Physico-Chemical Analysis of Some Wells and Streams in North Bank, Makurdi – Benue State, Nigeria

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Abstract - Four different samples of water were collected within North bank, Makurdi. The samples collected were tested for both physical and chemical properties in the laboratory. The parameters include colour, taste, odour, P^H, acidity, alkalinity, hardness, calcium and magnesium. The values of analysis obtained were temperature ranges from 25.8 to 23.0, P^H 5.11 to 7.64 mg/l, acidity ranges from 290 to 330 mg/l, total alkalinity ranges from 41.3 to 57.4 mg/l, total hardness ranges from 27 to 39 mg/l, calcium ranges from 22.8 to 27.3 mg/l, magnesium hardness ranges from 0.30 to 0.96. The results of the analysis generally revealed that all the samples fall within the acceptable standard for drinking water by World Health Organization (WHO) and National Agency for Food Drug Administration and Control (NAFDAC).

Keywords: ***Physico-Chemical, Analysis, Wells, Streams, North Bank, Makurdi, Alkalinity, Reagent, Permissive Concentration and Acidity.***

I. INTRODUCTION

Water is one of the most abundant chemical substances in the world. It covers 70% of the earth surface. It varies in depth and volume from one region to another. Water is regarded as a universal solvent because it has the ability to dissolve most substances. It is one of the most known compounds to man, water is an essential ingredient of all living organisms and a major component of the environment in which we live [6]. The average total human intake of water per day (in drinking, food and through oxidation process) is about 2.5 liters.

Drinking water in its free state may be unhygienic. Indeed the presence of pathogenic micro-organism in drinking water which may cause water-borne diseases has been reported. [16].

It was the need to provide safe drinking water and sanitation that the World Health Organisation [18] in 1981 declared the International Drinking Water Supply and Sanitation Decade (IDWSSD), with the main focus on the provision of adequate quality water for the growing population of the world.

The quality and quantity of water from surface and underground, the two main sources are influenced by climatic and human activities. Ground water can normally be used with little or no treatment. Surface water on the other hand needs extensive treatment particularly if polluted [3].

Surface water exists in natural basins and stream channels where minimum flows in streams or river are large in relation to water demands of adjacent lands, towns and cities. While ground water results predominantly from precipitation that has reached the zone of saturation in the earth through infiltration and percolation [1]. [4] regards water as the second most important necessity of man, air being the first and the man's dependency on water starts in womb. The importance of water cannot be over emphasized as life on earth depends on the continuous existence of water. In order to survive, all animals and plants have ample supply of water free from toxic and pathogenic micro-organisms for contamination. [13] as a settlement turns into a metropolis accompanied with increase in population, the problem of supplying adequate quality of water also increased because not all water is fit for human consumption. Drinking water must have appropriate organoleptic properties as being tasteless, colourless and odourless. Condition of water supply assessed shows that African countries have an average of 59% of the urban areas provided with safe drinking water [2] Similarly, an adequate safe water supply is a basic requirement for all communities and is a fundamental means of promoting health [15]. The drinking water of most areas is obtained from surface source, such as rivers, streams and rainwater.

Methods of Determination of Water Quality

1. Physical Methods.

Under this method, sample collected from some wells and streams are to be tasted for some physical parameters such as colour, odour and taste.

2. Chemical Methods

Specific detection of each of the elemental composition is done by filing the beaker with part of the water samples and adding appropriate reagents.

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3. Biological Methods.

It involves the use of additional reagents to test the presence of bacteria, virus and other water-borne diseases [17]. The choice of a particular method is based on comparing the quality of water from source with specifications or requirements of a consumers technology [11].

Pollution caused by human activities is more widespread. The sources of water pollution are classified into two: point source and polluted run-off. Polluted run-off is caused by land pollutants that enters bodies of water over large areas rather than at a single point. Polluted run-off includes agricultural run-off, miring wastes, municipal wastes and construction sediments. Soil erosion is a major source of this pollution. The point source includes animal feedlots chemical dumpsites, storm and server outlets and other identifiable points of origin [14] Although sewage is the micro-pollutant produced by cities and towns, urban run-off from city streams is often worse than that of sewage. Urban run-off carries salt from road-ways untreated garbage. It often contains such contaminants as chloride, copper, cyanides, lead motor oil, organic waste [9].

