Caliphate Journal of Science & Technology (CaJoST)

ISSN: 2705-313X (**PRINT**); 2705-3121 (**ONLINE**) **Research Article**

Article Info

Received: 18th March 2020

Revised: 25th May 2020

Accepted: 30th May 2020

Assessment of Drinking Water Quality from Chanchaga Area, Minna, Niger State, Nigeria

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Cite this: *CaJoST,* 2020, 2, 101-110

The accessibility to safe drinking water is essential to prevent water-borne diseases like diarrhea and cholera, thus this study assessed the quality of drinking water sources available to the inhabitant of Chanchaga area, Minna, Niger State. A total of twelve water samples consisting of four boreholes, four wells, and four taps water, including one from Chanchaga water works were collected and analyzed for some physicochemical parameters and heavy metals using standard procedures. The results showed that the average physicochemical properties of tap, well and borehole water samples respectively were pH, 6.60, 6.62 and 6.67, turbidity, 1.58, 3.42 and 3.15 NTU, total suspended solids, 0.03, 0.09 and 0.00 mg/L, total dissolved solids, 0.96, 4.68 and 1.14 mg/L, total solids, 0.99, 4.79 and 1.14mg/L, electrical conductivity, 158.25, 799.25 and 778.25 µS/cm, alkalinity, 13.50, 50.00 and 117.50 mg/L, chloride,18.75, 74.00 and 47.25mg/L, total hardness65.50, 227.75 and 149.50 mg/L while the heavy metal concentrations in tap, borehole and well water samples were Cu, 0.02, 0.20 and 0.33 mg/L, Mn, not detected, 0.23 and 0.32, Pb was not detected in all the samples and Fe, 0.21, 3.10 and 2.12 mg/L respectively. All the parameters analyzed were below maximum permissible limits specified by WHO except the total hardness of well water and concentration of Fe in well and borehole water which were above the maximum permissible limits. It can be concluded that the three sources of water at different locations in the study area are safe for human consumption at the time this research was conducted.

Keywords: Assessment, drinking water quality, physicochemical parameters, heavy metal, Chanchaga.

1. Introduction

Water is one of the most essential and valuable natural resources. It is important for the survival of living organisms from the simplest plant and microorganism to the most complex living system, the human body (Reda, 2016). It is important due to its unique chemical and physical properties. It is also known to be the most available compound (70%) on the earth surface (Obi and Okocha, 2007).

The two general classifications of water are surface and groundwater. Surface water is the water that is available on the surface of earth, such as rivers, lakes and ponds while underground water is found beneath the earth's surface (Bello, Huzaifa, Abdulrahaman, and Halidu, 2016). Surface and underground water are polluted when exposed to natural factors like a volcanic eruption, growth of algae and microorganisms, soil erosion and anthropogenic factors like sewage, domestic waste, industrial and agricultural effluent which contain simple nutrients to highly toxic substances (Aryal, Gautam, and Sapkota,2012; Bello *et al*., 2016) and when consumed can cause waterborne diseases like dysentery, diarrhea, typhoid, cholera, hepatitis and many other infections (Aryal *et al*., 2012).

Accessibility to portable drinking water is the most fundamental key factor in sustainable development. Water is essential for food production, quality health, and poverty reduction. Portable drinking water, free from disease-causing microorganisms or toxic chemicals, is important to life and a satisfactory safe supply must be made available for human consumptions (Balbus and Embrey, 2002; Ackah, Anim, Gyamfi, Acquah, and Nyarko, 2012).Public water supplier treats surface water and distributes the treated water to the various residential areas but in the course of transporting treated water to the various residences, it is sometimes exposed to contaminants before getting to the consumers as a result of leakages, corroded pipes, as well as deposits of contaminated dust on taps which have a physical, chemical and bacteriological effect on drinking water quality and when consumed can cause negative health effects. It is therefore important to monitor drinking water quality (Reda, 2016).

Monitoring of drinking water quality is an important part of water management. Information gained from the monitoring is essential for assessing water quality and the verification of possible contamination as a result of factors like corrosion action (Durmishi, Ismaili, Shabani and Abduli, 2012).

Niger State, like several other states in Nigeria, is faced with the challenge of the inadequacy of potable water. The supply of public pipe-borne water is grossly inadequate due to increased population and human activities. Consequently, many households sought for alternative sources like boreholes, hand-dug wells, ponds, water vendors and packaged water, to meet their domestic water needs (Yisa, Gana, Jimoh and Yisa, 2012; Emigilati, Mohammed, Kuta, Usman and Hassan, 2014; Adeleye, Medayese and Okelola, 2014; Adegbehin, Yusuf, Anumonye and Shehu, 2016).

