THE INFLUENCE OF DRINKING WATER QUALITY ON HEALTH AND FOOD SECURITY IN TARABA STATE, NIGERIA

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ABSTRACT

Water is life, only when it's safe and wholesome, and therefore an essential ingredient for the maintenance of life as well as safe and healthy environment. The significance of access to safe water and effective sanitation is fundamental for any developmental transformation and linked to the overall achievement of the Millennium Development Goals (MDGs). Water quality is usually not given the required attention it deserved in Nigeria. Government and private sectors involved in water supply projects are yet to meet the targets of providing sufficient and safe access to good water supply to the populace, despite being requisite and vital to the social, health and economic wellbeing of the people, which undoubtedly are the overriding factors that determines food security. Though there are a number of bottlenecks to achieving this social responsibility, particularly in developing countries like Nigeria. In situations where these services are provided, consistent maintenance and sustainability cultures are lacking. Therefore, the assessment of drinking water quality in Taraba State was conducted with a view to having a far-reaching understanding of the linkage between drinking water quality, health (i.e. wellbeing) and food security in the State.

Keywords: Drinking water quality, food security, health, millennium development goals (MDGs), sanitation.

INTRODUCTION

Water quality is a measure of the condition of water in relation to human need or purpose. The water quality assessment in a given drinking water catchment may be conducted under a wide variety of conditions and at varying spatial scales and levels of sophistication [1]. The assessment can produce a wide range of outcomes and the conditions may range from simple settings with identification of key hazards to highly complex scenarios with diverse human activities [2]. This complexity may perhaps be coupled with variations in industrialization, geological/hydrogeological conditions and level of sanitation and hygiene practices, rendering vulnerability assessments equally demanding [2]. The quality assessment of water allows the determinations of water quality condition/status, proper identification of possible sources of contamination and addressing specific problems and ensuring that water sources are properly protected from potential contamination and decision making about the water supply source [3].

Water quality is usually not given required attention it deserved in Nigeria, from both government and private sectors involved in water supply services provisions, despite being requisite and vital to the social, health and economic wellbeing of the people [4]. Although,

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great stride have been made in meeting the challenges in terms of provision of services, but still the safety of many water supplies remains unknown and uncertain [5]. Water to be supplied is required to meet guidelines for microbial and chemical contamination [5]. Indicators used to assess water quality include pH, salinity, colour, clarity and the presence of contaminants such as metals, dissolved gases, trace elements, and microbial contaminants [6; 7]. According to [8], an estimated 103 million Nigerian still lack basic sanitation facilities and 69 million do not have access to improved source of water. Urban sanitation is in a dismal state and requires better formulated policies and massive injection of well formulated investments [9; 10]. For semi-urban settings, 15 % are without access to safe excreta disposal facilities, and 75 % use pit latrines, while 60 % discharge wastewater directly to the environment [9; 10]. The situation in the rural areas is not better as only 55 % are said to have access to reliable sanitation facilities and the national access to sanitation is put at 42 % [10]. A recent report by [11] showed that the number of people with access to improved sanitation facilities in Nigeria dropped from 31 % to 28 % in 2014 of the population. The study further revealed that each person practicing open defecation spends almost 2.5 days a year finding a private location to defecate, leading to a loss of yearly access time and annual productivity loss when people fall sick, adding that a whooping amount is spent annually on health care, which includes the costs of consultation, medication, transport and hospitalization [11; 12]. Sanitation receives far less attention than water supply in Nigeria [10].

Study Area

Taraba State has a total landmass of about 60,291.83 km^2 [13], created on August 27th, 1991 from the defunct Gongola State. The State derives its name from one of the three major rivers in the State. At inception the State comprised only nine local government areas, namely: Jalingo, Zing, Lau, Karim Lamido, Sardauna, Bali, Gashaka, Wukari and Takum. The State currently has sixteen local government areas and it is bounded in the north by Bauchi and Gombe State in the north-east and Adamawa State on the eastern part and by Plateau State on the north-western side. It is also bounded to the west by both Nassarawa and Benue States respectively, while it shares an international boundary with the Republic of Cameroon to the south and south eastern stretch (Fig. 1).

