Assessment of Quality of Public Water Supply in Jalingo Metropolis

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Abstract

This study assessed quality of public water supply in Jalingo metropolis. With increase in human population and improvement in innovation, the danger for water contamination increases, affecting the quality of surface (Dams, streams, rivers, ponds, lakes) and ground (wells, boreholes) waters. The specific objective of the study is to assess the quality of public water supply within Jalingo metropolis. The study adopted survey and experimental research designs. The experimental design involved the laboratory analysis of water quality, whereas the survey design involves sampling of consumers' mode of access to public water supply. This was done by selecting seven supply points each served by the three (3) production units of the Taraba State Water and Sewerage Corporation (TAWASCO) in Jalingo metropolis. Washed bottle water containers were used for water sample collection, which were analysed using the Wagtech Water Quality analysis machine in the World Health Organization Modern Laboratory located within Rural Water Supply and Sanitation Agency (RUWASA) office in Jalingo. While the water data were analysed using ANOVA. The result shows that the physical characteristics of public water supply in Jalingo metropolis are within the permissible limits of WHO and NSDWQ except TDS which recorded high values of 523 and 548 at two supply points respectively, with overall mean value of 399.95 ± 113.07. The study found that the chemical properties of the water sample were within the WHO/ NSDWQ permissible limits except for chloride which recorded higher values in four supply points: B (Runde) (39), F (Star Exclusive) (69), A (Jauro Gana) (127) and G (Green Farm) (194) respectively. The coliform count for the water samples were in trace amount and within the standard limits of WHO/NSDWQ with mean value of 5.24 ± 0.46. There was no significant difference in the mean values of water samples across all sampling points/production units. The ANOVA result shows that there is significant relationship between water production unit and the water quality supplied to the consumers (p-value = 0.417; $P>0.05$). The study therefore recommended that the government should ensure equitable distribution of portable water to the generality of the public. It further recommended that modern equipment should be provided and highly specialized staff employed to manage the production process in order to ensure quality water is provided for the consumption the populace.

Keywords*:* Assessment, contamination, laboratory analysis, permissible limits, water quality,

Introduction

Water in adequate quantity and suitable quality is a pre-requisite for maintaining urban life and economic activities, and it serves as the vehicle for drainage of wastes. A variety of activities are depending on the availability of water. Water supply, in particular, is a vital aspect in public health and economic development (Ahmed, Jamil & Ibrahim, 2016).

For any city, one of the basic and essential services is efficient water supply (Oruonye & Ahmed, 2016). Unless and until this demand is met, the health of the community and development activities will be negatively affected. When the organizational structure of any water supply agency does not promote efficient operation then the overall management will function poorly. Management in this regards is the act of giving directions to water activities and channeling resources towards the achievement of better and efficient water supply system. Water supply management comprises of financial management and water demand management such as water pricing system, metering and tariff financial and cost recovery of' water supply, willingness and ability to pay for the services and how various institutions will participate in management of water supply (Abdulai, 2016).

Water quality refers to the synthetic or chemical, physical, organic, or biological characteristics of water (Diersong, 2009). It is a proportion of the state of water in comparison to the requirement of at least one biotic animal category, or maybe any human need or purpose. It is most commonly used in conjunction with a set of criteria against which consistency and compliance can be measured. The most well-known rules for determining water quality concern the health of biological systems (ecosystems), as well as the safety of human interaction and ingestion.

Safe (quality) drinking water is defined as water that poses no major health risk during a lifetime of use, including any sensitivity that may develop at various periods of life (Standard Organization of Nigeria [SON], 2007). It is water that is free of harmful bacteria, dangerous chemicals/substances, and is aesthetically beautiful (i.e. pleasing to sight, odourless and good taste). It is critical that this sort of water be available not only at all times, but also in sufficient amount, four, i.e. twenty-four hours a day, seven days a week ("24/7").

Physical, chemical, and bacteriological characteristics must all be addressed when analyzing the quality of drinking water. Although water from a source poses no health risks to consumers, they may dislike it owing to its color, odor, or taste (SON, 2007). Color, fragrance, temperature, pH, turbidity, and other physical properties are examples. There are several chemical substances that may be naturally present or introduced into the water (including chemicals used for water treatment); those that are normally present rarely represent a health danger. However, anthropogenic chemicals (fertilizers, pesticides, herbicides, industrial effluents and byproducts, etc.) pose a greater health risk to consumers.

