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Physicochemical and Bacteriological Analyses of Sachets Water Samples in Kano Metropolis, Nigeria

Uwah, E. I., Busari, W. R., Sayi, A.
Department of Chemistry, University of Maiduguri, Nigeria

Abstract:*Physicochemical and bacteriological analyses of sachets water samples in Kano metropolis were carried out using standard procedures to assess the quality of such water consumed in the area. Samples were collected from four different water depots in different parts of Kano metropolis. The results showed variations in the concentrations of the analyzed parameters in the water samples. The pH values ranged from 6.97±0.20 to 7.25±0.33; Electrical Conductivity ranged from 176 ±0.02 to 282±0.25µS/cm; Alkalinity ranged from 0.17±0.02 to 0.69±0.28 mg/l; Total solids were in the range of 100.30±0.25 to 157.34±0.30mg/l. Total Dissolved Solids ranged from 67.80±0.30 to 84.70±0.23mg/l; Total Suspended Solids ranged from 15.60±0.36 to75.84±0.02mg/; Total Hardness ranged from 85.00±0.03 to 103.00±0.20 mg/ and turbidity ranged from 0.60±0.21 to 2.23±0.32 NTU. Escherichia coli (E.coli) were not detected in all the samples. The levels of some of the anions analyzed ranged from 0.03±0.00 mg/l NO_2^- to 7.06 ±0.02 mg/l SO_4^{2-}. Similarly, the levels of some of the heavy metals analyzed ranged from 0.12±0.02mg/l Cu to 0.71±0.01mg/l Fe. Accordingly, the water samples were colourless and odourless. In general, the concentrations of all the parameters analyzed in the samples were below or within the World Health Organization (WHO) permissible limits, indicating that the sachets water were safe for human consumption.*

Keywords: *Analyses, Physicochemical, bacteriological, sachets water, Kano metropolis*

I. Introduction

Water is needed by all forms of life, man, animals and plants. It is present in almost all part of the earth, about three quarter (¾) of the entire earth surface is make up of water and it exists in three states; vapour, liquid and solid [1]. Water supplies are derived from springs, rivers, reservoirs, boreholes and natural lakes. The water passes through the ground and during which it dissolves some minerals in rocks, suspended particles, and pathogenic microorganisms from feacal matters. These and other factors make water unfit for drinking leading to problem of scarcity or insufficient potable water [2]. Good quality water is odourless, colourless, tasteless and free from faecal pollution. A reliable supply of clean wholesome water is highly essential in a bid to promoting healthy living among the inhabitants of a defined geographical region. Safe and potable water supplies in urban areas in Nigeria are still inadequate in spite of four decades of independence and several efforts from various governments. The standard industrialization world model for delivering of safe drinking water and sanitation technology is however, not affordable in most of the developing countries [3]. It was reported that in Nigeria, about 80% of all diseases and over 30% of deaths are water related [4].

Water constitutes a sizeable percentage of our daily food intake, as human bodies do not have reserve supply and due to its natural abundance, it is considered a universal solvent [5]. Going by the renewed global commitments toward the Millennium Development Goal (MOGs), marked for 2015, the importance and contribution of locally sourced low-cost alternative drinking water schemes to sustainable access in rural and urban settings of developing nations cannot be overemphasized. One of such local intention in Nigeria where public drinking water supply is unreliable is drinking water sold in polythene sachets [6]. Sachets water is readily available and affordable, but there are concerns about its purity. The integrity of the hygienic environment and conditions where the majority of the water in sachets are produced has been question. Apart from the environmental contaminants, contamination from improper vendor handling also poses threats to the health of the ignorant consumers who drink often time without any proper cleaning of the sachets. Therefore, water related diseases continued to be one of the major health problems globally [6].

The National Agency For Food and Drug Administration and Control (NAFDAC) is mandated to enforce compliance with internationally defined drinking water guidelines, but regulation of the packaged water industry aimed at good quality assurance has remained a challenge to the agency. To control this menace of contaminated water in sachets, NAFDAC declared a possible gradual nationwide barn on sachets water to allow manufacturers of sachets water to start winding down or change to bottle packaging. Successful implementation of this barn has remained for from reality as the sachets water market is witnessing tremendous growth especially among the poor and middle social classes [7]. Pure water as it is popularly called is assumed to be of sufficient quality to serve as drinking water, treated and packaged in transparent polythene sachets with name, address of manufacturer, expiry date, NAFDAC number and logo boldly printed on it [7].

