling Site	As	Cd	Cu	Fe	Pb	Zn	Total load per sampling site (µg/mL)
				Dry Season			
Agboola	0.250	0.180	1.620	92.550	0.730	51.260	146.590
Odunola	0.320	0.210	2.930	101.60	0.780	48.150	153.990
Worgor	0.210	0.130	2.080	83.440	0.810	56.180	142.850
Control	0.010	0.030	0.220	18.440	0.050	8.440	142.850
Max.	0.320	0.210	2.930	101.60	0.810	56.180	26.840
Min.	0.010	0.030	0.220	18.440	0.050	8.440	153.990
Overall mean	0.198	0.138	1.713	0.090	0.593	41.008	26.840
SD	0.006	0.004	0.090	12.867	0.032	8.030	13.418
CV	3.000	2.899	5.254	17.407	5.396	19.582	11.413
				Wet Season			
Agboola	0.420	0.360	2.180	99.030	1.060	57.500	160.550
Odunola	0.390	0.270	2.980	106.120	1.430	52.480	163.670
Worgor	0.330	0.200	2.550	102.260	1.280	60.280	166.900
Control	0.020	0.040	0.310	22.130	0.080	10.280	32.860
Max.	0.420	0.360	2.980	106.120	1.430	60.280	166.900
Min.	0.020	0.040	0.310	22.130	0.080	10.280	32.860
Overall mean	0.290	0.218	2.005	82.385	0.963	45.135	130.996
SD	0.016	0.012	0.093	16.488	0.053	10.317	16.542
CV	5.517	5.505	4.638	20.013	5.504	22.858	
Benchmark value [FW]	0.050	0.100	0.440	4.100	4.400	3.500	
TEL [FW] **[P]	0.20	0.01	0.20	0.20	0.05	24.00	
PEL [FW] **[P]	0.20	0.05	0.50	0.30	0.10	25.00	
FAO [27]*	10.00	5.00	1300	10.00	20.00	5000	

FAO* [27]; Menafoglio and Secchi, [19]; Min-Minimum; Max-Maximum; SD-Standard Deviation; MCL-Maximum Content Level; TEL: Threshold Effect Limit, TET: Toxic Effect Threshold. **FW represents fresh water; Poultry animal [24, 25, 26]

Table 4. Mean Enrichment Factor (EF), Contamination Factor (CF) and Geo-accumulation Index (*I-geo*) Values in some Poultry Farms Hand-dug Well Water for Dry and Wet Seasons

ite	As			Cd			Cu			Fe			Pb			Zn		
Dry Season																		
	EF	CF	*I-geo*	EF	CF	*I-geo*	EF	CF	*I-geo*	EF	CF	*I-geo*	EF	CF	*I-geo*	EF	CF	*I-geo*
Agboola	0.221	5.000	1.737	0.080	1.800	0.263	0.042	3.682	1.296	1.000	22.573	3.912	0.007	0.166	-3.177	0.649	14.646	3.288
Odunola	0.258	6.400	2.093	0.085	2.100	0.485	0.069	6.659	2.151	1.000	23.090	4.047	0.007	0.177	-3.081	0.555	13.757	3.197
Worgor	0.206	4.200	1.486	0.064	1.300	-0.059	0.059	4.727	1.656	1.000	20.351	3.762	0.009	0.184	-3.027	0.789	16.051	3.420
Control	0.045	0.200	-2.907	-0.068	0.300	-2.322	0.029	0.500	-1.585	1.000	4.412	1.557	0.003	0.011	-7.045	0.547	2.411	0.685
Max.	0.258	6.400	2.093	0.085	2.100	0.485	0.069	6.659	2.151	1.000	23.090	4.047	0.009	0.184	-3.027	0.789	16.051	3.420
Min.	0.045	0.200	-2.907	-0.068	0.300	-2.322	0.029	0.500	-1.585	1.000	4.412	1.557	0.003	0.011	-7.045	0.547	2.411	0.685
Overall mean	0.183	3.950	0.974	0.040	1.375	-0.445	0.050	3.892	0.880	1.000	17.607	3.320	0.007	0.135	-4.083	0.635	11.716	2.648
SD	0.061	0.904	0.013	0.001	0.483	0.001	0.015	0.830	0.460	0.000	3.687	0.069	0.002	0.711	0.054	0.009	1.434	0.535
Wet Season																		
Agboola	0.348	8.400	2.486	0.149	3.600	1.263	0.052	4.955	1.724	1.000	24.154	4.010	0.010	0.241	-2.639	0.680	16.429	3.454
Odunola	0.301	7.800	2.379	0.104	2.700	0.848	0.067	6.773	2.175	1.000	25.883	4.109	0.013	0.325	-2.207	0.579	14.994	3.322
Worgor	0.265	6.600	2.138	0.080	2.000	0.415	0.059	5.795	1.950	1.000	24.971	4.056	0.012	0.291	-2.367	0.690	17.223	3.522
Control	0.074	0.400	-1.907	0.074	0.400	-1.907	0.033	0.705	-1.090	1.000	5.398	1.848	0.003	0.018	-6.367	0.544	2.937	0.960
Max.	0.348	8.400	2.486	0.149	3.600	1.263	0.067	6.773	2.175	1.000	25.883	4.109	0.013	0.325	-2.207	0.690	17.223	3.522
Min.	0.074	0.400	-1.907	0.074	0.400	-1.907	0.033	0.705	-1.090	1.000	5.398	1.848	0.003	0.018	-6.367	0.544	2.937	0.960
Overall mean	0.247	5.800	1.809	0.102	2.175	0.259	0.053	4.557	1.677	1.000	20.102	3.506	0.010	0.219	-7.070	0.623	12.896	2.815
SD	0.084	1.014	0.080	0.008	0.091	0.027	0.013	0.923	0.098	0.000	4.511	0.858	0.003	0.081	0.092	0.063	2.801	0.631

