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BACTERIOLOGICAL AND PHYSICO-CHEMICAL ANALYSIS OF LAPAI WATER SUPPLY

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ABSTRACT

Bacteriological and Physico-chemical analysis of Lapai water source was investigated. Lapai is the headquarters of Lapai Local Government Area of Niger state, Nigeria. Bacteriological quality of water samples was determined by enumeration through Total Viable Count and Coliform count using the Most Probable Number (MPN) method. The Isolates were subjected to Series of Biochemical tests for characterization and identification. The physicochemical parameters were determined according to the standard analytical methods for the examination of water and waste water and Romanian standard. Findings from this work includes the following: Maximum Total Viable Count (TVC) and Coliform count were recorded to be 2.45 x 10^7cfu/mg and > 1100 MPN index/100ml,while minimum TVC and Coliform count were recorded to be 1.05 x 10^7cfu/mg and 0MPN index/100ml in the water samples. Total bacteria count and identified from all the water sources in Lapai metropolis indicated that Escherichia coli and Klebsiella sp occurred most with five (5) and four (4) isolates respectively.The conductivity data for the raw water samples indicated that State low-cost (LN), IBB Hostel (LE) and Emir Palace (LW) analysed were 250, 120 and 580 µs/cm. The pH, conductivity, chloride, nitrate and total hardness decreases with increasing treatment time in the column for the borehole water samples. While, the pH, temperature, turbidity, conductivity, total suspended solid (TSS), total dissolved solids (TDS), and total solids (TS), BOD, COD, nitrate, phosphate, ammonia and heavy metal analysis for the surface water (stream/river) samples also decreases with increasing treatment time in the packed column. Treatment of the water using nanocellulose revealed a decrease in all the investigated parameters with increasing treatment time. Most water samples examined did not meet up with the WHO standard for portable water, and the presence of these bacteria are potential pathogens that can significantly affect microbiology water quality, resulting to great health risk.

Key words: Analysis, Water source, Bacteria.

INTRODUCTION

Water is one of the most available indispensable and useful natural resources made available to man and it accounts for a total of about 75% of the earth's surface. Globally, ground water accounts for the world's largest and most important source of safe portable water (Howard *et al*., 2006). Ground water serves as source of water to an estimated population of about 1.5 billion people around the world every day. On a general note, the quality of water differs and varies from one place to another. This variation at times depends on certain factors such as seasonal changes (Trivedi *et al*., 2010), the type of soil and rocks surrounding or within the water body, as well as surfaces through which the water flows (Seth *et al*., 2014; Thivya *et al*., 2014). Anthropogenic activities can also change the natural composition of and value of water especially through the disposal of chemicals and microbial contaminants on the surface of land and also into soils or through injection or deposition of waste directly into the ground water and water bodies such as lakes, rivers or streams. Industrial wastes discharge or effluent (Govindarajan and Senthilnathan, 2014), Agricultural and urban activities (Bello *et al*., 2013) can affect the quality of ground water. In most developing countries like African countries, the normal and effective means of human waste disposal system is the pit latrine. This leads to increased risk of microbial contamination of fresh water. Proximity of some water sources such as boreholes, wells, rivers or streams to waste dump sites and animal droppings littered around (Bello *et al*., 2013) could also serve as source of contamination and can also pollute fresh water.

World Health Organisation (WHO) documented that about one billion population worldwide lack access to safe portable water (Ichor *et al*., 2014). Most or almost all developing countries are confronted with the challenge of poor access to adequate and sufficient drinking water supply. In Nigeria, the quality and quantity of portable fresh water are two major problems we are confronted with over the years. This problem has led to increasing rate of water borne associated diseases such as Diarrhoea, Typhoid fever and Cholera, experienced in some parts of the country, which are transmitted majorly via consumption of food and water contaminated by faecal materials that carries the infective dose of the infectious organisms (Oguntoke *et al*., 2009; Oluyege *et al*., 2011). This most times occurs in form of an outbreak in an area as it affects people sharing common source of water supply.

