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Bacteriological and physicochemical assessment of different types of drinking water source in Keffi

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Abstract

There have been a lot of emphasizes that contaminated drinking water is a major cause of diarrheal diseases, which remain a leading cause of morbidity and mortality globally. This study aimed at bacteriological and physicochemical assessment of different types of drinking water source in keffi. Forty four different drinking water sources were collected. Standard microbiological techniques were used to carry out the analysis. The pH concentration of different water ranged from 6.2-7.8. The Turbidity ranged from 0.02-0.12NTU, the Total Hardness ranged from 6.12-17.18Mg/l. The E.C ranged from 132-204 µs/cm3. The TSS ranged from 0.02- 1.23Mg/l. TDS ranged from 1.02 - 7.1Mg/l. The Nitrate ranged from 2.11 - 5.14 mg/l, Sulphate ranged from 3.03 - 4.41 mg/l, Chloride ranged from 1.03-7.16 mg/l, Magnesium ranged from 9. 70 - 14.13 mg/l. The Calcium ranged from14.04- 31.03 mg/l, copper ranged from 0.00- 0.016 mg/ml and Iron ranged from 0.02 – 0.17 mg/l. The THBC from stream water was 48.21 x 10^{-6} cfu/ml, TCC was 32.18 x 10^{-6} cfu/ml and TFC was 24.08 x 10^{-6} cfu/ml. From well water the THBC was 35.11 x 10^{-6} cfu/ml, TCC was 23. 09 x 10^{-6} cfu/ml and TFC was 19.01 x 10^{-6} cfu/ml. From the borehole water the THBC was 29.12 x 10^{-6} cfu/ml, the TCC was 19.16 x 10^{-6} cfu/ml and TFC was 14.07 x 10^{-6} cfu/ml. From the sachet water the THBC was 3.09 x 10^{-6} cfu/ml, the TCC was 1.10 x10^{-6} cfu/ml and TFC was 1.04 x 10^{-6} cfu/ml. The occurrence *E. coli* from stream water was (63.6 %), from well water and borehole water was (45.4 %). The occurrence of *Klebsiella* species from stream water was (81.8 %), well water was (72.7 %), borehole water was (54.5 %) and from sachet water was (27.2%). From stream water *Enterobacter* species was (45.4 %), well water was (27.2 %) and from sachet water was (18.1%). The occurrence of *Salmonella* species from stream water was (63.6 %), from well water (54.5 %) and from borehole water it was (27.2 %). The occurrence of *Citrobacter* species from stream water was (54.5 %), (45.4 %) from well water (45.4%) from borehole and sachet water was (36.3 %). It was observed that different drinking was sources in Keffi is contaminated and not fit for drinking.

