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Bacteriological Analysis of Water Sources in Dutsinma Metropolis Katsina State

Mzungu Ignatius, Orpin James Bemshima*, Bem Alexander Adi

Department of Biological Sciences, Federal University, Dutsinma, Nigeria

Abstract

To ascertain the quality of major sources of water for drinking and general uses in Dutsinma metropolis, physicochemical and bacteriological quality of water sources were examined. Samples were collected from four major water sources (Tap, Borehole, Well and Dutsinma Dam). Physicochemical parameters were accessed using the Hanna™ Instruments. Bacteriological quality was analyzed using the Most Probable Number Technique. Results of total coliform count and faecal coliform counts for Dam and Well water were above the recommended standards for WHO for drinking water. However, Borehole 5 (62.5%) and Tap 9 (90%) water had total coliform counts within the WHO limits. The prevalence of two bacteria isolates; *Escherichia coli* 16 (57.14%) and *Salmonella sp.* 12 (42.28%) were observed among the samples. Analysis of the physicochemical parameters showed that most of the samples (56.57%) recorded a value of PH below WHO guidelines PH (6.5 – 8.5). This study reveals that Tap and Borehole water are suitable for general use while Well and Dam need extra treatment to prevent pathogenic disease outbreak.

Keywords

Bacteriological, Analysis, Water Sources, Dutsinma

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1. Introduction

Water is a valuable commodity for the survival of all life forms in the ecosystem [1]. It is a critical requirement in the maintenance of metabolic functions and homeostasis. In living cells, the human body is composed of about 60% water by weight in adult males, 50% in females and 70% in new born infants [2]. The human dietary requirement of water is estimated to be approximately two litres per day for an average adult [3]. This means that drinking water must not contain harmful contaminants, such as disease-causing microorganisms (pathogens), toxic substances, physical and chemical residues, as well as undesirable properties like odour, colour and taste [4].

Water can be from underground sources or from surface sources; it can be treated (processed) including tap, sachet andbottled or untreated (unprocessed) water from dam, well, borehole. Both treated and untreated water can be delivered to consumers through bottles, transport vehicles and municipal taps [5]

Water is essential for the composition and renewal of cells, growing crops, plants, household uses such as drinking, cooking, sanitation and in industries for various physical, chemical and biological processes [6]. Despite this, human beings continue to pollute water sources resulting in provoking water related illnesses [5]. Provision of quality water to rural and urban population is necessary in order to prevent health hazards [7].

Water is examined microbiologically to determine its

* Corresponding author
E-mail address: jorpin@fudutsinma.edu.ng (O. J. Bemshima)

sanitary quality and its suitability for general use. The aim being that it will be acceptable for internal consumption and other uses by man. Water may contain poisonous chemical substances, pathogenic organisms (infectious and parasitic agents), industrial wastes or sewage and these constitute contaminants or pollutants of water. Most of the infections in developing countries including diarrhea, Cholera, Typhoid, Hepatitis and Poliomyelitiscan be attributed to lack of safe drinking water.

*Escherichia coli*is usually considered as an indicator organism for faecal contamination and is an important parameter in food and water hygiene. While generic *E. coli* is considered as an intestinal flora, many strains of these species can be pathogenic leading to diarrheal disease. Many drinking water and recreational water sources are reported nowadays with contamination of a particular strain of *E. coli* known as *E. coli* 0157:H7 which is a strain of the *enteroheamorrhagic E. coli* group, and is recognized as an organism whose presence in any water can lead to serious disease outbreak.

Presence of faecal coliforms or *Escherichia coli* is used as an indicator for the presence of any of these water borne pathogens; *E. coli*, *Salmonellasp., Shigella sp., Proteus.*, Citrobacter, and Enterobacter [8]. Good quality water is odourless, colourless, tasteless, and free of faecal contamination and harmful chemical substances.

The public health significance of water quality cannot be over emphasized. Many infectious diseases are transmitted by water through the faecal-oral route. Diseases contacted through drinking water kill about 5 million children annually and make 1/6th of the world population sick [5]. Water is vital to our existence in life and its importance in our daily life makes it imperative that thorough microbiological and physicochemical examinations be conducted on water. Portable water is the water that is free from disease producing microorganisms and chemical substances that are dangerous to health [9].