Busayo *et al*. (2016) stated that the common sources of portable fresh drinking water in most urban, rural and semi-urban areas includes wells, boreholes, pipe borne water, streams and rivers. Indicator organisms are mainly bacteria mostly used as signs of quality or hygienic status in food, water or environment. The term "indicator" includes the concept of the indicator organism. The most commonly used indicator organisms include the coliform group of bacteria such as *Escherichia coli*, *Salmonella* spp and the entire members of the family of Enterobacteriaceae (Mary, 2003). Physico-chemical characteristics are vital water quality monitoring parameters as documented by Nwachukwu and Ume (2013). Physico-chemical parameters are also well known for their ability to affect the quality of a water source. This study is aimed at evaluating the general bacteriological and physico- chemical parameters of Lapai water supply.

MATERIALS AND METHODS

Study Area

The research study was conducted in Lapai metropolis. Lapai is a Local Government Area in Niger State, Nigeria adjoining the Federal Capital Territory. Its headquarters is in the town of Lapai. Lapai is located between longitudes 4°27'30" to 13^{0}60'95" North and 2°60'60" to 14°89'44".

Sample Collection

Twelve (12) sampling sites comprising of three (3) different water sources that includes; well water, surface water from streams and rivers and borehole water samples were collected from the four cardinal points (North, South, East, and West), one sample from well water, one sample from streams and rivers and one sample from borehole water in the four cardinal points making up three (3) samples from each cardinal point and twelve (12) samples in all. All water sampling, transportation and preservation procedures were carried out according to standard methods for examination of water (World Health Organization guidelines for drinking water quality) (WHO, 2004). All water samples collected were transported to the laboratory in an Ice Pack within the time frame of two hours. Exactly 200ml capacity glass bottle was used for sampling. The bottles were fitted with ground glass stopper or screw caps. The cap and neck of the bottles were protected from contamination by covering with thin aluminium foil. The glass bottles were sterilized at 121^{o}C for 15 minutes. All samples collected were packaged in an ice pack and were transported to the laboratory for immediate analysis.

Total Viable Count

In the determination of total viable/heterotrophic count, a tenfold (10^{-1} to 10^{-10}) serial dilution was set up. 1ml of sample from the water (100ml) to be tested was transferred into the first test tube and this was done to the tenth test tube (Serial dilution). 1ml of the diluent from dilution factor 10^{-6} was inoculated into prepared plate of nutrient agar (20ml) by pour plate method. Wire loop was used to spread the sample onto the surface of the nutrient agar and the plate was incubated at 37^{o}C for 48 hours. Pure cultures of the isolate were obtained by sub-culturing on the surface of freshly prepared nutrient agar plates. The colonies were counted using colony counter, gram stained and subjected to Biochemical tests for identification of each bacteria species (Cheesbrough, 2006).

Determination of the Most Probable Number (MPN)

The most probable number method is also referred to as the multiple tube method. The method is based on an indirect assessment of microbial density in the water sample by reference to statistical table to determine the most probable number of microorganisms present in the original water sample.

The most probable number (MPN) method was used for the enumeration of total coliform isolates. 10 mls of water from each of the sample source; well water, borehole water and stream was dispensed into each of three set of test tubes containing 10mls of double strength Lactose broth containing inverted Durham's tube, 1.0ml of each of the test water sample into three set of test tubes containing 10mls of single strength lactose broth and 0.1ml of each of the test water sample into each of three set of test tube containing 10mls of single strength lactose broth using sterile syringe. Durham's tubes were observed at the end of each incubation period for gas production, colour change and turbidity (Cheesbrough, 2006).

The most probable number (MPN) was carried out in three steps:

Presumptive, Confirmatory and Completed test.

