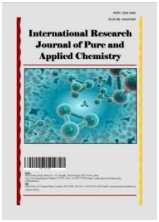

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Determination of Physicochemical Parameters and Mineral Compositions of Hand Dug Well Water Samples Collected from Selected Local Government Areas in Oyo State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Authors SAO, OGO and AMO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors LOO and AOO managed the analyses of the study. Authors AIA and AIA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Potable water is essential for human survival but contaminations through human activities have jeo pardized it. This research will create awareness on the condition of hand dug well water used and reduce transmission of diseases in the study areas. The study deals with the determination of physic-chemical parameters and Mineral composition of water samples collected in the month of September, 2019 from hand dug well from selected local government areas in Oyo State Nigeria, (Ibadan North-East, Ibarapa Central, Afijio, Ogbomoso South and Iseyin local government). The parameters examined were Temperature (T^oC), Potential Hydrogen (pH), Conductivity ($\mu/S^{-1}/cm$), Total Dissolved Solid (TDS ppm), Salinity (ppm), Dissolved Oxygen (DO mg/L),Potassium (K^+), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Zinc (Zn^{2+}) and Chloride (Cl^-). Standard analytical methods were used. The analytical results of the study revealed that Temperatures are within 27 and 28^oC, the pH of the samples ranges from 4.7-6.8, Conductivity falls between 785-1671 $\mu/S^{-1}/cm$. The TDS ranges from 550-1346 ppm, Salinity from 384-956 ppm while DO had the values ranges of 6.03-11.44 mg/l.

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Potassium (K^+) (1.92-6.22 mg/l), Calcium (Ca^{2+}) (14.74-18.52 mg/l), Magnesium (Mg^{2+}) (6.34-7.81 mg/l), Zinc (Zn^{2+}) (0.39-0.47mg/l) and Chloride (Cl^-) (26.19-28.70 mg/l). It was noted that, Conductivity, salinity and DO were high compared to WHO and NSDWQ permissible standard limits. This indicated that pollution from dumpsites and erosion has great impact on the water. The mineral compositions of the water samples are within the permissible limit recommended by WHO. It is advisable that proper drainage and sewer systems should be constructed in all areas to ensure proper disposal of hazardous liquid waste, thereby preventing seepage into groundwater and surface water.

Keywords: standard limits, hand dug well; local governments; TDS; pH; D.O; mineral composition.

1. INTRODUCTION

The researchers on environmental quality focused on water because of its importance in maintaining the human health and health of the ecosystem [1]. Although water is the most common and important chemical compound on earth, only 2.6% of the global water is freshwater and consequently available as potential drinking water. Water is the essence of life and soft drinking water is basic human right essential to all and also essential for the wellbeing of mankind and for sustainable development [2,3]. According to Aminu, *et. al.* [4], the importance of water ranges from cooking, drinking, agricultural and industrial processes, human recreation and waste disposal. Availability of sufficient volume of drinking water continues to present major problems worldwide to public health [5,6]. Due to the increase in population growth and elevated living standards and coupled with the increasing demands for clean water around the world, more water is required for growing environmental concerns such as aquatic life, wildlife refuges, scenic values, and riparian habitats [7,8].

Pollution of water bodies are usually caused by chemical and microbial contaminants which leads to waterborne infections and diseases [9]. Also, Rapid urbanization of rural areas, industrialization and population growth have been the major causes of stress on the environment leading to problems like human health problems, eutrophication and fish death, coral reef destruction, biodiversity loss, ozone layer depletion and climatic changes [10,11]. Improper disposal of industrial effluents which is most common in major African urban and rural centers has led to heavy contamination of the available fresh water resources reducing the volume of safe agriculture, domestic, irrigation and drinking water [12].

In a research conducted by [13,14,15], on groundwater quality of the southeastern parts of Lagos from 1999-2001on the impact of urbanization, found that water samples analysed, contains high concentrations of sulphate, nitrate and chloride in all the wells. Nitrate particularly was noted to be very high and is linked with anthropogenic activities. Groundwater in Lagos is particularly vulnerable to contamination due to shallow depth and the unconsolidated permeable sand and gravel aquifer. Therefore guidelines and legislation has stated that water suitable for drinking should contain some parameters including microorganisms and physicochemical only in low amounts that the risk for acquiring waterborne infections is below an acceptable limit [8-16].

The term physic-chemical quality is used in reference to both physical and chemical characteristics of water which may affect its acceptability due to aesthetic considerations such as colour and taste; produce toxicity reactions, unexpected physiological responses of laxative effect, and objectionable effects during normal use such as curdy precipitates [17].

