ASSESSMENT OF PHYSICOCHEMICAL PARAMETERS OF HAND DUG WELL WATER IN MAKURDI, BENUE STATE, NIGERIA

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ABSTRACT

This paper presents the physicochemical parameters of well water in Makurdi metropolis, Benue State, Nigeria. Water samples were collected from North Bank, High-Level, Tse-Poor and Kanshio areas of Makurdi metropolis over a period of two weeks and analysed for physicochemical parameters using instrumental methods. The results revealed that most of the parameters were within the limits of Nigerian Standard for Drinking Water Quality (NSDWQ) and the World Health Organization (WHO). Parameters that were within the permissible limits in all the samples (100%) were electrical conductivity, total dissolved solid, chloride, fluoride and temperature. Their mean values were 262.91±148.33 µS/cm, 133.13±72.86 mg/L, 93.08±48.30 mg/L, 0.44±0.23 mg/L and 28.46±1.27 °C respectively. The compliance of other parameters such as dissolved oxygen, turbidity, total hardness, nitrate and pH with NSDWQ and WHO standards ranged from 50–91.67% of the samples. Meanwhile the reference value for the level of total suspended solids in drinking could not be obtained from the available literature. It was concluded that the well water in Makurdi contains some properties at variance with set standards and should be treated before consumption. There is also a need for periodic assessment of the well water quality to guide against the consumption of water with deteriorated quality.

Keywords: Well water, Physicochemical properties, Makurdi, Turbidity, Dissolved oxygen

INTRODUCTION

Water plays many different roles in daily life and is a vital component of human nutrition, either directly as drinking water or indirectly as a component of food. It is also an essential parameter in the public health due to possibility of transmitting water borne diseases and a major contributor to infant mortality in many developing nations [1 - 3]. The World Health Organization (WHO) has asserted that safe drinking-water is a human right and the source of drinking-water for a significant proportion of the global population ranges from individual household wells to piped supplies [4]. The quality of water has been continuously threatened by the rapid rise in industrialization, urbanization, increase in human population, various anthropogenic activities and the effects of climate change [5]. These factors have led to a high demand for good quality water for home, recreational, industrial, and other applications [6]. Physicochemical and microbiological properties of water are valuable indicators of its quality. UN report indicated that in 2022, 2.2 billion people lacked safely managed drinking water, including 703
million without a basic water service globally [5]. Surface water is still the main supply of water and the means of waste disposal for the great majority of people who live in developing nations. Most of this population get their drinking water from unprotected or contaminated sources, which can result in outbreaks of waterborne diseases. Untreated water from sources, such as rivers, reservoirs, springs, streams, water wells, and boreholes are used for drinking and other domestic purposes in developing countries because a large portion of the population lacks access to potable water supply [2]. The provision of safe drinking water, particularly in poor nations like Nigeria has not been adequate [7]. Due to lack of clean water many households in North-central and far-Northern Nigeria depend entirely on well water, springs, streams, ponds, rivers, dams, and rainwater for their domestic needs [8-15]. These sources are more likely to experience deficiencies in terms of water safety, which can result in water-related illness as well as adverse social and economic impacts [4]. Makurdi the study area is not an exception. Even though it is located near River Benue, the second largest river in Nigeria, it suffers portable water shortage [16]. Consequently, residents of Makurdi metropolis rely mostly on hand dug water wells and bore holes for household needs including drinking, cooking, and washing. This has necessitated research to ascertain the physicochemical characteristics of the well water in four different parts of Makurdi metropolis with high utilization of well water.

MATERIALS AND METHODS

Sample collection

Samples were collected from twelve (12) wells in four different settlements of Makurdi metropolis of Benue State namely, Kanshio, Tse-Poor, High-level and North-Bank. The labels (codes) and coordinates of the samples are contained in Table 1. The water samples were collected using rope tied to plastic fetcher, dipped into the wells and drawn out into labelled plastic bottle containers that were properly washed and rinsed with distilled water. The samples were then taken to laboratory at Benue State rural water supply and sanitation agency (BERWASA) for analysis. All samples were collected between 8:00 am and 11:00am