Presumptive Test: Coliform count was obtained using the three tubes method of the most probable number (MPN) method. Double strength and single strength Lactose broth was prepared and using a sterile pipette, 10ml of double strength Lactose broth was dispensed into three test tubes containing inverted Durham tubes and the tubes were labelled LB2X. Also, 10ml of single strength Lactose broth was dispensed into 6 test tubes containing inverted Durham tubes and were labelled LB1X. The nine (9) set of test tubes were autoclaved at 121^{o}C for fifteen (15) minutes and was allowed to cool to room temperature. The water sample to be tested was mixed thoroughly by shaking. Using 10mls sterile pipette, 10ml of water sample to be tested was dispensed into 3 test tubes containing double strength Lactose broth, 1ml of water sample was also dispensed into 3 single strength Lactose broth tubes. Exactly 0.1ml of water sample was dispensed into the other 3 single strength Lactose broth tubes. All the nine (9) set of test tubes were shaken gently to ensure even mixture and were incubated aerobically at 37^{o}Cfor 24 to 48 hours for estimation of total coliform and at 44^{o}C for fecal coliform. All the tubes were examined for production of acid (yellow colour) and gas production after 24 to 48 hours of incubation. Positive presumptive tubes were retained and the most probable number was then estimated from the MPN (most probable number) statistical table.

Confirmatory Test: This was carried out by dispensing 0.1ml from Lactose broth positive presumptive tubes into a freshly prepared sterile Brilliant Green Lactose Bile tubes containing inverted Durham tubes. The tubes were shaken gently for even mixture and were all incubated at 44^{o}C for 48 hours. The tubes were all observed for gas production after 48 hours of incubation. The record of number of tubes showing positive confirmed test was taken. The Most Probable Number (MPN) was determined using the MPN statistical table.

Completed Test: Completed test was performed by streaking a loopful of broth from positive tube onto freshly prepared Eosin Methylene Blue (EMB) agar plate for pure colonies. The plates were incubated. Brilliant Green Lactose broth and Nutrient agar slant were inoculated with coliform culture from the Eosine Methylene Blue (EMB) agar plates. The broth tubes and the agar slant were incubated at 35^{o}C for 24 hours. The Lactose broth fermentation tubes were observed for gas production and the organisms found on the slant were Gram stained. The slides were observed for positive or negative Gram reaction and cell morphology was observed.

Characterization and Identification of Bacteria Isolates

Stock cultures of the pure isolates with different cultural characteristics were made on nutrient agar slants. Gram staining procedure was used to observe cell morphology and biochemical tests were performed to identify the isolates to species level. Various tests performed and used for identification of the isolates included; Oxidase test, Catalase test, Coagulase test, Urease test, Indole test and Citrate utilization test (Ibe and Okpelenye, 2005).

Test for Physico-chemical Parameters

The physicochemical parameters determined includes, temperature, nitrate, turbidity, conductivity, total alkalinity, pH, chloride, dissolve oxygen, nitrite, phosphate, ammonia, BOD, COD, total solid, total suspended solid, total dissolve solid, iron, zinc and copper were determined according to the standard analytical methods for the examination of water and waste water and Romanian standard (Eaton and clesceri, 2005;Uwah *et al*., 2014).

Treatment Methodology

A fixed-bed column method was carried out using a 50 mL burette with a diameter of 1.5 cm and length of 68.2 cm and three gram (3 g) of the nanocellulose was used as adsorbent packed in column. The bed height of 11.2 was used. The burette containing the wastewater solution was placed at a higher elevation so that the solution could be introduced into the column by a downward flow mode through the packed column. The effluent maintained a length of 4cm; filtrates were collected at different time intervals into sample bottles. This process was repeated until the time elapsed and samples collected were analyzed for physicochemical parameters, microbial activities and heavy metal (Azeh *et al*., 2019[ab]).

RESULTS

Mean Total Viable Count of Bacteria from Lapai metropolis

The highest total viable count of Bacteria in the water of Lapai metropolis occurred in Lapai East Stream(LES) with 245 colonies, and a corresponding population of 2.45 x 10^{7}cfu/mg, while the least total viable count occurred in Lapai East borehole (LEB) with 105 colonies and a corresponding population of 1.05 x 10^{7}cfu/mg. Generally in table 1, stream water sources has the highest number of colonies, followed by the well water sources and lastly borehole water sources with the least colonies.

The borehole water from LEB (1.05 x 10^7cfu/mg) has the best Microbiological water quality throughout the period of analysis in the metropolis.

Table 1: MeanTotal Viable Count of bacteria from the water sources in Lapai Metropolis.

