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WATER QUALITY ASSESSMENT: BACTERIOLOGICAL AND PHYSICOCHEMICAL EVIDENCES FROM RIVER NGALDA, NORTHEAST NIGERIA

*[1]Raji, M., [2]Adeleye, A.O., [1]Amoo, F.K., [1]Saadatu, A.Y., [1]Isah, S.F. and [2]Amoo, A.O.

[1]Department of Microbiology and Biotechnology, Faculty of Science, Federal University Dutse, Nigeria.

[2]Department of Environmental Sciences, Faculty of Science, Federal University Dutse, Nigeria.

*Corresponding Author: madinat_raji@yahoo.com

ABSTRACT

Pollution of surface water is a serious problem in the world over. This study was carried out with a view to determining the sanitary status of River Ngalda which residents solely depend on for their numerous water needs. Bacteriological and physicochemical analyses were conducted on the quality and safety of the river water for human consumption. River water was aseptically collected from three sampling points; A, B and C. Most Probable Number (MPN) method was employed for the bacteriological assay while pH, temperature, turbidity, taste and odour, alkalinity, total hardness (TH), calcium, magnesium, chloride, electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), and total solids (TS) were analysed for the physicochemical attributes of the sampled river water. Results obtained indicate that the river water samples from Point A (540 mL) and Point C (17 mL) recorded the highest and lowest MPN/100mL respectively. The pH of the river water ranged between 6.0 and 6.4, turbidity ranged between 1658 and 3310 NTU, EC ranged between 8.21 and 109.7 µS/cm, TDS ranged between 30.0 and 54.3 mg/L while temperature was 25^0C across all the sampling points. However, TS, TSS, turbidity and coliform counts were above WHO permissible limits while magnesium, calcium, EC, alkalinity, chloride, pH, TH, odour and colour conformed to recommended standards. It is therefore recommended that the water from River Ngalda should be treated with appropriate disinfectants before usage for home purposes most specifically drinking so as to avert imminent dangers accruable from the consumption of polluted water.

Keywords: River water, Most Probable Number, River Ngalda, Total and Faecal coliforms.

INTRODUCTION

It has been documented in the literature that pollution of a typical river which is an example of surface water emanates from different sources and therefore, there is a need to subject such water to effective treatment before it can be certified fit for human consumption [1, 2]. The quality of water meant for human consumption is a prevailing environmental determinant of public health [1]. This author further reiterated that provision of potable water for human consumption remains the surest way of preventing and controlling water borne diseases. Water plays avital role in wherewithal of life and it is a significant pillar of health determinant, owing to the fact that 80% of diseases in developing countries have been directly linked with lack of potable water [2, 3]. Water pollution has been implicated in the transmission of infectious diseases; dysentery, cholera, diarrhea, typhoid, shigellosis, salmonellas is coupled with fungal, viral, and parasitic infections [4].

These days, the need to assay the bacteriological quality of water has become mandatory [5-8] owing to the fact that it has direct effects on the health of individuals that consume such water. The acknowledgement of the link between pollution and the utmost need to protect public health, recreation and fisheries production ultimately gave birth to the early development of water quality regulations and monitoring methods [9]. There are a wide range of physicochemical attributes which should be present within allowable limits that water needs to possess before it can be considered potable enough for human consumption [10]. This author listed these attributes as pH, turbidity, temperature, electrical conductivity (EC), alkalinity, total hardness (TH), total dissolved solids (TDS), total suspended solids (TSS), total solids (TS), chloride, magnesium and calcium.

At any point in time, the quality of any river water replicates numerous key impacts ranging from climatic conditions, atmospheric inputs, lithology of the basin and anthropogenic inputs [11]. These days, the quality of surface water has become a solemn issue deliberated upon within the global scientific community, specifically in developing countries [12]. Ngalda village is remotely located thereby making the provision of municipal water that is wholesome for human consumption completely out of reach for residents. Consequently, residents of the village solely depend on the water from River Ngalda as the main household supply for their domestic activities and drinking.