The quality of water obtained from different sources in Niger State had been evaluated by different researchers like Yisa, e*t al.* (2012) and Amadi, Obaje, Goki, Abubakar, Shaibu and Nwakife (2016).The study on the quality of drinking water in Suleja, Niger State by Amadi *et al.*(2016) revealed that water sources, hang-dug wells, boreholes and surface water, in the area were poor for domestic purposes. Yisa *et al.* (2012) carried out a quality assessment of underground water in Doko community in Niger State, Nigeria and reported that the chemical oxygen demand (COD) and nitrate (NO_3^-) values of the water sources exceeded the permissible limit of WHO, while chloride and iron contents were below the WHO limits. It is therefore important to routinely evaluate the quality of water available to homes as a means of measuring the accessibility to safe drinking water. Hence, this study was undertaken to assess the quality of different sources of water available to the inhabitant of Chanchaga area, Niger State to ascertain their portability.

2. Material and Methods

2.1 Description of Study Area

Chanchaga is a community under Chanchaga Local Government Area, Minna, Niger State. It covers an area of about 8 km^2 and is located on the latitude of 9° 31′ 18″ to 9° 34′ 39″ N and longitude 6° 33′ 25″ to 6° 35′ 10″ E. It falls within the Guinea Savannah Belt; it has grassland which is mainly used for Agriculture purposes. The community is characterized by two climatic seasons, each lasting for about six months. The annual rainfall of the area is between 1200 mm in the North to 600 mm in the south and the dry season begins in November and usually ends in March (Adedeji, 2011; Waheed, Abdullahi, Akobundu, Ibrahim, Adekolajo and Tauheed, 2016). It has a maximum temperature of about 32˚C, particularly between March and June, while the lowest temperatures occur usually between December to January, during the harmattan period. The reliefs of the study area are relatively flat and rocky at the river channel, drained by the river Chanchaga. The flat nature of this area enables the easy drilling of boreholes and digging of wells. However, dweller in Chanchaga area depends on taps, wells, and boreholes as their major sources of drinking water and domestic activities. The socio-economic activities of the inhabitant of this area are majorly small businesses, farming and civil services (Salihu, 2018).

2.2 Sample Collection

Water samples were collected from four wells, four boreholes, three residential taps and a sample from Chanchaga water works. The water samples were collected towards the end of the wet season in pre-cleaned plastic containers and were immediately transported to the laboratory for analyses.

2.3 Physical Parameters

The turbidity using the turbidity meter (Model WT3020), total suspended solids (TSS) using filtration method (filtering a known volume of the water sample), total dissolved solids using filtration and evaporation to dryness methods and total solid by the summation of total dissolved solid and total suspended solids were determined in all the samples according to the procedures of the American Public Health Association (APHA) (1992).

2.4 Chemical Parameters

The pH by potentiometric method using pH meter (Model pHs-25), electrical conductivity using conductivity meter (Model DDS-307), concentrations of chloride by Argentometic titration method using silver nitrate, $AgNO_3$ (0.014M) as titrant, total hardness by complexometric titration method using ethylenediaminetetraacetic acid, EDTA(0.01M) as titrant and alkalinity by acid-base titration method in all the water samples were determined using standard procedures (APHA, 1992, Ademorati, 1996; Sa’eed and Mahmud, 2014).

2.5 Heavy Metals Analysis

The trace metals analyzed in the water samples were Cu, Mn, Fe and Pb. The samples were digested using concentrated nitric acid and the concentrations of the heavy metals in the digests were analyzed using the Atomic Absorption Spectrophotometer, AAS (Model PYE Unican SP9). The concentration of each metal was extrapolated from a standard calibration curve (Janan and Muhammad, 2011).

2.6 Statistical Analysis

Descriptive statistics mean and standard error of the mean were used to describe data obtained for all parameters measured. The data were checked for statistical variations, between the sources of water and between the different locations for each source of water, using Analysis of Variance (ANOVA) and significant means were separated using Least Significant Difference (LSD) or Duncan Multiple Range Test (DMRT) as applicable.

3. Results and Discussion

The physicochemical properties of the three sources of water as shown in **Table 1** revealed some levels of significant difference ($p < 0.05$) between the three sources of water studied with the exception of pH that shows no significant differences ($p > 0.05$).