The EF values of As, Cd, Cu, Pb and Zn in all the locations were found to be not more than 1 (EF < 1) which signified that these metals had no enrichment. The lowest EF values were found in Pb (overall mean 0.007 and 0.010) in dry and wet seasons which probably emanated from natural weathering process. The overall mean EF values of Fe (1.000) suggested that the enrichment was due to minor influences from the anthropogenic sources. Iron is usually supplied as an additives to accomplish augmentation of feed conversion and also added to the diets to counteract likely toxicity as a result of the high addition of Cu and Zn [24, 25]. Local commercial compost, refuse compost and chicken manure also had substantial amount of Fe. The extensive and continual applications of these materials can, consequently, cause elevated Fe contents whenever seepage into the agricultural wells occurs. In a nutshell, EF of these metals was higher in the poultry-influenced part than domestic-influenced part.

Contamination Factor (CF): The determined CF for the study sites reveals that Odunola farm has the highest CF and after that Agboola and Worgor farms while Control recorded the lowest values of CF for dry and wet seasons, respectively (Table 4).

These farms had been effectively producing poultry birds for nearly 25 years. It is obvious that poultry well water area indicated higher content of metal concentration in comparison to the enclosing part. The CF values in groundwater area in poultry locations are more than 1.0, indicating that metal contents are above prescribed value. The likely sources of pollution to poultry well water might be runoff from untreated poultry manures, untreated wastewater from poultry pen units, emission from feed milling machine, un-hatch eggs, unused or expired commodities and waste containers, medication, spraying of pesticides and herbicides, empty feed bags, empty vials and disposal materials, add nobly to the contamination load of poultry farm well [25].

Pollution Load Index (PLI): Poultry farms groundwater has revealed to be contaminated with manifold trace metals from poultry emissions. It contains As, Cd, Cu, Fe, Pb and Zn, the more paramount being Fe from feed preservatives like amino acids, antibiotics, drugs, hormones, vitamins and minerals. Iron, Zn, As and Cu and their compounds were widely used as feed concentrates and preservatives. The PLI is maximum at Odunola poultry farm in Osogbo which is the state capital of Osun. The farm is not far off the freeway and highway which is not more than 1.5 ft. to the major road. Supposed prominent sources of elevated water Fe, Zn, As and Cu were animal feed factory, hatchery machine, bedding, wood shavings and sawdust used to grow chickens, growers, layers and broilers, excessive usage of pharmaceutical antibiotic, pesticides, herbicides, wastewater from slaughterhouse, emission from traffic and intrusion community. The PLI was more than 1 in Agboola and Worgor farms which might be as a result of long-term deposition of poultry manure wastes, unhygienic status, agrochemical wastes, corrosion of metallic objects for example feeding and watering troughs, head pan, shovel, spade, matchet, galvanized iron sheet roofs, battery cage wire system, laying boxes, egg trays, nails, careless deposition of local gun powder and so on augments the elevated levels of trace metals found in that water ecosystem. The higher value of the PLI at these farms indicates that the trace metal pollution of poultry hand-dug wells was largely influenced by the discharge from agriculture and poultry farm industrial compound. Notwithstanding, the PLI of Control groundwater revealed a different status from Odunola, Agboola and Worgor indicator for the consideration that trace metal content in Control was not just influenced by external status quo.

