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Quality assessment of potable water from treatment plant storage reservoirs in Makurdi, Benue State, Nigeria

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Abstract

This research was conducted to assess the quality status of potable water in Makurdi, Nigeria. The reservoirs from which potable water was collected as samples in various surface water treatment plants was 32. The mean physicochemical and Bacteriological parameters were carried out; Range of parameters obtained were, TDS 500±3.35-1860±3.38mg/L, Conductivity 62±1.35-75±1.11µS/cm, Copper 0.08±0.01-0.09±0.02mg/L, E.coli 0-10±0.5. The results obtained can be said to be of low quality measured against standards, hence there is need for improvement in water treatment processes.

Keywords: Potable, storage reservoirs, sedimentation, surface water, river Benue.

Introduction

The abundant universal liquid on earth's surface is water with unique properties that sustains life[1]. According to WHO estimate, about 80% of the illnesses in the world are contracted through contaminated or polluted water and poor sanitation[2]. This has caused a lot of death in Nigeria and other developing countries. Taking into consideration the increasing rate of illnesses caused by polluted and contaminated water in Makurdi, Benue state, it is considered pertinent assessing the wholesomeness (hygienic condition) of reservoirs surface water treatment plants whose main source of water supply is River Benue. It is an economic resource and is sold as a commodity and water rights are continuous source of conflicts[3].

Globally, problems associated with potable water treatment include but not limited to pumping costs, surface water contamination as a result of natural toxins such as ammonium, nitrates, sulphates, other substances arising from leakages of environmental pollutants (emission) originating from human activities[4-6]. Despite some of these aforementioned facts, there is low impact of the governments especially in the developing countries around the globe. Adequate technological know-how, intensive awareness and vital information on surface water sources with corresponding total quality management are infinitesimally small in the developing countries and the international community inclusive[7].

It is a common practice to dump refuse and human waste into the rivers for easy disposal. Nowadays, many homes in town have many closet lavatories. The human waste and liquid from the lavatories are emptied directly into rivers and seas without treatment.

Water polluted by sewage contains many diseases causing organisms[8]. Irrigation is necessary for crop production; however, this leads to water quality degradation and salinity problems. Surface runoff may contain chemicals, fertilizers or pesticides. In addition, some chemicals are injected in irrigation water for application to the field and are carried on the run-off water. Most irrigation water contains dissolved salts which remain in the soil after water is removed by vapour transpiration[9].

Chemical effluent is characteristic of the processing plants and factories. These toxic substances known as the industrial wastes are supposed to be detoxified before being released into the surrounding rivers and seas. Many production plants often emptied the toxic substances which includes but not limited to mercury compounds, organic solvents and detergents. Usually, water from a nearby river or lake is pumped in and used for cooling processes. The resulting warm water is then emptied back into the rivers which increases the temperature of the rivers. Indiscriminate dumping of refuse and garbage heaps coupled with the shrinking gutters and blocked drains resulting from market women and road side food sellers also contribute to water pollution.

Potable water treatment plants in developing countries are being faced with challenges of operations, treatment chemicals, machinery efficiency, insufficient equipment, lack of skilled manpower and dedication. These challenges could ultimately result to low quality of product produced. The presence of pathogenic microorganisms in drinking water which causes water borne diseases has been reported. Most of these are the most deadly diseases known to mankind.

For the fear of these, many people hardly drink water outside their homes. Water for human consumption must therefore be potable, free from disease causing microorganisms, chemical substances, and of low turbidity. These parameters need to be checked on any body of water to maintain their conformity with established set standards[2]. Fitness of the water for drinking from some if not all the treatment plants are questionable owing to unacceptable organoleptic properties (taste, odour and colour) and consequently the observed low patronage for such products.