S/NO	LOCATION	Dilution factor	Number of colonies	Population (cfu/ml)
1	LNW	10^{-5}	195	1.95 x 10^7
2	LNB	10^{-5}	163	1.63 x 10^7
3	LNS	10^{-5}	239	2.39 x 10^7
4	LEW	10^{-5}	205	2.05 x 10^7
5	LEB	10^{-5}	105	1.05x 10^7
6	LES	10^{-5}	245	2.45 x 10^7
7	LWW	10^{-5}	181	1.81 x 10^7
8	LWB	10^{-5}	169	1.69 x 10^7
9	LWS	10^{-5}	191	1.91 x 10^7
10	LSW	10^{-5}	184	1.84 x 10^7
11	LSB	10^{-5}	161	1.61 x 10^7
12	LSS	10^{-5}	225	2.25 x 10^7

KEY:
LNW: Lapai North Well, **LNB:**Lapai North Borehole, **LNS:**Lapai North Stream, **LEW:**Lapai East Well, **LEB:**Lapai East Borehole, **LES:**Lapai East Stream, **LWW:**Lapai West Well, **LWB:**Lapai West Borehole, **LWS:**Lapai West Stream, **LSW:**Lapai South Well, **LSB:**Lapai South Borehole, **LSS:**Lapai South Stream

Most Probable Number of Coliform bacteria.

In table 2, Most Probable Number (MPN) of coliform bacteria is generally low from Borehole water sources (LNB, LWB and LSB), with no coliform from Lapai East Borehole (LEB). In other water sources, such as the stream and well, the MPN values are higher, ranging from 1100 to 1100+.

Table 2: Most Probable Number of Coliform bacteria from the water sources in Lapai Metropolis

S/NO	LOCATION	MPN Index/100ml (cfu/ml)
1	LNW	1100
2	LNB	210
3	LNS	1100
4	LEW	1100+
5	LEB	00
6	LES	1100+
7	LWW	1100+
8	LWB	09
9	LWS	1100+
10	LSW	1100
11	LSB	210
12	LSS	1100+

KEY:
LNW: Lapai North Well, **LNB:**Lapai North Borehole, **LNS:**Lapai North Stream, **LEW:**Lapai East Well, **LEB:**Lapai East Borehole, **LES:**Lapai East Stream, **LWW:**Lapai West Well, **LWB:**Lapai West Borehole, **LWS:**Lapai West Stream, **LSW:**Lapai South Well, **LSB:**Lapai South Borehole, **LSS:**Lapai South Stream

Bacteria population in the water sources of Lapai metropolis

Escherichia coli and *Klebsiella* sp are the most occurred bacteria specie from the water sources of Lapai metropolis (Table 3). The other bacteria had two (2) isolates each.

Table 3: Occurrence of Bacteria in the water sources of Lapai Metropolis.

S/NO	BACTERIA	No. of isolate	% of occurrence
1	*Escherichia coli*	5	29.41
2	*Klebsiella* sp	4	23.53
3	*Enterobacter* sp	2	11.76
4	*Citrobacter* sp	2	11.76
5	*Proteus* sp	2	11.76
7	*Serratia* sp	2	11.76
Total		17	100.00

Physico-chemical analysis of Borehole Water Samples (Raw and Treated)

The result of analysis carried out on different samples of borehole water is as shown in **Table 4**. The conductivity data for the raw water samples State low-cost (LN), IBB Hostel (LE) and Emir Palace (LW) analysed were 250, 120 and 580 µs/cm. After treatment, the conductivity values of the water samples reduced in the order: State low-cost (LN): 240 µs/cm/180 min; IBB Hostel (LE): 110 µs/cm/60 and 120 min while Emir Palace (LW): 120 µs/cm/120 min. The pH of the treated water samples increased with increasing treatment time. However, the best results were achieved at 360 min for samples State low-cost and IBB hostel and at 180 min for sample Emir Palace. In treatment for hardness it was observed that after 30mins of the treatment, hardness reduces greatly. Generally, parameters such as, pH, conductivity, chloride, nitrate and total hardness decreases with increasing treatment time in the column.