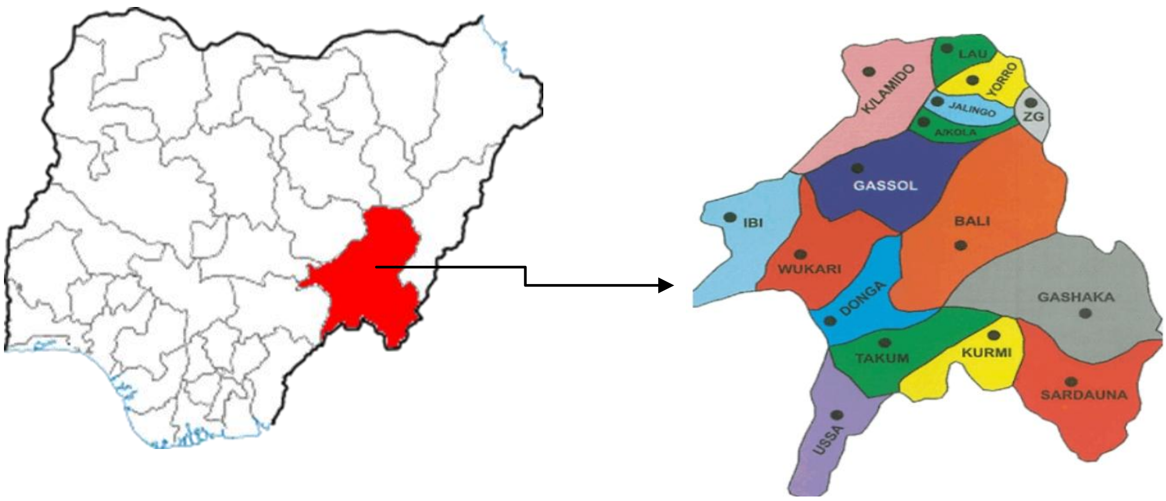

Figure 1. Taraba State and local government areas

Existing Water Supply Situation in the Study Area

The Taraba State water supply agency was established by Law No 5 of 1992 and saddled with mandate for the supply of water for various uses in urban and semi-urban centres in Taraba State with the general headquarters in Jalingo. According to [14], there are fourteen (14) water supply schemes spread across the state including Jalingo metropolis. Presently, only Jalingo and Ibi - Wukari are operational, while the remaining are either grounded or not operational due to lack of operation inputs such as diesel, lubricants, water treatment chemicals, etc. The current administration made significant strides in water supply development in Taraba State through rehabilitation and extension of pipelines in Jalingo metropolis since 2007. The State government in 2007 embarked on spring water development for community water supply under the small town water supply, in collaboration with the MDGs/CGS programme of the Federal government. The towns include Mbamnga, Nguroje, Furmi, Mayondaga, Dorofi, Bang-3 Corner, Tamnya, Maisamari and Leme and Gomu, Munga-Lelau, Bambuka. [14], reported that water service delivery across the State is far below average, and the obvious reason being lack of operational materials like diesel, lubricants, water treatment chemicals and broken down machines and equipment in some cases. In addition to this, there is no functional laboratory for such analysis in the state as at the time when this study was been conducted. The State water agency has constructed a laboratory which is yet to be equipped. The existing spring water schemes have no provision for disinfection, leaving the water unsafe and the network unprotected from recontamination.

In order to meet the State's water supply and sanitation provisions, the State government has also made significant momentum by establishing Taraba State Rural Water Supply and Environmental Sanitation Agency under Edict No 5 of 1996. This agency service delivery coverage for potable water and sanitary facilities stand at 53.5 % and 41.3 % respectively, achieved through the support of the State, FGN, LGAs, External donors and NGOs [15].

METHODOLOGY

Drinking water sources were strategically selected to cover the various sections of the state. Two clusters (50 samples) of the hand pump and motorized borehole water supplies alongside two clusters of the pipe borne water supplies were randomly selected to cover all the existing water supply schemes. The random distributions of these sampling locations are shown in Fig. 2 (a & b) for the boreholes and pipe borne water respectively.