This study attempted evaluating the physical and chemical properties of quite a number of reservoirs in the chosen study area. Apparently, there has not been pertinent data recorded regarding the management of potable water. Characterization of water from various treatment plants focusing on their physical, chemical and biological constituents is crucial as it relates to the public health. Therefore, pertinent data generated and validated from this study would serve as a record that provides basic information for experts in the field of ground water.

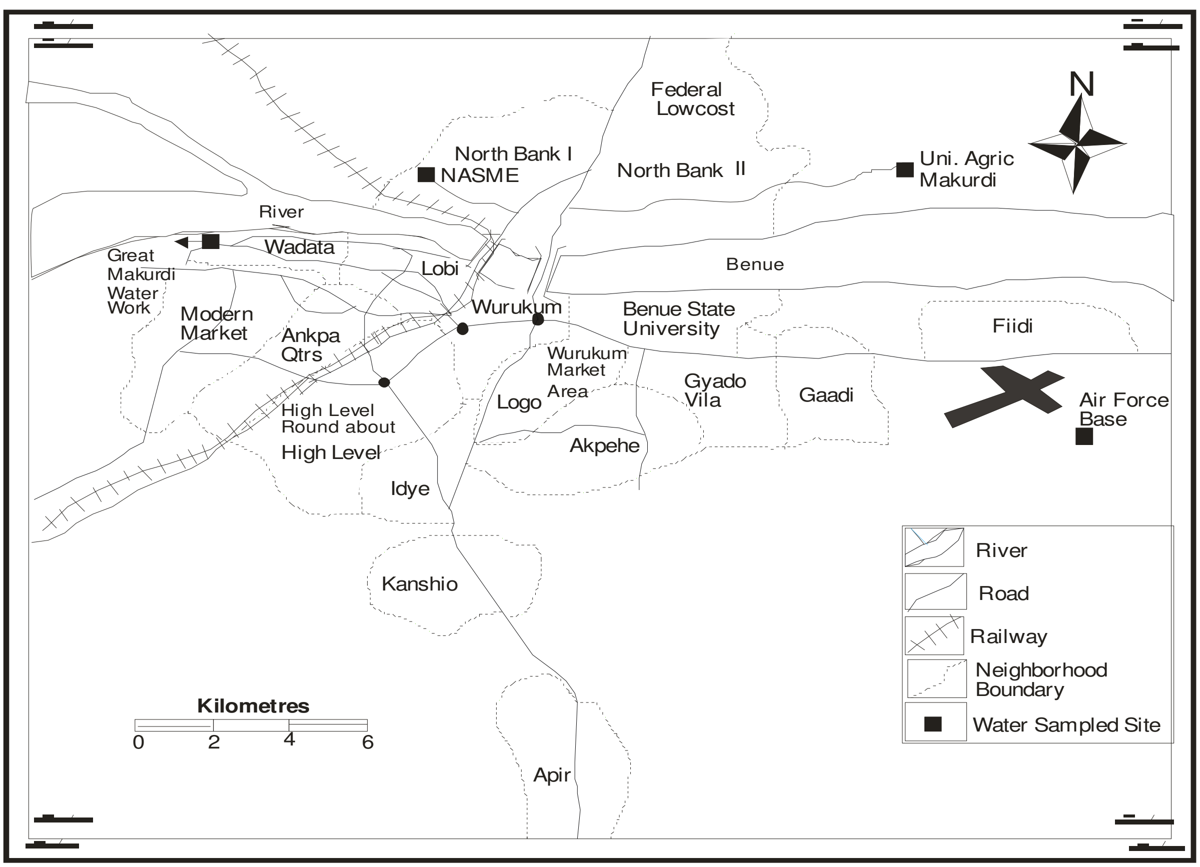
Materials and methods

Area under study: The study area is Benue State of Nigeria having a land mass of 33,955SqKm and 4,253,641 population[11]. The location under study basically shares boundary with Kogi and Enugu states to the west, Taraba State to the east Cross River to the south, Nassarawa State and Cameroon. Benue State comprises of 23 Local Government Areas (LGAs). The location is a less industrialize, the geo survey of the survey revealed that the location is made up of sandstones, mudstones and limestone that influences both surface and groundwater availability[12].