Fortunately, the World Health Organization (WHO, 2011) has proposed a maximum tolerable concentration (limit) for most chemicals, which can be used as a guide. Some of the chemical compounds are residual chlorine (RC), iron (Fe), fluoride (Fl), nitrate/nitrite, lead (Pb), and mercury (Hg) (SON, 2007; Reynolds, Mena, & Gerba, 2008).

Using the index/indicator concept recommended by Waite (1991), cited in Gimba, 2011). , bacteriological (microbial) parameters are utilized to assess drinking water quality. The most seductive risks associated with drinking water are those posed by faecal contamination, and their control hinges on the ability to assess the risk from any water source and apply appropriate treatment to eliminate it. Instead of aiming to identify bacteria when the consumer is at danger of infection, it is advisable to practice looking for organisms that show the existence of faecal contamination and, thus, the possibility for the presence of germs, even if they are not harmful. As a result, Escherichia coli (E. coli) are commonly used as an index organism for faecal contamination and as an indicator organism to evaluate water treatment. A thermo-tolerant coliform count (Faecal coliform) is acceptable when E. coli identification is not achievable (SON, 2007).

The quality assessment of water allows the determinations of water quality condition/status, proper identification of possible sources of contamination and addressing specific problems and ensuring that water sources are properly protected from potential contamination and decision making about the water supply source (Oliver *et al.*, 2016).

However, in underdeveloped nations, the provision and management of water supply and sanitation systems is often poor, resulting in service interruptions and, in extreme cases, entire system failure, forcing consumers to rely on potentially contaminated traditional water sources. According to the WHO/UNICEF (2006) joint monitoring program, urban population growth in Nigeria increased from 25% to 48% between 1990 and 2004, while urban access to improved water sources went from 80% down to 67 % during the same time period. According to the World Bank, "at least 25% of the urban population in Nigeria (and 50% of the urban population in Africa) are not connected to official networks and rely on alternate sources of water delivery."

National and state water supply policy focuses on providing adequate water for rural and urban people, and one of MDGS's (Goal No. 7; Environmental Sustainability) is to have access to excellent water by 2015. Water supply sustainability, which entails ensuring the continuous availability of sufficient quantities of good-quality water within adequate institutional frameworks, as well as employing sound production practices, appropriate technologies, and high-cost accounting, as well as effectively maintaining facilities and equipment, is required to have an adequate water supply (Seth *et al*., 2015).

Since the creation of Taraba State in 1991, the Taraba State Water and Sewerage Corporation (TAWASCO) have been in charge of managing public water supply in Jalingo, the state capital. The TAWASCO operates a water supply system for Jalingo town with a capacity of (about 3 million gallons per day), which is insufficient to meet current demand of 75,640.8 m3/day (TAWASCO, 2021).

As the human populace and improvement in current innovation increase, the danger for water contamination additionally increases (Benjamin, Yusuf, Abdullahi, Clement & Audu, 2021). However, the two significant waters whose qualities are evaluated by scientists are the surface (Dams, streams, rivers, ponds, lakes) and ground waters (wells, boreholes). The explanation is that surface waters are inclined to contamination, and it was accounted for that surface waters are, for the most part, poor in quality (Okeola, Kolawole & Ameen, 2010). Ground waters, on the other hand, are more reliable for domestic and agricultural (irrigation) needs (Okeola *et al.*, 2010).

As an urban center, Jalingo faces the issues of a failing waste management system and rapid urban sprawl seen within the township. For their various water needs, the population of Jalingo Metropolis rely on both surface and groundwater sources. These sources are frequently exposed to pollutants classified as heavy metals, which are frequently related with human activities and exacerbated by urban development and inadequate waste management (Odoh & Jidauna, 2013). Along these lines, obtaining a stable, secure, safe, and sufficient supply of freshwater is a critical requirement for humanity's existence, prosperity, and socioeconomic advancement (Jidauna *et al.*, 2014). As a result, the need for a portable water source cannot be overstated. Therefore, in view of the above argument, the study sets out to investigate the quality of the public water supply within Jalingo metropolis.

