Assessment of the Quality of Water Supplied By Water Vendors to Households in Sabon-Gari Area of Kano, Northern Nigeria

Bichi, M. H.[1*] and Amatobi, D. A.[2]

[1]*Department of Civil Engineering, Faculty of Engineering, Bayero University, Kano-Nigeria.*[2]*Yakasai Quarters, Yankaba Kano.*

---**ABSTARCT**---

The study involved assessment of the quality of drinking water supplied by water vendors to households in Sabon-gari area of Kano City in Northern Nigeria. The quality of the water was assessed at commercial sales points, water vendor's distribution Jeri-cans and household storage tanks. Ninety (90) water samples were collected at 10 locations spread across Sabon-gari and analyzed for physico-chemical and bacteriological parameters. The results obtained were compared with standards recommended by the World Health Organization (WHO), the Nigerian Standard for Drinking Water Quality (NSDWQ) and the European Community (EC). Total Hardness (as $CaCO_3$); Conductivity and Free Chlorine values were not within acceptable limits in most of the samples. Colonies of microorganism were in excess amounts in 9 samples while coliform organism was detected in 19 samples. The percentage of colonies of microorganisms was 27%, 43% and 70% for commercial sales points, hawkers' Jerry-can, and household storage respectively. Also percentage of samples that tested positive to coliform organism was 10%, 20%, and 33% for commercial sales points, hawkers' Jerry-can, and household storage respectively. Thus it was concluded that water quality was compromised at the private commercial supply, during hawker's distribution and in the household storage. It is recommended that the activities of the water vendors need to be regulated and monitored in order to ensure the protection of the public health.

KEYWORDS: *Contamination, Drinking water, Water vendors, Households, Water quality.*

I. INTRODUCTION

Water is fundamental to sustenance of life and safe drinking water is so essential that it is recognized as a basic human right (Anan, 2001). Despite its basic importance, safe drinking water is not readily available to many households across the world, due to various factors such as increasing population, source pollution and poor management of water resources. When drinking water becomes scarce many families, especially the poor, are prone to securing their drinking water in a manner and condition that could endanger their health and general wellbeing. Studies (UNICEF/WHO, 2004; UNDP, 2006) have point out that the way people secure their drinking water has a direct impact on their health and on the economic status of the family units. Water secured from a remote and unprotected source can jeopardize the health of households. Drinking water, defined in the context of this discussion, is the water which is suitable both for human consumption and for usual domestic uses, including cooking and personal hygiene (Busari, 2006). People's right to good life cannot be guaranteed if they do not have a reliable and a convenient access to safe drinking water. Water is considered a renewable resource but in many parts of the world, water resources have become so depleted or contaminated that they are unable to meet ever-increasing demands (UNEP, 2004). The USAID (2005) estimates that over 1.2 billion people (one in every four people in the developing world) lack access to a safe water supply. According to United Nations estimates, by the year 2025, up to 20% of the world's population could live in countries where water is in short supply (WWDR, 2003). Steep increase in population, rise in consumption and the desire for a better living has placed a greater strain on the security of freshwater supply. Freshwater scarcity manifests in the form of rising demands or water depletion and water pollution. It is estimated that water use for human purposes has increased six-fold in the past 100 years (UNEP, 2004). Not surprising, reports indicate that the water problem is worse in poor countries, more especially in sub-Saharan Africa (Population Reports, 1998; UNICEF /WHO, 2000).

The Population Reports (1998) mentioned Nigeria among the countries likely to face water shortages by the year 2025. The *Drinking water availability ranking* published in NationMaster.com, placed Nigeria at 116th position out of 147 countries. In the same report, the Nigeria's 62% availability was below the global weighted average of 79% (UNICEF/WHO 2000, cited in NationMaster.com 2008). The United Nations Children's Fund and World Health Organization also in a joint report raised an alarm over water contamination in Nigeria, noting

that more than 70 per cent of water sources in Nigeria are contaminated and injurious to health (UNICEF/WHO, 2005). Matsuura (2003) also reported that water demand in Nigeria far exceeds sustainable supply. Ibiam (2008) also reported that drinking water supply in Nigeria is grossly inadequate especially in the rural areas. In a survey conducted by the Federal Ministry of Health, only 15 per cent of villages have adequate and potable drinking water. The situation in urban areas is also not cheerful. Less than 50% of the 85 million urban dwellers have "reasonable access to reliable water supply" (FMWR and World Bank, 2000). Both rural and urban areas of Kano State experience water shortages. According to Kazuare, (2005), less than 20% of the sixty wards in the six metropolitan local governments of the state have access to potable drinking water.