Most potable water in Nigeria comes from three sources, which include rainwater, surface water and ground water. Due to the metropolitan authority's inability to extend potable water supply to the entire area owing to lack of maintenance or increased population, ground water consumption has become a common practice with many homes having resorted to the use of hand-dug wells for domestic purposes. This research work focuses on physicochemical and mineral quality of water in hand dug wells in Oyo State South West of Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Oyo State, Nigeria which lies between latitudes 6.5^o and 9^o north of

the equator and between longitudes 3° and 5° east of the Greenwich meridian [18].

2.2 Samples Collection and Preservation

Hand dug well water samples were collected randomly from six local government areas in Oyo State Nigeria, in September, two samples per local Government into separate cleaned container and labeled to indicate location (Location 1(A and B): Afijio Local Government (Awe town),Location 2 (A and B): Ogbomoso South Local Government (Esaanu-Aje),Location 3 (A and B): Ibadan North Local Government (Yemetu),Location 4 (A and B): Ibadan North West Local Government (Eleyele),Location 5 (A and B): Ibarapa Central Local Government (Igboora),Location 6 (A and B): Iseyin Local Government (Ladogan) all in Oyo State Nigeria). The samples collected were brought to the Oyo State College of Agriculture and Technology Research Laboratory for analysis. To retain the water sample properties, all the samples were protected from heat and direct sunlight during transportation and preserved with Lugol solution until laboratory analysis was carried out.

2.3 Experimental Procedures

Temperatures were measured using Mercury thermometer (°C), Potential Hydrogen (pH), Conductivity (μ/S^{-1}/cm) and Total Dissolved Solid (TDS ppm) were determined using Extech Multi meter portable water kit EC_{500}. Dissolved Oxygen (DO) was fixed in separate BOD sample bottles. Analysis of other parameters such as Salinity (ppm), and elemental analysis were carried out using APHA [19] methods.

3. RESULTS AND DISCUSSION

The following physic-chemical parameters pH, electrical conductivity, dissolved oxygen, total dissolve solid, salinity and mineral element such as potassium, calcium, magnesium, zinc and chloride were analysed for the hand dug well water samples collected from six different local government areas in Oyo State.

The result presented in Table 1 showed the Temperature of samples (°C), collected in Locations 4A, 4B, 5A, 6A and 6B have the same temperature values of 27°C while Location 5B had the highest temperature value of 28°C. The Temperature range is still within ambient temperature (18.45-36.90°C) as stated by WHO for drinking water.

pH is defined as the intensity of the acidic or basic character of a solution at a given temperature. pH is the negative logarithm of hydrogen ion concentration ($pH= -\log_{10} [H^+]$). The pH in water samples of the present study ranged from 4.7 to 6.8ppm. pH of water is important for the biotic communities as most of the plant and animal species can survive in narrow range of pH from slightly acidic to slightly alkaline condition [22]. This research work showed that two locations (2B and 4B) are slightly acidic and other revealed no significant differences as they are so close and still within the WHO standard for water pH 6.5-8.5.

Water capability to transmit electric current is known as Electrical conductivity and serves as tool to assess the purity of water [23]. This ability depends on the presence of ions, their total concentration, mobility, valence, relative concentrations and temperature of measurement [24]. The Electrical conductivity of the different water samples ranged from 785 μs^{-1}/cm to 1671 μs^{-1}/cm. The highest electrical conductivity was reported in sample 6A and sample 4B was reported to have lowest electrical conductivity value. The results correspond to Musa, *et.al*. and Godwin and Abdullali [3,25] of 1210-1678 μs^{-1}/cm and 1056-1324 μs^{-1}/cm for dry and wet season respectively. This research shows that the Conductivity values for some of the water samples analysed were above and some are within WHO standard permissible limit of 1000 μs^{-1}/cm. These results were clearly indicated that most of the water in the studies were considerably ionized and had the higher level of ionic concentration activity due to high dissolved solids.

Total dissolved solids (TDS) refer to the solid suspended and dissolved matter in water. They are very useful parameters describing the chemical constituents of the water and can be considered as edaphic factor that contributes to productivity within the water body [24]. The total dissolved solids in the sampled hand dug well water ranged from 550ppm to 1346ppm. The highest TDS was found in sample 6A and lowest TDS was reported for sample 4B due to the addition of organic matter and solid waste which are very close to the well. This is higher compared to research conducted by [4] on groundwater (143.70-402.00 ppm). These results were below 1000 ppm recommended by W.H.O

except location 6B. Water containing high solid may cause laxative or constipation effects [23].
Salinity is the measure of salt content or concentration of Sodium chloride in water molecules. The result obtained from Table 1 showed that concentration of Salt content (Salinity) in the water samples obtained from local government areas in Oyo State were above WHO recommended value of 200 ppm, the results indicated that Location 6A had the highest salt content of 956ppm, followed by Location 6B with salinity value of 758 ppm, 2A (678 ppm), 5A (661 ppm), 5B (605 ppm) and 2B (600 ppm), Location 1A, 1B, 3B, 4B, 3A and 4A have their values of salt content to be 450, 400, 393, 389, and 384ppm respectively. This may resulted from erosion coming from weathering of rocks.

