

Original Research Article

Physico-chemical Parameters and Bacteriological Quality Assessment of some Domestic Water Sources in Pankshin LGA of Plateau State Nigeria

Abstract

Due to human activity and other natural influences, drinking water is seldom found in 100% pure forms in nature. Drinking polluted water is a major source of sickness in underdeveloped nations. The United States Environmental Protection Agency (USEPA) and standard methodologies for the investigation of water and wastewater were followed in the analysis of the collected water samples, which were conducted using automated instrumental methods. The obtained results indicated that the samples used had the following ranges of concentrations: SO_4^{2-} ranges from ND to 19.00 mg/L; NO_3^- ranges from 4.40 to 100.32 mg/L; PO_4^{2-} from 2.02-11.34 mg/L; pH 6.64 to 7.70; Cd from 0.0020 ± 0.001 to 0.245 ± 0.01 mg/L; Ni, from 0.0074 ± 0.003 to 0.848 ± 0.021 mg/L; Cr, ND to 0.386 ± 0.082 mg/L; Pb ND to 0.428 ± 0.003 mg/L; total bacteria count TaBC, 4×10^2 to 3.3×10^4 CFU/mL. Most of the physicochemical parameters were above acceptable limits. The bacteriological study of the water samples also revealed that the water samples were all polluted with bacteria and coliforms. From the foregoing, these drinking water sources, therefore require treatment before consumption to minimize or avoid the incidences of water-related diseases.

Keywords: Bacteriology, Physicochemical, Water quality, Disease, Treatment

1.0 INTRODUCTION

Mohammed [1] states that water is a liquid that is vital to life and makes up a significant portion of the body. According to [2], water makes up more than 65% of the human body. The availability of clean drinking water is essential to human physiology and to the continuous survival of man [3] [4]. A sizable portion of the global populace lacks access to clean drinking water. Over one billion people, or one in six of the world's population, do not have access to pure drinking water [2], particularly in developing nations like Nigeria. In Sub-Saharan Africa, there are currently over 300 million rural residents without access to clean water sources, and this number is rising [5]. The only realistic option for meeting rural water demands is through groundwater exploitation [6]. A large world population, especially in sub-Saharan Africa, depends on groundwater as their main source of domestic water [7] [8].

Approximately 1.8 billion people worldwide drink water tainted by faeces, which results in two million deaths from diarrheal illnesses each year [9]. The most frequent cause of chemically induced intoxication and infectious diseases may be water. Because of this, a single source frequently provides for a sizable population, making water quality the most crucial component in ensuring public health [10]. Certain aquatic illnesses can hinder a child's growth and cause cognitive impairment in young children under five years old [11]. Contaminated non-potable water harbouring pathogens is the medium via which waterborne infections are spread. Nearly 3.6% of all diseases with a worldwide burden are diarrheal illnesses, highlighting the need for water portability [12][13]. Even while newly discovered pollutants are common in aquatic environments, the majority of them originate from the release of wastewater effluents from municipal facilities. Because of the potential ecological effects (such as endocrine disruption) on the environment's biota, the presence of these pollutants is extremely concerning [14].

The demand for essential services, access to a suitable water supply, and sanitation has increased due to the urban population's fast development [15]. Due to overuse of resources, inefficient

Comment [A1]: Instead of using a name, I will suggest that you start the sentence with "Water is a liquid that is vital to life"

waste disposal techniques, and a rise in urban population, the fast expansion of metropolitan areas has further impacted water quality [16].

Total suspended solids (TSS), dissolved oxygen (DO), hardness, alkalinity, turbidity, pH, Cu, Fe, Mn, Zn, P, Cl, and other chemical and biological properties and components of surface and groundwater sources are all included in the concept of water quality [17]. Numerous substances found in drinking water are essential to human health. However, high quantities of these substances and consuming them in excess might lead to serious health issues [18][17][19]. This research is therefore aimed at assessing the Physico-chemical Parameters and Bacteriological Quality of some Domestic Water Sources in Shendam LGA 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 different locations in Jos South Local Government Area of Plateau state. The water samples were collected from different sources such as hand-dugwells, drilled boreholes, pipe and sachet water which serves as a source of drinking water for the inhabitants. The samples were collected in a sterile container suitable for sample transport to the laboratory for analysis.