The providers of water supply services in the low-income areas are: the Kano State Water Board, the Vendors, the private water supply operators and the hawkers. The Water Board functions include treatment, distribution and sale of water together with public enlightenment on water conservation. Vendors are the people that Water Board leases standby water taps from which they sell to individuals. The Private Water Supply Operators produce water (usually from boreholes equipped with electric submersible pumps) and sell to individuals and hawkers at the water source site. Water hawkers are individuals who use Jerry-cans (usually loaded on hand push trucks) to buy water from the vendors or other sources and deliver water to households. This study is concerned with the assessment of the quality of water supplied by hawkers to households in Sabon-gari area of Kano in Northern Nigeria.

II.   MATERIALS AND METHODS

2.1 Sample Collection

Water samples were collected from 10 drinking water supply locations out of 13 existing major water source points and were selected to cover the spread of different districts of Sabon-Gari, Kano (Figure I). At each location a sample (sample A) was taken from a commercial drinking water source, a second sample (sample B) was taken from the Jerry-can of a water hawker who purchases water from the source and the third sample (sample C) was collected from household storage where the vendor supplied. Each location was sampled thrice. - Thus for a location identified with number 1, the samples collected are labeled 1A, 1B, 1C and a total of 90 water samples were collected and analyzed. The samples were collected in clean sterilized bottles with stopper. Each of the bottles was rinsed 3 times with the water samples and labeled; indicating the source, date and time of collection. Clinical hand gloves were used to avoid hand contact. The samples were transferred to the laboratory and analyzed within 48 hours for Bacteriological tests and 7 days for physico-chemical tests.
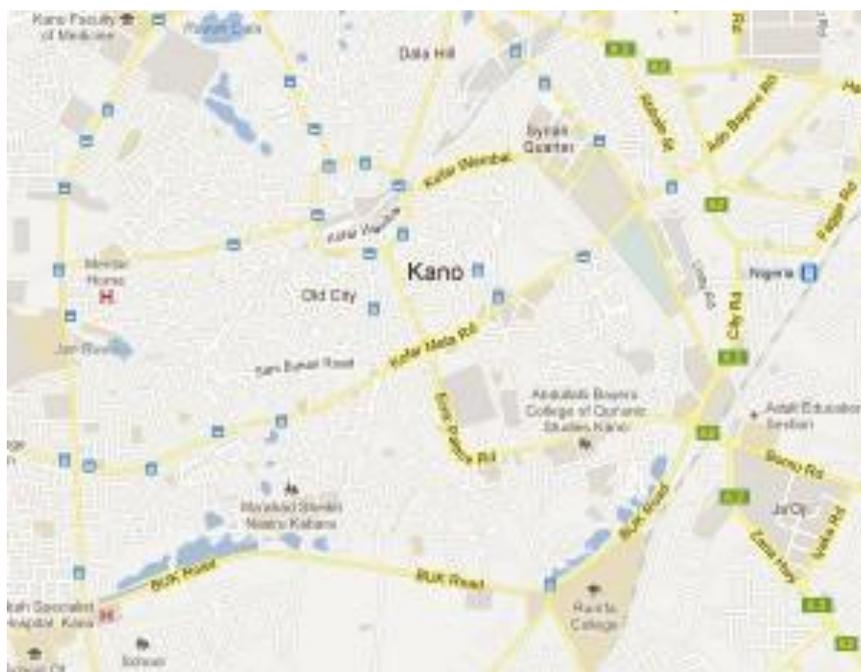
Figure 1: Sabon Gari Area, Kano-Nigeria. (Source-Google, 2013)

The analyses were carried out in the laboratories (Civil Engineering, Chemistry department and Central Laboratory) of Bayero University Kano and the Kano State Water Board Laboratory in Challawa.