Owing to the susceptibility of surface water sources to various forms of pollution which may invariably render it unfit for human consumption, this study was conducted with a view to assessing the potability of the water obtained from River Ngalda.

MATERIALS AND METHODS

Study Area

River Ngalda is in Fika Local Government Area of Yobe State, Nigeria. It is geographically located on Longitude $11^0$05'40.9"N and Latitude $11^0$22'48.6"E (Figure 1).

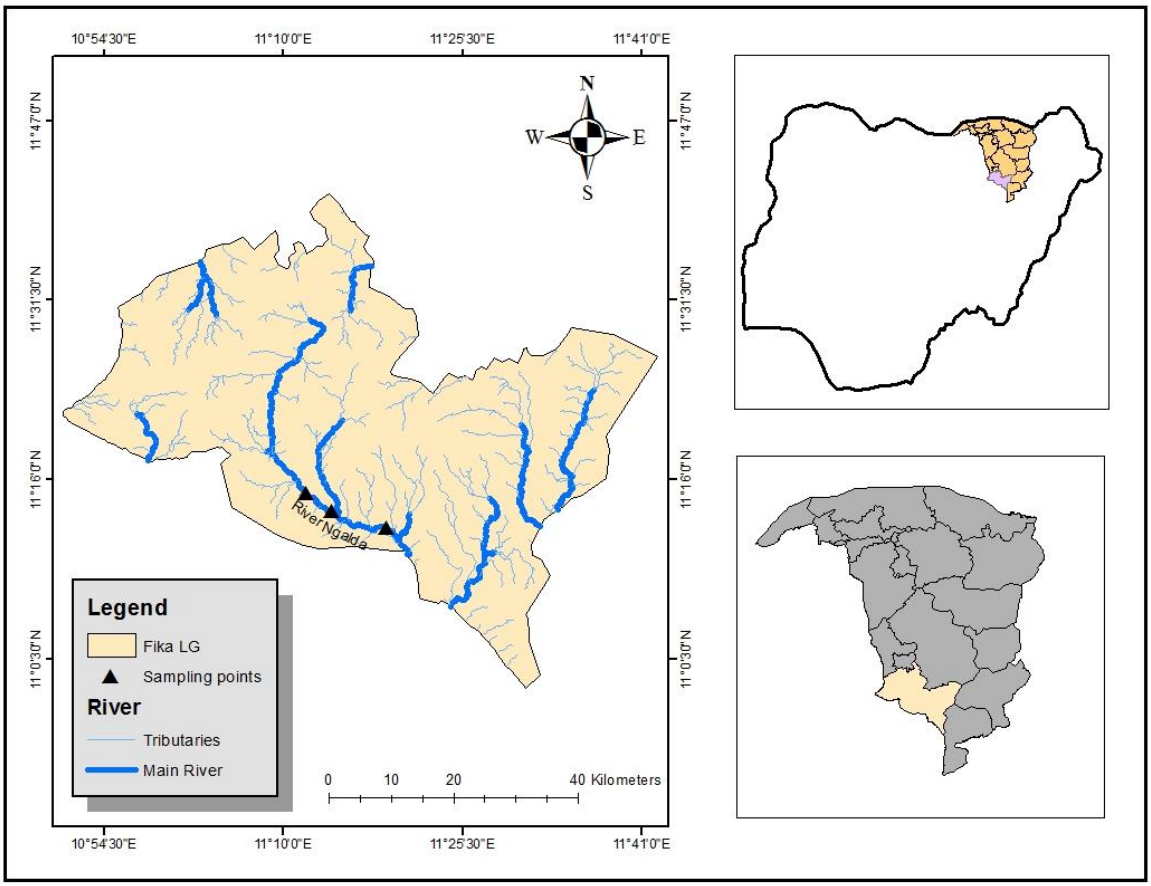

Figure 1: A Map showing the Sampling Points on River Ngalda

Water Sample Collection

River water was collected from three (3) sampling points along the flow of the river. The sampling points were tagged as Point A (Up River), Point B (Mid River) and Point C (Down River). Collection of water samples was done at the commencement of wet season in May, 2019.

