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Physicochemical Analysis of Different Well Water Samples Used for Drinking and Domestic Purposes in Bali Metropolis, Taraba State

Naziru Nuri[1], Abdulkarim Adamu[2]
Department of Civil Engineering, Federal polytechnic Bali, Taraba State
nazirunuri@gmail.com[1] adamuabdelkariim@gmail.com[2]

Abstract: *The consumption of unsafe water is harmful to human health. It is therefore important to ascertain the quality and clarity of water set out for drinking. This study assessed and compared the physiochemical properties of well water used for drinking and domestic purposes in Bali metropolis with the acceptable limits set by WHO and NSDWQ. Water samples were collected from sixty (60) selected wells in Ten (10) different geographical zones used for drinking and domestic purposes. Water samples were collected and analyzed for the physico-chemical parameters. Temperature, conductivity, pH and dissolved oxygen (DO) levels were determined in the field using pH and conductivity meters. Total Alkalinity, copper, Fluoride, zinc, phosphorus, Total Dissolved Solids and nitrate levels in water were determined in the laboratory by standard apparatus and Atomic Absorption Spectrophotometer. All the mean values for physical parameters were within the acceptable limits set by W.H.O and NSDWQ. Only Fluoride was below the recommended limits as the values ranged between 0.12mg/l to 1.32mg/l for chemical parameters. The principal aims of monitoring drinking water are to prevent the spread of water related diseases and to protect the health of the community. The importance of access to good quality water cannot be overemphasized, considering the large number of the community consuming water from well, which constitute a major health problem, therefore, there is an urgent need for awareness to be created about the present situation of these wells, to enlighten the people on the necessity for further treatment of this water before they can be used for drinking and domestic purpose.*

Keywords: Physicochemical Parameters, Well Water, WHO (World Health Organization), NSDWQ (Nigerian Standard for Drinking Water Quality).

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Background

The quality of water over the decade had been defined by the colorless, odorless, tasteless and its transparent atmosphere. It is a basic resource necessary for sustaining all human activities, so its provision in desired quantity and quality is of utmost significance (Taruna and Alankrita, 2013). The two major sources of freshwater are the surface water and groundwater. The groundwater offers a valued fresh water resource to human population and creates about two-third of the fresh water reserves presently occupying various spaces across the world (Adeyemi, et al., 2017). Well water is used primarily as a source of drinking water by the vast majority (94%) of the rural population in Bali metropolis (Abubakar B and Ibrahim M, 2016). A well is an excavation or structure formed in the ground by digging, driving, or by drilling to access water. It is the oldest and most common kind of well is water well to access groundwater in underground aquifers. Water quality refers to the, chemical, physical, and biological characteristics of water centered on the standards of its usage. The most common standards used to monitor and assess water quality carry the health of ecosystems, safety of human contact, and condition of drinking water. Water quality has a major impact on water supply and oftentimes defines supply options (Bartram and Balance, 1996; Alley, 2000; Ahuja, 2009; Boyd, 2015). It is pertinent that approximately 90% of residents of Bali metropolis are not connected to safe drinking water and sewage services. Most of the residents in the metropolis draw water from well (Abubakar B and Ibrahim M, 2016).In addition, the well is prone to contamination from surface run off of agricultural chemicals from the farms and defecations in bushes particularly due to lack of pit latrines in some neighboring homes and the water taken from the wells for various uses does not undergo through any treatment before use for any activity(Nwankwoala, 2011).These wells are widely recognized within the vicinity, and are used primarily as a source of drinking water by the vast majority of the population in the area in many cases, immediate environmental conditions are unfavorable e.g., the distance of wells from latrines or sewage-contaminated may be insufficient to avoid contamination of the well water with human-pathogenic bacteria (Nwankwoala, 2011). Scanty data exists on the well water quality and how it affects residents' health. Thus, there was a vital need to conduct a research to assess the level of physico-chemical parameters of the wells which is the main source of water in the town so as to ascertain its suitability for various uses (WHO, 2011). Thus, the possibility of these contaminations may justify the purpose of this study. The main theme of this study was to analyze the physical and chemical parameters of well water within Bali metropolis and the major objectives are to:

i. To assess the physical and chemical concentration in well water in Bali metropolis. To assess
ii. To compare with the acceptable limits set by World Health Organization Standard (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) for drinking water.