Table 1. Physical and chemical properties of the water samples

Parameters	Sources of water			
	Tap	Well	Borehole	WHO Guideline for Drinking water (2011)
pH	6.60 ± 0.09^a	6.62 ± 0.08^a	6.67 ± 0.07^a	6.5 – 8.5
Turbidity (NTU)	1.58 ± 0.18^b	3.42 ± 0.22^a	3.15 ± 0.13^a	5
Total Suspended Solid (mg/L)	0.03 ± 0.01^b	0.09 ± 0.01^a	0.00 ± 0.00^c	25
Total Dissolved Solids (mg/L)	0.96 ± 0.07^b	4.68 ± 1.85^a	1.14 ± 0.05^b	500 – 1000
Total Solid (mg/L)	0.99 ± 0.07^b	4.79 ± 1.85^a	1.14 ± 0.05^b	-
Electrical conductivity (µS/cm)	158.25 ± 3.52^b	799.25 ± 56.28^a	778.25 ± 56.25^a	1000
Alkalinity (mg/L)	13.50 ± 0.93^c	50.00 ± 4.36^b	117.50 ± 7.27^a	120 – 600
Chloride (mg/L)	18.75 ± 1.61^c	74.00 ± 4.15^a	47.25 ± 3.34^b	250
Total hardness (mg/L)	65.50 ± 12.00^c	227.75 ± 21.27^a	149.50 ± 5.69^b	60 – 180
Cu (mg/L)	0.02 ± 0.00^c	0.20 ± 0.05^b	0.33 ± 0.05^a	2
Mn (mg/L)	ND	0.23 ± 0.01^a	0.32 ± 0.09^a	0.4
Pb (mg/L)	ND	ND	ND	0.01
Fe (mg/L)	0.21 ± 0.02^c	3.10 ± 0.34^a	2.12 ± 0.20^b	0.3

Means± Standard errors on the same row with different superscripts are significantly different from each other ($p < 0.05$); ND: Not detected

3.1pH

The pH values of the three sources of water from the study area were statistically comparable and fell within the range of neutral pH and the World Health Organization (WHO) (2011) specified range of 6.5 – 8.5 for drinking water. The average pH of tap, well and borehole water samples were 6.60, 6.62 and 6.67, respectively. These values are within the range obtained by Ojikutu, Ibrahim and Raymond (2013) for tap and well waters samples in Minna town, Niger State. The decreasing order, though not significantly different ($p>0.05$), in the pH of the water samples was borehole > well > tap. Water with pH below 6.5 is considered acidic and reticulation of such acidic water could lead to adverse effect and corrosion of pipes (McFarland, Provin and Boellstorff, 2008).

3.2 Turbidity

The turbidity of tap water ranged from 1.08 to 2.62 NTU while that of well water ranged from 2.78 to 4.65 NTU and borehole water from 2.70 to 3.44 NTU. The average turbidity of well and borehole water in the study area were not significantly different ($p>0.05$) with the values of 3.42 NTU and 3.15 NTU respectively but were significantly higher than that of tap water (1.58 NTU). The results obtained for well water samples in the study area were similar to those obtained for well water of Sabo Yeregi in Katcha Local Government of Niger State by Yanda, Mohammed, Tsado, Zalihat, Ndarubu and Ilemona (2015). The decreasing order in the turbidity of the water samples was well > borehole > tap. The turbidity of the three sources of water were below the maximum limit of 5 NTU specified by WHO (2011) in drinking water. High turbidity of well and borehole water could be as a result of surface runoff that carries several particle and organisms into the well water which were not properly covered (Rahmaman *et al*., 2015). The turbidity of the three sources of water in the study area was below the WHO (2011) permissible limit of 5 NTU for drinking water.

3.3 Electrical Conductivity

The conductivity of tap water samples from the study area ranged from 150 to 176 µS/cm and those of well and borehole water ranged from 532 to 1029 µS/cm and 557 to 1071 µS/cm, respectively. The average electrical conductivity of well and borehole water samples (799.25 µS/cm and 778.25 µS/cm, respectively) were not significantly different ($p>0.05$) from each other but were significantly higher than that of the tap water (158.25 µS/cm). The EC of borehole and well water samples were similar to that reported for selected towns in Niger State by Ibrahim and Ajibade, (2012).The decreasing order of the electrical conductivity of the water samples was well > borehole > tap. It was observed that all water samples had their electrical conductivity below the maximum specified limit of 1000µS/cm set by WHO (2011) and National Drinking Water Quality Standard (NDWQS) (2004).

3.4 Total Suspended Solid

The total suspended solid (TSS) for tap water from the study area ranged from 0.012 to 0.080 mg/L while those of well and borehole water samples ranged from 0.052 to 0.104 mg/Land 0.003 to 0.006 mg/L, respectively. The average TSS of well water sample (0.09 mg/L) was significantly higher than those of tap and borehole water samples (0.03 mg/L and 0.00 mg/L respectively). Borehole water sample had no suspended solids. The decreasing order of TSS in the water samples was well > tap > borehole. All the water samples from the study area had TSS below the permissible limit of 30mg/L for drinkable water set by WHO (2011) which indicated that the water from the three sources could be safe for consumption and use in laundry, irrigation and industrial boilers.

