ASSESSMENT OF THE BIOPHYSICO-CHEMICAL QUALITY OF SACHET WATER IN GIWA LOCAL GOVERNMENT AREA OF KADUNA STATE

YUSUF, Y.O.*, IJIMDIYA, P.T., MUHAMMAD, H.D., UMORU, J., BABATUNDE, E. AND YAKUBU, S.

Department of Geography and Environmental Management, Ahmadu Bello University, Zaria.

ABSTRACT

The rise of sachet water production and its widespread consumption as an alternative to the challenge of potable drinking water in Nigeria, is a phenomenon experienced nationwide. Studies however have shown that some sachet water brands are agents of disease transmission. The aim of this study is to assess some of the biophysico-chemical qualities of the sachet water brands sold in Giwa Local Government Area (LGA) of Kaduna State and compare with the World Health Organization (WHO) and the Nigerian Standard for Drinking Water Quality (NSDWQ) guideline values for potable water. Six of the most popular sachet water brands were purposively selected for laboratory analysis in duplicates from each sampling point (production and retail points) within the LGA. The results obtained showed that all the water samples were within permissible WHO and NSDWQ levels for the physical parameters except one which was out of limit for Turbidity. However, for the chemical parameters, all the samples were within limits for Electrical Conductivity, Dissolved Oxygen and Chloride while some were out of the limits for pH, Total Hardness and Total Dissolved Solids. There is therefore no evidence of serious chemical contamination among the parameters studied. Biological analysis revealed high coliform levels in five samples; factory water samples had the lowest, with only two brands within limits while retail points had higher coliform values, with only one brand within WHO limit and only three brands were within NSDWQ limit at the points of production and retail. This could be the result of inadequate treatment and storage at the factories and retail points respectively which can pose a health threat to consumers. Thus, there is need for regulatory bodies to improve the safety of drinking water in communities through adequate surveillance, monitoring and enforcement of regulations to avert the outbreak of waterborne diseases in the study area.

Keywords: Biophysico-chemical, Giwa, Sachet water, Water quality

***Correspondence:** yyobadaki@gmail.com

INTRODUCTION

Water constitutes four fifths of the body's weight and performs various biological roles and supports the internal functions of animals and plants. It is necessary for proper digestion of food and flushing toxins out of the body [1]. According to Traven [2], water is a basic necessity of life, second to air, because it serves as a source of nourishment to man, animals, micro-organisms and even plants. Water is also considered to be an essential ingredient for human survival and development throughout history as it is used in domestic activities (cooking, drinking, washing, bathing etc), agricultural activities (e.g irrigation, gardening), generation of power (hydroelectric power plants), running industries, recreational activities etc [3]. Access to safe drinking water is key to sustainable development and essential to food production, quality health and poverty reduction [4, 5]. Safe drinking water is essential to life and a satisfactory safe supply must be made available to consumers [6].

The demand for water doubles every 20 years which is more than twice the rate of the world's population growth, making water sources scarce to treat and remediate and existing sources, more expensive [7, 8]. Mustapha [9] reported that in many developing countries, availability of water has become a critical and urgent problem and it is a matter of great concern for families and communities depending on non-public water supply system. Global statistics show that over 1.2 billion people do not have access to potable water and 70% of Nigerians lack access to potable water.

Potable water is defined as water that is free from disease-producing micro-organisms and chemical substances deleterious to health [10]. There are several sources that water can be obtained from among which include streams, lakes, rivers, ponds, rain, springs and well, but unfortunately clean, pure and safe water only exist briefly in nature and is immediately polluted by prevailing environmental factors and human activities [11]. Water from most sources is therefore unfit for immediate consumption without some sort of treatment otherwise it does not meet the WHO standard. These water bodies are closely interconnected and may affect each other directly though they have different hydrodynamics [12]. At a certain level, minerals may be considered contaminants that can make water unpalatable or even unsafe. These substances can be the result of human activities or can be found in nature. Deep groundwater is generally of very high bacteriological quality (i.e. pathogenic bacteria or the pathogenic protozoa are typically absent), but the water may be rich in dissolved solids, especially carbonates and sulphate of calcium and magnesium [13].