Materials and Methods

Study Area and Sample site

Bali local government area (LGA) is one of the 16 local government areas in Taraba State, Nigeria. it covers a total land area of about 9,146km^2 and ranges between latitude $7^0$30''00'' to $8^0$10'00'' North of the equator and $5^0$45'00'' to $6^0$15'00'' East of the Greenwich meridian (Taraba State Government 2005). The area is generally positioned on the banks of the upper course of Taraba River at some 150km from Jalingo, by virtue of its location in the water shed area of the river Benue and it proximity to Taraba River a major arm of river Benue at an altitude of 450m above seller. The temperature region is warm to hot throughout the year with a slight cool period between November February, temperature ranges between 23 – 40^{0}C. There is a gradual increase in temperature from January to April which also increases the demand of water for domestic uses in the area. The water supply situation in the area is mainly characterized by scarcity especially in the dry season, most of the households do not have access to pipe borne water as such they rely on wells. In this study, ten (10) geographical zones were randomly selected, these include Anguwan Bayan tasha, Anguwan Idi, Anguwan TIV, Anguwan Chamba, Aguwan Adamu, Anguwan mission, Anguwan Musa, Sabon-Layi, Aguwan Kundi, Dania A and Dania B respectively. Water samples were collected from sixty (60) different wells and used for microbial quality.

Sampling Procedure

The study involved sampling water from wells. Water samples were collected from wells from the selected districts. The Ten (10) zones were randomly sampled, taking into cognizance location of residential density and other periphery. Water samples were collected from 60 different wells, sixty (60) for the analysis. Taking the water samples and analysis procedure were guided by the standard method for water analysis (APHA, 1989), and were done with the help of two assistances. They were trained and pre-brief before the actual sampling, thus they were acquainted with the technicalities of water sampling procedure, handling and conveyance of samples. The necessary resources for smooth sampling exercise were also mobilized at that point. All water samples were collected using plastic bottles, which were washed with the samples water in addition to the earlier sterilization. All samples were appropriately labeled with the respective districts.

Table 1: Sampling Area Description.

Sampling Number	***Sampling Zone/Description***
Sample A	Anguwan Bayan Tasha
Sample B	Anguwan Idi
Sample C	Anguwanchamba
Sample D	Anguwan TIV
Sample E	AnguwanAdamu
Sample F	Anguwan mission
Sample G	Sabonlayi
Sample H	Anguwanmusa
Sample I	Anguwankundi
Sample J	Dania A
Sample K	Dania B

Sample Collection

Water samples were collected from sixty (60) wells located at different wells sampling points within Bali metropolis. Sampling protocols described by APHA (2005) were strictly adhered to during sample collection. Each sample for analysis was collected in sterilized 500ml plastic bottle with screw caps; care was taken not to allow bubbles into the bottles during the collection. Sample collected was kept in an ice chest, and transported immediately to the laboratory for the analysis.

Laboratory Analysis.

Physical Parameters Analysis

***Temperature*:** was measured using a temperature sensor of Sens ION 1 pH meter: (HACH model with a range of -2.00 to 20 and temperature -10 to1000c). The temperature sensor of the probe was immersed in water to a depth of 10cm, allowed to stabilize and temperature read in degrees Celsius (WHO, 2009).

***pH*:** Water pH was examined using a Sens ION 1 pH meter: (HACH model) with temperature compensation up to 250c. The probe was lowered into the water to a depth of 10cm, allowed to stabilize and the pH read directly and recorded (Taruna and Alankarita, 2013).

