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STUDIES ON SOME PHYSICO-CHEMICAL PARAMETERS AND BACTERIAL DIVERSITY AND ABUNDANCE OF RIVER ADO, KARU L.G.A. NASSARAWA STATE

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Abstract

The current investigation was aimed to determine the composition and diversity of bacteria and macroinvertebrates of River Ado. Water samples were collected from four different points along the river for six months. Using standard methods, total heterotropic bacteria count, total coliform, total faecal coliform count were determined. Heterotropic counts ranged from 52.09±2.11 to 29.12±0.63 (cfu/ml). Total coliform ranged from 38.10±1.01 to 19.16±0.11 (cfu/ml). Total Faecal coliform ranged from 27.08±1,15 to 14.07±0.21 (cfu/ml). Six bacterial genera which includes *E. coli, Klebsiella* species, *Enterobacter* species,

Introduction

A safe, reliable, affordable, and easily accessible water supply is essential for good health. Yet, for several decades, about a billion people in developing countries have not had a safe and sustainable water supply. It has been estimated that a minimum of 7.5 litres of water per person per day is required in the home for drinking, preparing food, and personal hygiene, the most basic requirements for water; at least 50 litres per person per day is needed to ensure all

Salmonella species, *Shigella* species, *Citrobacter* species were isolated from the water samples. *Shigella* species and *Citrobacter* species had the highest frequency of 15. The physico-chemical parameters showed high significant difference ($P<0.05$) across the sampling months. Temperature, Electrical conductivity, Total dissolved solids, water hardness, Alkalinity, Chlorine, Sulphate, Phosphate and Calcium were significantly affected by seasons.

Keywords: Bacteria, physicochemical parameters, faecal coliform, water source, karu L.G.A

Personal hygiene, food hygiene, domestic cleaning, and laundry needs [1]. This domestic water consumption is dwarfed by the demands of agriculture and ecosystems, even in wealthy countries where per capita domestic water consumption greatly exceeds these figures [2]. To cover all these requirements and to avoid water stress, experts generally agree that about 1,000 cubic meters of freshwater per capita per year is needed [3].

Open dumping of solid waste remains the prevailing form of waste disposal in developing countries like Nigeria. Contamination of water bodies has become an issue of serious environmental concern [4]. Since urban population is increasing due to various factors like better employment opportunities, and concentration of industries than the rural areas. Municipal solid waste management gets the lowest priority, mainly because disruptions and deficiencies in it do not directly and immediately affect public life and cause public reaction [5]. Solid waste generated from residential, commercial and institutional activities are not properly monitored by municipal bodies. Therefore, supply of adequate fresh water in large quantity to meet the increasing

population's demand and maintaining the quality is now a thing of concern [6]. Hence, contamination of ground water through the infiltration of leachates via the soil and rocks needs to be avoided. It normally takes many years and takes place within a particular distance from the dump site. Since pipe born water is not readily available in many parts of the country and even in the urban areas the pipe water supply is not adequate [7]. With these problems there is need for other sources of water supplies such as ground water, but due to lack of proper waste management the groundwater is usually affected by the refuse dump site. Water is said to be polluted when the water body is adversely affected by both the organic and inorganic contaminants [8].
According to Food and Agricultural Organization (FAO) African countries, particularly Nigeria, water related diseases had been interfering with basic human development. Improper management of huge amount of wastes generated by various anthropogenic activities indiscriminate dumping of refuse faecal, agricultural and industrial contamination or pollution which is continually threatening aquatic ecosystem due to increasing exposure of untreated wastes and urbanization in developing countries has gradually led to the deterioration of water bodies in recent years. Major agents of surface water pollution include bacteria, viruses and other substances present in such concentration or numbers to impair the quality of the water rendering it less suitable or unsuitable for its intended use and presenting a hazard to man and other components of the ecosystem [9].
The increase in microorganisms and anthropogenic contaminants enhances the risk of pathogen outbreaks, bacterial antibiotic resistance, and public health costs. Incidence of diseases such as typhoid, paratyphoid, giardiasis, infectious hepatitis, leptospiriosis,

schistomiasis, shigellosis, amoebiasis etc., have been implicated in the consumption of contaminated water. Some of these pollutants are decomposed by the action of micro-organisms through oxidation and other biochemical processes. The major problem is the reconcentration of these harmful substances in natural food chain. During the decomposition process, natural bacteria and protozoan in the water source utilize the oxygen dissolved in the water. This could significantly reduce the oxygen level to less than two parts per million [10].

