Groundwater Quality Assessment of some Poultry Farms in Osun State, Southwestern Nigeria, for Irrigation and Household Uses

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ABSTRACT: *The development of enormous irrigation systems has been a major instrumental to worldwide food security, especially in arid zones, but it has also been associated with land and water salinity issues. The shallow hand-dug wells of some poultry farms in Osun State were sampled on seasonal basis and evaluated for their quality and suitableness for agricultural uses. Twenty-four water samples taken from wells were evaluated for physicochemical variables, applying standard methods. The main constituents that determine the water quality for irrigation like electrical conductivity, total dissolved solids, sodium adsorption ratio, soluble sodium percentage, residual sodium bicarbonate, magnesium adsorption ratio, Kelly's ratio and Permeability index were evaluated and in comparison with safe limits. Quality assurance procedures included blank test, recovery analysis and calibration of standards. Descriptive and inferential statistics were used for data interpretations. The mean values of EC (<600.00 µS/cm), TDS (<400.00 mg/L), SAR (<1.00 meq/L), SSP (<25.00%), RSBC (<0.50 meq/L), MAR (< 50.00%), KR (<0.50 meq/L) and PI (<2.00 meq/L) were found to be in the safe limits of the National Environmental Standards and Regulations Enforcement Agency and Food and Agricultural Organization/World Health Organization. Thereby, the groundwater would not cause detrimental effects on the soil properties of the assessment area.*

KEY WORDS: Groundwater, physicochemical variables, irrigation, water quality, assessment, poultry farms

INTRODUCTION

Water characteristic and agriculture occurrences are diverse and complicated (FAO, 2015). The growing of enormous irrigation systems has been a major instrumental to worldwide food security, especially in arid areas, but it has also been pertinent to land and water salinity issues (FAO, 2015). In Nigeria and precisely in Osun State, both development and increase of agriculture and proliferation of poultry operations in the recent times have caused an increasing use of fertilizers and agrochemicals that, when not well controlled, can give rise to water quality deterioration of rivers, lakes, streams, groundwater and marine water bodies (Ogunwale *et al*., 2021).

Quddus and Zaman (1996) surveyed the irrigation water characteristic of some chosen villages of Meherpur territory of Bangladesh and claimed that some of the subsequent ions like Ca^{2+}, Mg^{2+}, Na^{+}, HCO_3^{-}, SO_4^{2-}, Cl^{-}, K^{+}, and the rest are more or less valuable for crop growth and soil qualities in minute amounts. Talukder *et al*. (1998) asserted that poor quality irrigation water lessens land fertility, alters soil physical and chemical properties, causes crop harmfulness and in the end affects harvest. Shahidullah *et al*. (2000) evaluated the groundwater quality in Mymensigh area of Bangladesh and obtained a linear correlation between SAR and SSP. They also revealed that the groundwater can without harm be employed for long-term irrigation. Sarkar and Hassan (2006) studied the water quality of an aquifer reservoir in Bangladesh for irrigation uses and found that conventional water characteristic indices like pH, EC, SAR, RSBC, MAR, PI, KR and TDS were within the safe level for crop production. Raihan and Alam (2008) demonstrated a pictorial depiction of groundwater quality all over the Sunamganj zone that acceptable for description of groundwater on the basis of its suitableness for irrigation purposes. Also, Obiefuna and Orazulike (2010) conducted related work in Yola area of Northeast Nigeria and finalized that the groundwater of the site is generally suited for irrigation purposes. Lastly, Obiefuna and Sheriff (2011) affirmed the shallow groundwater quality of Pindiga Gombe zone for irrigation and household utilizations and found that the water samples also fell within the safe levels for irrigation uses and household consumptions.

Increase of livestock and poultry farming systems are cases in point in which growing efforts developments the impending transmission of pollution from both animal waste and fodder output sometimes bringing about the emergence of eutrophication of freshwater bodies. The resultant effects include water scarcity and pollution such that millions of farmers worldwide are moved to irrigate with marginal quality water for instance wastewater from urban areas or saline agricultural drainage water (FAO, 2015). Minimalizing both the productivity and food safety risks and, at the same time, exploiting benefits when making use of such water is a countless challenge. Moreover, matters about the utilization of naturally occurring metal-laden groundwater in agriculture are heightening and, therefore, this developing issue will need unusual consideration. These are all examples of the complicated correlations between agriculture and water quality that are scientifically conducted in this assessment.

Farm water sources are by dint of hand-dug wells, dams, boreholes, rain-fed, town water, channels, recycled water and surface water. Water out of manifold sources may be of unfitting quality for its deliberate use, such as for irrigation, stock, household or other farm activities. Activities that may negatively affect water quality comprise the use of agrochemicals, fumigation, disinfectant and antibiotics by most farmers and improper disposal of poultry wastes. It is paramount to identify and correct water quality issues that may have an impact on farm use and yield.

Many of the hand-dug wells are shallow, not concealed, and not casing lined. Thereby, the well is rendered susceptible to pollution by surface water for the period of heavy downpour (precipitation) along with agricultural activities all of which could present the prevalence of water borne diseases. It is against this baseline that the physico-chemical assessment of shallow groundwater of some poultry farms in Osun State area was being evaluated. The investigation recommendation would serve as practical guide in preventing deteriorating in the future. With the purpose of accomplishing the above objective, different indices employing water for irrigation, like SAR, RSBC, SSP, MAR, KR, PI, EC and TDS were estimated obtained from previous assessments (Quddus and Zaman, 1996; Talukder *et al*., 1998; Shahidullah *et al*., 2000; Sarkar and Hassan, 2006; Raihan and Alam, 2008; Obiefuna and Orazulike, 2010; Obiefuna and Sheriff, 2011) and applied to quantify the acceptability of groundwater for irrigational uses in the area under study.

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The most importance of the study was to add to initial information on the subject of study. Therefore, it was bound that this study would add to the previous literature on the subject**.** Results from this study will be helpful in the following points:

1. Information provision on the suitableness state of groundwater sources of the community from the on-site poultry locations.
2. Indicator information provision on the impact of nearness of the poultry litter dispose of to shallow wells within chosen poultry industries.
3. Water quality problems have impact on human and ecological health, so the more we investigate and monitor our water, the better we would be able to identify and avert pollution problems.

Similar literature studies on the above topic had been studied. The subsequent gaps (which this existing work attempts to fulfill) were discovered: (i) There are recorded works on groundwater pollution, most of which occur in Nigeria, but there are just a couple that emphasized on evaluation of hand dug well on poultry productions. This work investigated the groundwater quality attributes of Ejigbo, Isundunrin and Osogbo metropolis with focus on the quality attributes of water from poultry farm well. (ii) Another main gap was in the feature of site of the study. Diverse of the literatures studied were conducted on Southwestern region, none focused on the groundwater quality condition of poultry farm in Ejigbo, Isundunrin and Osogbo community. The similar studies were performed in Osun State and environs occasionally without emphasized on poultry farm well water of these communities. This study was a comprehensive study on the suitableness of well waters from poultry community. (iii) Most of the literature that reviewed either concentrated on the other sources of water supplies like the streams, rivers, springs and rain water or on groundwater pollution by saltwater intrusion. This study was focused on the human-related pollution of groundwater springs and (iv) A good number of the reviewed literature concentrated just on physiochemical variables utilizing just some boreholes, whilst this current work utilized analytical sampling and has comprehensive investigation on both physiochemical and irrigation parameters of well waters in poultry environment.

The present work aimed at gaining insight into the irrigation indices of poultry farm water in Ejigbo, Isundunrin and Osogbo, Osun State, Nigeria, concerning water collected inside the designated sites had the subsequent objective. The main aim of this work is to evaluate the shallow groundwater quality of some poultry farms in Osun State metropolis for irrigation and household uses.