The inability of government to consistently provide adequate water has contributed to the proliferation of the so-called 'pure water' production and sale of sachet water which has become a thriving business in Nigeria and other African countries. Consequently, a number of small-scale industries are packaging and marketing factory-filled sachet drinking water, popularly called "pure water" that many consider a safer source of potable water [14]. Sachet drinking water was introduced into the Nigerian markets in the late 90's and today the advancement in scientific technology has made sachet water production one of the fastest growing industries in the country as a less expensive means of accessing drinking water than bottled water [15, 16]. There has been countless number of diseases outbreak and poisoning around the world resulting from the consumption of untreated or poorly treated drinking water [17]. Water consumers are frequently unaware of the potential health risks associated with exposure to water borne contaminants which have often led to diseases like diarrhoea, cholera, dysentery, typhoid fever, legionnaire's disease and parasitic diseases [18].

Several studies on the quality of sachet water have reported violation of international quality standards as they are produced under mostly questionably hygienic conditions which predispose people to preventable life-threatening conditions [4, 16 21]. There is the possibility that the same situation may be applicable to Giwa Local Government Area (LGA) of Kaduna state, Nigeria where there is no potable pipe-borne water and many of residents rely on sachet water.

This study therefore attempts to provide more information on the quality of sachet water in Giwa LGA by identifying the spatial distribution of sachet water production points, collecting samples from the different production and retail points, analysing them in the laboratory and assessing their quality in comparison with the WHO [22] and NSDWQ [23] standards.

MATERIALS AND METHODS

Study area

Giwa LGA was created in 1991 out of Igabi LGA in Kaduna state. The Local Government has an area of 2,066km^2 and it is bounded in the North by Funtua LGA in Katsina State, while in the south, it is bounded by Igabi LGA. In the west, it is bounded by Birnin Gwari LGA while in the east, it is bounded by Zaria and Sabon-Gari LGAs. Geographically, the study area lies between Latitudes 10° 40´- 11° 22´N and Longitudes 7° 00´- 7° 40´E. It has eleven (11) Geographical districts namely: Giwa, Shika, Danmahawayi, Kakangi, Kadage, Yakawada, Idasu, Kidandan, Galadimawa, Kadage, and Panhauya wards respectively (Figure 1). The population of Giwa LGA is about two hundred and eighty-six thousand, four hundred and twenty-seven (286,427), according to the 2006 population census [24] and is estimated to be 398,135 by 2019 using a growth rate of 3.1%.

Sample collection and analysis

Using purposive sampling technique, water samples for the biophysico-chemical analysis were collected in duplicate from each sampling point (production and retail points). Six sachet water brands were selected: MYHAZAS (MZS), M. GUGA (MGS) NAPRI (NPS), YUZAFA (YZS), ZAD (ZDS) and IBRAISHA (IBS). These samples are the major brands gotten across eight (8) out of the eleven (11) wards present in Giwa LGA, namely; Giwa, Shika, PanHauya, Danmahawayi, Kakangi, Gangara, Kadagi and Yakawada. The remaining three wards were not accessible due to security threats during the period of study. The source of water for all the sachet water samples collected in the Giwa LGA factories is borehole. The sampling points are shown in Figure 2.