3.5 Total Dissolve Solids (TDS)

The total dissolved solids (TDS) in mg/L of the tap water samples from the study area ranged from 0.0077 to 1.33 while those of well and borehole water ranged from 0.79 to 15.29 and 0.89 to 1.30, respectively. The average TDS of well water samples (4.68 mg/L) was significantly higher than those of borehole and tap (1.14 mg/L and 0.96 mg/L respectively). TDS in borehole and tap water samples were not significantly different ($p>0.05$) from each other. The TDS values obtained in this study were very low compared those obtained in dry season for well and borehole water samples (521.05 and 343.6 mg/L respectively) and in wet season (534.5 and 344.3 mg/L, respectively) by Ibrahim and Ajibade (2012) from a medium sized town in Niger State. The decreasing order in the TDS of the water samples was well > borehole > tap. The result obtained were below the minimum range of 500 mg/L set by WHO (2011) for drinking water.

3.6 Total Solids

The total solids (TS) in tap water samples from the study area ranged from 0.90 to 1.35 mg/L while those of well and borehole water samples ranged from 0.89 to 1.31 mg/L and 0.88 to 15.29 mg/L, respectively. The average value of the total solids in well water samples (4.79 mg/L) was significantly higher than those of borehole and tap water samples (1.14 mg/L and 0.99 mg/L, respectively), which were not significantly different ($p>0.05$) from each other. The decreasing order of TS in the water samples was well > borehole > tap. The results of TS in the water samples were below the permissible limit of 500 mg/L set by WHO (2011).

3.7 Alkalinity

The total alkalinity (TA) for the tap water samples from the study area ranged from 13 to 14 mg/L while those of well and borehole water samples ranged from 28 to 60 mg/L and 96 to 156 mg/L, respectively. The average TA value of borehole water sample (117.50 mg/L) was significantly higher than those of the well and tap water samples (50.00 mg/L and 13.5 mg/L, respectively). The TA of well water sample was significantly higher than that of tap water. These values, for well and borehole water, were within the ranged obtained by Ojikutu *et al.,* 2013 for samples collected from Minna. The decreasing order of TA in the water samples was borehole > well > tap. All the water samples had TA below the minimum permissible limit of 120 mg/L set by WHO (2011). This implies that the water samples have good buffering capacity (Ojikutu *et al.,* 2013).

3.8 Chloride

Anthropogenic contamination or presence of chloride salt in the underground formation could be responsible for the high concentration of chlorides in borehole samples (Venkateswara, 2011).The presence of chlorides in drinking water provide a measure of protection against contamination from germs but it must be present in adequate quantity; if the concentration is low, the water cannot be kept for a long time before consumption but if very high, it can have adverse effect on human health (Yisa *et al*.,2012). The concentration of chlorides in tap water from the study area ranged from 15 to 14 mg/L while those of well and borehole water samples ranged from 53 to 87 mg/L and 37 to 64 mg/L, respectively. The average concentration of chlorides in well water sample (74.00 mg/L) was significantly higher than those of borehole and tap water samples (47.25 mg/L and 18.75 mg/L respectively). Chlorides concentration in borehole water sample was significantly higher than that of tap water. Yisa *et al.*(2012) and Yanda *et al.* (2015) also had concentration of chlorides in well water samples in Doko and Katcha communities in Niger State which were comparable to those obtained for the underground water samples (well and borehole) in this study. The decreasing order of the concentration of chlorides in the water samples was well > borehole > tap. The water samples had chloride concentration below the maximum recommended limits of 250 mg/L specified by WHO (2011) for drinking water.

3.9 Total Hardness

The total hardness (TH) of tap water from the study area ranged from 30 to 132 mg/L while those of well and borehole water samples ranged from 150 to 322 mg/L and 132 to 162 mg/L, respectively. On the average, the total hardness of well water (227.75 mg/L) was significantly higher than those of borehole and tap water samples (149.50 mg/L and 65.50 mg/L respectively). The decreasing order of the total hardness of the water samples was well > borehole > tap. The total hardness of both tap and borehole water samples were within the range for drinking water (60 – 180mg/L) recommended by WHO (2011).Water can be classified as soft (TH, 0 – 60 mg/L), moderately hard (TH, 60 – 120 mg/L) and very hard (TH> 120 mg/L) (McGown, 2000) and based on this classification tap water from the study area was soft while borehole water sample was moderately hard and well water sample was very hard. However, the hardness of water could be removed by simple boiling, addition of chemical such as washing soda and calcium hydroxide (Reda, 2016).