MATERIALS AND METHODS

Location, Sketch and Relevance of the Assessment Area

The assessment area included poultry farms in Ejigbo, Isundunrin and Osogbo in Osun State, Southwestern Nigeria. The map of the study area is shown in Figure 1, while Table 1 offers the geographical positions of the sampling sites. The assessment area lies 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 level is within 311.81 to 357.23 m above water level. The area encompasses a landscape of about 100 km^2 on a map of scale 1:50 000.The occupants of the farm relies mostly on groundwater for their poultry and irrigation activities. The water sources made up of shallow wells by reason of high water table in the area and low-cost means of shallow well construction. The low-lying landscape of the area causes probable the deposition of alluvial soils productive for agriculture and digging of shallow wells which are commonly employed by members of the poultry farmers for domestic utilizations, for example washing of their tools and equipment, cleaning of the poultry housing units, irrigation, drinking, cooking, bathing and gardening. The assessment area falls within the tropical dry forest and derived savanna ecosystem depicted by a distinct alternation of wet and dry seasons, normal of South West Nigeria. The highest diurnal temperature could be up to 28.0ºC or a little more which relates to the hottest period commonly present in the months of February to March, and the months of December to January are generally cold with temperatures as low as 24.4ºC (Ogunwale *et al*., 2021). The dry season outspreads from early November to early April, while the rainy season commences from mid-April to late October. The mean annual rainfall is in the range of 1000 to 1250 mm (Ogunwale *et al*., 2021). Osun State parts boundaries on the West and North-West with Oyo State; on the North and North-East with Kwara State; on the East and South-East with Ondo State and on the South-West with Ogun State and on the East and North-East with Ekiti State (Ogunwale *et al*., 2021). Osun State is well drained by moderately ample rivers, like River Osun, and their tributaries, some of which spring from outer the frontiers of the state.

Several poultry farmers in the area have private hand-dug wells or deep boreholes that tap shallow fluvial aquifers to depth of 1 to 8 m, respectively for drinking and various domestic uses (Table 2). Deep boreholes are however less common than hand-dug wells specifically in poultry areas. The shallow aquifer arise in the current fluvial sediments comprising of gravels, sands, silts and clays while the deep aquifers develop in the underlying fine to coarse grained Osun Sandstone Formation (Ogunwale *et al*., 2021).The farmlands are gently dry and cover of deep clayey soils formed on low smooth hill crests and upper slopes; and the sandier hill wash soils on the lower slopes where sustenance agri-business is being practiced (Ogunwale *et al*., 2021). The food crops cultivated in the area consist of banana, plantain, pawpaw, maize, pepper, tomatoes, yam, guinea corn, soya bean, cowpea, groundnut, cocoyam, vegetables and cassava. An additional key activity is small-and large-scale poultry keeping. The main residents of the region are Yoruba, with other itinerant tribes, like Egede, Sabe, Igbo and Fulani who are engaged in farming, herding and trading. The sampling stations selected for this research were considered suitable because all of them have been involved in active poultry business for over 25 years; long-term land use history is known and also serves a large percentage of the populaces of Osun metropolis. Furthermore, the farm produce (fowls and eggs) enjoys large patronages on daily basis from neighboring states.

Water Sampling and Analysis

At various sites, water samples were taken on seasonal basis from hand-dug wells within the poultry farms for physico-chemical variable analysis. For wet season, sampling covered the months of July to October, 2014, while for dry season; samples were carried out in the months of December, 2014 to March, 2015 using standard technique (APHA/AWWA/WPCF, 2014). A total of twenty-four water samples were collected through plastic bucket attached to a calibrated polymer rope from three hand-dug wells. The 2.5 L sampling plastic kegs meant for sampling were first washed with liquid detergent and rinsed with distilled water. They were then soaked in 10% nitric acid for 48 hours. This was followed by active rinsing with distilled water for three times. Earlier to sample collection, the plastic kegs were rinsed with the water samples at the sampling site four times before being filled to the brim with the sample. The samples were filtered by means of pre-washed 0.45 µm millipore membrane filters (47 mm diameter) to eliminate any suspended solids. All samples were conducted in triplicates, stored in iced chest and carried to the research laboratory, refrigerated at a temperature of 4^0C until analysis to keep their *in situ* qualities. The analytical quality monitoring conducted involved daily analysis of standard and replicate assay of samples and blanks. Experiments were conducted in triplicate and the results arithmetic mean to reduce experimental flaws (Ogunwale *et al*., 2021). Chemical analyses were done in the Department of Chemistry laboratory, Bowen University, Iwo, employing UV/visible spectrophotometer (Jenway 6305), Flame Emission Spectrophotometer (Jenway PFP 7), Flame Atomic Absorption Spectrometer (PG 990 Model) for cations, while standard titration was carried out for anions. Ions were converted from milligram per litre (mg/L) to milliequivalent per litre (meq/L) and anions balanced against cations as a control check of the reliability of the analyses findings. The analytical results were in relation to the standards requirement (NESREA, 2018; FAO/WHO, 2011).

Assessment of Groundwater Variables for Irrigation Utilizations

Assessment of the groundwater quality of the area under study was conducted to estimate its suitableness for household and agricultural uses. Water for each of these uses was needed to satisfy peculiar safety guideline that had been established by Food and Agriculture Organization/World Health Organization and National Environmental Standards and Regulations Enforcement Agency.

Domestic Usage: Drinkability of water for human intake is controlled by factor like TDS, the National Environmental Standards and Regulations Enforcement Agency and Food and Agriculture Organization/World Health Organization (FAO/WHO, 2011; NESREA, 2018) have established pH, ORP, Dissolved oxygen and temperature guideline by National Environmental Standards and Regulations Enforcement and Food and Agriculture Organisation/World Health Organisation Standards.

Agricultural Usage: Water for agricultural uses should be acceptable for both plant and animals. Good quality of waters for irrigation is controlled by safe level of: Sodium Adsorption Ratio (SAR); The Soluble Sodium Percentage (SSP); Residual Sodium Bicarbonate (RSBC); Magnesium Adsorption Ratio (MAR); Kelly's Ratio (KR); Total Dissolved Solids (TDS); and Permeability Index (PI).

Variables determined included SAR, SSP, RSBC, PI, MAR, KR and TDS.

Sodium Adsorption Ratio (SAR): The sodium adsorption ratio gives a clear knowledge about the adsorption of sodium by soil. It is the amount of sodium to calcium and magnesium, which influence the availableness of the water to the crop.

The Sodium Adsorption Ratio (SAR) was evaluated in relation to the subsequent equation provided by Richards (1954) as:

$$SAR \text{ (meq/L)} = \frac{Na^+}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}} \quad [1]$$

The Soluble Sodium Percentage (SSP) was computed in accordance with the relationship provided by (Todd, 1995):

$$\text{SSP (meq/L)} = \frac{(Na^+ + K^+) \times 100}{Ca^{2+} + Mg^{2+} + Na^+ + K^+} \quad [2]$$

The Residual Sodium Bicarbonate (RSBC) was determined in line with Gupta and Gupta (1987):

$$RSBC \text{ (meq/L)} = HCO_3^- \times Ca^{2+} \quad [3]$$

The Permeability Index (PI) was carried out on the basis of Doneen (1964) employing the subsequent equation:

$$\text{PI (meq/L)} = \frac{Na^+ + \sqrt{HCO_3^- \times 100}}{Ca^{2+} + Mg^{2+} + Na^+} \quad [4]$$

The Magnesium Adsorption Ratio (MAR) was conducted by means of the following equation (Raghunath, 1987):

$$\text{MAR (meq/L)} = \frac{Mg^{2+} \times 100}{Ca^{2+} + Mg^{2+}} \quad [5]$$

The Kelly's Ratio was estimated with the subsequent equation (Kelly, 1963) as:

$$KR \text{ (meq/L)} = \frac{Na^+}{Ca^{2+} + Mg^{2+}} \quad [6]$$

The Total Dissolved Solid (TDS) was done using the subsequent equation (Richards, 1954):

$$TDS = (0.64 \times EC \times 106 \ (Micro - mhos/cm) \quad [7]$$

in which Electrical Conductivity (EC) and TDS were reported in µS/cm and mg/L, respectively.

Data Interpretation

The standard deviation for the physico-chemical variables and irrigation indices from three replicate quantifications was conducted. Assessment of the result was performed utilizing the mean values. Analysis of variance (ANOVA) was utilized to express the statistical difference between the means of the irrigation indices values found employing SPSS 21.0 for Windows. Coefficient of variation was used to assess the intra and inter site temporal variableness of the variables. A Model PG 990 Atomic Absorption Spectrophotometer provided with a single slot burner was utilized. Analyzes were performed in triplicate.