Espousing the method described by Amoo *et al.* [5], water samples were aseptically collected in clean sterile one (1) litre plastic containers dipped with de-ionized water [13] and subsequently rinsed with the river water before final collection. Each water sample bottle was well labeled according to its respective sampling location. All the samples were preserved in a cooler stocked with ice cubes and immediately transported to the laboratory for onward physicochemical and bacteriological analyses.

Physicochemical Analysis of the River Water Samples

The three samples were subjected to physicochemical analysis: odour, pH, turbidity, temperature, EC, alkalinity, TH, TDS, TSS, TS, chloride, magnesium and calcium. The odour was determined from perceiving the water sample directly. During odour analysis, if odour was perceived, it was recorded as objectionable and if it was odourless, it was recorded as unobjectionable. pH was detected using pocket pro pH tester, 2100Q portable turbidimeter was used for measuring turbidity, temperature was measured using Thomas high-accuracy thermometer, bicarbonate test was adopted for determining alkalinity, HQ430D laboratory single input multi-parameter meter was employed for determining TDS, TSS, TS, calcium and magnesium while SP510 hardness analyzer was used for determining TH.

Bacteriological Assay of the River Water Samples

Bacteriological tests (presumptive, confirmed and completed) were conducted for assessing total and faecal coliforms in the river water sampled as done by Adeleye *et al.* [14].These tests were conducted as described below:

Presumptive Test

The total coliform in the river water was detected through the procedure prescribed by Aryal [15]. In this procedure, a three (3) tube assay of the Most Probable Number (MPN) technique and sterilized MacConkey broth was employed. Fifty (50) mL of river water sampled was aseptically allotted into an already sterilized test tube having 50mL of double strength MacConkey broth, 10mL of water was allotted into five (5) already sterilized test tubes having10mL single strength MacConkey broth and 1mL of river water was dispensed into five (5) test tubes having 5mL single strength MacConkey broth. Already sterilized Durham tubes were placed in an inverted position in all the test tubes used. The test tubes were incubated at 37^0C for 48hours so as to estimate total coliforms and at 44 ^{0}C for 48 hours for the estimation of

faecal coliforms. Additionally, the incubated test tubes were screened for acid and gas production after incubation periods. A change in the colour of the broth from reddish purple to yellow was documented as acid production while the manifestation of bubbles and gas entrapment in the Durham tubes was documented as production of gas by the coliforms. The MPN was successively estimated using suitable MPN table.

Confirmed Test

Confirmed test was staged following the procedure outlined by Ochei and Kolhatkar [16]. It was done by transferring a loopful of culture from positive test tubes in the presumptive test into sterile petri dishes having sterilized Violent Red Blue Agar (VRBA) and test tubes having sterilized peptone water aseptically. The petri dishes and test tubes were incubated at 37^0C for 48hours for total coliforms and 44 ^{0}C for 48hours for faecal coliforms. Subsequently, gas and indole production in peptone water were documented being positive for the presence of *Escherichia coli.* Again, development of pink colonies with metallic sheen, decolorizing at the center of VRBA plates established the presence of coliforms.

Completed Test

This test was carried out following the procedure described by Willey *et al.* [17] and WHO [18]. Positive results from the confirmed test were aseptically streaked on sterile petri dishes containing sterilized Eosin Methylene Blue (EMB) agar with the sole aim of obtaining discrete colonies. The petri dishes were incubated at 37^0C for 48 hours. The emergence of green metallic sheen colonies on the EMB was documented as a completed test for further identification of coliforms or faecal coliforms (*Escherichia coli*).

Morphological Attributes and Biochemical Tests Conducted on the Bacterial Isolates

Gram staining was done following the procedure recommended by Olutiola, Famurewa, and Sonntag [19] with a view to examining the morphological attributes of the bacterial isolates. Having gram stained, following the recommendation of Barrow and Feltham [20] on the shape and gram reaction derived, series of biochemical tests ranging from voges-proskauer, gelatin, triple sugar iron, catalase, mannitol, oxidation fermentation, indole, citrate, urease, nitrate reduction, lactose, glucose and methyl red were done following the recommended procedures [3, 15, 16, 19, 21] so as to confirm the identity of the bacterial isolates that were isolated.