3.10 Heavy Metals

i. Copper

The concentration of Cu in tap water samples from the study area ranged from 0.01 to 0.04 mg/L while those of well and borehole water samples ranged from 0.08 to 0.46 and 0.13 to 0.55 mg/L, respectively. The average concentration of Cu in borehole water (0.33 mg/L) was significantly higher than those of well and tap water samples (0.20 mg/L and 0.02 mg/L, respectively). Well water had Cu concentration significantly higher than that of tap water. The concentrations of Cu in decreasing order was borehole > well > tap. The concentrations of Cu in the three sources of water were below the permissible limit of 2.00 mg/L set by WHO (2011).

ii. Manganese

According to Standard Organization of Nigeria, (SON) (2007), the presence of Mn in drinking water beyond the permissible limit had the tendency to cause neurological disorder in human, troublesome stains and deposits on light coloured clothes and plumbing fixtures. The concentration of Mn in well and borehole water samples ranged from 0.17 to 0.29 mg/L and 0.13 to 0.81 mg/L, respectively. However, the presence of manganese in tap water sample was not detected. The average concentration of Mn in well water sample (0.32 mg/L) was significantly higher than that of well water sample. The decreasing order of the concentration of Mn in the water samples were borehole > well > tap. The concentrations of Mn in the water samples were below the maximum permissible limit of 0.40 mg/L recommended by WHO (2011)

iii. Lead

The presence of lead was not detectable in the three sources of water from the study area. Ojikutu *et al*. (2013) reported similar result for well and borehole water samples from Minna metropolis. The maximum limit recommended for lead in drinking water is 0.01 mg/L (WHO, 2011).

iv. Iron

The concentration of Fe in tap water from the study area ranged from 0.11 to 0.31 mg/L while those of well and borehole water samples ranged from 1.25 to 4.08 mg/L and 1.66 to 3.24 mg/L respectively. The average concentration of Fe in well water sample (3.10 mg/L) was significantly higher than those of the borehole and tap water samples (2.12 mg/L and 0.21 mg/L respectively). Similar to the result obtained in this study are those of Yisa *et al.* (2012) and Yanda *et al.*(2015) that studied among other parameters, the concentration of Fe in well water of Doko and Katcha communities respectively in Niger State. Fe concentration in the borehole water samples was significantly higher than that of the tap water samples. The order with which the concentration of Fe in the water samples decrease were well > borehole > tap. The recommended concentration of Fe in drinking water according to WHO (2011) is 0.30 mg/L and that of tap water was below this limit while those of well and borehole were higher. The high concentration of Fe in borehole and well water samples may result from the infiltration of rain water into the soil and the underlying geologic formations which dissolves the Fe, causing it to seep into aquifers that serves as sources ground water for wells, including boreholes. Although iron is not hazardous to health but it is considered as the secondary contaminant (Elinder, Friberg, Nordberg and Vouk, 1986).

3.11 Effect of Location on Quality of Drinking Water

3.11.1 Tap Water

In the distribution of tap water from the treatment plant to customers, the quality of water, physical chemical and biological, can change due to several factors like the growth of bacteria and fungi in pipes when the quality of treated water is poor due to low or none presence of disinfectant. This implies that the type and intensity of processes occurring within the water supply systems determines the form and level of contamination of tap water. Clean water is one without precipitations due to the presences of calcium carbonate. Other indicators of contaminated water are the odour, taste, turbidity, concentration of iron and presence of other heavy metal beyond the permissible limits (Jachimowski, 2017).

The effect of location on the portability of tap water in the study area is shown in **Table 2**.All the parameters analyzed for in the tap water samples from different locations within the study area were below the maximum limits specified by WHO (2011).

Table 2. Physical and chemical parameters and levels of some heavy metals in tap water samples