2.2 Physico-Chemical Tests
2.2.1 Determination of Colour

The colour was determined using Alpha Platinum- Cobalt Standard Range: 0-500 Units and DR /3 Spectrophotometer. Fifty milligrams of demineralized water was filtered and one drop of Triton® x-100 solution was added to the filtered water in the flask. Without swirling or shaking, 25ml was poured into a clean sample cell. Fifty milligrams of the water sample was filtered and one drop of Triton x-100 solution was added to the filtered sample in the flask. Without swirling or shaking, 25ml of the filtered sample was poured into another clean sample cell. The sample containing the demineralized water was placed into the cell holder and the light shield was closed. The colour meter scale was inserted into the meter and the wavelength dial adjusted to 455nm. The mode switch was then set to LEFT SET and the left set adjustment was checked. The mode switch was set to NORM and the RIGHT SET controls were adjusted for a meter reading of zero colour units. The filtered water sample was finally placed in the cell holder and the light shield was closed and the units of true colour read.

2.2.2 Determination of Turbidity

Turbidity was determined using Nephelometric Method. The turbidimeter was prepared for operation as described in the instrument instruction manual by verifying that the calibration has been checked recently with the turbidimeter standard supplied with the unit and that instrument has been warmed up properly. The appropriate range was selected and the cell riser installed in the cell holder. A clean sample cell was then filled with the water sample to 25ml mark. The sample was placed in the instrument and it was covered with the light shield. The turbidity was then read directly in nephelometric turbidity units (NTU).

2.2.3 Determination of pH

The activated electrode (pH) was standardized with known pH buffer solutions of 4.0, 6.86 and 9.18 respectively. The electrode was rinsed thoroughly with distilled water. The pH values of sample were determined by dipping the probe in each of the samples and the pH readings obtained electronically.

2.2.4 Determination of Conductivity

Conductivity was determined using a conductivity meter. The meter was switched on and allowed to warm up for about 15 minutes, and then standardized with 0.01M of KCL solution where a conductivity value of 1413 micro-seimen per centimeter was obtained. The electrode was thoroughly rinsed with distilled water and then introduced directly into the samples and the conductivity values were obtained.

2.2.5 Determination of Total Hardness

Hardness was determined using EDTA titrometric method. Fifty milligrams of the sample was measured into a clean beaker and 0.5ml of 0.1N HCL was added. The solution was heated to boil in order to expel CO_2, then cooled to 50^0C and 2ml of the buffer solution was added. Two drops of Erischrome T indicator was added and the solution was titrated with EDTA standard titrant until the colour changed from red to blue and the volume of EDTA used was recorded. Three tests were carried out per sample. The hardness was then computed as

$$\text{Total Hardness mg/l CaCO}_3 = \frac{\text{ml of EDTA titrant} \times f \times 1000 \times 0.1 \times 17.8}{\text{ml of sample}}, \text{Where f} =$$

multiplication factor = 1

2.2.6 Determination of Calcium Hardness

Fifty milligrams of sample was measured into clean beaker. One milligram of Sodium Hydroxide (NaOH) solution was added to the sample. Two drops of Eriochrome T. indicator was then added. The solution was thoroughly mixed. It was then titrated with EDTA standard titrant until colour changed from purple to violet.

$$\text{Calcium Hardness as Mg/l CaCO}_3 = \frac{\text{ml of EDTA} \times 1000}{\text{ml of sample}}$$

2.2.7 Determination of Magnesium Hardness

The difference between the total hardness and calcium hardness is the magnesium hardness. i.e. total hardness - calcium hardness = magnesium hardness.

2.2.8 Determination of Chloride
This was determined using Argentometric Method. One hundred milligram of the water sample was put into a 250ml conical flask. One milligram of the potassium chromate indicator Solution was then added. The Solution was then titrated with 0.0lM standard Silver Nitrate ($AgNO_3$) Solution until a permanent (golden brown) colour was obtained at a pH range of 7 to 10. The volume of Silver Nitrate used was then recorded.

Mg/l of Cl^- = ml of Ag NO_3 x multiplication factor x 5 where: Multiplication factor = 9.87.

2.2.9 Determination of Nitrate (Nitrogen)
This was determined using spectrophotometric method. The absorbance or transmission was read against distilled water and set at Zero absorbance or 100% transmission. A wavelength (λ) of 220 nm to obtain NO_3^- reading and a λ of 275 nm to determine interferences due to dissolved organic matter. Subtract 2x the absorbance (abs) reading at 275 nm from the reading at 220nm to obtain abs due to NO_3^-. Convert this abs. value to NO_3^--N from Standard curve by extrapolation.

