

QUALITY ASSESSMENT OF WELL WATERS IN FOUR LOCAL GOVERNMENT AREAS IN ILORIN, KWARA STATE, NIGERIA.

Nwosu, F. O. *, Saliu, O. D., Ajayi B. O. and Abolaji, O. E.

Department of Industrial Chemistry, University of Ilorin, Ilorin, Nigeria.

Abstract

The natural sources of portable water are becoming less available thus constituting a major social and economic concern. In this study, two well locations were selected from four local government area of Kwara state to access their physicochemical properties and quality as per metal ion and non metal ion concentrations. The detailed analysis of physicochemical parameters such as colour, temperature, acidity, alkalinity, hardness, conductivity, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Total Suspended Solids (TSS), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), metal ion contents, sulphate and chloride ions content were done using standard methods. All these parameters provide information about quality of the well water from the four local governments for drinking, industrial and analytical purposes.

Key words: Well water, physico-chemical properties, metal ions, sulphates and chloride ions

Introduction

Water covers 70.9% of the earth surface and is vital for all known forms of life. Water which is a liquid at ambient conditions often coexists with its solid state- “ice”, gaseous state- “water vapour” and in a liquid crystal state near hydrophobic surfaces (Henniker, 2000 and Gerald, 2001). Geographers divide Earth’s water bodies into three types: oceans, surface and underground water. All three types are vulnerable to human impact such as oil spills, other pollution, and lessened flow; however, those water bodies close to large population concentrations are the most affected by human activities

The usual sources of natural drinking water which is from streams, rivers, wells are usually not properly treated and cannot be adequate as portable water at the untreated state. Obtaining portable water is now a major problem in Nigeria and some parts of developing countries since most water bodies are contaminated through environmental degradation and pollution effects which arises from various anthropogenic activities. (Efe, 2005; Kaizer *et al.*, 2001; Obasi and Balogun 2001; Fakayode 2005).

Solutes in water affect water activity which in turn affects many chemical reactions and growth of microbes in food (DeMan and John, 1999). Water activity which is the ratio of vapour pressure of water in a solution to the vapour pressure of pure water (Vaclavik *et al.*, 2007) is normally lowered as concentration of solutes in water increases. Most bacterial growth ceases at low levels of water activity (DeMan and John, 1999)

Groundwater which occurs beneath the water table in soils supports drinking water supply; livestock irrigation, industrial and many commercial activities since it is generally less susceptible to contamination and pollution when compared to surface water bodies. Groundwater especially well water, can be contaminated by dispersed fertilizers and pesticides, industrial effluents, municipal waste and leaching from soils which contain high levels of heavy metals.

Therefore knowledge of extent of pollution and the status of well water fitness for use is needed so as to preserve the valuable sources of water for future uses (Gaay and Proop, 1993; Chowdhury, 2007). Access to safe drinking water has improved steadily over the last decades around every part of the world (Navneet *et al.*, 2010) and the significance correlation between access to safe water and Gross Domestic Product (GDP) per capita has made some observers to estimate that by 2025, more than half of the world population will face water scarcity. For example, out of the 85 million people living in urban and semi-urban areas, more than half have no reasonable access to reliable water supply (FMWR, 2000).

The various uses of water include- maintenance of body hydration (Rhoades and Tanner, 2003) drinking, recreational and industrial purposes (UNESCO, 2006). Therefore, this study is aimed at assessment of the quality of water from two wells each from four local governments of Kwara state, Nigeria. A total of eight wells were investigated for physicochemical properties and levels of concentrations of some metals as well as those of sulphates and chloride ions. These parameters were compared with each of the location sites as well as with some standard threshold limits (Sawyer *et al.*, 2000).