Materials and Methods

Description of Study Area

Jalingo LGA is roughly located between latitudes 8º 47’ to 9º 01’N of the equator and longitudes 11º 09’ to 11º 30’E of the Greenwich Meridian with a total land area of about 195km^2 (Fig. 1) . The area is bounded by Ardo-kola Local Government to the West, Yorro local Government area to the South, and Lau Local Government Area to the North. Jalingo Metropolis serve as the capital city of Taraba State and also as the royal traditional seat of the Muri Emirate.

Jalingo Metropolis is drained by River Lamurde and its tributaries which flow into the River Benuel which is situated at the North-western part of the area. The climate of the area is the tropical climate type with two major seasons in the area, the dry season begins from November to March while the wet season commences from April to October with high temperature throughout the year. The vegetation is the Guinea Savannah vegetation type comprising dominantly of grasses with some trees and shrubs.

There are ten political administrative wards in Jalingo metropolis, which include Kona, Barade, Sarkin Dawaki, Majidadi, Kachalla Sembe, Turaki A, Turaki B, Sintali A, Sintali B and ATC-Koffai which are serviced by three production units of the Jalingo public water works. The study covered public water supply in Jalingo urban area. The Water Board has 13 water systems across the State but this study focused only on Jalingo urban water supply system.

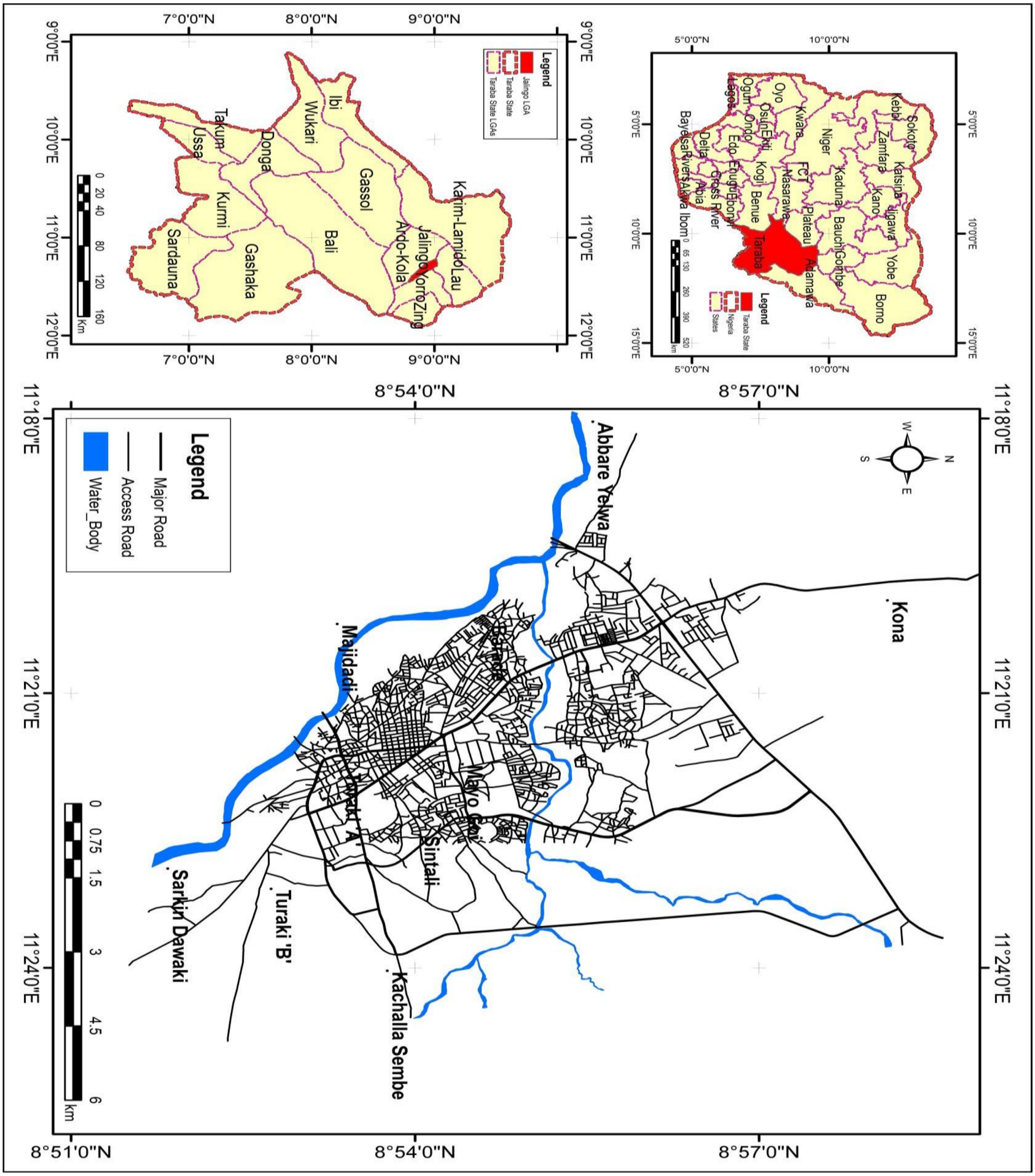

Figure 1: Map of Taraba showing study area

The population of the study comprises all public water supply points and tap water consumers in Jalingo metropolis. There are 3,345 registered tap water consumers in Jalingo Metropolis on the revenue chart of Taraba State Water and Sewerage Corporation (TAWASCO) as at 27th May, 2021 (TAWASCO, 2021). Table 1 shows the number of registered consumers according to supply units as at 27th May, 2021.

Table 1: Number of registered tap water consumers in Jalingo Metropolis

Supply Unit	No. of Consumers	Sample Size	Percentage (%)
Magami		221	64
Santali	476		
Magami	573		