2.2.10 Determination of Sulphate
This was determined using Turbidimetric method. 100 ml sample was measured into a 250 ml conical flask and 5 ml of conditioning reagents added. While mixing and stirring, a spoonful of $BaCl_2$ crystals was added and timing started immediately. The contents were stirred for exactly 1 minute at constant speed. Some of the solution ws poured into absorption cell and the absorbance read at 425 nm. The SO_4^{2-} concentration was determined by extrapolation from the calibration curve.

2.2.11 Determination of Silica
Silico-molybdate Method was used for this determination. A clean sample cell was filled with water sample to the 25ml mark. The contents of one molybdate reagents powder pillow was added and mixed thoroughly by swirling. The contents of one acid reagents powder pillow was then added and the solution thoroughly mixed by swirling. A yellow colour developed when silica and/or phosphate are present. The sample was then allowed to stand for 10 minutes. Contents of one citric acids powder pillow were added to the sample and mixed thoroughly by swirling to allow any colour due to the presence of phosphate to disappear. The sample was allowed for at least two minutes to fully stabilize. Another sample cell was filled with distilled water to the 25ml mark and placed into the cell holder. The light shield was closed. The silica metre scale was inserted into the meter and the wavelength dial adjusted to 410nm. The mode switch was set to the LEFT SET and the left set adjustment checked. The mode switch was set to NORM and the RIGHT SET control adjusted for a meter reading of zero mg/l. The prepared sample was then placed in the cell holder, the light shield closed, and mg/l silica as (SiO_2) read.

2.2.12 Determination of Residual/Free Chlorine
This was done by DPD (N,N Diethyl –p-phenylenediamine) Method. Water sample was taken by filling a clean sample cell to the 25ml mark. Another sample cell was filled with demineralized water to the 25ml mark and placed into the cell holder and the light shield closed. The chlorine meter scale was inserted into the meter and the wavelength dial adjusted to 530nm. The Mode switch was set to LEFT SET and the left set adjustment checked. The switch was set to NORM and the RIGHT SET controls adjusted for a meter reading of zero mg/L. The content of one DPD Free Chlorine Reagent powder pillow was added to the test sample and shaken several times to mix. A red colour developed when chlorine was present. The prepared sample was then placed in the cell holder, the light shield closed, and the mg/l chlorine read.

2.2.13 Determination of Chemical Oxygen Demand
Dichromate Reflux Method was used. 100ml of water sample was measured into an Erlenmeyer flask, 2ml of 8% sodium hydroxide added and boiled. 10ml of $KMnO_4$ solution was added and the boiling continued for 10 minutes. 10ml of oxalic acid was added, mixed and the excess oxalic acid titrated with potassium permanganate.

$$O_2 \text{ (COD) mg/l} = \frac{\text{ml of } 0.01N \, KMnO_4 \times 0.08 \times 1000}{\text{ml of sample}}$$, Where ml of sample = 100ml

2.3 Metals Analysis
2.3.1 Digestion of Water Samples
A measured volume of 5ml of HCL was added to each of the measured water samples in a beaker and heated on a hot plate in a fume cupboard until the volume was reduced to about 20ml. It was then cooled, filtered and the volume made up to 100ml mark with distilled water in a volumetric flask (ASTM, 2004).

2.3.2 Determination of Mg, Fe, Mn, Ni, Zn, Pb, Cr and Cu

AAS Method was used. For each sample, 100ml was digested. A hollow cathode lamp of the desired metal was installed into the AAS machine and the wavelength characteristics of that metal set. The slit width and the amount of current applied to the hollow cathode lamp were all set according to manufacturer's instruction. The instrument was then switched on and allowed to warm up until the energy source stabilized. The oxidant and fuel gases (air and acetylene) were then allowed to flow and then ignited while the flow rates were adjusted as specified by the manufacturer. Acidified distilled water (1.5ml HNO_3 /l and specific gravity 1.42) was then aspirated and the aspiration rate adjusted after which the instrument was set at zero. The blank and the digested sample solution were all aspirated one after the other and the absorbances obtained recorded. Concentration of the analytes in mg/l of the digested samples were obtained by extrapolation from the calibration curve prepared (APHA,1990).

2.3.3 Determination of Na, K and Ca.

Flame Photometric Method. 100ml each of water sample was digested. Blank sample was also digested by the same method. Calibration standard of 2, 4, 6, 8, and 10 mg/l for Sodium and Potassium were prepared, while 5, 10, 15, 20, 25 and 30 mg/l for Calcium were also prepared for each metal. The absorbance of the samples, calibration standards and the blank were then measured and recorded. The concentration of the metals was calculated from calibration curves by extrapolation (APHA, 1990).