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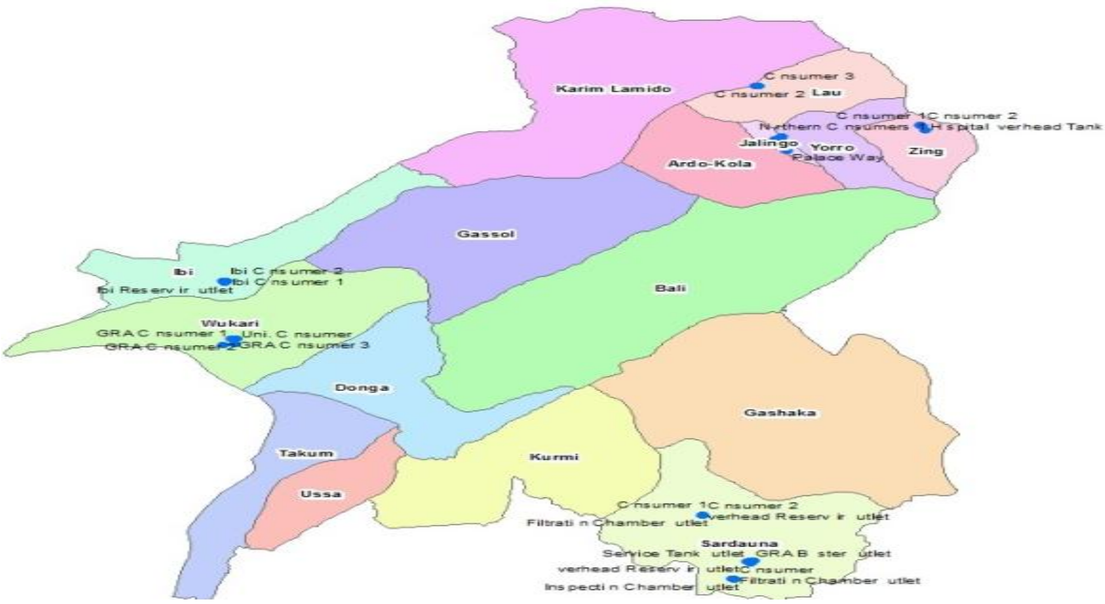
Figure 2(a). Distributions of borehole and pipe borne water supplies sampling locations



KEY

•	**Sampled location**
	LGA name
	LGA boundary

Figure 2(b). Distributions of borehole and pipe borne water supplies sampling locations

MATERIALS AND METHODS

Measurements and Sample Analyses

The analytical methods adopted were based on international acceptable methods and analytical application principles. Even though, various kinds of instrument by different manufacturers were used in the course of carrying out the sample analyses. The principles employed were all based on approved standard methods and were strictly adhered to. The comprehensive procedure used for testing each of the parameter is given below. The geographical coordinates was measured (latitude (^{o}N) and longitude (^{o}E)) at each selected measurement site using a Global Positioning System (GARMIN GPS 12XL) meter.

Measurement of Acidity or Alkalinity of the Samples (pH)

This was analysed using Wagtech WE30200 pH meter. The water samples pH test was conducted by dipping the electrode into the water sample at about 2 – 3 cm, stirred once and reading allowed to stabilize. Calibration of the pH meter was conducted on daily basis at three points using pH 4, 7 and 10 standard solutions.

Electrical Conductivity and Total Dissolved Solids

Electrical conductivity and total dissolved solids was determined using Wagtech WE30120 conductivity/TDS meter. The testing were conducted by submerging the probe into the water sample in a plastic beaker to minimize any electromagnetic interference, stirred once and reading allowed to stabilize. Calibration of the EC/TDS meter was conducted on a daily basis using compatible EC standard solution (12.88 mS/cm). The temperature of the water samples were measured with the EC/TDS meter, because the EC value is automatically compensated for temperature.

Turbidity

Turbidity was measured using Wagtech WE30140 Potalab turbidimeter. The turbidity measurement was conducted by placing the meter on a flat surface, filling a clean sample vial to mark, then placed well in a sample and the vial covered with light shield cap. The display reading was recorded as sample turbidity. Calibration of the turbidity meter was conducted on a daily basis using Cal 1: 800NTU; followed by Cal 2: 100NTU; then Cal 3: 20NTU and finally Cal 4: 0.02NTU standards.

Nitrate

Nitrate was determined via reduction method and the resulting nitrite determined by reaction with sulphanilic acid in the presence of N- (1-naphathyl)-ethylene diamine to form reddish dye. Detection limit of the method is 0 – 20 mg/l. The reduction stage was carried out by adding unique Zinc-based nitratest powder and nitratest tablet to 20 ml of the water sample to be tested in a nitratest tube. Nitratest tablet aids rapid flocculation after one minute contact period and inverting the tube content 3 or 4 times. Then 10 ml of the clear solution was carefully decanted and nitricol tablet was added, crushed and mixed to dissolve. The content was mixed and allowed to stand for 10 minutes to allow full colour development. The intensity of colour produced is directly proportional to the nitrate concentration and was measured using Wagtech WE10441 Potalab photometer 7100. The percentage (%) transmittance obtained was converted to concentration with aid of nitratest calibration chart and mg/L NO_3 obtained by multiplying the result by a factor of 4.4. The photometer was calibrated with the water sample to be tested.