Geo-accumulation Index (*I-geo*): The mean results shown that the *I-geo* for both seasons in As (0.183 and 0.247); Cd (-0.445 and 0.259) and Pb (-4.083 and -7.070) were below grade 1, indicating no anthropogenic pollutants in the poultry groundwater. On the basis of this evaluation, it can be inferred that the regional parent bedrock attributes and natural proliferation process in the collection are the major factors influencing As, Cd and Pb contents in the groundwater [3]. Nonetheless, Cu with a mean *I-geo* of 0.880 and 1.677, Fe with a mean of 3.320 and 3.506, and Zn with a mean of 2.648 and 2.815 in dry and wet seasons, respectively revealed that the poultry hand-dug wells were moderately polluted with these metals. This might be by cause of their being effectively included as feed preservatives and medication in poultry nutrition.

Table 5. Mean Pollution Load Index of Trace Metals for Dry and Wet Seasons across the Sampling Sites

Site	Dry	Wet	Overall mean
Agboola	3.494	4.928	4.211
Odunola	4.140	5.119	4.630
Worgor	3.402	4.608	4.005
Control	0.390	0.564	0.477

Quantification of Groundwater Contamination (QoC): On the underlying condition of the quantification of anthropogenic input of the trace metals in the groundwater presented in Table 6, one may sequence the contamination with individual metals for both seasons along these lines: Agboola Farm: As > Pb > Cd> Cu > Zn > Fe; Odunola Farm: As > Pb > Cu > Cd > Zn > Fe; and Worgor Farm: As > Pb > Cu > Zn > Cd > Fe. Geo-accumulation factor is not easily analogous to CF because of the nature of *I-geo* computation which contains a logarithmic function and a benchmark working factor 1.5 [35]. In spite of that, results from the diverse impact-assessing indices indicated common trend with one another. This could just be an evidence that the anthropogenic sources of the metals in the water in these poultry farms were of the identical origin, with anthropogenic inputs of the metals in groundwater. Collectively, the percentage mean decreasing order of the metals was: As (95.35%) > Pb (93.53%) > Cu (88.59%) > Cd (83.34%) > Zn (82.75%) > Fe (79.36%).

Table 6. Percentage Mean Quantification of Anthropogenic Content of Metals for Dry and Wet Seasons

Site/Metal	As	Cd	Cu	Fe	Pb	Zn
			Dry Season			
Agboola	96.00	83.33	86.42	80.45	93.15	83.53
Odunola	96.88	85.71	92.49	82.19	93.59	82.47
Worgor	95.24	76.92	89.42	78.32	93.83	84.98
Mean	96.04	81.99	89.44	80.32	93.52	83.66
			Wet Season			
Agboola	95.24	88.89	85.78	77.65	92.45	82.12
Odunola	94.87	85.19	89.60	79.15	94.41	80.41
Worgor	93.94	80.00	87.84	78.36	93.75	82.95
Mean	94.68	84.69	87.74	78.39	93.54	81.83

Water Quality Guidelines for Poultry (WQGs)

Water quality guidelines are devised to let assessment of the suitability of water for the particular purposes. The present Canadian Council of Ministers of the Environment [24] water quality guidelines are devised simply for the safeguard of the animal and do not address prospective accrual of contaminants that may be dispensed to consumers via egg, meat, feather and so forth. With the intention of estimating adverse ecological effects in contaminated groundwater, several water quality guidelines for poultry (WQGs) have been devised over the past decade [24, 25, 26]. In this study, we juxtaposed our total content with WQG of threshold effect limit (TEL), which comprises threshold effect contents, and toxic effect threshold (TET), which comprises probable effect contents (PEC) as explicit by Olkowski, [25] to assess the probable ecological effects of the metal contents in the well water (Table 3).