Parameters	CW	TW_1	TW_2	TW_3	WHO Guideline for Drinking water (2011)
pH	6.42 ± 0.15bc	6.73 ± 0.02ab	6.93 ± 0.05a	6.32 ± 0.15c	6.5 – 8.5
Turbidity (NTU)	1.080 ± 0.005c	2.620 ± 0.074a	1.340 ± 0.015b	1.290 ± 0.005b	5
Total Suspended Solid (mg/L)	0.0150 ± 0.0005b	0.0160 ± 0.0005b	0.0120 ± 0.0005b	0.0800 ± 0.0047a	25
Total Dissolved Solids (mg/L)	0.77 ± 0.01c	1.33 ± 0.04a	0.89 ± 0.02b	0.83 ± 0.02bc	500 – 1000
Total Solid (mg/L)	0.79 ± 0.00c	1.35 ± 0.02a	0.90 ± 0.03b	0.91 ± 0.01b	-
Electrical conductivity (µS/cm)	150.00 ± 0.72c	176.00 ± 0.94a	161.00 ± 0.72b	146.00 ± 0.47d	1000
Alkalinity (mg/L)	14.00 ± 2.89a	13.00 ± 0.58a	13.00 ± 1.15a	14.00 ± 2.89a	120 – 600
Chloride (mg/L)	14.00 ± 0.58c	26.00 ± 2.89a	20.00 ± 1.73b	15.00 ± 0.58bc	250
Total hardness (mg/L)	54.00 ± 3.46b	132.00 ± 2.89a	46.00 ± 4.04b	30.00 ± 5.77c	60 – 180
Cu (mg/L)	0.0100 ± 0.0048b	0.0400 ± 0.0054a	0.0100 ± 0.0045b	0.0300 ± 0.0032a	2
Mn (mg/L)	ND	ND	ND	0.0100 ± 0.0006	0.4
Pb (mg/L)	ND	ND	ND	ND	0.01
Fe (mg/L)	0.3000 ± 0.0048a	0.1600 ± 0.0054c	0.1100 ± 0.0045d	0.2700 ± 0.0032b	0.3

Means ± standards error followed by different letters on the same row is significantly different ($p \leq 0.05$)
ND: Not detected; TW_1 – $TW_3$are water from different taps; CW is water from Chanchaga water works station

The alkalinity of the tap water samples from the different locations were not significantly different ($p>0.05$) from each other but other measured parameters showed some levels of significant differences ($p<0.05$).The pH of TW_1 and TW_3 were statistically comparable to that of CW. TW_2 was had significantly higher pH than CW. The change in the pH of tap water after been transported from the treatment plant, CW, to each of locations TW_1 and $TW_3$was not significant but only slight change (7.94 %), though significantly significant, was observed at tap TW_2 which may be due to some physical, chemical or biological changes in the course of transportation through the pipes (Jachimowski, 2017).The electrical conductivity of TW_1 and TW_2 were significantly higher than CW but that of TW3 was significantly lower than CW; this is due to variation in the pH of TW_1, TW_2 and TW_3 in comparison to that of CW (Jachimowski, 2017).The turbidity of and total solid in TW_1, TW_2 and TW_3 were significantly higher than that of CW; this showed that the treated water from CW was contaminated during the supply process by particle or bacteria (Jachimowski, 2017).The total dissolved solids in TW_1 and TW_2 were significantly higher than CW but TW_3 was statistically comparable to CW; this implied that TW_1 and TW_2 were contaminated with particles that dissolve in water during the supply process (Jachimowski, 2017). The total suspended solid of TW_3 was significantly higher than CW but those of TW_1 and TW_2 were not significantly different from CW; this implied that the treated water from CW was contaminated with particle that cannot dissolve during the supply process (Jachimowski, 2017).The total hardness of TW_1 was significantly higher than TW_2, CW and TW_3. TW_2 and CW were not significantly higher than TW_3.

The concentration of Cu in TW_1 and TW_3 were not significantly different from each other but were significantly higher than those of TW_2 and

CW, which were not significantly different from each other; this implied that one of the contaminants introduced into the treated water supplied to TW_1 and TW_3 contain Cu. The concentration of Mn in TW_3 was detectible but was not in other tap water from other locations. Lead was below detectible limit in the entire tap water sample. The order with which the concentration of Fe in the tap water samples were significantly higher than each other was $CW>TW_3>TW_1>TW_2$; the significant reduction in the concentration of Fe could be that some of the metal were adsorbed onto the pipes, made of polyvinyl chloride (PVC) (Oremusová, 2007). The concentration of Mn in CW, T_1 and T_2 and the concentration of Pb in all the tap water samples were not detected by the model of AAS used.

The result of the physicochemical properties of tap water samples discussed above showed that the type and intensity of processes occurring within the water supply systems can introduce contaminates into the water, making not portable for use (Jachimowski, 2017).

3.11.2 Underground Water

There are several factors that affect the quality of underground water, wells and boreholes. Among these factors are soil characteristics and filtration capacity which can prevents the diffusion of environmental contaminants by anthropic pressure causing reduction of water availability, progressive deterioration of the water quality, population size and growth, weathering of rocks, evapo-transpiration, erosion, runoff and many anthropogenic activities like the use of fertilizers, manures and pesticides, animal husbandry activities, inefficient irrigation practices, aquaculture, deforestation, industrial activities, mining, improper domestic sewage disposal and recreational activities. These factors, which varies with location, elevates the concentration of heavy metals and nutrient load of underground water, causes changes in the physicochemical properties of underground water like pH, alkalinity, BOD, COD, DO, phosphate and many others. Also sitting of wells and boreholes close to septic tanks or along water ways could cause the water to be contaminated easily by sewage and contaminants from runoffs respectively (De-Giglio, Quaranta, Barbuti, Napoli, Caggiano and Montagna, 2015; Khatri and Tyagi, 2015; Wrisdale, Mokoena, Mudau, and Geere, 2017).

i. Borehole Water

The effect of location on the portability of borehole water in the study area is shown in **Table 3**.