Constant monitoring of the quality of surface water cannot be overstressed especially now that increase in population has resulted in generation of more waste thus exposing the water to more pollutants.

Materials and Methodology

Study area

The study area is River Ado located in Karu L.G.A. Nassarawa State. The area lies within the latitude 9 01 N and longitude 7 37 E some 100km North West of Lafia, the State Capital and about 15km east of Abuja, the Nigerian Federal Capital. The river has its source from the Gurku Mountains in Karu L.G.A. of the State [11].

The topography of the area is undulating terrain occasionally punctuated by outcrops of hills that are dissected by a network of small and seasonal rivers. Major river systems in the area include Uke river system which is a tributary of the Okawa river and flows through the northwestern corner of Karu hills. Its major tributaries are River Ado, Antau and Obi [12].

Tropical humid climate characterized by two distinct seasons is experienced in the study area. The wet (rainy) season last from the ending of March and ends in October while the dry season is experienced between November and February [13].

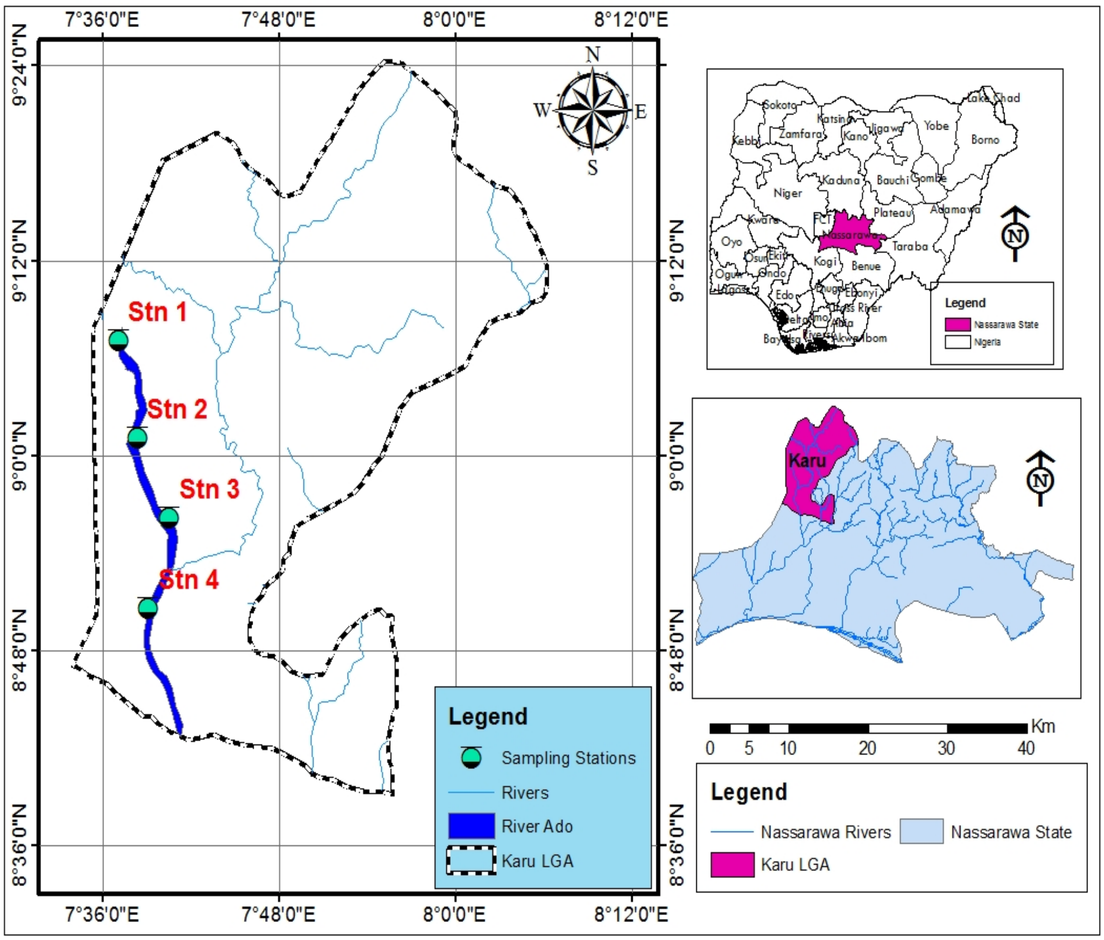

Figure:1. Map of Karu LGA Showing Sampling Stations.
Source: GIS and Remote Sensing Software Arc Map 10.1 Department of Geography ABU, Zaria.