Threshold effect contents should be employed to distinguish groundwater that are suspected to be negatively affected by well-associated contaminants, while the PECs should be employed to determine waters that are probable to be noxious to water-using organisms [24, 25, 26]. The data of this study revealed that As, Cd, Cu, Fe, Pb and Zn contents of well waters in almost all the locations were more than the TEL value of 0.20, 0.01, 0.20, 0.20, 0.05 and 24.00 µg/mL (unless for Control station) and more than the TET value of 0.20, 0.05, 0.50, 5.00, 0.10 and 25.00 µg/mL (unless for Control station) (Table 3). In overall, all the metals contents in the well water sample of the poultry farms were more than the TEL and TET. The consequence of the presence of increased level of metals more than the TEL, TET and FAO/WHO levels particularly those of As, Cd, Cu, Fe, Pb and Zn on poultry water output is that it has an effect upon feed consumption, declined feed intake, body mass, immune function, decreased egg efficiency, increased the percentage of embryonic lethal rate and disrupt ideal performance [24, 25].

Statistical Analysis

Statistical Analysis of Variance (ANOVA) of Total Metal Determination: Results were evaluated by ANOVA utilizing the common linear models procedure of PAST software version 2.17 probabilities below 0.05 ($p < 0.05$) were regarded statistically different. As of the statistical findings obtained, since the pooled p-value (0.62) is more than (p-0.05), there is no significant difference between the physico-chemical and trace metal variables of the poultry farms aquifers. Therefore, we accept the null hypothesis and reject alternate hypothesis at 0.05 level of significance {$F_{calculated}$ (1.67) < $F_{critical}$ (2.84)} Table 7. The qualities of water sources are quantified by the content of the indicator variable present in them.

Table 7. Analysis of Variance of Total Metal Determination

Source of Variation	Sum of Squares	Degree of Freedom	Mean Squares	$F_{calculated}$	P-value	$F_{critical}$
Between Groups	1137.77	3	379.256	1.666	0.618	2.840
Within Groups	30322.30	48	631.715			
Total	31460.07	51				

Table 8. Interphysicochemical and Trace Metals Sampling points Correlation

	Temp	pH	Do	BOD	COD	TOC	TOM	As	Cd	Cu	Fe	Pb	Zn
Temp	1												
pH	0.73216	1											
Do	0.059065	0.72319	1										
BOD	-0.5831	-0.98028	-0.84542	1									
COD	0.067763	-0.62996	-0.99196	0.77102	1								
TOC	0.1702	-0.54659	-0.97364	0.7013	0.99468	1							
TOM	0.16907	-0.54755	-0.9739	0.70212	0.9948	0.99999	1						
As	0.67277	-0.01137	-0.69882	0.20876	0.78374	0.84356	0.84295	1					
Cd	0.9477	0.47646	-0.26264	-0.29331	0.38266	0.47581	0.4748	0.87372	1				
Cu	-0.46477	-0.94338	-0.91134	0.99033	0.8519	0.79341	0.79411	0.34241	-0.15786	1			
Fe	0.17757	-0.5403	-0.9719	0.69595	0.99388	0.99997	0.99996	0.84756	0.48238	0.78883	1		
Pb	-0.75026	-0.99964	-0.7043	0.97459	0.60878	0.52381	0.52478	-0.0156	-0.5	0.9341	0.51741	1	
Zn	-0.41289	0.31807	0.8848	-0.49916	-0.93667	-0.96777	-0.96748	-0.95162	-0.68199	-0.61453	-0.96962	-0.29238	1

Hence, differences in means of variables tested affirm identical sources. The result of this analysis of statistics implies the on-the site remark on the raw statistics of the water attribute when differentiated with CCME [24], Watkins [26] and Olkowski [25] poultry drinkable water guideline.

Correlations among Quality Variables: There are considerable correlations occurring between the physico-chemical and trace metals variables of the poultry farm well waters. This assumption was examined utilizing linear correlation coefficient (r) tool to conduct the correlations between the physico-chemical and trace metals variables of the water sources of the close proximity. The linear correlation is applied to analyze a correlation between at least two continuous variables. The value can fall between -1 (perfect inverse correlation) through 0 (no correlation) to +1 (perfect sympathetic correlation). The test revealed many considerable between the physico-chemical variables and trace metals (Table 8) in the water samples of the area under study. At $p < 0.05$, pH correlated positively with Cd ($r = 0.48$) and Pb ($r = 0.52$); TOM with Cd ($r = 0.47$) and Pb ($r = 0.52$), respectively. The other physico-chemical and trace metals correlated with various others at $p < 0.01$, save temperature with BOD, Cu, Pb and Zn; pH with BOD, COD, TOC, TOM, As, Cu, Fe and Pb; DO with BOD, COD, TOM, TOC, TOM, As, Cd, Cu, Fe, Pb and Zn; BOD with Cd and Zn; COD with Zn; TOC with Zn; TOM with Zn; As with Pb and Zn; Cd with Cu, Pb and Zn; Cu with Zn; Fe with Zn and Pb with Zn, which did not reveal considerable correlation at either $p < 0.05$ or < 0.01 (Table 8). As at $p < 0.05$ some variables correlated with each other while many variables correlated with others at $p < 0.01$. We posit alternate hypothesis that there are considerable correlations between the physico-chemical and trace metals variables in the groundwater samples of the area under study and discard the null hypothesis. This affirms that the presence of particular pollution measure will have an effect upon the occurrence or increment of some other variables. For instance, a higher COD infers there is more chemically oxidized organic material than ecological material in the water, and with more organic components in the water, the water's organic matter (OM) rises. By determining the water's organic matter, we can empirically conduct its COD content. At an elevated COD value, water turns out to be organically polluted.