The study area has basically River Benue, River Katsina-Ala, Aya, Guma, Konshisha, Logo, Mu, Okpokwu, Obi. During the dry season, the surrounding rivers seems to dry up, compelling the surrounding communities to drink water from various unhygienic sources which predispose them to water related health hazards.

Sampling sites: The sample site is shown in Figure-1.

Sample collection: All samples were collected by manual methods in labeled empty and clean plastic containers. The containers were thoroughly washed and rinsed severally with the samples before collection. The samples were collected and refrigerated to avoid change in the composition till analysis was carried out.



Source: Ministry of Land and Survey Mukurdi.

Figure-1: Map of Mukurdi Town showing water sampled sites.

Analytical procedure: The various analyses carried out on the water samples include the chemical, physical and microbiological. All analyses were carried out in duplicates.

Appearance: Employed principle was based on the degree of pollution and the level of contamination inherent in most water. The water samples were thoroughly shake and carefully observed to note clarity.

Odour: The samples were brought to the nose and inhaled and the odour perceived. This was recorded as objectionable or unobjectionable by panel of judges.

Taste: The taste was noted as either objectionable or unobjectionable by panel of judges.

Temperature: Thermometer was used in the determination of the water samples at the point of collection. It was measured by dipping the thermometer immediately into the samples as soon as it was collected.

Turbidity: The turbidity of the water samples was determined with the aid of a water quality multi-tester (Horiba U-53). The turbidity values were evaluated and recorded in Nephlometric Turbidity Unit (NTU).

Chemical Parameters: pH: A calibrated pH meter with standard buffer solutions was used. The pH meter was inserted a beaker containing a 100ml of the water sample and reading was taken after the stabilization of the values on the pH meter.

Total dissolved solid: The total dissolved solids of the water samples were evaluated with the aid of TDS meter. The unit in which the TDS values were recorded was mg^{-L}.

Conductivity (Electric) Test: Conductivity of the water samples collected to be examined was evaluated with the aid of TDS meter. Readings were taken after the stabilization of the electrode. Milli-volts was the unit in which the electrical conductivity of water samples were recorded.

Chloride: The method employed in evaluating the chloride involves the reaction of silver with chloride ions while potassium chromate was used as an indicator. Silver chromate as a product was formed while silver chloride was precipitated. A conical flask containing about 50ml of sample was prepared into which 0.5Ml of H_2O_2 was added. Additionally, potassium chromate (K_2CrO_4) of about 0.5ml was added. The resulting solution was titrated Silver Nitrate ($AgNO_3$) titrant, which produced a pinkish yellow end point.

$$\text{Chloride (mgL}^{-}\text{)} = \frac{(N \times 35450x\ A - B)}{Volume\ of\ sample} \quad (1)$$

Note: A: mL titration for sample; B: mL titration for blank; N: Normality of Silver nitrate

Alkanity: Alkanity was determined by the titrimetric method (API-RP45). Bromocresol green indicator of about 3 drops was added to a conical flask containing a known volume of sample. Relationship estimation was used in calculating the total alkalinity concentration in mgL^{-} using the titre values. The resulting solution was titrated with Sulphuric acid of 0.01N which gave a pink colour at the end point.

$$\text{Alkalinity (mg/L)} = \frac{V \times E \times N \times 100}{Vol.of\ sample} \quad (2)$$

Note: V: Titre volume; E: Equivalent weight of alkalinity = 50; N: Normality of Sulphuric acid 1000 = Constant

Digestion of water sample for metals analysis: In the digestion of water sample in preparation for metal analysis, 5 mL of nitric acid was added into a 250 conical flask containing 100mL water sample. Reduction in the original volume to one-third was achieved through application of heat to the sample. Filtration of the resulting mixture into 100mL volumetric flask when the sample was cooled to room temperature. De-ionized water was added to the content in the volumetric flask until filled to the mark. Atomic Absorption Spectrophotometer calibrated with Specific metal standards in the linear range of the metal was used to determine the concentrations in mg/L of metals in the digested samples. Aspiration was done with the digested samples giving rise to the evaluation of actual concentrations with reference to the calibrated graph while importantly calculations were done.