Jalingo Central	95		
Jalingo North	560		
Abuja	434		
	2,143		
Mile Six		179	5
Mile Six Area	179		
	179		
Lamurde		107	31
Kofai/ATC	372		
Lamurde	345		
Sabon Gari	306		
	1,023		
Total	**3,345**	**345**	**100**

Source: Taraba State Water and Sewerage Corporation (TAWASCO 2021)

The sample size for the study was 345 tap water consumers and 21 water supply points (sampling sites) served by three production units. Purposive sampling was used to select Jalingo metropolis, which is made up of ten (10) wards. Random sampling was used to select 21 supply points, seven (7) per production unit. Ten percent (10%) of the total registered water consumers in Jalingo Metropolis was used as the sample size of the study. This is based on the recommendation of Krejcie and Morgan (1970).

The primary data was sourced through Ground Truth Observations (GTOs) in the field. This includes collection of water samples from seven (7) points each served by the three (3) major production units; Magami, Lamurde and Mile six in Jalingo Metropolis. The secondary data were obtained from journal publications, books, WHO water standards, online articles, published and unpublished theses. The water samples were collected based on standard procedure.

All parameters, physical, chemical and biological, were analysed using Wagtech Water quality analysis machine in the World Health Organization's Modern Laboratory located within the Rural-Urban Water Supply and Sanitation Agency (RUWASSA) Office Complex, FGGC Road, Jalingo.

Analysis of variance (ANOVA) was carried out using statistical software (SPSS version 23.0) to compare the relationship between water sources and the physicochemical characteristics of water in Jaingo Metropolis.

Result of the findings

This section presents the results and the findings of the study.

Mean Values of Physical Properties of Public Water Supply in Jalingo

The mean values of physical properties of public water supply in Jalingo are presented in Table 2. The physical properties of the public water considered include colour, odour, taste, temperature, total dissolved substance, turbidity and suspended matter.