Table 4: Physico-chemical analysis of Borehole Water Samples (Raw and Treated)

Samples/Time (min)	pH	Conductivity µs/cm	Chloride mg/L	Nitrate mg/L	Hardness mg/L
Raw Values/LS	5.23	250	284	Nil	160
30	3.28	4.60	70.9	6.0	22.5
60		270	283.6	4.51	18.0
120	6.36	250	70.90	4.53	17.0
180	6.35	240	70.90	4.49	15.0
360	6.12	300	283.6	4.32	14.0
	6.35				
Raw Values/ LE	6.83	120	213	Nil	200
30	6.07	120 110	70.9	0.201	15.0
60	6.74	110	70.9	0.190	60.0
120	6.83	120	70.9	0.180	130.0
180	6.79	140	70.9	6.0	25.0
360	6.88		70.9	0.193	150.0
Raw Values/ LW	5.32	580	1134	Nil	105
30	6.29	250	70.9	6.20	30
60	6.30	270	141.8	4.68	25
120	6.22	120	70.9	4.70	25
180	7.06	280	70.9	0.980	30
360	5.80	410	70.9	4.60	65
Raw Values/ LW					
	4.19	310	284	4.20	160
30	5.59	3	70.9	4.80	60
60	6.28	5	141.8	2.01	30
120	4.97	230	70.9	2.00	25
180	6.28	130	70.9	3.00	30
360	6.22	130	70.9	3.01	40
Raw Values/ LW	5.37	6.00	284	4.50	160
30	28.61	6.39	52.0	70.9	0.321
60	28.22	6.42	56.0	70.9	0.432
120	27.80	6.47	61.0	0.00	0.325
180	27.65	5.30	56.0	14.8	0.511
360	27.38	6.20	58.0	70.9	0.215
Raw Values/ LN	5.02	520	213	4.42	225
30	27.60	27.58	27.44	27.21	27.00
60	6.15	5.06	6.29	4.43	6.30
120	5.20	530	470	530	500
180	141.8	70.9	70.9	70.9	70.9
360	0.121	0.101	0.123	0.103	0.131

Key: State low-cost (LS); Hostel (LE); Emir Palace (LW); ECWA (LW); Federal Low-Cost (LW); Secretariat (LN).

Physicochemical Analysis of Raw and Treated Surface Water (River/Stream)

The physicochemical parameters like taste, odour, pH, temperature, turbidity, conductivity, total suspended solid (TSS), total dissolved solids (TDS), and total solids (TS), BOD, COD, nitrate, phosphate, ammonia and heavy metal analysis in **Tables 5, 6, and Figs, 1, 2** carried out on the surface water samples were observed to decrease with increasing treatment time in the packed column. The raw BOD values were 896 mg/L and 874 mg/L for surface water collected at the stream along Suleja road and the river bordering between Lapai and Agaie LGA, designated as Lapai north (LN) and Lapai South (LS) respectively. At 360 min of the treatment, BOD values dropped to 301 mg/L(LS) and 341 mg/L(LN). The COD level in the raw water read 87.45 mg/L and 88.17 mg/L for LN and LSsurface water respectively. After treatment, the levels of COD decreased with increasing treatment time with the best results achieved at 360 min with values of 27.45 mg/L(LS) and 35.78 mg/L (LN).

Table 5: Results for Physicochemical Analysis of Raw and Treated LN Surface Water (River/Stream)

Sample	Temp. (^oC)	Nitrates (mg/L)	Turbidity (NTU)	Cond. (µS/cm)	T/Alkalinity (mg/L)	pH	Chlo. (mg/L)	D/O_2 (mg/L)
RAW/Time (min)	29.20	9.25	12.44	120.28	6.47	3.92	2.01	3.52
30	28.83	5.18	7.69	75.63	2.18	6.12	1.62	2.78
60	27.41	5.70	7.46	79.06	1.77	6.17	1.23	2.65
120	27.64	5.38	7.43	77.82	1.69	6.26	1.83	2.40
180	28.27	5.77	7.61	78.53	1.80	6.33	1.61	2.70
360	27.55	5.86	7.84	77.53	1.75	6.41	1.57	2.34