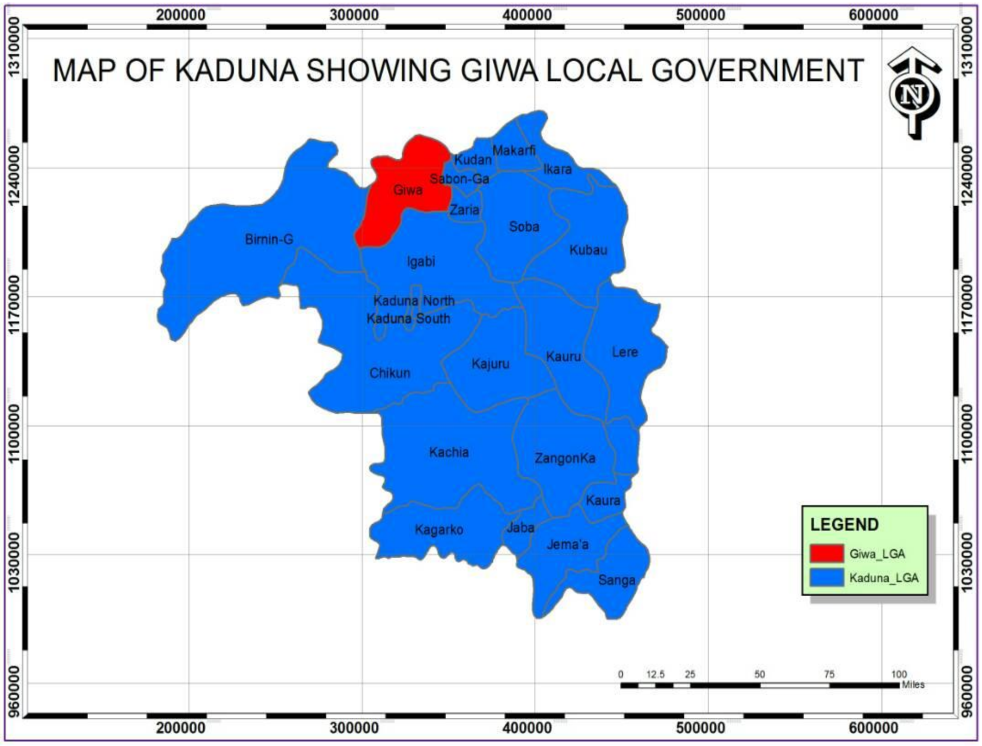

Figure 1: Study area

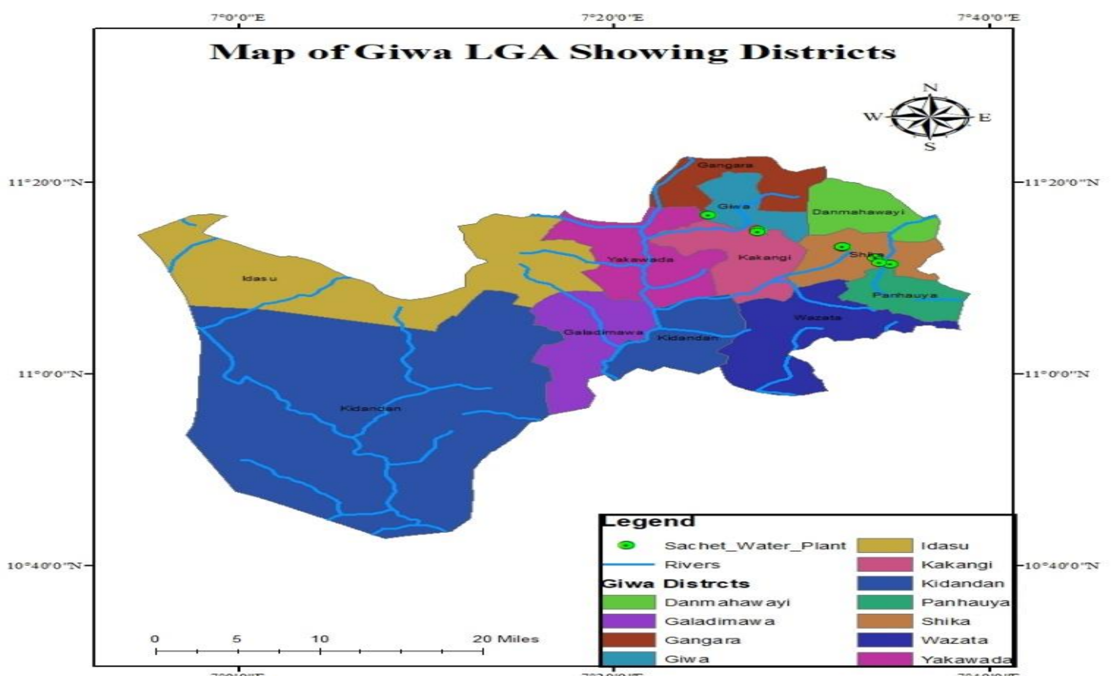

Figure 2: Study sites in Giwa LGA

Each of these samples was collected at both the manufacturers' station, immediately after production, as well as at the retailer sales points, making the samples a total of twelve. They were labeled with their respective initials and the suffix P and C to connote Producer and Consumer samples respectively. This was immediately transferred to the Water Resources and Environmental Engineering Department Laboratory at the Ahmadu Bello University, Zaria for analysis using standard procedures. The physical parameters analysed are colour and turbidity; chemical parameters: pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), Total Hardness (TH), Total Dissolved Solids (TDS) and Chloride; biological parameter is Total Coliform (TC) by comparing with the WHO and NSDWQ standards. The results were statistically analyzed using descriptive and inferential statistics through SPSS and Excel application developed by Microsoft Inc. and the results were presented in tables, charts and graphs.