In Africa nearly 80% of the populations rely on surface water as the main source of water [10]. This relatively high percentage of the population that is without proper water supply services indicates that many of the people still utilize untreated surface water for domestic purposes. Most of these people are poor and rely on State Interventions for improved water supply.

In Nigeria, majority of the rural populace do not have access to potable water and therefore, depend on well, stream and river water for domestic use. The bacterial qualities of groundwater, pipe borne water and other natural water supplies in Nigeria, have been reported to be unsatisfactory, with coliform counts far exceeding the level recommended by WHO [11, 12]. The reason for elucidation of important parameters in water quality assessment may be attributed to the fact that in the overall portability of water, such parameters should not be ignored [13].

The raw water from different water sources is been used by the people residing in areas around Dutsinmametropolis to feed their animals, for drinking and as sources for irrigation. As these water sources are loaded with high population of microorganisms (bacteria and fungi) may result in the infection of the people and their livestock with pathogenic microorganisms and may also be the source of associating of irrigated food products with harmful microorganisms.

This study was aimed at carrying-out the Bacteriological Analysis of Water Sources in DutsinmaMetropolis, Katsina state with the following objectives:

1. To analyze physiochemical parameters of the different water sources within Dutsinma Metropolis.
2. To determine the total coliforms/faecal coliforms in the water sources.
3. To isolate and identify *E. coli* and *Salmonella sp.*
4. To determine the antibiotic susceptibility of the *Salmonella* isolates

2. Materials and Methods

2.1. Study Area

The study was conducted in Dutsinma Local Government Area, Katsina State and samples were collected from four different sources within the Metropolis. It is located on Latitude 12° 27'18"N and longitude 7° 29'29"E and has its headquarters in the town of Dutsinma. It has an estimated area of 527km^2 (203sqkm) and a population of 169,671 as at 2006 census. The Local Government is bounded by Kurfi and Charanchi Local Governments to the North, Kankia Local Government to the East, Safana and Dan- Musa Local Governments to the West, and Matazu Local Government to the South. The people are predominantly farmers, cattle rearers and traders.

2.2. Sampling Frequency

Water samples for all microbiological analysis, from different sources within Dutsinma local government area was collected on a weekly basis from each source mostly within the hours between 9.00 am to 12 noon.

2.2.1. Collection of Water Sample from Tap

The outside nozzle of the tap was properly wiped with a clean cloth, then the tap was turned on full and the water was

allowed to run for a minute. The tap head was then sterilized using flame from a lighter until the whole tap was hot. After this the tap was allowed to cool by running the tap for a few seconds, the sample 200ml capacity sample bottle was then filled with a gentle flowing water from the tap and cap of bottle replaced. This was appropriately labeledwithgrease pencil [14]

2.2.2. Collection of Water Sample from Dam

Sample bottles were clamped to the end of a stick, aseptically and inserted into the dam with the necks of the bottles plunged downwards about 30cm below the water surface andslightly tilted. The bottles were removed and screwed tight after been filled with flow of water andlabeled with sample code number [14]

2.2.3. Collection of Water Sample from the Well

Sample bottle was tied to a weighted length of rope and lowered into the well to a depth of about 1m to collect water. Bottles was then raised out of the well and caps carefully replaced when no more air bubbles rose to the surface and the sample bottles were labeled with code number [14]

2.3. Transportation of Water Sample to Laboratory

Immediately after collection, samples were placed in an insulated cold box and transported to the Microbiology Laboratory of Federal University Dutsinma for analysis

2.4. Physiochemical Parameters

2.4.1. pH (pH Units)

Water pH was determined using a HANNA HI-2211 Bench Top pH meter. pH readings was taken to the nearest one decimal place and recorded

2.4.2. Temperature (°C)

Temperature of water sample was taken using HANNA HI 2210 pH meter with Temperature Thermometer at site of water collection and recorded appropriately.

2.4.3. Dissolve Oxygen

Dissolve oxygen of the water samples was measured with a HANNA Uni-T 70d Universal digital meter multipurpose meter and recorded accordingly.

2.4.4. Conductivity

Conductivity of water sample was taken using a HANNA HI-2211 Bench Top pH meter and Conductivity Meter. A conductivity (mV) meter reading was taken to the nearest one decimal place and recorded

2.5. Determination of Total Coliform/Faecal Coliforms

The multiple tube fermentation method also known as the most probable number (MPN) was used to obtain the total coliforms and test was performed using three test tube sets to determinefaecal coliform. All positive tubes from the MPN procedures were sub-cultured on Eosine Methylene Blue agar plates and incubated at 35°C for 24 hours [14].