Keywords: drinking water, contaminated; stream, sachet, borehole; well

1. Introduction

Access to clean water is a fundamental human right and an essential resource for the existence of man and other living things(Joanne, 2000). Even, a minor loss of one per cent of body fluids can lead to dehydration in humans, while fluid loss reaching ten percent poses high risk of mortality (Onyeze *et al*., 2013). Scientifically, water is defined as a chemical compound with the formula H2O (Bramer, 2011). A significant portion of the biochemical reactions that take place during the metabolism and growth of living cells relies on water and an aqueous environment. Conventional water sources encompass streams, springs, rivers, lakes, reservoirs, wells, and boreholes. Rivers and lakes hold a more 0.33 per cent of freshwater at any given time, whereas the atmosphere contains only 0.035 percent of freshwater. Given the scarcity of freshwater, many countries prioritize it is treatment and recycling (Okafor, 2011). Groundwater, in conjunction with surface water from streams and lakes, represents an essential supply of drinking water and stands as the largest freshwater reserve, accounting for 0.76 percent of such reserves after glaciers (Plummer *et al*., 2013). However, these water sources are susceptible to contamination stemming from both point and non-point sources. Common issues such as subpar plumbing systems, pipe leaks, the proximity of water supply pipelines to pollution sources, buried underground pipes in disrepair, and inadequate facilities for human waste disposal render the water distribution system susceptible to microbial contamination Etido U. E. (2023).Contaminated water supplies contribute to the proliferation of water-borne diseases. The quality of water quality inevitably deteriorates within distribution networks, mainly due to pipe leaks and infiltration issues (Adedeji *et al*., 2017). Several studies (Kamal & Hashm, 2021; Nwandkor & Ifeany, 2015) have reported unsatisfactory bacterial qualities of pipe-borne water, groundwater, and other natural water sources, with coliform counts significantly exceeding the recommended levels set by the World Health Organization (WHO). In a study conducted by Okoko and Idise (2014), *Micrococcus* sp., *Streptococcus* sp., and *Pseudomonas* sp. were isolated from pipe-borne water sources. The predominant water-borne diseases include typhoid and paratyphoid diseases (Salmonellosis), cholera, dysentery, and schistosomiasis (Ukpong & Okon, 2013).Providing safe drinking water to both urban and rural populations is essential for preventing water-borne diseases (Okorafor *et al.,* 2012). According to World Health Organization (2022), water supplies contaminated with microorganisms, which can lead to illnesses such as cholera, diarrhea, gastroenteritis, and typhoid, are projected to cause 485,000 diarrheal deaths annually. Shockingly, at least two billion people worldwide are exposed to water contaminated with fecal matter (WHO, 2022).

The widespread consumption of drinking water sources in Keffi Metropolis, Nasarawa State, where municipal water access remains inconsistent, raises critical questions about bacteria safety and the potential role of the drinking water as a reservoir for water born infection. This study focused on bacterial assessment of different types of drinking water source in keffi.

2. Materials and Methods

2.1 Study Area

This study will be carried out in Keffi, Nasarawa State, Nigeria. Keffi is approximately 68km away from Federal Capital Territory (FCT), Abuja and 128km away from the State Capital, Lafia and is located at located at longitude 8’5E along the Greenwich meridians and at latitude 7’5N at the equator and is 850m above the sea level (Akwa *et al.,* 2007)

2.2 Sample collection

Forty four (44) water samples were collected from different water sources in Keffi such as stream water, wells, boreholes water and Sachet water. The water samples were collected using sterile 50 ml containers which was first washed and

properly sterilized to avoid contamination. The stream water samples were collected by unscrewing the cap of the container and holding the container near its base in the hand and plunging its neck downwards below the surface. The containers were turned until neck points slightly upwards and mouth directed towards the current. When the water fills the containers, it was carefully removed and corked. In collecting sample from borehole, cotton wool soaked in ethanol was used to disinfect the nozzle of the boreholes and then the tap was turned on and the water was allowed to run for two minutes before sterile 50 ml screw capped plastic containers were carefully uncapped and filled with water and recapped. Sachet water were bought from different Sachet water producing factory in Keffi. The samples were labeled with code names for proper identification. Thereafter the water samples were transported to the laboratory for analysis within six hours of collection

2.3 Physicochemical Analysis

The physicochemical parameters were determined in accordance with the method of APHA (1998). The water sample temperature and pH was taken immediately at the site of water collection using a simple thermometer calibrated in degree Celsius.

2.3.1 Electrical Conductivity Measurement

Electrical conductivity measurement was done using a digital conductivity meter. Standardization of the meter was performed using 0.1N KCl at 25°C.

2.3.2 Turbidity Measurement

Turbidity measurement was conducted using a digital turbidity meter. The meter was standardized with clean deionized water, and this was introduced into the water samples. The turbidity reading of each sample was recorded.