Table 3. Physicochemical properties and levels of some heavy metal in borehole water samples

Parameters	BW_1	BW_2	BW_3	BW_4	WHO Guideline for Drinking water (2011)
pH	6.33 ± 0.05c	6.89 ± 0.09a	6.78 ± 0.05ab	6.68 ± 0.03b	6.5 – 8.5
Turbidity (NTU)	2.70 ± 0.05a	3.44 ± 0.47a	3.17 ± 0.03a	3.30 ± 0.05a	5
Total Suspended Solid (mg/L)	0.003 ± 0.000b	0.005 ± 0.000a	0.006 ± 0.001a	0.003 ± 0.000b	25
Total Dissolved Solids (mg/L)	0.890 ± 0.005c	1.300 ± 0.019a	1.280 ± 0.009a	1.080 ± 0.029b	500 – 1000
Total Solid (mg/L)	0.89 ± 0.01c	1.31 ± 0.02a	1.29 ± 0.01a	1.08 ± 0.03b	-
Electrical conductivity (µS/cm)	557.00 ± 0.47d	774.00 ± 0.47b	1071.00 ± 0.72a	711.00 ± 2.49c	1000
Alkalinity (mg/L)	96.00 ± 4.04b	106.00 ± 3.46b	156.00 ± 6.93a	112.00 ± 5.77b	120 – 600
Chloride (mg/L)	64.00 ± 1.73a	43.00 ± 5.77b	37.00 ± 1.15b	45.00 ± 1.73b	250
Total hardness (mg/L)	154.00 ± 9.24a	162.00 ± 9.24a	150.00 ± 8.66a	132.00 ± 15.01a	60 – 180
Cu (mg/L)	0.1300 ± 0.0008d	0.2800 ± 0.0006c	0.5500 ± 0.0007a	0.3700 ± 0.0035b	2
Mn (mg/L)	0.1800 ± 0.0008b	0.1300 ± 0.0006d	0.8100 ± 0.0007a	0.1500 ± 0.0035c	0.4
Pb (mg/L)	ND	ND	ND	ND	0.01
Fe (mg/L)	1.6600 ± 0.0008d	1.8400 ± 0.0006b	3.2400 ± 0.0007a	1.7500 ± 0.0035c	0.3

Means ± standards error followed by different letters on the same row is significantly different ($p \leq 0.05$); ND: Not detected; BW_1 – $BW_4$are water from different boreholes.

The total hardness and turbidity of borehole water from different locations in the study area were not significantly different ($p>0.05$) from each other. The total suspended solids of B_3 and B_4 were not significantly different from each other but were significantly higher than those of B_1 and B_2, which were not significantly different from each other. The total dissolved solid and total solids of B_2 and B_3 were not significantly different from each other but were not significantly higher than those of B_4 and B_1. B_4 was significantly higher than B_1. The electrical conductivity and concentration of iron in the borehole water samples (B_1 and B_4) were not significantly higher than each other in the order $B_3>B_2>B_4>B_1$. The alkalinity of B_1, B_2 and B_4 were not significantly different from each other but were significantly lower than that of B_3. The concentration of chlorides in B_2, B_3 and B_4 were not significantly different from each other but were significantly lower than that of B_1.

The presence of Pb in the borehole water samples was not detected. There were some levels of significant differences ($P<0.05$) in the pH, total suspended solids, total dissolved solids, total solids, electric conductivity, alkalinity, chlorides, Cu, Mn and Fe between the borehole waters sampled (B_1, B_2, B_3 and B_4) from different locations in the study area. The pH of B_2 was significantly higher than B_4 and B_1. B_3 had its pH statistically comparable to those of B_2 and B_4. The pH of B_3 and B_4 were significantly higher than that of B_1.The order with which the concentration of Cu in the borehole water samples from different locations were significantly higher than each other was $B_3>B_1>B_4>B_2$.

ii. Well Water

The effect of location on the portability of well water in the study area is shown in **Table 4**.