Table 2: Mean Values of Physical Characteristics of Public Water

Parameters	ATC	Magami	Shagari Qtrs	Overall Mean	WHO/ NSDWQ
Colour	9.57 ± 1.9^b	10.57 ± 1.27^b	10.71 ± 0.76^b	10.29 ± 0.62	15
Odour	Rob	Rob	Rob	Rob	
Taste	Rob	Rob	Rob	Rob	
Temperature	25.21 ± 1.66^b	25.77 ± 1.91^b	28.64 ± 0.50^b	26.54 ± 1.84	30
TDS	269.57 ± 158.94^b	471.14 ± 47.25^b	459.14 ± 14.25^b	399.95 ± 113.07	500
Turbidity	1.77 ± 1.33^b	2.86 ± 0.87^b	3.26 ± 0.79^b	2.63 ± 0.77	5
Suspended matter	484.43 ± 82.92^b	463.14 ± 18.51^b	463.14 ± 18.51^b	470.24 ± 12.29	2,000
Total coliform count	4.71 ± 0.73^b	5.6 ± 0.86^b	5.4 ± 0.77^b	5.24 ± 0.46	10

Means with the same letter are not significantly different (a=P>0.05; b=P<0.05)

The result presented in Table 2. shows that there is no mean difference in the colour of the water samples across the supply points served by the three production units, with an overall mean of 10.29 ± 0.62, which is within the permissible limit of the WHO and NSDWQ. This means that both the water production is in accordance with stipulated standards and storage facilities are maintained, with water being supplied within a specified timeframe.

The mean temperature for the water samples from all supply points is 26.54 ± 1.84 ˚C is in accordance with the WHO/NSDWQ standard of drinking water. This low temperature recorded could be as a result of the time the samples were collected. Most of the samples were collected during the morning and evening hours. This finding is similar to that reported by Ikhuoriah and Oronsaye (2016) for water samples collected from a river source, which ranged from values of 25.87 to 27.56˚C. The temperature values obtained from this study were within the WHO permissible limit of 30 ˚C.

There are inorganic matters and small amounts of organic matter, which are present as a solution in water. They are referred to as Total Dissolved Substance. The result of this study found TDS values from the tap water samples are all within the maximum limit of 500 mg/L except for sample H (Magami I) and K (Alhaji Lezuya) which recorded the highest values of 548 and 523 respectively. These values are higher than the standard permissible limit of the WHO/NSDWQ. The mean value of TDS for all sample points range from 269.57 ± 158.94 – 459.14±14.25 with an overall mean of 399.95±113.07. The result shows that there was no mean difference in the TDS values between the supply points. The high values of TDS recorded could be attributed to the pipelines used in channeling of the water from the main supply. Most of the pipes in the area are old and rusty due to aging and reaction of chlorine with Fe^{2+}. The low levels of TDS recorded in points A (Jauro Gana) and B (Runde) could be attributed to the fact that these two are new points and the pipes used in channeling of the water are still new, thus, the low levels of TDS. The high TDS value obtained in this study is higher than 476.67mg/L reported by Moses and Ishaku (2020) in the evaluation of physicochemical properties of well water qualities in selected villages in the Zing Local Government Area of Taraba State, Nigeria.

Turbidity is the measure of impurity status of the water caused by a variety of particles and is a key parameter in drinking water analysis. The mean turbidity values obtained from the study sites range 1.77±1.33 – 3.26±0.79, with an overall mean of 2.63±0.77. This is within the standard recommended maximum turbidity limit set by WHO/NSDWQ at five nephelometric turbidity units (5 NTU). The relatively high turbidity recorded in this study shows that the impurities introduced in water could be from pipelines and/or storage facilities. The values were below the WHO/NSDWQ permissible levels of 5NTU.

Mean Values of Chemical Properties of Public Water Supply in Jalingo

The mean values of chemical properties of public water supply in Jalingo are presented in Table 3. The chemical properties comprise of the Electrical conductivity, the pH, free chlorine, manganese, sulphate, Nitrate, total harness, Copper and chloritde.