Microbiological Quality: The two most important quality parameter associated with water quality are coliform count and bacteria count. These were estimated employing the most common method which is "Multiple Tube Fermentation Technique". It gives values which are expressed as Most Probable Number.

Coliform Test: The agar used in coliform test is Mac Conkey broth which are introduced into test tubes containing inverted tubes. Water sample was then dispensed into the 10mL sterile bottle. There was a 5mL single strength Mac Conkey broth into which 1.0mL water sample was also dispensed. Also, there were other set of test tubes containing about 5mL sterile single strength Mac Conkey broth adapted with Durham tubes into which 0.1mL of water sample had been dispensed. Then all the tubes were incubated at the temperature of about 35°C for 24 hours. The coliform organisms in each sample was estimated with the aid of MPN evaluation table. The coliform number were reported using MPN/100mL.

Confirmation Phase: E.*coli* is gas-forming organism. Therefore, to confirm their presence in any sample a 24-hour culture that was streaked into an EOSIN-Methylene Blue (EMB) plate and incubated for 24 hours. The growth of E.*coli* on EOSIN-Methylene Blue gave a colony with a metallic sheen which is a positive confirmatory test.

Completed Phase: Taking a loop away the culture confirming the presence of coliform. Incubated test tubes at 44.5°C for 24hrs for fecal coliform and 35°C for total coliform. Evaluation of the number of E.*coli* was reported with the aid of MPN table

Hardness (EDTA) titrimetric method: To the de-ionized water in conical flask was added 25mL of sample and made up to 50mL. Also, 2 drops of Eriochrome black T was added to a 1mL of buffer solution. The colour changes from pink to blue as the end point was observed when the resulting solution was titrated with standard EDTA. The volume of EDTA used for sample less the volume of EDTA used for blank which gives the hardness value. It is estimated as shown below;

$$\text{Hardness (mg of } CaCO_3 \text{ per litre)} = \frac{A \times B \times 1000}{\text{mL of sample}} \quad (3)$$

Note: A: volume of titrant used for sample; while B: mg $CaCO_3$ equivalent to 1.00mL EDTA titrant.

Data Treatment: All analysis were carried out in duplicate, data were analysed using mean, standard deviation and range.

Table-1: Sampling Sites of Water Treatment Plants.

Site	Site code
North bank	A: Barrack Nigerian Army School of Military Engineering Water Treatment Plant
North bank	B: University of Agriculture Water Treatment Plant
South bank	C: Benue State Water Board Water Treatment Plant
South bank	D: Air force Base Water Treatment Plant

Results and discussion

High quality water is identified by the microbiological quality, organoleptic and chemical properties of such water with reference to the end use. Table-2, 3 and 4 shows the physical, chemical properties, and microbiological quality of the water analyzed. The results obtained are compared with acceptable standards as shown below.
The results of the analyses indicated that various water sample temperature were between 23^0C to 23.3^0C with sample sites A and D having the temperature of 23^0C and sites B and C having the temperature of 23.3^0C. This shows that sample sites B and C have a temperature which does not correlate with WHO, NAFDAC and NSDWQ potable water quality standards.

The turbidity of various water samples being examined falls within the values of the accepted standards with sample site C having the lowest value of 3.2NTU and site A 4.5NTU, the organoleptic properties of the water samples were unobjectionable which are in agreement with WHO, NAFDAC and NSDWQ drinking water standards. The colour of water samples from sites A, B and C have the values 4 TCU which is in agreement with the standards while the colour sample from site D is above the acceptable standard with the value of 7 TCU.