*Corresponding author email: f.o.nwosu@gmail.com

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Materials and Method

Location of study sites

Two samples of well water were randomly taken from different locations of four different local government area in Ilorin namely Ilorin West (Oja Oba and Ode Adua), Ilorin East (Sabo Oke and Fate-Tanke), Ilorin South (Garage Offa and Igboro) and Ilorin Central (Shao garage and Gori Ola) to give a total of eight water samples (Fig. 1). These are located between Latitude 8.4871259 – 8.5919437 °N and longitude 4.55434339 – 4.59726945 °E with exception of site 1 (S1) at oja oba that has geo coordinate of latitude 8.48817919 °S and longitude 4.534 °E.

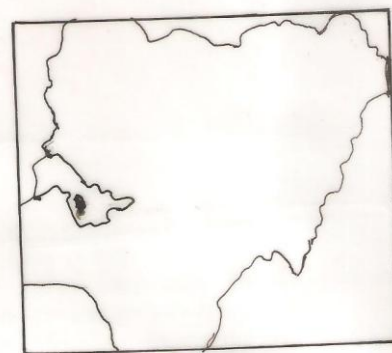
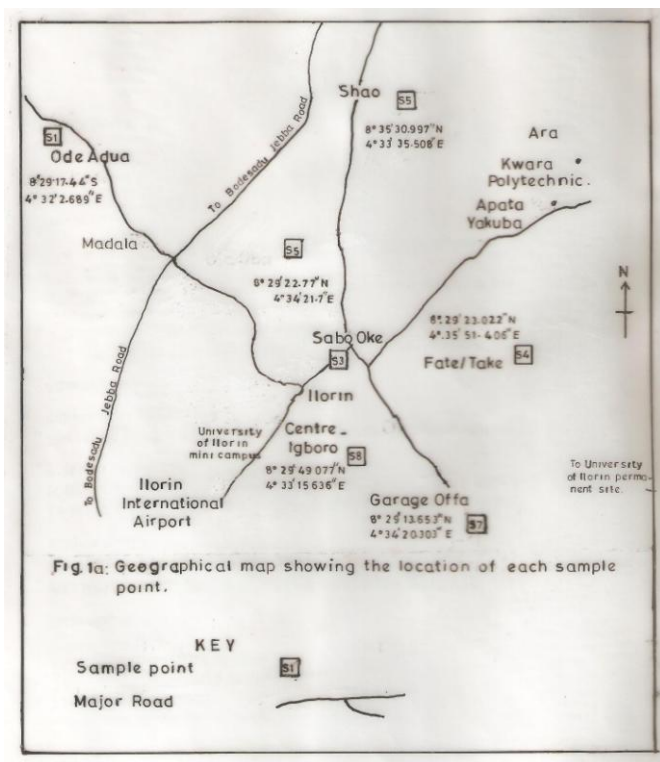


Fig1b: Map of Nigeria showing Kwara State with research area .

Physicochemical Properties of water samples

Determination of temperature and pH

Thermometer was inserted into 100 ml of the water sample in a beaker and was allowed to stand steady in the water sample for about 5 minutes before the temperature was accurately measured and was repeated for other water samples. Duplicate analysis was performed on the samples. A previously standardized pH meter was also separately dipped inside 100 ml of the water samples to determine the pH of the various water samples.

Determination of total suspended solids and total dissolved solids.

The difference in weight of a filter paper before and after use for the filtration of the water sample was used to determine the total suspended solid content of the water samples. This was repeated for other water samples. A blank study was also conducted.

Dissolved solids were determined using the method of Hydrological Project (2002). A 100 ml of the water sample was pipetted into an evaporating dish and filtered. The filtrate was then dried, cooled and weighed.

$$\text{Dissolved solids (mg/l)} = \frac{(A - B) \times 1000}{\text{ml of sample}}$$

Where, A is the weight of dried residue plus evaporating dish (mg) and B is the weight of filter, (mg)

Determination of chemical oxygen demand(COD) and biological oxygen demand (BOD).

