ASSESSMENT OF THE DRINKING WATER QUALITY IN SHENDAM LOCAL GOVERNMENT AREA OF SOUTHERN SENATORIAL DISTRICT OF PLATEAU STATE, NIGERIA

ABSTRACT

Introduction: Access to clean water is fundamental to human health. The importance of water to human's health and wellbeing is encapsulated in the human right to water, reaffirmed by the united nation in 2010. The, aim of this study was to assessed the quality of drinking water in Shendam Local Government Area of Plateau State Nigeria.

Place and Duration of Study: The water samples were collected from Shendam Local Government Area of Plateau State Nigeria. 20 samples of the water were collected in the month of May from different locations within the study area.

Methodology: The samples were analyzed using automated instrumental methods prescribed by standard methods for the analysis of water and wastewater and the United States Environmental Protection Agency (USEPA, 2010).

Results: The results showed SO_4^{2-} range from ND to 69.00mg/L; pH 6.93 to 7.69; NO_3^- 4.40 to 113.08 mg/L; PO_4^{2-} 1.48 to 69.00 mg/L; Cd range from 0.002 ± 0.03 to 0.036 ± 0.005 mg/L; Ni, from 0.002 ± 0.010 to 0.162 ± 0.013 mg/L; Cr, ND to 0.337 ± 0.051 mg/L; Pb 0.012 ± 0.002 to 0.213 ± 0.029 mg/L. The calculated average daily intake (ADI) for Cd, Ni, Cr and Pb were within acceptable limits while the hazard quotients (HQ) for some of the metals were >1, while some are < 1 signifying that some of the population would experience non-cancer risks due to exposure to these metals in drinking water. The bacteriological study of the water samples also revealed that the water samples were all polluted with bacteria and coliforms.

Conclusion: From the foregoing, these drinking water sources, therefore require treatment before consumption to minimize or avoid the incidences of water-related diseases.

Keywords: Bacteriology, water quality, Hazard Quotients, Average daily intake, and heavy metals

1.0 INTRODUCTION

Water is an essential resource for the global economy as well as for sustaining life. However, because of the combined effects of anthropogenic and natural factors, the quality of drinking water worldwide has been worsening for decades [1]. Evaluating water quality for many different purposes, particularly home, industrial, agricultural, and conservation, is a crucial approach to ensuring food safety and public health. The purpose of evaluating water quality is to detect the causes of contamination and create a plan for managing water sources sustainably, preserving and advancing the economy and society as well as human health [2]. An increase in activity by humans has a direct effect on water quality, and any pollution—physical or chemical—modifies the receiving water body's quality. [3]. Achieving universal access to safe and high-quality water is a fundamental human right, as stated by [4]. The United Nations General Assembly (UNGA) has identified universal access to clean water and sanitation as one of the goals for sustainable development that must be met by 2030. Water's quality is defined by its physical, chemical, biological, and aesthetic characteristics, which also affect its suitability for various applications such as safeguarding human health and the aquatic ecosystem. The majority of these characteristics are determined by substances that are suspended or dissolved in water, and both natural and man-made processes can have an impact on the quality of the water. [5][6].Water security is the capacity of a population to maintain sustainable access to adequate quantities and acceptable quality of water for socioeconomic growth and human well-being, as well as to protect against pollution and water-related disasters and to conserve ecosystems in an environment of peace and political balance [7].

Furthermore, people in both developed and developing nations have been linked to chronic health issues as a result of emerging pollutants and disinfection byproducts [8]. Governmental and non-governmental groups' initiatives to guarantee the federal government and other relevant organizations have set national criteria for drinking water, which should be used as a standard for assessing the quality of water supplied by the municipality [9]. According to these guidelines, some characteristics are primary to the quality of drinking water, while others are deemed secondary. Drinking water quality guidelines generally state that no 100 mL sample of drinking water should include any faecal indicator bacteria (FIB), particularly Escherichia coli (E. coli) or thermotolerant coliform (TTC) [10]. Even if these principles and standards are available, Faecal contamination of drinking water sources, including improved sources such as pipe water, has been shown in multiple papers from the World Health Organization (WHO) and the United Nations International Children Emergency Fund (UNICEF), particularly in low-income countries [11]. Worldwide, the leading cause of the high death rate among children under five years old is still water-related disorders. These issues are particularly prevalent in developing nations' security and safety of water.