In a related study, [8] noted that the bacteriological and physicochemical properties observed in all the sachets water samples analyzed were within the World Health Organization (WHO) permissible limits and that the results showed an improvement in the quality of sachets water produced in Abeokuta metropolis because [9] in an earlier study had observed that the sachets water obtained in Abeokuta as at the time of the study had offensive taste and all the parameters did not meet the recommended standards for potable water stipulated by the WHO.

There is therefore every need to analyze the physical, chemical and bacteriological parameters as well as some anions and heavy metals levels in sachets water consumed in Kano metropolis in order to ascertain whether they conform to the recommended standards for potable water.

II. Materials and Methods

I.1. Sample Collection

The sampling locations were chosen to give a good geographical coverage of Kano Metropolis. Samples were collected in February, 2013 from four different sachets water depots designated as: A, B, C and D in different locations of Kano Metropolis.

III. Methodology

III.1. Determination of Some Physical Parameters

The appearance of the water samples were observed virtually and the samples were inhaled to note odour. A conductivity meter was used to measure the conductivity of the water samples. KCl standard solution with the conductivity of 100 umhocm^{-1} was first prepared by diluting 5.1g of KCl in 1litre of distilled water and conductivity cell was then carefully suspended in the KCl standard solution and the conductivity reading adjusted to100 umhocm^{-1}. The cell was then rinsed with distilled water and the measurements were carried out in the same way on the water samples. The turbidity of the water sample was determined using a turbidity meter. The pH determinations were done using Jenway model pH meter. The instrument was calibrated with standard buffers of pH 4.0, 7.0 and 9.0 [10].

III.2. Determination of Some Chemical Parameters

Total Dissolved Solids (TDS), Total Suspended Solids (TSS) and Total Solids (TS) were estimated by gravimetric method.

TDS and TSS were each measured using conductivity/TDS meter. 100cm^3 of each water sample was measured into a 250 cm^3 beaker. 100 cm^3 of distilled water was measured into another beaker for the calibration of the TDS meter. The TDS meter was immersed into each of the samples and the readings recorded [11-13]. The sum of the TDS and TSS gives the TS [10]. Alkalinity was obtained by titrating 100 cm^3 of the samples with 0.02M HCl solution using methyl orange as indicator [10]. Total hardness in the water samples was determined by EDTA titration method using HACH DR/2000 Spectrophotometer. A clean delivery tube was inserted into the titration cartridge of the equipment. The delivery tube was then turned to eject a few drop of the titrate. The counter was then reset to zero and the tip of the tube wiped. 25cm^3 of the sample were measured and diluted to 100cm^3 in a 250cm^3 flask. 1cm^3 of Hardness indicator powder pillow was then added and stirred. The tip of the delivery tube was placed in the solution and then titrated with the EDTA until there was a colour change from red to blue and the results recorded [14].

III.3. Bacteriolgical Analysis

Bacteriolgical analysis was carried out using the spread plate technique. 1cm^3 of water sample was transferred into prepared sterilized medium (macconkey agar) in the glass petri dish, the content in the petri dish was mixed by gentle agitation, cooled, then transfer into the incubator for 24hours at 35^{o}C.Durham tubes were used for detection of coliform. Total coliform counts in the samples were determined using the multiple tube fermentation technique [15]. This involved inoculating multiple fermentation tubes containing MacConkey broth with 1 cm^3 of water sample at 37°C for 24 hours, after which the count was done with a Suwtex 560 colony counter. Detection of E. coli in the water was carried using the presumptive and confirmative tests [16].

III.4. Determination of Some Heavy Metals

The water samples were acid digested with nitric acid and the heavy metals determined spectrophotometrically at the appropriate wavelengths using the Atomic Absorption spectrophotometer (AAS), Unicom model fitted with air- acetylene atomizer [17].