Data Analysis

The most probable number (MPN) analysis was adopted to estimate the random distribution of microorganisms per volume in a given water sample was employed to analyze data derived from the presumptive, confirmed and completed assays conducted [15]. Data generated were abridged in Tables and compared with WHO permissible standards.

RESULTS AND DISCUSSION

Results of the physicochemical attributes of the river water detected in the three sampling points are depicted in Table 1. It can be seen that all the river water from the sampling points recorded the same temperature (25 ^{0}C). The total hardness of the river water samples ranged from 44.8 to 85.29 mg/L while TS ranged from 914.4 to 1718.3 mg/L (Table 1).

Table 1: Physicochemical Properties of the River Water Detected from the Sampling Points

Parameters	Point A	Point B	Point C	WHO Permissible Standards
Turbidity (NTU)	1658	3310	2032	5
pH	6.0	6.4	6.4	≥7 to ≤ 9.2
Alkalinity (mg/L)	30	60	40	250
Chloride (mg/L)	16.78	11.35	15.79	200
Calcium (mg/L)	14.44	14.44	15.79	≥100 to ≤ 300
Magnesium (mg/L)	2.19	11.06	6.02	150
Temperature (^{0}C)	25.0	25.0	25.0	No specified standard
TH (mg/L)	44.89	85.29	47.13	150 to 500
Odour	Odourless	Odourless	Odourless	Odourless
Taste	Tasteless	Tasteless	Tasteless	Tasteless
TSS (mg/L)	860	1664	97	100
EC (µS/cm)	108.2	109.7	60.1	1000
TDS (mg/L)	54.2	54.3	30.0	500
TS (mg/L)	914.2	1718.3	1000	600

Note: TH=Total Hardness; TSS=Total Suspended Solids; EC=Electrical Conductivity; TDS=Total Dissolved Solids; TS=Total Solids; Tasteless= Absence of taste (if EC<1000)

As depicted in Table 2, all the river water samples assayed bacteriologically had bacterial growth across the dilution strengths employed. Acid production was witnessed across all dilution strengths while gas production was evident in all the Durham tubes inserted in all the test tubes across the dilution strengths (Table 2).

Table 2: Bacteriological Assay of the Sampling Points in River Ngalda

SP	Growth			Acid Production			Gas Production		
	50 mL	10 mL	1 mL	50 mL	10 mL	10 mL	50 mL	10 mL	1 mL
Point A	Yes	Yes	Yes	+	+	+	+	+	+
Point B	Yes	Yes	Yes	+	+	+	+	+	+
Point C	Yes	Yes	Yes	+	+	+	+	+	+

Note: SP= Sampling point; + = Positive

It can be seen that the MPN values ranged from 17 to 540 mL across the three sampling points (Table 3). River water samples from Point A (540 mL) and Point C (17 mL) recorded the highest and lowest MPN/100 mL respectively (Table 3).

Table 3: Coliform Count of the Sampling Points in River Ngalda

	MPN Ratio	Coliform forming unit (CFU/100mL)	Estimated coliforms
Point A	5:5:2	540	54000
Point B	3:5:1	350	35000
Point C	3:3:0	17	1700

Results gotten from Gram staining indicate the bacterial isolates from the river water samples as reddish gram negative rods that were positive to catalase, indole, mannitol, glucose and methyl red tests while they were negative to citrate, gelatin, urease and triple sugar iron (Table 4).