Agriculture is the leading source of water quality impairment of surface water nationwide. For example, 73% of the water pollution in the rivers is attributed to agriculture. Agriculture practice produce several types of pollutants that contributes to run-off pollution [12].

Many industries such as steam generating, electric power plants, use water to remove excess heat from their operations. Thermal water pollution occurs when water needed for cooling industrial plants, especially fossil fuels and nuclear power plants is withdrawn from a lake, river and other bodies of water, and returned to that body at higher temperatures that undesirable ecological changes occur in aquatic system [10]

Government, generally control point source pollution through penalties on polluters by taxing polluters for the clean-up. In Nigeria, the defunct federal government environmental protection agency set up by the decree 58, of 1999 serves as a watch dog in this aspect [6]

The quality of neutral water is judged after making a complete set of analysis. According to [16] assessing water quality, it is often convenient to group these parameters into physical and chemical properties. The relevance of water quality parameters depend upon the nature of the waste or waste water and its actual potential use.

Water possesses several unique physical and chemical properties.

Physical properties:

Pure water is colourless, tasteless, and odorless liquid with the following properties:

- Usually described as a universal solvent due to its ability to dissolve many substances.
- A boiling point of 100^0C.
- A maximum density of 1gram/cm^3
- Neutral to litmus paper. [8].

Chemical properties:

The chemical composition of water depends on the characteristics of the catchments area. Ground water acquires the characteristics of the soil through which it flows.

pH is defined as the logarithm of the reciprocal of hydrogen ion concentration. That is hydrogen ion index and is a measurement of the acidity and alkalinity of water. It is one of the most important determination in chemistry since many of the processes in water treatment are PH dependent.

Pure water is only slightly ionized and contains equal amount of hydrogen and hydroxyl ions. The PH values of the unpolluted water is mainly determined by the interrelationship between free carbon dioxide and the amount of carbonate and bicarbonate present. The World Health Organisation (WHO) guidelines recommended a PH of 6.8 to 8.5. The PH level can be determined by using PH meter [3].

Total hardness:

Water is said to be hard when it does not form lather with soap. The principal ions causing hardness in natural water is not harmful to human health. The associated anions are usually sulphate, chloride and bicarbonate. The alkaline earth metal cations calcium and magnesium, are found more in fresh water than ground water. Their presence is due to the action of dissolved carbon dioxide in water or limestone [16].

Calcium and magnesium hardness.

Calcium is often the most common metallic ion in fresh waters and among the most common in ground waters. Weathering of calcium bearing rocks or the ions exchange is the major source of calcium in water.

Magnesium salts are in ground more soluble than calcium salts. But magnesium is less abundant in rocks and soil. Calcium and magnesium are often associated with alkalinity and hardness [7].

Total Alkalinity:

Total alkalinity measured by titrating with a standard acid neutralizing capacity of the sample [5] Because of the abundance of carbonate minerals and their availabilities of carbon dioxide from the atmosphere of micro-activities. The most common of alkalinity are calcium bicarbonate and magnesium bicarbonate, referred to as carbonates

II. OBJECTIVES OF STUDY

The main objectives of this study include:

i. To test for some physical and chemical parameters of wells and stream from different wells and stream in North Bank environment.

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ii. To relate these parameters to standard approved by the World Health Organization (WHO) and National Agency for Food, Drugs Administration and Control (NAFDAC), for drinking water.
iii. To compare the difference in water quality between wells and streams in North Bank.
iv. To draw the meaningful conclusion and recommendation for the physical and chemical parameters of the water in the study area.