A known volume (100 ml) of distilled water was measured into 250 ml conical flask and 10 ml of 25% H₂SO₄ was added with exactly 20 ml of 0.01M KMnO₄. A purple solution was obtained and boiled in water bath for 30 minutes. The flask was cooled and then 10 ml of 10% KI solution was added and a reddish wine colour was obtained due to the liberation of iodine. The solution was titrated against 0.05M Na₂S₂O₃ with 2-3 drops of freshly prepared starch indicator to a colourless end point. The result of this titre values obtained represented as 'A' and with the same procedure followed using 10 ml of the water sample and 90 ml of distilled water was represented as 'B' (Yang et al., 2009; SAPWA, 1999). The COD is calculated using the formula:

$$\text{Chemical Oxygen Demand (COD)}(\text{mg/l}) = \frac{(A - B) \times \text{Molarity} \times 40000}{\text{ml of sample taken}}$$

Where, A is the volume of distilled water, B is the volume of sample titrated and M is the concentration of KMnO_4 in moles/L.

The dissolved oxygen was determined using the Winkler (iodometric) method (Yang *et al.*, 2009). The sample was collected in a glass stopper bottle and two BOD bottles were completely filled with the water sample and third BOD bottle was filled with distilled water. The first BOD bottle was kept in a dark cupboard for seven days and 20 ml was pipetted from the second bottle into another BOD bottle and 5.0 ml of 10% w/v of MnCl_2 solution was added followed by 5.0 ml of alkaline iodide solution (20% NaOH, 15% w/v KI). The bottle was stoppered, avoiding trapping air bubbles, and mixed by inverting several times. A 10 ml of 25% HCl solution was added, stoppered and mixed. The content was poured into 500 ml conical flask and the liberated iodine was titrated with 0.05M sodium thiosulphate using freshly prepared starch as the end-point indicator. The procedure was repeated after seven days to determine the dissolved oxygen of 7 days (using the first bottle). The DO (mg/l) is thus calculated:

$$\text{Dissolved oxygen(DO)}(\text{mg/l}) = \frac{\text{titre} \times \text{Molarity} \times 8000}{\text{volume (ml) of the sample}}$$

Determination of conductivity, alkalinity and acidity

The electrical conductivities for the water sample were measured using digital conductivity bridge of model 1152. Alkalinity was determined by the method of Arunkumar, (2012). A 100 ml of the water samples were measured separately into a conical flask and 3 drops of phenolphthalein indicator was added followed by 3-4 drops of methyl orange indicator to each conical flask. The solutions were titrated against 0.1M HCl. The value of alkalinity was calculated using the following formula:

$$\text{Alkalinity (mg/l)} = \frac{\text{volume(ml)} \times \text{Molarity of titrant} \times 100000}{\text{Volume (ml) of sample}}$$

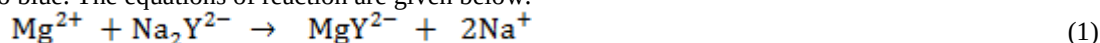
Acidity of each of the water sample was also determined using the method of Arunkumar, (2012). A 25 ml of the sample was measured into conical flask and 2-3 drops of phenolphthalein indicator was added. The colourless solution was titrated against standard 0.01M NaOH until pink was obtained at the end point. The acidity is calculated using the following formula

$$\text{Total acidity (mg/l)} = \frac{V \times M \times 50 \times 1000}{\text{ml of sample used}}$$

Where V is the Volume of NaOH used and M is the concentration in moles/L of NaOH used.

Estimation of total hardness in water

Total hardness was estimated by direct titration with EDTA. A known volume (100 ml) of the water sample was measured into conical flask and then buffered to pH 10 by the addition of 5 ml ammoniacal buffer. It was then titrated against 0.01M of standardized EDTA solution. The end point was noted when the solution changed from purple to blue. The equations of reaction are given below:



$$\text{Total hardness of Mg and Ca (mg/l)} = \frac{V \times A \times 1000}{\text{ml of sample used}}$$

Where, A is the weight of CaCO_3 in milligram equivalent to 1 ml EDTA titration and V is the titre value.