The higher value of Dissolved oxygen (DO) indicates good aquatic life. The amount of dissolved oxygen from the samples ranged between 6.03 mg/l to 11.44 mg/l. The highest DO value recorded was in location 4A due to the turbulence of water facilitating the diffusion of atmospheric oxygen and the increased solubility of oxygen at lower temperature. The lowest dissolved oxygen recorded was found in Location 1B due to the high temperature and addition of sewage and other waste which can be responsible for low value of dissolved oxygen. The dissolved oxygen for the hand dug well water analyzed was above 2.50 mg/L recommended by WHO, high dissolved oxygen in water samples denoted the free invasion of microorganisms in such water, which may expose users of the water to danger.

Table 2 showed the concentration of minerals (mg/L) of water samples obtained. The table revealed that potassium in Location 4A was the highest at 6.22 ± 0.15 mg/L, followed by Location 4B with the value 4.83 ± 0.13mg/L, and then Location 6A, 6B, and 5A had their values at 4.07 ± 0.06 mg/l, 3.71 ± 0.14 mg/L and 3.67 ± 0.29 mg/L respectively while Location 5B had the lowest value of 2.78 ± 0.08 mg/L. It was reported by the WHO and NSDWQ that no permissible limit was set for Potassium, this shows that higher concentration of potassium has little or no effect on water quality. Potassium is an essential element for human nutrition, and requirements are generally measured in grams per day. Potassium and sodium maintain the normal osmotic pressure in cells and also a cofactor for many enzymes and is required for the secretion of insulin, creatinine phosphorylation, carbohydrate metabolism and protein synthesis [26].

Calcium is an important source of mineral that helps in development of strong bones and teeth, the presence of calcium in food and water serves as co-enzyme in the production of haemoglobin in blood cells. The Table 2 revealed that Location 2A had the highest mean concentration of calcium with value 18.52 ± 0.27 mg/l, followed by Location 5B with value 16.77 ± 0.20 mg/L, Locations 6A, 4A and 6B had the mean concentration values of 16.24 ± 0.09 mg/L, 16.17 ± 0.18 mg/l and 14.89 ± 0.13 respectively while Location 5A had the least value of 14.74 ± 0.17 mg/L. This result indicated that all the water samples were found to be within the permissible limit when compared with the WHO standard which was recorded to be 200 mg/L for drinking water.

The analysis of Magnesium (mg/L) in water samples ranges from 6.34±0.06 -7.81±0.03 where Location 4B has the highest composition value and Location 6A had the lowest composition value. The analysis carried out showed that the entire water sampleshas magnesium values that were found to be within the permissible limit recommended by WHO which was 50mg/L.

Zinc is one of the important trace elements that play a vital role in the physiological and metabolic process of many organisms. Nevertheless, higher concentrations of zinc can be toxic to the organism [27]. It plays an important role in protein synthesis and is a metal which shows fairly low concentration in surface water due to its restricted mobility from the place of rock weathering or from the natural sources [28]. However, the Concentration of Zinc in all the water samples revealed that Location 2B had the highest composition of Zinc to be 0.47 ± 0.00 mg/L while Location 3A and 6A had the lowest concentration value of 0.39 ± 0.00 mg/L as it was recorded in the Table 2 above. Therefore, the concentration of Zinc in all the water samples analysed were within the permissible limit recommended by WHO which was 3 mg/L.

Chlorine is an essential component required in the body. The result showed that Location 6B had the highest chloride concentration of 28.70 ± 0.02mg/L, followed by Locations 5A, 3B, 3A, 2B, 6A, 5B with concentration value of 28.49 ± 0.05 mg/L, 28.36±0.24 mg/L, 28.32±0.06 mg/L, 28.