***Electrical Conductivity*:** The electrical conductivity was examined using a Sens ION 5 conductivity meter, (HACH-USA with conductivity range of 20 to 199.9µs/cm and temperature compensation of up to 250c. The conductivity probe was immersed in water to a depth of 10cm, allowed to stabilize and conductivity read in micro siemens per centimeter (µs/cm) (WHO, 2009).

***Dissolved Oxygen* (*DO*):** The dissolved oxygen was measured using a Sens ION 15b dissolved oxygen meter (HACH model). The DO probe was immersed in water to a depth of 10cm, while stirring the water. The readings were allowed to stabilize and dissolved oxygen read in mg/l (WHO, 2009).

Chemical Parameters Analysis

Alkalinity: This was determined by titrating the sample with 0.02M sulphuric acid using methyl orange as indicator and recorded as milligrams per liter of calcium carbonate, (APHA, 2010).

Total suspended solids: The measure of Total suspended solids in the water test was examined gravimetrically. A pre-gauged filter paper was utilized to channel 100ml of the water sample. The combined filter paper and filtered solids was dried at 1050C and reweighed. This was done until a constant value was reached. The weight of suspended solids was computed using the formulae below:
TSS (mg/l) = ((Wc - Wt) X 106) V-1

Where TSS = Total suspended solids,

Wt = Weight of pre-combusted filter in grams;

Wc= Constant weight of filter + residue;

V = volume of water sample used (WHO, 2009).

Metals (Copper, Zinc): Samples for analyses of metals were first pretreated and digested (metals were dissolved by acidifying with hydrochloric acid 1ml per 100ml of sample then boiled gently for five minutes and made to a known level with distilled water) and analyzed using atomic absorption spectrophotometer (Taruna and Alankarita, 2013).

Fluorides: May also enter water as a result of industrial discharges (Slooff, 1988). Many water bodies are polluted with chemicals such as fluoride and other heavy metals in part of country including, Northern East regions (GWP, 2007). Fluoride is known to have an adverse effect on tooth enamel and may give rise to mild dental fluorosis (prevalence: 12– 33%) at drinking-water concentrations between 0.9 and 1.2 mg/litre (Dean, 1942)

Nitrate-Nitrogen (NO3-N): The Nitrate-nitrogen concentration was determined using filtered water samples following modified sodium salicylate procedure. Nitrate-nitrogen was reacted with sodium salicylate and sulphuric acid to produce a yellow compound (nitro salicylic acid). Color intensity was then estimated calorimetrically utilizing a digital spectrophotometer (HACH Model) at a frequency of 420nm. Standard of known NO3-N fixation was exposed to similar treatment as water sample and readings used to examine the real concentration of nitrate in the example (APHA, 2010).

Total phosphorus: Total phosphate concentration was examined utilizing filtered water by the ascorbic acid reduction. The unfiltered water test was oxidized to PO4-P via autoclaving the samples at 1200C for 40 minutes utilizing Ammonium persulfate oxidizing agent. Phosphate particles join with ammonium molybdate to shape a molybdophosphate complex. The complex is promptly reduced by ascorbic corrosive to a seriously blue molybdophosphate complex. Colour intensity was estimated calorimetrically at a frequency of 690nm utilizing a digital spectrophotometer (HACH Model), (APHA, 2010).

Results and Discursions

Table 2: Mean values of all the samples analyzed for Physical Parameters.