III. MATERIALS AND METHODS

Sample and sample collection

Four samples of water were collected through grabbing method, two from wells and two from streams source, in a container containing 200 to 400 ml of water. A total of 800 to 1600 ml of water were collected from four different water samples. The following wells and streams samples were collected and analysed.

i. Jor Jamu well water (Point A)
ii. Jor Chinkafa well water (Point B)
iii. Kpege stream (Point C)
iv. Keereke stream (Point D)

3.1 REAGENTS USED

Laboratory analyses were carried out at the laboratory of the State Environmental Protection agency Makurdi. The following reagents were used:

- EDTA solution
- Ammonia buffer solution
- Eriochrome black T indicator (EBT)
- Carbon dioxide- free water
- Standard hydrochloric acid solution (0.1N)
- Standard hydrochloric acid solution (0.02N)
- Methyl orange indicator solution
- Sodium hydroxide (1N)
- Phenolphthalein indicator solution
- Methyl red indicator solution
- Silver nitrate standard solution (0.028N)
- Potassium chromate indicator solution
- Barium chloride solution

3.2 PROCEDURE:

ALKALINITY DETERMINATION

500ml of each sample was measured into four different conical flasks and three drops of well mixed methyl orange indicator added. The sample turned yellow when titrated with standard (0.02N) HCL solution until the first appearance of the orange colour was noticed. The titration was repeated three times and average titre values were recorded. The alkalinity was calculated in mg/liter.

3.4 ACIDITY DETERMINATION

50ml of sample was measured into four different conical flasks and three drops of phenolphthalein indicator was added and titrated with (1N) NaOH solution until pink colour was observed. This was done for each sample. The titration was repeated two times and the average titre value was taken. The acidity was calculated in mg/litre.

3.5 TOTAL HARDNESS

50ml of each sample was measured into four different conical flasks and 1ml of ammonia buffer solution was added and three drops of EBT indicator was added and titrated with EDTA solution to a wine blue colour. The titration was repeated two times and the average titre was taken. The total hardness was calculated in mg/litre.

3.6 CALCIUM HARDNESS

50ml of each sample was measured into four different conical flasks and 1ml of NaOH was added and pinched amount of murexide indicator was added and titrated with ETDA until the colour changed from pink to purple. Each sample was titrated three times and the average titre value was taken. The calcium hardness was calculated in mg/litre.

3.7 PH DETERMINATION

PH was determined using pH metre. A beaker was filled with the sample and the PH metre electrode was inserted in the sample for three minutes and the value was recorded.

3.8 TEMPERATURE DETERMINATION

A beaker was filled with about 30ml of the water sample and a thermometer was inserted in the sample for two minutes and the value was recorded.

3.9 COLOUR DETERMINATION

The colour of the sample was determined visually

3.10 ODOUR DETERMINATION

About 20ml of sample was taken into a beaker and sniffed in the laboratory.

IV. CALCULATIONS

4.1 Formula for Alkalinity is given as:

$$alkalinity = \frac{T \times N \times 1000}{Volume\ of\ sample}$$

Where T = Volume of acid used

N = Normality of acid used

Alkalinity for sample A

T = 140

N = 0.02

V = 50 (volume of sample)

$$Alkalinity\ A = \frac{140 \times 0.02 \times 1000}{50} = \frac{2800}{50}$$
$$= 56mg/l$$

$$Alkalinity\ B = \frac{138 \times 0.02 \times 1000}{50} = \frac{2760}{50}$$
$$= 55.2mg/l$$

$$Alkalinity\ C = \frac{137 \times 0.02 \times 1000}{50} = \frac{2740}{50}$$
$$= 54.8mg/l$$

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$$Alkalinity\ D = \frac{135 \times 0.02 \times 1000}{50} = \frac{2716}{50}$$
$$= 54.3mg/l$$

4.2 Formula for Acidity is given as:

$$Acidity = \frac{V1 \times N \times 50 \times 1000}{V}$$

Where V1 = Volume of NaOH used
V = Volume of sample taken
N = Normality of NaOH

$$Sample\ A = \frac{0.04 \times 1 \times 50 \times 1000}{50} = \frac{2000}{50}$$
$$= 400mg/l$$

$$Sample\ B = \frac{0.38 \times 1 \times 50 \times 1000}{50} = \frac{1900}{50}$$
$$= 380mg/l$$

$$Sample\ C = \frac{0.35 \times 1 \times 50 \times 1000}{50} = \frac{17500}{50}$$
$$= 350mg/l$$

$$Sample\ D = \frac{0.34 \times 1 \times 50 \times 1000}{50} = \frac{1700}{50}$$
$$= 340mg/l$$