Determination of metals

A 42 mL of the water sample was mixed properly with 6 mL of HNO_3 and 2 mL of HCl. The mixture was heated until the solution boils for one hour. A blank solution was also digested by mixing 42 mL of deionized water with 6 mL of HNO_3 and 2 mL of HCl until the solution boiled for 1h. The solution obtained was made up to mark in a 25 mL standard volumetric flask. The solutions were subjected to air-acetylene flame using atomic absorption spectroscopy (AAS).

Determination of sulphate by gravimetric method

A known volume (50 ml) of the sample was carefully measured into beakers and 2 drops of methyl red indicator was added and it turned the solution light yellow. Two drops of concentrated HCl was added and it turned solution to pink. The solution was boiled to reduce its volume to one-third. Hot barium chloride solution prepared was then added to it and stirred until the formation of white precipitate was completed. The precipitate was allowed to settle down, filtered and washed several times with distilled water until it was free of chloride ion. The filter paper and the filtrate were transferred carefully into crucible and ignited at 100 °C in oven, then cooled in desiccator and finally weighed. Sulphate ion was calculated as thus:

$$X_g = \frac{W_g \text{ of } 96.06}{233.4} = Y_g \text{ of } SO_4^{2-} \text{ in 50 ml}$$

Determination of Chloride

Chloride ion was determined using Mohr's method by titration of each of the water samples with silver nitrate (AOAC, 2002). Potassium chromate (5%, 1 ml) was added to 100 mL of water sample and titrated with 0.01M silver nitrate solution. The first appearance of buff colour, marks the end point of the titration. The chloride concentration was calculated as thus:

$$\text{Chloride (mg/l)} = \frac{V_T \times M \times 100,000}{\text{ml. of water sample}}$$

Where V_T = titre value and M = Molarity of $AgNO_3$

Results and Discussion

The physicochemical parameters of various well water samples are represented in Table 1.

The pH range (7.00-7.20) of the study sites showed a narrow range of variation within the standard pH for drinking water (BIS, 1991). The maximum (7.20) and minimum values of 7.00 show that the water is neutral and this indicated that the water sample is less corrosive. Since the pH values were not less than 7, it is impossible for the water to dissolve dangerous and toxic metals (Mahananda *et al.*, 2010)

The alkalinity values- 200, 164, 158, 156, 160 of the wells in Ode Adua, Sabo Oke, Fate Tanke, Garage Offa and Centre Igboro respectively were more than the maximum permissible level of WHO (150 mg/L) which may be as result of the presence of carbonates and bicarbonates in the water. The acidity of the well water at the study sites showed the maximum value of 290 mg/L and the minimum value of 190.12 mg/L which indicated that the level of toxic metals and hydrogen ion present in the water sample is moderate for drinking and domestic uses. The conductivity values are within permissible limits for drinking water.

The higher relative conductivity of the two wells located at Oja Oba and Ode Adua in Ilorin West may be due to differences in geochemical conditions and soluble ions in the location (Aremu *et al.*, 2011). Table 1 also revealed maximum conductivity value of 1140 $\mu S/cm$ and minimum value of 114 $\mu S/cm$ indicated the presence of dissolved metal ions which are charge carrier in the water (WHO, 2008).

The TDS with maximum value of 7.68 mg/L and minimum value of 2.70 mg/L showed that the water sample contained low amount of dissolved minerals (Chinedu *et al.*, 2011).