Comment [A2]: State the number of samples collected and if it is possible but not necessary, state their GPS locations.

2.3 Sample Analysis

2.3.1 Physicochemical analysis

Water samples collected were analyzed 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.

Comment [A3]: Add the bacteriological analysis.

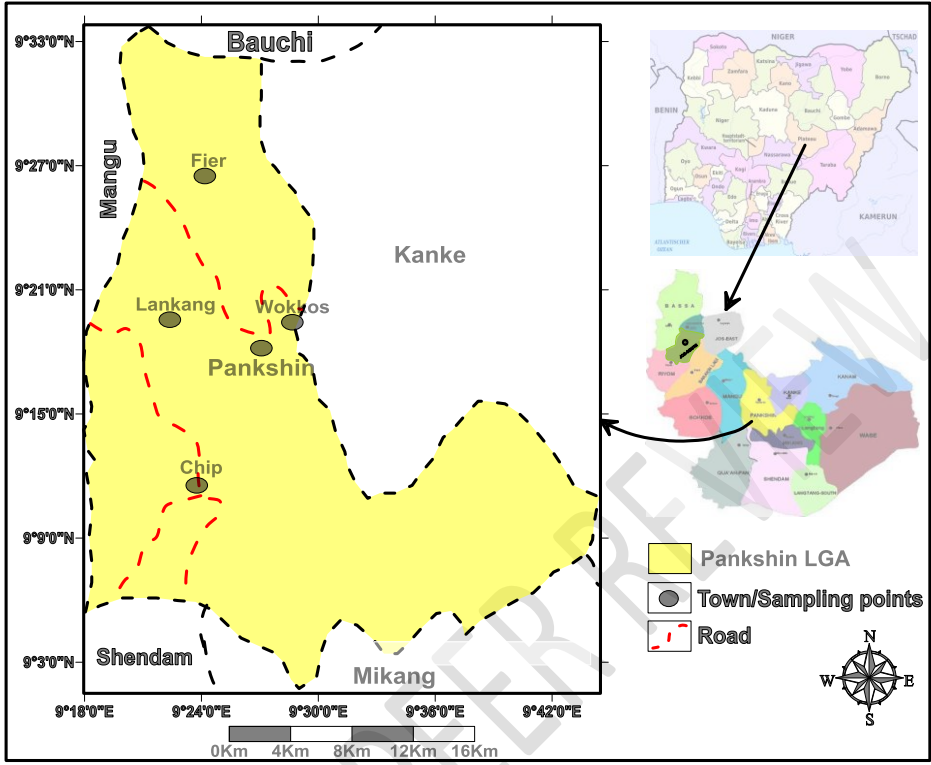


Figure 1: Map Pankshin Local Government Area of Plateau state.