Fluoride

Fluoride was analysed by adding Zirconyl chloride and Eriochrome cyanine reagents tablets to a 10 ml sample of the water in acid solution to form a red coloured complex. This colour is destroyed by fluoride ion to give a pale yellow. The content was mixed and allowed to stand for 5 min for full colour development. The colour produced is directly proportional to the fluoride concentration and was measured using Wagtech WE10441 Potalab photometer 7100 at 570 nm wavelength. Percentage (%) transmittance obtained was converted to mg/l F with the aid of fluoride calibration chart. The photometer was calibrated with the water sample to be tested. The detection limit of the method is 0 - 1.5 mg/l.

Sulphate

Sulphate was determined by modified turbidimetric method with barium in Sulpha Ver 4 Sulphate reagent. Sulphate ions in the sample react with barium in the Sulpha Ver 4 Sulphate reagent to form insoluble barium sulphate turbidity. The amount of turbidity formed is directly proportional to the sulphate concentration. Detection limit of the method is 0 – 70 mg/l. The test was carried out by adding Sulpha Ver 4 Sulphate reagent to a 25 ml sample of the water, mixed to form whitish turbidity content and was allowed to stand for 5 min for full colour development. The colour produced is directly proportional to the sulphate concentration and was measured using DR/2010 HACH spectrophotometer at 450 nm wavelength. The spectrophotometer was calibrated with the water sample to be tested.

Iron

Iron was measured by using Wagtech spectrophotometer. The photometer is calibrated with the water sample to be tested. The test is simply carried out by adding iron tablet (alkaline thioglycolate) to a 10 ml sample of the water sample. The content is allowed to stand for 1min to allow full colour development. The colour produced is directly proportional to the iron concentration and is measured using the Wagtech photometer at 570 nm wavelength. The percentage (%) transmittance obtained is converted to mg/L Fe with aid of iron calibration chart.

Total Alkalinity

Total alkalinity was measured by titrating 100 ml sample using 0.01 moldm^{-3} of H_2SO_4, phenolphthalein indicator, methyl orange indicator and pH meter, at end point pH of 4.5 and the amount was computed following the formula used by [16].

$$\text{Total Alkalinity as mg/L } CaCO_3 = \frac{\text{Titre value}}{\text{Vol. of sample}} \times 1000$$

Total Hardness

Total hardness was measured by complexometric titration of 100 ml sample using 0.01 moldm^{-3} disodium slat of ethylene diamine tetra acetic acid (EDTA) in the presence of Eriochrome Black T. At the titration endpoint colour changes from wine red to bluish-green and the total hardness content was computed following the formula used by [17].

$$\text{Total Hardness as mg/L } CaCO_3 = \frac{\text{Titre value}}{\text{Vol. of sample}} \times 1000$$

Chloride

Chloride was measured by complexometric titration of 100 ml sample using 0.141 $moldm^{-3}$ silver nitrate ($AgNO_3$) in the presence of 1ml potassium chromate indicator (K_2CrO_4), at pH of 7 - 8. At the endpoint, titration colour changes from yellow to pinkish-yellow and the chloride concentration was computed following the formula used by [18].

$$\text{Chloride (mg/l)} = \frac{(A - B) \times N \times 35.45}{\text{Vol. of sample}}$$

Where, 'A' is the sample titre value, 'B' is the blank titre value and N = 0.0141.

Arsenic

Arsenic determination was achieved when inorganic arsenic is liberated as arsine by zinc in sulphamic acid. The generated arsine produced a yellow-brown stain on arsenic test paper strips using an arsenic indicator containing less than 10 % sodium borohydride. The colour developed on the arsenic filter strip is proportional to the arsenic concentration and was measured using Wagtech WE10500 Arsenator in µg/L.

Lead, Cadmium, Manganese and Chromium

Lead, Cadmium, Manganese and Chromium were determined by direct aspiration into an air-acetylene flame using atomic absorption spectrometer. The concentration of each metal in a sample was determined at specific wavelength by using appropriate hollow cathode lamp and freshly prepared standards calibration solution.