The positive correlation obtained among BOD, COD, TOC and TOM affirms that rising temperature could embolden microbial accumulation, by that given rise to more oxygen demands. Increasing nutrient contents appeared to support the microbial growth, especially in the shallow aquifers [36]. The manifold considerable correlations found between the physico-chemical and trace metals variables connote their correlation in the aquifers. Considerable correlations between most of these physico-chemical and trace metals were possibly on account of inflows of some non-lithogenic and geogenic sources into the groundwater. The negative correlation between pH and Pb, reveals that acidification causes increased metal availableness in ecological matrices [36]. Temperature highly exerted positive impact on the trace metal (apart from Cu, Pb and Zn) examined in this study. This signifies that increasing temperatures could result in increased dissolvability of the inorganic pollutants. The positive correlations found between TOC and some trace metals assert that organic pollutants also form dissolved constituents of the liquid matrix, especially in the poultry groundwater. Also, elevated positive correlations indicated by some trace metals implied that these metals have strong correlation with organic carbon. The number and strength of binding sites are variable among kinds of organic matter. Some kinds of organic matter contain few sites per unit surface (e.g. lignin) and others contain many (fulvic matters). Though, metal availability is controlled by organic matter content, some qualities of the water like pH, oxidation-reduction reactions and the metal binding capability which influence the solubility, availability and mobility of metals, are also paramount [37].

Cluster Analysis: Cluster analysis was conducted applying nearest neighbor relation to obtain groundwater that had related water chemical quality distinctive. It helps to reveal some intrinsic general patterns in vivid shapes. The Dendrogram of hierarchical cluster analysis as depicted in Figure 2 demonstrates three clusters for poultry groundwater on the basis of pollution scale as non-lithogenic, mixed (non-lithogenic and lithogenic) and lithogenic for the dry and wet seasons, respectively. The clustering of hand-dug wells signifies that water qualities of groundwater varied in ways to indicate the effect of both natural (mineralogical formation of the ecosystem) and anthropogenic sources which contain the pollutants emanating from poultry-keeping.