The results showed that the water sample pH was between 6.55 and 6.73 which were in the acceptable limit set by regulatory organizations such as NAFDAC, NSDWQ and WHO. In terms of conductivity, water samples under examination were found to be far below the acceptable values. Summation or simply put the total solid that were dissolved (TDS) varied between 500 to 1860mg/L with the site C showing the minimum while site D had the maximum value which was far beyond recommended standard values, the copper content ranged from 0.0991 to 0.1118. Flouride also ranged from 0.03 to 0.06, silver was not detected in all the water sample, cadmium detected in all the water samples was below 0.001 and mercury detected in all the samples was below the minimum limit recommended by WHO, NAFDAC and NSDWQ. Iron content ranged from 8.61 to 10.66 mg/L, lead varied between 0.34 and $1.15mgL^-$ and nickel contents are far above the recommended limits with sample site D having the highest value. E. *Coli* was not detected in sample from site A while sites B, C and D had E. Coli values of 1, 2 and 10 CFU respectively. Water samples from sites A and C have total germ count of 5 and 8 CFU/100ml while sites B and D had values which that was higher than the recommended values of 10 total germ count out of 100ml as set by NSDWQ and zero count out of 100ml by WHO. High total coliform counts and E. *Coli* content clearly revealed faecal contamination of the water samples under investigation. It is a well known fact that surface water bodies are naturally impure as they are vulnerable to many forms of contamination.

Table-2: Physical parameters.

Parameters	Units	A	B	C	D	WHO	NAFDAC	NSDWQ
Temperature	^{0}C	23±0.01	23.3±0.01	23±0.03	23.3±0.01	Ambient	Ambient	Ambient
Turbidity	NTU	4.5±0.01	3.3±0.03	3.2±0.03	4.2±0.01	5	5	5
Colour	TCU	4±0.03	4±0.02	4±0.02	7±0.07	6	5	5
Taste	-	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj
Odour	-	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj	Unobj

Key: Unobj: Unobjectionable; WHO: World Health Organization; NAFDAC: National Agency for Food, Drug Administration and Control; NSDQW: Nigerian Standard for Drinking Water Quality.

Table-3: Chemical Parameters.

Parameters	Units	A	B	C	D	WHO	NAFDAC	NSDWQ
pH	-	6.75±0.07	6.83±0.06	6.79±0.18	6.55±0.03	6.5	6.5-8.5	6.5-8.5
Conductivity	µs/cm	72±1.10	75±1.11	73±1.30	62±1.35	1000	1000	1000
TDS	mg/L	880±3.67	800±3.23	500±3.37	1860±3.38	500	500	500
Calcium	mg/L	0.02±0.007	0.28±0.005	0.09±0.003	0.01±O.O4	<75	-	-
Flouride	mg/L	0.06±0.04	0.06±0.04	0.03±0.02	0.06±0.04	1.5	1.5	1.5
Nitrite	mg/L	0.003±1.2	0.005±0.01	0.002±0.03	4.00±0.02	0-2	-	0.2
Chloride	mg/L	60.39±0.04	40.19±0.05	40.10±0.03	40.59±0.04	250	250	50
Sulphate	mg/L	7.20±0.06	4.31±0.05	3.360.01	10.3±0.07	100	100	-
Iron	mg/L	8.15±0.02	8.72±0.11	7.85±0.03	8.22±0.02	0.3	-	3
Lead	mg/L	1.14±0.03	0.34±0.01	1.30±0.03	1.52±0.01	0.01	-	0.001
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	0.01	-	0.001
Copper	mg/L	0.0991±0.02	0.0832±0.01	0.0993±0.01	0.1118±0.01	1.0	1.0	1.0
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	0.003	0.003	0.003
Nickel	mg/L	0.0238±0.01	0.0252±0.01	0.0226±0.01	0.0285±0.01	0.02	-	-
Silver	mg/L	<0.001	<0.001	<0.001	<0.001	-	-	0.001
Hardness	mg/L	7.12±0.05	0.04±0.01	0.04±0.02	7.72±0.09	-	150	150
Ammonium	mg/L	0,06±0.04	0.17±0.01	0.23±0.02	0.07±0.03	-	-	-
DO	mg/L	9.1±0.03	7.6±0.02	10.0±0.03	4.3±0.15	-	-	
BOD_5	mg/L	3.2±0.07	4.1±0.02	6.0±0.15	1.81±0.01	-	-	-