2.4 Bacteriological Examination of Water Samples

The colonies of micro-organism present in the water samples were examined using the nutrient agar plate count method. One hundred and twenty eight grams of nutrient agar was added to 1 litre of distilled water in a round bottom flask and allowed to soak for 15 minutes. The media was sterilized for 15 minutes at a temperature of 130^0C in an autoclave. The sterilized media was mixed well by swirling and cooled to below 20^0C in a refrigerator.

2.4.1 Determination of Total Bacterial Colonies

Each original water sample was diluted with distilled water. One milligram of each diluted sample was placed in a separate Petri-dish. The sterile prepared nutrient agar was raised to the temperature of about 42^0C. Ten milligrams of the sterile agar was added to each Petri-dish, under flame. The contents were mixed thoroughly by tilting and rotating and allowed to solidify. Each Petri-dish was placed in an incubator set at 37^0C for 48 hours. The white spots in the dishes indicate the presence of colonies and was counted using colony counter.

2.4.2 Coliform Examination

The media was prepared by dissolving forty grams of Mconkey Broth in 1 litre of distilled water and mixed thoroughly. Fifty milligrams of the Mconkey Broth was put into a round bottom flask. Ten milligrams each of the dissolved Mconkey Broth was put into five test tubes. The content of the round bottom flask and the five test tubes were sterilized and allowed to cool to room temperature. Fifty milligrams of water sample was added into round bottom flask containing 50ml of Mconkey Broth. Ten milligrams of water sample each was added into 5 test tubes containing 10ml each of Mconkey Broth under flame. The contents of both the round bottom flask and the tubes were incubated at 37^0C for 48 hours. The presence of coli form was observed by checking for any colour change from purple to yellow. The number of coliform was estimated using probability table for Coliform organisms (Punmia et al, 1995).

2.4.3 E-coli Examination.

The media was prepared by adding 36.5g of Endo-Agar to 1 litre of distilled water and soaked for 15 minutes. The mixture was sterilized in an autoclave for 15 minutes at 130^0C. The sterilized Endo-Agar was mixed thoroughly, distributed into Endo-Agar plates and allowed to solidify. Each subculture tube which tested positive for coliform was placed onto Endo-Agar plates. The Endo-Agar plates were incubated for 24 hours at 37^0C. The presence of E-coli was checked by observing the colour of the incubated agar. The presence of E-coli raises the colour of the Endo-Agar to deep red, which colours the surrounding medium and possess a golden metallic sheen. Absence of E-coli indicates no colour change of the endo-agar.

III.   RESULTS AND DISCUSSIONS

Tables 1, 2 and 3 show a summary of the results for physic-chemical parameters of the water from the supply point, water vendors, and households respectively.

Table 1: Physico-chemical parameters for sampled water from private (commercial) supply in Sabon-Gari Kano with WHO, NSDWQ and EC limits

s/no	Parameters	Mean	Standard dev	WHO (2004)limits	NSDWQ(2007) limits	EC(1980) limits
1	Colour (TCU)	5	0	15	15	20
2	PH	6.48	0.27	6.5-8.4	6.5-8.5	9.5
3	Cond. µS/cm	1631	652.79	NS	1000	NS
4	Turbidity NTU	2.82	1.31	5	5	NS
5	C.O.D (mg/l)	12.28	0.95	NS	NS	NS
6	F. Chlorine (mg/l)	0.12	0.05	NS	0.2-0.25	NS
7	Total Hardness (mg/l)	644.57	219.31	500	150	NS
8	Calcium Hardness (mg/l)	524.33	164.9	NS	NS	NS
9	Magnesium Hardness(mg//l)	120.23	88.23	NS	NS	NS
10	Chloride-CL(mg/l)	247.3	71.01	250	250	NS
11	silica (mg/l)	0.88	0.11	NS	NS	NS
12	Nitrate (mg/l)	2.92	1.8	50	50	50
13	Sulphate (mg/l)	7.2	6.55	250	100	250
14	Zn(mg/l)	1.44	0.34	3	3	5
15	Cu(mg/l)	0.6	0.23	2	1	3
16	Mg(mg/l)	59.4	21.84	150	120	50
17	Fe(mg/l)	0.22	0.06	0.3	0.3	0.2
18	Cr(mg/l)	0.03	0.01	0.05	0.05	0.05
19	Mn(mg/l)	0.06	0.02	0.1	0.1	0.5
20	Ni(mg/l)	0.01	0.01	0.02	0.02	0.05
21	Pb(mg/l)	0.01	0	0.01	0.01	0.1
22	Na(mg/l)	10	3.39	200	200	150
23	K(mg/l)	3.8	2.43	NS	NS	12
24	Ca(mg/l)	9.7	6.12	NS	NS	NS