TABLE 1: Physico-Chemical Parameters of various Well Water Samples

L.G.A	Ilorin West		Ilorin East		Ilorin Central		Ilorin South	
	S1	S2	S3	S4	S5	S6	S7	S8
Parameters	Oja Oba	Ode Adua	Sabo Oke	Fate-Tanke	Shao Garage	Gori Ola	Garage Offa	Centre Igboro
pH	7.10	7.00	7.00	7.00	7.10	7.20	7.00	7.00
Conductivity ($\mu S/cm$)	1066	1120	221	209	114	520	510	440
Acidity (mg/L)	248.75	190.12	226.25	243.75	212.50	251.25	290	268.75
Alkalinity (mg/L)	150	200	164	158	130	140	156	160
Hardness (mg/L)	100.4	53.73	144.72	234.70	93.12	15.89	116.86	102.53
TDS (mg/L)	6.96	7.68	3.11	3.13	2.80	2.43	4.17	5.08
DIGESTION (mg/L)	20.00	23.00	10.00	22.00	18.00	14.00	21.00	19.00
DO (mg/L)	72.00	63.20	60.40	66.64	68.80	70.40	76.40	75.20
COD (mg/L)	3.12	2.20	2.00	1.80	3.92	3.60	4.00	4.20
TSS (mg/L)	00.31	00.28	00.75	00.32	00.35	00.17	00.38	00.13
BOD (mg/L)	32.00	27.20	42.40	44.00	35.20	32.88	48.80	47.20

Where S1 and S2 are different study sites within the same local government; L. G. A. means local government area. Values are average of duplicate samples with standard deviation less than 5%.

The TSS value which fell within the range of 0.031-0.075 mg/L showed that the amount of undissolved minerals is very low. Adequate DO is necessary for good water quality, survival of aquatic organism and decomposition of waste by microorganism (Islam *et al.*, 2010, Nowara *et al.*, 2013). The BOD value ranged from 48.80 for Garage Offa to 27.20 for Ode Adua. The wells which showed lower BOD values could be said to contain comparatively low organic wastes (Mahananda, *et al.*, 2010).

Table 2 shows the concentration values of metal ions that were obtained from the various well water samples from the different study sites. The level of magnesium and calcium in the water samples are not high enough to cause hardness of the water but when this combine with the alkalinity present in the water sample it can result in a slight brown deposit (AWWA, APHA, 1998).

The Fe ranged from 2.57 mg/L in Offa Garage well to 0.02 mg/L in Centre Igboro well water. Sabo Oke, Goriola, Centre Igboro water wells exhibited Fe concentration values of 0.35 mg/L, 0.18 mg/L, 0.02 mg/L respectively which are lower than the USEPA (2003) and APHA (2010) permissible limit of 0.3 mg/L for Iron. Other study sites have value of Fe concentration which were higher than the permissible limits of USEPA(2003) and APHA (2010), this higher concentrations might be as a result of industrial and vehicular activities contribution and other anthropogenic activities (Adebisi *et al.*, 2006; Knezevic *et al.*, 2009)

The value of Zinc in well water ranged from 3.30 mg/L for Centre Igboro to 0.007 mg/L for Gori Ola. The study sites with concentrations of 1.32, 1.165, 0.305, 3.30 mg/L were found to be above the WHO threshold limit of 0.3 mg/L (WHO, 2010). It might be as a result of leakages of storage tanks or periodic overflow of petroleum products (Yahaya *et al.*, 2010).

Table 2: Metal ion concentrations for the investigated study sites.

L.G.A sites	Study	mg/L							
		Ca	Mg	Fe	Zn	Co	Cr	Cd	Pb
	Oja oba	33.0	9.27	1.047	1.32	0.000	0.000	0.014	0.000
	Ode adua	26.5	9.35	1.047	1.32	0.000	0.153	0.000	0.000
	Sabo oke	23.5	19.35	0.35	0.010	0.000	0.000	0.000	0.000
	Fate/ tanke	71.6	5.65	1.24	1.165	0.000	0.000	0.008	0.000
	Shao	23.8	10.35	2.24	0.080	0.000	0.116	0.000	0.000
	Gori ola	62.4	8.60	0.18	0.007	0.000	0.000	0.000	0.000
	Ofa garage	52.38	8.60	2.57	0.305	0.000	0.000	0.015	0.000
	Centre igboro	6.52	4.52	0.02	3.30	0.000	0.096	0.061	0.000

Chromium was only detected at Ode Adua (0.153 mg/L), Shao (0.116 mg/L) and Centre Igboro (0.096 mg/L). Possible source of Chromium include automobile brake lining, catalytic converters and chrome pigments for automobiles (Popoola *et al.*, 2012; Melaku *et al.*, 2005)

The presence of low level of Cadmium and the absence of lead and Cobalt which are poisonous indicated that the water is suitable for drinking and other domestic uses (FEPA; Olatunji and Osibanjo, 2012; Abidemi, 2001).