Total and Thermotolerant Coliforms

The membrane filtration technique was employed in the tests for total and thermotolerant coliforms using Wagtech field kits. Water samples were appropriately filtered, inoculated and incubated at 37 ^{o}C for total coliforms. For thermotolerant coliforms, 100 ml of the water samples was filtered, inoculated and incubated at 44.5 ^{o}C. Plates which had characteristic colonies after 16 hrs of incubation in each case were selected and the colonies counted and calculated following the formula used by [19].

$$\text{Cfu/100 ml} = \frac{\text{No. of colonies counted}}{\text{Sample filtered (ml)}} \times 100$$

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RESULTS AND DISCUSSION

Table 1. Summary for borehole water quality assessment

No	Parameter	Parameter Range	Parameter average	WHO limits	WHO (%) compliance	NSDWQ limits	NSDWQ (%) compliance	Remark
1.	Appearance	Clear brownish / S. cloudy	–	Clear	–	Clear	86	Acceptable
2.	pH	5.0 – 8.4	6.436	6.5 – 8.5	40	6.5 – 8.5	40	Acceptable
3.	Electrical conductivity (µS/cm)	49.9 – 1,822	315.4488	1000	90	1000	90	Acceptable
4.	Total dissolved solids (mg/l)	25 – 917	157.95	500	90	500	90	Acceptable
5.	Turbidity (NTU)	0.0 – 38.6	2.6836	5	86	5	86	Acceptable
6.	Total alkalinity (mg/l)	13 – 580	110.68	500	96	–	–	Acceptable
7.	Total hardness (mg/l)	10 – 568	110.48	500	96	150	74	Acceptable
8.	Salinity (mg/l)	14.9 – 267.1	66.568	250	92	200	90	Acceptable
9.	Iron (mg/l)	0.0 – 0.5	0.0748	0.3	94	0.3	94	Acceptable
10.	Manganese (mg/l)	0.00 – 0.63	0.06478	0.2	94	0.2	94	Acceptable
11.	Chromium (mg/l)	0.01 – 0.05	0.0346	0.05	100	0.05	100	Non toxic
12.	Lead (mg/l)	0.001 – 0.004	0.00266	0.01	100	0.01	100	Non toxic
13.	Cadmium (mg/l)	0.000 – 0.012	0.00276	0.001	48	0.003	84	Acceptable, but toxic in 16 % by NSDWQ
14.	Arsenic (mg/l)	0.00	0	0.01	100	0.01	100	Non toxic
15.	Fluoride (mg/l)	0.0 – 8.0	0.9088	1.5	92	1.5	92	Acceptable, but all samples in Zing LGA are harmful
16.	Nitrate (mg/l)	0.0 – 91	9.6534	50	94	50	94	Acceptable
17.	Chloride (mg/l)	9 – 161.9	40.492	250	100	200	100	Acceptable
18.	Sulphate (mg/l)	3 – 170	36.26	200	100	100	96	Acceptable
19.	Faecal coliform cfu/100ml	0 – TNTC	n/a	0	74	0	74	Unsafe and harmful
20.	Total coliform cfu/100 ml	0 – TNTC	n/a	10	70	10	70	Unsafe and harmful

Sanitary risk analyses results signified that, 78% of the borehole water sources had poor sanitary condition in its surrounding area, TNTC - too numerous to count, S - Slightly, N/A - not applicable

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Table 2. Summary for pipe borne water quality assessment

No	Parameter	Parameter Range	Parameter Average	WHO Limits	WHO (%) Compliance	NSDWQ Limits	NSDWQ (%) Compliance	Remark
1.	Appearance	Clear brownish / S. Cloudy	–	Clear	–	Clear	72	Acceptable
2.	pH	5.1 – 8.9	6.77	6.5 – 8.5	64	6.5 – 8.5	64	Averagely non acidic
3.	Electrical conductivity (µS/cm)	31.1 – 550	155.928	1000	94	1000	94	Acceptable
4.	Total dissolved solids (mg/l)	15.5 – 278	79.932	500	94	500	94	Acceptable
5.	Turbidity (NTU)	0.0 – 45.1	6.8114	5	72	5	72	Acceptable
6.	Total alkalinity (mg/l)	10 – 157	52.14	500	100	–	–	Acceptable
7.	Total hardness (mg/l)	7 – 194	47.06	500	100	150	94	Acceptable
8.	Salinity (mg/l)	10.7 – 91.9	31.1367	250	100	200	100	Acceptable
9.	Iron (mg/l)	0.0 – 0.48	0.0626	0.3	88	0.3	88	Acceptable
10.	Manganese (mg/l)	0.00 – 1.17	0.07178	0.2	96	0.2	96	Acceptable
11.	Chromium (mg/l)	0.00 – 0.05	0.264	0.05	100	0.05	100	Non toxic
12.	Lead (mg/l)	0.002 – 0.004	0.00306	0.01	100	0.01	100	Non toxic
13.	Cadmium (mg/l)	0.000 – 0.004	0.00184	0.001	28	0.003	94	Acceptable but toxic in 6% by NSDWQ
14.	Arsenic (mg/l)	0.00	0	0.01	100	0.01	100	Non toxic
15.	Fluoride (mg/l)	0.0 – 4.4	0.913673	1.5	86	1.5	86	Acceptable, but all samples in Zing LGA are harmful
16.	Nitrate (mg/l)	0.0 – 55.9	10.5762	50	98	50	98	Acceptable
17.	Chloride (mg/l)	6.5 – 55.7	19.558	250	100	200	100	Acceptable
18.	Sulphate (mg/l)	3 – 57	18.8	200	100	100	100	Acceptable
19.	Total residual chlorine (mg/l)	0.00	0	0.2	0	–	–	Unpleasant and worrisome
20.	Faecal coliform Cfu/100 ml	0 – TNTC	n/a	0	44	0	44	Unsafe and harmful
21.	Total coliform Cfu/100 ml	0 – TNTC	n/a	10	36	10	36	Unsafe and harmful