RESULTS AND DISCUSSION

Water Quality Physico-chemical Variables

Values of water quality physico-chemical variables pertinent to agricultural and drinking utilizations are revealed in Table 2. Temperature plays a major function in the physical, chemical and biological activities of a particular body of water. Results indicated that the mean temperature of the sampled water ranged between 27.40±0.26^{0}C and 28.10±0.30^{0}C with the overall mean value of 27.70±0.29^{0}C (wet season) and from 28.20±0.14^{0}C to 28.60±0.18^{0}C with overall mean value of 28.40±0.16^{0}C (dry season). The least value was found at the Agboola Farm and maximum value at Odunola Farm in both seasons. The spatial distribution forms of temperature at the three sampling stations were commonly related as temperatures were moderately lower during the wet season than the dry seasons. The non-significance of water temperature for both seasons has been likewise described by Ogunwale *et al*. (2021) and slight changes have been as a result of variation in clime states. The least and maximum temperatures (27.40^{0}C and 28.60^{0}C) are likely for derived savannah waters and are necessary for the healthful development of water organisms, poultry and crops (Ogunwale *et al*. 2021).

The pH scale of a water supply depicts how acidic or alkaline it is. The acidity (or alkalinity) of a water supply may affect plant growth, irrigation equipment, pesticide efficacy and drinking water (Ogunwale *et al*. 2021).The pH values of poultry farm hand-dug well waters sampled had an overall mean of 7.25±0.11 and varied from 7.10±0.13 at Agboola Farm to 7.35±0.16 at Worgor Farm for wet season and from 6.70±0.06 at Odunola Farm to 6.90±0.09 at Worgor Farm for dry season (Table 2). The pH of the groundwater remained neutral all through the assessment season in all the sampling stations with the maximum values obtained in wet season possibly owing to seepage of effluent in neutral form and presence of bicarbonate which passes through hydrolysis in solution (Ogunwale *et al*., 2021). The mostly conventional pH for irrigation water is between 5.5 and 8.5, while for drinkable is between 6.5 and 8.5 (FAO/WHO, 2011). The pH values of the groundwater at all the stations fell within this threshold. Generally, slight variations in pH values during diverse seasons of the year are resulting from factors like variations in temperature, biological activities, infiltration of agricultural wastes, reduction of salinity, and attenuation of seawater by freshwater inflow and deduction of CO_2 by photosynthesis utilizing bicarbonate decline (Ogunwale *et al*., 2021). On the ground of their pH levels, with some correction, the hand-dug well waters in the region were usually harmless to sustain nutrient balance, controls scale development in irrigation instrument and gives operational chemical disinfection in agricultural, farm animal, domestic and recreational utilizations.

Electrical conductivity (EC) is an invaluable measure of the level of constituents solubilized in water. Conductivity of water body may be as a result of the occurrence of dissolved salts and other ionic species which function as transmitting materials (Ogunwale *et al*., 2021). Fairly high value of conductivity may be as a result of the occurrence of some dissolved solids. Salinity controls stock, domestic, plants and irrigation (Watkins, 2008). The obtained mean values of conductivity in Poultry Farm water during the assessment seasons were in the range of 288.60±10.30 µS/cm (Worgor Farm) to 456.29±14.10 µS/cm (Agboola Farm), with an overall mean of 380.19±12.27 µS/cm in wet season whilst the range was from 393.10±13.40 µS/cm (Worgor Farm) to 580.70±22.08 µS/cm (Odunola Farm), with an overall mean of 511.45±20.09 µS/cm in dry season. In spite of that, the overall mean value of EC was significantly higher (at $p < 0.05$) during the dry season (511.45±20.90 µS/cm) than in the wet season (380.19±12.27 µS/cm). The higher values of EC in dry season could be as a result of diminishing dilution factor during the season on account of decreased water volume, increased water consumption by livestock animal as a result of heat and heightened intake of dry feed, rises in natural minerals on account of evaporation during these seasons (Ogunwale *et al*., 2021). The ECs values in all the assessed samples for both seasons were in compliance with NESREA (2018) and FAO/WHO (2011) safe limits for poultry drinking and irrigation water. The differences in EC values in various wells in this analysis may also have been contributed by the underlying soil sorts to groundwater. Percolation of water encompassing slight ionisable salts could have enhanced the EC values in this study have found somewhere else by Jayalakshmi *et al*. (2011).

Total Dissolved Solids (TDS**)** is an indicator of all dissolvable substances solubilized in water. The mean content of TDS in the examined water samples (Table 2) varied from 187.50±8.88 mg/L to 294.82±12.06 mg/L and 255.58±13.09 mg/L to 375.65±14.90 mg/L, yielding an overall mean value of 246.34±10.42 mg/L and 331.33±14.82 mg/L for wet and dry seasons, respectively. Moderate contents of dissolved solids present in most of the water samples positively correlated with their observed medium EC values. This inferred that most of the TDS were inorganic ions, like Ca^{2+}, Mg^{2+} and Na^{+} in nature. These are known to effectively contribute to moderately elevated TDS levels.

The relatively moderate values of TDS in this work could be ascribed to mild seepage of poultry waste to groundwater even though TDS can also spring from weathering of rocks, soils, solubilizing of lime, agricultural operation and other sources (Ogunwale *et al*., 2021). Ordinarily, the TDS values obtained in all the sampling locations were found to be below the safe level of 1000 mg/L for poultry and irrigation water by NESREA (2018) and FAO/WHO (2011); the poultry hand-dug well water is thereby safe for poultry intake, household, irrigation and other agricultural utilizations. Also, values of Ca^{2+}, Mg^{2+} Na^{+} and K^{+} that contributed to the available TDS level might not cause any harm to plants if the water is applied for irrigation purposes. However, when found in extreme measures, these cations may decrease the osmotic activities of the plants and even inhibit adequate aeration. The TDS in both seasons were usually below 400 mg/L and could be categorized as excellent irrigation water in line with Richards (1954) (Table 4).

Hardness does not affect plants entirely, but hardness activated by bicarbonates can impair soils, hence causing an indirect effect on plant growth. Bicarbonates (HCO_3^-) cause calcium and magnesium from soil and water to form as insoluble carbonates. The occurrence of HCO_3^- makes hard water which disrupts soil, stock and household water utilization, and impairment pipes and equipment. The mean total hardness contents in this work varied from 125.30±5.20 to 138.10±5.30 mg/L and 128.50±5.30 to 144.10±5.40 mg/L in wet and dry seasons, respectively (Table 2). The overall mean±standard deviation value of total hardness (131.54±5.23 mg/L $CaCO_3$) (wet season) and (136.30±5.37 mg/L $CaCO_3$) (dry season) indicated values that were satisfactory for chicken growth and irrigating crops (FAO/WHO, 2011).

Alkalinity of water is its potential to neutralize a strong acid. In natural waters, CO_3^{2-}, HCO_3^-, PO_4^{3-} and OH^- are regarded as principal bases; on this occasion alkalinity is depicted as total alkalinity. The WHO prescribed value for total alkalinity is 500 mg/L for optimal poultry satisfaction. Above this value, water taste may turn out to be objectionable. Excessive alkalinity water may cause a threat to poultry organism and irrigating crops (Ogunwale *et al*., 2021).

In this assessment, the values of mean total alkalinity in the hand-dug wells water samples in mg/L varied from 90.08±4.53 at Worgor Farm to 113.84±4.78 at Odunola Farm in wet season and from 98.03±3.66 at Worgor to 121.70±3.76 at Odunola Farm in dry season. The overall mean alkalinity values of 102.24±4.71 mg/L $CaCO_3$ (wet season) and 109.31±3.70 mg/L $CaCO_3$ (dry season) (Table 2) indicated that water from the poultry farm hand-dug wells were moderate and satisfactory for freshwater poultry activity and irrigation.

Acidity is an indicator of the capacity of a certain water sample to counteract strong bases to a randomly appointed pH or a measure end point (Ogunwale *et al*., 2021). The recorded mean values of acidity ranged from 33.10±2.75 mg/L at Agboola Farm to 40.10±2.93 mg/L at Odunola Farm, with an overall mean of 36.77±2.87 mg/L for wet season and 35.18±2.60 mg/L at Agboola Farm to 42.16±2.90 mg/L at Odunola Farm, with an overall mean of 38.51±2.86 mg/L for dry season (Table 2). Mean seasonal variations revealed that the value of acidity in dry season (38.51±2.86 mg/L) was not significantly higher (at $p < 0.05$) than wet season (36.77±2.87 mg/L). The lower value of acidity in wet season could be as a result of higher rate of rainfall which diluted the water in the aquifer.