Table 3: Mean Values of Chemical Characteristics of Public Water

Parameters	ATC	Magami	Shagari Qtrs	Overall Mean	WHO/ NSDWQ
pH	6.19 ± 0.58[b]	6.13 ± 0.50[b]	6.41 ± 0.51[b]	6.24±0.15	6.5 – 8.5
Electrical Conductivity	461.34±306.42[b]	516.86±88.49[b]	513.29±45.51[b]	497.16±31.07	1,000
Free Chlorine	0.12 ± 0.05[a]	0.09 ± 0.05[a]	0.09 ± 0.05[a]	0.10±0.05	0.02 – 1
Iron (Fe^{2+})	0.04 ± 0.03[a]	0.07 ± 0.05[a]	0.06 ± 0.05[a]	0.06±0.02	0.3
Fluorine (F)	0.17 ± 0.14[a]	0.11 ± 0.04[a]	0.08 ± 0.04[a]	0.12±0.05	1.5
Manganese (Mn^{2+})	0.08 ± 0.07[a]	0.08 ± 0.05[a]	0.08 ± 0.05[a]	0.08±0.00	0.2
Sulphate (SO_4^{2-})	26.71 ± 12.08[b]	66.86 ± 9.03[b]	66.86 ± 9.03[b]	53.48 ± 23.18	250/100
Nitrate (NO^{-3})	0.84 ± 0.81[b]	1.36 ± 0.65[b]	1.36 ± 0.65[b]	1.19 ± 0.30	50
Total Hardness ($CaCO^3$)	86.71 ± 32.90[b]	101.14± 16.43[b]	101.14±16.43[b]	96.33 ± 8.33	150
Copper (CU^{2+})	0.06 ± 0.03[a]	0.13 ± 0.21[a]	0.13 ± 0.21[a]	0.11 ± 0.04	1
Chloride (Cl^-)	181.14 ± 106.02[b]	417.14±38.05[b]	417.14±38.05[b]	338.48 ± 136.25	500/250

Means with the same letter are not significantly different (a=P>0.05; b=P<0.05)

Electrical conductivity, often abbreviated as (EC), is the ability of the water to carry electrical current. The presence of dissolved solids (DS) such as calcium, chloride, and magnesium in water samples carries the electric current through water. Conductivity values obtained in this study (Table 3) showed that all the sample sites contained an appreciable amount of dissolved ions (88.6 – 971.00 S/m). The mean EC range from 461.34 ±306.42 – 516.86 ± 88.49, with an overall mean of 497±45.51. There was no mean difference in EC across the supply points. These high EC values observed in some sites may be as a result of the chemicals present in ionic form in the water samples. The EC of all sites falls within the WHO recommended limit of 1,000 ohm/cm. The EC range obtained in this study is higher than the range of 62.03 to 70.11ohm/cm reported by Ikhuoriah and Oronsaye (2016) in assessing the physicochemical characteristics and some heavy metals of Ossiomo River, Ologbo – a tributary of Benin River, in Southern Nigeria.

pH is an important water quality parameter, which measures the acidity or alkalinity of the water. The pH for the supply points range from 5.2 – 7.1 as shown in Table 3 with a mean value of 6.13±0.50 – 6.41±0.51 shown in table 4.4. The highest pH value recorded during the was 7.1, which were higher than the range of 5.76 to 6.01 reported by Ikhouriah and

Oronsaye (2016) in Ossiomoo river Ologbo – a tributary of Benin River, Southern Nigeria. The pH values reported in this study is also higher than the range of 5.96 – 5.54 reported by Chinedu, Nwinyi, Oluwadamisi and Eze (2011) is assessing tap water quality in Canaan land, Ota, Southwest Nigeria. The mean pH of 6.24±0.15 for all sites in the study area is within the WHO/NSDWQ permissible limit of 6.5 – 8.5.

Free chlorine mean values recorded in this study range from 0.09±0.05 – 0.12±0.05, with an overall mean of 0.10±0.05 (Table 3), which is within the permissible limit set by the WHO and the NSDWQ The presence of free chlorine (also known as residual chlorine) in drinking water indicates that a sufficient amount of chlorine was added initially to the water to inactivate the bacteria and some viruses that cause diarrheal disease. It also indicates that the water is protected from recontamination during storage. The presence of free chlorine in drinking water is correlated with the absence of most disease-causing organisms, and thus is a measure of the portability of water. The values of free chlorine recorded in this study could be attributed to the water treatment procedures and other standardized measures taken in ensuring that the water supplied within the metropolis is safe and portable for drinking.

(The mean Fe^{2+} concentrations recorded for all sites range between 0.04±0.03mg/l – 0.07±0.05mg/l as shown in Table 3. with an overall mean value of 0.07±0.02mg/l. These values obtained in the study are lower than the range of 0.15mg/l and 3.26 mg/L reported by Popoola, Yusuf and Aderibigbe (2019) in the assessment of natural groundwater physicochemical properties in major industrial and residential locations of Lagos metropolis. The values of Fe^{2+} recorded are within the WHO permissible limit of 0.3mg/l. Therefore, the Fe^{2+} concentrations recorded in the sampled water are just traces and not harmful to humans.