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>Coordinates (Latitude/Longitude)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW1</td>
<td>N 7° 43’ 23.86“ E 8° 31’ 54.84”</td>
</tr>
<tr>
<td>HW2</td>
<td>N 7° 43’ 15.61“ E 8° 32’ 5.26“</td>
</tr>
<tr>
<td>HW3</td>
<td>N 7° 43’ 24.04“ E 8° 32’ 13.47“</td>
</tr>
<tr>
<td>KW1</td>
<td>N 7° 42’ 15.12“ E 8° 32’ 9.17“</td>
</tr>
<tr>
<td>KW2</td>
<td>N 7° 40’ 54.13“ E 8° 32’ 2.83“</td>
</tr>
<tr>
<td>KW3</td>
<td>N 7° 41’ 28.49“ E 8° 33’ 33.21“</td>
</tr>
</tbody>
</table>
NW1  N 7° 45' 36.52"  E 8° 33' 36.92"
NW2  N 7° 45' 39.20"  E 8° 33' 31.78"
NW3  N 7° 45' 3.71"   E 8° 33' 11.29"
TW1  N 7o 40' 26.36"  E 8o 35' 7.76"
TW2  N 7o 41' 10.15"  E 8o 35' 6.29"
TW3  N 7o 40' 46.64"  E 8o 35' 13.26"

Key: HW1-3 = High-level wells 1-3, KW1-3 = Kanshio wells 1-3, NW1-3 = North bank wells 1-3 and TW = Tse-Poor wells 1-3.

**Water Quality Analysis**

Water Parameters analysed for include Temperature, turbidity, Total Dissolved Solids (TDS), Total Suspended Solid (TSS), Total Solid (TS), Electrical Conductivity (EC), Hardness, pH, Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Nitrate, Fluoride and Chloride. The analyses were done in a standard laboratory at Benue State Rural Water Supply and Sanitation Agency (BERWASA). The temperature and pH were determined on site immediately after the samples were collected using mercury thermometer and Jenway pH meter model 3510 respectively. Dissolved oxygen demand was determined using digital dissolved oxygen meter (Hanna DO meter model HI 9146). Electrical conductivity and total dissolved solids (TDS) were measured using Wagtech conductivity/TDS meter. Total suspended solids were determined using TSS meter sensor while total solids (TS) was the sum of TSS and TDS. Turbidity was determined using HACH 2100P turbidity meter while total hardness, nitrate, fluoride, chloride were determined using Palintest methods. The Palintest method are based on a unique colorimetric method. The reagents are provided in tablet form and the test is carried out simply by adding the appropriate tablets to a sample of water. Under the controlled conditions of the test the required reactions occurred to produce appropriate colouration. The intensity of the appropriate colour which is proportional to specific parameters is measured using a Palintest Photometer [17].

**RESULTS AND DISCUSSION**

The results of physicochemical properties of the well water samples from different locations in Makurdi metropolis are shown in table 2 which also contains the World Health Organization (WHO) standards and Nigerian Standards for Drinking Water Quality (NSDWQ) [4, 18-19].
### Table 2: Physicochemical Parameters of Well Water in Makurdi and Permissible Limits set by WHO and SON