The mean content of HCO_3^- in the measured samples ranged from 58.40±4.10 to 70.60±5.10 mg/L and 63.20±5.03 to 72.50±5.20 mg/L in wet and dry seasons, respectively (Table 2). The study showed varying levels of HCO_3^- for groundwater of poultry ecosystem with the HCO_3^- values below 500.00 mg/L. The different contents of HCO_3^- in the water samples examined could be, in line with Nduka and Orisakwe (2009), ascribed to the variation sources of inorganic contaminants from wellhead rocks, pollutions stemming from raw waste water from the poultry, along with household sewage. The maximum recorded value was found at Odunola Farm in both seasons, of which the dry season was higher than the wet season. The HCO_3^- of the water samples were usually below the maximum acceptable value of 500.00 mg/L NESREA (2018) and FAO/WHO (2011) directives benchmark for irrigation.

Chloride (Cl^-) is a key anion in irrigation water. The Cl^- content is more in salinity water and its greater value in natural water is a positive sign of water salinity risk (Kumar *et al.,* 2009). A number of scholars (Kumar *et al.,* 2009; Zhang *et al.,* 2010) have expounded Cl^- in water was attributed to the household refuses, sodium chloride and chlorinated lime to reference some. The importance of Cl^- rests in its ability to influence salinity of water and utilizations effect osmotic tension on aquatic ecosystem. It is so imperative that the Cl^- content of water supplies should be maintained as low as feasible. Chloride content of below 250 mg/L is usually regarded to be good for drinking, irrigation and agricultural water (FAO/WHO, 2011). Chloride is available in the state of Na, K and Ca salts. In this study, mean Cl^- concentrations in mg/L varied from 55.36±5.60 (Agboola Farm) to 71.60±5.10 (Odunola Farm) in wet season and from 61.50±6.05 (Agboola Farm) to 75.10±6.40 (Odunola Farm) in dry season (Table 2). All the water samples indicated suitable levels that fell within the NESREA (2018) and FAO/WHO (2011) guideline values. Chloride level were found to be more in dry season than in wet season as a result of very high evaporation rate at store watering ponds or tanks for the period of these seasons with the significant higher salt contents. This pattern validates the seasonal pattern obtained somewhere else by dint of Shaikh and Mandre (2009). No sample in the research area passes the standard limit of 250 mg/L.

Sulfur in water is not a concern for plants, but is an issue for livestock and humans (Ogunwale *et al*., 2021). Magnesium sulphate gives water a foul taste and water pH reduces as sulfur content increases. Elevated values of sulfur may cause diarrhoea in animals and humans. In some situations, smell may also be an obstacle. Aerating and oxidizing the water spring can alleviate sulfur difficulties. In the case of SO_4^{2-}, mean levels available correspondingly ranged from 10.41±0.73 to 15.24±0.86 mg/L and 16.20±1.75 to 18.10±1.80 mg/L during the wet and dry seasons (Table 2). The highest recorded value was at the Odunola Farm in dry season. This study revealed that SO_4^{2-} content in all the sampling sites fell within the 200 mg/L prescribed value (FAO/WHO, 2011).

Phosphates (PO_4^{3-}**)** may be introduced into the groundwater as of PO_4^{3-}comprising rocks, fertilizers or seepage of sewage and animal refuse. The NSW, WHO and NESREA prescribed values for phosphates in irrigation water is 1.00 mg/L. All well samples had their PO_4^{3-} values above these values. Generally, groundwater comprises merely a slight phosphorus level by reason of the low dissolvability of indigenous PO_4^{3-}minerals and the potential of soils to keep PO_4^{3-} as it infiltrates. Phosphates are not generally detrimental to humans, crops and animals apart from they are found in very elevated concentrations (Galadima *et al.*, 2011). Digestive difficulties may arise from elevated levels of PO_4^{3-} and PO_4^{3-} levels above 1.00 mg/L may interrupt with coagulation in water management plants, and consequently, organic particles that shelter microbes may not be entirely eradicated (NSW, 2005). Elevated content of PO_4^{3-} and NO_3^- in water can encourage the growth of algal blooms and aquatic weeds. In this study, the mean values of PO_4^{3-} ranged between 2.10±0.19 mg/L (Agboola Farm) and 2.88±0.26 mg/L (Odunola Farm) in wet season and 2.30±0.20 mg/L (Agboola Farm) 2.98±0.28 mg/L (Odunola Farm) in dry season (Table 2). The overall mean PO_4^{3-} measured was 2.41±0.23 mg/L (wet season) and 2.56±0.25 mg/L (dry season). Elevated contents of PO_4^{3-} in both seasons could possibly be as a result of low quality hygiene, poultry dung, use of any synthetic surfactant and other agrochemicals and closeness to poultry waste disposal sites. The higher dry season values might also be as a result of the solar radiation which might have stimulated the biological deterioration of the organic matter partially into phosphates.

By and large, surface water sources comprise low levels of NO_3^-. Higher levels of nitrate may be present in groundwater and reused irrigation water. At low levels, NO_3^- do not harm plants and can be utilized by plants for growth. Levels of nitrates more than about 25 mg/L, on the authority of the New State of Wales Department of Primary Industries (2005) may interrupt crop outputs. The mean levels of NO_3^- in this assessment ranged from 5.26±0.63 to 8.01±0.93 mg/L and 7.08±0.72 to 9.23±0.88 mg/L in wet and dry seasons, respectively (Table 2). It is observed that the maximum content (9.23 mg/L) was found during the dry season at Odunola Farm. This was possibly for the reason that the place is situated down slope course of the sewage transportation wastewater and has been in operation for over 25 years. Ele *et al.* (2005) remarked that the main input to NO_3^- content is ascribed via biologic oxidation of organic nitrogenous matters from effluent and industrial refuses and the higher concentration of nitrate could be pertained to filtration from dumping sites. Levels of NO_3^- in all the samples were below the maximum acceptable value of 25 mg/L WHO guideline level (Jayalakshmi *et al.*, 2011; WHO, 2011). This may be consequently of somewhat steady thermal formation or deposition of layers, partial diffusion of water and denitrification via facultative anaerobic bacteria (Ele *et al.*, 2005). Thus, from NO_3^- levels observation, water from the wells were considered good specifically for human and animal intakes and irrigation utilizations.

In the case of Mg^{2+}, the mean level varied from 22.60±2.03 to 30.01±2.30 mg/L with the overall mean of 25.90±2.08 mg/L (wet season) and from 25.70±2.62 to 34.30±2.80 mg/L with the overall mean of 30.42±2.56 mg/L (dry season) (Table 2). The values were largely within the maximum admissible content of 30 mg/L derived from NESREA (2018) and WHO (2011) prescribed values. The higher contents of Mg^{2+}in some cases were present mainly in water samples from Odunola Farm probably on account of geologic context that contains carbonate rock as a constituent. Because the Mg^{2+} contents of the hand-dug wells were within the safe limit in both seasons, the water from the wells examined was acceptable for chicken productivity, human drinking and irrigating crops.

For the values of Ca^{2+} in the samples, the mean values ranged from 60.25±3.16 to 68.10±3.50 mg/L and 68.80±3.30 to 77.18±3.46 mg/L during the wet and dry seasons, respectively. Samples taken from Worgor Farm contained the highest values in both seasons. At large, the Ca^{2+} level in the water samples was higher in dry season than wet season most likely as a result of reduced water volume of water owing to evaporation and diminished filtration from periphery watersheds that normally depicted dry seasons. The elevated Ca^{2+} content in the groundwater could be as a result of oxidation of organic matter discharging free Ca^{2+} in the solution in the neutral pH (Ogunwale *et al*., 2021). The dispersed of Ca^{2+} from the soil substance or from the pollutant solution normally reacts with bicarbonates available in the pollutant solution or source of the deposited organic matter in the porous material which emanates from the waste from poultry field to yield $CaCO_3$formation. Additionally, $CaCO_3$ in the soil ecosystem reacts with water to give up Ca^{2+} and HCO_3^-. The proportion of reaction counts on the quantity of hydrogen ion (acidity) of the soil, subsequent in variations of Ca^{2+} in aquifer (NSW, 2005).