Sanitary risk analyses results signified that pipe borne water supply recorded 100 % poor sanitary conditions in its surrounding area. TNTC - too numerous to count, S - slightly, N/A - not applicable.

Aesthetic parameters

These are parameters that may ruin the taste, smell, or the appearance of water. They do not directly cause adverse health effects, but indirectly does so. The values obtained for borehole and pipe borne water are within the permissible levels of 0.00 as recommended by recommended by [20] and [21] as shown in Tables 1 & 2.

Appearance and Turbidity

The borehole water supplies appearance ranges between clear to slightly brownish, whilst the pipe borne water supplies ranges between clear to brownish and a consumer location recording slightly cloudy. Turbidity ranges between 0.0 – 38.6 NTU for the borehole water supplies, with 86 % satisfactory allowable level of clear appearance and 5 NTU turbidity recommended by [20] and [21]. However, the pipe borne water supplies turbidity ranges from 0.0 – 45.1 NTU, with 72 % satisfactory allowable level of clear appearance and 5NTU turbidity. Data of both the turbidity and appearance signifies that water sources are slightly harmless to the community members (see Tables 1 & 2).

Total dissolved solids (TDS) and Electrical conductivity (EC)

The borehole water supplies recorded TDS and EC values ranging from 25 – 917 mg/L and 49.9 – 1,822 µS/cm respectively. Whilst, the pipe borne water supplies correspondingly has values ranging from 15.5 – 278 mg/L and 31.1 – 550 µS/cm. Salty teste was not detected in both supplies, as 90 % of the borehole and 94 % of the pipe borne showed TDS values below the 500 mg/L as recommended by [20] and [21] guidelines for drinking water, leading to increased palatability of the water sources (see Tables 1 & 2).

Acidity or alkalinity (pH)

Pipe borne water supplies pH values fell within 5.0 – 8.4 and the borehole water supplies pH values ranges from 5.1 – 8.9. In the overall, 64 % of the entire sampled pipe borne water supplies and 40 % borehole water supplies recorded values within the 6.5 – 8.5, [20] and [21] recommended guideline values for drinking water (see Tables 1 & 2).

Total Alkalinity

The total alkalinity ranges between 13 – 580 mg/L for the borehole water supplies, with 96 % permissible level of 500 mg/L recommended by [20] and [21]. The pipe borne water supplies total alkalinity ranges from 10 – 157 mg/L, with 100 % satisfactory level of 500 mg/L. Nevertheless, 48 % of pipe borne water supplies may cause corrosion of the distribution systems, which may result to indigestion of carbohydrates among consumers (see Tables 1 & 2).

Total Hardness

Total hardness for the borehole water supplies ranges between 10 – 568 mg/L**,** with 26 % that may lead to scale deposition on hot water boilers forming excessive scum with soaps resulting in wastage of soaps during cleansing. This is confirmed from the measured values of 150 mg/L above that recommended by [20]. The pipe borne water supplies had total hardness ranging from 7 to 194 mg/L, with only 6 % having propensity to cause scale deposits on hot water boilers and form excessive scum with significant increase in wastage of soaps during cleansing, due to measured values above the recommended 150 mg/L (see Tables 1 & 2).