2.3.3 Total Hardness Determination

Determination of total hardness was conducted by measuring 10 cm^3 of water pipetted into a conical flask. 1cm3 of buffer solution (NH4Cl) with pH =10 and 3 drops of Erichrome black T indicator was added to the flask. The mixture was then titrated with 0.01M ethyl diamine tetra acetic acid (EDTA) until the colour changed from wine red to blue. The procedure was repeated two more times to obtain the average liter value

2.3.4 Total dissolved solid

Total dissolved solid was determined by subtracting the values of the suspended solids from the corresponding total solids of the samples. Total suspended solid was determined by using Whatman filter paper rinsed in double distilled water and was dried in an oven at 105 C for exactly one hour and cooled in desiccators. Its residue weight ($W1$) was determined using a digital balance. The sample of 100 mL of water was filtered through the resin paper and then evaporated at 105°C for one hour. This weight which represents $W2$ of the filter paper containing the residue was noted, and TSS was calculated using $(W2 - W1) \times 100$ mg/L

2.3.5 Determination of Alkalinity

Alkalinity values were determined by titration methods (APHA 1998). 50 ml of the water samples was taken in a clean 150 mL conical flask, and three drops of the phenolphthalein indicator were added. After that, it was titrated with 0.05 M H_2SO_4 until colour disappeared. To the colourless solution, three drops of the methyl orange indicator were added and titrated further until colour changed from yellow to permanent reddish or orange red, and then titre values were recorded, and alkalinity was calculated

2.3.6 Determination of Sulphate

Sulphate was determined by the gravimetric/turbidimetric method using $BaCl_2$ as precipitant. 50 mL of the sample was measured into a 250 mL beaker and diluted to 150 mL with distilled water. 1 mL of conc. HCl and four drops of the methyl orange indicator was added. To this, 10 mL of 10% barium chloride solution was added and then boiled for 5 minutes. The solution

was retained overnight and then filtered using Whatman filter paper. The filter paper was rinsed with distilled water to free it from chloride ions. The filter paper was dried at 80°C in an oven by using the silica crucible, ignited at 800°C in a muffle furnace for 1 hour, cooled in a desiccator, and then weighed. Ignition, cooling, and weighing were repeated to give a constant value. Sulphate content of the water sample was then calculated.

2.3.7 Determination of Nitrate

Determination of nitrate was done by the phenoldisulphonic acid method. Phosphate was determined by the colorimetric method. 2 ml aliquot of the water sample was taken in a 25 ml volumetric flask, and one drop of the phenolphthalein indicator was added followed by 2 mL of ammonium molybdate, and then, 1 mL of freshly diluted stannous chloride solution was added. These were made up to 25 mL volume with distilled water and mixed thoroughly. After 5-6 minutes and before 20 minutes, the colour intensity (absorbance) was measured at a wavelength of 660 nm in a spectrophotometer

2.4 Isolation of bacteria

A ten-fold serial dilution was carried out as described by (Obekieze *et al.,* 2012) by transferring one (1) ml of each of the water sample drawn using a pipette, and was transferred into a test tube containing 9ml of sterile water and another 1ml was picked and transferred to another test tube containing 9ml of sterile water, this was repeated till 10^{-7}fold. 0.5ml of the diluent from $10^{-5}$and 10^{-6} was spread on Nutrient agar for bacteria count, MacConkey for coliform count, Eosin Methylene Blue (EMB) for faecal count then incubated at 37^{o}C for 24 hours to determine the bacteria load.

2.4.1 Identification and Characterization of Bacterial Isolates

The identification and characterization of bacterial isolates were based on cultural, morphological and biochemical characteristic using standing method. (Kalpana *et al.,* 2012).

The biochemical analysis carried out include Gram reaction, Indole Methyl red, Voges Proskauer Citrate Utilization, Catalase, Oxidase, Coagulate and carbohydrate utilization test and culture characteristics the cultural characteristics which include the colony shape, size, surface texture edge elevation pigmentation and so on was determine by direct observation of the colonies on the plates.