Calcium is the primary cause of water hardness, and may adversely influence harmfulness of the other elements found in the water. For examples, excess Ca^{2+}as obtains in limed soils may immobilize Fe by that causing Fe insufficiencies, even when Fe is found in the soil in large amounts (Jayalakshmi *et al*., 2011). High content of Ca^{2+} and Mg^{2+} are important for the reason that they make categorization of water samples possible and support to evaluate the soil general composition of rock sequence available in the assessment area (Ahaneku and Animashaun, 2013). The concentrations (mg/L) of Na^+ found from various poultry farms in wet and dry seasons are also presented in Table 2. The mean values for Na^+ in this study were usually low in comparison to the maximum levels permitted. Sodium was maximum in dry season with 36.40±2.70 mg/L at Odunola Farm and minimum in wet season also with 21.18±02.09 mg/L at Agboola Farm. Saline invasion, mineral ores, seawater spray, sewage emissions and salt-lick applied in poultry concentrates can all add substantial amounts of Na^+ to water. Furthermore, water-treatment chemicals, like NaF, $NaHCO_3$, and NaClO, can collectively give rise to Na^+ levels as high as 30 mg/L. At this value, Na^+ may begin to affect the taste of drinking-water and at values above 200 mg/L, the taste of drinking water is drastically affected.

Mean K^+ values in this study ranged from 11.08–15.23 mg/L and 12.25–17.50 mg/L in wet and dry seasons, respectively as revealed in Table 2. In both seasons, Odunola Farm samples contained the maximum value of 15.23 mg/L for wet and 17.50 mg/L for dry seasons, respectively. The content of K^+ in line with European Directives is 12 mg/L of K^+ in water (FAO, 2015). Yet, moderate amounts of it do not adversely affect the water quality (Weiss and William, 2008). The higher values of K^+ were most likely as a result of the occurrence of potential sources of K^+ in the well basement soil and moderate utilization of potash fertilizers in the study region. Similar to Na^+, mechanical or chemical breaking down of rocks are the main source in natural water. Waste dumping from the poultry activities bunches can heighten the content of K^+ and immense amounts of it in drinkable water may be purgative (NSW, 2005). Potassium ion is a nutritional criterion for almost any organism. It performs a vital function in plant growth, and it usually restricts it. In excess amounts potassium salts may destroy plant cells as a result of high osmotic reaction (Agbede, 2016).

Groundwater Quality for Agricultural and Irrigation Utilizations

Standard for quality water for irrigation and agricultural determinations, to wit: Sodium Adsorption Ratio (SAR), Kelly's Ratio (KR), Residual Sodium Bicarbonate (RSBC), Soluble Sodium Percentage (SSP), Permeability Index (PI), Magnesium Adsorption Ratio (MAR), Electrical Conductivity (EC) and Total Dissolved Solids (TDS) have been elucidated (McKee and Wolf, 1963; NESREA,2018; FAO/WHO, 2011). The values of these variables are shown in Table 3 for the groundwater samples from the assessment area in wet and dry seasons.

Sodium adsorption ratio (SAR) is regarded as a better indicator of sodium (alkali) hazard in making use of water for irrigation. It is nearly had to do with the adsorption of Na^{+} by means of soil and is a good measure for determining the suitableness of water for irrigation. This measure determined the ratio of Na^{+} to Ca^{2+} and Mg^{2+} in a sample. High contents of Na^{+} compared with Ca^{2+} and Mg^{2+} in irrigation water can deleteriously affect the soil composition (Agbede, 2016). By and large, water containing SAR values below or equivalent to 10 are signified to be of excellent quality, 10 to 18 as good, 18 to 26 as fair and more than 26 are signified to be unsuited for irrigation (Richard, 1954). In this study, it was found that the mean SAR values in meq/L for wet season ranged from 0.58±0.06 (Agboola Farm) to 0.83±0.11 (Odunola Farm) and from 0.73±0.05 (Agboola Farm) to 0.88±0.07 (Odunola Farm) in dry season. In line with the earlier categorizations of SAR values, all the samples of groundwater for both seasons were not more than 10 which signified that the water samples were of excellent quality for irrigation utilizations.

The SSP is referred to as the percentage (%) of Na^{+} to Ca^{2+} and Mg^{2+}. If the value of SSP found is below 50%, then the water is of good quality for irrigation utilizations but if it is over 50%, the water is unsuited for irrigation. A water with a SSP beyond 60% may induce Na^{+} accumulations that will give rise to a deterioration of the soil's physical qualities. In the assessment area, the mean SSP content of groundwater values in % (Table 3) varied from 19.20±1.86 (Agboola Farm) to 24.11±1.92 (Odunola Farm) in wet season and from 20.87±1.08 (Agboola Farm) to 23.74±1.20 (Odunola Farm) in dry season. When the content of Na^{+} is high in irrigation water, Na^{+} tends to be absorbed by clay particles, supplanting Mg^{2+} and Ca^{2+} which declines the soil permeability and at last causes soil with inadequate internal drainage. In wet and dry seasons, all SSP values of groundwater samples were less than 50%. This more buttressed the top property of the natural groundwater of the assessment area for irrigational and agricultural utilizations.

A supplemental constraining influence for irrigation water is the content of HCO_3^{-} anion, which can induce carbonate formation and give rise to scaling in irrigation pipes and pumps. High content of bicarbonate minerals may decrease the Ca^{2+} and Mg^{2+} content of the soil water, and as a result increase SAR values. To determine this cause, an experiential variable called RSBC was applied (Eaton, 1950). In addition to the TDS, the fair abundant of Na^{+} with regard to alkaline earths and boron, the level of $CO_3^{2-}$and HCO_3^{-}in excess of alkaline earths also affect the well-being of water for irrigation determination (Richard, 1954).Bicarbonate is a vital ion in the assessment of irrigation water quality. Bicarbonate is accountable for alkalinity of the groundwater. In line with Eaton (1950), irrigation water having residual sodium bicarbonate (RSBC) values more than 5 meq/L are regarded toxic to the growth of crop, while irrigation waters with RSBC value around 2.5meq/L is properly riskless for irrigation, a value between 1.25 and 2.5 meq/L is of minimal and a value of greater than 2.5 meq/L is inappropriate for irrigation (Richard, 1954).In this study of

groundwater, the mean RSBC values in meq/L (Table 3) ranged from -2.44±0.25 (Odunola Farm) to -1.91±0.20 (Agboola Farm) in wet season and from -2.82±0.24 (Worgor Farm) to -2.30±0.19 (Agboola Farm) in dry season. Residual sodium bicarbonate has been computed to quantify the deleterious effect of bicarbonate on the water quality for agriculture determination. All the values of RSBC for groundwater samples were below 1.25 meq/L. This also inferred that the natural reservoir groundwater was harmless and acceptable for irrigational and agricultural utilizations.
Magnesium ion content of water is regarded as one of the most significant qualitative standards in measuring the quality of water for irrigation. Mostly, Ca^{2+} and Mg^{2+}support a status of stability in many waters. A lot of Mg^{2+} in water will negatively affect crop productions as the soils turn into more saline (Joshi and Umayoru, 2013). The mean values of the MAR of shallow groundwater in this study varied from 35.36±3.48% (Worgor Farm) to 43.92±3.60% (Odunola Farm) in the wet season and from 35.44±3.40% (Worgor Farm) to 43.25±3.60% (Odunola Farm) in dry season signifying that they were lower than the prescribed value of 50% (Ayers and Westcot, 1985). By reason of Mg^{2+} content perspective, the waters were also regarded acceptable for irrigational utilizations.

Kelly's ratio (KR) signifies the alkali hazards of water. It is the proportion of Na^+ to that of Ca^{2+} and Mg^{2+} in water. If $0 < KR \leq 1$, for a water sample, in that case such water is suitable for irrigation (Richard, 1954; Gupta and Gupta, 1987). In this study, the KR values of groundwater in meq/L (Table 3) varied from 0.18±0.01 (Agboola Farm) to 0.25±0.03 (Odunola Farm) in wet season and from 0.21±0.01 (Agboola Farm) to 0.24±0.02 (Odunola Farm) in dry season. As a result, the water was satisfactory for irrigation utilization.