The inadequacy of water supply systems has resulted in numerous failures in recent times [12]. Water quality can be harmed during collection, transportation, and home storage, particularly when it comes to the microbial content. Agricultural, industrial, and commercial activity, animal faeces, open field defecation, domestic waste, and flooding are all potential sources of contaminated drinking water. Such contamination is particularly prone to affect any source of water [13]. Therefore, in the absence of better water storage and sanitation, having access to a safe source does not guarantee the quality of the water ingested, nor does having a good source of water guarantee full health benefits [14]. In underdeveloped nations, Prior research conducted in developing nations has revealed a progressive increase in E. Coli and total coliform contamination of samples of water for drinking from the point of use in households to the source, particularly when unclean containers are used for collection and storage [15] [16][17]. Levels of water contamination in households have also been linked to the type of water treatment method used at the household level, the type of container used to store drinking water, the number of days of water storage, inadequate knowledge, and a lack of personal and domestic hygiene [18][19].

Previous investigations carried out in Plateau State Nigeria, had found that drinking water samples from Jos South and Pankshin Local Government area were gradually contaminated with E. coli, total coliforms, and some physicochemical parameters from various sources.[20]. Thus, the purpose of the study was to evaluate the drinking water quality in Shendam Local Government Area of Plateau State Nigeria.

2. 0 MATERIALS AND METHODS

2.1 Materials/Equipment

The materials used for this analysis were a spectrophotometer HACH/DR 900, Wagtech Photometer 7100, wagtech pH/conductivity/TDS meter and atomic absorption spectrometer (AAS).

2.2 Sample collection and analysis

Water samples were collected from various sites within the Shendam Local Government Area of Plateau state. The water samples were taken from a variety of sources such as Stream, hand-dug wells, and drilled boreholes which supply drinking water to the locals. The samples were collected in a sterile container. The samples were divided into two. The first portion for the heavy metal analysis was treated with two drops of trioxonitrate (V) acid to prevent heavy metals from being adsorbed by the walls of the container.The second portion for the bacteriological and other physicochemical parameters were left without any treatment.This was then transported to the lab for further analysis.

2.3 Sample Analysis

2.3.1 Physicochemical analysis

Water samples collected were analysed by automated instrumental methods prescribed by standard methods for the analysis of water and wastewater and the United States Environmental Protection Agency (Standard Method, 1999). The concentrations of major ions; such as Sulphates (SO_4^{2-}), Nitrates (NO_3^-) and Phosphate (PO_4^{2-}) were determined spectroscopically using HACH/DR 900. The water surface temperature was determined by lowering the probe to about 1cm below the water surface for about five (5) minutes until it stabilized and the temperature was recorded immediately. Conductivity, Total Dissolved Solids, Turbidity and pH were measured by Wagtech Photometer 7100 and Wagtech pH/conductivity/TDS meter respectively, while the heavy metal content was analyzed using an atomic absorption spectrophotometer.

2.3.2 Media preparation and Bacterial isolation

Plates of Blood Agar (BA), Salmonella Shigella agar (SSA), MacConkey (MCA), and Nutrient Agar (NA) agars were made following the manufacturer's instructions and the number of plates required for bacterial identification. To get the various counts of heterotrophic bacteria, dry NA plates were infected with 1.5 ml of the samples from the 10-2 plate using the spread plate technique after a 10-4 serial dilution of water samples from different sources. The plates were then incubated for 24 hours at 37°C. After distinct bacterial colonies were identified through macroscopic analysis, isolates were selected and subsequently cultivated on BA, SSA, and MCA agars to produce pure cultures of gram-positive and enteric species.