<table>
<thead>
<tr>
<th>Location</th>
<th>Sample</th>
<th>Parameters</th>
<th>DO (mg/L)</th>
<th>EC (μS/cm)</th>
<th>TDS (mg/L)</th>
<th>Turb. (NTU)</th>
<th>TSS (mg/L)</th>
<th>Cl⁻ (mg/L)</th>
<th>T.H (mg/L)</th>
<th>F (mg/L)</th>
<th>NO₃⁻ (mg/L)</th>
<th>Temp (°C)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Bank</td>
<td>NW1</td>
<td>5.3</td>
<td>394</td>
<td>122</td>
<td>2.38</td>
<td>366</td>
<td>70.90</td>
<td>0.60</td>
<td>25.8</td>
<td>28.0</td>
<td>6.7</td>
<td>27.0</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>NW2</td>
<td>4.7</td>
<td>243</td>
<td>122</td>
<td>2.38</td>
<td>366</td>
<td>70.90</td>
<td>0.60</td>
<td>25.8</td>
<td>28.0</td>
<td>6.7</td>
<td>27.0</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>NW3</td>
<td>5.8</td>
<td>223</td>
<td>114</td>
<td>6.63</td>
<td>495</td>
<td>78.00</td>
<td>0.62</td>
<td>45.6</td>
<td>28.0</td>
<td>7.0</td>
<td>28.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Tse Poor</td>
<td>TW1</td>
<td>4.8</td>
<td>127.8</td>
<td>63.9</td>
<td>4.4</td>
<td>245</td>
<td>70.90</td>
<td>0.14</td>
<td>24.0</td>
<td>28.0</td>
<td>6.3</td>
<td>28.0</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td>TW2</td>
<td>4.5</td>
<td>77.8</td>
<td>39.0</td>
<td>1.2</td>
<td>159</td>
<td>85.1</td>
<td>0.11</td>
<td>41.4</td>
<td>29.0</td>
<td>6.6</td>
<td>29.0</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>TW3</td>
<td>4.5</td>
<td>23.1</td>
<td>23.1</td>
<td>2.80</td>
<td>32</td>
<td>28</td>
<td>0.13</td>
<td>42.0</td>
<td>28.0</td>
<td>6.2</td>
<td>28.0</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>Mean±SD</td>
<td>5.27±0.5</td>
<td>286.67±93.49</td>
<td>144.33±45.7</td>
<td>5.24±2.47</td>
<td>558.67±231.1</td>
<td>106.36±55.3</td>
<td>195.00±43.3</td>
<td>0.57±0.07</td>
<td>28.60±15.7</td>
<td>27.67±0.5</td>
<td>6.87±0.1</td>
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</tr>
<tr>
<td></td>
<td>Kanshio</td>
<td>Mean±SD</td>
<td>4.60±0.1</td>
<td>76.23±52.37</td>
<td>42.00±20.56</td>
<td>2.80±1.60</td>
<td>145.33±107.1</td>
<td>61.33±29.73</td>
<td>73.33±43.11</td>
<td>0.13±0.02</td>
<td>35.80±10.2</td>
<td>28.33±0.5</td>
<td>6.37±0.2</td>
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<tr>
<td></td>
<td>Entire Range</td>
<td>Mean±SD</td>
<td>5.00±0.60</td>
<td>262.91±148.33</td>
<td>133.13±72.8</td>
<td>3.77±12.8</td>
<td>355.92±253.8</td>
<td>93.08±48.30</td>
<td>140.00±64.0</td>
<td>0.44±0.23</td>
<td>35.35±14.5</td>
<td>28.46±1.2</td>
<td>6.84±0.9</td>
</tr>
<tr>
<td></td>
<td>WHO [4, 18]</td>
<td>NSDWQ [19]</td>
<td>5.00±0.60</td>
<td>262.91±148.33</td>
<td>133.13±72.8</td>
<td>3.77±12.8</td>
<td>355.92±253.8</td>
<td>93.08±48.30</td>
<td>140.00±64.0</td>
<td>0.44±0.23</td>
<td>35.35±14.5</td>
<td>28.46±1.2</td>
<td>6.84±0.9</td>
</tr>
<tr>
<td></td>
<td>Entire Range</td>
<td>% of Samples within set standards</td>
<td>58.33**</td>
<td>NA**</td>
<td>100***</td>
<td>66.67***</td>
<td>NA***</td>
<td>100***</td>
<td>83.33**</td>
<td>100***</td>
<td>91.67***</td>
<td>100***</td>
<td>50***</td>
</tr>
</tbody>
</table>