The soil permeability is affected by the long-term application of irrigated water and the significant components are the TDS, $NaHCO_3^-$and the soil type. In this study, the mean permeability index (PI) in meq/L values varied between 1.71±0.06 (Worgor Farm) to 1.90±0.09 (Agboola Farm) in wet season and from 1.54±0.02 (Odunola Farm) to 1.64±0.04 (Agboola Farm) in dry season. The above results signified that the water samples fell within Class I and can be classified as satisfactory irrigation water (Doneen, 1964).

Categorization of Groundwater on the basis of US Salinity Schematic
The US Salinity Laboratory (USSL) of the Department of Agriculture formulated asserted methods on the ground of which the suitableness of water for agriculture is explained (Wilcox, 1950; USSL, 1954). The relationship between SAR and EC was schemed on the US salinity schematic. The importance and explanations of quality grades on the USSL schematic can be summed up like this: (i) Low salinity water (C1) can be applied for irrigation with most crops on moist soils. Some leaching is needed, but this arises under conventional irrigation practices exclude with soils of exceedingly low permeability. (ii) Medium salinity water (C2) can be applied if a moderate amount of leaching founds. Plants with moderate salt tolerance can be grown in most cases outside distinctive practices of salinity influence. (iii) Medium to high salinity water (C3) is acceptable for plants containing moderate salt tolerance on soil of moderate permeability with leaching. (iv) High salinity water (C4) is unable to be employed on soils with delimited drainage. In spite of good drainage, certain management for salinity control may be required and plants with adequate salt tolerance should be adopted. (v) Very high salinity water (C5) is not fitting for irrigation under normal terms, but may be applied sometimes, under very unique terms. The soil is imperative to

be permeable, drainage requires to be satisfactory, irrigation water needs to be in superfluous to give substantial infiltration and salt tolerant crops should be taken.

The categorization of irrigation waters with regard to SAR is present mainly upon the influence of exchangeable sodium on the physical state of the soil. Low sodium water (S1) can be meant for irrigation on virtually all soils with little deleterious effect of the growth of detrimental level of exchangeable sodium. Still, sodium sensitive crops, for instance deciduous fruit, nuts, vegetable, citrus and avocados may amass noxious content of sodium (NSW, 2005). Medium sodium water (S2) in fine-textured soils of high cation exchange capacity, especially under low percolating states, unless gypsum is available in the soil, shows substantial sodium hazard, but may be applied on coarse textured or organic soil which possess good permeability. High sodium water (S3) is adequate only with good drainage; high leaching and organic matter give organic matter accumulation. Very high sodium water (S4) is usually unacceptable for irrigation utilizations, unless at low and most likely medium salinity. Use of gypsum or other amendments may cause this water practicable. Use of gypsum also improves the crust conductivity characteristic of the soil (NSW, 2005).

Figures 2 and 3 infer that the groundwater from all the assessment wells fell in the C2-S1 classifications signifying moderate salinity and low sodium hazards. This signified that these waters could be applied for irrigation in almost all soil types with little or no negative effect of exchangeable sodium and no threat to soil and crops.

CONCLUSION

The groundwater quality of some poultry farms in Osun State, Southwest Nigeria was evaluated for its irrigational and poultry acceptability. Deduced from the results obtained, it was concluded that there were narrow differences in the physico-chemical variables determined in the groundwater sources of this study in addition to heterogeneity in their spatial and seasonal distribution over the assessment season. The shallow well expressed significantly moderate temperature, pH, EC, TDS, total hardness, total alkalinity, total acidity, HCO_3^-, Cl^-, SO_4^{2-}, NO_3^-, Mg^{2+}, Ca^{2+}, Na^+, k^+, SAR, SSP (%), RBSC, MAR, KR and PI. The results of water quality analyses also pointed out that all the variables, apart from PO_4^{3-} fell within the safe levels for drinkable and irrigation water of NESREA and FAO/WHO. As a result, the groundwater in this area would neither cause salinity hazards nor have a deleterious effect on the soil properties, and are in this manner, largely acceptable for irrigation and other household uses. Farmers have to adopt effective irrigation and water management system to decline water losses, heighten the water adsorbing efficiency by the crop and decline contaminants leaching. Further studies on environmental pollution should be conducted often so as to monitor the seasonal variations in contents of irrigation indices and relate to the previous irrigation studies. The work has provided information on the extent of irrigation in the poultry farm well water as a way of measuring the ecological health of the area under study as a result of water pollution. The work had also added to the baseline data on irrigation studies in our environment.

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Sampling Site	**Latitude (N)**	**Longitude (E)**	**Elevation (m)**
Agboola 1	07^{0} 51.540ʻ	004^{0} 16.134ʻ	318.52
Agboola 2	07^{0} 51.563ʻ	004^{0} 16.119ʻ	311.81
Agboola 3	07^{0} 51.587ʻ	004^{0} 16.095ʻ	311.82
Worgor 1	07^{0} 53.961ʻ	004^{0} 17.855ʻ	353.87
Worgor 2	07^{0} 53.948ʻ	004^{0} 17.852ʻ	357.23
Worgor 3	07^{0} 53.927ʻ	004^{0} 17.850ʻ	356.62
Odunola 1	07^{0} 45.196ʻ	004^{0} 30.826ʻ	317.30
Odunola 2	07^{0} 45.243ʻ	004^{0} 30.778ʻ	323.39
Odunola 3	07^{0} 45.290ʻ	004^{0} 30.622ʻ	313.94

Table 1. Geographical Locations of the Sampling Sites

Site	Temp (°C)	pH	EC µS/cm	TDS mg/L	TH	T Alk	T Aci	HCO_3^-	Cl^-	SO_4^{2-}	PO_4^{3-}	NO_3^-	Mg^{2+}	Ca^{2+}	Na^+	K^+
								Wet Season								
Agboola	27.4±0.26	7.1±0.13	456.10±14.10	294.82±12.06	131.22±1.70	102.80±1.43	33.10±0.62	66.83±5.06	55.36±5.60	10.41±0.73	2.10±0.19	5.26±0.63	25.08±2.05	60.25±3.16	21.18±2.09	11.08±0.61
Odunola	28.1±0.3	7.30±0.14	395.86±12.38	256.70±10.50	138.10±1.82	113.84±1.55	40.10±2.93	70.60±5.10	71.20±5.80	15.24±0.86	2.88±0.26	8.01±0.93	30.01±2.30	63.16±3.30	32.10±2.50	15.23±0.72

Worgor	27.6±0.28	7.35±0.16	288.60±10.30	187.50±8.88	125.30±1.75	113.84±1.55	37.11±2.89	58.40±4.10	59.08±5.73	13.10±0.80	2.26±0.20	5.06±0.70	22.60±2.03	68.10±3.50	26.26±2.31	13.08±0.65
Min.	27.40	7.10.	288.60	187.50	125.30	113.84	33.10	58.40	55.36	10.41	2.10	5.06	22.60	60.25	21.18	11.08
Max.	28.10	7.35	456.10	294.82	138.10	113.84	40.10	70.60	71.20	15.24	2.88	8.01	30.01	68.10	32.10	15.23
Overall mean	27.70	7.25	380.19	246.34	131.54	102.24	36.77	65.28	61.88	12.92	2.41	6.11	25.9	63.84	26.51	13.13
SD	0.29	0.11	12.27	10.42	5.23	4.71	2.87	4.21	5.76	0.77	0.23	0.8	2.08	3.24	2.46	0.69
CV	1.05	1.52	3.23	4.23	3.98	4.61	7.81	6.45	9.31	5.96	9.54	13.09	8.03	5.08	9.28	5.26
								Dry Season								
Agboola	28.20±0.14	6.85±0.08	560.56±20.10	362.76±14.88	136.30±5.37	108.20±3.71	35.18±2.60	69.10±5.10	61.50±6.05	16.20±1.75	2.30±0.20	7.08±0.72	31.26±2.78	68.80±3.30	29.20±2.40	12..25±0.74
Odunola	28.60±0.18	6.70±0.06	580.70±22.08	375.65±14.90	144.10±5.40	121.70±3.76	42.16±2.90	72.50±5.20	75.10±6.40	18.10±1.80	2.98±0.28	9.23±0.88	34.30±2.80	74.20±3.42	36.40±2.70	17.50±0.86
Worgor	28.40±0.15	6.90±0.09	393.10±13.40	255.58±13.09	128.50±5.30	98.03±3.66	38.18±2.83	63.20±5.03	62.05±6.10	17.30±1.77	2.40±0.22	7.28±0.76	25.70±2.62	77.18±3.46	32.20±2.50	13.99±0.76
Min.	28.2	6.70	393.1	255.58	128.50	98.03	35.18	63.20	61.50	16.20	2.30	7.08	25.70	68.80	29.20	12.25
Max.	28.6	6.90	580.70	375.65	144.10	121.70	42.16	72.50	75.10	18.10	2.98	9.23	34.30	74.20	36.40	17.50
Overall mean	28.4	6.82	511.45	331.33	136.3	109.31	38.51	67.75	66.22	17.20	2.56	7.86	30.42	73.39	32.60	14.38
SD	0.16	0.08	20.09	14.82	5.37	3.70	2.86	5.08	6.29	1.78	0.25	0.85	2.56	3.40	2.60	0.80
CV	0.56	1.17	3.93	4.47	3.94	3.38	7.43	7.5	9.5	10.35	9.77	10.81	8.42	4.63	7.98	5.49
NESREA, 2018	30	5.5-7.5	1000	1000	350			90	250	250	1	50	200	200	200	
FAO/WHO, 2011	32	5.5-8.5	1000	1000	350	90		90-366	250	250	1	50	200	200	200	55