Table 1. Physico-chemical parameters of hand dug well water samples from selected areas

Parameters Sample sites	Temperature (^oC)	pH	Conductivity ($\mu/S^{-1}/cm$)	TDS (ppm)	Salinity (ppm)	DO (mg/l)
Location 1A	27	6.1	937	656	469	8.21
Location 1B	27	6.1	889	629	450	6.03
Location 2A	27	6.6	1355	948	678	6.84
Location 2B	28	5.9	1200	840	600	10.19
Location 3A	27	6.8	799	560	389	8.33
Location 3B	27	6.7	801	561	400	7.30
Location 4A	27	6.4	800	557	384	11.44
Location 4B	27	4.7	785	550	393	8.90
Location 5A	27	6.2	1321	925	661	8.15
Location 5B	28	6.7	1209	846	605	8.75
Location 6A	27	6.1	1671	1346	956	7.43
Location 6B	27	6.2	1603	989	758	8.10
W.H.O & NSDWQ	Ambient	6.5-8.5	1000	1000	200	5.0

The data presented in Table1 represents the values of physicochemical composition of water samples from six local Governments, two per location compared with WHO & NSDWQ standard [20,21]
((Location 1(A and B): Afijio Local Government (Awe town),Location 2 (A and B): Ogbomoso South Local Government (Esaanu-Aje),Location 3 (A and B): Ibadan North Local Government (Yemetu),Location 4 (A and B): Ibadan North West Local Government (Eleyele),Location 5 (A and B): Ibarapa Central Local Government (Igboora),Location 6 (A and B): Iseyin Local Government (Ladogan)*)*

Table 2. Mean values of mineral compositions of hand dug well water samples from selected areas

Parameters Sample Sites	Potassium (K^+) (mg/L)	Calcium (Ca^{2+}) (mg/L)	Magnesium (Mg^{2+}) (mg/L)	Zinc (Zn^{2+}) (mg/L)	Chloride (Cl^-) (mg/L)
Location 1A	2.18±0.03	15.06±0.06	7.16±0.07	0.43±0.01	26.43±0.03
Location 1B	2.85±0.03	16.31±0.01	7.20±0.03	0.46±0.01	26.82±0.09
Location 2A	4.01±0.08	18.52±0.27	6.92±0.02	0.41±0.01	26.19±0.10
Location 2B	4.01±0.08	15.87±0.09	7.06±0.09	0.47±0.00	28.27±0.08
Location 3A	1.92±0.13	15.07±0.09	6.86±0.05	0.39±0.00	28.32±0.06
Location 3B	2.21±0.14	16.39±0.07	6.95±0.05	0.41±0.01	28.36±0.24
Location 4A	6.22±0.15	16.17±0.18	7.59±0.02	0.43±0.00	26.87±0.06
Location 4B	4.83± 0.13	18.06±0.07	7.81±0.03	0.46±0.01	27.48±0.30
Location 5A	3.67±0.29	14.74±0.17	7.33±0.00	0.41±0.00	28.49±0.05
Location 5B	2.78±0.08	16.77±0.20	7.36±0.08	0.43±0.01	27.88±1.47
Location 6A	4.07±0.06	16.24±0.09	6.34±0.06	0.39±0.00	28.12±0.14
Location 6B	3.71±0.14	14.89±0.13	6.84±0.04	0.41±0.01	28.70±0.02
WHO [19]	No limit	75	50	2.50	250

The data in Table 2 are analysed in triplicate and presented as Mean ± SD

27±0.08 mg/l, 28.12 ± 0.14 mg/L and 27.88 ± 1.47 mg/L respectively then Locations 4B, 4A, 1B, 1A and 2A with concentration of 27.48 ± 0.30 mg/L, 26.87±0.06 mg/L, 26.82±0.09 mg/L, 26.43±0.03 mg/L and 26.19±0.10 mg/L respectively. This phenomenon was also been reported by Godwin and Abdullali [25] that, standard for well water as it was recommended W.H.O to be 250 mg/L. The result showed that all the samples were found within the permissible limits.

4. CONCLUSION AND RECOMMENDA-TION

The aim of evaluating the quality of water from hand dug wells in six local government areas in Oyo State was achieved by analyzing the physicochemical and mineral parameters in the water samples collected from various locations within the State. From the analyzed results, most of the physic-chemical parameters were found to be higher in concentrations from the permissible standard limits (WHO and NSDWQ), except pH and TDS found to be lowered to the standard. The results in this work was in line with the research conducted by Oladunjoye, *et, al*. and Ojoawo and Seriboh [29,30] on ground water in Ibadan and Ogbomoso town respectively, both in Oyo state and Raut, *et. al.* [24]. Where they reported that Conductivity, Total dissolved solids, hardness, alkalinity and pH are high in concentration due to leachate from dumpsite. However, all minerals determined in all locations were within the permissible limits of WHO Standards.

Therefore, it is concluded that if possible, water from Locations 6A and 6B should not be used for domestic purposes because of high salinity which results to its high temperature and conductivity which caused by pollution. These may result into hardness of water which may cause funning of kettles and boiler, Improper lathering of soap, that is unfit for irrigation and many more.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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