Table-4: Bacteriological Parameters.

Parameter	Unit	A	B	C	D	WHO	NAFDAC	NSDQW
E. Coli	CFU	0	1±0-12	2±0.11	10±0-15	0	0	0
T. Gerncount	CFU	5±0.12	12±0.13	8±0.01	50±0.10	0	0	0

Conclusion

In concluding, the potable water from reservoirs that were investigated did not meet the acceptable standard set in terms of total quality. Precisely, for bacteriological analysis, results obtained fell short of standard, for heavy metals same trends were observed. Physical parameters were within the WHO standard.

It is therefore recommended that the regulatory bodies in an holistic approach should prioritize highly issues centered on potable water production and ensure conformance to the set standards. There should be creation of awareness programs on the effects of polluted water consumption and the law enforcement agencies should also enact laws on water pollution.

References

1. Meseret B.A. (2012). Assessment of Drinking Water Quality and Determinants of house hold Portable Water Consumption in Simada District, Ethiopia. (Master's thesis in Professional Studies), Cornell University, Ithaca NY USA.

2. World Health Organization (WHO, 2011). Guidelines for drinking water quality. 4^{th} Edition. Available online at http://whqlibdoc.who.int/publications/2011/978924154815 1_eng.pdf Accessed on 25th

3. Efe S.I., Ogban F.E, Horsfall M. and Akporhonor E.E. (2005). Seasonal variation of Physico-chemical Characteristics in water Resources Quality in Western Niger Delta Region, Nigeria. *Journal of Applied Science and Environmental Management*, 9(1), 191-195.

4. Burke J.J. and Moench M.H. (2000). Groundwater and Society: Responses and Opportunities. United Nations Publication, No99, 11A.

5. FAO (2003). Groundwater management: The Search for Practical Approaches. Water Report, 25, Food and Agricultural Organisation.

6. Richardson S., Evans R., Middlemis H., Ross J., Howe P., Hiller J. and Dayson P. (2004). Guiding principles for sustainable groundwater management. IAH Background paper.

7. Villholth K.G. (2006). Groundwater assessment and management: Implications and opportunities for globalization. *Hydrogeology Journal*, 14, 330-339.

8. EPA (2012). Environmental Protection Agency Basic information about copper in drinking water. Available on http://water.epa.gov/drinking/contaminants/basicinformatio n/copper.cfm. Last update on 6 March, 2012.

9. Kolo B., Dibal J.M. and Ndakawa I.I. (2009). Elemental analysis of tap and borehole waters in Maiduguri, semi arid region, Nigeria. *European Journal of Applied Sciences*, 1(2), 26-29.

10. Caliandro A., Hamdy A., Lacirignola C. and Catalano M. (1995). Environmental Impacts of Water Resources Development and management. *CIHEAM-Options*, Mediterraneens.

11. NPC (2006). National Population Commission, The Nigeria Census. Federal Government of Nigeria.

12. Kogbe C.A., Torkaeshi A., Osijuk D. and Wozney D.E. (1978). Geology of Makurdi Sheet 257 in the middle, Nigeria. *Occassional Publication 5, Department of Geology, Ahmadu Bello University, Zaria, Nigeria*.