Water sample collection

Four sampling stations were selected, located in the upper, middle, and lower stretches of the river. The selection of sampling sites was based on the magnitude of human activities along the river. The first station was at the upper stretch of the River close to the Source of the river at Gurku Mountain, this served as the control. The second station was at Orange Market where the wastes disposed are mainly food waste. The third station was at Adehi Petrol Station where the wastes disposed are mainly water sachets and bottles. Station four was at ECWA Church, Where the wastes disposed are mainly household waste. The distance between the sampling stations was 5km apart. All the stations are located in Karu L.G.A. of Nassarawa State.

The water was sampled at the surface level by sliding the 1 liter pre-labelled bottles over the upper surface of the water with their mouth open against the water current to permit undisturbed passage of the water into the bottle, the bottles was first rinses with the water before final collection of the water sample, the bottles was securely covered with tight lid to prevent leakage and kept in a container containing ice block during transport to Central Research Laboratory, Nassarawa State University, Keffi for analysis of physico-chemical.

Bacteriological Assessment

The bacteriological assessment such as total heterotrophic, total coliform count and total feacal count of the water samples was carried out according to the method described by Abolude *et al.,* [14] and Anyanwu and Okoli [15]. A volume of 1 mL from each water sample was carefully transferred into first test tube containing 9 mL of sterilized distill water, serially diluted was carried out by transferring 1ml from the first test to the second test tube also containing 9ml of sterilized distill water these step was repeated till the 10^{th} test tube, then 0.5 mL aliquots of 10^{-6} were spread onto duplicate nutrient agar plates for the total heterotrophic count, spread on MacConkey agar for total coliform

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count and spread on Eosine Methylene Blue agar for total feacal count. The plates were incubated aerobically at 37°C for 24 hours, and the mean number of discrete colonies on each plate was recorded as colony forming unity per milliliter (CFU/mL).

The physicochemical quality of the water sample was analyzed for pH, Temperature, Electrical Conductivity, Total Dissolved Solids, water hardness, dissolved oxygen, alkalinity, chloride, sulphate, nitrates, phosphate, and Calcium.

Results

The cultural, morphological and biochemical characteristics of the bacteria isolated from different points in river Ado is as given in Table 1. *E. coli* grow Pinkish colony on MaConkey agar and greenish metallic sheen colony EMB agar, Indole positive, methyl-red positive, *Klebsiella* species grow Pink and mucor colony on MaConkey agar, Indole negative, methyl-red positive, Voges-Proskauer positive.

Table 1. Cultural, morphological and biochemical characteristic of bacteria isolated from river Ado

Biochemical characteristics										
Cultural	Morphology	Gram test	In	MR	VP	CuT	Ox	TSI	OF	Inference
Pinkish colony on MCA and greenish metallic sheen colony EMB agar	Rod shape	Gram negative	+	+	-	-	+	+	+	*E. coli*
Pink and mucor colony on MaC agar	Rod shape	Gram negative	-	+	+	-	-	-	+	*Klebsiella* species
Mucoid, pale, opaque cream to pink on MCA	Bacilli	Gram negative	-	-	+	+	-	+	+	*Enterobacter*species
Colorless colonies on	Rod shape	Gram negative	+	+	-	+	+	-	-	*Salmonella* species

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DCA and black metallic sheen on BSA										
Whitish/ colorless, transparent on SSA	Rod shape	Gram negative	+	+	-	+	+	-	-	*Shigella* species
Entire, creamy, raised	Cocci	Gram negative	-	-	+	-	-	+	-	*citrobacter*species

Note: - = Negative; + = positive; OF= Oxidative/Fermentation, CT = Citrate; VP = Voges-Proskauer; MR= methyl-red, In = Indole; TSI=Triple sugar iron, CuT= Citrate utilization test