3.0 Result and Discussion

Table 1: Result of the physicochemical analysis of water collected from Pankshin 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 °C
FBW	4.00	4.89	38.72	0.00	0.28	1080.00	539.00	7.30	27.80
DWW	0.00	3.17	4.40	0.00	0.68	332.00	166.00	7.40	27.10
JfWW	3.00	2.02	26.40	3.00	1.23	366.00	183.00	7.11	26.70
McBW	0.00	7.21	4.40	0.00	0.25	915.00	457.00	7.39	27.30
GWW	8.00	5.96	100.32	0.00	1.06	903.00	451.00	7.18	27.10
FrBW	0.00	3.90	16.28	4.00	2.30	155.60	77.90	7.00	27.20
JfBW	3.00	8.35	31.68	46.00	32.10	331.00	165.00	7.70	26.40
KpBW	0.00	5.68	9.80	2.00	1.68	753.00	377.00	7.53	27.20
LkBW	19.00	4.52	93.72	0.00	0.35	1547.00	773.00	7.01	27.10
FcBW	0.00	6.55	8.36	0.00	0.26	205.00	99.60	7.62	26.90
TBW	0.00	2.19	10.12	0.00	0.94	55.80	27.90	7.36	27.10
LtWW	0.00	8.54	5.28	0.00	0.28	286.00	114.00	7.02	27.10
KBW	0.00	4.94	88.00	0.00	0.37	310.00	155.00	6.97	27.10
MWW	1.00	11.34	43.56	2.00	1.31	148.50	74.20	6.72	27.40
LBW	1.00	9.18	32.12	0.00	0.32	630.00	315.00	7.06	26.40
LcBW	0.00	10.98	38.28	0.00	0.42	301.00	150.00	6.77	27.30
GBW	0.00	10.30	28.16	5.00	2.25	198.60	99.60	7.03	27.10
LtBW	0.00	8.54	5.28	0.00	0.28	286.00	114.00	7.02	27.10
VBW	0.00	5.99	81.40	3.00	9.35	417.00	209.00	7.33	27.10
BWW	0.00	7.65	23.32	0.00	0.40	272.00	136.00	6.64	27.50
JBW	0.00	8.22	12.32	1.00	0.97	595.00	297.00	7.20	27.20
LKRW	5.00	6.16	43.56	0.00	0.45	83.50	41.80	7.39	27.00
VWW	0.00	9.64	57.20	0.00	0.54	467.00	233.00	6.66	27.70
TKWW	0.00	6.39	34.32	0.00	0.14	198.90	102.00	7.17	27.20
NSDWQ	100	1.00	50		5.00	<1000	500.00	6.5-	22-32
2007								8.5	

Comment [A4]: Sampling from multiple points and estimating the standard deviations will help us to understand the variability in your data set and to measure the quality of your data. If I understand correctly, you sample three points from each of the sampling points. It will make more meaning if you add the standard deviations to this data.

Comment [A5]: The colour and haziness are very high or out of range unless you are sure that the water is very murky to the eyes. Please confirm the values again and add this exceptional trend to your discussion of result.

KEY - FBW = Fwenzak Bore Hole water: DWW = Dakatu Well Water : JfWW = Jari-Fier Well Water: McBW = Mugulum Chip Bore Hole Water: GWW = Gille Bore Hole water: FrBW = Fwor Bore Hole Water: JfBW = Jari-Fier Bore hole water: KpBW = Kapil Bore Hole water: LkBW = Langkang Bore Hole Water: FcBW = FCE Hostel Bore Hole Water: TBW = Tazuk Bore Hole water: LtWW = Le- Tazul Well: KBW = Kwalla Bore Hole water: MWW = Mile 8 Well Water : LBW = Lepbwai Bore Hole water: LcBW = Lunchan Bore Hole Water: GBW = Gohotfwan Bore Hole: LtBW = Larpya Takkas Bore Hole water: VBW = Vel Bore Hole Water: BWW = Bumnan Well Water : JBW = Jibam Bore Hole Water: LKRW = Langkang Spring (River) Water: VWW = Vel Well Water: TKWW = Tukung Well Water:

The physico-chemical parameters analyzed included Sulphate (SO₄²⁻), Phosphate (PO₄²⁻) Nitrates (NO₃⁻), pH, TDS, turbidity and electrical conductivity. While the bacteriological parameter analysed was Total Aerobic Bacteria count, Tables 1 to 3 present the values obtained from parameters analyzed for each sample alongside the maximum permitted levels for every parameter provided by Nigeria's standard for drinking water quality

The findings of the physicochemical study of the water showed that the pH of the 24 samples examined meets Nigerian recommendations for the quality of drinking water. The result of the findings falls within the 6.5 to 8.5, which is the pH range that is advised by the WHO, SON, NAFDAC, and NSDWQ. It is impossible to overstate pH's indirect impact on physiological processes, despite its lack of direct influence on human health [20][21]. With the exception of FBW, whose result was 538.00 mg/L, all

of the samples that were evaluated had a total dissolved solids concentration (TSD) that was below the 500 mg/l limit that had been recommended by the NSDWQ, WHO, and NAFDAC. The inorganic salt and trace amounts of organic materials found in water or solutions are referred to as TDS. According to WHO [22], the main ingredients are typically carbonate, hydrogen carbonate, calcium, magnesium, sodium, and potassium cations, chloride, sulphate, and nitrate anion. Water's flavour may be impacted by TDS levels (WHO, 1996). According to reports, the flat, insipid taste of drinking water with exceptionally low TDS concentrations may make it undesirable [21]. All of the water samples utilized in this investigation had turbidity that complied with [23] and NWDSQ guidelines. Because high turbidity is frequently linked to larger concentrations of disease-causing microbes, such as bacteria and various parasites, water turbidity is particularly significant [24].