Procedure

Sterile bottles of MacConkey broth containing an inverted Durham tube for the collection of gas, it was ensured that inverted Durham tube inside the bottles of sterile MacConkey broth was fully filled with broth eliminating all air bubbles. The Broth was then sterilized in autoclave at 121°C for 15 minutes; sample water bottle was labeled with sample code number, Sample water was mixed thoroughly by inverting the bottles several times, the bottle cap and covers was removed aseptically and mouth flamed then bottles of sterile broth were inoculated as follows:

Fifty (50) ml of water sample was added to 50ml of broth then 10ml from the water sample was added to each of the five bottles containing 10ml of broth, using a sterile pipette. For untreated samples; 1ml of water was added into each of five bottles containing 5 ml broth with a pipette. The inoculated broth was then incubated in a water bath at 44°C for 24 hours, with the bottles loosely capped. After incubation, each bottle which produced gas was examined and counted. Acid production was shown by a change in colour of the MacConkey broth from purple to yellow and gas production by the collection of a bubble in the Durham tube. The Most Probable Number Table was used to determine the most probable number (MPN) of faecal coliform bacteria in the 100ml and 105ml water sample. All positive tubes from the MPN procedures were sub-cultured on Eosine Methylene Blue agar (EMB) plates for isolation of *E. coli.*

2.6. Isolation of *Salmonella* Species

Salmonella species were isolated using Salmonella/Shigella agar (SSA). The media was prepared following the manufacturer's directives and 0.1ml aliquot of each water sample was transferred aseptically onto the surface sterilized SSA plates. The plates were inoculated in triplicates and incubated at 37°C for 24 to 48 hours. Thereafter, pale colour colonies with dark centres (H_2S production) was counted and identified following standard procedures [14].

2.7. Identification of Isolates

The cultural, morphological and biochemical characteristics of the respective isolates of *Escherichia coli* and *Salmonella*

sp. Were done while EMB plates were used to identify *Escherichia coli*, SSA plates were used to identify *Salmonella sp* [14].

2.8. Antibiotic Susceptibility Testing for *Salmonella sp*

Isolates were screened using sensitivity multiple disc (AbteckBiologicals Ltd). The procedure included inoculation of pure culture on nutrient agar plates. Antibiotic sensitivity disc was later placed on solidified plates and both plates were incubated at 37°C for 24hrs. Zone of inhibition seen round the antibiotic disc the following day were measured while length was categorized as resistant, intermediate and sensitive after comparing with CLSI standard for each bacteria isolate [15].

3. Result

Result in table 1 shows presumptive test results for coliform counts as detected by Most Probable Number technique. It showed the types of water sampled and each percentage positive result with tap and well water showing 26.09% and 30.43% respectively while borehole and dam recorded 21.74% each. The result of Presumptive test revealed that Dam water and Well water showed 100% presumptive test, followed by borehole water and Tap water which recorded a total of 62.5% and 60% positive Presumptive test respectively.

Table 1. Result of Presumptive Coliform Detection by Most Probable Number Technique.

Type of Water	Total No. Tested (%)	Positive (%)	Presumptive Test (%)
Tap Water	10 (33.33)	6 (26.09)	60.00
Well Water	7 (23.33)	7 (30.43)	100.00
Borehole Water	8 (26.67)	5 (21.74)	62.50
Dam	5 (16.67)	5 (21.74)	100.00

The results in tables 2 to 5 show the Bacteriological analysis and physicochemical parameters of Tap water, Dam Water, Borehole Water and Well Water. The tables display the maximum, minimal, Mean and Standard Deviation values of pH, Temperature, Dissolve Oxygen, Conductivity, Total Coliform and Faecal Coliform from each water source. The results clearly showed that Dam water recorded the highest number of both Total Coliform and Faecal Coliform followed by Well water then Borehole. The least counts were recorded from Tap water.

Table 2. Bateriological and Physiochemical Parameters of Dam Water Samples.

Parameter	Maximum	Minimum	Mean± S.D
PH	6.5	6.0	6.2±0.497
Temperature	27.0	26.0	26.5±0.50
Dissolve Oxygen	4.6	4.0	4.22±0.249
Conductivity	6.7	6.5	6.66±0.102
TCC/100ml	180	50	128±55.59
FCC/100ml	25	40	33±7.583

Table 3. Bacteriological and Physiochemical Parameters of Well Water Samples.