The bacteria count from different point in river Ado is as given in Table 2. The total heterotrophic bacteria count from 1 was 48.21 x 10^{-6} cfu/ml, total coliform count was 32.18 x 10^{-6} cfu/ml and total feacal count was 24.08 x 10^{-6} cfu/ml. From 2 the total heterotrophic bacteria count was 35.11 x 10^{-6} cfu/ml, total coliform count was 23.09 x 10^{-6} cfu/ml and total faecal count was 19.01 x 10^{-6} cfu/ml. From the 3 the heterotrophic bacteria count was 29.12 x 10^{-6} cfu/ml, the total coliform count was 19.16 x 10^{-6} cfu/ml and total faecal count was 14.07 x 10^{-6} cfu/ml. From 4 the heterotrophic bacteria count was 52.09 x 10^{-6} cfu/ml, the total coliform count was 38.10 x10^{-6} cfu/ml and total faecal count was 27.18 x 10^{-6} cfu/ml respectively.

Table 2. Total bacteria count from different points in river Ado

Samples	Count (CFU/mL x 10^{-6})		
	Total heterotrophic bacteria	**Total coliform**	**Total faecal coliform**
1	48.21±1.41	32.18 ±0.11	24.08 ±0.15
2	35.11±0.23	23.09 ±0.31	19.01 ±0.35
3	29.12 ±0.63	19.16 ±0.11	14.07 ±0.21
4	52.09±2.11	38.10±1.01	27.18 ±1.15

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Bacteria occurrence from different point in river Ado

The bacteria occurrence from different point in river Ado is as given in Table 3. The occurrence *E. coli* from 1 was (63.6 %), from 2 and 3 was (45.4 %) and from 4 was (37.5 %). The occurrence of *Klebsiella* species from 1 was (81.8 %), 2 was (72.7 %), 3 was (54.5 %) and from 4 was (40.0 %), from 1 *Enterobacter* species was (45.4 %), 2 was (27.2 %) and from 3 was (50.0 %). The occurrence of *Salmonella* species from 1 was (63.6 %), from 2 (54.5 %), from 3 it was (27.2 %) and 4 was (75.0 %). The occurrence of *Shigella* species from 1 was (36.3 %), from 2 and 3 was (27.2 %) and from 4 was (80.0 %). The occurrence of *Citrobacter* species from 1 was (54.5 %), (45.4 %) from 2 and 4 was (36.3 %) from 4water was (66.6 %).

Table 3: Bacteria occurrence from different point in river Ado

	No (%) isolated							
Bacteria isolated	**No. sample**	**1**	**No. sample**	**2**	**No. sample**	**3**	**No. sample**	**4**
E. coli	5	2 (40.0)	5	3(60.0)	5	5(100)	5	4 (80.0)
***Klebsiella* species**	5	1(20.0)	5	4(80.0)	5	3(60.0)	5	2(40.0)
***Enterobacter* species**	5	3(60.0)	5	2(40.0)	5	0(0.0)	5	3(60.0)
***Salmonella* Species**	5	2(40.0)	5	2(40.0)	5	3(60.0)	5	4(80.0)
***Shigella* species**	5	4(80.0)	5	3(60.0)	5	3(60.0)	5	5(100)
***Citrobacter* species**	5	3(60.0)	5	5(100)	5	4(80.0)	5	3(60.0)

Table 4: Seasonal Variation in physicochemical parameters of River Ado

	SEASONS		
	Dry	Wet	P-value
pH	6.73±0.23 [a]	6.96±0.33 [a]	0.081
Temp (°C)	28.94±1.88 [a]	26.74±0.16[b]	0.001
EC (µs/cm)	396.25±237.32 [a]	87.09±17.19[b]	0.001
TDS (mg/l)	245.43±155.26 [a]	52.21±10.26[b]	0.001
H (mg/l)	29.33±10.27 [a]	31.50±2.61 [a]	0.493
DO (mg/l)	2.81±1.46[b]	5.12±0.76 [a]	0.002
BOD (mg/l)	1.41±0.25[b]	3.88±0.34 [a]	0.000
Alk mg/L.CaCO3	59.92±21.98 [a]	44.33±12.79[b]	0.004
Cl (mg/l)	19.53±12.67 [a]	20.65±6.98 [a]	0.699
SO4 (mg/l)	9.45±7.26 [a]	0.37±0.27[b]	0.001
N (mg/l)	6.68±5.24 [a]	4.93±1.65 [a]	0.190
PO4 (mg/l)	2.33±1.10 [a]	1.13±0.41[b]	0.005
Ca (mg/l)	9.51±1.74[b]	20.05±6.51[a]	0.000

KEY: DO – Dissolved Oxygen, Cl – Chloride, PO4 –Phosphate, N – Nitrates, SO4, - Sulphate, pH – pH value, Temp. – Temperature, EC – Electrical Conductivity, TDS – Total Dissolved Solids, H – Hardness, BOD – Biological Oxygen Demand, Ca – Calcium, Alk – Alkalinity.