III.5. Determination of Some Anions

Each of the investigated anion levels in the samples were determined using Smart spectrophotometer (model 2000) at their respective wavelengths. Nitrate was determined at a wavelength of 543nm. The equipment was

scrolled to select 64 Nitrate-N. A clean sample tube was filled to the $10cm^3$ mark with the water sample and inserted into the spectrophotometer and then 'scan blank 'selected. $5cm^3$ of the sample was the taken in another clean sample tube and 5 cm^3 of mixed acid reagent added, mixed and allowed to stand for 2 minutes. Two measures of nitrate reducing reagent were then added into the tube, mixed and allowed to stand for 10 minutes for the maximum colour development. The tube was inserted into the spectrophotometer, 'scan sample' selected and the result recorded. The result, obtained as Nitrate-Nitrogen (NO_3^--N) was converted to ppm or mg/l Nitrate (NO_3^-) by multiplying by 4.4 (conversion factor) [18]. Nitrite levels in the samples were similarly determined except that in this case, different reagents were used, 67 Nitrite-N was selected and the reaction period was five minutes. The result obtained as Nitrite-Nitrogen (NO_2^--N) and was converted to ppm or mg/l Nitrite (NO_2^-) by multiplying by 3.3 (conversion factor) [18].

For the determination of phosphate, the instrument was scrolled to select 'Programmed test', followed by 'All test' and then '78' phosphate-L. A clean tube was filled with sample to the $10cm^3$ mark. The test tube was inserted into the spectrophotometer and 'Scan Blank' selected. The tube was removed and 1.0 cm^3 phosphate reagent added. This was followed by the addition of another one measure of phosphate reducing reagent using a 1.0 mg spoon and was allowed to stand for 5 minutes for full colour development. The formation of blue colour indicates the present of phosphate. The tube was then inserted into the spectrophotometer, 'Scan Sample' selected and the result recorded in ppm or mg/l.

Sulphate was determined at a wavelength of 420nm. The instrument was scrolled to select 'Programmed test', followed by 'All test' and then '89' sulphate-HR. A clean tube was filled with sample to the $10cm^3$ mark. The tube was inserted into the spectrophotometer and 'Scan Blank' selected. The tube was then removed and one measure of sulphate reagent added using a 0.1mg spoon. A white precipitate which indicates the present of sulphate was observed. The tube was then inserted into the spectrophotometer, 'Scan Sample' selected and the result recorded in ppm or mg/l.

IV. Results And Discussions

The results of this study are presented in Tables 1 to 5. Table 1 showed the concentrations of some physical parameters in the water samples. The pH values ranged from 6.97±0.20 in samples obtained from sampling site C to 7.25±0.33 in samples obtained from site B. Turbidity ranged from 0.60±0.21NTU in samples obtained from site D to 2.23±0.32NTU in samples obtained from site B. Electrical Conductivity ranged from 176 ±0.02 µS/cm in samples obtained from site D to 282±0.25 µS/cm in samples obtained from site B. These values were below the WHO maximum permissible limits. Accordingly, all the water samples from each of the sampling sites were colourless and odourless which are in line with the WHO standards. It could therefore be argued that physically, the sachets water conforms to the recommended standards for potable water. Table 2 showed the concentrations of some chemical parameters in the water samples. TDS ranged from 67.80±0.30 mg/l in samples obtained from site C to 84.70±0.23 mg/l in samples obtained from site B. TSS ranged from 15.60±0.36 mg/l in samples obtained from site B to75.84±0.02mg/l in samples obtained from site A. Similarly, TS ranged from 100.30±0.25mg/l in samples obtained from site B to 157.34±0.30 mg/l in samples obtained from site A. Alkalinity was in the range of 0.17±0.02 mg/l in samples obtained from site C to 0.69±0.28 mg/l in samples obtained from site A. Total hardness in the other hand ranged from 85.00±0.03 mg/l in samples obtained from site A to 103.00±0.20 mg/l in samples obtained from site C. The values of all the chemical parameters investigated in this study were below the WHO maximum permissible limits. An indication that the sachets water depots were not polluted in terms of the chemical parameters.

Table 3 showed the results of the bacteriological analyses of the water samples. Bacteria and E. coli were not detected in the water samples, indicating non feacal pollution of the sachets water depots which can be attributed to an effective quality control system and a high level of sanitation in all the production depots. The concentrations of some of the heavy metals determined in this study are presented in Table 4. Pb was only detected in samples obtained from sampling site D. The concentrations of Cu ranged from 0.12±0.02 mg/l in samples obtained from site D to 0.21±0.02 mg/l in samples obtained from site A. Zn on the other hand ranged from 0.22±0.01mg/l in samples obtained from site C to 0.33±0.02mg/l in samples obtained from site B while the concentrations of Fe ranged from 0.33±0.02 mg/l in samples obtained from site A to 0.71±0.01mg/l in samples obtained from site C. The concentration levels of the analyzed heavy metals in the water samples were lower than the WHO maximum permissible limits, indicating the conformity of the sachet water to the recommended standards for potable water.