Parameter	Maximum	Minimum	Mean± S.D
PH	6.8	5.5	6.1±0.42
Temperature	28.0	26.5	27.2±0.64
Dissolve Oxygen	6.5	3.9	4.9±0.91
Conductivity	19.4	14.0	16.4±1.68
TCC/100ml	160	2	49.4±56.34
FCC/100ml	25	0	11.3±8.09

Table 4. Bateriological and Physiochemical Parameters of Borehole Water Samples.

Parameter	Maximum	Minimum	Mean± S.D
PH	6.8	4.9	5.9±0.769
Temperature	29.0	27.0	28.0±0.695
Dissolve Oxygen	7.1	2.5	5.05±1.628
Conductivity (m/V)	16.0	5.8	12.3±3.828
TCC/100ml	50	0	9.61±16.97
FCC/100ml	4	0	1.3±3.50

Table 5. Bateriological and Physiochemical Parameters of Tap Water Samples.

Parameter	Maximum	Minimum	Mean±S.D
PH	8.2	6.0	7.0±0.585
Temperature	28.0	27.0	27.10±0.316
Dissolve Oxygen	6.8	3.8	6.27±0.397
Conductivity	19.0	15.1	18.00±1.075
TCC/100ml	16.0	0.0	3.20±4.830
FCC/100ml	6.0	0.0	1.00±1.870

Results from table 6 show the prevalence of bacteria isolated from the water samples collected including *E. coli* recording the highest prevalence in well water (37.5%) followed by borehole and dam water recording 31.25% and the least seen in tap water of 12.5% and *Salmonella sp.* recording the highest prevalence rate in well and dam water of 41.67% respectively followed by borehole and tap water of 8.33% each.

Table 6. Prevalence of bacteria isolates in Water Samples.

Isolates	Tap Water (%)(n =3)	Well Water (%)(n=11)	Borehole (%) (n=4)	Dam Water (%) (n=10)	Total (%)
Escherichia coli	2 (12.5)	6 (37.5)	3 (31.25)	5 (31.25)	16 (57.14)
Salmonella sp.	1 (8.33)	5 (41.67)	1 (8.33)	5 (41.67)	12 (42.86)

Table 7 Show the antibiotics susceptibility test of Salmonella isolates, as detected in different water sources displaying the sensitivity, resistance and intermediate susceptibility of different antibiotics with their disc content or potency and the resistance pattern of the isolates.

Table 7. Antibiotics susceptibility testing for *Salmonella sp.* Isolates.

Isolates	Result of Susceptibility							
	AMX (25ug)	NIT (30ug)	GEN (10ug)	NAL (30ug)	OFL (5ug)	COT (25ug)	AUG (30ug)	TET (30ug)
ATI	S	R	S	R	I	R	R	R
AWI	S	I	S	R	I	R	R	R
BWI	S	R	S	S	I	R	R	R
DSI	I	R	S	S	R	R	R	R
DS2	I	R	S	S	R	R	R	R
DS3	I	R	S	S	R	R	R	R
DS4	I	R	S	S	R	R	R	R
DS5	I	R	S	S	I	R	R	R
HW1	S	I	S	R	R	R	R	R
IB2	S	I	S	R	R	R	R	R
KW2	S	I	S	R	I	R	R	R
KW3	S	I	S	R	I	R	R	R

Key:
AMX: Amoxicillin, OFL: OflaxacinAUG: Augmentin, TET: Tetracycline
COT: CotrimoxazoleNIT: NitrofuratoinGEN: GentamicinNAL: Naldixic Acid
I: Intermediate, R:Resistance, S:Sensitive

4. Discussion

Analysis of the physicochemical parameters shows that most of the samples recorded a value of PH (56.57%) below WHO guidelines PH (6.5 – 8.5). The Temperature, Dissolve Oxygen and Conductivity were all (100%) within WHO permissible limit. This study reveals that Tap and Borehole water are suitable for general use while Well and Dam water need extra treatment to prevent pathogenic disease outbreak. Physical or visual observable dirtiness of water resources are indicators of water pollution, most water samples from the Dam water were found to be dirty and turbid, this could be attributed to direct emptying of wastes materials into the water sources. All borehole water sampled was observed to be hard and total hardness of water is a function of the geological area with which the water is associated. This affects the taste of water as well as influences its leathering ability when used for washing. But on the other hand the presence of Calcium and Magnesium in hard water is essential for formation of strong bones [16].