Key: *** WHO and NSDWQ; ** WHO; * NSDWQ; DO = Dissolved Oxygen; COD = Chemical Oxygen Demand; EC = Electrical Conductivity; TDS = Total Dissolved Solid; Turb = Turbidity; TSS = Total Suspended Solid, TS = Total Solid; T.H = Total Hardness; Temp = Temperature; WHO = World Health Organization; SON = Standards Organization of Nigeria, NSDWQ = Nigerian Standard for Drinking Water Quality, SD = Standard Deviation.
Dissolved Oxygen (DO) is a critical physicochemical parameter in water quality assessment, it refers to the amount of oxygen that is present in water and available for aquatic organisms to respire. Low DO levels can be indication of pollution by organic matter. The results obtained from this analysis (Table 2) showed that the level of DO from Kanshio well water ranges from 4.1–4.9 mg/L in the order of KW2<KW1<KW3. Dissolved oxygen in North bank well water was in the order of NW2<NW1<NW3 with values ranging from 4.7-5.8 mg/L. The values for well water at High Level ranged from 5.5-5.9 mg/L in the order of HW1 HW3<HW2 while DO in well water from Tse Poor ranged from 4.5-4.8 mg/L in the order of TW2=TW3<TW1. In general, the results showed that 5 of the well water samples representing 41.67 % were above the minimum 5 mg/L recommended by WHO. The other samples with DO values in the range of 4.1 – 4.9 mg/L were below the minimum value recommended by WHO [4]. The mean value of the dissolved oxygen in all the samples was 5.0±0.60 mg/L which was within the permissible limit set by WHO. Although there is no health-based concerns for dissolved oxygen in water, it may exacerbate corrosion of metal pipes at very high levels [4]. The mean values of DO obtained are higher than those reported for well water in Wukari, Nigeria [20].

The electrical conductivity (EC) values of well water in the four parts of Makurdi ranged from 23.1-435 µs/cm with a mean of 262.91±148.33 mg/L. The EC mean value for all the samples in this research is very similar to the one reported Gwagwalada Area Council Abuja [10] Based on electrical conductivity, the water samples were of either excellent or good quality. Samples KW3, NW2, NW3 and TW1 – TW3 which have EC values less than 250 µs/cm are of excellent quality while samples HW1 – HW3, KW1, KW2 and NW1 which have EC values between 250 – 435 µs/cm are of good quality [1]. Variation of EC mean values among the sample locations was in the order of High Level > North Bank > Kanshio >Tse Poor. All the EC values are within the limits recommended by SON.

Total Dissolved Solid (TDS) of the well water ranged from 23.1-218 mg/L with a mean of 133.13±72.86 mg/L. The mean values for the various locations varied in the order of High Level > North Bank > Kanshio >Tse Poor. The highest value of TDS was obtained from sample HW2 while the least was from sample TW3. All the values were less than the maximum limit 500 mg/L set for Nigerian Standard for Drinking Water Quality (NSDWQ) and the 600 mg/L recommended by WHO. High TDS values cause harmful effects to the central nervous system, provoking paralysis of the tongue, lips, and face, irritability, dizziness to the public health. The presence of synthetic organic chemicals even in small concentrations imparts objectionable and offensive tastes, odors and colors to fish and aquatic plants [21]. The values of TDS from this study are similar to those report for well water in
Achusa area of Makurdi in the range of 58.7 – 193 mg/L [22] differ from the range of 34 – 274 mg/L reported for well water in Jos, Plateau State of Nigeria [11].

Turbidity refers to the cloudiness or haziness of a fluid caused by large numbers of individual particles suspended in it. High turbidity levels can indicate the presence of contaminants or particles in water, which may affect its suitability for various purposes. The turbidity of all the well water samples ranged from 0.13 – 9.79 NTU with an average value of 3.77±12.89 mg/L. The highest and least turbidity values were obtained from KW2 and KW3 respectively. The results showed that 66.67 % of the samples had turbidity values inline with the Nigerian Standard for Drinking Water Quality (NSDWQ) and the limit set by WHO while 33.33 % of the samples had turbidity values above limits. The mean turbidity values for the various sample location were within the acceptable limits except the mean value (5.24±2.47) for North Bank samples which was a little above the set limit of 5.00 NTU. High turbidity values may be due to the presence of clay, silt, finely divided organic matter, plankton and other microscopic organisms [23]. The risk of having gastrointestinal diseases increases as the turbidity increases [24]. The increase of turbidity of water results in interference of the penetration of light. High turbidity in drinking-water can harbour microbial pathogens and reduce the efficacy of disinfection [4].

The total suspended solid (TSS) of well water from ranged from 28 – 815 mg/L with a mean value of 355.92±253.89 mg/L. The mean TSS values from the various settlements in Makurdi varied in the order of North Bank > High Level > Kanshio > Tse Poor. The TSS values in this research are high above those reported for well water in Gwagwalada Area Council, Abuja, Nigeria in the range of 0.26-1.33 mg/L [10]. High level of suspended solids results in increased turbidity [15].