2.4. Health Risk Assessment of the Water

Using equations 1 and 2 below, the health risk of drinking water from different sources daily was determined from the average daily intake (ADI) and hazard quotient (HQ) of heavy metals in the water (EPA, 2011).

$$ADI = \frac{Cx \times Ir \times Ef \times Ed}{Bwt \times At}$$ … Equation --- I

Where: ADI = average daily ingestion of heavy metals per kilogram of body weight; Cx=concentration of heavy metals in water; Ir = ingestion rate per unit time; Ef = exposure frequency; Exposure duration; Bwt = body weight; At = the average time (Ed x Ef). According to [21], the standard values and units of the mentioned variables are as follows: EF=365 days/years; Ir=2L/day; Ed=55 years; Bwt = 65 kg; At = 20075 days.

$$HQ = \frac{ADI}{RFD}$$ … Equation --2

Where: HQ=hazard quotient; RFD=heavy metal oral reference dose. According to (USEPA 1993), the RFD (mg/L/day) of Pb=0.0035; Cd=0.0005; Ni=0.020; Cr=0.0003.

In general, the value of HQ or HI >1 indicates significant non-carcinogenic effects, which increased with the increasing value of HQ or THQ whereas HQ < 1 shows that there will be no obvious risk. [22][23].

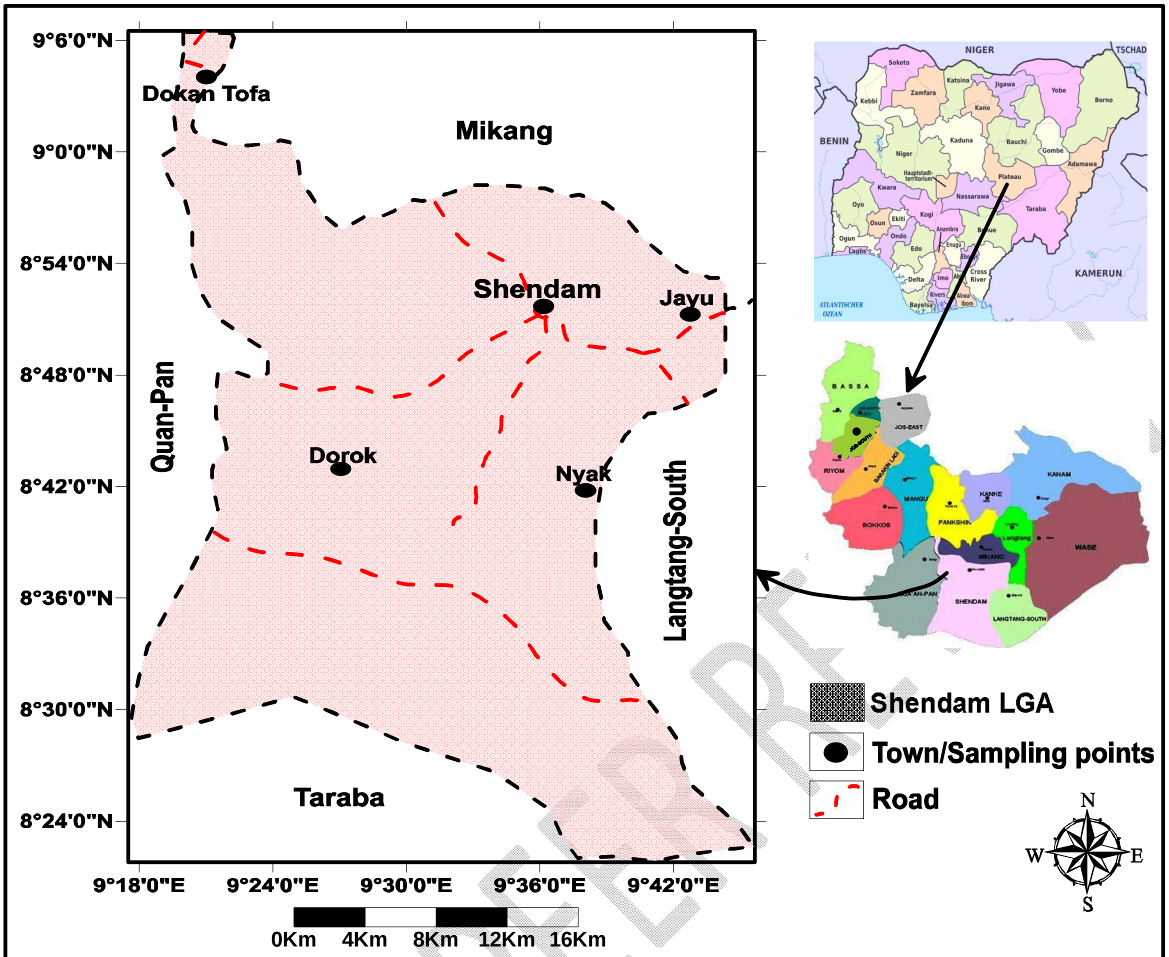

Figure 1:Map of Shendam Local Government Area.