Parameters/ Sample Zones	***pH***	***Temperature (^0C)***	***Dissolved Oxygen (uS/cm)***	***Electrical Conductivity (uS/cm)***
Sample A	7.8	36	413	765
Sample B	7.2	33	313	507.1
Sample C	6.44	37	366	407
Sample D	7.44	34	418	654.2
Sample E	8.18	32	415	765
Sample F	7.93	38	411	663
Sample G	6.43	30	322	687
Sample H	8.03	30	356	466.5
Sample I	7.54	31	441	819.19
Sample J	7.22	39	431	587
Sample K	7.26	37	411	601
Range	6.43 – 8.18	30 - 39	313 - 441	407 – 819.19
WHO	**6.5 – 8.8**	**23 - 40**	**-**	**-**
NSDWQ	**6.5 – 8.5**	**23 - 40**	**500**	**1000**

Sources: *Field work (August – September 2023).*
Note: *Bold value indicate the standard recommended value set by WHO and NSDWQ.*

pH: From table 2,the pH mean value ranged between 6.43 to 8.18. The results showed that lowest pH mean value of 6.43 was observed at Sample G, and the highest pH mean value was observed in Sample E. The mean pH value was higher in sample H. Which records 8.03 as compared with the mean value in sample A 7.8, sample B 7.2, sample C 6.44, and sample D 7.44, respectively. 7.93 was recorded in sample F, 7.54 recorded in sample I, sample J recorded 7.22, while sample K recoded 7.26 correspondingly. These findings were tandem with the earlier report by Nduka *et al.* (2008) as they observed a pH of 5.0 for the Uduwell water which incidentally is located in Delta State, Nigeria. Furthermore, the present study agrees strongly with the report of Igwe *et al.* (2021) whose investigation obtained a range of values between 6.8 to 6.9 while the control samples had a range from 6.0 to 7.1. In a related study, Ocheli *et al.* (2020) reported ranges between pH 6.6 and 8.3 for shallow well and pH 6.5 and 8.4 for borehole water while WHO permissible limit of 6.5–8.5. pH is generally considered to have no direct impact of humans.

Temperature: From table 2, the study showed that the mean temperature ranged from 32°C and39°C in (Fig.4.2). The highest mean temperature was recorded in sample I and the lowest at sample G and sample H (39°C and 30°C) respectively, according to Akungah (2003), temperature of well is influenced by ambient temperature, time of the day when it's recorded, presence and number of vegetation and amount of dissolved solids in the well. The lower temperature recorded at the sample G and sample H could be attributed to the time of sampling; the water was sampled early in the morning when light intensity was low.

Dissolved Oxygen: The dissolved oxygen mean value of all the sample water analyzed ranged from 313mg/l to 441mg/l (Fig 4.3 above). The levels at sample I 441mg/l was higher compared with the sample F which recorded the lowest 313mg/l. The level of dissolved oxygen in the water constantly changes depending on depth, temperature, wind and number of biological activities such as degradation (UNESCO, 2014). According to Langat (2009), DO in surface water is regulated by free interchange at the water and atmosphere interface, production through photosynthesis and consumption by plants and decomposer organisms during respiration. Agricultural runoff result to lower DO levels (Srivastava et al., 2011and Addo et al., (2013). The high levels of DO can be attributed to the presence of vegetation along the sampling points which adds oxygen to the water through photosynthesis, thus resulting to a progressive increase of DO in the well as the amount of vegetation increase.

Electrical Conductivity: The study showed that the mean conductivity value of all the water samples ranged from 407µS/cm to 819.19µS/cm. The mean conductivity of water was higher at sample I of 819.19µS/cm and the lowest mean conductivity was recorded in sample C of 407µS/cm respectively. Conductivity of well water is influenced by positive and negative ions, total suspended solids, total dissolved solids and diatomic nitrates (Sankpal and Naikwade, 2012).

Chemical Parameters

Table 3: Mean values of all the samples analyzed for Chemical Parameters.