Table 2. Mean Physico-chemical Variables and Principals Ions of Groundwater Samples for Wet and Dry Seasons

Site	SAR (meq/L)	SSP (%)	RSBC (meq/L)	MAR (%)	KR (meq/L)	PI (meq/L)
				Wet Season		Wet Season
Agboola	0.58±0.06	19.20±2.00	-1.91±0.20	40.70±3.55	0.18±0.01	1.90±0.09
Odunola	0.83±0.11	24.11±2.08	-1.99±0.20	43.92±3.60	0.25±0.03	1.73±0.07
Worgor	0.70±0.10	21.93±2.03	-2.44±0.25	35.36±3.48	0.22±0.02	1.71±0.06
Min.	0.58	19.2	-2.44	35.36	0.18	1.71
Max.	0.83	24.11	-1.91	43.92	0.25	1.9
Overall mean	0.7	21.75	-2.11	39.99	0.22	1.78
SD	0.10	2.01	0.23	3.53	0.02	0.08
CV	14.29	9.24	-10.9	8.83	9.09	4.49
				Dry Season		
Agboola	0.78±0.05	20.87±1.08	-2.30±0.19	42.82±3.58	0.21±0.01	1.64±0.04
Odunola	0.88±0.07	23.74±1.20	-2.51±0.20	43.25±3.60	0.24±0.02	1.54±0.02
Worgor	0.81±0.06	22.77±1.18	-2.82±0.24	35.44±3.40	0.23±0.01	1.57±0.03
Min.	0.78	20.87	-2.82	35.44	0.21	1.57
Max.	0.88	23.74	-2.3	43.25	0.24	1.64
Overall mean	0.81	22.46	-2.54	40.5	0.23	1.58
SD	0.06	1.19	0.21	3.58	0.01	0.04
CV	7.41	5.3	-8.27	8.84	4.35	2.53

Table 3. Mean for Various Irrigation Indices for Assessment Groundwater Quality and its Suitableness of the Area under Study (Wet and Dry Seasons)

S/NO	EC (µmmhos/cm $^{-1}$)	Kind of water	Suitableness for Irrigation	Comments
1	Below 280	Low saline water	Completely good	Nil
2	280-800	Moderate saline water	Good under practically circumstances	All samples in the assessment area fall within this class
3	800-2,300	Medium to high salinity water	Good only with permeable soil	Nil

			and moderately leakage	
4	Above 2,300			
(i)	2,300-4000	High salinity	Unsuitable for irrigation	Nil
(ii)	4000-6000	Very high salinity	Unsuitable for irrigation	Nil
(iii)	>6000	Extremely high salinity	Unsuitable for irrigation	Nil

Table 4. Quality of Irrigation Water Observing Electrical Conductivity in Line with Richard (1950)

S/No	Categorization	Total Dissolved Solids (mg/L)	Comments
1	Non-saline	<1000	All samples in the area under study fall in this class
2	Slightly saline	1000-3000	Nil
3	Moderately saline	3000-10,000	Nil
4	Very saline	>10,000	Nil

Table 5. Range of Total Dissolved Solids for Irrigation Utilization in line with Robinove *et al*. (1958)

Category	EC (µmmhos/cm^{-})	RSBC (meq/L)	SAR (meq/L)	SSP (%)	Appropriateness for irrigation
I	<117.509	<1.25	<10	<20	Excellent
II	117.509	1.25-2.5	10-18	20-40	Good
III	508.61	>2.5	18-26	40-80	Fair
IV	>508.61	-	>26	>80	Poor

Table 6. Constraints of some Variable Indices for Evaluation Groundwater Quality and Appropriateness in Irrigation (Eaton, 1950; Ayers and Westcot, 1985)