Comment [A6]: Please check this again, is it TDS or TSD?

The electrical conductivity has the lowest value of $7.53 \mu\text{Scm}^{-1}$ from KpBW and the highest value of $1080.00 \mu\text{Scm}^{-1}$ in FBW. Most of the values recorded in the other samples were not significantly different ($p > 0.05$) as they were within the recommended limit of ≤ 1000.00 of the NSDWQ (2007) standard. Though higher than normal value was recorded in FBW.

Comment [A7]: I think it will be better to explain the effect and impact of the carbonate, hydrogen carbonate, calcium, magnesium, sodium, and potassium cations, chloride, sulphate, and nitrate anion in the water, so that your readers will understand.

Likewise, all the water samples analyzed in this study have unobjectionable colour which is in agreement with the standard colour of 5 TCU by NWDSQ and WHO standard, even though an exception was seen in JfBW whose colour was 46 TCU, very high turbidity was also noticed in JfBW thus responsible for the very high colour observed in that sampling area.

Comment [A8]: Please, confirm this statement very well and I don't think colour of 46 and turbidity of 32 confirmed with the standard for drinking water. I am sure WHO specify a maximum turbidity of 5NTU for drinking water. Check <https://iris.who.int/bitstream/handle/10665/254637/9789241549950-eng.pdf?sequence=1> for latest WHO documents.

In all the samples analysed, the sulphate (SO_4^{2-}) result ranged from 0.00 mg/L to 19.00 mg/L, the findings of this study are lower than those [25] in Jos South LGA of Plateau State Nigeria. However, it was found to be below the acceptable limits of 100 mg/L (NWDSQ). Nitrate (NO_3^-) range from 4.40 mg/L to 100.32 mg/L. A higher than 50.00 mg/L acceptable limit was recorded in GWW, LkBW, KBW, VBW, and VWW respectively. All the other samples were below acceptable limits. Phosphates (PO_4^{2-}) analysed in all the samples are above the 1.00 mg/L acceptable limits, it is also higher than the work of [25]. This may be a result of the use of manure or phosphate fertilizer on farmland around the study area.

Comment [A9]: I will suggest that you add the effect of high or low electrical conductivity (EC) in drinking water. Same as you did for TDS so that your readers can follow through.

Comment [A10]: If high turbidity is responsible for the haziness or high colour in the water. There should be a reason for the high turbidity of the water.

Comment [A11]: I think it is not enough to state only the values of your findings, but to give a little insight as to how they occur and what is their effects on human and animal consumption.