3.0 Result and Discussion

Table 1: Result of the physicochemical analysis of water collected from Shendam Local Government Area of Plateau State

Sample Code	SO_4^{2-} Mg/l	PO_4^{2-} Mg/l	NO_3^- Mg/l	Colour Pt.co	Turbidity NTU	Conductivity µS/cm	TDS Mg/l	pH	Temp ^{0}C
GgBW	1.00	6.25	9.16	3.00	1.26	136.50	68.30	7.44	25.90
ShBW	20.00	3.51	8.80	18.00	1.35	1229.00	616.00	7.61	26.80
KWW	69.00	2.09	54.60	2.00	0.74	2560.00	1270.00	7.35	26.80
GaWW	10.00	4.24	17.67	90.00	4.43	1427.00	713.00	7.69	26.50
KBW	6.00	4.41	113.08	0.00	0.23	921.00	460.00	7.47	26.90
LWW	5.00	4.09	6.71	0.00	2.04	736.00	368.00	7.50	29.90
DtBW	ND	5.96	7.48	15.00	1.56	1032.00	515.00	7.68	27.00
TWW	21.00	4.34	4.40	16.00	2.87	1480.00	739.00	7.60	26.70
TBW	2.00	3.53	4.40	11.00	2.54	1113.00	557.00	7.63	26.50
GaBW	ND	3.98	7.41	0.00	0.60	873.00	436.00	7.67	26.50
YBW	25.00	69.00	77.88	0.00	0.44	469.00	940.00	7.42	26.70
JWW	2.00	3.98	5.72	0.00	0.47	424.00	212.00	7.55	26.80
SWW_1	11.00	5.44	30.80	6.00	3.67	555.00	277.00	7.42	26.80
SWW_2	8.00	3.80	7.92	46.00	9.50	311.00	155.00	7.40	26.90

GgWW	3.00	3.63	12.32	142.00	22.90	134.30	67.90	7.26	27.70
DtSW	2.00	4.07	6.16	0.00	0.94	478.00	239.00	7.13	27.50
SBW	7.00	1.89	95.92	0.00	0.25	539.00	269.00	6.93	27.00
JBW	ND	4.08	5.28	3.00	7.86	1047.00	522.00	7.25	27.20
LBW	5.00	4.13	16.72	5.00	7.86	447.00	223.00	7.46	27.20
LyWW	ND	1.48	88.00	0.00	0.61	683.00	341.00	7.03	27.20
NSDWQ 2007	100.00	1.00	50.00	-	5.00	1000.00	500.00	6.5-8.5	22-32

KEY: (GgBW). GidanGaladima borehole water; ShBW= Shendam borehole water; KWW=Kalong well water; GaWW= Gidanadamu well water; KBW=Kalong borehole water; LWW= Laraba well water; DtBW= DokanTofa borehole water; TWW=Tengzet well water; TBW= Tengzet borehole water; GaBW=Gidan Adamu borehole water; YBW= Yelwa borehole water; JWW=Jak well water; SWW_1 = Shimankar well water; SWW_2=Shimankar well water; GgWW= Gindangaladima well water; DtSW=Dokantofa stream water; SBW=Shendam borehole water; JBW=Jayu borehole water; LBW=Laraba borehole water; LyWW= Luyilnan well water

ND: Not detected

Sulfate (SO_4^{2-}), phosphate (PO_4^{2-}), nitrates (NO_3^-), pH, TDS, turbidity, and electrical conductivity were among the physicochemical characteristics examined. Tables 1 through 3 provide the results of the bacteriological parameters assessed for each sample, along with the highest possible levels permissible in each parameter as prescribed by Nigeria's drinking water quality standard. The bacteriological parameter that was investigated was the Total Aerobic Bacteria count.