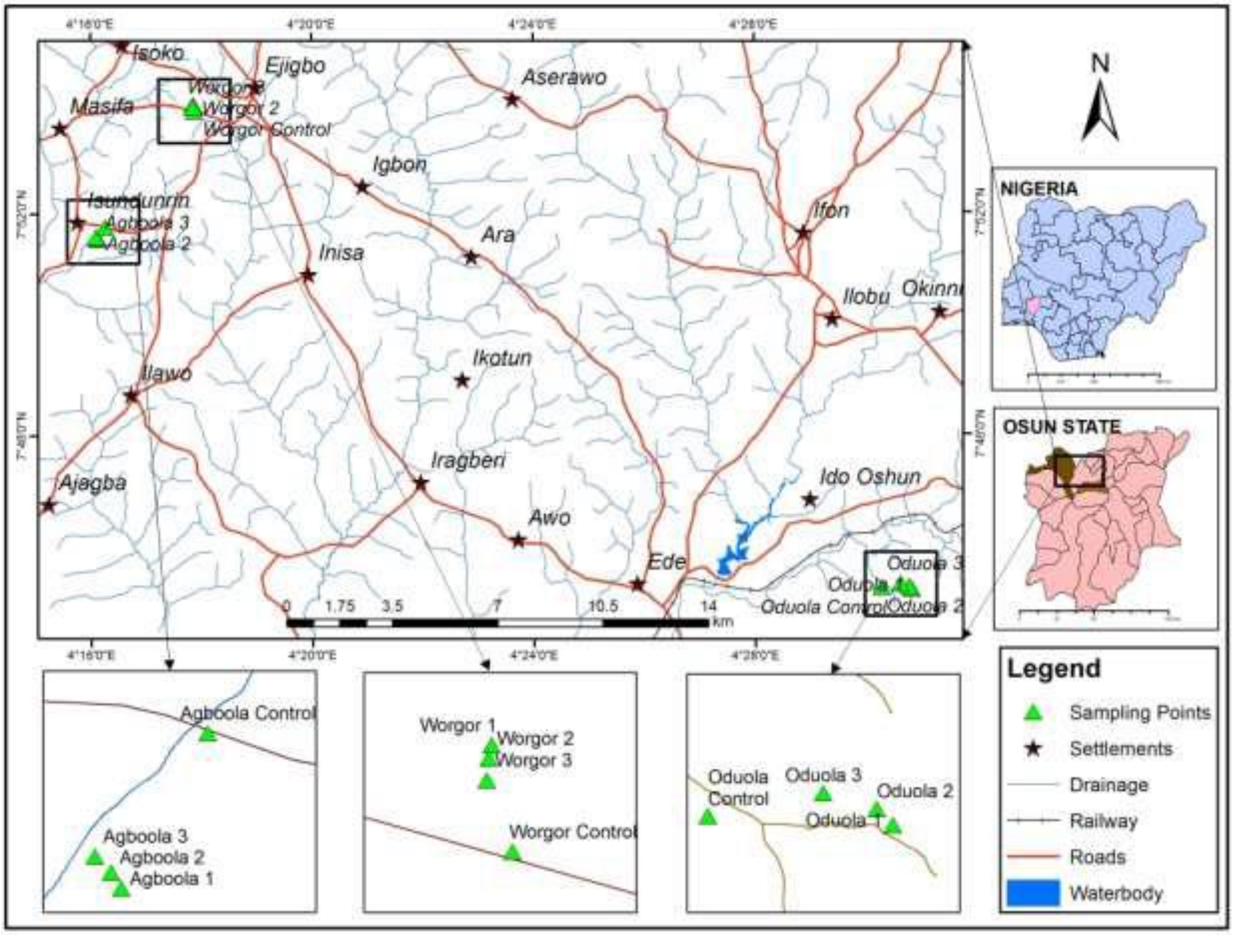

Fig.1. Map of the Assessment Area Signifying Sampling Locations
Scale: 1: 500000

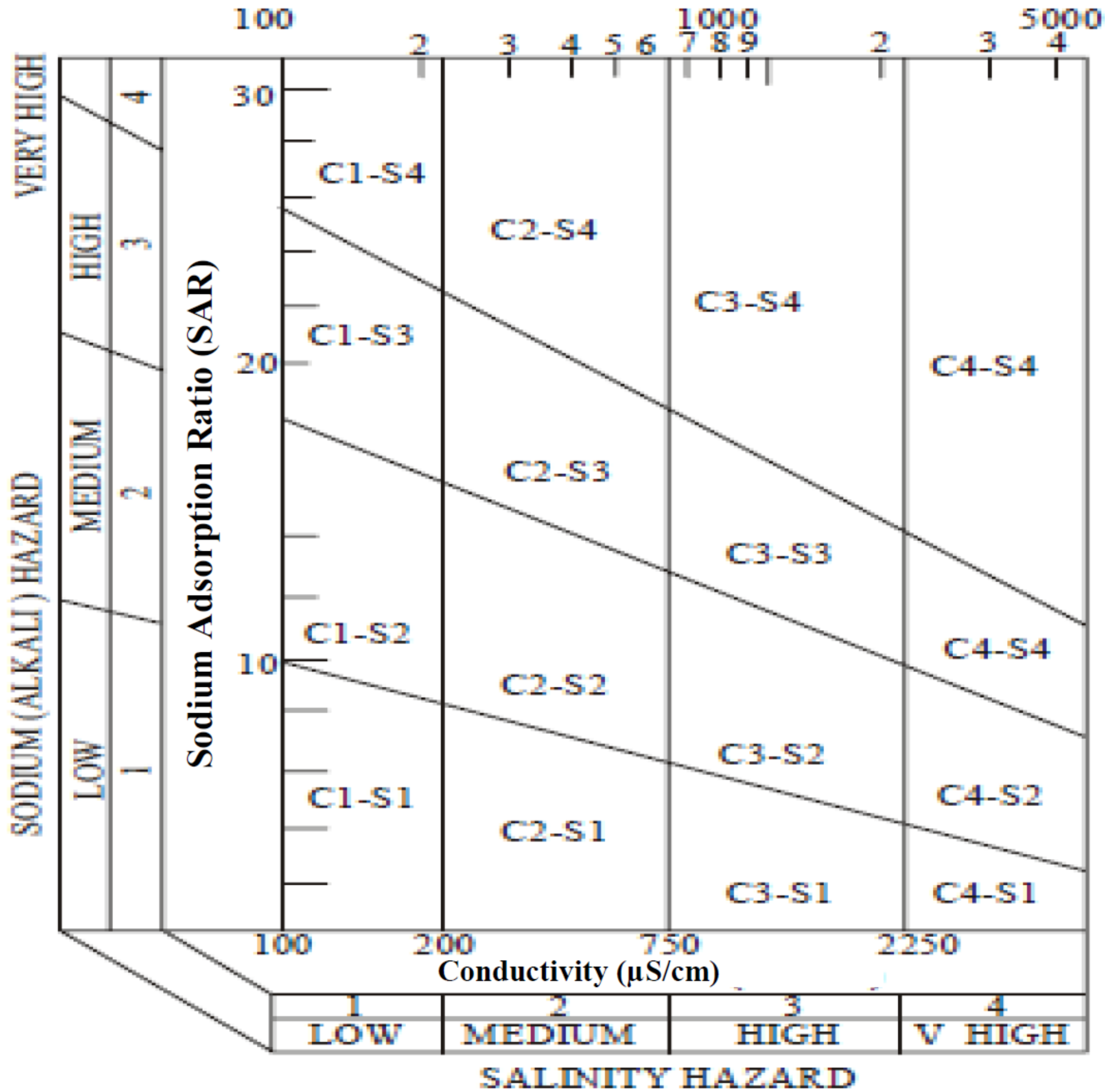

Figure 2. Categorization of Evaluated Water Sample Pertaining to Sodium Adsorption Ratio and Salinity Hazard (US Salinity Lab., 1954)

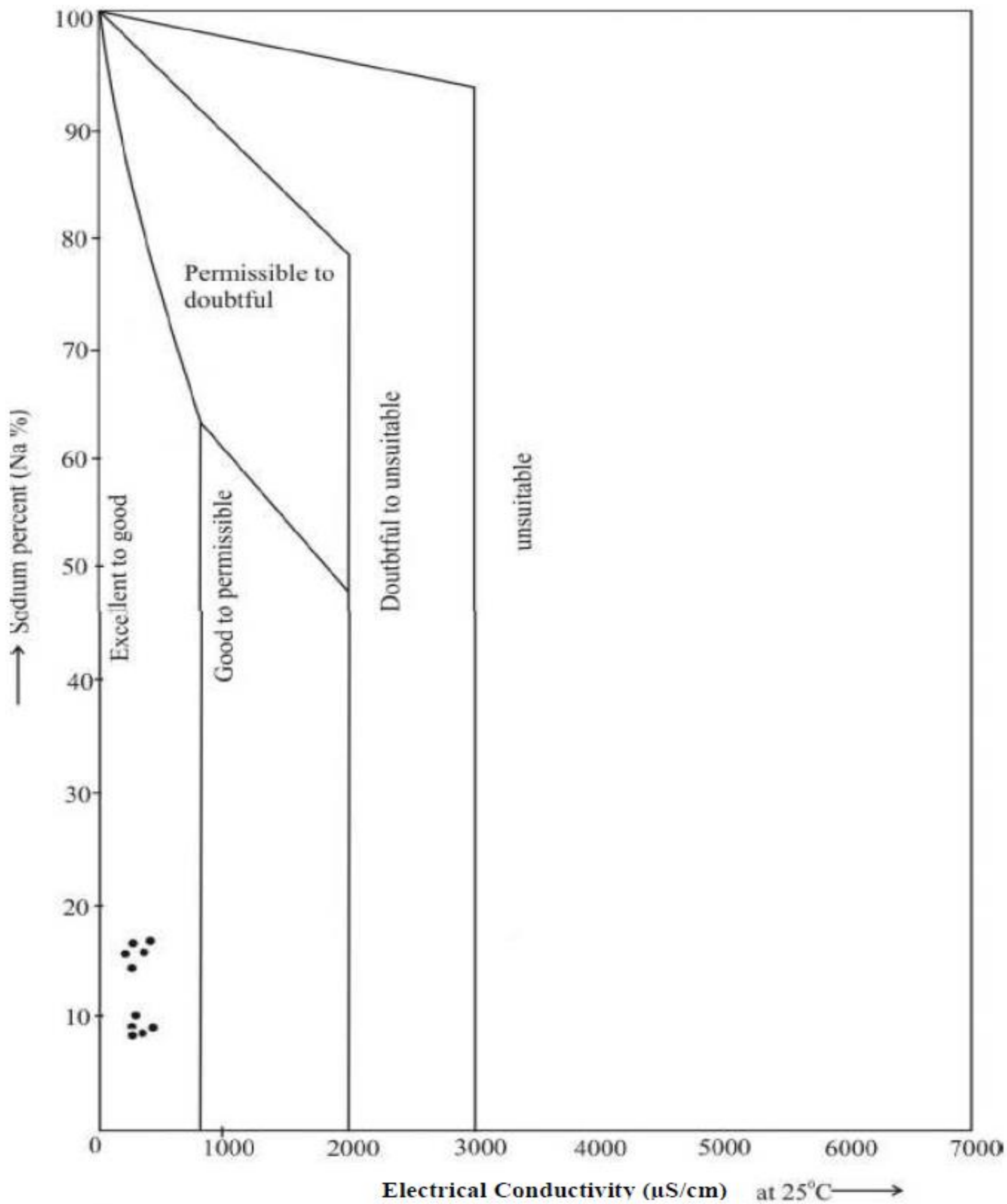

Figure 3. Acceptability of Groundwater of Irrigation in Wilcox Schematic (In line with Wilcox, 1950)