Table 4. Physical and chemical properties and levels of some heavy metal in well water samples

Parameters	W_1	W_2	W_3	W_4	WHO Guideline for Drinking water (2011)
pH	6.72 ± 0.17a	6.77 ± 0.14a	6.36 ± 0.21a	6.64 ± 0.04a	6.5 – 8.5
Turbidity (NTU)	4.650 ± 0.028a	3.000 ± 0.079c	3.230 ± 0.085b	2.780 ± 0.052d	5
Total Suspended Solid (mg/L)	0.104 ± 0.001a	0.097 ± 0.001b	0.052 ± 0.002d	0.093 ± 0.001c	25
Total Dissolved Solids (mg/L)	15.29 ± 0.04a	1.41 ± 0.01b	1.21 ± 0.16b	0.79 ± 0.02c	500 – 1000
Total Solid (mg/L)	15.39 ± 0.05a	1.61 ± 0.01b	1.26 ± 0.02c	0.88 ± 0.03d	-
Electrical conductivity (µS/cm)	1029.00 ± 0.27a	903.00 ± 1.41b	733.00 ± 0.47c	532.00 ± 0.72d	1000
Alkalinity (mg/L)	64.00 ± 2.89a	48.00 ± 2.31b	28.00 ± 3.46c	60.00 ± 1.15a	120 – 600
Chloride (mg/L)	87.00 ± 0.58a	53.00 ± 2.89c	72.00 ± 2.89b	84.00 ± 2.31a	250
Total hardness (mg/L)	267.00 ± 6.93b	322.00 ± 5.77a	172.00 ± 8.66c	150.00 ± 2.89d	60 – 180
Cu (mg/L)	0.4600 ± 0.0003a	0.1200 ± 0.0016c	0.1500 ± 0.0006b	0.0800 ± 0.0014d	2
Mn (mg/L)	0.2900 ± 0.0003a	0.1700 ± 0.0016d	0.2200 ± 0.0006c	0.2500 ± 0.0014b	0.4
Pb (mg/L)	ND	ND	ND	ND	0.01
Fe (mg/L)	3.8400 ± 0.0003b	3.2300 ± 0.0016c	1.2500 ± 0.0006d	4.0800 ± 0.0014a	0.3

Means ± standards error followed by different letters on the same row is significantly different ($p \leq 0.05$)
ND: Not detected; $W_1 – W_4$: water from different wells.

The pH of the well water samples obtained from different locations in the study area were not significantly different ($P>0.05$) from each other but other parameters studied showed some level of significant differences ($P<0.05$). The decreasing orders with which some the water quality parameters analysed were significantly higher than each other were $W_1> W_3> W_2> W_4$ for turbidity, $W_1> W_2> W_3> W_4$ for total solids and electrical conductivity, $W_2> W_1> W_3> W_4$ for total hardness, $W_1> W_3> W_2> W_4$ for Cu, $W_1 > W_4> W_3> W_2$ for Mn and $W_4> W_1> W_2> W_3$ for Fe. The concentrations of Pb in all the well water samples were not detected by the AAS model used. The total dissolved solid of W_1 was significantly higher than W_2, W_3 and W_4. W_2 and W_3 were not significantly different from each other but were significantly higher than W_4. The alkalinity of W_1 and W_4 were not significantly different but were significantly higher than those of W_2 and W_3. W_2 was significantly higher than W_3. The concentration of chlorides in W_1 and W_4were not significantly different from each other but were significantly higher than those of W_3 and W_2 respectively. W_3 was significantly higher than W_2.

The variations in the physicochemical properties of the underground waters, boreholes and wells, could be due to the differences in the population size, erosion, runoffs and anthropogenic activities like the use of fertilizers, manures and pesticides, animal husbandry activities, improper domestic sewage disposal and recreational activities at the different locations in the study area (De-Giglio *et al.,* 2015; Khatri and Tyagi, 2015; Wrisdale, Mokoena, Mudau, and Geere, 2017).

4. Conclusions

In this research, drinking water samples from Well, Borehole, and Tap at different locations in Chanchaga, area Minna, Niger State, Nigeria were collected and some physical and chemical parameters were analyzed. The physicochemical properties of the three sources of water met the requirements for drinking water quality set by WHO (2011), the water can then be said to be portable for the dwellers in the community at the time of this study. Also, the study of the effect of location within the study area revealed that some level of significant variations existed in some parameters at different locations which could be due to the differences in the population size, erosion, runoffs, and anthropogenic activities like the use of fertilizers, manures and pesticides, animal husbandry activities, improper domestic sewage disposal, and recreational activities.

Acknowledgement

The authors of this work sincerely acknowledge the assistance rendered by the laboratory technologists in the Department of Chemistry and Department of Soil Science and Land Management, Federal University of Technology, Minna, Niger State, Nigeria.

Conflict of interest

The authors declare no conflict of interest.

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