Table 4: Morphological Attributes and Biochemical Tests of the Bacterial Isolates

	Bacterial Isolates		
Attributes/Tests	Point A	Pont B	Point C
Shape	Rod	Rod	Rod
Colour	Reddish	Reddish	Reddish
Gram reaction	-	-	-
Voges-Proskauer	-	-	-
Gelatin	-	-	-
Triple Sugar Iron	-	-	-
Catalase	+	+	+
Mannitol	+	+	+
Oxidation Fermentation	-	-	-
Indole	+	+	+
Citrate	-	-	-
Urease	-	-	-
Nitrate reduction	+	+	+
Lactose	+	+	+
Glucose	+	+	+
Methyl Red	+	+	+
Possible bacteria	*E. coli*	*E. coli*	*E. coli*

Note: + = Positive; - = Negative

The WHO has not endorsed any temperature that is normal for potable water. The temperature (25 ^{0}C) recorded in River Ngalda can be considered moderate. However, Palamulen and Akoth [22] did report that favourable temperature enhances the overall quality of water regarding its biological and physicochemical properties. According to WHO [23], high water temperature boosts the growth of microbial life and may invariably heighten problems related to corrosion, taste, odour and turbidity. During this study, the total hardness and pH of the River Ngalda that ranged from 44.89 to 85.29 mg/L and 6.0 to 6.4 respectively fell below the permissible limit recommended by WHO [23]. The turbidity of the river water recorded during this study was very high compared to WHO recommended limit (5 NTU). High turbidity is habitually related to higher levels of suspended organic matter and microorganisms present in any water body [24,25].

The EC recorded in River Ngalda which ranged from 60.1 to 108.2 µS/cm is a clear indication that during this study, the river water had low amount of dissolved ions and as such low level of EC when compared with the limit (1000 µS/cm) set by WHO [23].These low EC values are in concord with the EC values reported in River Jakara in Kano State [12, 26]. The TSS recorded which ranged from 860 to 1664 mg/L was above the recommended limit (100 mg/L) set by WHO [23]. The high TSS values recorded for the river water in this study are in agreement with Adamu [26] who reported a mean value (560.96 mg/L) for the river water in his study. In the same vein, the TS recorded during this study which ranged from 914.2 to 1000 mg/L completely contradicts the WHO recommended limit (600 mg/L) in potable water meant for human consumption. However, the recorded TDS which ranged from 30.0 to 54.3 mg/L was way below WHO recommended limit (500 mg/L) [23]. Interestingly, water sampled from River Ngalda met the WHO standards in terms of being odourless and tasteless.

The results of the bacteriological assay conducted show that all the river water samples assayed revealed substantial growth of total and faecal coliforms signifying microbial pollution of River Ngalda during this study. The production of gas and acid by the total and faecal coliforms present in all the river water sampled has been reported by Ochei and Kolhatkar [16] as the hallmarks of these coliforms in terms of their ability to produce acid and gas when incubated at the temperature ranges adopted in this study. These results have clearly shown a serious breach in the sanitary reliability of the river water due to the discovery of these

coliforms. According to literature, *E. coli* or thermo-tolerant coliform bacteria should not be present and detectable in any water meant for human consumption [3, 23].

The results obtained in this study corroborate the report of Habtu, Samuel, and Zewdu [25], on the detection of bacterial contaminants in the water sampled from the river and stream that flow across Gondar city in Ethiopia. As recorded in this study, Onyango *et al.* [27], equally reported coliform counts higher than the recommended minimum limit (0 CFU/mL) in the surface water sources present in Isiolo County, Kenya. Evidently, poor sanitary status of the residents of Ngalda village in terms of indiscriminate deposit of faeces in the bush close to River Ngalda must have led to the pollution level recorded in the river water during this study.

RECOMMENDATIONS AND CONCLUSION

The results obtained in this study have clearly confirmed that some of the physicochemical attributes of the water from River Ngalda did not conform to WHO permissible standards. The detection of total and faecal coliforms in all the sampling points assayed in this study has revealed that the river water is not fit for human consumption. It is therefore recommended that the water from River Ngalda should be treated with appropriate disinfectants before usage for home purposes most specifically drinking. Again, Fika Local Government Authority should as a matter of urgency provide borehole water for the villagers in lieu of river water currently depended upon with a view to averting imminent public health crisis that may ensue owing to consumption of polluted river water.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest regarding this study.

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