All chloride values of well water from the various settlements in Makurdi metropolis were within the permissible limit of NSDWQ and the WHO standard (250 mg/L). The results ranged from 18 – 170.19 mg/L with a mean value of 93.08±48.30 mg/L. The mean values for the various sample locations varied in the order of Kanshio > North Bank > High Level > Tse Poor. All the chloride values were within the limits of Nigerian Standard for Drinking Water Quality and the WHO maximum limit of 250 mg/L. The chloride values from this study were lower than those reported in a similar studies in the ranges of 155.00 – 327.50 mg/L [22] and 91.54 – 159.2 mg/L [25] but higher than the values reported for another study in the range of 4.29 – 8.93 mg/L [10]. Chloride in drinking-water originates from natural sources, sewage and industrial effluents, urban runoff containing de-icing salt and saline intrusion [18].

The total hardness of the well water samples in Makurdi ranged from 35 – 220 mg/L with a mean
of 140.00±64.00 mg/L. The mean values of the samples per location were in the order of North Bank > High Level > Kanshio > Tse Poor. The results showed that 50 % of the samples were within the limits of Nigerian Standard for Drinking Water Quality and 83.33 % were within the 100 – 200 mg/L range recommended by WHO. Hardness of water is indicative of the presence of trioxocarbonates/hydrogen trioxocarbonates which may cause poor lather formation and scales on boilers. Water with a hardness above approximately 200 mg/L may cause scale deposition in the treatment works, distribution system, pipework and tanks within buildings [18].

The pH of the well water ranged from 5.8 – 8.6 with a mean of 6.84±0.94. The mean values of the sample locations were in the order of High Level > North Bank > Tse Poor > Kanshio. The results showed that 50 % of the pH values were within the NSDWQ and the WHO limits while all the other pH values were slightly below the lower recommended except sample HW2 which was above the upper recommended limit by 0.1 unit. The order of the mean pH values among the various sample locations indicated that the water samples from High Level area were slightly alkaline while those from Kanshio, North Bank and Tse Poor were slightly acidic except sample NW3 which was neutral. pH affects mucous membrane, taste and corrosion [3].

Fluoride is one of the essential parameters in water to monitor due to its effects when in high concentrations. The level of fluoride in all the samples ranged from 0.11 – 0.77 mg/L with a mean value of 0.44±0.23. All the values were below the maximum limit of NSDWQ and WHO indicating that the water samples were safe drinking in terms of fluoride level. Fluoride in drinking water reduces dental decays [13] but at a concentration above 1.5 mg/L it has an increasing risk of dental fluorosis and progressively higher concentrations lead to increasing risks of skeletal fluorosis [18].

Nitrates indicates the presence of fully oxidized organic matter. The values of nitrate in the well water samples ranged from 14.4 – 55 mg/L with a mean of 35.35±14.59. All the values were below the 50 mg/L maximum limit of NSDWQ and WHO except sample HW3 which was 55 mg/L. The mean values of nitrate varied among the sample locations in the order of High Level > Tse Poor > North Bank > Kanshio. High nitrate concentrations in drinking water causes blue-baby syndrome in bottle-fed infants [4].

The temperature of the well water ranged from 27 – 31 °C with a mean of 28.46±1.27. The highest value was obtained HW3 and the least from NW2 and KW3. The variation in temperature values could be due to the ambient weather conditions of the sample locations.

CONCLUSION
This study assessed the physicochemical properties of well water samples in four different settlements in Makurdi metropolis. The results revealed that most of the parameters were within the limits of Nigerian Standard for Drinking Water Quality (NSDWQ) and WHO. Parameters that were within the permissible limits in all the samples (100 %) were electrical conductivity, total dissolved solid, chloride, fluoride and temperature. The compliance of the other parameters such as dissolved oxygen, turbidity, total hardness, nitrate and pH with NSDWQ and WHO standards ranged from 50 – 91.67 % of the samples. It was concluded that the well water in Makurdi contains some properties at variance with set standards and should be treated before consumption. There is also a need for periodic assessment of the well water quality to guide against the consumption of water with deteriorating quality.

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