RESULTS

Biophysico-chemical characteristics of the sachet water samples

Table 1 represents the biophysico-chemical properties results obtained from the laboratory

Table 1: Biophysico-chemical laboratory test results

S/N	Sample	Colour (Hz)	Turbidity (NTU)	pH	EC (µmho s/cm)	DO (mg/l)	TH (mg/l)	TDS (mg/l)	Chloride (mg/l)	TC (Cfu/100 ml)
1	IBS_P	5	1.79	6.1	33	3.1	101	160	4.99	4
	IBS_C	5	2.88	6.9	19	3.3	111.1	220	4.99	20
2	MZS_P	5	2.65	6.3	60	2.9	60.6	60	6.99	0
	MZS_C	5	1.42	6.7	21	2.6	80	110	6.99	7
3	MGS_P	5	1.59	6.5	50	3.6	70.7	130	3.99	10
	MGS_C	5	0.83	6.6	8.5	3.6	90.9	170	4.49	45
4	ZDS_P	5	6.15	6	4.5	2.6	313.3	670	43.38	60
	ZDS_C	5	7.56	6.2	4	2.6	325.1	600	45.49	100
5	NPS_P	5	0.60	6.1	5.6	3.6	151.5	60	3.99	0
	NPS_C	5	0.56	6.2	150	3	181.8	170	3.49	0
6	YZS_P	5	0.54	6.5	4.8	3.3	80.8	80	4.99	2
	YZS_C	5	1.96	6.4	90	3.3	111.1	230	6.99	5
	Mean S_p	5	2.22	6.3	26.32	3.18	129.65	193.33	11.39	12.67
	Mean S_c	5	2.54	6.5	48.75	3.07	150	250	12.07	29.5
	WHO	15	5	6.5-8.5	400	None	None	500	250	0
	NSDWQ	15	5	6.5-8.5	1000	5	150	500	250	10

Source: Laboratory Analysis, 2018

The results of the physical analysis show that the colour and turbidity of the samples were within the permissible limits of 15 Hz and 5 NTU respectively for WHO and NSDWQ except the turbidity of ZDS. All the water samples had colour values of 5 Hz while the turbidity for water samples at the points of production and retail ranged from 0.54 – 6.15 and 0.56 – 7.56 NTU respectively.

The results of the chemical analysis show that all the samples were within limits for EC, DO and Chloride while some were out of the limits for pH, TH and TDS. The pH values for water samples at the points of production and retail ranged from 6 – 6.5 and 6.2 – 6.9 respectively, TH values for water samples at the points of production and retail ranged from 60.6 – 313.3 and 80 – 325.1 mg/l respectively while TDS values for water samples at the points of production and retail ranged from 60 – 670 and 110 – 600 mg/l respectively. Factory water samples had more values below the lower acceptable limit of 6.5 for pH. ZDS and NPS had values above the NSDWQ acceptable limit of 150 mg/l for TH at both points of production and retail while all samples were within limit of 500 mg/l for TDS except ZDS in both points.

The results of the biological analysis for TC revealed high coliform levels in four samples at the point of production and five samples at the retail point with values ranging from 2 – 60 and 5 – 100 Cfu/100ml respectively when compared with the 0 Cfu/100ml WHO acceptable value. With respect to the NSDWQ acceptable value of 10 Cfu/100ml, three samples were within permissible limits at both points, another two and a sample at the points of production and retail respectively. Generally, factory water samples had the lowest values, with only NPS within the WHO and NSDWQ limits at both points of production and retail.It is evident from above that most of the parameters tested have better point of production values. In order to investigate whether there is a significant difference between the two points, t-test was used and the results are presented in Table 2 where it can be concluded that there is no significant difference in the sachet water quality at the points of production and retail.