Sulphate is a substance that occurs naturally in drinking water, intake of water containing high concentrations of sulphate will lead to diarrhoea [23]. The range of concentrations for the sulfate concentration that was analyzed in the research region was ND to 69.00 mg/L. This is less than the NSDWQ 2007's suggested threshold, which states that the amount of sulphate in drinking water shouldn't exceed 100 mg/L. In a similar vein, the water samples' phosphate concentrations range from 1.48 mg/L to 69.00 mg/L. These values are comparable to those of [20], but higher than those of [24]. Overall, the work's results exceeded the Nigerian standard for drinking water quality (NSDWQ 2007's) suggested threshold of 1.00 mg/L. Consuming excessive amounts of phosphate may cause blood vessel damage, accelerate ageing, raise the risk of cardiovascular disease, and increase the death rate in patients suffering from renal illness.

Nitrate concentration in the water samples ranges from 4.40 mg/L to 113.08 mg/L, samples collected from KWW, KWB, YBW and LyWW recorded higher than normal concentrations. These are samples of water collected from both the well and borehole. These values were higher than those of [24]. Turbidity is a measure of the level of particles such as sediments, plankton, or organic by-products, in a body of water. As the turbidity of water increases, it becomes denser and less clear due to higher concentrations of these light-blocking particles. The turbidity of the water samples ranges from 0.23 to 22.90. A few of the samples include JBW. LBW, SWW_2 and GgWW were above the 5.00 NTU recommended by NSDWQ 2007.

The average temperature of water samples from the study area was 28.49 °C and in the range of 28–29 °C. The temperature in this study was found within the permissible limit of the NSDWQ (2007) standard of (22-32 °C). [20] report similar results in drinking water samples in Jos South and Pankshin in Plateau State Nigeria.

Total dissolved solids (TDS). Many inorganic and some organic minerals and salts, including potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulfates, and others, can dissolve in water [25]. These minerals gave the water an undesirable taste and a diluted colour. High TDS water suggests that the water is heavily mineralized. TDS should not exceed 500 mg/l, as recommended by the NSDWQ (2007) for drinking reasons. In the current investigation, the TDS concentration was found to vary between 68.30 and 1270.00 mg/l. High values of TDS in groundwater are generally not harmful to human beings, but high concentrations of these may affect persons suffering from kidney and heart diseases. Water containing high solids may cause laxative or constipation effects,[26].

Electrical conductivity (EC) Water's electrical conductivity increases as ion concentration rises. Electrical conductivity in water is often determined by the concentration of dissolved particles in the water. Measured by electrical conductivity (EC), a solution's ability to transmit electricity is determined by its ionic process. The WHO states that an EC value of more than 1000 µS/cm is unacceptable. According to the current study, the EC values in drinking water varied from 134.30 to 2560.00 µS/cm; [20], observed a comparable value. These findings show that, as a result of some dissolved solids, the water in seven of the sampling sites is significantly ionized and has a higher ionic concentration activity (Table 1).

pH of water

When assessing the acid-base balance of water, pH is a crucial factor to consider. It also serves as a gauge for the water's acidity or alkalinity. A pH range of 6.5 to 8.5 is the maximum allowable level stated in NSDWQ 2007. The ranges of 6.93 to 7.69 in the current investigation fall within the NSDWQ requirements. The aggregate outcome shows that the sampling area's water supply fell within the ideal and appropriate range. The amount of dissolved carbon (IV) oxide (CO_2), which creates carbonic acid in water, determines the pH. The results of the current inquiry were comparable to those of [20] study.

Table 2 Result of the heavy metal analysis of water collected from Shendam Local Government Area of Plateau State

SAMPLE ID	Cd (mg/l)	Ni (mg/l)	Cr (mg/l)	Pb (mg/l)
GgBW	0.030±0.005	0.027±0.007	ND	0.084 ±0.007
ShBW	0.012±0.021	0.162±0.013	0.001±0.003	0.213±0.029
KWW	0.010±0.061	0.128±0.016	ND	0.188±0.004
GaWW	0.036±0.005	0.024±0.004	ND	0.094±0.003
KBW	0.008±0.076	0.083±0.012	ND	0.180±0.004
LWW	0.007±0.031	0.055±0.011	0.018±0.021	0.162±0.026
DtBW	0.019±0.002	0.004±0.002	0.016±0.011	0.042±0.012
TWW	0.007±0.006	0.040±0.003	0.337±0.051	0.123±0.019
TBW	0.007±0.005	0.037±0.011	0.277±0.008	0.064±0.006
GaBW	0.025±0.021	0.002±0.010	ND	0.034±0.038
YBW	0.024±0.007	0.003±0.001	0.006±0.021	0.034±0.035