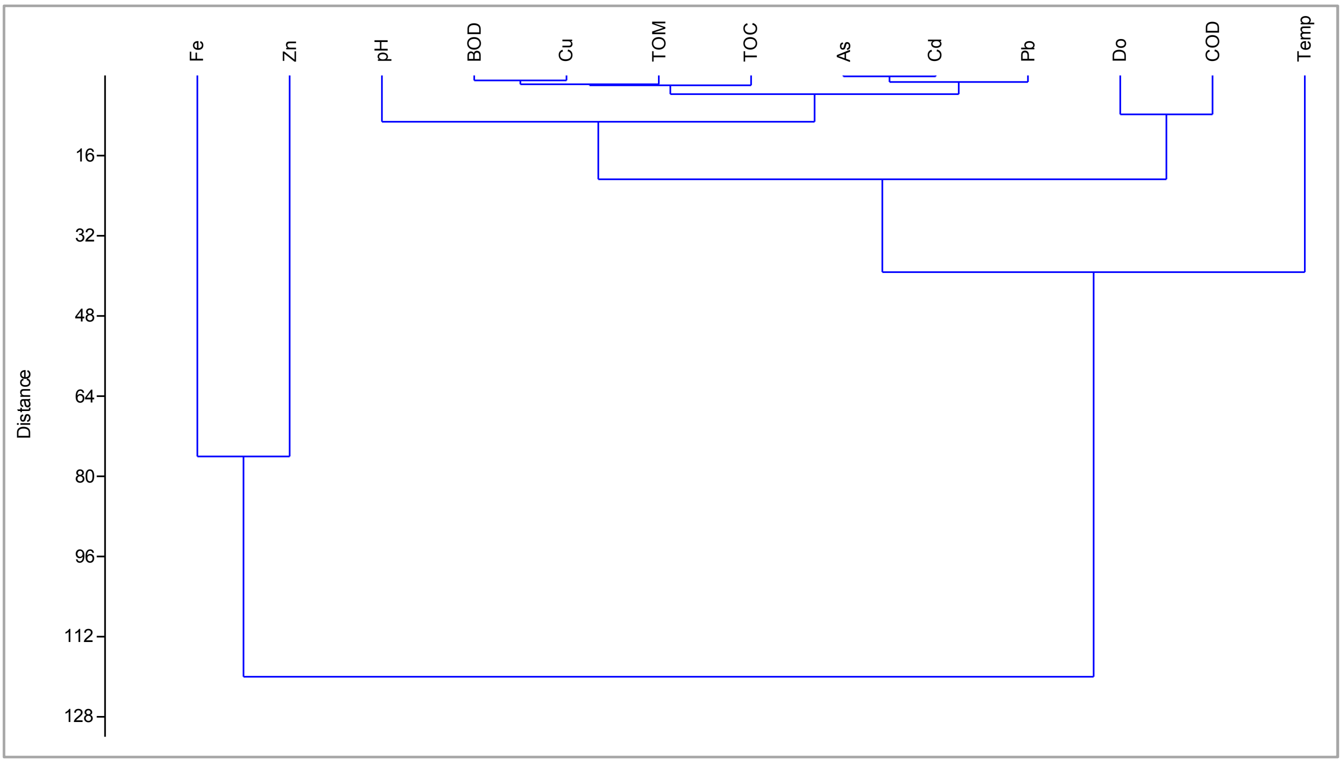


Figure 2. Cluster Diagram Signifying Correlation between Physico-chemical and Trace Metals Variables in the Poultry Farms Groundwater (Dry and Wet Seasons)

This concurs with Edet *et al*. [4] implies variation of water quality between seasons. Cluster 1 consists of Fe and Zn group. These are categorized as non-lithogenic in origin. The second cluster showing pH, BOD, Cu, TOM, TOC, As, Cd, Pb, DO and COD groups as emanating from mixed sources (non-lithogenic and lithogenic). The third cluster differentiated the lithogenic temperature. Similar research by Watkins [26] reported As, Cu, Fe and Zn to be heavily inherent in animal feed factory and Cd and Pb to be intrinsic in several industries and metal smelting processes. In accordance with Olkowski, [25] elevated COD, TOC, TOM, BOD and pH were connected with poultry associated sources like droppings, egg crates, used syringes, broken drug containers, rotten feeds, bedding materials, feathers, open burning, open burial of death birds and chicken processing facilities.

Conclusion

The usage of groundwater for poultry-keeping has gained significance in every part of the world on account of being the inexpensive, main practical ways of supplying water to poultry communities, demanded less treatment and the supply is probable to be assured even in the dry season. Groundwater contains a high amount of organic matter, chemical oxygen demand, nutrients and undeniable trace metals that are toxic to birds when present above prescribed limit. Groundwater may amass metals in adequate quantities to cause clinical problems to both animals and human being using up these metal-rich waters. This study gives a brief insight into the status quo of poultry water contamination and possible future health risk issues. In accordance with WQGs of TEL and TET, all of the metals in the poultry farm wells were above the TEL and TET values for poultry drinkable water. Different methods of trace metals pollution assessment are also addressed. These indices pointed out that poultry farm wells were more metal-enriched than control site. This analysis also revealed that risk of metal contents can be evaluated utilizing some indices and not only by quantifying of total metal contents. In spite of the fact that, the levels of most trace metals in the poultry groundwater did not demonstrate extreme enrichment and was not introduced any serious menace to the local fauna and flora, a pressing need exists to restrictively monitor the groundwater of the assessment area and to develop manifold strategies to prevent the buildup of trace metals in groundwater may finally reduce the negative health effect to the exposed populations. The contents of the metals in the groundwater will give reference point information and intensive sampling is necessary for the quantification of the findings in every part of the country. To check the ingress of polluted waters into the food chain, poultry groundwater should not be used not having prior treatment.

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Statement of Competing Interests:

The authors declare that they have no competing interests

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