Table 2: Test of difference results

Parameter	t	df	Sig.
Turbidity	-.232	10	.821
pH	-1.718	10	.116
EC	-.862	10	.409
DO	.502	10	.627
TH	-.374	10	.716
TDS	-.470	10	.649
Chloride	-.074	10	.943
TC	-.920	10	.379

DISCUSSION

Apart from the observation that all the brands of sachet water evaluated were tasteless and odourless, they also met the recommended WHO and NSDWQ standard for Colour and Turbidity (except for ZDS) implying that they had good aesthetic value (i.e. pleasantness, palatability and acceptability of the water) with low presence of suspended material such as clay, silt, organic material and other particulate materials. Although turbidity *per se* (e.g. from groundwater minerals or from post-precipitation of calcium carbonate from lime treatment) is not necessarily a threat to health, it is an important indicator of the possible presence of contaminants that would be of concern for health, especially from inadequately treated or unfiltered surface water [22, 23, 25]. The finding correlates with many previous studies where most physical parameters of water samples have been found to meet required standards [16, 18, 20, 21].

All the brands of sachet water evaluated met the recommended WHO and NSDWQ standard for EC, DO and Chloride with means of 26.32, 3.18 and 11.39 at points of production and 48.75, 3.07 and 12.07 at retail points indicating that water samples at points of production are of higher quality. It is pertinent to explain here that although mean DO value at the point of production is higher, it is an indication of better water quality because drinking water with very little or no Oxygen tastes unpalatable to some people [26].

pH, TH and TDS with means of 6.3, 129.65 and 193.33 at points of production and 6.5, 150 and 250 at consumption points had 42%, 67% and 83% of the water sample brands within required standards. The pH values for water samples at the points of production were lower but all the water samples can be generally described to be slightly acidic. ZDS and NPS had hardness values above 150 mg/l at both points of production and retail with ZDS having values above 300 mg/l and can be considered to be hard which is a term used to express the properties of highly mineralized waters [22, 25], while all samples were within limit of 500 mg/l for TDS except ZDS in both points. It is pertinent to note that the high TH of ZDS may not be disconnected from the result of the high TDS [27]. From these analyses, except for ZDS, there is no evidence of serious chemical contamination among the parameters studied. These findings correspond closely with those of Yusuf *et al.* [16], Oyelude and Ahenkorah [18], Fisher *et al.* [28] and Nwosu and Ogueke [29].

The Total Coliform of the samples when compared with the WHO and NSDWQ standards, shows only 17% and 67% compliance respectively with production point samples having higher quality. Only NPS, at both consumer and producer points, passed the test with a coliform count of zero. Interestingly, the sample of MZS gotten from the producer revealed no contamination whilst the consumer end was contaminated with a value of 7 Cfu/100ml. The results for ZDS show a remarkably high value in both producer and consumer samples of 60 and 100 Cfu/100ml. This finding suggests the fact that there is a correlation between Turbidity, TH, TDS and TC as evident in ZDS and NPS.

Investigations from the field actually revealed that ZDS table water had undergone change of identity thrice, from Algais to Dan Arewa and finally to Zad (ZDS). This was in response to consumers boycotting the product, due to its very poor quality. Shops located near the ZDS factory do not patronize the product; the company has to market its products to unsuspecting customers. Therefore, high levels of contamination could be attributed to poor quality of water source, inefficient treatment and storage process and insufficient or lack of personal hygiene. It would not be out of place to state that some of the producers' treatment process and distribution system employed by some of the water vendors are doubtful as it does not comply with standard operating procedure. The poor biological quality observed in this present study has also been reported in some parts of Nigeria and other parts of the Africa [16, 18, 28 - 31].

Although the t-test shows no significant difference between water quality parameters at points of production and retail, it can be derived from the analyses that there is reduction in water quality at the retail points as a result of poor distribution and storage processes along the supply chain as corroborated by the studies of Omalu *et al.* [19], Fisher *et al.* [28] and Macarthur and Darkwa [30].

CONCLUSION

Based on findings of the study, it was observed that physico-chemical parameters of most of the sachet water samples were within the WHO and NSDWQ specified limits. However, the biological water quality of most samples is found to be low when compared with the WHO standard and they could pose a health threat to consumers. Although there is no significant difference in water quality parameters between points of production and retail, vendor water samples were more contaminated due to poor distribution and storage processes along the supply chain. It is therefore recommended that adequate surveillance and monitoring by appropriate government agencies be carried out to avert outbreak of waterborne diseases in the study area. There is also the need for active involvement of manufacturers, distributors, vendors, consumers and handlers in the sachet water industry.

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