JWW	0.003±0.001	0.033±0.002	0.148±0.003	0.058±0.017
SWW_1	0.015±0.021	0.016±0.004	0.012±0.004	0.066±0.010
SWW_2	0.019±0.013	0.019±0.0132	ND	0.080±0.032
GgWW	0.027±0.004	0.015±0.004	ND	0.094±0.020
DtSW	0.022±0.001	0.008±0.002	0.010±0.008	0.033±0.001
SBW	0.010±0.010	0.156±0.015	ND	0.205±0.006
JBW	0.002±0.003	0.029±0.006	0.021±0.012	0.049±0.022
LBW	0.007±0.002	0.042±0.008	0.038±0.004	0.128±0.017
LyWW	0.026±0.001	0.010±0.003	0.004±0.007	0.012±0.002
permissible limit WHO (2008)	0.003	0.07	0.05	0.01

n = 3

Key: ND = Not detected

The concentration of Cd, Cr, Ni, and Pb heavy metals were examined in the different water samples. The average Cd concentration was 0.014, with a range of 0.003 ± 0.005 to 0.027 ± 0.004 mg/L (Table 2). The results of [27] at the Kuru dam in Jos, South Nigeria, are higher than these values. The majority of the findings in this study are higher than the WHO (2011) recommended threshold. Cd is a non-essential element that is extremely poisonous, and has negative impacts on living organism [28]. Because it is difficult for human bodies to expel, cadmium tends to accumulate in the kidneys. Therefore, kidney damage in older persons can develop from lifetime low-level cadmium exposures as well as lower to higher exposures.

The Ni results obtained from the water samples ranged from 0.003±0.001 to 0.162±0.0130, with an average value of 0.045 mg/L. These values are comparable to the findings of [20] in the Pankshin LGA Plateau State of Nigeria. However, it is less than the mean in river kampani that [29] recorded. [30]Reported that a shortage in Ni^+ causes low plasma cholesterol, elevated liver cholesterol, rough hair, altered liver cell ultrastructure, poor offspring growth, and reduced reproduction.

Cr in these study ranged from ND to 0.337 ± 0.051. Most of the samples analyze for Cr,has values that are within acceptable limits, with the exception TWW, TBW and JWW whose values are above the acceptable limits.The results of this investigation however,were similar to [20] in Pankshin but lower than those reported in Jos South by [31]. Cr (VI) is considered toxic and international agency for research in cancer (IARC) has classified it as Group 1 agent.

Pb concentrations vary from 0.012 ± 0.002 to 0.213 ± 0.029 mg/L.This research validated the findings of[32], who evaluated the contamination of stream water and irrigated crops by trace metals at Naraguta, Jos, in November 2008. They found that the mean concentration value at the river's centre was 1.57 ppm, which is higher than the values obtained in this study, where samples were taken in May after the rainy season had begun. This suggests that Pb concentration levels rise as precipitation decreases, as reported by [32]. The results of this study also yielded higher values when compared to the assessment of trace metal contamination in Kuru Dam Jos, South Nigeria, conducted by [27]. The result of the present study also appears to be lower than the findings of [33], who measured the lead (Pb) content of vegetables from a river Delimi artisanal mining site and reported a mean value of 2.50 ppm.