3. Results

3.1 Physicochemical Parameters of Water from different Sources in Keffi

Table.1. shows physiochemical Parameters of water from different sources in Keffi. The hydrogen ions (pH) concentration of different water sources in the study area ranged from 6.2-7.8. The Turbidity of water ranged from 0.02-0.12NTU, the Total Hardness of the water ranged from 6.12- 17.18Mg/l. Electrical Conductivity (E.C) -The E.C. in water samples ranged from 132-204 µs/cm3. The total suspended solids in water samples ranged from 0.02- 1.23Mg/l. Total Dissolved Solids in water samples ranged from 1.02 - 7.1Mg/l. The concentrations of minerals nutrients in water sample were Nitrate which ranged from 2.11 - 5.14 mg/l, Sulphate ranged from 3.03 - 4.41 mg/l, Chloride ranged from 1.03-7.16 mg/l, Magnesium ranged from 9. 70 - 14.13 mg/l. The concentrations of heavy metal were as follow Calcium ranged from14.04- 31.03 mg/l, copper ranged from 0.00- 0.016 mg/ml, Iron ranged from 0.02 – 0.17 mg/l respectively.

Table 1. Physicochemical parameters of water from different sources in Keffi

Parameter	Stream Sample	Well sample	Borehole Sample	Sachet Sample
pH	6.2	7.0	7.8	6.57
Turbidity	0.3	0.2	0.02	3.7
TotalHardness (Mg/l)	11.58	10.46	6.12	0.18
Conductivity	154	141	132	204
TSS	0.07	0.05	0.02	1.23
Total dissolve Solids	3.1	1.9	1.02	7.1
Nitrate	4.54	3.86	2.11	5.14
Sulphate	3.11	3.09	3.03	4.41
Chloride (CL)	6.86	3.16	1.03	7.16
Magnesium	11.83	10.75	9. 70	14.13
Calcium	28.03	21.62	14.04	31.03
copper	0.006	0.002	0.00	0.016
Iron	0.07	0.05	0.02	0.17

Key: TSS= Total suspended solids

3.2 Bacteria Count from Different Water Sources in Keffi

The bacteria count from different water sources in Keffi is as given in Table 2. The total heterotrophic bacteria count from stream water 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 well water 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 borehole water 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 the sachet water the heterotrophic bacteria count was 3.09 x 10^{-6} cfu/ml, the total coliform count was 1.10 x10^{-6} cfu/ml and total faecal count was 1.04 x 10^{-6} cfu/ml respectively.

Table. 2 Bacteria Count from Different Drinking Water Sources in Keffi

Samples		**Count (CFU/mL x 10^{-6})**	
	Total heterotrophic Bacteria	**Total Coliform**	**Total Faecal Coliform**
Stream water	48.21±1.41	32.18 ±0.11	24.08 ±0.15
Well water	35.11±0.23	23.09 ±0.31	19.01 ±0.35
Borehole water	29.12 ±0.63	19.16 ±0.11	14.07 ±0.21
Sachet water	3.09±0.11	1.10 ±0.01	1.04 ±0.15

3.3 Cultural, Morphological and Biochemical Characteristics

The cultural, morphological and biochemical characteristics of the bacteria isolated from different water sources in Keffi is as given in Table 3. *E. coli* grow Pinkish colony on MaConkey agar and greenish metallic sheen colony EMB agar, Indole positive, methyl-red positive.

Table 3 Cultural, Morphological and Biochemical Characteristic of Bacteria Isolated from Drinking Water

			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 DCA and black metallic sheen on BSA	Rod shape	Gram negative	+	+	-	+	+	-	-	*Salmonella* species
Entire, creamy, raised	Cocci	Gram negative	-	-	+	-	-	+	-	*citrobacter* species

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

3.4 The percentage of Bacteria Occurrence

The percentage of bacteria occurrence from different water sources in Keffi is as given in Table 4. The occurrence *E. coli* from stream water was (63.6 %), from well water and borehole water was (45.4 %). The occurrence of *Klebsiella* species from stream water was (81.8 %), well water was (72.7 %), borehole water was (54.5 %) and from sachet water was (27.2%). From stream water *Enterobacter* species was (45.4 %), well water was (27.2 %) and from sachet water was (18.1%). The occurrence of *Salmonella* species from stream water was (63.6 %), from well water (54.5 %) and from borehole water it was (27.2 %). The occurrence of *Citrobacter* species from stream water was (54.5 %), (45.4 %) from well water (45.4%) from borehole and sachet water was (36.3 %)