Note: NS- Not specified

Table 2: Physico-Chemical parameters for sampled drinking water from hawkers in Sabon-gari Kano with WHO, NSDWQ and EC limits

s/no	Parameters	Mean	standard dev	WHO (2004)limits	NSDWQ (2007) limits	EC(1980) limits
1	Colour (TCU)	5	0	15	15	20
2	PH	6.59	0.26	6.5-8.4	6.5-8.5	9.5
3	Cond. µS/cm	1665	669.72	NS	1000	NS
4	Turbidity NTU	2.48	0.69	5	5	NS
5	C.O.D (mg/l)	12.38	1	NS	NS	NS
6	F. Chlorine (mg/l)	0.11	0.04	NS	0.2-0.25	NS
7	Total Hardness (mg/l)	634.3	234.15	500	150	NS
8	Calcium Hardness (mg/l)	514.53	171.42	NS	NS	NS
9	Magnesium Hardness(mg//l)	119.77	95.63	NS	NS	NS
10	Chloride-CL(mg/l)	258.93	77.28	250	250	NS
11	silica (mg/l)	0.9	0.11	NS	NS	NS
12	Nitrate (mg/l)	2.84	1.8	50	50	50
13	Sulphate (mg/l)	7.31	6.46	250	100	250
14	Zn(mg/l)	1.47	0.38	3	3	5
15	Cu(mg/l)	0.56	0.22	2	1	3
16	Mg(mg/l)	60.23	22.45	150	120	50
17	Fe(mg/l)	0.23	0.05	0.3	0.3	0.2
18	Cr(mg/l)	0.03	0.01	0.05	0.05	0.05
19	Mn(mg/l)	0.07	0.02	0.1	0.1	0.5
20	Ni(mg/l)	0.01	0.01	0.02	0.02	0.05
21	Pb(mg/l)	0.01	0	0.01	0.01	0.1
22	Na(mg/l)	10.13	3.63	200	200	150
23	K(mg/l)	3.8	2.76	NS	NS	12
24	Ca(mg/l)	9.57	5.89	NS	NS	NS

Note: NS- Not specified

Table 3: Summary of Physico-Chemical parameters for sampled drinking water from household storage in Sabon-Gari Kano with WHO, NSDWQ and EC limits

s/no	Parameters	Mean	standard dev	WHO (2004)limits	NSDWQ (2007) limits	EC(1980) limits
1	Colour (TCU)	5	0	15	15	20
2	PH	6.68	0.23	6.5-8.4	6.5-8.5	9.5
3	Cond. µS/cm	1642.67	819.16	NS	1000	NS
4	Turbidity NTU	2.67	0.79	5	5	NS
5	C.O.D (mg/l)	12.37	1	NS	NS	NS
6	F. Chlorine (mg/l)	0.12	0.04	NS	0.2-0.25	NS
7	Total Hardness (mg/l)	625.27	260.48	500	150	NS
8	Calcium Hardness (mg/l)	506.67	192.21	NS	NS	NS
9	Magnesium Hardness(mg//l)	118.6	106.73	NS	NS	NS
10	Chloride-CL(mg/l)	242.3	72.02	250	250	NS
11	silica (mg/l)	0.89	0.1	NS	NS	NS
12	Nitrate (mg/l)	3.3	1.68	50	50	50
13	Sulphate (mg/l)	6.92	5.84	250	100	250
14	Zn(mg/l)	1.6	0.6	3	3	5
15	Cu(mg/l)	0.56	0.2	2	1	3
16	Mg(mg/l)	53.8	22.75	150	0.2	50
17	Fe(mg/l)	0.27	0.07	0.3	0.3	0.2
18	Cr(mg/l)	0.04	0.02	0.05	0.05	0.05
19	Mn(mg/l)	0.08	0.02	0.1	0.2	0.5
20	Ni(mg/l)	0.01	0.01	0.02	0.02	0.05
21	Pb(mg/l)	0.01	0	0.01	0.01	0.1
22	Na(mg/l)	9.7	3.44	200	200	150
23	K(mg/l)	3.93	2.77	NS	NS	12
24	Ca(mg/l)	7.5	6.2	NS	NS	NS