Table 3 Average daily intake and non-cancer hazard quotients for drinking water collected from Shendam Local Government Area of Plateau State

	ADI				HQ			
Sample Code	**Cd**	**Ni**	**Cr**	**Pb**	**Cd**	**Ni**	**Cr**	**Pb**
GgBW	0.0009	0.0008	-	0.0026	1.80	0.04	-	0.74
ShBW	0.0004	0.0051	0.0000	0.0066	0.80	0.26	-	1.89
KWW	0.0003	0.0042	-	0.0058	0.60	0.21	-	1.66
GaWW	0.0011	0.0007	-	0.0029	2.20	0.02	-	0.83
KBW	0.0002	0.0033	-	0.0055	0.40	0.17	-	1.57
LWW	0.0002	0.0021	0.0006	0.0013	0.40	0.11	2.00	0.37
DtBW	0.0006	0.0001	0.0005	0.0038	1.20	0.01	1.70	1.09
TWW	0.0002	0.0012	0.0104	0.0020	0.40	0.06	34.67	0.57
TBW	0.0002	0.0011	0.0085	0.0010	0.40	0.06	28.33	0.29
GaBW	0.0007	0.0000	-	0.0010	1.40	-	-	0.29
YBW	0.0007	0.0007	0.0001	0.0018	1.40	0.04	0.33	0.51
JWW	0.0001	0.0010	-	0.0020	0.20	0.05	-	0.57
SWW$_1$	0.0005	0.0005	-	0.0020	1.00	0.03	-	0.57
SWW$_2$	0.0006	0.0006	0.0003	0.0025	1.20	0.03	1.00	0.71
GgWW	0.0008	0.0005	0.0006	0.0029	1.60	0.03	2.00	0.83
DtSW	0.0007	0.0002	0.0003	0.0010	1.40	0.01	1.00	0.29
SBW	0.0003	0.0048	-	0.0063	0.60	0.24	-	1.80
JBW	0.0000	0.0009	0.0006	0.0015	0.00	0.05	2.00	0.43
LBW	0.0008	0.0013	0.0011	0.0039	1.60	0.07	3.67	1.11
LyWW	0.0008	0.0003	0.0001	0.0038	1.60	0.02	12.67	1.09
RDI Ullah *et al*. (2017)	0.06	0.50	0.20	0.21				

The health risk assessment of drinking water from different sources daily was determined using equations 1 and 2 above to assess the average daily intake (ADI) and hazard quotient (HQ) of heavy metals in the water [34]. The calculation was made based on the life expectancy of a fifty-five-year-old adult Nigerian. The results presented in Table 3 revealed that the average daily intake of all the water sources fell below the recommended daily intake limits of all the heavy metals analyzed. The Hazard quotients HQ for Cd, in ShBW, KWW, KBW, LWW, TWW, TBW, JWW, SBW and JBW, were < 1 for Borehole and well water respectively, signifying that the population would not experience non-cancer risks due to exposure to these metal in drinking water, whereas HQ >1 were obtained in all the other sampling locations, indicating an unacceptable risk for non-carcinogenic adverse health effects on the populace. This report is in line with the study of [31] in Jos South LGA of Plateau State Nigeria. Nickel in all the water samples had HQ values <1, whereas Cr in almost all the water samples had HQ >1 except GgBW, ShBW, KWW, GaWW, KBW, GaBW, JWW, SWW1, and SBW with values of HQ<1. Pb was detected in all the samples analysed, but ShBW, KWW, KBW, DtBW, SBW, LBW and LyWW have a value of HQ > 1. All the other samples have HQ < 1. This report is at par with the study of [31] in Jos South LGA of Plateau State Nigeria

Table 4: Bacteriological analysis of some drinking water samples in Shendam Local Government Area of Plateau State