4.3 TOTAL HARDNESS

$$Formula = \frac{T \times 1000}{V}$$

Where T = Volume of ETDA used
V = Volume of sample used

$$Sample\ A = \frac{1.80 \times 1000}{50} = \frac{1800}{50} = 36.0mg/l$$

$$Sample\ B = \frac{1.82 \times 1000}{50} = \frac{1820}{50} = 36.4mg/l$$

$$Sample\ C = \frac{1.78 \times 1000}{50} = \frac{1780}{50} = 35.6mg/l$$

$$Sample\ D = \frac{1.76 \times 1000}{50} = \frac{1760}{50} = 35.2mg/l$$

4.4 CALCIUM HARDNESS mg/L

$$Formula = \frac{T \times 1000X1}{V}$$

Where V = Volume of sample used
T = Volume of ETDA used

$$Sample\ A = \frac{1.46 \times 1000 \times 1}{50} = \frac{1460}{50} = 29.2mg/l$$

$$Sample\ B = \frac{1.45 \times 1000 \times 1}{50} = \frac{1450}{50} = 29mg/l$$

$$Sample\ C = \frac{1.38 \times 1000 \times 1}{50} = \frac{1380}{50} = 27.6mg/l$$

$$Sample\ D = \frac{1.34 \times 1000 \times 1}{50} = \frac{1340}{50} = 26.8mg/l$$

4.5 MAGNESIUM HARDNESS

$$Formula = \frac{T \times 1000 \times 1}{V}$$

Where V = Volume of sample used
T = Volume of ETDA used.

$$Sample\ A = \frac{0.98 \times 1000 \times 1}{50} = \frac{980}{50} = 19.6mg/l$$

$$Sample\ B = \frac{0.92 \times 1000 \times 1}{50} = \frac{920}{50} = 18.4mg/l$$

$$Sample\ C = \frac{0.65 \times 1000 \times 1}{50} = \frac{650}{50} = 13.0mg/l$$

$$Sample\ D = \frac{0.59 \times 1000 \times 1}{50} = \frac{590}{50} = 11.8mg/l$$

V. RESULT AND DISCUSSION

Table 5a. The result for the analysis of the water sample is presented in table below.

Parameters	A	B	C	D
PHYSICAL				
Temperature	29.6	31.2	26.3	24.6
P^H	7.64	7.63	6.8	5.17
Taste, odour and colour	U	U	U	U
CHEMICAL				
Total alkalinity mg/L	56	55.2	54.8	54.3
Acidity mg/L	400	380	350	340
Total hardness mg/L	36	36.4	35.6	55.2
Calcium hardness mg/L	29.2	29	27.6	26.8
Magnesium hardness mg/L	19.6	18.4	13.0	11.8

Table 5b. World Health Organization and National Agency for Food Drugs and Administration Control Standard for Drinking Water.

Element/allowable Parameter physical	Unit	WHO maximum	NAFDAC maximum
Temperature	^{o}C		
Colour	Pt – Co	5.0 – 50	
Odour		U	U
Taste		U	U
Turbidity	FTU	5	-
Total dissolved solids	Mg/L	1000	500
Chemical			
P^H		7.0 – 8.5	6.0 – 8.5
Alkalinity	Mg/L	100 – 500	-
Carbondioxide (CO_2)	Mg/L	100 – 500	-
Conductivity	Mg/L	75 – 200	-
Calcium (Ca)	Mg/L	50	75 – 200
Magnesium (Mg)	Mg/L	50	30 – 150
Sulphate (SO_4)	Mg/L	200	200
Chloride (CL)	Mg/L	200	200

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Nitrate (NO_3)	Mg/L	50	-
Mercury (Hg)	Mg/L	0.001	-
Iron (Fe)	Mg/L	0.05 – 0.5	-
Total hardness	Mg/L	600ml/L	-
Micro biological			
Coliform count/ml	Ml	Must be detectable in Any 100ml/sample	

- U: unobjectionable

VI. DISCUSSION OF RESULTS

6.1 - Water analysis as previously discussed is a measure of its physical and chemical characteristics of a body of water as well as its intended uses. The results obtained were compared with the acceptable standards of World Health Organization (WHO) and National Agency for Food Drug Administration and Control (NAFDAC).