Note: Mean with the same superscript are not significantly different at $p > 0.05$ across the rows

Table 5: Seasonal Variations in physicochemical parameters of River Ado among the sampling Stations

Parameters	Station 1	Station 2	Station 3	Station 4
pH	6.84±0.12a	6.88±0.21a	6.79±0.10a	6.86±0.05a
Temp(°C)	27.80±0.76a	27.75±0.75a	27.83±0.75a	27.98±0.75a

EC	147.83±28.71a	202.32±78.25a	312.82±124.78a	303.72±116.21a
TDS (mg/l)	89.28±16.99a	124.88±50.21a	193.62±80.20a	187.48±74.68a
H	29.50±2.49a	35.00±4.66a	30.00±1.59a	27.17±2.27a
DO (mg/l)	4.30±0.71a	4.28±0.75a	3.47±0.71a	3.80±0.62a
BOD (mg/l)	2.50±0.49a	2.62±0.64a	2.68±0.52a	2.78±0.61a
Alkmg/L.	31.00±1.46b	49.50±2.96a	65.33±9.99a	62.67±5.23a
Cl (mg/l)	11.73±1.54b	13.23±1.48b	28.4=58±3.89a	26.82±3.22a
SO4 (mg/l)	0.63±0.36a	8.27±4.13a	6.88±2.98a	3.85±1.69a
N (mg/l)	9.43±2.38a	4.50±0.73b	5.32±1.21ab	3.97±0.60b
PO4 (mg/l)	1.45±0.46a	2.08±0.57a	1.87±0.36a	1.52±0.28a
Ca (mg/l)	10.50±1.66a	12.82±1.75a	18.62±3.59a	17.18±3.41a

KEY: DO – Dissolved Oxygen, Cl – Chloride, PO4 –Phosphate, N – Nitrates, SO4, - Sulphate, pH – pH value, Temp. – Temperature, EC – Electrical Conductivity, TDS – Total Dissolved Solids, H – Hardness, BOD – Biological Oxygen Demand, Ca – Calcium, Alk – Alkalinity

Discussions

The level of total heterotrophic bacteria count from 1 was high 48.21 x 10^{-6} cfu/ml, coliform was 32.18 x 10^{-6} cfu/ml and total feacal count was 24.08 x 10^{-6} cfu/ml but is lower than study reported by Akpan-Idiok *et al.*, [16] 52.18 x 10^{-6} cfu/ml coliform and total feacal count of 44.08 x 10^{-6} cfu/ml in Yala, Cross River State. The total heterotrophic bacteria count, coliform and faecal count observed from 2 and 3 in this study was high but similar to study reported by Yusufu and Egwujeh [17] in Anyigba town, Kogi State, Nigeria, this showed that river Ado was highly contaminated with faecal matters either from human or animal making it unsafe for drinking. This was confirmed by different coliform bacteria isolated from different water sources sampled from the locations under study which were highly contaminated with one or more bacteria namely *Escherichia coli*, *Klebsiella* spp and *Salmonella* spp. The most predominant is the enteric coli form *Klebsiella* spp followed by *Escherichia coli* and *Salmonella typhi*. These are pathogenic organisms mainly of faecal origin. Any water source used for drinking or cleaning purpose should not contain any organism of faecal origin. Presence of enteric coliforms especially *Escherichia coli* makes the water samples unsuitable for human consumption according to the guidelines set by WHO for the evaluation of bacteriological quality of drinking water [19]. In this study, the pH regime of the study area both station wise and time wise was slightly acidic except for July when the water pH was observed to be slightly alkaline. The generally higher pH values recorded in the wet season and wet season months may attribute to the presence of organic load in the water body. Studies by Talalaj [20] showed that an increase in the organic content of a medium will trigger increased pH. However, the current pH levels observed for River Ado is within 6.5 – 8.5 and thus favorable for aquatic productivity as opined by WHO [21] and Hague *et al.*, [22]. River Amba in Nassarawa State also demonstrated suitable pH for aquatic fauna [23]. A recent study by Umar *et al*. [24], also shows that Ogele stream a water body within the same geographical zone had its pH to be suitable for aquatic life. The high temperature levels observed in the dry season in this study is related to the incidence of high solar radiations that is associated with the dry season in tropical environments [25]. In a similar study, higher temperature was recorded in dry season than in rainy season for River Pra and Adeyemo Stream [26][27]. Increase in temperature decreases the amount of dissolved oxygen (DO), increases biochemical oxygen demand (BOD) and