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

SAMPLE ID	Cd (mg/l)	Ni (mg/l)	Cr (mg/l)	Pb (mg/l)
FBW	0.0020 ± 0.001	0.00756±0.001	0.1041 ±0.009	0.0060 ± 0.013
DWW	0.0129 ± 0.009	0.0177 ± 0.009	ND	0.0027 ± 0.009
JfWW	0.0158 ± 0.003	0.3000 ± 0.003	ND	ND
McBW	0.0173 ± 0.002	0.7236 ± 0.053	ND	ND
GWW	0.0090 ± 0.005	0.0120±0.006	ND	0.0072 ± 0.010
FrBW	0.0135 ± 0.003	0.1470 ± 0.007	ND	0.0144 ± 0.005
JfBW	0.0169 ± 0.001	0.3573 ± 0.033	ND	ND
KpBW	0.0245 ± 0.001	0.2772 ± 0.049	ND	0.0048 ± 0.017
LkBW	0.0191 ± 0.008	0.2308 ± 0.008	ND	ND
FcBW	0.0170 ± 0.001	0.1975 ± 0.017	ND	0.0183 ± 0.013
TBW	0.0061 ± 0.002	0.0074± 0.003	0.0386 ± 0.082	0.0096 ± 0.015
LtWW	0.0206 ± 0.025	0.1642 ± 0.025	ND	ND
KBW	0.0091 ± 0.001	0.0169 ± 0.005	ND	0.0125 ± 0.014
MWW	0.0135 ± 0.003	0.0189 ± 0.008	ND	0.0067 ± 0.007
LBW	0.0139 ± 0.002	0.0556 ± 0.017	ND	0.4284 ± 0.003
LcBW	0.0122 ± 0.001	0.8483 ± 0.021	ND	ND
GBW	0.0093 ± 0.002	0.0061± 0.002	0.0145 ± 0.036	0.0073 ± 0.015
LtBW	0.0172 ± 0.003	0.6353 ± 0.035	ND	ND
VBW	0.0120 ± 0.004	0.0338 ± 0.008	ND	0.0024 ± 0.014
BWW	0.0095 ± 0.002	0.0073± 0.005	ND	0.0239 ± 0.012
JBW	0.0093 ± 0.001	0.0130 ± 0.008	ND	0.0052 ± 0.010
LKRW	0.0181 ± 0.004	0.5046 ± 0.062	ND	ND
VWW	0.0100 ± 0.004	0.0282 ± 0.002	ND	0.0078 ± 0.015
TkWW	0.0151 ± 0.017	0.1091 ± 0.017	ND	0.0075 ± 0.043
permissible limit WHO (2008)	0.003	0.07	0.05	0.01

n = 3

Key: ND = Not detected

The results of the analysis of heavy metal content in the water samples are presented in Table 2 above. Cd content in all the water samples used in this study ranged from 0.0020 ± 0.001 mg/l to 0.0245 ± 0.001 mg/l. These values are lower than those reported by [26] along river Dilimi in Jos North Plateau state of Nigeria, but were found to be similar to [27]. Cd was found to be greater than the WHO standard of 0.003 mg/l. Ni also range from 0.0061 ± 0.002 to 0.6353 ± 0.035 mg/l sample JfWW, McBW, FrBW, JfBW, KpBW, LkBW, FcBW, LtWW, LcBW, LtBW, LKWW and TkWW were all above the [29] recommended limit of 0.07 mg/l this are all water sampled from borehole and well, thus indicating that there is high concentration of Ni deep down the soil which is in line with the study of [28]. Cr was detected in only three sampling sites, with only one sampling point FBW having a value higher than the [29] permissible limit. Pb concentration ranges from ND to 0.4284 ± 0.003 mg/l. FrBW, FcBW, KBW, LBW, and BWW were all above the value recommended by the [29] limit of 0.01 mg/l. all except for BWW are water collected from the borehole. The sources of heavy metals that could contaminate drinking water supplies include industrial and domestic wastes as well as the release of heavy metals into streams, lakes, rivers, and groundwater because of acid rain [30]. In general, a strong relationship between contaminated drinking water with heavy metals and the incidence of chronic diseases such as heart disease, stroke, cancer, renal failure, liver cirrhosis, hair loss, and chronic anaemia has been documented [31].

Comment [A12]: Its possible that your SD is higher than your mean value because you added "0" while calculating mean and SD. I will suggest you take off the zero value and calculate with the other two values/

Comment [A13]: It will be good if your readers understand the effect of Cadmium, Nickel, Chromium and Lead in their drinking water. With one or two paragraphs, explain the effect of these heavy metals in drinking water and what they can cause of humans or animals consume them.

Table 3: Bacteriological analysis of some drinking water samples in Jos South Local Government Area of Plateau State