Note: NS- Not specified

The results were compared with the acceptable limits for drinking water recommended by Word Health Organization (WHO, 2004), the Nigerian Standard for Drinking Water Quality (NSDWQ, 2007) and European Community (EC, 1980). All the physico-chemical parameters fall within the acceptable limits of the World Health Organization (WHO), Nigerian Standard for Drinking Water Quality (NSDWQ) and the European Community (EC), except Total Hardness, Conductivity and free or residual Chlorine. Water samples in the study area were found to be generally very hard with   conductivity above 1000 µS/cm. The high hardness content could be due to the nature of the geology of the area. This will impact on the taste of water and its ability to encourage foaming of soap.   Residual Chlorine values which were found to be less than the recommended 0.2mg/l will make the water more vulnerable to contamination.-Tables 4, 5 and 6 show the results of the bacteriological examination for the water samples collected from supply points, water vendors, and households respectively.

Table 4: Summary of Bacteriological parameters for sampled drinking water from private (commercial) supply in Sabon-Gari Kano with WHO, NSDWQ and EC limits

S/no	Sample No	Mean	standard Dev	WHO(2004)	NSDWQ(2007)	EC(1980) limits
1	Colonies Per CC Growing on Nutrient Agar at 370c for 48 Hours (cfu/ml)	1.6	3.3	10	10	10
2	MPN of Coliform Organism Per 100mls of water Sample (cfu/100ml)	0.13	0.43	0	0	0
3	MPN E-Coli Organisms Per 100mls water Sample (cfu/100ml)	0	0	0	0	0

Table 5: Summary of Bacteriological parameters for sampled drinking water from hawkers in Sabon-gari Kano with WHO, NSDWQ and EC limits

s/no	Parameters	Mean	Standard dev	WHO(2004)	NSDWQ(2007)	EC(1980) limits
1	Colonies Per CC Growing on Nutrient Agar at 370c for 48 Hours (cfu/mL)	2.63	3.78	10	10	10
2	MPN of Coliform Organism Per 100mls of water Sample (cfu/100mL)	0.37	0.75	0	0	0
3	MPN E-Coli Organisms Per 100mls water Sample (cfu/100mL)	0	0	0	0	0

Table 6: Summary of Bacteriological parameters for sampled drinking water from household storage in Sabon-Gari Kano with WHO, NSDWQ and EC limits

s/no	Parameters	Mean	standard dev	WHO(2004) limits	NSDWQ (2007) limits	EC(1980) limits
1	Colonies Per CC Growing on Nutrient Agar at 370c for 48 Hours (cfu/mL)	4.3	4.37	10	10	10
2	MPN of Coliform Organism Per 100mls of water Sample (cfu/100mL)	0.57	0.84	0	0	0
3	MPN E-Coli Organisms Per 100mls water Sample (cfu/100mL)	0	0	0	0	0

Traces of colonies of microorganisms and coliform were found in some of the samples with increasing magnitude as the water moved from commercial source through the hawker to household storage. The percentage of colonies of microorganisms was 27%, 43% and 70% for commercial sales points, hawkers' Jerry-can, and household storage respectively. Also the percentage of samples that tested positive to coliform organism was 10%, 20%, and 33% for commercial sales points, hawkers' Jerry-can, and household storage respectively.   Thus it was found that water quality was compromised at the private commercial supply, during hawker's distribution and in the household storage.-The hygienic conditions of most boreholes/sales points where the hawkers obtain drinking water were also found to be very poor. There were cases where the borehole areas were littered with debris and waste; the borehole head were open and filled with dirty stagnant water. Some boreholes were too close to septic tank in residential house or to power house with fuming generator exhaust. None of the water supply sources was adequately fenced or protected to prevent fecal contamination by man or animals.-Most of the drinking water hawkers in the area exhibit lack of proper knowledge on good hygiene and water safety. This was evident in the manner they handled the water and their appearance.

IV.   CONCLUSION AND RECOMMENDATIONS
4.1 Conclusion
The sources of drinking water in Sabon-gari are primarily boreholes and Water Board standby tanks, and the households depend mostly on water hawkers for their drinking water supply. This is because pipe borne water through   functional public water mains is virtually non-existent in the area. The hawkers procure water largely from private commercial boreholes and a few water board standby tank operators. The hawkers then supply the water to the households from Jerry-cans loaded on hand push trucks.