Sample	Nit. (mg/L)	Phosphate (mg/L)	Ammonia (mg/L)	BOD (mg/L)	COD (mg/L)	T/SOLIDS (mg/L)	TSS (mg/L)	TDS (mg/L)
RAW/Time (min)	17.63	0.60	1.98	874	88.17	258	10.2	76.61
30	14.33	0.29	1.40	350	42.70	143	6.10	39.70
60	14.24	0.27	1.31	308	39.25	138	5.48	42.26
120	15.08	0.55	1.42	316	38.53	129	4.76	41.11
180	15.32	0.48	1.62	328	36.43	127	4.62	40.76
360	14.97	0.50	1.55	341	35.78	123	4.49	40.43

Table 6: Physicochemical Analysis of Raw and Treated of LS Surface Water

Sample	Temp. (^oC)	Nitrates (mg/L)	Turbidity (NTU)	Cond. (µS/cm)	T/Alkalinity (mg/L)	pH	Chlo (mg/L)	D/O_2 (mg/L)
RAW/Time (min)	29.27	11.08	10.62	96.71	5.46	3.89	1.8	2.1
30	28.46	7.51	6.53	47.98	2.43	6.62	1.1	4.3
60	27.52	8.60	6.73	56.56	2.89	6.70	0.8	4.5
120	28.47	8.31	6.62	55.73	2.64	6.52	1.2	4.6
180	28.54	7.89	6.39	54.90	2.78	599	1.6	4.8
360	27.78	7.65	6.58	49.22	2.53	6.07	1.4	4.4

Sample	Nit. (mg/L)	Phosphate (mg/L)	Ammonia (mg/L)	BOD (mg/L)	COD (mg/L	T/SOLIDS (mg/L)	TSS (mg/L)	TDS (mg/L)
RAW/Time (min)	18.07	0.39	2.69	896	87.45	199	8.9	81.21
30	12.58	0.16	1.80	321	26.37	174	6.16	25.54
60	13.25	0.19	1.41	305	33.28	150	5.29	22.82
120	12.65	0.20	1.39	327	28.52	166	5.32	23.46
180	13.07	0.22	1.43	331	28.78	153	5.43	22.75
360	12.54	0.25	1.40	301	27.45	148	4.77	21.79

Key: Temp = Temperature, Nit = Nitrites, Cond = Conductivity

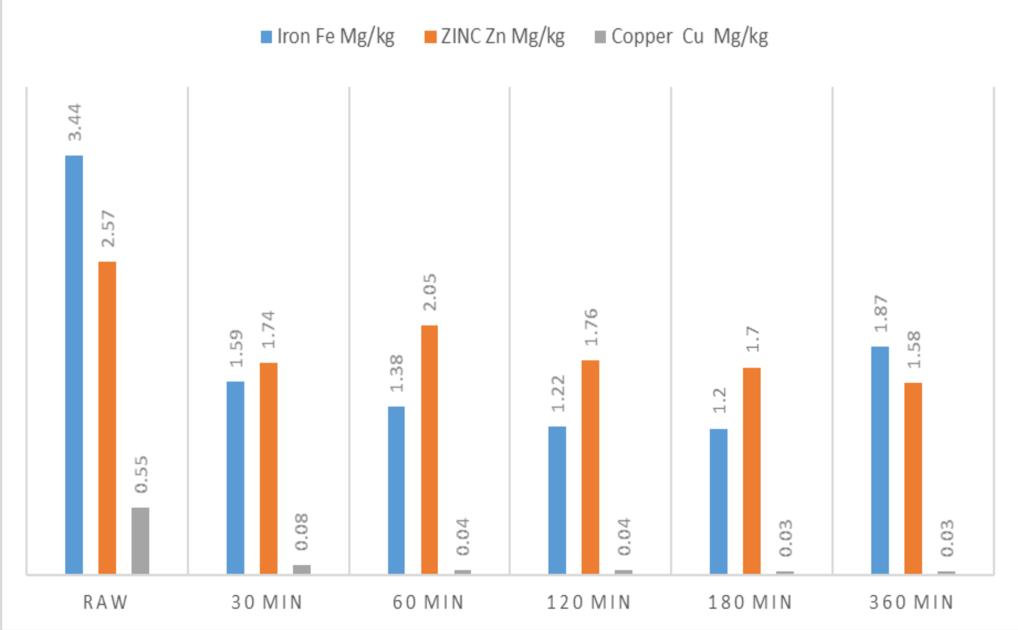

Fig 1: Heavy metal analysis of the Raw and Treated LN Surface Water (Stream/River)