SAMPLE CODE	Raw count for TaBC	TaBC (CFU/mL)	MPN/100 mL of water	Bacterial isolate
FBW	5	5×10^2	5	<i>Klebsiella aerogenes</i>
DWW	19	1.9×10^3	54	<i>Escherichia coli</i> , CoNS
JfWW	5	5×10^2	< 2	<i>Bacillus species</i>
McBW	15	1.5×10^3	20	<i>Bacillus species</i> , <i>Pseudomonas aeruginosa</i>
GWW	20	2×10^3	7	<i>E. coli</i>
FrBW	96	9.6×10^3	< 2	<i>Bacillus species</i>
JfBW	99	9.9×10^3	< 2	<i>Bacillus species</i> , CoNS
KpBW	148	1.5×10^4	< 2	<i>Bacillus species</i>
LkBW	332	3.3×10^4	280	<i>Klebsiella aerogenes</i>
FcBW	78	7.8×10^3	< 2	<i>Bacillus species</i>
TBW	4	4×10^2	< 2	<i>Bacillus species</i>
LtWW	310	3.1×10^4	< 2	<i>Bacillus species</i> , CoNS
KBW	228	2.3×10^4	54	<i>Klebsiella aerogenes</i>
MWW	19	1.9×10^3	20	<i>Enterobacter species</i> , <i>Bacillus species</i>
LBW	330	3.3×10^4	< 2	<i>Bacillus species</i> , CoNS
LcBW	19	1.9×10^3	25	<i>Klebsiella aerogenes</i> , <i>Bacillus species</i>
GBW	32	3.2×10^3	< 2	<i>Micrococcus species</i>
LtBW	342	3.4×10^4	11	<i>Klebsiella aerogenes</i> , <i>Bacillus species</i>
VBW	10	1×10^3	< 2	<i>Bacillus species</i>
BWW	13	1.3×10^3	54	<i>Pseudomonas aeruginosa</i>
JBW	80	8×10^3	< 2	<i>Micrococcus species</i>
LKRW	14	1.4×10^3	11	<i>Klebsiella aerogenes</i>
VWW	9	9×10^2	5	<i>Enterobacter species</i>
TkWW	44	4.4×10^3	< 2	<i>Bacillus species</i> , CoNS

Key: * = Too Few to Count (TFTC), ** = Too Numerous To Count (TNTC), TaBC = Total Aerobic Bacterial Count, MPN = Most Probable Number, CFU = Colony Forming Unit, CoNS = Coagulase-negative Staphylococci.

Table 3 above presents the result for the bacteriological content of the water samples. The results of the study show that most of the household water samples were contaminated with different species of bacteria. The FBW, LkBW, KBW, LcBW, LtBW, and LKWW were contaminated with *klebsiella aerogenes*, the highest count for *klebsiella aerogenes* was recorded in LtBW with a total count of 3.4×10^4 CFU/mL, whereas the lowest was recorded in LKWW with a total count of 1.4×10^3 . *E. coli* was found in samples DWW and GWW, with the highest total bacteria count of 2×10^3 CFU/mL recorded in GWW. The detection of coliforms indicated that the water samples were contaminated by faecal matter [32]. The majority of coliforms are non-pathogenic, however, some strains of coliforms such as *Escherichia coli* can cause diarrhoea [33]. *Bacillus species* total count ranges from 5×10^2 CFU/mL to 3.3×10^4 CFU/mL and was found in almost all the samples. CoNS count ranges from 3.3×10^4 CFU/mL to 1.9×10^3 CFU/mL respectively. Generally, bacteria can cause water-borne diseases such as gastrointestinal illness, diarrhoea, cholera and fever [34]. The total bacteria count in this study was found to be lower than those reported by [34] in Jos South LGA of Plateau State, Nigeria.

Conclusion

The examination of water quality parameters from different sources in Shendam Local Government Area of Plateau State revealed that the water contained high levels of toxic metals such as Cadmium and Nickel, whereas chromium and Lead were below the respective permissible limits. Most of the physicochemical parameters were within acceptable limits except Phosphate which was above the

Comment [A14]: Also in your method of analysis, add or explain briefly how you achieve your bacteriological analysis. Same way you did for the physicochemical analysis.

Comment [A15]: Also, you can take a short paragraph to explain the meaning of the acronym you stated.

Comment [A16]: There is the possibility of getting high bacteria count if the haze and colour are very high. Please check your data again.

acceptable limits. The bacteriological study of the water samples also reveals that the water samples were all polluted with bacteria and coliforms. It is therefore concluded that the water samples require treatment before consumption to avoid water-related diseases.

Reference

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Comment [A17]: This reference is very old. I will suggest you use online resources to get the latest WHO documents.

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