Parameters/ Sample Zones	***Alkalinity***	***Total dissolved solid TDS*** *(mg/l)*	***Zinc*** *(mg/l)*	***Fluoride*** *(mg/l)*	***Copper*** *(mg/l)*	***Nitrate-Nitrogen***	***Total Phosphorus*** ***(wmg/l)***
Sample A	0.66	1555	3.78	1.07	2.32	55.1	7.13
Sample B	0.2	663.5	3.21	0.87	2.32	51.2	5.5
Sample C	0.03	1764.3	3.017	1.1	2.4	54.34	5.07
Sample D	0.03	876.2	3.24	0.877	1.71	61.23	6.12
Sample E	0.01	1120	4.21	0.566	2.16	62.3	6.6
Sample F	0.03	606	4.01	1.02	2.22	55.4	6.2
Sample G	0.09	601	3.4	0.12	3.01	52.23	6.15
Sample H	0.8	576.6	4.23	0.67	1.09	50.78	6.7
Sample I	0.1	642.12	3.32	0.822	1.53	51.02	7.1
Sample J	0.02	719	3.5	0.72	2.01	50.5	7.12
Sample K	0.02	987.2	5.12	1.32	2.71	61.1	6.18
Range	0.02 – 0.8	601 – 1764.3	3.017 – 5.12	0.12 – 1.32	1.09 – 3.01	50.5 – 62.3	5.07 – 7.12
WHO	**-**	**500**	**-**	**1.5**	**2**	**50**	**-**
NSDWQ	**-**	**1000**	**3**	**0.0**	**1**	**50**	**5**

Sources: *Laboratory Analysis (September - October 2023).*
Note: *Bold value indicate the standard recommended value set by WHO and NSDWQ.*

Alkalinity: From table 3, all the samples analyzed shows that the Alkalanity mean value ranged from 0.01mg/l to 0.66mg/l. The lowest mean for alkalinity was recorded in sample E/sample I and the highest in sample D (0.01mg/l and 0.66mg/l) respectively. According to table 3 above, the mean value of alkalinity in all the samples analyzed are above the standard recommended value by WHO and NSDWQ. According to Ndeda and Manohar, (2014) water alkalinity is mainly affected by carbonates and bicarbonates due to waste discharge, weathering of rocks and microbial decomposition of organic matter in the water body. In sample D, the higher levels could be attributed to increased microbial decomposition of agricultural products and animal wastes and municipal effluents. Compare to others similar studies, higher value of 153.20mg/l was reported by Alani et al. (2014) at Ogun State. A similar higher value was recorded in Narmada in India whose mean value was 125mg/l in a study carried by Kumar et al 2013.

Total Dissolved Solid (TDS): Table 3, showed the mean value of total dissolved solids of all the water samples analyzed within Bali metropolis. The dissolved 576.7mg/l to 1764.3mg/l. None of the samples analyzed where within the standard values recommended set by WHO, Seven (7) values where within standard value of NSDWQ. The total dissolved solid content in water samples were influenced by amount of soil, silt, human activities and amount of run off which drain into them (Akan et al., 2008). The higher values in sample C could be attributed to run off, human activities and municipal wastes from the metropolis.

Zinc: Table 3 showed that the Zinc mean value ranged from 3.017mg/l to 5.12mg/l. The lowest means were recorded in sample C and the highest in sample K (0.12mg/l and 0.19mg/l) respectively. The mean levels of zinc were 4.23 mg/l at sample H and 4.01mg/l at sample F. Also 4.21mg/l, 3.78mg/l, 3.5mg/l, 3.4mg/l, 3.24mg/l and 3.21mg/l were recorded in sample E, sample A, sample J, sample G, sample D and sample B respectively. None of the sample falls within the standard set by WHO (0mg/l) and NSDWQ (3mg/l). According to UNESCO, (2014) Agricultural chemicals contain traces of Zinc. The rate of flow and water characteristics such as pH, hardness influences the levels of Zinc in water (ATSDR, 2002). The observed Zinc levels at sample locations can be attributed to the agricultural activities. Farmers in the study area use different chemical preparations, in agro production which contain traces of zinc. The maximum allowable zinc value in water tentatively is set at 3.00 mg/l (Swaminathan *et al.*, 2011).