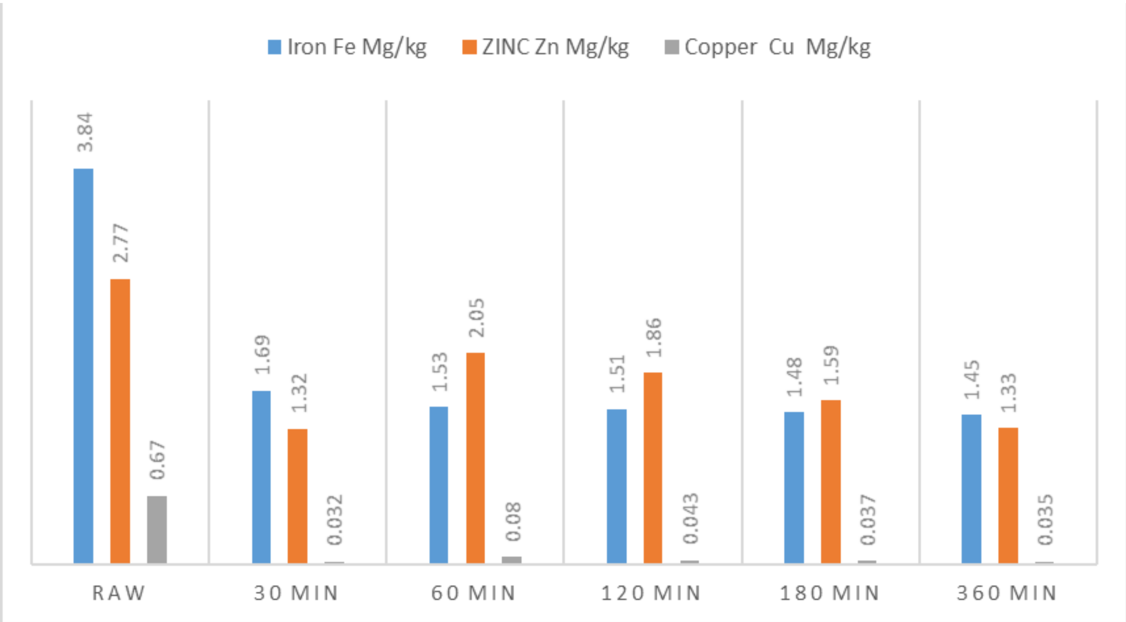

Fig. 2: Heavy metal analysis of the Raw and Treated LS Surface Water (Stream/River)

DISCUSSION

The findings from this research study revealed that all the water samples examined from the four locations and from the three main water sources (well, borehole and stream) had high total viable and coliform counts, except for borehole water source with less count compared to the other water sources. The World Health Organisation (WHO) standard for viable count in portable water supply indicates that the Total Viable Count (TVC) should not exceed 100cfu/mg (WHO, 2004). Based on the WHO standard, the result from this study showed that all the water sources from Lapai metropolis are of unacceptable quality for human consumption (WHO, 2004). Borehole water from the four locations (LNB, LEB, LWB and LSB) which are less contaminated with a lower TVC is also of unacceptable microbiological water quality, because of their high microbial loads. Vulnerable water sources such as streams and wells from this study showed the highest level of fecal contamination of above 1100 (MPN) index/100ml, and hence have the lowest quality, which is in agreement with the research carried out by Bain *et al.*(2014).