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accelerates nitrification and oxidation of ammonia to nitrates as observed in this study. Higher temperature also increases toxicity of many substances (pesticides, heavy metals) and susceptibility of organisms to toxicants. This implies that the abundance and diversity of the aquatic organisms of River Ado is likely to be compromised or reduced in the dry seasons compared to the rainy season. The high levels of conductivity in dry season and station three reflects the amount of substances dissolved in it, such as phosphate, nitrate and nitrites, different ions vary in their ability to conduct electricity [28]. Gadzama and Mondo [29] reported that high conductivity in dry season could also be attributed to high rate of evaporation an effect that is related to increased concentration of ions as water volume decreases. While the relatively low conductivity observed at station 1 which was the control station is hereby attributed to the low anthropogenic activity noticed during the sampling period. The composition, distribution and abundance of aquatic organisms could be affected by the electrical conductivity of the water. It is also used as an index of chemical pollution [30]. The relatively high-water hardness observed in the wet season coincided with calcium content of the river in the wet season too. The hardness of water is influenced by the content of calcium and magnesium salts [31]. Hardness is important to aquaculture in that calcium and magnesium are essential in the biological processes of phytoplankton and aquatic animals for bone, shell and scale development [32][33][34]. The present investigation therefore shows that in future, the abundance of macroinvertebrates and macrobenthic like molluscs may be more favored in the wet season than in the dry season due to high calcium and hardness content that are important for that survival. The higher dissolved oxygen observed at station 1 is related to the low human activities that characterized the River at the time of sampling. The general decrease in the dissolve oxygen content of the River across the stations reflects the deteriorating nature of the stations as a function of heavy organic loadings observed at the time of sampling. Higher dissolved oxygen observed in the wet season is attributed to the fact that turbulent waterbodies have higher levels of dissolved oxygen than stagnant pools. A phenomenon that is only common in the wet season [35]. The dissolved oxygen content of River Ado is generally greater than 2 mg/L and thus does not constitute a threat to aquatic life. The BOD levels shows that more organic pollution occurred in the wet season than in the dry season, this may be due to increased microbial activities. While it was observed that the level of alkalinity during the study period and across the stations is suitable for aquatic life as stipulated by USEPA [36]. Increased dilution may be responsible for the lower Sulphate concentration observed in the wet season than in the dry season. Also, increased chlorine content of the river in wet season may be related to surface run-off from municipal wastes and fertilizers from farms. Nitrate and phosphates were higher in dry season than wet season, this could be due to the various factors such as decomposition of organic matters, disposal of human and animal wastes and from fertilizers used within the immediate catchment area of the River in the dry season. The anthropogenic activities around the stations did not significantly alter the Chlorine, Sulphate, nitrate, and calcium levels. This shows that the stations relatively receive similar effect of the sources of these parameters. Although, generally, the control station was showed lower levels of the determined parameters in indication of relatively undisturbed environment.

The microbiological quality of drinking water has brought about great preoccupation to mankind because of implied public health repercussions. Bad quality of drinking water, poor sanitation and hygiene have been pointed out among the top risk factors for health burden in developing countries [37].

Conclusion

The physico-chemical parameters showed high significant difference (P<0.05) across the sampling months. Temperature, Electrical conductivity, Total dissolved solids, water hardness, Alkalinity, Chlorine, Sulphate, Phosphate and Calcium were significantly affected by seasons. The Shannon – Weiner diversity indices indicates wet season (2.22) to be more diverse than dry season (1.77). Station 3 was observed to be the least diverse (2.20) while station1 was most diverse (2.24). This study shows that, phosphate, Alkalinity, Hardness, calcium, DO and BOD influenced the survival and distribution of bacteria such as *Escherichia coli*, *Klebsiella* spp and *Salmonella* spp.

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Conflict of interest

Authors have declared that no conflict of interests of any kind exists.

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