Concentration of chlorides and sulphates in well waters

According to the State Pollution Control Board, the standard limit of chloride for drinking purpose is (250-1000 mg/L). Chlorides are stable components of water from the leaching of chloride containing rocks and soils with which the water comes in contact. Table 3 showed that the concentration of chloride fell within the range of 209.0-428.2 mg/L. The result obtained from the level of chlorides in the water sample does not pose any adverse effect whatsoever (Ezeribe *et al.*, 2012).

TABLE 3: Levels of concentrations of SO_4^{2-} and Cl^- ions in eight well water samples studied.

L.G.A	ILORIN WEST		ILORIN EAST		ILORIN NORTH		ILORIN SOUTH	
PARAMETER	Oja Oba	Ode Adua	Sabo Oke	Fate/ Tanke	Shao Garage	Goriola	Garage Offa	Center Igboro
Chloride	427.2	428.2	329.8	275.5	255	427	209	218.6

Sulphate	86.82	77.36	65.84	59.67	78.13	76.13	50.61	60.90
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The units are in mg/L, level of contamination are below 5 % standard deviation

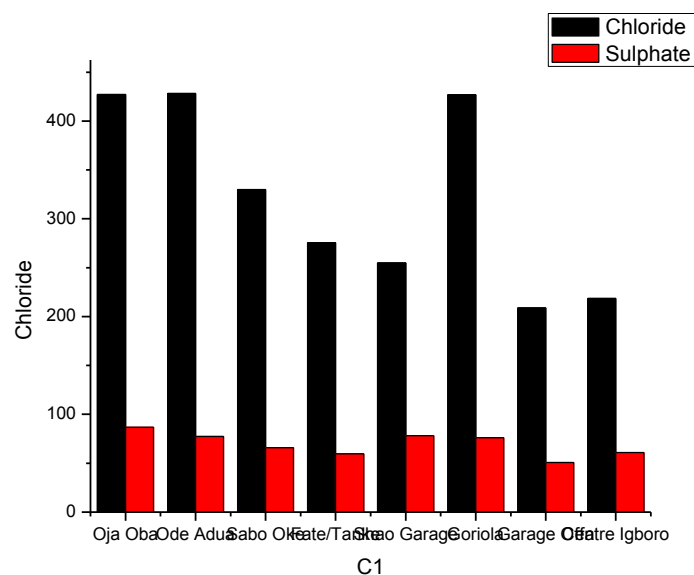


Fig 2: Pictorial summary of the level of chloride and sulphate ions in the well water samples studied.

The chloride ion content obtained are within acceptable limits and this shows lower degree of eutrophication and sewage in-flow to the well water at the study sites (Mahananda *et al.*, 2010; Behera *et al.*, 2014).

Oja Oba has the highest level of sulphate ion concentration of 86.82 mg/L while Garage Offa has the lowest concentration of 50.61 mg/L. The sulphate concentration value (Table 3) of Oja Oba well water exceeded the critical level of 85.5 mg/L as established by Kang and Osiname (1976). The low sulphate concentration values observed at all other points show that their water is less coagulated and turbid (Mahananda *et al.*, 2010; Ogeh *et al.*, 2012). The variations of concentrations of chloride and sulphate ions are depicted in figure 2.

Conclusion

The various physico-chemical parameters as well as metal, chloride and sulphate ions were determined and compared with the respective standards to monitor the well water quality of Ilorin, West, Ilorin South, Ilorin, East and Ilorin North located at some local government areas of Kwara state, Nigeria. Analysis of pH, conductivity, TDS, DO, chloride, calcium, magnesium, total hardness are the important parameters used to monitor the pollution status of the well waters and the major parameters were not at the level of pollution. Therefore the well waters can be said to have satisfied the requirements for use in various purposes.

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