Salinity

The salinity content ranges between 14.9 – 267.1 mg/L for the borehole water supplies, with 90 % satisfactory level of 200 mg/L recommended by [20] and [21]. However, the remaining 10 % leads to detectable and objectionable saline taste of the water, even though some consumers may have adapted to this level found. The pipe borne water supplies salinity ranges from 10.7 – 91.9 mg/L, with 100 % satisfactory level of 250 mg/L recommended for drinking water (see Tables 1 & 2).

Iron

Borehole water supplies had iron content ranging from 0.0 – 0.5 mg/L, with 6 % of the boreholes having iron values that can cause staining and aesthetically objectionable effects, due to their measured values above 0.3 mg/L recommended by [20] and [21] guideline for drinking, thereby increasing palatability of the water. The pipe borne water supplies iron content ranges from 0.0 – 0.48 mg/L, with 12 % that will result in staining and aesthetically objectionable effects, due to their measured values of 0.3 mg/L, which is above that recommended for drinking (see Tables 1 & 2).

Manganese

Borehole water supplies had manganese values ranging from 0.00 – 0.63mg/L and 6% of the boreholes had measured values of above 0.2 mg/L [20] and [21] recommended guideline value for drinking, thereby increasing palatability of the water. The pipe borne water supplies manganese concentration ranges from 0.00 – 1.17 mg/L, with 4 % predisposed to manganese related problems and aesthetically objectionable effects, as a result of their measured values above the recommended value of 0.2 mg/L (see Tables 1 & 2).

Fluoride

The measured fluoride concentration for borehole water supplies varies between 0.0 – 8.0 mg/L. It was also observed that 8 % of the borehole drinking water sources had fluoride concentrations above the 1.5 mg/L of [20] and [21] recommended guideline value for drinking water. All the affected groundwater locations are in Zing local government area (LGA). Most of the people living in this area characterized by dental fluorisis as exhibited by infected persons among the randomly observed and interviewed community members shown in Fig. 3. Fluoride concentration in the pipe borne water supplies ranges from 0.0 – 4.4 mg/L, with 14 % prone to dental fluorisis among the teaming consumers, as a result of their measured values above the recommended value for drinking water. The source of the raw water is from reticulated boreholes, which are located in Zing LGA (see Tables 1 & 2).

Figure 3. Dental mottled persons from Zing

Nitrate

The nitrate concentration measured for borehole water supplies varies from 0.0 – 91 mg/L. Higher nitrate values were mostly measured in areas where good hygiene and sanitation are rarely practiced, coupled with seepages associated with pit latrines and/or soak away. Results showed that 6 % of the boreholes drinking water sources had nitrate concentration above the [20] recommended guideline value of 50 mg/l for drinking, thereby increasing children health risk. The pipe borne water supplies had nitrate concentration ranging from 0.0 – 55.9 mg/L, with 2 % that may potentially cause nitrate related health risk among children consumers, as a result of their measured values above the recommended value for drinking water. The issue is more complicated as this 2 % was recorded at a booster outlet (hospital booster outlet) and might be due to the presence of used drugs bottles seen inside the water reservoir (see Tables 1 & 2).

Chloride and Sulphate

The results of the analyses revealed that the concentrations of the chloride and sulphate in the water bodies were all below the [20] and [21] recommended guideline value for drinking water, except that, 4 % of the borehole water supplies recorded sulphate above [20] recommended guideline value of 100 mg/L (see Tables 1 & 2).

Total Residual Chlorine

All the samples obtained (100 %) for the pipe borne water supplies including samples from the treatment plants recorded 0.00 mg/L. Total residual chlorine signifying improper and inadequate treatment operations, such as coagulation and disinfection, thereby posing health risk among the teaming consumers. There is no provision for disinfection as part of operation for the spring water supplies (see Tables 1 & 2).

Figure 4. Inspecting Improper dosing of disinfectant (HTH) at Ibi-Wukari water treatment plant

Chromium

Results of laboratory analyses conducted showed that chromium concentration in the borehole water supplies ranged from 0.01 – 0.05 mg/L, whilst the pipe borne water supplies had chromium concentration ranging from 0.00 – 0.05 mg/L, and all were below the [20] and [21] guideline value of 0.05 mg/L (see Tables 1 & 2). Thus, chromium is not a problem in the assessed drinking water sources of Taraba State.

Lead

Pipe borne water supplies had lead concentrations within the range of 0.001 – 0.004 mg/L and the borehole water supplies concentration of lead ranged between 0.002 – 0.004 mg/L. Both the water supplies were below the [20] and [21] guideline value of 0.01 mg/L (see Tables 1 & 2) therefore, lead is not a problem in the drinking water sources of Taraba State.