Table 4. Percentage of Bacteria Occurrence in Different Water Sources in Keffi

	No (%) isolated							
Bacteria isolated	No. sample	Stream water	No. sample	Well water	No. sample	Borehole water	No. sample	Sachet water
E. coli	11	7 (63.6)	11	5(45.4)	11	5(45.4)	11	0 (0.0)
Klebsiella species	11	9(81.8)	11	8(72.7)	11	6(54.5)	11	3(27.2)
Enterobacter species	11	5(45.4)	11	3(27.2)	11	0(0.0)	11	2(18.1)
Salmonella Species	11	7(63.6)	11	6(54.5)	11	3(27.2)	11	0(0.0)
Citrobacter species	11	6(54.5)	11	5(45.4)	11	4(36.3)	11	4(36.3)

4. Discussion

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 (Diakite *et al*., 2019) This study was carried out to determine the bacteriological and physicochemical assessment of different drinking water sources in Keffi. The concentration of pH in different water sources in the study area ranged from 6.2-7.8. The result indicates that the water sample were slight acidic (6.2) to slight alkalinity (7.8). The range suggests uniformity in the concentration of pH among water sources; this is similarly to Abugu *et al.,* (2022) who reported uniformity in pH of borehole water in Abuja, Nigeria

Electrical Conductivity (E.C) in different water sources ranged from 132-154 µs/cm3. The range indicates wide distribution of electrical conductivity of water sources. However, a wider range of EC has been reported by Nkamare *et al*., (2017). However, the closer range of 122-154µs/cm3 is relatively low because water of good quality for domestic use should have EC from 1500 µs/cm3and above (WHO, 2010). The concentrations of minerals nutrients in different water sources in the study area are relatively low which did not meet the ideal good quality for domestic use.

The level of total heterotrophic bacteria count from stream water 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*. (2012) 52.18 x 10^{-6} cfu/ml coliform and total feacal count of 44.08 x 10^{-6} cfu/ml in Yala, Cross Sachet State. The total heterotrophic bacteria count, coliform and faecal count observed from well and borehole in this study was high but similar to study reported by Yusufu and Egwujeh (2019) in in Anyigba town, Kogi State, Nigeria, this showed that different water sources in Keffi is 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 (Sabongari 2002). 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 (WHO 2016). However, bacteriological water quality can display substantial and speedy variations. Intermittent spikes in concentrations can considerably heighten infection risks and back to water-borne diseases out breaks. The severest bacterial concerns are linked to water sources contaminated with human or animal feces (WHO, 2008). Such contamination may result from factors like inadequate public waste disposal facilities, insufficient waste collection and treatment systems, and on-site sanitation facilities discharging directly into water bodies. Additionally, bacteriological analysis may reveal contamination levels that particularly concerning during epidemics such as cholera or typhoid (WHO, 2004). The shortage of potable drinking water is persistent issue across Keffi. Consequently, the collection and storage of water under unhygienic conditions may lead to contamination. Safeguarding water supplies is this significant public health responsibility, with the WHO emphasizing the microbiological quality of drinking water. Outbreak of water-borne diseases continue to pose a tremendous burden on society, emphasizing the importance of ensuring that water is free from microbial and physical impurities and aesthetically acceptable to consumers. Therefore, physical and or chemical treatment of water before use for domestic purposes is imperative

5. Conclusion

From different water source samples collected from Keffi local government area. The concentrations of minerals nutrients were below standard and contain high total suspended solids and heavy metal. The total viable count, total coliform count and total faecal count were high. The bacteria isolated were *Klebsiella* spp, *Salmonella* species *Enterobacter* species and *E. coli*.

Conflict of Interest statement

The authors declare no conflicts of interest

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