Table 5 showed the concentrations of some anions analyzed in this study. NO_3^- ranged from 1.82±0.08 mg/l in samples obtained from sampling site C to 2.70±0.26mg/l in samples obtained from site B. NO_2^- ranged from 0.03±0.00mg/l in samples obtained from site C to 0.12±0.01mg/l in samples obtained from sampling site A.

Table 1: Concentrationsof Some Physical Parameters in the water samples

Sample Sites	pH	Turbidity (NTU)	Electrical Conductivity (µS/cm)	Appearance	Odour
A	7.02±0.21	1.01±0.01	191±0.30	Colourless	Odourless
B	7.25±0.33	2.23±0.32	282±0.25	Colourless	Odourless
C	6.97±0.20	1.53±0.30	256±0.03	Colourless	Odourless
D	7.12±0.30	0.60±0.21	176 ±0.02	Colourless	Odourless
WHO Standard	6.5-9.5	5.00	900	Colourless	Odourless

Results of triplicate determinations ±S.D

Table 2: Concentration (mg/l) of Some Chemical Parameters in the water samples

Sample Sites	Total Dissolved Solids (TDS)	Total Suspended Solids (TSS)	Total Solids (TS)	Alkalinity	Total Hardness
A	81.50±0.31	75.84±0.02	157.34±0.30	0.69±0.28	85.00±0.03
B	84.70±0.23	15.60±0.36	100.30±0.25	0.20±0.12	71.00±0.02
C	67.80±0.30	75.10±0.20	142.90±0.03	0.17±0.02	103.00±0.20
D	70.60±0.30	49.40±0.21	120.00 ±0.02	0.51±0.04	56.00±0.32
WHO Standard	100	--	500	--	500

Results of triplicate determinations ±S.D

The concentrations of SO_4^{2-} were in the ranged of 0.49±0.03mg/l in samples obtained from sampling site B to 7.06 ±0.02mg/l in samples obtained from site D and PO_4^{3-} ranged from 0.93±0.02mg/l in samples obtained from site C to 1.33±0.04mg/l in samples obtained from site D. Similarly, the concentration levels of the investigated anions in the sachets water samples were below the WHO maximum permissible limits, which are also in conformity to the recommended standards for potable water.

Table 3: Bacteriological Analyses of the water samples

Sample Sites	Bacteria (CFU/ml)	E.Coli (CFU/ml)
A	Nil	Nil
B	Nil	Nil
C	Nil	Nil
D	Nil	Nil
WHO Standard	<10	<10

Results of triplicate determinations

Table 4: Concentration (mg/l) of some Heavy Metals in the water samples

Sample Sites	Heavy Metals			
	Pb	Cu	Zn	Fe
A	BDL	0.21±0.02	0.25±0.02	0.33±0.02
B	BDL	0.19±0.01	0.33±0.02	0.67±0.03
C	BDL	0.15±0.01	0.22±0.01	0.71±0.01
D	0.05 ±0.00	0.12±0.02	0.24±0.00	0.56±0.12
WHO Standard	0.01	2.00	3.00	3.00

Results of triplicate determinations ±S.D; BDL = below detection limits

Table 5: Concentration (mg/l) of some Anions in the water samples

Sample Sites	Anions			
	NO_3^-	NO_2^-	SO_4^{2-}	PO_4^{3-}
A	2.44±0.01	0.12±0.01	5.90±0.05	1.22±0.03
B	2.70±0.26	0.10±0.00	0.49±0.03	0.98±0.02
C	1.82±0.08	0.03±0.00	6.56±0.03	0.93±0.02
D	2.23±0.08	0.07±0.00	7.06 ±0.02	1.33±0.04
WHO Standard	50	3	500	5

Results of triplicate determinations ±S.D

IV. Conclusion

Based on the analyses and the results, it could be concluded that the physicochemical and bacteriological parameters in sachets water consumed in Kano metropolis conformed to the WHO recommended standards for potable water and that the consumption of the sachets water may not pose health hazards to the consumers at the time of the study.

Since the analyzed parameters may cause great health problems to humans at concentrations greater than the recommended standards, it is recommended that the levels of the studied parameters in sachets water obtained in the studied area and it environ be constantly monitored in order to ascertain the suitability of such water for human consumption.

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