Cadmium

The cadmium concentration ranges between 0.000 – 0.012 mg/L for the borehole water supplies, and 16 % of the drinking water sources had measured values above the 0.003 mg/L recommended by [20] and [21] for drinking water, thereby posing health risk to consumers. The pipe borne water supplies had cadmium concentration ranging from 0.000 – 0.004 mg/L, with 6 % cadmium related health risk exposure to the teaming consumers, as a result of their measured values above that recommended value for drinking water. The source of cadmium into water points might be from corroded galvanized pipes, since cadmium compounds are normally used in electroplated materials and electroplating wastes may as well be a significant source of the drinking water contamination (see Tables 1 & 2).

Arsenic

Results from this drinking water quality assessment showed that, there was no arsenic contamination of the drinking water sources, as there was 100 % compliance in relation to 0.01 mg/L arsenic recommended by [20] and [21] in all the borehole water and pipe borne water supplies tested (see Tables 1 & 2).

Faecal Coliforms

The pipe borne water supplies had faecal coliforms content ranges between 0 – TNTC (too numerous to count) cfu/100mL, with 56 % having potential faecal pathogenic (disease causing) organism, as a result of their measured faecal coliforms values above the 0 cfu/100mL recommended by [20] and [21] for drinking water. The cause of the faecal contamination might be due to improper/inadequate disinfection, inappropriate connections and lots of leakages along the distribution network [See Figs 5(A, B & C)] as signified by 0.00 mg/L total residual chlorine for all the pipe borne water sampled locations. Furthermore, no process control (Jar test and chlorine demand test) and quality control were carried out.

Figure 5. (A) Improper connection at GRA, Wukari, (B) Leakage covered gabage sack at Kaka Qtrs, Gembu, (C) Leakage alond network at Mansur Qtrs, Gembu

Faecal coliforms content for the borehole water supplies ranges between 0 – TNTC cfu/100mL, with 26 % having values above 0 cfu/100mL faecal coliforms recommended by [20] and [21] for drinking water thus a potential health risk to the consumers (see Tables 1 & 2). The location (Maramara – Wukari, motorized borehole) that recorded TNTC, had very poor hygiene and sanitation (H & S) practices within and around its surroundings, coupled with lack of protection to the pumping mechanism and its sited downhill/down slope of the area [Figs. 6 (A – D)].

Figure 6. (A–D). Poor sanitation and hygiene practices around boreholes, hand pumps/pumping mechanisms and the location of boreholes at the downhill/down slope site

Total Coliform

The total coliforms content for borehole water supplies ranges between 0 – TNTC cfu/100mL, with 30 % having values above 10 cfu/100mL of the total permissible coliforms recommended by [20] and [21] for drinking water, thus potentially dangerous to consumers' health. The location (Maramara – Wukari, motorized borehole) that recorded the TNTC had very poor hygiene and sanitation practices around/within its surroundings, coupled with lack of protection to the pumping mechanism and the fact that it was sited downhill/down slope of the area Figs. 6 (A–D). Pipe borne water supplies had total coliforms content ranging from 0 – TNTC cfu/100 mL, with 64 % containing potential pathogenic organisms, as a result of

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their measured values above the 10 cfu/100mL recommended by [20] and [21] for drinking water. The cause of the total coliforms contamination may be due to inadequate disinfection, improper connections, leakages and intake mismanagement activities as shown in Figs. 6 (A–D).

RESULTS AND CONCLUSION

Water supply with consideration of quality requirements is important irrespective of the source type, so that the intended benefits of better water supplies can be achieved. Both boreholes and pipe borne water supply facilities can deliver contaminated water if adequate quality provisions are not effectively considered. The importance of good quality water supply continues to be emphasized as critical in reducing poverty and improving health and well-being of the worlds' children and adults. In the course of this assessment, the major concern that contributes to health, social and economic problems include but not limited to the following: Residual chlorine recorded 0 % at the treatment plants and consumer points. Deformity due to excessive fluoride contamination problems exist in the State, this may be not unconnected to the high values of fluoride contaminations recorded across most of the local government areas with highest values recorded in Zing local government area. Cadmium is the only toxic problem, occurring in some sampled locations among the boreholes and pipe borne water. Sanitary risk analyses signified that 78% of the assessed borehole water sources had poor sanitary conditions in their surrounding area. Conversely, pipe borne water supplies recorded 100% sanitary conditions. Since drinking water quality is a requisite in determining social, health and economic wellbeing of people, it is undoubtedly that food security in Taraba State will be compromised.

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