Fluoride: The Table 3 above showed the Fluoride mean value analyzed ranged between 0.12mg/l to 1.32mg/l. The results showed that lowest fluoride mean value of 0.12mg/l was observed at sample G, and the highest fluoride mean value was observed in sample J. The mean fluoride value was higher in sample C which records 1.10mg/l as compared with the mean value in sample A1.07mg/l, sample F 1.02mg/l, sample B0.87mg/l, sample D0.877mg/land sample I 0.822mg/l respectively. 0.566mg/l was recorded in sample E, 0.67mg/l sample H and 0.72 sample J. Fluorides were both within the WHO and NSDWQ standards. For Fluoride, concentrations above 1.5mg/l carry an increasing risk of dental fluorosis, and much higher concentrations lead to skeletal fluorosis as indicated by GWP (2007). However, Low concentrations provide protection against dental caries, especially in children (WHO, 1984). Drinking water must therefore be tested for Fluoride before consumption.

Copper: Table 3 above, revealed that the mean concentration of Copper ranged from 1.09mg/l to 2.71mg/l.The lowest mean was recorded in sample H and the highest sample G (1.09/mg/l and 2.71mg/l) respectively. Mean Copper concentration in sample D 1.71mg/l, sample H 1.09mg/l and sample I 1.53mg/l, are within standard recommendation by WHO of 2mg/l, while other samples where above WHO and NSDWQ Standard. According to Kumar et al 2013 Agricultural chemicals contain traces of copper. The rate of flow and water characteristics such as pH, hardness influences the levels of copper in water (ATSDR, 2002). The observed Copper levels could be attributed to the agricultural activities in the vicinity. Farmers, with their activity in agro production, use different chemical preparations, which contain trace amounts of copper.

Nitrate- Nitrogen: The study showed that the mean value of Nitrate-Nitrogen in all the water samples analyzed ranged from 50.52mg/l to 62.3mg/l. The lowest mean Nitrate-Nitrogen was recorded in sample J and the highest sample E (50.5mg/l and 62.3mg/l) respectively. Nitrate-Nitrogen in the water is attributed to agricultural land use practices, anthropogenic activities (Langat, 2009). It is also influenced by run-off from municipal wastes and decay of vegetation (Langat, 2009). Nitrate, were higher during the wet season than the dry season and this may be as a result of the introduction of certain pollutants from runoffs into the water table.

Total phosphorus: Table 3 showed that the total phosphorus mean value ranged from 5.07mg/l to 7.13mg/l. The lowest mean for total phosphorus was recorded in sample C and the highest in sample A (5.07mg/l and 7.13mg/l) respectively. According to APHA, 2005 phosphorus is naturally come from rock weathering and the decaying of organic material. Moreover, it also enters the water bodies through discharges of soil and fertilizers, domestic and municipal effluents and sewage which are also rich in phosphorus. The slightly higher values recorded in the downstream could be attributed to decomposition of organic materials from runoff from agricultural farms and municipal effluents which end up in the river. The other source of phosphorus is through detergents as people bath and wash directly at the river. There are also many watering points for livestock along the river.

Conclusion and Recommendations

This study assessed and identified that the well water sources were tainted with chemical agents. No natural water is absolutely free from pollution and for that reason, the WHO has set minimum standard to make water drinkable without any health implication. All the Physical parameters analyzed were all within the acceptable standards. While the chemical parameters some of which were higher than recommended limits. There was a positive association between the chemical values obtained from the study which further revealed that the sources of water were under some attack. As such the water sources must therefore be protected from activities such as poor waste management, over use of fertilizers and chemicals which pollute surface and underground water sources. Authorities in charge of water sources must constantly or regularly monitor the catchment areas to avoid severe pollution of these water bodies to ensure good water quality standards. The general public especially those close to the water sources must be educated to protect the water sources from pollution. Above all, further research in other water treatment facilities across the metropolitan must be examined to confirm the quality of the water sources.

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