PHYSICAL PARAMETERS.

6.2 Colour:

- Some of the color has bright appearance. This is an indication that the samples were not contaminated with dissolved solids. The colour observed are in line with the WHO and NAFDAC standards.

6.3 Taste and Odour

- The samples have unobjectionable taste and odour which is in line with the WHO standards.

6.4 Temperature:

- The average temperature ranged from 31.2 to 24.6 ^oC. This can be related to the prevailing atmosphere conditions during the period of measurement. Comparatively, well water had higher temperatures compared with streams because of their large surface area which expose a larger volume of water to evaporation (Agunwamba *et al*, 2016).

6.5 P^H

- The P^H of the water is the degree of the acidity and alkalinity of the water. From the result in table 5a, the P^H of the sample D is 5.17, which is acidic and sample C is slightly acidic, which is 6.8 and that of A and B are slightly alkaline (Majajan, 1989). The World Health Organisation (WHO) permissible limit for potable water is 6.5 to 8.5, indicating that A and D are within acceptable range of both WHO and NAFDAC.

CHEMICAL PARAMETERS

6.6 Total Hardness

- Total hardness in water is due to calcium and magnesium ions. The value obtained for total hardness range from 36.4 to 36mg/L. The values of the total hardness obtained are very low compared to the WHO permissive concentration of 600mg/L maximum. This low concentration of total hardness indicates suitability of water sample for drinking. (Tebbutt, 1980).

6.7 Alkalinity:

- Alkalinity is the measure of carbonate and bicarbonate content of water sample. In some water samples, soluble carbonate and hydroxide also give rise to alkalinity, which can be regarded as the capacity of water to receive acid without substantially lowering the P^H. These values are below WHO maximum permissive concentration of 100 to 500mg/L indicating the suitability of the sample for drinking.

6.8 Calcium and Magnesium

- Calcium is often the most common metallic ion in fresh surface water and among the most common in ground water. Magnesium sulphates are in general more soluble than calcium salts as magnesium is less in abundance in rocks and soil.
- Magnesium level in natural waters is often lower than calcium. Water quality aspect of calcium and magnesium are often associated with alkalinity and hardness. The calcium content to collected samples ranges from 26.8 to 29.2 mg/l. They all fall within the maximum allowable concentration of regulatory bodies which is 75 – 200 mg, and the magnesium content of water samples collected ranges from 11.8 to 19.6 mg/l which fall within the acceptable concentration of 30 – 500 mg/l for NAFDAC and WHO.

6.9 Acidity

Acidity is a measure of the ability of a given sample of water to neutralize strong base and arbitrary designated P^H or an indicator. Acidity in water could be due to presence of organic acids as well as hydrolysis salt like iron (ii) or Aluminum sulphate. The values of acidity are given in table 5a. The values range from 340 to 400 mg/L.

VII. CONCLUSION

This piece of research work was designed to evaluate and analyse wells and streams in North bank environment as a case study.

Physical tests like temperature, pH, taste, odour and colour and chemical tests such as total alkaninity, acidity, total hardness, calcium and magnesium hardness were carried out on some wells and streams in north bank environment.

All the parameters tested complied with both World Health Organization (WHO) and National Agency for Food, Drugs Administration and Control (NAFDAC) standard for drinking water.

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From all parameters tested, well water proved to a better water source compared to stream water for drinking purposes.

Excluding microbiological analysis, wells and streams in North bank environment are fit for drinking purposes.

VIII. RECOMMENDATION

This study was limited by time and unavailability of some reagents for analysis such as phosphate, nitrate, while the unavailability of Atomic Assumption Spectrometer (AAS) hindered the analysis of trace and heavy metals such as lead, cadmium, chromium, cobalt, and manganese. The following suggestions are therefore made for future research in this area:

i. Analysis should be carried out to evaluate concentration of phosphate, nitrate trace and heavy metals.
ii. Microbiological analysis should also be carried out on the water samples.
iii. Seasonal analysis of both in dry and raining seasons should be carried out on wells and streams to check the effect of turbidity on theses physicochemical parameters.

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