The Most Probable Number (MPN) results indicated that surface water samples from streams were observed to be most contaminated with coliform count of between 1100 MPN index/100ml to >1100 MPN index/100ml in the four locations. The result also indicated that only water samples from Lapai East Borehole (LEB) of the four locations investigated recorded counts of 0 MPN index/100ml The well and stream water especially are unacceptable for drinking, and this could be due to proximity of some water sources such as wells and streams to waste dump sites and animal droppings littered around (Bello *et al*., 2013). The high fecal contamination level of > 1100 MPN index/100ml of water could also be as a result of the location of water sources in close proximity to potential contamination sources such as closeness to latrines and location of ground water in close proximity sites of open human defecation. The research result indicated variations in the microbial loads and the quality of the twelve water samples been examined from the first location, Lapai North Well(LNW) down to the last location, Lapai South Stream (LSS). This variation depends on seasonal changes (Trivadi *et al*.,2010) surfaces through which the water flows (Seth *et al*., 2014; Thivya *et al*., 2014), and human activities including the discharge of domestic wastes, urban and other waste water, agricultural waste and washing of farm product directly into fresh water sources. The slope, topography and weather conditions were also observed in the research to have contributed to the increase in the number of microorganisms in water (Yisa *et al.,* 2010). *Escherichia coli* had the highest number of occurrences among the isolated bacteria, this is in agreement with the research conducted by Yisa *et al.* (2010). Other bacteria isolated includes, *Klebsiella* sp, *Citrobacter* sp, *Salmonella* sp etc. The occurrence of these bacteria serves the reason for the increase in the cases of outbreak of waterborne diseases experienced most especially at the beginning of the rainy seasons. Some researchers posed that higher faecal contamination is expected during the dry season where they attributed this point to the excessive evaporation of water and increase in temperature that favours the establishment of coliform in the water (Umolu and Aemere, 2001). However, Yisa *et al*.(2010) disagrees with this and argued that highest number of coliform and viable bacteria count occur during the dry season where they attributed this to the discharge of potential contaminants, such as domestic wastes, agricultural waste, wash water from car wash, microbial seepage and other nutrient rich wastes through surface run-off or erosion into water sources.

The conductivity value recorded during the study was quite low as can be found in some water bodies similar to the findings by Ibrahim *et al*. (2009). The mean value of conductivity of the water sample collected at Federal low cost (LW) and Secretariat borehole (LN) was 511 µs/cm similar to the findings by Ibrahim *et al*. (2009). This could be as a result of dissolved ions present. The pH of the treated water samples increased with increasing treatment time. The result for total hardness reveals that the borehole water collected from ECWA church, Federal Low cost and Secretariat, Lapai Local Government Area of Niger state shows mean average to be below the WHO standard of 150 mg/l which may be as a result of some dissolved minerals such Ca and Mg ions, which are known as major causes of hardness of water. The varying level of hardness in the locations could be as a result of local condition as reported by Chukwu (2008) in Umuahia South of Abia state in Nigeria. Sixtus *et al*. (2016) noted that it is easiest to identify water hardness by its effect on soap and other detergents. The treated borehole water has excellent water quality level of 0 to 25 in accordance with water quality index (WQI) and its status similar to the findings by (Shweta *et al*., 2013; Muhammad *et al*., 2018).The physicochemical parameters like taste, odour, pH, temperature, turbidity, conductivity, total suspended solid (TSS), total dissolved solids (TDS), and total solids (TS), BOD, COD, nitrate, phosphate, ammonia and heavy metal analysis carried out on the surface water (rivers and streams) samples were observed to decrease with increasing treatment time in the packed column similar to the findings by Azeh *et al*. (2019[ab]).

CONCLUSION

Most water sources in Lapai metropolis portray their unsuitability for drinking without any form of proper treatment. The major cause of water quality deterioration in the locations examined is simply due to lack of proper sanitation, poor personal hygiene, location of water source in close proximity to dump sites, latrines, population pressure on the water sources and lack of adequate protection of most water sources.This study also demonstrated that nanocellulose adsorbent exhibited various degrees of reductions of the concentration in the physicochemical parameters of Surface (rivers/ streams) and borehole water investigated.

Authors' contributions

Baba John supervised microbiological analysis; Soda Gaius Baga was responsible for collection of samples and microbiological analysis; Azeh Yakubu conducted chemical analysis; Bala Ezekiel assisted in the microbiological analysis.

Conflict of Interest - None

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