The fluorine mean concentration recorded in this study range from 0.08±0.04 – 0.17±0.14mg/l as shown in Table 3. The permissible range of fluoride by WHO is 0.5 to 1.5 mg/l. The fluoride concentrations found in the study, both in the dry and rainy seasons, are within the permissible WHO standards. Therefore, the fluoride concentration found in the drinking water in the study area is not detrimental to life. Increased fluoride levels in drinking water above 1.5 mg/L causes a higher risk of dental fluorosis, though increasingly greater concentrations can lead to the risk of skeletal fluorosis as well.

The mean concentration of manganese from the study range from 0.08±0.05 – 0.8± 0.07mg/l. there was no mean difference in the values of Manganese obtained in the study in the sampled water as shown in Table 3. The result recorded in this study are higher than the value of 0.010 – 0.057 mg/l reported by Ayeki, Asikhia and Ojeh (2018) in the study of seasonal and spatial Variation in Physico-chemical and biological quality of water in Benin

City, Edo State, Nigeria. All the manganese values obtained from the study are within the WHO and NSDWQ permissible standards of 0.1 to 0.2 mg/l.

The mean sulphate (SO_4) concentrations of the sampled tap water range from 26.71mg/l ± 12.08 mg/l – 66.86±9.03 as shown in Table 3. The concentrations recorded in this study are below the range of 3.10mg/l to 66.10 mg/L reported by Moses and Ishaku (2020) in the evaluation of physicochemical properties of well water qualities in selected villages in the Zing Local Government Area of Taraba State, Nigeria. In contrast, the range found in the present study is higher than the range of 13 – 63 mg/L reported by Popoola, Yusuf and Aderibigbe (2019) in the assessment of natural groundwater physicochemical properties in major industrial and residential locations of the Lagos metropolis. The concentrations recorded in this study are both within the permissible limit of the WHO and NSDWQ standard for good quality water.

The mean nitrate levels obtained in this study ranged from 0.84 ± 0.81 – 1.36 ± 16.43mg/l, with overall mean value of 1.19 ± 0.30 as shown in Table 3. The values recorded are lower than the range of 0.33mg/l and 2.37mg/l reported by Popoola, Yusuf and Aderigbe (2019) in the assessment of natural groundwater physicochemical properties in major industries and residential locations of Lagos metropolis. The result of this study is higher than the value of 0.27±0.005mg/l reported by Bolarinwa, Fasakin and Fagbenro (2016) in the analysis of the physicochemical parameters of coastal waters of Ondo State, Nigeria. All the Nitrate values obtained are lower than the WHO (2012) recommended guidelines value of 50mg/l, which implies that the nitrate concentrations obtained in the study are within the acceptable limit and might not cause any health risk.

The result shows that Chloride has the lowest values of 39 and 69 at points B (Runde) and Points F (Star Exclusive) respectively. Similarly, Points A (Jauro Gana) and G (Green Farm) recorded low chloride values of 127 and 194 respectively. All these values within the set standard of drinking water by the WHO and NSDWQ. The low values recorded in these points could be attributed to the fact that the supply points are new and the pipes used in channeling the water are still new, thus, there are no rust in the pipeline which would have elevated the levels of chloride in the water. The rest of the samples recorded chloride values lower than the WHO standard for drinking water but higher than the NSDWQ. The mean chloride levels recorded in this study range from 181.14±106.02mg/L – 417.14±38.05mg/L as shown in Table 3 with an overall mean value range of 338.48±136.25mg/L. The high values of chloride found in the water samples could be attributed to the high concentration of chloride in the underneath rocks or soils due to spraying of agrochemicals like DDT and atrazine for irrigation and vegetable framing around the location of the water treatment plants.

The increased levels of chloride in the water samples may be attributed to the treatment processes in which chlorine or chloride is used. Another possibility for the high levels of chloride in the water samples could be as a result of the reaction of chloride with oxides of iron (metal ions) giving rise to soluble salts, thus increasing levels of metals in drinking water and elevating levels of chloride as well.