S/N	SAMPLE CODE	Raw count for TaBC	TaBC (CFU/mL)	MPN/100 mL of water	Bacterial isolate
1	**SWWI**	98	9.8×10^3	**23**	*Klebsiella aerogenes, Bacillus* species (spp), *Micrococcus* spp.
2	**SWWII**	43	4.3×10^3	**13**	*K. aerogenes,*
3	**SBW**	82	8.2×10^3	**2**	*K. aerogenes, Bacillus* spp.
4	**GaWW**	194	1.94×10^4	**79**	*Escherichia coli, Bacillus* spp.
5	**GaBW**	212	2.12×10^4	**< 2**	*Bacillus* spp
6	**GaSW**	164	1.64×10^4	**23**	*K. aerogenes*
7	**GgBW**	95	9.5×10^3	**920**	*E.coli*
8	**JWW**	202	2.02×10^4	**70**	*K. aerogenes, Bacillus* spp.
9	**JBW**	120	1.21×10^4	**< 2**	*CoNS, Bacillus* spp.
10	**LBW**	121	1.21×10^4	**< 2**	*CoNS,*
11	**LWW**	79	7.9×10^3	**11**	*Enterobacter* spp.
12	**LyWW**	112	1.12×10^4	**280**	*Pseudomonas aeruginosa, K. aerogenes*
13	**KBW**	67	6.7×10^3	**< 2**	*CoNS*
14	**KWW**	72	7.2×10^3	**920**	*K. aerogenes*
15	**TWW**	42	4.2×10^3	**46**	*Hafnia alvei,*
16	**TBW**	33	3.3×10^3	**< 2**	*CoNS*
17	**YBW**	40	4.0×10^3	**5**	*E. coli*
18	**DtSW**	56	5.6×10^3	**540**	*E. coli*
19	**DtBW**	85	8.5×10^3	**>1800**	*P. aeruginosa, K. aerogenes*
20	**ShBW**	116	1.16×10^4	**4**	*Enterobacter* spp.

Key: = TaBC = Total Aerobic Bacterial Count, MPN = Most Probable Number, CFU = Colony Forming Unit, CoNS = Coagulase-negative Staphylococci.

The total bacteriological count of the water samples taken from the Shendam Local Government Area in Plateau State, Nigeria, is shown in Table 4 above. The study's findings demonstrate that several bacterial species were present in all of the residential water samples. The findings shows that areas like JWW, LyWW, SBW, GaWW, GaSW, JWW, LyWW, and DtBW were found to be contaminated with *Klebsiella aerogenes*. The greatest total count of *Klebsiella aerogenes* was found in JWW, measuring 32.02 x 104 CFU/mL, while the lowest total was found in SWW II, measuring 4.3 x 103. Samples GgBW, YBW, and DtSW all contains *E. coli*, with GgBW having the highest overall bacterial count (9.5 x 103 CFU/mL). Coliforms have been found in some of the water samples, which suggests that the samples were contaminated by feaces[35]. Although most coliform strains are not harmful, others, like Escherichia coli, can result in diarrhea [36]. The total count of Bacillus species, which varies from 8.2 x 103 CFU/mL to 2.12 x 104 CFU/mL, was detected in a limited number of samples. The range of CoNS counts is 3.3 x 103 CFU/mL to 1.21 x 104 CFU/mL, in that order. Water-borne illnesses like fever, cholera, diarrhoea, and gastrointestinal disorders are typically brought on by bacteria. [36]. It was discovered that this study's overall bacterial count was lower than [31] reports.in Jos South LGA of Plateau State, Nigeria. Even though the total bacteria count in this study was low, the water still needs to be treated because present of bacteria in water is responsible for water related diseases. Apart from sanitary conditions and anthropogenic activities that may vary across the Local Government, seasonal variations might be an important factor involved in this issue being that the current research was carried out in the dry season.

Conclusion

Access to clean water is fundamental to human health. The importance of water to human's health and wellbeing is encapsulated in the human right to water, reaffirmed by the united nation in 2010, which entitle everyone to sufficient, safe, acceptable and physically accessible and affordable water for personal and domestic uses. The assessment of water quality parameters from different sources in Shendam Local Government Area of Plateau State Nigeria, revealed that the water contained high levels of toxic metals such as Nickel, Cadmium and Lead, whereas Cr was not detected in most of the samples, while some of the Cr detected were below the respective permissible limits. The physicochemical parameters for SO_4^{2}, turbidity, conductivity, temperature and pH $^-$were within acceptable limits. Whereas PO_4^{2-} has values that are all above the recommended limit. Few of the water samples, have NO_3^- values that are above the recommended limits. The calculated average daily intake (ADI) for Cd, Ni, Cr, and Pb where within acceptable limits while the hazard quotients (HQ) for most of the metals in most of the sampling point have a HQ value >1, signifying that the population would experience non-cancer risks due to exposure to these metals in drinking water, while a few of the samples that has HQ < 1 signifies possible non cancer risk to people living around those areas. The bacteriological study of the water samples also reveals that the water samples were all polluted with bacteria and coliforms. This is therefore concluded that the water samples require treatment before consumption to avoid water-related diseases.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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