Traces of colonies of microorganisms and coliform were found in some of the samples with increasing magnitude as water moved from commercial source through the hawker to household storage. Thus it was found that water quality was compromised at the private commercial supply, during hawker's distribution and in the household storage.

4.2 Recommendations

The importance of safe drinking water to the wellbeing of every individual cannot be over-emphasized. Unclean or unprotected water can be a veritable source of infection and propagation of diseases.
In view of the overall findings in the study area the following recommendations are deemed appropriate.

[1]   The health and water regulatory agencies should ensure that all commercial drinking water suppliers are not only licensed but are also trained regularly on water safety and personal hygiene.

[2]   The agencies should carry out regular inspection to ensure that water supply areas are tidy and are adequately protected to prevent contamination of drinking water by human or animal fecal wastes.

[3]   Water sales operators should be discouraged from citing boreholes/water sales points near septic tanks or close to generator exhaust. They should be required to dose Chlorine to a level of 0.2mg/l in drinking water sold to the public.

[4]   There is a need for public enlightenment for water hawkers and households in the study area on personal hygiene, handling and storage of drinking water. Households should boil their water before drinking especially water from outside public mains.

[5]   The water supply agency should endeavour to restore or build adequate and functional public water infrastructure such that portable water could be supplied to all households in the area through water pipes.

[6]   Further research on water quality in the area could look into drinking water quality under household storage conditions.

REFERENCES

[1]   Anan, K. (2001): Message of UN Secretary-General Kofi Anan on World Water Day.
[2]   UNICEF/WHO (2004): Meeting the MDG drinking water and sanitation target: a mid-term assessment of progress. United Nations Children's Fund/World Health Organization, New York.
[3]   UNDP (2006): Human development report: beyond scarcity: power, poverty and the global water crisis. United Nations Development Programme. New York: Palgrave Macmillan
[4]   Busari, O. (2006):   Rural water quality guidelines and rationale: case study from Swaziland.   Available at:http://www.dbsa.org/Research/Documents/RURAL%20Water%20Quality%20Guidelines%20and%20Rationale.doc [Assessed 5 April 2008].
[5]   UNEP (2004): Challenges of water scarcity. United Nations Environmental Programme. Washington.
[6]   USAID (2005): Investments in drinking water supply projects and related activities in 2005. The United States Agency for International Development Washington D, C.
[7]   WWDR (2003): Mitigating risks and coping with uncertainty. United Nations World Water Development Report, Paris:
[8]   Population Report (1998): Solutions for a water-short world. Population Information Program, Center for Communication Programs, USA. The Johns Hopkins School of Public Health, Vol. 26, Number 1.
[9]   UNICEF/WHO (2000): Global water supply and sanitation assessment 2000 report. United Nations Children Fund and World Health Organization.
[10]   NationMaster.com (2008):   Drinking water availability (% most recent)   by country.   Available at: http://www.who.int/ipcs/publications/newsletters/en/04.pdf [Assessed 10 July 2008].
[11]   UNICEF/WHO (2005): Joint report on drinking water quality in Nigeria. United Nations Children Fund and World Health Organization.
[12]   Matsuura, K. (2003): while demand is growing dramatically at an unsustainable rate, water supplies are falling…. An address delivered at the opening session of the intergovernmental ministerial conference at the Third World Water Forum, Kyoto, Japan.
[13]   Ibiam, A. (2008): Watch what water you're drinking. Thisday Newspapers Lagos. May 20.
[14]   FMWR (2000);"National Water Supply and Sanitation Policy", Department of Water Supply and Quality Control, FMWR, Abuja.
[15]   Kazuare, U. (2005) : Kano State Water Board present situation problems and the way out. Seminar paper; Technical Session, Nigerian Society of Engineers, Kano Branch.
[16]   APHA (1990); Standard Method for the Examination of Water and Waste Water, 18th ed., American Public Health Association.
[17]   Punmia, B., Ashok, J., and Arun, J., (1995): Water supply engineering. New Delhi: Laxmi Publications ltd.
[18]   WHO (2004): Guidelines for drinking-water quality. World Health Organization Geneva Vol.1: 3 ed. ISBN 92 4 154638 7
[19]   NSDWQ (2007): Nigerian standard for drinking water quality. Standard Organization of Nigeria. Wuse, Abuja.