Mean Values of Biological Properties of Public Water Supply in Jalingo

The mean values of biological properties of public water supply in Jalingo are shown in Table 4. The only biological property recorded in the water quality of public water supply in Jalingo was the Total coliform count.

Table 4: Mean Values of Biological Characteristics of Public Water

Parameters	ATC	Magami	Shagari Qtrs	Overall Mean	WHO/ NSDWQ
Total coliform count	4.71 ± 0.73^{b}	5.6 ± 0.86^{b}	5.4 ± 0.77^{b}	5.24 ± 0.46	10
E. Coli	0	0	0	0	

Means with the same letter are not significantly different (a=P>0.05; b=P<0.05)

Total Coliform: The result found that there was coliform in the water samples (Table 4). The mean values range from $4.71 \pm 0.73 - 5.6 \pm 0.86$ with an overall mean of 5.24 ± 0.46. The coliform found in this result are in trace quantity because at this level, it is not harmful to humans.

In summary, no taste or odour were recorded for all the samples. Lead was also not found in the water samples collected in the study area. This is because the study area is not known to have lead deposits or lead-related activities. E. coli was also not present in the water samples used for the study. This can be allured to the fact the water has undergone proper treatment before distribution to the various supply points in the study area. Therefore, there is little or chance of further contamination by any organic matter in the process.

Descriptive analysis of the public water supply in Jalingo

Analysis of variance (ANOVA) carried out to describe results of the public water supply in Jalingo as seen on Table 5, 6 and 7 respectively.

Table 5. Water_Quality

Production Units	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximum
ATC	42	128.943	221.9978	34.2550	59.763	198.122	.5	971.0
MAGAMI	42	172.221	233.9616	36.1011	99.314	245.129	1.8	636.0
SHAGARI	42	170.243	227.5644	35.1139	99.329	241.157	2.2	563.0
Total	126	157.136	226.9490	20.2182	117.121	197.150	.5	971.0

ANOVA

Table 6. Water Quality

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	50156.953	**2**	25078.476	.483	.618
Within Groups	6388072.176	123	51935.546		
Total	**6438229.129**	**125**			

Water Quality

Table 7. Duncan

Identity	No.	Subset for alpha = 0.05 1
ATC	42	128.943
Shagari	42	170.243
Magami	42	172.221
Sig.		.417

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 42.000.

The ANOVA result presented in Table 7 shows that each of the production units have alpha values of 128.9, 170.2, and 172.2 for ATC, Shagari and Magami production units respectively. The result shows a P-Value of 0.417 which is more than 0.05 (P>0.05) which implies that there is a significant relationship between water sources, i.e. the production units, and the physicochemical characteristics of water in Jalingo metropolis. This implies that the quality of water supplied is determined by the source from which it is produced. Thus the production units are responsible for the quality of water supply in Jalingo metropolis and not the supply channels.

Conclusion

The study has assessed the quality of public water supply in Jalingo metropolis using experimental and survey research designs. The findings of the study reveal that the physical characteristics of public water supply in Jalingo metropolis are within the permissible limits of WHO and NSDWQ except TDS which recorded high values of 523 and 548 at point H and K respectively, with mean value of 399.95 ± 113.07. The chemical properties were found to be within permissible limits except for chloride which recorded values above the permissible limits of NSDWQ except for four supply points, B (Runde), F (Star Exclusive), A (Jauro Gana) and G (Green Farm) which recorded 39, 69, 127 and 194 respectively. The coliform count for the water samples showed that they were in trace amount and fall within the standard limits of WHO and NSDWQ with a mean value of 5.24 ± 0.46. The study found no taste, odour or E. coli.

The ANOVA result shows that there was significant relationship between each water production unit and the water quality supplied to the consumers. The quality of water supply system in the study area shows that the water was good for public consumption.

Recommendations

Based on the findings of the study, the following are recommendations are made.

i. The physical and chemical characteristics of water are critical to its consumption by customers, thus the quality of public water supply should be maintained and regulatory standards strictly adhered to.

ii. modern equipment should be provided and highly specialized staff should be employed to manage the production process in order to ensure quality water is provided for the consumption the populace.

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