Conductivity which is a numeric measure of the capacity of an aqueous solution to pass electric current was found to be within WHO limit. The low conductivity value of some samples, mostly dam water samples implies that the dissolve

salt is minimal. This research indicates that most of the water sources did not meet the standard for World Health Organisation.

The microbiological analysis of total coliform and faecal coliform count in water samples revealed the presence of coliform bacteria in both treated water and untreated water. This high

total coliform and faecal coliform count may be attributed to runoffs from nearby farms, this agrees with findings of [17] that agricultural wastes are usually high in organic matter and nutrients and could also cause increase in the microbial flora of open water bodies thereby resulting in high bacteria counts.

The highest number of bacterial count recorded in raw water samples from the Dam water source 128MPN/33MPN for total coliform and faecal coliform could be as a result of the increased surface area of the dam which exposes the water to contaminants as well as human activities. This finding agrees with similar studies as reported, that the sources of heterotrophic bacteria in water are human and animal waste, runoff, pasture, natural soil or plant bacteria, sewage and other unsanitary practices [18].

However, according to [5], drinking water can be categorized into four (4) depending on their bacterial count value. Water with a zero is excellent, count of 1 – 3 is satisfactory, presumptive count of 4 – 10 is suspicious and count above 10 is unsatisfactory. Water with a count greater than 3 is not suitable for drinking. The high Total Coliform obtained in Tap water sources may be an indicator that the water samples were faecally contaminated, these can be as a result of improper processing and purification procedures, unhygienic handling after production. It may also be attributed to many or more of the following; contamination of treated water by organisms harbored in the distribution system, lack of or poor quality control system, otherwise the level of treatment of the water source would have been identified before distributing to municipal taps, poor treatment mechanism, it is also possible that the equipment or machines used in the purification were not functioning effectively. Similar studies reported the presence of these bacteria coliform in drinking water source [19, 20, 21] and attributed it to indiscriminate human and animal defecation, general poor sanitation and general treatment mechanism.

Some few Borehole water sources recorded total coliform and faecal coliform exceeding WHO standard of 10MPN/100ml and 0MPN/100ml respectively, these counts can be as a result of its closeness to dumpsite and depth of the borehole. The borehole water sampled recorded mean value of 9.81MPN/100ml and 1.31MPN/100ml. This result agrees with the findings of [22] that the MPN index per 100ml of water samples collected from selected boreholes in Ilorin metropolis ranged from 0 to 16MPN/100ml. [23] in a related research isolatedsome members of coliforms in stored borehole water samples.

All well water sources recorded total coliform and faecal coliform far exceeding WHO values, ranging from the least, 2MPN/100ml and 0MPN/100ml to the highest 160MPN/100ml and 25MPN/100ml. The low value in some of the well water sources could be due to the fact that the water source is from a private well or because the well is properly closed after each use. On the other hand, the high count of bacteria in well water could be due to the following; improper disposal of sewage and wastewater from domestic activities, discharge from septic tanks and latrines close to some of the well water sources. This is in agreement with work of [24].

The prevalence of two bacteria isolates and indicator organisms in water samples collectedreveals that of all the total 30 samples collected 28 detected *Escherichia coli* (57.14%) and *Salmonella sp.* (42.86%). These organisms are important human pathogens associated with a variety of infectious diseases such as gastroenteritis, typhoid fever, dysentery, cholera, urinary tract infectious diseases [25]. Their presence raises public health concern because they are known causative agents of many water borne diseases.

5. Conclusion

Unsafe drinking water continues to burden developing countries, Nigeria and the area were this research was carried out, despite improvements in clean water delivery and sanitation, unsafe drinking water presents increased risk of opportunistic infections. The results of this study clearly suggest that most of the different water sources are unsafe for human consumption. This study also reveals the presence of *E. coli* and *Salmonella sp.* suggesting that some of the water sources could present public health risk in the areas covered

6. Recommendation

Based on the findings of this research, it is important to create public health enlightenment on the risk of consuming untreated water, especially from Dam.

It is also recommended that appropriate agencies should properly monitor the location and drilling of wells and boreholes by putting in place correct measures and enforce the right policies concerning portable water.

Boiling in addition to other methods (Household Water treatment), should be improved.

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